MULTIPOINT MEASURING SYSTEM FOR VIDEO AND SOUND
- 100-camera and microphone system -

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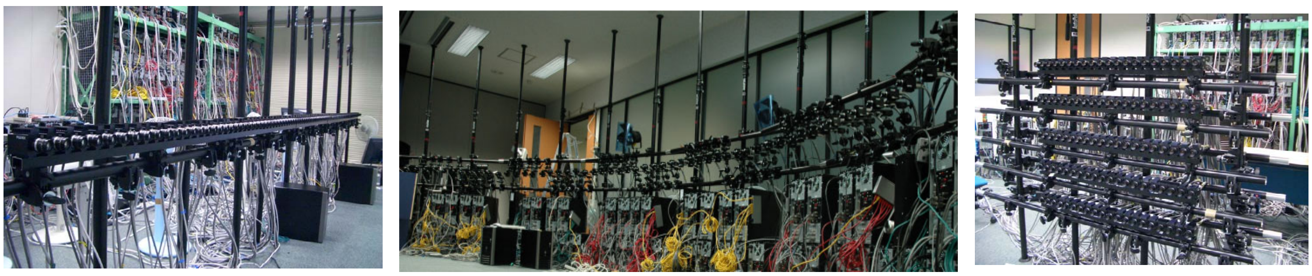

Figure 1: Overview of 100-camera and microphone system.

ABSTRACT

We developed a novel multipoint measurement system capable of acquiring video and sound at more than 100 points in a "synchronized" manner. In this paper, we first describe the specification of the system and how the system works in detail. Then we report some experimental results that confirm the performance of the system. We also describe test data set we provided for MPEG(Moving Picture Experts Group) Multi-viewpoint Video Coding activities. Using this system, we are planning to conduct projects to measure humans and their activities, collect a large volume of real-world data of video and sound, and release them to the public.

1. INTRODUCTION

We humans use our sense organs to process the information we encounter every day. Among them, we rely mostly on two major senses: "hearing" (in relation to speech media processing) and "seeing" (in relation to image media processing) via the ears and eyes, respectively. Therefore, these media play an important role for us to recognize and understand real-world environment, communicate each other, and so on. Media information processing technology, since it provides the interface between computers and humans, is essential in developing a social information infrastructure. The upgrading of media information processing technology is therefore expected to improve the convenience, amenity and safety of everyday living.

Since media take various forms, research groups around the world work on different types of media, such as speech and image media. And hence it is not a simple matter to comparatively evaluate the processing systems designed for respective media types. However, these media processing should not independently treated, because they are closely related to each other in real-world environment. From this viewpoint, we are conducting empirical research into media information processing through intelligent integration of speech and image media processing. And then we are pursuing an academic frontier to open a new media-processing framework based on Intelligent Media Integration.

To achieve this goal, we launched a project to measure humans and their activities to collect a large volume of real-world data on speech and images and release them to the public. The real-world data to be released include spoken language data with visual information and actual dynamic data derived from interactions between multiple individuals and the surrounding environment (e.g., data on road traffic and conferences). We will designate a common research subject regarding the released real-world data, and conducts an international competitive evaluation of the research results. For this purpose, we organized a Task Force that aims to create a system capable of acquiring speech and images at 100 points in a "synchronized" manner, accumulating and communicating data for multi-channels.

In this paper, we describe the multipoint measurement system we have developed and report some experimental results using the system.

2. OVERVIEW OF THE SYSTEM

We developed a multi-dimensional multi-point measuring system, which is also called by its function a 100-camera and 200-microphone system. Although similar camera array system has already been reported by Wilburn et al.[1], our system has the following special features:

- Scalable multi-channel recording system (no limitation of channels)
- Simultaneous recording of video and analog signal
- High accuracy of synchronization (< 1 us)
- High image resolution (1392H x 1040V)
- “Uncompressed” raw data capturing
- C-mount lens for high resolution cameras available
- Synchronization in remote site (using GPS, < 1ms)
- Long recording time (> 1 hour)

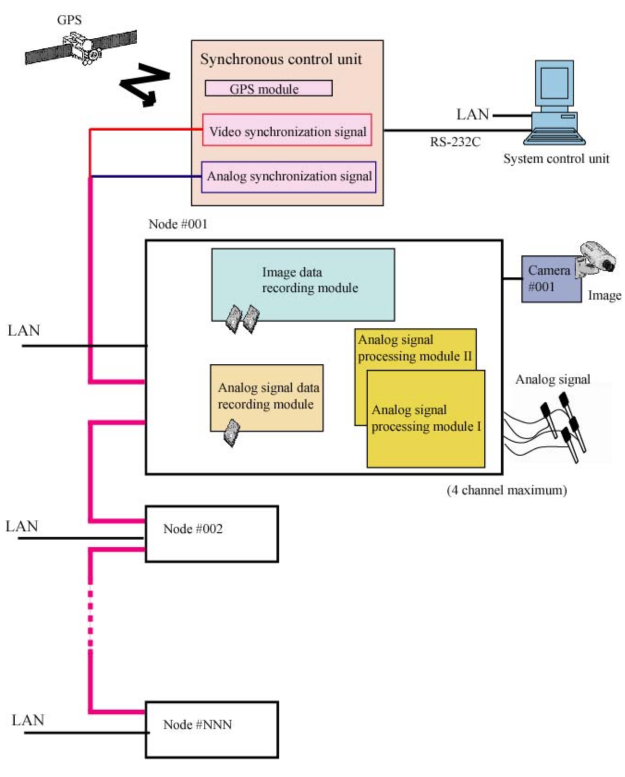

Figure 2: System architecture

Figure 3: Recording unit (node) and custom boards.

2.1. System Architecture

Figure 2 shows the basic architecture of the system. The system consists of a system control unit, a system server unit a synchronous control unit, and a number of recording units (nodes). To communicate system commands and measured data, the server unit and all the nodes are connected by Gigabit Ethernet LAN. Another connection over the system is cables between each node and the synchronous control unit. A synchronization signal is generated by the synchronous control unit and distributed to all the nodes via the cable. In the figure, star connection between each node unit is depicted as an example. Daisy-chain connection or mixture of star and daisy chain connections are also possible. The number of nodes can be increased without limitation. The only limitation we have to consider is the delay of the synchronization signal over a number of hops and a long cable. The detail of the limitation is described below in detail.

2.2. Server Unit

The server unit consists of a system control unit and a system server unit. Although the system control unit and the system server unit are separately depicted in the Fig. 2, one PC can serve as the both units. The specification of the PC need not to be very high, and therefore, a commercially available PC can be used. The operating system is Windows 2000. The system server unit gives a user interface. The system control unit is connected to the synchronous control unit with serial line (RS-232C). It controls the generation of synchronization signal and therefore recording timing.

Table 1: Specification of the system.

Image resolution	1392(H) x 1040(V)
Frame rate	29.4118 [fps]
Color	Bayer matrix
Synchronization	Less than 1 [us]
Sampling rate of A/D	96 [kS/s] maximum
Maximum number of nodes	No limit. (128 max for one sync output)

Figure 4: Camera and microphone.

2.3. Recording Unit (Node)

A recording unit (called node) is a PC-based system which is equipped with specially developed custom boards. These boards are: (1) a module which controls the record of video data, (2) a base module which controls the record of analog signal data, and (3) an analog signal processing module. A node inputs one video data via CameraLink interface and 2ch (4ch maximum) analog signal. As for video capturing, since the dot clock is very high (50MHz), transfer speed exceeds to 32 bit PCI bus and single HDD interface. We overcame this problem by adopting RAID technique to record high-bandwidth video data. The high-bandwidth data is divided into two and recorded on the two HDDs simultaneously. The nodes receive synchronization signal and sample video and analog signal in time with the sync signal. Since a node is droved by Linux operating system, it can flexibly execute remote commands via network. This feature enables us to construct flexible software environment.

2.4. Camera and Analog Sensors

We adopted a high-resolution color camera (JAI PULNiX TM-1400CL) as an imaging device. The image resolution is 1392(H)x1040(V), 8 bits/pixel. The camera has a CCD imager with a Bayer color filter. The interface between camera and PC is CameraLink(TM). The camera accepts external exposure signal, so generated synchronization signal is used as the external exposure signal. Considering accurate synchronization of video and analog signal, we set the frame rate 29.4118 frames per second for the system. As for analog signal input, various signals can be input. If we use microphones, we can construct high-channel of microphone array. One of interesting applications is for ITS applications; various types of sensor can be used which can measure like car speed, rotating speed of the engine, air temperature, heart rate of a driver, etc.

2.5. Synchronization

A synchronous control unit is composed of three components video synchronization signal generator, analog synchronization signal generator, and GPS(Global Positioning System) module. The sampling interval of video is set to be integral multiple of that of analog signals. This enables us to avoid frame drop and high accuracy of synchronization between video and analog signal is realized. The sampling interval of video is 29.4118 frames per second, and that of analog signal is up to 96kHz. The synchronization signal is transmitted on the cable with the delay of 5 ns/m. One buffering of the synchronization signal can cause 40 ns delay.

3. EXPERIMENTAL RESULTS

3.1. MPEG Test Sequences

We provided MPEG (Moving Picture Experts Group) with test sequences for Multi-view Video Coding experiment [2-4]. Since MPEG is targeting to decide international standard for video coding, test sequence for the multi-view video coding experiment must be “uncompressed”. In this sense, our 100-camera system is suitable for the purpose.

The test sequences are submitted for Call for Proposals on Multi-view Video Coding (MVC). We captured three test sequences with different camera arrangement: 1-D line, 1-D arc, and 2-D array. In the following, we describe the specification of the capturing system and the test sequences.

We captured two sequences with different camera arrangements. The first sequence is 'Rena' captured with 1-D line arrangement, in which 100 cameras are aligned in a line with the camera interval 5cm, hence, the viewing zone is 5 meters in length. The orientation of camera is set so that the optical axis of each camera is converged to one reference point near object. The second sequence is 'Akko&Kayo' captured with 2-D array camera arrangement, in which 100 cameras are aligned in 20(H) x 5(V) in camera interval 5cm and 20cm, respectively. The optical axes were set to parallel in this case.

Table 2 shows the specification of the test data. The original picture size is 1392(H)x1040(V) (progressive), and the frame rate is 30 frames/sec. The length of the original sequence is 60-150 seconds. The original images were transformed into rectified ones, and then cropped and resized to VGA(640x480), and finally converted to YUV 4:2:0 format. In addition to the 'geometrical correction', color and illumination correction is also applied.

Table 2: MPEG Test sequences

Data Set	Sequences	Image Property	Camera Arrangement
Nagoya University	Rena	640x480, 30fps (rectified)	100 cameras with 5cm spacing; 1D/parallel
	Akko&Kayo	640x480, 30fps (rectified)	100 cameras (H: 5cm spacing x 20 columns and V: 20cm spacing x 5 rows; 2D array

Figure 5: Nagoya Univ. MPEG Test sequences: ‘Rena’ (left), and ‘Akko&Kayo’ (right).

3.2. Synchronous recording of collision experiment

We conducted an experiment that simulates a collision of cars in a crossroad. The experimental scenario is as follows. Car-A is running at the center of a crossroad. Another car-B comes into the crossroad and crashes into car-A. In the experiment, a balloon is set in the center of a crossroad, which represents car-A. The car coming into the crossroad is equipped with needles and bursts the balloon at the time of impact. Figure 6 shows the setup of collision experiment. In order to record video and sound simultaneously, totally 5 nodes are arranged: 4 nodes at corners of the crossroad, and 1 in car-A. Figure 7 shows results of synchronous recording of video and sound in collision scenario.

4. CONCLUSION AND FUTURE WORK

In this paper, we explained a multi-dimensional multi-point measuring system we have developed. The system has the features capable of acquiring high-resolution uncompressed raw format video, high accuracy of synchronization between video and analog signal, synchronization in remote sites using GPS sensor. Our future plans include gathering large volumes of real-world data on video and sound, and releasing them to the public.

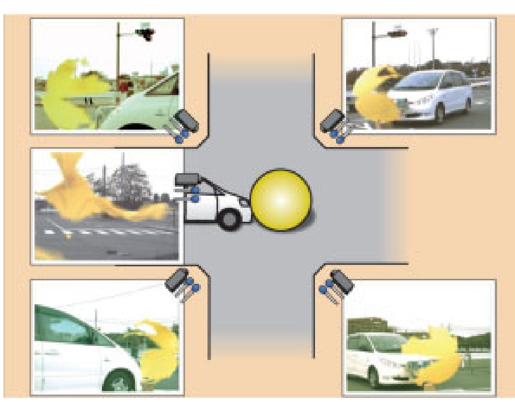

Figure 6: Experimental setup of collision experiment.

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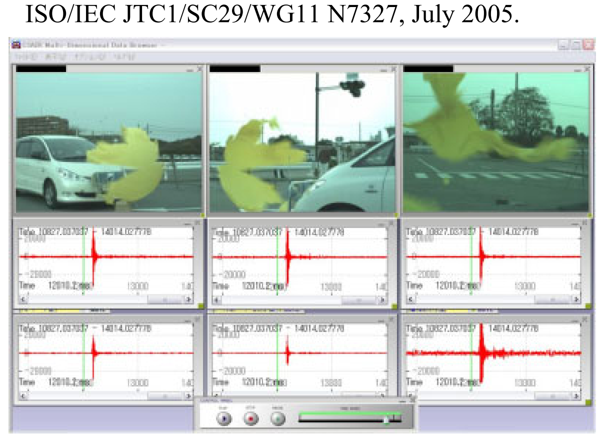

Figure 7: Results of synchronous recording of video and sound in collision scenario.