Development of a Camera Control System for Lecture Recording Using Pointing Stick

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Abstract **The quality of the delivered lecture image becomes an important factor to improve an educational effect in a real time distance-education. In this paper, we pay attention to teacher's needs for the lecture video image. We developed the camera control system using a pointing stick corresponding to the teacher's need. In this paper, we describe the proposal of camera control model, the outline of our system and the experimental use of our system.**

Index Terms **Distance learning system, Camera control, Image processing.**

I. Introduction

Recently, the spread of high-speed network infrastructure facilitates the practice of distance learning and real-time using high quality audio and video. In our universities, we made interactive and real-time distance learning that are connected to three campuses. In real-time distance learning, the quality of the video lectures is an important factor in order to improve educational effectiveness. Thus, there are many attempts to deliver high-quality high-definition video. It is important to provide appropriate camera angle on the teacher's intention. For example, the teacher wants to shoot her/him or her/his writing characters on the blackboard. Therefore, it is necessary to control the video camera, such as providing appropriate delivery using multiple cameras. One way of controlling the camera, the teacher operates the camera by her/himself. However, this approach may cause problems such as lectures progress is interrupted. There are some researches on this issue. For example, some researchers have attempted to automate camera control by recognizing the position of teachers and extracting feature points of the blackboard. However, it does not match the movements are not intended for instructors. In our study, we think that a video recording system is necessary to meet the needs of the teacher. So, we have developed a camera control system developed using a pointing stick. Specifically, our system recognizes the movement of pointing stick for cameras control which are pan, tilt and zoom. The teacher can control the camera directly by moving the stick. In this paper, we describe the video control framework, the system implementation and the operation verification on the experimental use.

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II. The Needs and Problems of Lecture Video Shooting

A. Our target environment

Our research assumes a real-time distance-learning environment where the teacher uses a blackboard type or whiteboard with multiple media such as a projection screen at the same time. The learners attend the lecture through a wide screen which receives the video. In this environment, multiple media are targets for a video shooting. The shooting range is more widely. Therefore, we think that control of the camera angles is necessary for the lecture. In real-time typed distance learning, primarily information suites the teacher's needs is often required. However, her/his needs change with the lecture scenario. For example, "Focus on the blackboard," "Notice the slide", "Focus on me," and so on.

Therefore, the camera control for shooting lecture requires the video shooting technique that based on the lecture scenario.

B. Our consideration of solution

We think that the camera control for responding to teacher's needs is the following ways.

1) Introduction of camera crew
2) Controlling the camera by the teacher

In the former, it is possible for the crew to control the camera without the intent of the teacher. Therefore the crew must understand the purpose of lecture and lecturer's scenario in order to make the appropriate camera control. However, it is difficult for the crew to predict the progression of the lecture scenario as a practical matter. The crew must communicate with the teacher to understand the teaching contents and scenarios before the lecture. However, it has many costs to prepare them beforehand. So it is not realistic. In the latter case, the teacher can control the camera with her/his intentions. However, the camera operation disturbs the progression of the lecture. For example, if the operation device is separated from the standing position of teacher, the process of the lecture often takes a break in order to operate the camera. Hand-held remote controller has the potential to solve this problem. However, it is necessary that the teacher is familiar with the remote control.

On the other hand, there some researches that are automatic camera control [1][2][3]. However, it does not necessarily suit his intention and is not appropriate to improvise dialogue in the lecture. Therefore we think it is better to involve human interaction for the camera control.

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III. PROPOSAL OF CAMERA CONTROL FRAMEWORK

A. Our approach of Camera Control

There are two approaches as a way to control the camera angle (Table 1).

1) Hardware Control
2) Software Control

The former set the shooting angle by changing the direction of the camera physically. In addition, the optical zoom is able to capture a high quality image.

On the other hand, the latter set the shooting angle by software processing that is cropping or software zoom. However the angle changes are limited physically by the camera. It often degrades image quality.

In recent years, there are many commercially cameras that has the control functions which are pan, tilt and zoom control over the network. Therefore we adopt the approach of hardware control.

TABLE 1
COMPARISION OF HADWARE AND SOFTWARE PROCESSING FOR CAMERA CONTROL

	Zoom	Range	Processing time
Hardware	High quality	Wide	Slow
Software	Deterioration	Fixed	Fast

B. Camera Control Model

We consider the issues of the previous section and propose the following requirements for a camera video control responding to teacher's needs.

1) Introduction of multiple cameras

This model introduces the primary video camera and secondary video cameras introduced in the lecture environment. The former shoots a main video image for the lecture. The camera has the angle control function by hardware. The latter shoots a surrounding video image. The camera is located in the manner to shoot the teacher, the black board and the screen.

2) Primary camera control by teacher

The teacher controls the primary camera in order to deliver the primary video. The control method of the camera angle is a hardware approach in order to shoot a wide range and high quality image.

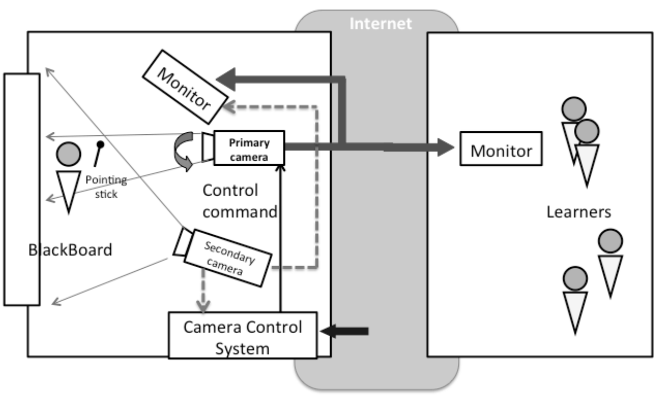

Fig. 1. Camera Control Model

3) Changing the angle by the teacher's instruction with a pointing stick

We focus on the image processing technology in order to control the camera. Richard [4] introduces a set of natural camera control and multimedia synchronization schemes based on the individual object interaction. On the other hand, there are some researches about hand gesture recognition and finger detection for sign language [5][6]. These approaches are superior in terms without any special device.

We think that the blending image processing technology with human interaction is better. We adopt a pointing stick as a control device to control the shooting angle by the teacher's movement directive. In our approach, the secondary camera recognizes the teacher's instructions with the pointing stick in order to control the primary camera. As the result, the teacher can control the primary camera by her/his intention.

IV. FEATURE OF OUR SYSTEM

We implement the control software using Microsoft Visual C++ with MFC and Open CV Library [7].

A. Camera Control using Trajectory Recognition of Pointing Stick

The system divides nine shooting ranges on the primary and secondary cameras. Panning and Tilting control of the system is based on these ranges. Secondary camera tracks the trajectory of the support rod with the instructor. The system controls the primary camera angle response to the pattern of marker's trajectory. The corresponding trajectory pattern is reciprocation (Horizontally and vertically) and rotational (clockwise and counterclockwise) motion. Each movement corresponds to panning/tilting and zooming handle.

B. Registration function of marker's color

Our system can register the color of the marker to adapt many classroom environments. It clips 25x25 pixels square from the user's selected area in order to set the marker's color (Figure 2). Our system calculates HSV values of the square, the average and the standard deviation.

C. Trajectory Recognition Method

Our system calculates the centroid of the marker's area in each frame and records the coordinates corresponding to last 15frames in buffered memory. It recognizes the four patterns using the trajectory of the centroid in the frames.

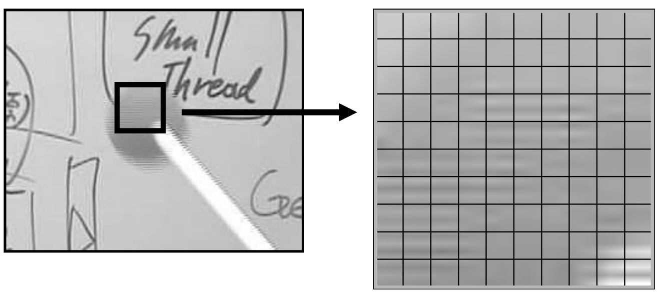

Fig. 2. Marker's Area

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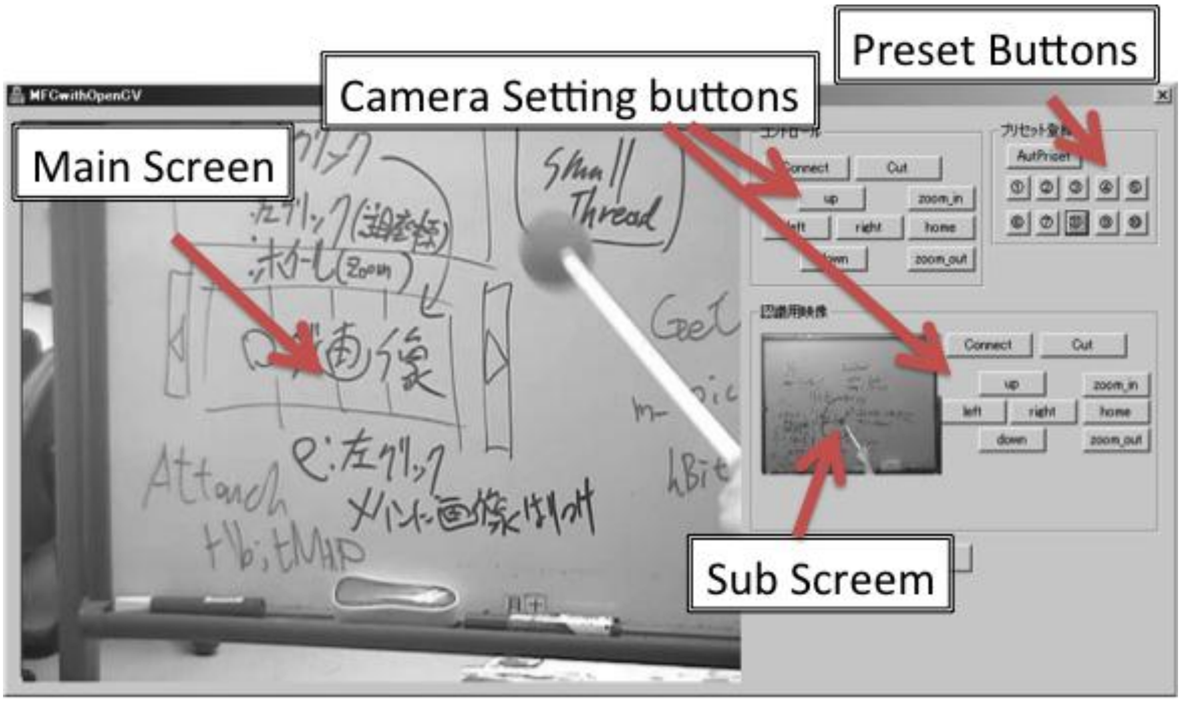

Fig. 3. User interface

V. USER INTERFACE

Figure 3 shows the user interface. This interface is used to configure the system. Description of each area of the interface described below.

A. Main Screen

This area displays the main image from the primary camera. By clicking on any point of the screen, the user can get the pixel information of the point. This function is used to register the new marker.

B. Sub Screen

This area displays the image from secondary camera around and are drawn the trajectory path of the marker. Users are able to understand the state of the marker in our system.

C. Preset buttons

When the user presses these buttons, the system automatically divides nine shooting ranges. The system assigned the preset number to each range so that the user can change the camera angle depending on the range.

D. Camera Setting Buttons

This area has some buttons to connect and control the primary/secondary camera manually. When the connection of primary / secondary camera is successful, each video image is displayed on the main/sub screen. The user can make adjustments of each camera by these buttons in the initial setting.

VI. EXPERIMENTAL USE.

A. The outline of experience

We performed the following experiment in order to examine the practicality of camera control instructions using the pointing stick.

[exp 1] Relationships the camera recognized pixel size and actual size about the marker on the stick.

[exp 2] Relationship the accuracy of operation recognition and the pixel size of the marker.

In the experiment, we consider the effectiveness and capability of introducing our system to a real lecture environment.

B. Experimental Method

Figure 4 shows the pointing stick used in the experiment. We set 5.5cm spherical markers in diameter on the edge of the stick to make the following experiment.

[Exp1] We measured the stick position from the camera in order to determine how changes the number of marker's pixels in the image.

[Exp2] We investigate the recognition rate and marker's pixel size on each control operation.

Table 2 shows the other equipment.

TABLE 2
THE EQUIPMENT IN THE EXPERIMENT

Network Camera	Panasonic BB-HCE481
OS	Microsoft Windows XP SP2
CPU	Xeon 2.0GHz
Memory	2.0GB

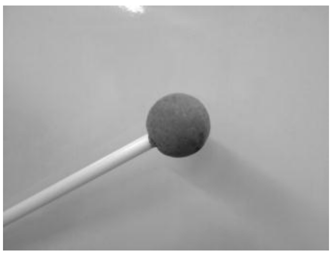

Fig. 4. Pointing Stick

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C. Experimental results and discussion

Table 3 shows the results of Exp 1. Results in Table 3 show the relationship between the pixel size and the distance from the marker and the camera. Table 4 shows the results of Exp 2. Results in Table 4 show the recognition rate is stable when the number of marker's pixels is more than 100 on the screen. About spherical marker 5.5cm, the distance between the camera and the marker must be kept within 3.0meters for more recognition accuracy than 90 percent.

Considering the recognition rate must place the installation position of the secondary camera. In addition, we must discuss the improvement about the methods of recognition, the appropriate size of the marker and the preparation of high-resolution camera.

TABLE 3
NUMBER OF PIXELS OF THE MARKER AND THE DISTANCE FROM CAMERA

Physical size (5.5cm in diameter)	Distance (m)				
	2.4	2.7	3.0	3.3	3.6
Pixel	180	140	112	92	80

TABLE 4
RECOGNITION RATE AND TRAJECTIORY PATTERN

Pixels	1-100	101-200	201-300	301-400	401-500
Horizontal	53.3 %	93.3 %	93.3 %	100 %	96.7 %
Vertical	50.0 %	96.7 %	96.7 %	96.7 %	100 %
Clockwise	33.3 %	90.0 %	93.0 %	93.3 %	100 %
Counter clockwise	43.3 %	93.3 %	96.7 %	100 %	96.7 %

VII. CONCLUSION

In this research, we developed the lecture image control system compatible with a teacher's needs. Our system has a camera control functions (pan, title and zoom) by recognizing the trajectory of a pointing stick. In the evaluation experiment we get the result that our system can control the camera smoothly with keeping the certain distance from the camera. A future works are the specification experiment and the improvement in performance by introduction in classroom environment.

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