Development of SightVisor Information Browsing Device using H.264

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[Summary] To improve the quality of video surveillance, cameras, encoders and decoders will switch to H.264 images compression in the future. In these circumstances, we have developed the SightVisor Information Browsing Device offering both H.264 and legacy MPEG-2 images compression in one box to support customers' mixed video surveillance environments. We also outline the H.264 technical specifications.

1 Introduction

The Japanese Ministry of Land, Infrastructure, Transport and Tourism (MLIT) plays a key role in maintaining social infrastructure to assure the safety and wellbeing of the nation. As one example, the Ministry installs video monitoring equipment on roads and river banks to monitor dangers resulting from natural disasters such as typhoons and earthquakes, as well as risks caused by aging infrastructure (figure 1).

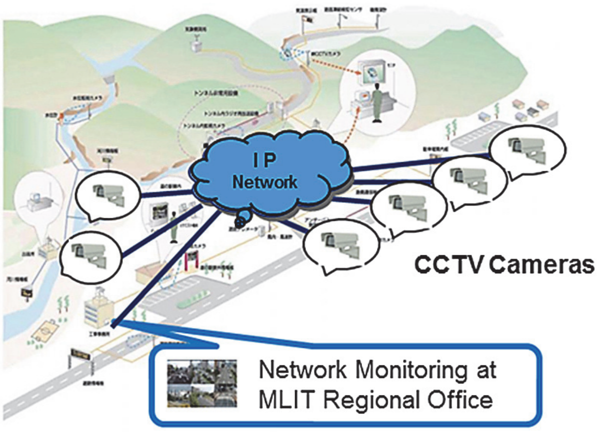

Figure 1 Overview of Video Monitoring

Since FY1998, MLIT has deployed more than 14,000 CCTV cameras connected to a central optical network to implement a high-level video monitoring system using a general-purpose IP network[4]. Monitoring is also expected to play an increasingly important role in assuring the safety of aging social infrastructure such as bridges, elevated expressways, etc.

In the first stages, the video monitoring system deployed by MLIT used the MPEG-2 images compression technology to match the video bandwidth of available transmission lines (Standard Definition (SD) resolution of 740 × 480 pixels). However, devices using the H.264 standard offering higher video compression rates than the earlier MPEG-2 have appeared on the market and are being deployed due to the H.264 advantages of high video resolution with reduced data communications traffic. Makers of encoders are now marketing H.264 devices supporting high-definition (HD) video (1920 × 1080 pixels) when used in combination with HD cameras over conventional general-purpose IP networks. As a result, video monitoring systems are evolving towards HD.

However, making a complete and immediate switchover to the H.264 technology is difficult due to the numbers of legacy installed MPEG-2 encoder/decoder equipment and these older facilities will have to be updated gradually while controlling maintenance costs. Future issues to tackle in this mixed MPEG-2 and H.264 images compression environment, involve how to continue video monitoring while upgrading facilities appropriately.

To help with these issues, we have developed the SightVisor Information Browsing Device supporting both H.264 and MPEG-2 images technologies as well as easy switching between different video monitoring systems. Section 2 of this article explains the main features of the H.264 technology used by SightVisor. Section 3 explains its development concept and basic structure. Section 4 presents some usage applications.

2 Features of H.264

H.264 is one of the video compression standard devised jointly by ITU-T and ISO/IEC in May 2003. The ITU-T recommends it as H.264, whereas ISO/IEC standardized it as MPEG-4 Part10:Advanced Video Coding.

The fundamental encoding algorithm of H.264 is the same as conventional MPEG-2; the input video is subjected to predictive processing between macroblock unit frames, DCT conversion and quantization before encoding.

Macroblocks are small 16 × 16 or 8 × 8 pixel sub-divisions of the image each of which is encoded. Interframe Prediction finds similarities in multiple compressed and encoded image screens (called frames) and encodes the differences between a frame and the preceding frame.

Figure 2 shows a H.264 Encoder Circuit Diagram. The parts labeled motion compensation, DCT quantization, entropy encoding, deblocking filter, etc., are upgrades from MPEG-2 and provide the better image quality and video compression efficiency.

Motion compensation predicts the amount of movement between frames in an area caused by movement of things in images. This motion compensation encodes movement vectors as additional information. Either Context-based Adaptive Variable Length Coding (CAVLC), or Context-based Adaptive Binary Arithmetic Coding (CABAC) is used for entropy encoding at the encoded parts to implement large improvements in encoding efficiency. Table 1 shows the key differences between MPEG-2 and H.264.

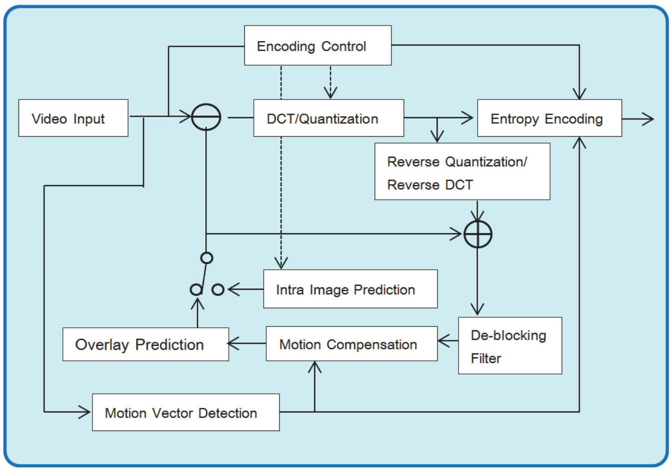

Figure 2 H.264 Encoder Circuit Diagram

2.1 Effects of H.264

(1) Reduced data traffic due to high compression

The MLIT video monitoring system uses 6 Mbps data traffic for MPEG-2 images. By comparison, H.264 SD images at the same resolution use 2 Mbps, or 66% less data traffic (table 2). As a result, it becomes possible to deploy more video cameras without increasing the volume of data traffic on the current network. Moreover, video monitoring becomes possible on networks with circuit capacities of less than 6 Mbps.

(2) Reduced amount of saved video data due to high compression

Since H.264 SD images use 66% less data than comparable MPEG-2 images, data storage devices such as hard disks can save three times as much video data. Or put another way, data storage devices can be 66% smaller while still saving the same duration of video images.

(3) Better monitoring quality due to high image quality

The resolution of MPEG-2 images used by the MLIT system is SD 740 × 480 pixels with 6 Mbps of data whereas the resolution of H.264 HD images is 1920 × 1080 pixels with 8 Mbps of data traffic (table 2). Although using HD data streams increases traffic by 1.3 times, the video resolution is 5.8 times better, supporting high quality monitoring and making it much easier to see fine details that are hard to see using conventional MPEG-2 images.

Table 1 Effects of H.264 and Differences between MPEG-2 and H.264

	MPEG-2	H.264	Effects
DCT	2D DCT	Integer Precision DCT	Fewer errors due to operation precision and less image degradation
Quantization	37 Step Sizes	52 Step Sizes	Improved image quality due to finer quantization
Encoding	VLC Encoding	Entropy Encoding	Improved encoding efficiency
Noise Filtering	None	Deblocking Filter	Less image degradation due to encoding blocking
Motion Vector Detection	1/2 Precision Prediction Accuracy	1/4 Precision Prediction Accuracy	Better compression efficiency due to finer predictability
Motion Compensation	Block Size of 16 × 16 Pixels Only	7 Block Sizes	Better Compression Efficiency

Table 2 Comparisons of MPEG-2 images and H.264 images Resolution and Communication Rate

Compression Method	Resolution	Communications rate
MPEG-2	740 × 480	6 Mbps
H.264 SD	740 × 480	2 Mbps
H.264 HD	1920 × 1080	8 Mbps

3 SightVisor Development

The MLIT uses CCTV cameras to perform video monitoring in branch office disaster control rooms and offices. The required number of decoders is installed at the monitoring sites along with controllers for switching images of the areas under surveillance displayed in the control rooms, etc. As the number of sites under surveillance, the number of video channels can exceed 500 leading to massive video monitoring infrastructure.

We developed the SightVisor Information Browsing Device to simplify video channel switching as well as implement dual support for both MPEG-2 and H.264. It supports simultaneous monitoring of images from both MPEG-2 and H.264 CCTV cameras in an all-in-one box. Figure 3 shows the external view of the SightVisor, figure 4 shows the block diagram and table 3 lists the main specifications.

Figure 3 External Appearance of SightVisor

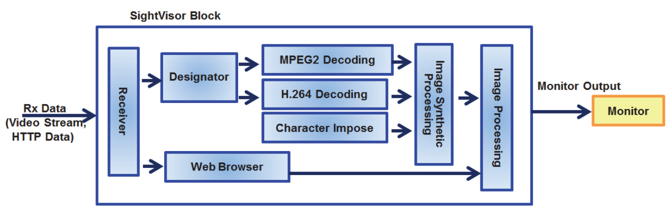

Figure 4 SightVisor Block Diagram

Table 3 SightVisor Specifications

Item		Specification
Video/Audio	Video Encoding Method	MPEG-2 ISO/IEC13818-2 H.264 ISO/IEC14496-10
	Profile and Level	MPEG-2 MP@ML, SP@ML H.264 MP@L3 min., MP@L4 min.
	Audio Encoding Method	MPEG-2 MPEG-1 Audio Layer II (ISO/IEC11172-3) H.264 MPEG-1 Audio Layer II (ISO/IEC11172-3) MPEG-2 AAC
	Video Output I/F	HDMI (Type A) × 1, Analog RGB × 1
	Audio Output I/F	HDMI (Type A) × 1, Stereo Mini-jack × 1
System/ Transmission Method	Multiplexing Method	MPEG-2 PS, MPEG-2 TS (ISO/IEC13818-1) TTS (ISO/IEC13818-1, ARIB STD-B24)
	Transfer Protocol	RTP/IP, UDP/IP, Unicast/Multicast
	LAN	10BASE-T/100BASE-TX/1000BASE-T × 1 Port
Functions	Video Registration	1100 ch max.
	Split Image	1/4/6 Split Images
	WEB Display	1/4/6 Split Images
	Image Patrolling	Individual in split screen units
	WEB Patrolling	Individual in split screen units
	Smooth Patrolling	Every 5 to 1800 s
	Power Management	Automatic operation (preset screens) at power-on
	Timer Function	Clock display synchronized with NTP, or manual setting
	Others	Remote Controller and Extender
Power Supply		100 Vac (50/60 Hz)
External Dimensions		300 (W) × 220 (D) × 86 (H) mm (excluding protruding parts)

3.1 Development Concepts

(1) No awareness of video compression method

Normally, a decoder is required for each technology when monitoring video using different compression technologies. However, since the SightVisor supports both MPEG-2 and H.264, and automatically recognizes the compression technology of the received image, the compression technology is transparent to users, greatly simplifying their monitoring workload (figure 5).

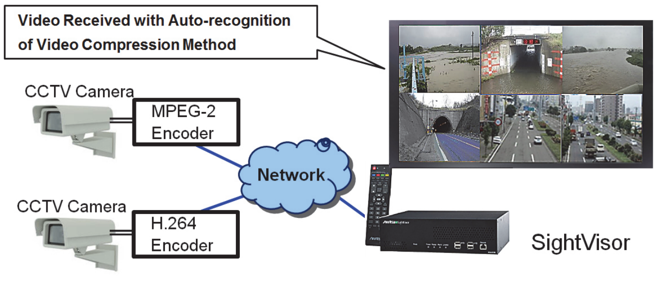

Figure 5 Dual Support

(2) Blackout-free video monitoring

The MLIT video monitoring control rooms perform site monitoring by sequentially sweeping through several hundred video camera images (patrolling). At switching between video channels, there are a few seconds of delay required for transmission and decoding before the next video data are received and displayed, causing a short blackout (figure 6). This blackout at switching is stressful for people trying to asses the on-site conditions. The developed SightVisor eliminates video switching blackouts to support smooth and stress-free patrolling of images (figure 7), which it achieves using multiple built-in decoder modules that are performing pre-decoding of video data.

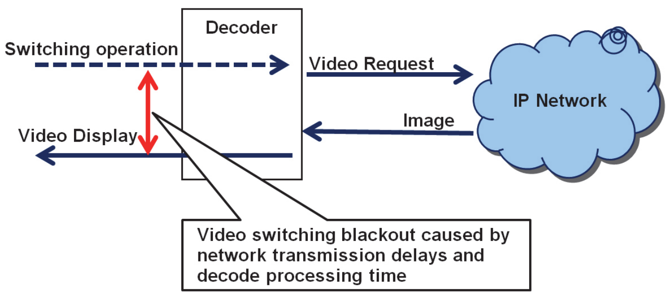

Figure 6 Cause of Video Switching Blackouts

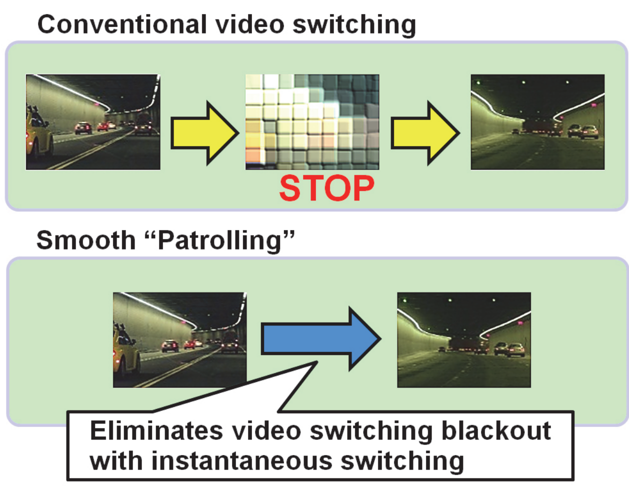

Figure 7 Smoothing Image Switching/Patrolling

(3) Easy operation

SightVisor has been designed for easy use by anyone without even needing to read the manual. Dedicated function buttons on the remote controller (figure 8) support automatic one-touch operation.

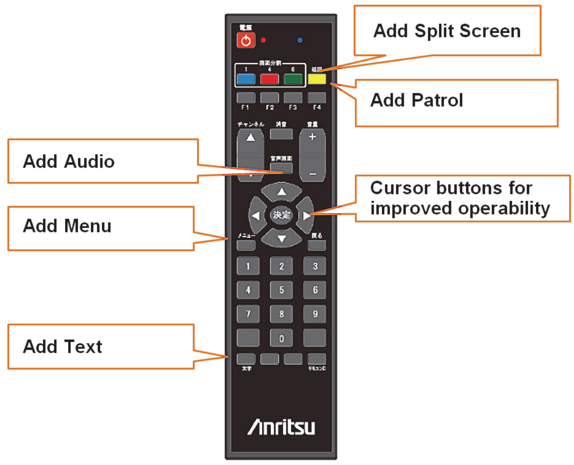

Figure 8 External View of Remote Control

The remote controller extender (figure 9) supports easy operation while facing the screen.

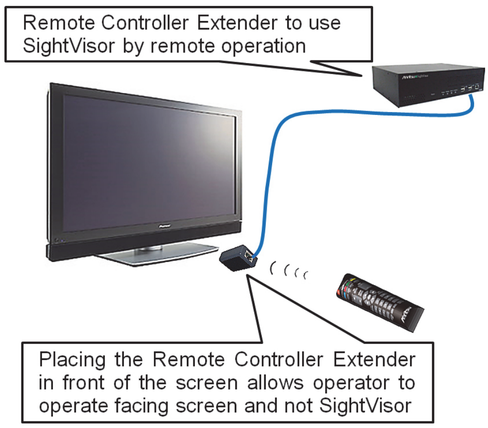

Figure 9 Remote Control Extender

The Main menu (figure 10) displays Help messages at the bottom of the screen to help the operator work without confusion.

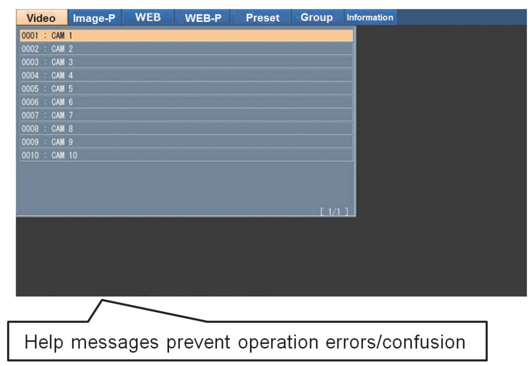

Figure 10 Main Menu Screen

(4) Dedicated unit

Although the functions of SightVisor can be implemented using commercial PC application software, a dedicated, single-purpose hardware design offers many advantages over software (table 4).

Table 4 Comparison between Dedicated Unit and PC-based System

	Dedicated Device	Software (PC)
Power Cut	No problem	Risk of damage to HDD
Power Recovery	Auto-restart	Requires manual restart by administrator
Operation Stability	No problem due to dedicated design	Depends on OS stability if other applications running simultaneously, video decoding may be unstable sometimes

4 SightVisor Application Examples

4.1 Monitoring River Levels

River monitoring levels to issue emergency alerts over public address systems, etc., requires monitoring of water flows using telemetry as well as visual checks on levels and conditions using CCTV cameras.

With MPEG-2 images, the image resolution and poor image quality (figure 11a) make visual confirmation difficult and require patrolling through many images. However, the high resolution and image quality of H.264 (figure 11b) make it easy to confirm river conditions without image patrolling. In addition, the details of flood debris caught under bridges can be seen easily using HD H.264 images.

a) MPEG-2 b) H.264 HD

Figure 11 Video Image Comparison

4.2 Monitoring Roads

Visual monitoring of tunnels, roads, etc., is performed while switching automatically between images. With conventional systems there is a short video blackout of a few seconds as the images switch. Monitoring moving things such as automobiles when the video stops for a few seconds makes it hard for operators to determine whether it is the vehicle or the video that has stopped but with SightVisor road monitoring becomes much easier and stress-free because the built-in smooth patrolling function eliminates video pauses and blackouts.

4.3 Monitoring at Branch Offices

Video images of nearby sites must be easy to confirm. Consequently, SightVisor is designed to support intuitive remote operation by onsite personnel. The remote controller has function-defined buttons and an extender supports easy operation while facing the screen. Help messages are displayed on-screen during operation using the remote controller to support easy operation without reading the manual and simplify monitoring while improving work efficiency.

5 Summary

Video monitoring systems are progressively introducing H.264 images compression to improve image quality and reduce data traffic. However, it is difficult to replace all existing legacy MPEG-2 images monitoring infrastructure in the short term, leading to a mix of technologies until all infrastructure is replaced gradually over time. We have developed SightVisor with built-in MPEG-2 and H.264 to help support smooth introduction of new H.264 installations during this transition period, and we will continue with future development of new technologies helping to ensure the safety of people and infrastructure.

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