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Lecturer's Silhouette Display System for Distance Education Using Screen Sharing between Interactive Whiteboards

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Abstract: In distance education using interactive whiteboard, students in the receiving classroom cannot know the point indicated by the lecturer while looking at the interactive whiteboard. Therefore, we have developed a prototype system that displays lecturer's silhouette to the interactive whiteboard. Students can read the learning contents and see where teacher pointing at the same time. For evaluation of our system, we have examined the students' eye-gaze difference between two cases that silhouette is enabled or disabled. Moreover, our prototype system is used in actual distance education of a prefectural high school. By analyzing the results, we confirmed how effective our system is.

Keywords: distance education, Kinect sensor, interactive whiteboard, nonverbal behavior

1. Introduction

In Kochi Prefecture where our university is located, most of prefectural high schools in mountainous areas are getting smaller due to depopulation every year. Kochi Prefecture Board of Education is worried about high school reduction. Since a small school has few teachers, it could be happened there are no teachers who can teach elective subject which students want to take. To give equal opportunities which students in small school can take desired subjects, Kochi Prefecture Board of Education promotes an introduction of distance education which students can take classes by teachers in distance school. Distance education of prefectural high school in Kochi uses prevailing information technology. So, we launched studies project which supports introduction of distance education by using advanced information technology. This study by the project will deal with a method of displaying learning contents and teacher's behavior in distance education.

2. Problem in Distance Education Using Interactive whiteboard

In distance education that the students exist at both classrooms, two large monitors are commonly introduced. One monitor should "zoom out" to display the teacher's move and the ambience of the classroom and the other one should "zoom in" to display the close-up of the learning contents. If there are not any students in the classroom providing the class, it might need only one zoom-in-monitor because the teacher does not have to walk around. However, if there are some students in the providing classroom, both monitors are needed because the teacher has to walk around for checking the learning conditions of their students. In this case, if the zoom-in-monitor is an interactive whiteboard, it only displays the learning contents. Therefore, the teacher will be not displayed in the monitor. Because of this, students have to watch both monitors to look at the learning contents and the teacher's face.

In the prefectural high schools of Kochi, a telepresence system and interactive whiteboards are used at the providing classroom and the receiving classroom in a distance education, as shown in figure 1. The interactive whiteboard of providing classroom is a display monitor of the PC. The interactive whiteboard of receiving classroom is able to display the same as the screen of the interactive whiteboard of providing classroom by a shared screen function of the interactive

whiteboard. The students in the receiving classroom will not know the lecturer's facial expressions and the point indicated by the lecturer while looking at the interactive whiteboard. They also have difficulty in reading the learning contents written in the interactive whiteboard by looking at the monitor, which shows the image of the network camera of the providing classroom, because the characters of the learning contents on the monitor are too small. Therefore, we think that it is important to display visually both verbal and nonverbal information on one of the monitors.

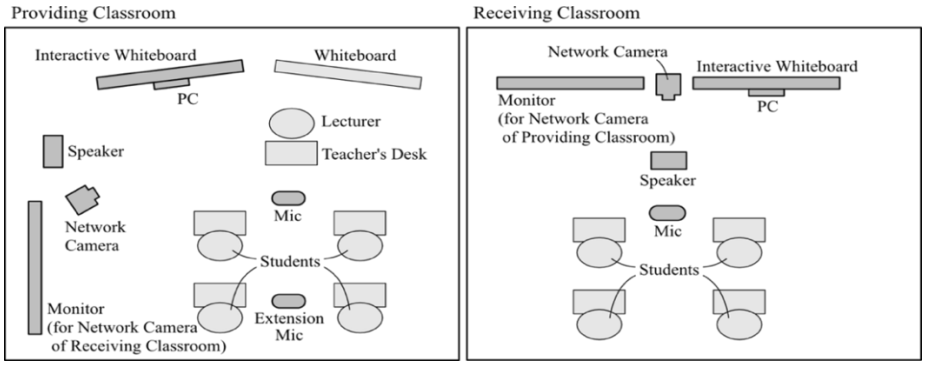

Figure 1. Disposition of Equipment for Telepresence System in Distance Education Promoted by Kochi Prefectural Board of Education

3. Lecturer's Silhouette Display System

3.1 Our Approach and Prototype System Using Kinect Sensor

As described above, the problem is caused by not displaying the teacher on zoom-in monitor. Accordingly, we propose an approach, which is to detect teacher's shape and then to overlay the semi-transparent shape (teacher's silhouette) on the screen of zoom-in monitor. Students can read the learning contents written in interactive whiteboard even if the contents hide among the teacher's body, by semi-transparentizing the teacher's silhouette. Based on our approach, we have developed a prototype of lecturer's silhouette display system. A Kinect V2 sensor manufactured by Microsoft was used here to develop the prototype for simplicity. Figure 2 shows the outline of lecturer's silhouette display system. The Kinect sensor is connected to a PC associated with an interactive whiteboard at the providing classroom. When the PC shows the lecturer's silhouette to the interactive whiteboard, the receiving classroom's whiteboard also displays it by using screen-sharing with the screen of the providing classroom.

3.2 Related Works

Okumoto et al. (2017) have developed a live broadcasting system for a lecture using a chalkboard or whiteboard. Their system can provide a video that shows the obstructed content through the lecturer's silhouette. Although our system uses a depth sensor that is included in a Kinect sensor to detect a lecturer's shape, their system uses only RGB color image by image processing. In addition, their system shows the silhouette by transparentizing the lecturer appearing in the video, in contrast, our system displays the silhouette that does not appear in the screen in theory. Marutani et al. (2005) have proposed a method for extracting deictic information from gestures of a lecturer. It can suppose locus of indicated points and also can classify the lecturer's deictic gestures into four kinds that are defined as "emphasizing, highlighting, pointing and outlining" by Pozzer-Ardenghi and Roth (2003). The purpose of Marutani et al. is to solve the same problem that we have indicated in chapter 2 by extracting deictic gestures and adding deictic information in the movie of the lecture. Our system displays the movement of the lecturer's gestures on the screen. Consequently, there is no need for us to extract deictic gestures.

Although the purpose of the study is slightly different, Ochi and Takeda (2013) have developed a camera control system that commands a network camera and uses a Kinect sensor to recognize the lecturer's gestures. The network camera used by them is equivalent to the network

cameras shown in figure 1. Consequently, it is probable that our system will be used together with their system.

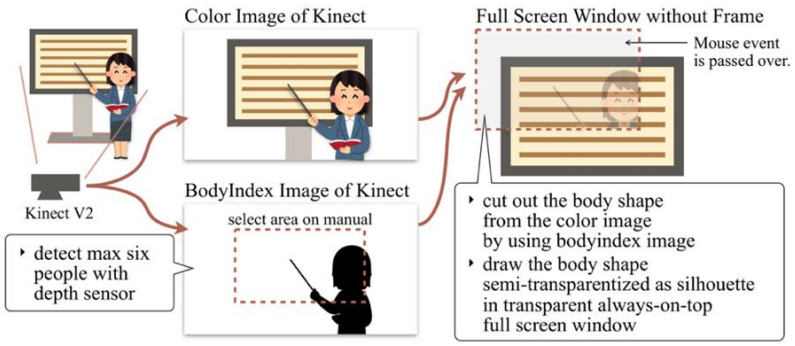

Figure 2. Outline of Lecturer's Silhouette Display System

4. Experiment

We have experimented to evaluate and/or verify of how effective the lecturer's silhouette display system that we have prototyped. While a lecturer points something on an interactive whiteboard, students can perceive the pointing place and read learning contents, by displaying the lecturer's silhouette on the board. Therefore, most students may gaze into the interactive whiteboard when a silhouette is displayed. To confirm this, we have examined the subjects' eye-gaze difference between two cases that silhouette is enabled or disabled, in the following two situations.

4.1 Students' Eye-Gaze Analysis at Lecture without Telepresence System

One of the authors, as a teacher, did simulated lecture before three undergraduate and two postgraduate students (Subject A-E) in the classroom which has a ceiling-mounted monitor rearward. We analyzed subjects' gazes on manual. This lecture is not distance education but face-to-face lecture, so we did not use a telepresence system. The subjects watched a ceiling-mounted large monitor as zoom-in monitor, and they watched directly the teacher, instead of zoom-out monitor, doing lecture with interactive whiteboard in front of the classroom (shown in figure 3). We made subjects sit behind the classroom and recoded the subjects taking the lecture with a video camera to check which monitors they are watching. At the same time, we recorded zoom-in monitor and the behavior of the teacher doing lecture instead of zoom-out monitor, with another video camera. The teacher's silhouette was disabled for about ten minutes in the first half of the lecture. And then it was enabled for about ten minutes in the latter half. We attempted a comparison of subjects' gazes in two cases that silhouette is enabled or disabled, at some scenes that the teacher pointed his finger at the interactive whiteboard.

4.2 Students' Eye-Gaze Analysis at Lecture with Telepresence System

We analyzed gazes of high school students that attended a class which is distance education at a prefectural high school in Kochi on manual. The high school has a branch school and then the main school provides the branch school with the class by the distance education. In this distance education, there are not any students at the providing classroom but there are students at only the receiving classroom (like shown in figure 4, not as shown in figure 1). The number of subjects is eight, and we named them Subject F-M. We recorded students' gazes with a video camera in two days, because we must not interrupt the class to change the configuration of the silhouette display system in the middle of the class. The first day, we recorded gazes of the students taking the distance education as usual without silhouette. The second day, in distance education using the prototype system, we recorded gazes of them. Students' gazes were recorded by a video camera from in front of the receiving classroom. Zoom-in and zoom-out monitors were recorded by another video camera from behind the classroom. As with the section 4.1, we attempted a comparison of subjects' gazes in

two cases that silhouette is enabled or disabled, at some scenes that the teacher pointed his finger at the interactive whiteboard. After the class of the second day, the teacher answered some simple oral questions and the students answered a brief questionnaire. These questions are about the impression of displaying the silhouette.

Figure 3. The Classroom where the Pre-test was Performed

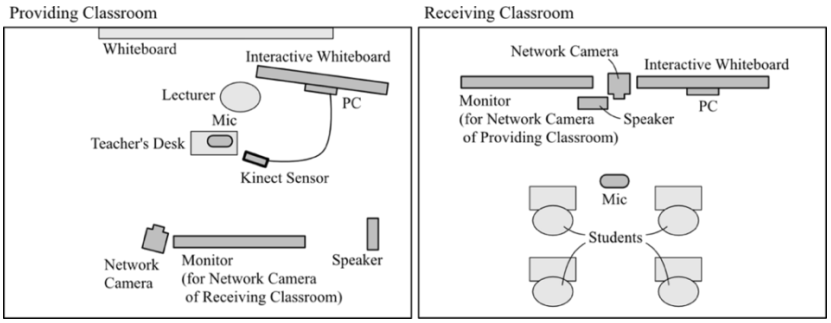

Figure 4. Disposition of Equipment for the Prototype System at the Time of Experiment

4.3 Results and Discussion

We have picked up three scenes from each four lecture movies. Each three scenes are numbered younger by earlier in lecture. Scene S1-S3 and S7-S9 are from teacher start pointing until end pointing. Scene S4-S6 and S10-S12 are from teacher start pointing until silhouette cleared. Figure 5 and figure 6 are screenshots of the movie clip for analyzing students' gazes. Zoom-in monitor is framed in orange, zoom-out monitor is framed in sky blue. Each subject is marked on orange and sky blue by which monitor watching. Being marked on gray is the case of students looking down. Results of analyzed gazes in every scene are shown in table 1 and table 2. Table 1 shows that a percentage of watching zoom-out monitor in the scenes whose silhouettes were disabled is very high (89.4%), and a percentage of watching zoom-in monitor that displays silhouette becomes high (68.5%). In table 1, there is no subject watching except monitor such as looking down. But in table 2, a percentage of subjects looking down is high (no silhouette is 71.4% and with silhouette is 38.4%). Regardless of silhouette is enabled or not, percentages of watching zoom-in monitor except looking down are both high (about 70%) in table 2. There is about two seconds delay to provide silhouette for receiving classroom. Also, there is a case that this system in providing classroom stopped about two seconds by overloaded, though we developed to reduce loading. The answers of oral questions for the teacher after the class in section 4.2, has contained no negative opinion. However, as the questionnaire results of Subject F-M, we have gained opinions "better without silhouette" by seven subjects out of eight. This means that students did not get positive impression to displaying silhouette.

Figure 5. Screenshot of the Movie Clip for Eye-Gaze Analysis (Scene S5)

Figure 6. Screenshot of the Movie Clip for Eye-Gaze Analysis (Scene S11)

We shall discuss the reason why the percentage of the students watching zoom-out monitor without silhouette is high (89.4%). We consider that students get information unconsciously from not only verbal ones like handouts, but also nonverbal ones like teacher's action and expression. Only zoom-in monitor, they get verbal information. They have to watch zoom-out monitor to get nonverbal information. On the other hand, the reason why the percentage of subjects watching zoom-in monitor is high (68.5%) with silhouette is that subjects can get nonverbal information by displaying silhouette. As a result, subjects can get both verbal and nonverbal information at the same time without changing eye-gaze. And they only have to watch zoom-in monitor to learn. The teacher made students write a board in class in the high school. It is for the reason that the percentages of looking down are high (with silhouette is 71.4%, without silhouette is 38.4%). There are two reasons why the percentages of looking down are high in table 2. One of the reasons is that we consider that students easily watch zoom-in monitor more to write a board. Another reason is that there is about two seconds delay to display silhouette in receiving classroom, so we could not provide useful information by silhouette. Because of teacher silhouette displaying system did not work effectively, the percentage of watching zoom-in monitor did not affect the silhouette enabled or not. In high school, they use movie transceiver (send and receive) and sharing screen system as distance education system. So, communication loading is a lot, we could not use enough fields to provide silhouette. This is why displaying silhouette cause delay. The result of Subject F-M questionnaire was not good. As the lecturer pointed speedy, the silhouette's delay caused that the silhouette system could not keep up with teacher's action like silhouette and teacher point different places. From this, we consider that there are many opinions which is better not to display silhouette. Also, the positive answers about displaying silhouette of questionnaire are only two students of eight. Answers that you understood pointed place has many positive answers. But, we judged that the results of questionnaire are not useful enough to refer because the delay was large in this experiment.

5. Conclusion

We confirmed that students gain nonverbal information better than verbal one when listen to teachers. And, students directed to write a board by teachers, they are likely to gain verbal information by their sight. But in distance education, that is students have to give up getting nonverbal information. Also, students look down long time to accomplish directions. The prototype display silhouette system which we made increased the percentage of students in watching zoom-in

Table 1. Time in Seconds of Students' Gazes at Lecture without Telepresence System

Silhouette		disable									enable								
Gaze		monitor						other			monitor						other		
		zoom-out			zoom-in						zoom-out			zoom-in					
Scene		S1	S2	S3	S1	S2	S3	S1	S2	S3	S4	S5	S6	S4	S5	S6	S4	S5	S6
Subject	A	14.0	12.0	10.5	0.0	2.5	2.5	0.0	0.0	0.0	2.0	0.0	5.0	6.0	13.0	1.0	0.0	0.0	0.0
	B	10.0	11.0	9.0	4.0	3.5	4.0	0.0	0.0	0.0	2.5	0.0	2.0	5.5	13.0	4.0	0.0	0.0	0.0
	C	14.0	12.4	13.0	0.0	2.1	0.0	0.0	0.0	0.0	2.0	10.0	5.0	6.0	3.0	1.0	0.0	0.0	0.0
	D	14.0	14.5	13.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	3.0	4.0	6.0	10.0	2.0	0.0	0.0	0.0
	E	14.0	13.2	11.0	0.0	1.3	2.0	0.0	0.0	0.0	1.0	2.0	2.0	7.0	11.0	4.0	0.0	0.0	0.0
Mean		13.2	12.6	11.3	0.8	1.9	1.7	0.0	0.0	0.0	1.9	3.0	3.6	6.1	10.0	2.4	0.0	0.0	0.0
		12.37			1.46			0.00			2.83			6.17			0.00		
Ratio		89.4%			10.6%			0.0%			31.5%			68.5%			0.0%		

Table 2. Time in Seconds of Students' Gazes at Lecture with Telepresence System

Silhouette		disable									enable								
Gaze		monitor						other			monitor						other		
		zoom-out			zoom-in						zoom-out			zoom-in					
Scene		S7	S8	S9	S7	S8	S9	S7	S8	S9	S10	S11	S12	S10	S11	S12	S10	S11	S12
Subject	F	0.0	0.0	0.5	0.0	2.0	0.5	23.0	19.0	14.0	3.0	0.0	0.0	9.0	5.0	2.0	1.0	0.0	13.0
	G	0.0	0.0	2.0	15.0	0.0	0.0	8.0	21.0	13.0	6.0	0.0	4.0	7.0	1.0	5.0	0.0	4.0	6.0
	H	7.0	0.0	0.0	0.0	0.0	0.5	16.0	21.0	14.5	10.0	5.0	6.5	3.0	0.0	7.5	0.0	0.0	1.0
	I	0.0	0.0	3.0	7.0	0.0	3.0	16.0	21.0	9.0	4.0	3.0	0.0	6.0	0.0	0.0	3.0	2.0	15.0
	J	5.0	0.0	0.5	12.5	8.0	5.0	5.5	13.0	9.5	0.0	0.0	0.0	13.0	5.0	1.0	0.0	0.0	14.0
	K	0.0	0.5	3.5	4.0	6.5	6.5	19.0	14.0	5.0	2.5	0.0	0.0	10.5	5.0	5.0	0.0	0.0	10.0
	L	0.5	7.5	3.5	12.5	1.5	9.5	10.0	12.0	2.0	0.0	0.0	0.0	0.0	0.0	11.5	13.0	5.0	3.5
	M	0.0	4.0	2.0	0.0	1.0	1.0	23.0	17.0	12.0	2.0	0.0	0.0	10.0	5.0	5.0	1.0	0.0	10.0
Mean		1.6	1.5	1.9	6.4	2.4	3.3	15.1	17.3	9.9	3.4	1.0	1.3	7.3	2.6	4.6	2.3	1.4	9.1
		1.65			4.00			14.06			1.92			4.85			4.23		
Ratio		8.4%			20.3%			71.4%			17.4%			44.1%			38.4%		
		29.2%			70.8%			–			28.3%			71.7%			–		

monitor. We consider that this shows nonverbal information gotten from silhouette is enough for the students. As teachers stand not to obstruct the interactive whiteboard, a silhouette which shows like teacher's face are not displayed much. But when teachers are pointing board, since students could be satisfied with nonverbal information which is contained in silhouette, students should choose watching the monitor which also can make up verbal information. These results lead to the conclusion that this prototype system is effective. Providing silhouette in distance we tried, did not work well because of delay problem. We consider many people want nonverbal information if both nonverbal and verbal ones could be gained in the case of verbal one is more important. We would like to continue discussing the system improvement, which can display silhouette without telepresence system like sharing screen.

Acknowledgements

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