High-Sensitivity Camera for Round-the-Clock Surveillance

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Abstract

With potential threats such as natural disasters, criminal activity and terrorism increasing in scale, destructiveness and cost, accurate and reliable video surveillance of critical infrastructure has never been more important. Advance detection of disasters and acquisition of evidence can be accomplished through the installation of surveillance, security, and disaster-monitoring cameras with higher resolution and image quality. Focusing on the latest high-sensitivity camera available from NEC, this paper discusses NEC's component technologies for construction of surveillance systems that operate 24 hours a day, providing uninterrupted coverage day and night.

Keywords

high sensitivity, improved image clarity, improved visibility, reduced noise, fog reduction, surveillance, disaster prevention

1. Introduction

In recent years, there has been growing demand for surveillance systems able to better visualize critical areas of interest regardless of environmental conditions or time of day. In response, the surveillance industry has boosted its efforts to develop imaging technologies that increase sensitivity and make images sharper and clearer.

As a corollary to this, more sophisticated automation is required so that critical images can be effectively imaged with minimum human intervention, not only reducing the workload of surveillance system operators, but also minimizing the chances that human error or inattention will result in loss of data.

In this paper, we will discuss NEC's component technologies for construction of surveillance systems that operate 24 hours a day, focusing particular attention on the NC-H1200, NEC's newest high-sensitivity camera.

2. Overview of High-sensitivity Camera Component Technologies

A high-sensitivity camera is a camera that is able to capture color images in dark or low-light environments by amplifying whatever light is available. The higher the sensitivity, the less light the camera needs to capture an image. High-sensitivity cameras comprise three main component technologies: a high-sensitivity image sensor, signal amplification, and noise reduction (**Fig. 1**).

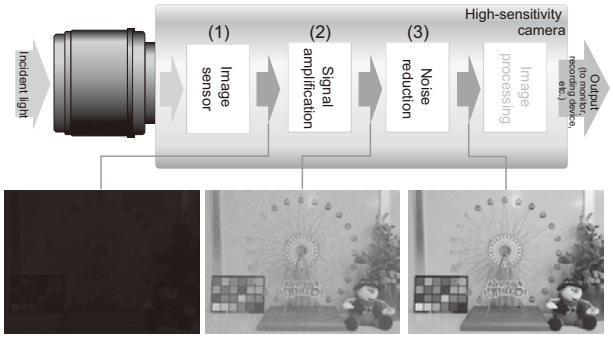

Fig. 1 How a high-sensitivity camera works.

(1) High-sensitivity image sensor

At the heart of any video imaging system is image sensor that converts the light taken in through the camera lens into electric signals. Features critical to optimizing the performance of the image sensor include the following:

1) Maximizing the amount of incident light entering the image sensor
2) Preventing unnecessary incident light from entering the image sensor
3) Converting the incident light which has reached the image sensor into electric signals (providing it with linearity)
4) The ability to detect and convert the minimum available light into electric signals
5) Preventing noise (random unwanted electric signals) from being generated inside the image sensor

(2) Signal amplification

If the amount of available light is insufficient, the resulting electric signal will be too small to successfully convert into an image. To boost the strength of the signal, an amplifier circuit is incorporated in the camera. In the case of the high-sensitivity camera from NEC that we will be discussing in this paper, signals can be amplified by several thousand times.

Unfortunately, signal amplification processing not only amplifies the desired video signal, but also any noise included in the signal. Because the signal components are increased after amplification, any noise generated subsequently will have comparatively less impact on the signal. In other words, the effect of noise can be minimized by performing the signal amplification at as early a stage as possible. High sensitivity can also be achieved by the adoption of a special image sensor with a built-in signal amplifier with a large amplification factor.

It is especially important that the amplifier circuit itself generates as little noise as possible, maintains linearity during amplification, and has sufficient bandwidth to handle video signals.

(3) Noise reduction

Noise can be produced both inside and outside the camera, potentially interfering with the video signal and degrading the image. Suppressing noise generation and keeping it from getting mixed into the video signal are of critical importance when it comes to assuring reliable high-sensitivity imaging performance. As described above, both the imaging unit and signal amplifier feature technologies that are designed to minimize the amount of noise generated and to prevent it from getting into the signal. Nevertheless, it is not currently possible to reduce all noise to zero.

It is for this reason that a high-sensitivity camera also incorporates noise processing technology to reduce any remaining noise that gets into the signal. Efforts to reduce noise have been an integral part of video development since the invention of the first video camera. Each method has its pros and cons; however, the enhanced imaging technologies recently developed by NEC include a noise reduction technology that has solved many of the problems inherent in conventional systems. We will take a closer look at these technologies in the next section.

3. Visibility Improvement Technologies

As explained above, the brightness of images captured in environments where very little light is available can be increased by amplifying the video signals output from the image sensor. The downside of this technique, however, is that quality of the image actually deteriorates and clarity decreases since any noise in the signal is amplified at the same time. Image clarity also is adversely affected by bad weather conditions or when shooting a distant subject.

To deal with this problem, what is required is a visibility improvement technology able to effectively suppress image noise and improve image quality.

(1) Noise reduction technology

Because images shot in the dark generate a lot of high-frequency noise, it is difficult to separate those images from edges (boundaries between objects and their backgrounds), as these are also high-frequency components. Consequently, any attempt to reduce the noise will also cause the sense of resolution to decrease, resulting in blurred images. This means that in order to reduce only the noise components, the edge components and noise components have to be separated from each other. NEC's new technology achieves this by taking advantage of the differences in the properties of the various signal components, allowing it to remove noise components, while leaving the edge components intact (**Fig. 2**). Noise contained in images includes not only high-frequency noise, but also low-frequency noise (e.g. color unevenness). By processing the signal from low resolution to high resolution using multiplexing resolution, all noise - from low frequency to high frequency - can be reduced.

As a result, it is now possible to reduce noise, while maintaining edges to ensure a sharp, clear picture even when shooting in the dark.

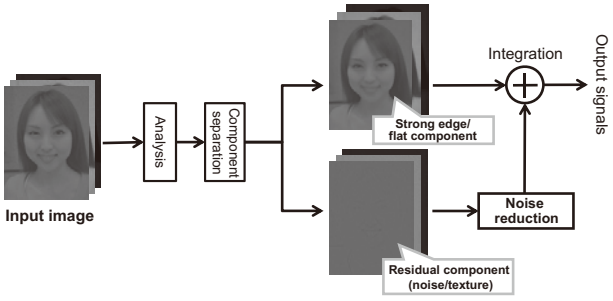

Fig. 2 Principles of noise reduction technology.

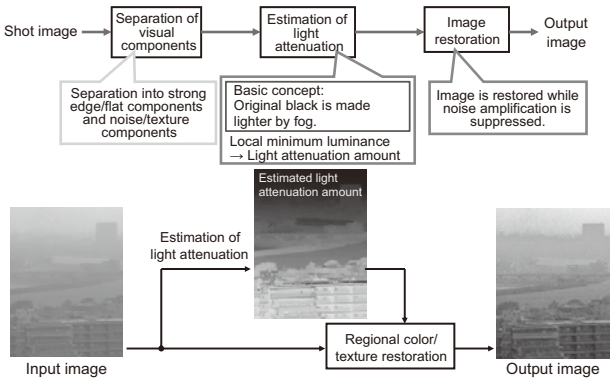

Fig. 3 Principles of fog reduction technology.

(2) Fog reduction technology

Fog reduction technology is required when image clarity is affected by bad weather, mist, or fog. This technology analyzes the visual characteristics of the images being shot, breaking them down into structural components composed of areas with large color changes and areas with small color changes such as the boundaries and backgrounds of objects and texture components composed of fine patterns. Processing is then applied to the structural components to increase brightness and contrast, and to the texture components to suppress sensor noise that can occur in the dark and or under bad weather conditions (**Fig. 3**).

Images are typically hard to see in bad weather, but visibility can be improved when this function is used to clarify images.

4. Operator Support Functions

(1) Automatic functions

Changing conditions over the course of a surveillance period make it difficult for operators to assure that the camera is optimally set at all times, if manual adjustment is required. NEC has eliminated this problem by providing automatic adjustment capabilities that allow the camera itself to execute a range of operations as required. The level of amplification is automatically adjusted according to the subject's brightness, while sensitivity is adjusted based on the amount of light available, covering a range of dozens of million times from a bright, sunny day to the dark of night. The result is optimum picture quality at all times, enabling surveillance personnel to focus on image monitoring and other surveillance operations.

Other image enhancing technologies include a contour compensation function and a gamma correction function that ensure that high image quality is maintained during high-sensitivity shooting by modifying their adjustment values according to the sensitivity setting.

(2) Digital zoom

Even when the subject is relatively dark and the aperture of the zoom lens is set wide open, the image will become darker once the lens is zoomed in to the TELE side. If it is necessary to zoom in even closer than is possible with the zoom lens, an extender can be used. However, when an extender is used, image brightness is reduced to about 25% of that obtaining in the image without using the extender.

To solve this problem, a digital zoom is used. Since the digital zoom performs processing with digital signals without exerting any optical effect, the subject can be zoomed in without making any reduction in brightness or decrease in camera sensitivity.

5. Introduction to NEC's High-Sensitivity Camera

(1) NC-H1200 - NEC's latest high-sensitivity camera

The NC-H1200 is an ultrahigh-sensitivity camera that uses three full HD CMOS sensors (**Photo 1**). Not only is this camera highly effective in low-light shooting situations where its sensitivity-boosting and image-enhancing technologies play a critical role, its full HD capability means that it is able to capture sharp, clear high-definition images even in bright shooting situations. Outstanding performance in a wide range of conditions makes this camera suitable for application in many different usage scenarios, ranging from ENG cameras employed by broadcasting stations, video surveillance at public infrastructure facilities and ports, and surveillance cameras for disaster prevention (**Fig. 4**).

(2) System expansion

Also available is a portable camera with improved mobility that enables battery operation, viewfinder installation, easy outdoor carrying, and recorder docking (**Photo 2**).

This camera can be applied to a wide range of fields in-

Photo 1 NC-H1200 HDTV ultrahigh-sensitivity color camera.

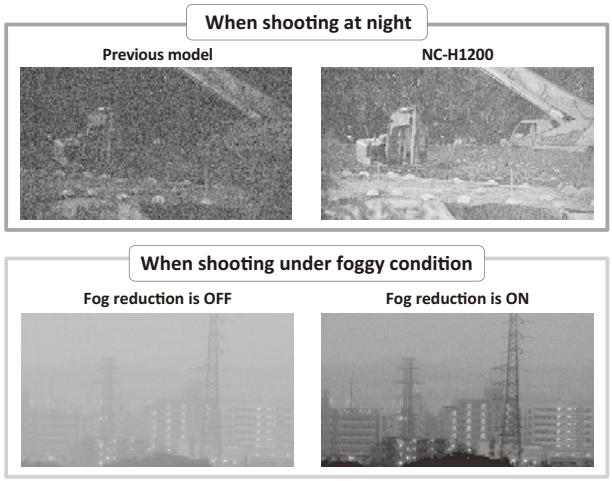

Fig. 4 Comparison of outdoor images.

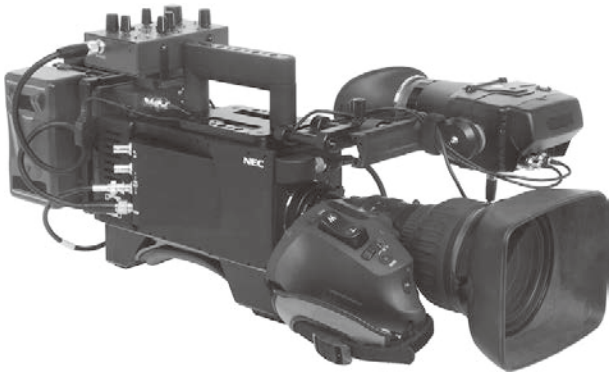

Photo 2 NC-H1200P HDTV ultrahigh-sensitivity color camera (portable type).

cluding electronic news gathering, surveillance by law enforcement agencies, visual data collection at accidents, disasters, and other destructive events, and imaging of celestial or biological objects.

6. Conclusion

With NEC's advanced component technologies for image enhancement and the new NC-H1200 high-sensitivity camera, it is now possible to construct a powerful and flexible surveillance system capable of providing clear, high-resolution images day or night. The NC-H1200's unique combination of high sensitivity, high image quality, and operational simplicity - something which conventional models have been unable to achieve - is sure to enable it to play a vital role in helping minimize potential losses or damage that could result from criminal activity or natural disasters. Even now, however, it is apparent that there is a need for even greater improvements in sensitivity and performance. All of us at NEC are committed to continuing our efforts to develop new technologies and products that will meet and exceed market demands.

Finally, we would like to thank all of those who worked together to develop the high-sensitivity camera introduced in this paper.

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