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Development and Future Deployment of Cloud-based Video Surveillance Systems

Wataru Ebihara
Yoshikuni Mae
Fukuyasu Abe
Shinichiro Hirooka

OVERVIEW: The market for video surveillance systems has been growing, with the technology being seen as essential for preventing unauthorized or criminal activity at logistics or financial services branches, and for quickly resolving violent incidents and similar. With the spread of networks in recent years, there has been growing demand for use of these systems in business. This demand extends beyond existing applications for preventing crime to also include uses such as remote monitoring to keep track of people and equipment, and image analysis to support customer operations and business management. Hitachi has been developing cloud-based video surveillance systems to meet this demand, and has plans to extend this development to future cloud services such as using image analysis for customer business support and equipment operation monitoring.

INTRODUCTION

WITH growing concerns about public safety and security, video surveillance systems are being installed in a variety of different locations, including retail outlets, offices, public places, and factories.

Along with the spread of networks and greater use of digital video, video surveillance systems are increasingly using network cameras with high image quality and definition. The 2012 market for network cameras in Japan and overseas grew by 18% over the previous year, with the number of network camera shipments in Japan being forecast to exceed those of analog cameras in 2015[1].

The trend toward networked systems is also leading to increased demand for large, cloud-based systems that perform centralized management of video at a data center or similar. Uses for these systems

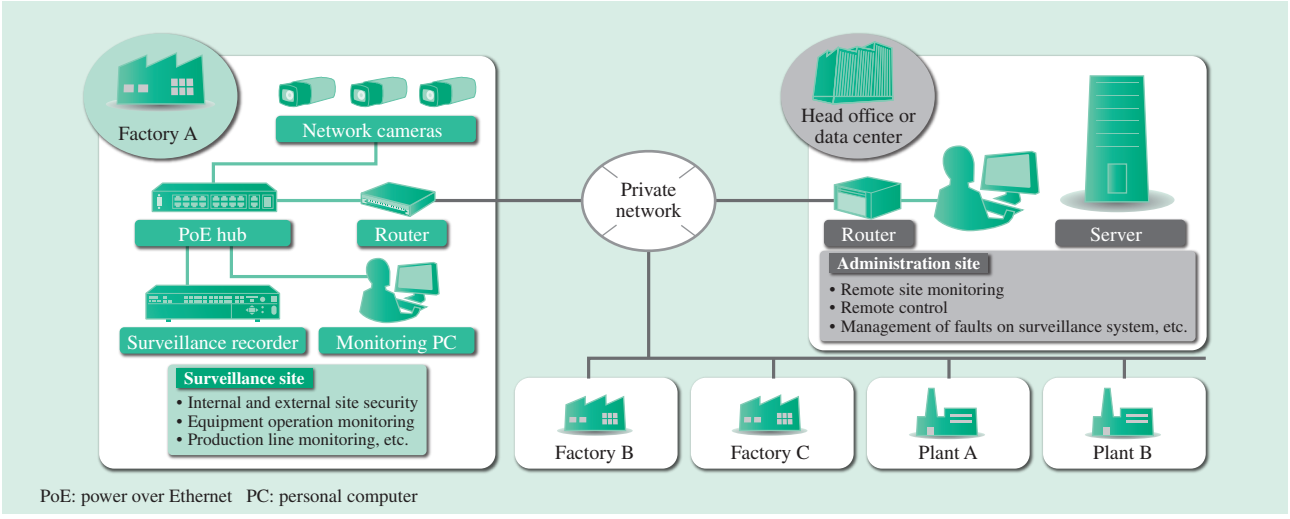

Fig. 1—Example System Block Diagram of Video Surveillance Solution.
Installing the video management system on a server at the customer's head office or data center allows centralized management of an entire surveillance system to be performed remotely, with capabilities that extend from acquiring video from each site to monitoring system operation.

extend beyond crime prevention to include growing demand for business applications such as remote site monitoring, or the use of images and their analysis to support customers' operations and management.

This article describes Hitachi's work on cloud-based video surveillance systems, their future commercialization in applications that utilize image analysis, and camera image enhancement techniques that play an important role in image analysis.

CLOUD-BASED VIDEO SURVEILLANCE SYSTEMS

Video Surveillance Solution

Hitachi developed the integrated video management software for use with video surveillance systems that are becoming larger in scale (see Fig. 1).

Past video management software has been based on a standalone model in which a copy of the software is installed on a personal computer (PC) at each site. As a result, the video surveillance system is split between different sites, making system management and the sharing of video between sites more difficult.

In contrast, the video management system is configured on a client/server model that provides client PCs with a full range of monitoring video display functions and that manages site information centrally on the server. This significantly reduces the amount of work that was previously required at each site because it enables a dedicated department to perform centralized administration via the network of the operation and other settings in the management information at the server. The system runs on an SQL Server* database that provides high-speed data retrieval. This enables the implementation of large video surveillance systems with up to 32,000 network cameras and 2,000 video recorders.

Because the client PCs at each site do not need to handle administration of the video surveillance system, they can be customized for video display. Similarly, because they work by retrieving management data from the server, sophisticated video display operation using the latest management data is made simple, even for large video surveillance systems that add and remove sites frequently.

Deployment of Video Surveillance Service Incorporating Image Analysis

Because the video management system provides interfaces to other applications and systems, it can act as a platform for flexible solution configuration. Accordingly, Hitachi is looking to deploy a cloud-based service that integrates the video management system with an image analysis application to help customers improve the efficiency of their operations and management (see Fig. 2).

This can provide solutions to suit different industries. One possible application for factories or other plants, which have been suffering from a

* SQL Server is either a registered trademark or trademark of Microsoft Corporation in the United States and/or other countries.

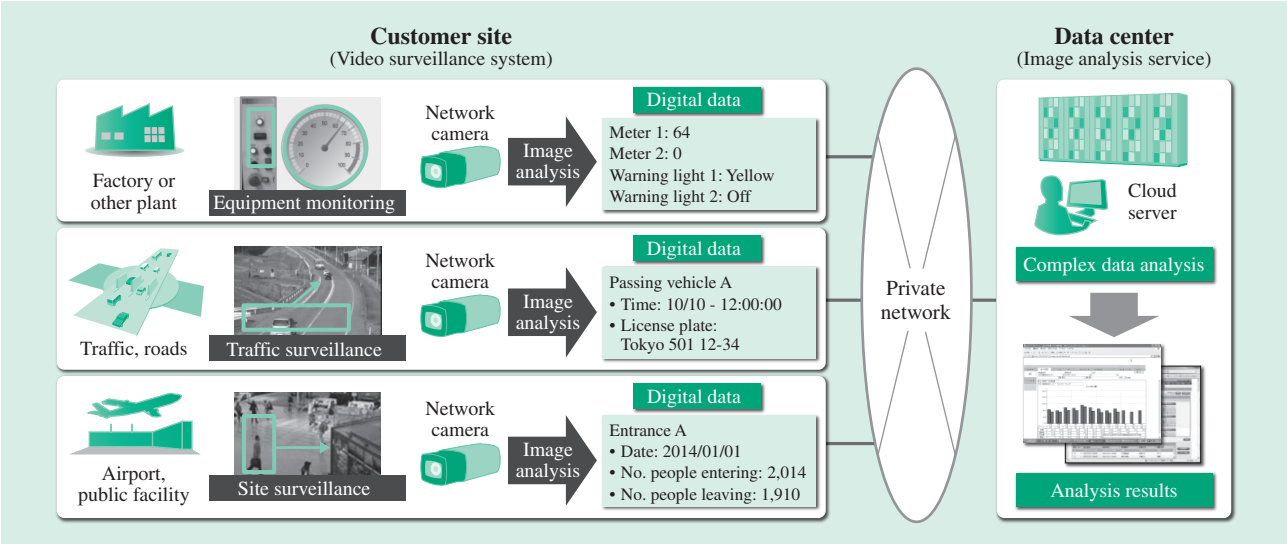

Fig. 2—Conceptual Model of Video Surveillance Service Utilizing Image Analysis.
This involves supplying image analysis services tailored to each customer to improve operational and management efficiency or otherwise help with their business.

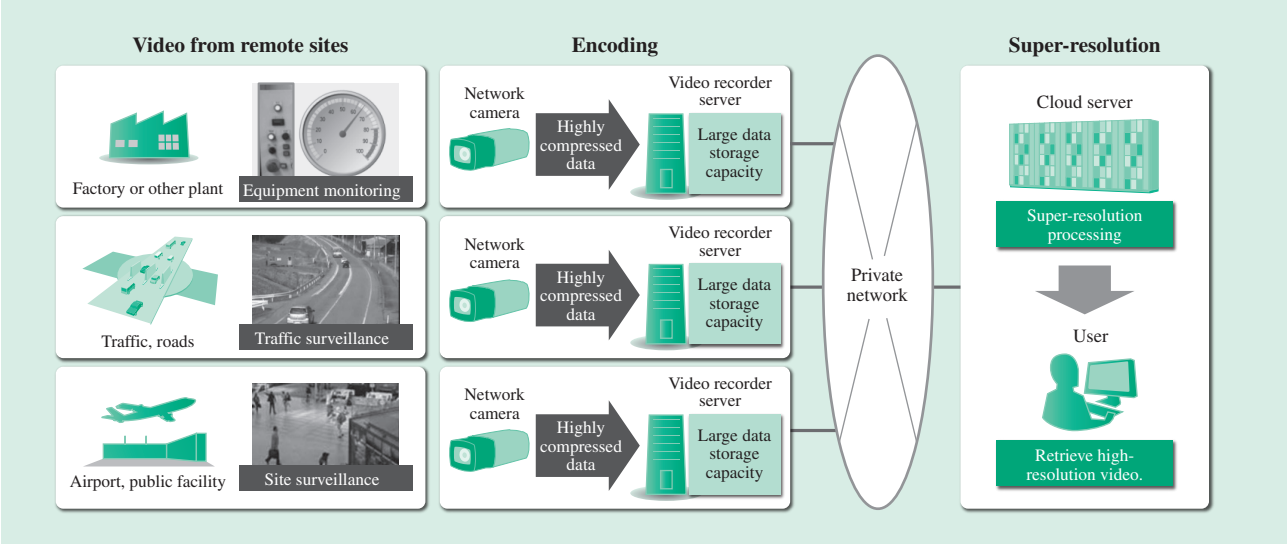

Fig. 3—Flow of Video Data.
Compressing the video data to a high degree at the camera reduces its size and allows large amounts of data to be sent to the cloud server.

shortage of experienced staff in recent years, is to use image analysis to monitor equipment operation in place of visual observation by an operator. A potential traffic application is to build a database using image recognition to read car number plates so that illegal vehicles can be quickly identified.

Hitachi currently provides a solution for retailers that works with an image recognition application to count the number of people passing in front of a video camera in order to automatically determine the number of people entering and exiting a site. The solution is utilized in marketing, such as for adjusting staff shifts to match rises and falls in the number of customers coming to a store, or measuring the effectiveness of promotional activities such as advertising flyers.

IMPROVING ACCURACY OF IMAGE ANALYSIS

Video Transmission Processing

Improving the accuracy of image analysis using video data received remotely from a network camera requires high image quality and definition together with large amounts of image data. However, factors such as the finite capacity of the hard disks on the video recorder server and limited network bandwidth mean that image data needs to be compressed in order to reduce its size. Unfortunately, as well as reducing the use of network bandwidth, image data compression also reduces the image resolution and therefore degrades the analytical accuracy.

In response to the problems due to compression, Hitachi is developing a video surveillance system that performs image data encoding at the camera using a technique that allows images to be decoded with super-resolution. By compressing the image data, this reduces the size of the data stored on the video recorder server and the network bandwidth needed to transmit the video to the cloud. The system provides users with high-resolution video by using a newly developed technique to perform super-resolution processing of the transmitted video data on the cloud servers (see Fig. 3).

This method supports the handling of large amounts of high-quality and high-definition image data and allows a variety of image analyses to be performed.

Camera Image Enhancement Techniques: Improving Camera Image Quality

Better camera functionality is also important for improving the accuracy of image analysis. Along with using network cameras that have adequate sensitivity and resolution, this also means capturing images with good visibility under difficult conditions, such as fog or backlight. In response, Hitachi has developed a new digital signal processor (DSP) to provide cameras with high performance (see Fig. 4).

(1) Development of Hitachi's unique DSP

In addition to noise reduction [brightness signal-to-noise ratio (S/N) improved by 6 dB and color S/N by 12 dB compared to previous model], the new DSP also performs adaptive region-based contrast enhancement. The contrast enhancement unit consists of tone

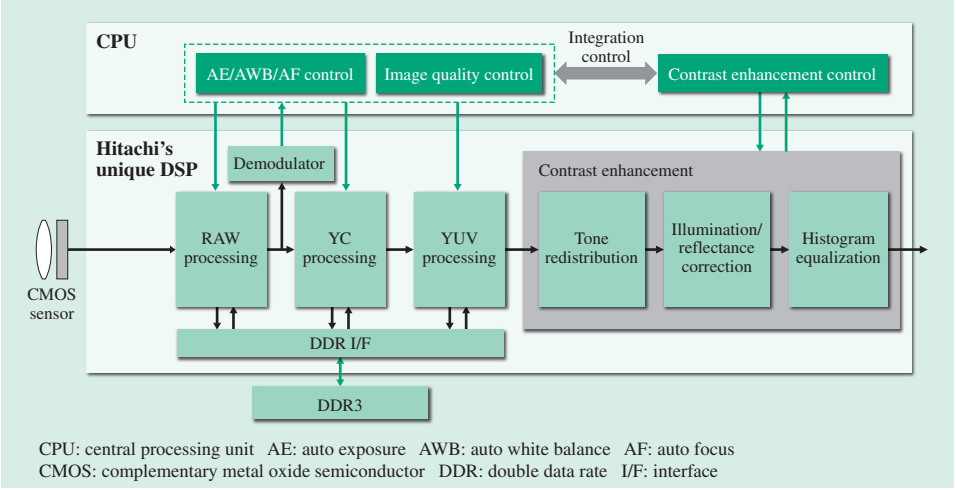

Fig. 4—Functional Block Diagram of Camera System with Hitachi's Unique DSP.
The DSP provides a single-chip solution that works in tandem with a host CPU to perform noise reduction and other camera signal processing, exposure, white balance, and other automatic control, and contrast enhancement for better image visibility.

redistribution, illumination/reflectance correction, and histogram equalization functions. Visibility can be improved under a variety of poor conditions by adjusting the enhancement parameters used by these functions to suit the scene.

(2) Use of contrast enhancement to improve visibility

The following section uses the example of contrast degradation caused by fog to explain how contrast enhancement is performed using Hitachi's unique DSP. The loss of contrast in fog is due to the scattering of light by water vapor droplets in the air. Under these conditions, it is known that the brightness of an object falls asymptotically to the level of ambient light as the distance between camera and object increases[2]. Accordingly, the basic concept behind defogging is to restore the contrast by adjusting the enhancement parameters for each region such that they reverse this process[3]. Based on this premise, enhancement can restore the brightness level by first estimating the level of ambient light in the region of interest in the image, and then widening the brightness distribution around this level (see Fig. 5).

Another form of enhancement is to combine wide dynamic range (WDR) and contrast enhancement to expand the dynamic range of scenes with large variations in light level. Hitachi's unique DSP can also perform Enhanced Intensity processing, a function for enhancing nighttime and other dark scenes to increase the brightness of objects that are difficult to see in the dark. This expands small differences in signal level in dark regions to improve their visibility (see Fig. 6).

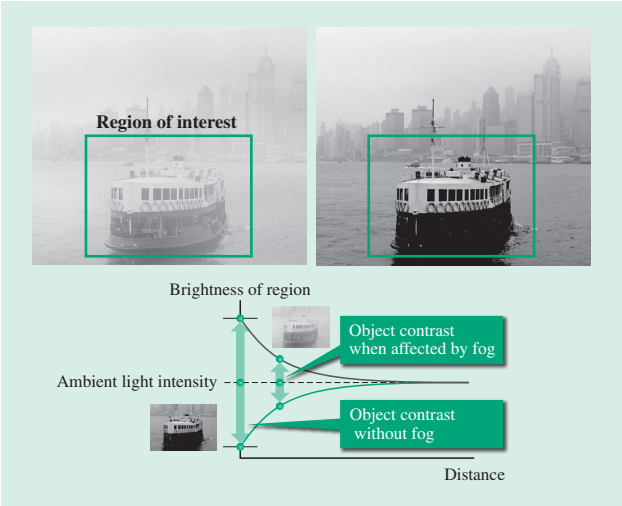

Fig. 5—Defog Function Implementation.
Defogging uses image analysis to estimate the ambient light intensity in each region and then widens the contrast around that intensity.

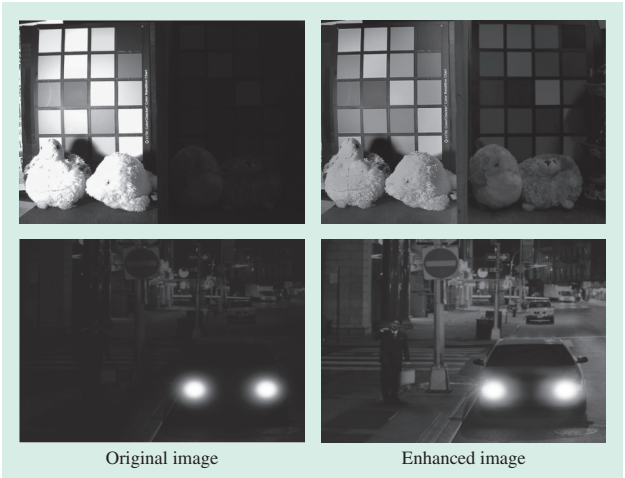

Fig. 6—Examples of Visibility Improvement.
Contrast enhancement can be used with wide dynamic range (WDR) processing to improve the visibility of images that combine both light and dark regions (top), and with the Enhanced Intensity function to improve the visibility of dark images (bottom).

(3) Commercialization of image enhancement techniques

Hitachi led its competitors in commercializing this image enhancement technology by including a defog function based on these techniques in a camera module developed in 2012. The technology was also used to improve the visibility of license plates and vehicle interiors in traffic surveillance cameras, with products released in 2013. Hitachi intends to continue developing techniques for using contrast enhancement to improve visibility, and to use the technology to differentiate itself from its competitors.

CONCLUSIONS

This article has described Hitachi's work on cloud-based video surveillance systems, their future commercialization in applications that utilize image analysis, and camera image enhancement techniques that play an important role in image analysis.

With Tokyo due to host the Olympics in 2020, it is anticipated that there will be growing demand for video surveillance systems to help ensure safety and peace of mind, and to enhance security. Hitachi intends to continue supporting public safety by supplying video surveillance solutions that deliver value to its customers.

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ABOUT THE AUTHORS

Wataru Ebihara
Security System Engineering Department, Security & Energy Solutions Division, Urban & Energy Solutions Division, Infrastructure Systems Company, Hitachi, Ltd. He is currently engaged in the planning of security solutions.

Yoshikuni Mae
Service Platform Development Department, Security & Energy Solutions Division, Urban & Energy Solutions Division, Infrastructure Systems Company, Hitachi, Ltd. He is currently engaged in the development of security solution's software.

Fukuyasu Abe
Security System Center, Security & Energy Solutions Division, Urban & Energy Solutions Division, Infrastructure Systems Company, Hitachi, Ltd. He is currently engaged in the development of surveillance cameras.

Shinichiro Hirooka
Embedded Solutions Research Department, Yokohama Research Laboratory, Hitachi, Ltd. He is currently engaged in the research and development of a surveillance camera system. Mr. Hirooka is a member of The Institute of Electronics, Information and Communication Engineers (IEICE).