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Automatic Videoing a Normal Classroom for a Distant Lecture with a Recording Function of a Blackboard

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Abstract: When lecture scenes are videoed for the distant lecture, a camera-person usually controls a camera to take suitable shots; alternatively, the camera is static and captures the same location all the time. Both of them, however, have some defects. It is necessary to control a camera automatically. We are developing ACE (Automatic Camera control system for Education) with computer vision techniques. The early version of ACE captures the lecture focusing on the latest object written on the blackboard. When noting something written on it or thinking over them, however, students may not always want to watch the latest object. We designed a recording function of the scene captured by ACE before for one of the solutions of this problem.

1 Introduction

The growth of a communication network technology enables people to take part in distant lectures. There are mainly two kinds of method to held a distant lecture. One is an web-page-based method and the other is a method of sending visual and audio of lecture scenes. We are studying a camera control system for the distant lecture held by the method of sending visual of lecture scenes[Suganuma 1997a, Suganuma 1997b]. We call it "ACE" (Automatic Camera control system for Education)[Suganuma 2002].

A traditional style lecture held in a normal classroom is the target videoed by ACE. Figure 1 illustrates the distant lecture we envisage. A teacher teaches his students in an ordinary classroom. There is a blackboard in the room. A teacher writes and explains something on it. Some video cameras are setting in the room in order to capture a lecture scene. The scene is sent to a distant room and projected on a screen. Students in the room take part in the lecture by watching the scene on the screen.

Nowadays, some teachers use an OHP and/or other visual facilities in his lecture. Indeed many lectures such as in the information technology or the programming are frequently held by using visual facilities or computers in many universities b But there are still many traditional style lectures, in which a teacher explains something with a blackboard. It seems that such lectures will not disappear in the future although they will hold by combining the blackboard and a visual facility such as an OHP or Power Point software. We are, consequently, developing ACE for the distant lecture with videoing the traditional lecture.

When a lecture screen is videoed, a camera-person usually controls a camera to take suitable shots; alternatively, the camera is static and captures the same location all the time. However, it is not easy to employ a camera-person for every occasion. And the scene videoed by a steady camera hardly gives us a feeling of the live lecture. It is necessary to control a camera automatically. ACE enables people to do it for taking suitable shots for a distant lecture. Receiving a scene from a camera, ACE analyses it and recognizes the complexion on the lecture. ACE judges an important thing in the scene and effectively controls the camera to focus on it.

The early version of ACE captured a lecture scene focusing on the latest object written on the blackboard. When noting something written on it or thinking over them, however, students may not always want to watch the latest object. We designed a function recording the scene captured by ACE before as one of the solutions of this problem.

In this paper, section 2 presents design of ACE and our strategy of a camera control and a recording function. Section 3 describes an implementation of the recording function and section 4 describes an evaluation of ACE. Finally, concluding remarks are given in section 5.

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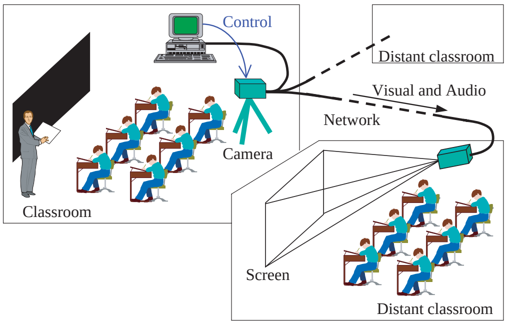


Figure 1: A form of the distant lecture by videoing the normal classroom

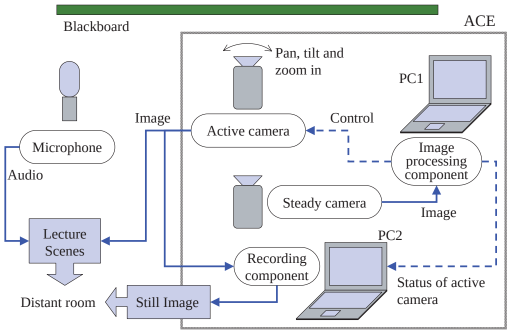


Figure 2: An Overview of ACE

2 Overview of ACE

2.1 Design

When we designed ACE, which is an application based on Computer Vision Technique, we assumed the following:

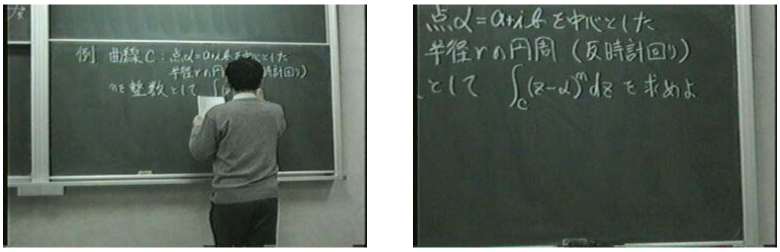
- A teacher teaches his students by using only a blackboard.
- Students aren't re ected in the scenes captured by the camera.
- A teacher doesn't give ACE a special cue.
- Each student in the distant room are assigned a PC to refer what he wants.

The rst three assumptions are made when we designed the early version of ACE. The rst assumption means the lecture captured by ACE is a traditional one, the second is assumed to decrease processing costs, and the third denotes a teacher is able to concentrate his attention on his teaching. These are realistic assumptions and the early version of ACE have been developed on them. The last assumption may not satisfy in same classroom. But ACE needs an interface to detect a student's demand and to display the requested scene. We adopted an Web browser as the interface. We make the browser run on the PC assigned to each student and supply the scenes as Web pages consisting of a still image.

An overview of ACE is shown in Figure 2. ACE requires two cameras. One is a steady camera and the other is a active one. The steady one captures a whole blackboard at a constant angle. The captured image is sent to an image processing component of ACE running on PC1 over an IEEE-1394 protocol. The component analyzes the sent image and decide how to control the active camera according to a camera control strategy shown in section 2.2. The control signals are sent to the active camera over an RS-232C protocol. The active camera, hereby, takes a suitable shot. ACE has a recording component which generates effective still image les from the scene captured by the active camera. It runs on PC2 because the procedure of the image processing component requires high CPU power. It receives a status of the active camera from the image processing component, analyzes the scene sent from the active camera and makes a decision whether to generate a still image le or not. A visual captured by the active camera and an audio picked up by a microphone are sent to the distant room. Students in the distant classroom watch and listen to them.

2.2 A camera control strategy

What does ACE capture? It is a very important thing for the system such as ACE. One solution is to take the scenes that students want to watch, but in this case many scenes are probably requested by many students at the same time. Although this solution needs the consensus of all students, it is very dif cult to make it. We adopted, therefore, a strategy that ACE captures something explained by a teacher. However to extract directly what a teacher explains is very dif cult. Consequently, we made an assumption that the latest object written on the blackboard closely



(a) An ordinary shot (b) A key shot

Figure 3: Sample shots of a lecture scene captured by ACE

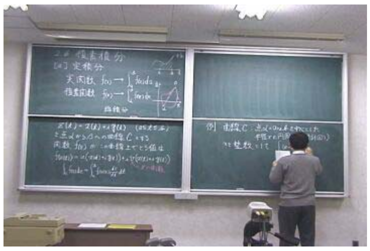


Figure 4: A sample shot captured by a steady camera

parallel something explained by a teacher because he frequently explains the latest object. ACE captures the latest object written on the blackboard.

It is important that students can easily read contents on the blackboard. A sample shot captured by ACE is shown in Figure 3. ACE usually takes a shot containing the latest object and a region near it in a discernible size. The blackboard often consists of four or six small boards like a picture of Figure 4 and a teacher frequently writes relational objects within one board. Now, ACE takes a shot by the small board such as Figure 3-(a). ACE takes a shot zoomed in on the latest object such as gure 3-(b) after the teacher has written it. After a-few-second zooming, ACE takes an ordinary shot again. On the other hand, if we take a scene by a steady camera, the shot may be like a shot in Figure 4. In this case, the characters in this shot are too small for students to read because the camera must capture the whole blackboard. The shot of ACE is superior to that of the steady camera.

2.3 A recording strategy

Indeed ACE captures the objects explained by a teacher, but some students probably want to watch another object. ACE has a recording function of the scene captured by the active camera before. Objects on the blackboard doesn't change when once a teacher writes or erases them. If a object is updated, it is detect as the latest object again. This is reason why a still image is good enough for sending information. We decided that the ordinary shot, which consists of a small board containing the latest object in a discernible size, was recorded because a teacher often wrote a meaningful object on one small board.

A sample of a interface to students is shown in Figure 5. This Web page has two frames. In the left one, some still images of a small board are placed in order of generating, and in the right one, the images are placed in its position. When clicking each image, students can watch its enlarged image.

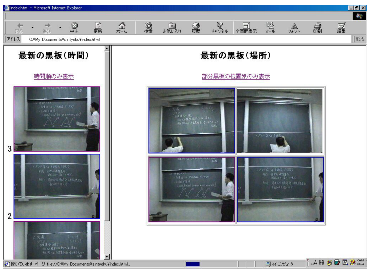


Figure 5: A sample of displaying small boards on which a teacher wrote some objects

3 Implementation of ACE

ACE has two components: an image processing component and a recording component. The image processing component extracts the latest object on a blackboard with some CV techniques and detects the timing of zooming in. For detailed implementation of the image processing, please see [Suganuma 2002].

The recording component of ACE gets the status of the active camera from the image processing component. ACE can easily generate an image from the ordinary shot according to the status. The ordinary shot, however, is not always suitable for the stored image. ACE have to estimate whether the objects on the small board is the same as that in the image which has been stored already. The image does not have to be stored if it has been already stored. The component checks it whenever the status of the active camera changes from a key shot into an ordinary shot.

Contents on the blackboard in the stored image have to be clear. A teacher sometimes occludes the contents in the ordinary shots. Then, the recording component also has to check whether he does not occlude the contents on the blackboard. The image processing component detects a teacher's region with the subsection image between two successive frames. The technique, however, sometimes extracts only a part of teacher's body or sometimes misses a teacher. So the position of the teacher sent from the image processing component is not good enough.

The recording component detects a teacher in the image captured by the active camera. The ordinary shot contains the whole small board, so four edges of the board appears a complete rectangle in the image. If the teacher is in front of the board, the bottom edge is divided into two pieces. When the edge is completely connected, the component guesses that a teacher does not occlude the board, and stores the shot from the active camera.

4 Evaluation

We evaluated the videoing strategy of ACE with a real lecture from a point of view that students could made a note. In our experiment, we didn't use our recording function because we couldn't use a classroom where there are PCs assigned to our students. Before the lecture, we informed the students that we would collect their notes after the lecture and check them. We precomposed a master note and wrote the all contents of it on the blackboard. After the lecture, we collected their notes, compared them with the master note, and counted their missing in each note. 36% of all the students can perfectly copy the contents from the shots captured by ACE and 45% of the students make only one mistake. Almost all students make not more than three mistakes. Some small characters such as the index of formulas caused almost all mistakes. As the results of this estimation, almost all students can make a note correctly enough to learn it. The shots of ACE seem good enough.

We also evaluated ACE separately in terms of the size of character in the still image, the timing of storing the image and the occlusion. The characters in almost all (98%) images are large enough for students to read. Those of 1.5% images are too small because they contain very small alphabets such as the index of formulas, which are originally written small by the teacher. Indeed mis-storing sometimes occurs because the image processing component miss the latest object, but almost all still images are worth recording.

5 Conclusion

ACE takes a suitable shot if the teacher explains the object as soon as he writes on the board. It cannot take, however, a suitable shot when he explains something in front of it and when he explains something written before. In the former case, he has to change his position because his students even in the local classroom can not watch them. In the latter case, the teacher usually teaches his students pointing the object which he wants them to look at. We will get ACE to interpret teacher's action and/or posture and to capture more suitable scene. We assumed that a teacher teaches his students with only a blackboard. But he sometimes also uses with a visual facility. We will also get ACE to apply to such a situation.

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