Posture and Face Detection with Dynamic Thumbnail Views for Collaborative Distance Learning

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Abstract. In this paper, we describe the use of a collaborative TERAKOYA learning system developed to help students actively study anywhere on a local area network (LAN) linked to multipoint remote users. In this environment, if many students send questions to a teacher, it is difficult for the teacher to provide answers quickly; furthermore, the teacher is largely unable to determine the degree to which each student has understood the course materials, because he or she cannot observe the students and their reactions in person. In this paper, we discuss a graphical user interface (GUI) system that prioritizes student screens by changing the GUI on the teacher's computer; more specifically, thumbnails of student screens zoom dynamically in proportion to each student's understanding level. By sorting these priorities on his or her screen, the teacher can observe each student's work and support their thinking process at each student's individual pace.

Keywords: Advanced Educational Environment, Ubiquitous Learning, Distance Education.

1 Introduction

In today's environment of ubiquitous computers, promoting the use of computers in school is very important. E-learning and learning through web content, however, are passive methods, and it is difficult to cultivate comprehensive active learning, which has recently gained prominence. Because active learning requires learner participation, computers are expected to complement classroom lectures. Systems for computer-based active learning enable in-class participation by transparently manipulating the input instruments of the students and the teacher. Several researchers have suggested that the challenge in our information-rich world is not only to make information available to people at any time, at any place, and in any form but also to specifically say the right thing at the right time in the right way [1]. In particular, the fundamental pedagogical concern is to provide learners with the right information at the right time and place in the right way instead of enabling them

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to learn at any time and at any place [2]. Moreover, as Jones and Jo [3] point out, educators should aspire to combine the right time and place learning with a transparent method that allows students to access lessons flexibly and seamlessly. Such an approach is a calming technology for ubiquitous computing environments and adapts itself to student needs by supporting specific practices.

In our present study, we have developed a new collaborative learning system called TERAKOYA [7] for remedial education, which helps students actively study anywhere on a LAN linked to multipoint remote users, as shown in Fig. 1. The TERAKOYA learning system provides both interactive lessons and a small private school environment similar to basic 18th-century Japanese schools called terakoya. In particular, the system provides an interactive evening lesson that uses tablets on a wireless LAN (WLAN) and custom-built applications that link students in the dormitory and at home with a teacher in the school or at home. In this new system, students and the teacher cooperate and interact in real time by using a personal digital assistant (PDA) [4]. This system can be used to submit and store lecture notes or coursework using a tablet.

We define TERAKOYA as a new evolving virtual private school realized on a network, which certainly distinguishes it from the 18th-century terakoya. TERAKOYA is a system for simultaneously achieving the following:

(1) Small group lessons for students, like those at a private school in which the teacher serves as the leader.

(2) Interactive lessons that provide dialogue with the teacher and allow students' work to be checked and thinking processes to be supported by online collaboration.

(3) Lessons enhanced by mutual assistance that can clarify any misperceptions in a student's thinking processes and provide appropriate support for each student via the opinions and answers of other students.

In short, TERAKOYA is an educational support system that can flexibly adapt to the learning demands of many students by applying a private school model for small group lessons. Therefore, as noted above, the TERAKOYA system realizes personal learning support for students in a dormitory or at home from a teacher in the school or at home.

In the original terakoya environment, it was not easy to keep students focused on learning, except for students with a high willingness to learn. Conversely, our TERAKOYA system is a more flexible learning environment that allows teachers to switch freely between the conventional terakoya environment and the mutually supportive environment using teacher-centered learning or self-paced learning, as needed. Because of this flexibility, we view our system as able to reach a wide range of vulnerable students and accommodate contemporary student attitudes toward learning. In addition, our system is expected to allow teachers to provide additional learning assistance to students with less additional work for the teacher than supplementary lessons conducted in the classroom or dormitory.

In this paper, we consider a realistic scenario of dynamically providing an interactive lesson for students in an active learning environment in their own living space. A serious problem occurs when many students send questions to the teacher; it is very difficult for the teacher to quickly answer all such questions. In addition, the teacher is largely unable to determine the degree to which each student understood the course content, because the teacher cannot observe individual student reactions. Accordingly, the GUI of our system prioritizes student screens through changing GUI interfaces on the teacher's computer. More specifically, these windows are shown as thumbnails that zoom dynamically based on student understanding levels. The teacher can then sort these as per priority. Using this approach, the teacher can observe student work and support their thinking process much more effectively. The teacher can also clarify any misperceptions in their thinking processes, providing appropriate support for each student.

In this paper, we present the basic configuration of a system that provides the dynamic delivery of full-motion video while following target users in a ubiquitous learning environment. The delivery of full-motion video uses adaptive broadcasting; the system can continuously deliver streaming data, including full-motion video, to the teacher's display as thumbnails of student screens. Because it maintains information about each user's attitude in real time, the system supports the user wherever he or she is without requiring a conscious request to obtain their information. Below, we describe a prototype implementation of this framework and a practical application.

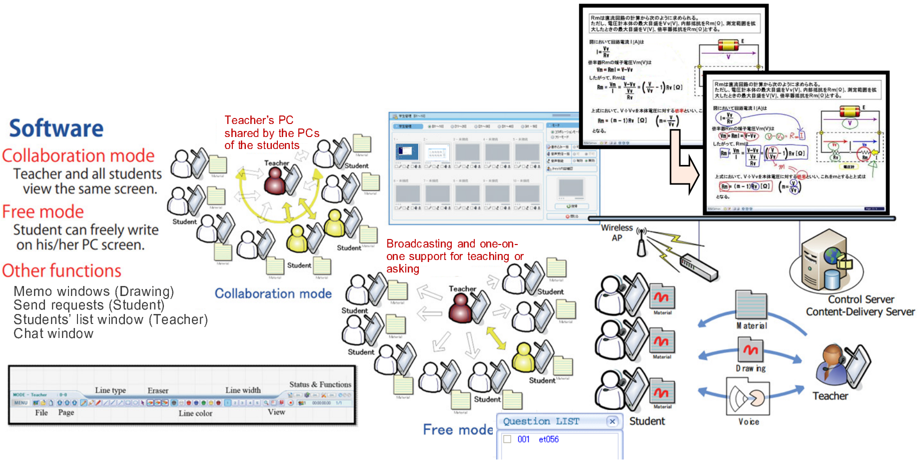

Fig. 1. Framework of TERAKOYA learning system

2 Basic Configuration

Our configuration consists of tablets, a server machine, and software to enable collaboration among the tablets over a WLAN, which covers the campus, the dormitory, and student and teacher homes. The interactive system software consists of server software, authoring software for the teacher, and client software for students. The authoring software synchronizes with clients via server software, and the system operates in either collaboration mode or free mode. The authoring software is launched on a teacher's computer with a 12-inch XGA display; its main functions are to distribute teaching materials, select collaboration mode or free mode, give a specific student's computer permission to write, view a student's screen, share files between a specific student's computer and another computer using the client software, and submit coursework using remote control from the teacher's computer. The main functions of the client software are browsing lecture notes, storing learning materials, and submitting coursework. Using the authoring software, teachers can view student screens as thumbnails; overall, the thumbnail view can display 50 client computers. When students submit coursework from their computers, the filenames are displayed in the order of submission on the teacher's computer. Thus, a teacher can immediately confirm the submission status of student coursework.

In collaboration mode, the display on the teacher's computer is shared and displayed on computer screens of up to 50 students. Each student computer serves as an electronic board on which they can write. All students in the class can view the activity of a selected student on their own screens when that student is completing his or her coursework. Furthermore, students with write access can post messages regarding their coursework; the teacher can control the write access rights of the students' screens. All students can browse through or view these group discussions.

In free mode, a student can freely write on the teaching material and coursework made available by the teacher on his or her screen. The teacher can then watch all student screens, although each student's writing is displayed only on his or her individual screen. If a student faces difficulties completing the coursework, the teacher can provide hints or receive student questions by sharing their screens. The displayed content in both modes can be saved on each student's computer or on an external memory device, such as a USB flash drive. Students can freely browse the saved data at any time. And when they submit their coursework to the teacher's computer, the teacher can immediately mark it and then later evaluate it in detail.

Furthermore, as one possible implementation, the system can support multiple servers, with server software used for data exchange between the teacher's client and that of a student; however, student computers in the dormitory cannot communicate directly with a teacher's computer connected with another network on campus, because each network is isolated by a firewall. To communicate through client computers on different networks, at least one control server and a steady network connection via TCP/IP are necessary for data exchange between a teacher's and a student's client. By using a server that runs the server software as a control server, our system can provide multipoint remote lessons via connections anywhere on the campus and in the dormitory. In addition, it can even be accessed from student homes.

Because interactive lessons are provided, each client is required to continuously maintain its connection to other computers. Thus, the traffic load between the server and clients grows when the number of connected users increases. Consequently, network hardware must provide adequate system performance for real-time information sharing. The system is optimized to work smoothly with one server machine and 50 client computers, each with a 12-inch XGA display, for one lesson; the network speed is maintained at 500 kbps or less for each connection. To limit the amount of data exchange between the client machines, all teaching materials and coursework are sent to the screens of all students when each interactive lesson begins.

After the lesson begins, the system sends only their own written data and the data controlled by the teacher to student screens.

If many students send frequent questions to the teacher, it is very difficult for the teacher to quickly provide answers. In addition, the teacher largely has no means to determine the degree to which each student understood the course materials, because the teacher cannot directly observe students and their reactions. By conducting a pre-survey requesting freeform advice in the subjective evaluation, we received useful comments, such as “It may take some time before a student’s question gets a response from the teacher.”

Accordingly, our advanced GUI is configured to prioritize student screens by changing the GUI interfaces on the teacher’s computer. Thumbnails are blinked, sorted, and scaled on the basis of student viewing and other parameters. In particular, the thumbnails of each student’s computer is zoomed dynamically based on their understanding level, as shown in Fig. 2. If the student screens can be sorted on the basis of their priorities on the teacher’s screen, the teacher can observe student work and support their thinking process as an effective teaching aid. The teacher can also clarify any misperceptions in student thinking processes, providing appropriate and individualized support for each student

Fig. 2. Overview of GUIs for viewing student screens as thumbnails on the teacher’s computer; student screens are zoomed dynamically based on their attitude

3 Practice and Evaluation

As a prototype for applying this system to a real lesson for students in campus, we assembled 20 computers. The proposed learning system was implemented in a pilot evening class. After conducting this class, the feasibility and practicality of the system in helping the students study actively and willingly was verified by observation and questionnaires. Using this system, a teacher in his/her office on the campus sent instructions or learning materials to all student PCs via the network. On receiving this material, the students could note their views and answer the questions in the learning material on their PC screens using the stylus pen attached to their tablet PCs. They could also submit their answers as an image to the teacher.

Because the students' PC screens were visible on the teacher's PC screen, the teacher could check the students' work and support their thought processes by online collaboration. The teacher could also identify any misinterpretations in their thought processes and provide appropriate clarification to each student by combining the images drawn on their PC screens and by verbal communication through the headset, respectively. In an investigation of the system, it was observed that students who were uninterested in a normal class exhibited a different attitude in the pilot evening lesson: they concentrated more, studied the coursework, and frequently sent their questions to the teacher. Consequently, it became easier for the students to ask questions to the teacher in a face-to-face interaction. In addition, it was very satisfying for students when their queries were answered immediately and therefore, their work could be adjusted appropriately.

To evaluate the implementation of our system, we measured its performance in actuating a target host for broadcast and subsequently measured the response in delivering streaming video to the entire target host. For this experiment, we used a delivery server and from five to twenty target hosts. The delivery server ran on a Core i7 (3.4 GHz) processor with Windows 7 Professional and the self-customized BigBlueButton [8] with Ubuntu; BigBlueButton is an open source web conferencing system developed primarily for distance education that supports multiple audio and video sharing, as well as presentations with extended whiteboard capabilities.

Each target host ran on a Core i5 (2.53 GHz) Mobile processor with Windows 7 Professional and a web browser as a BigBlueButton client. The system interconnected via a Gbit LAN from the server on our campus to an IEEE 802.11g/n WLAN for the target hosts. The streaming video for one target host was played in a 320×240-pixel (QVGA size) window with a webcam.

We verified the connection speed between the WLAN and the Gbit LAN for the server. When twenty target hosts for students and one host for the teacher were used on campus, the minimum throughput speed between the server and a target host was 12 megabits per second (Mbps). We also measured the time lag before a target host's actuation; the latency from capturing a webcam to passing a streaming server's IP address to a target host was less than 10 ms, and the latency of the web browser's connection between a streaming server and a target host over a TCP connection was set to minimum.

We also implemented a questionnaire survey to investigate the subjective impression of our prototype system. The test subjects were ten students in the department of electrical engineering, all in their twenties. We assumed that subjects in their twenties were well-versed with the use of computers in their daily life. We explained and demonstrated to the subjects how to use our prototype system before they filled out the questionnaire, which included the several questions. Next, questionnaires on the subjective impression were evaluated using the following five-point rating scale: Better (5), Slightly better (4), Fair (3), Slightly worse (2), and Worse (1).

Subjects evaluated our system favorably, focusing on the system's operability. The subjects' rating of the ease of use of the system increased to more than 4 points after conducting the supplementary lesson, whereas the comparison with using a notebook was low and decreased to less than 3 points. The reason for this result was that the response of the stylus pen was slightly slow, as reported in student comments. The ratings regarding the ability to concentrate during the supplementary lesson showed that, because it was possible to concentrate on the teacher's explanations without taking notes and to concentrate on hearing the teacher's voice using the headphones without other noises, this system helped students concentrate better. Furthermore, other evaluations of our system by these users indicated greater effectiveness. In particular, the subjects' rating of their wish to continue the supplementary lessons using this system increased to 5 points.

Regarding the educational impact, the subjects felt that the supplementary lessons using our system had the same effect as a face-to-face class. Further, their desire to attend supplementary lessons in the future increased. Overall, the subjects' rating regarding the benefits of studying was also high (more than 4 points), because all students answered that the supplementary lessons taken using our system were more useful for forming the habit of studying, whereas study time outside of the supplementary lessons was slightly low (less than 4 points). Regarding study time, two students answered "slightly yes," whereas one student answered "slightly no." Thus, one student had more incentive to study for the course because of the supplementary lessons, whereas the other students felt that the lessons were sufficient.

These ratings of the supplementary lessons provided by our system suggest that our system can achieve the same outcome as a face-to-face class if the supplementary lessons are provided as multipoint remote interactive lessons. Further, the evaluated value of our prototype system for these users might prove greater with more familiarity and experience using our system. As freely provided advice in the subjective evaluation, we received useful comments such as "It is inconvenient that the voice is interrupted sometimes," "It may take some time before a student's question gets a response from the teacher," and "We want more time to do a lot of exercises."

Because we need to analyze the evaluations of teacher performance, we will conduct this analysis and discussion as a future work.

4 Related Work

Studies of interactive support systems used in class with a pen-based interface focus on the way in which the system helps students answer questions and use the teaching materials with an electronic board, a PDA, or information and communication technology (ICT) equipment. To compare our TERAKOYA system to such related work, we weighed two technical areas: interactive systems [5] and active learning environments [6]. Both incorporate pen-based computers [6,13].

AirTransNote [5] is an interactive system that provides a mechanism for improving the interactive feature by using a PDA via WLAN in a normal class. The system is highly compatible with legacy interfaces using pencil and paper because it involves manipulating a stylus pen.

Livenotes [9] allows listeners to share slides on their tablet PCs and discuss issues with other listeners by collaborative note-taking in a shared space. The concept of the system, a new cooperative learning practice, fosters goals similar to those of our system. We particularly focused on a small private school environment on a LAN linked to multipoint remote users rather than collaborative learning among peers connected in small groups, as in Livenotes.

Classroom Presenter [10] is an alternative tablet PC note-taking system based on a broadcast model. The instructor can add annotations to his/her own slides, which are broadcast to all students. Students can also annotate their slides and provide aggregated feedback on the instructor's slides. However, there is no support for small-group student interaction.

Tablet PCs with a stylus pen are becoming increasingly common in engineering classrooms, as they provide the instructor with an extended set of educational tools. Even as a direct replacement for the traditional blackboard, they have many advantages [6,13]. One of the most important advantages is that the tablet PC enables the instructor to seamlessly switch between a standard blackboard-type interface to one of the many multimedia programs or materials to enhance the presentation of difficult subjects. The tablet PC clearly offers many advantages over the traditional blackboard approach for improving the overall learning experience of the students [11]. Ubiquitous Presenter [12] is a web-based extension to Classroom Presenter and facilitates distance learning.

Although each of these related systems is interesting, our system has numerous distinguishing features. First, our system makes it easier for students to ask the teacher questions just as they could in face-to-face interactions. Second, it is very satisfying for students to have their queries answered immediately, which is achieved by directly connecting the teacher and the students. Third, students may feel a sense of security and of being looked after, because the psychological distance between the teacher and each student is less. As a result, students can maintain their study concentration longer than in a normal remedial education class. Thus, the TERAKOYA system not only expands the accessibility of popular tablet support methods, but also accommodates a wide variety of learning styles by leveraging a transparent and calm learning environment.

5 Conclusions

In this paper, we detailed how our system helped students study actively anywhere on a LAN linking multipoint remote users; our system provides an interactive evening lesson using tablets and custom-built applications both in the dormitory and at home such that students and teachers can remain in their own living spaces. As a prototype, our proposed learning system was implemented in a classroom with a teacher in the teacher's on-campus office. Our implementation employed a handwritten electronic whiteboard with verbal and non-verbal information. By conducting the test, the effectiveness of our system in helping students study actively and willingly as an example of "right time, right place learning" was verified.

In addition, our system was configured to help the teacher quickly answer student questions. Thus, the teacher can better observe the degree to which each student understood the course materials by observing students and their reactions in real time. Our GUI implementation prioritizes student screens by changing the thumbnails on the teacher's computer; the thumbnails zoom dynamically based on each student's level of understanding. By sorting out these priorities via the GUI, the teacher can observe student work in real time and support each student's individual thinking process.

Using our system, the teacher distributed instructions or learning materials on all student screens via the network. On receiving these materials, students could note their views and answer questions in the learning material on their computers using pens attached to their tablets. They could also submit their answers as an image to the teacher. Because student screens were visible on the teacher's computer, the teacher could check student work and support their thinking processes via direct online collaboration. The teacher could also clarify any misperceptions by providing appropriate support for each student.

In conclusion, we feel that more specific and effective education programs are required. We would like to further evaluate the impact this system can have on the understanding and motivation of students. We would also like to study various configurations of our new interactive system under active learning conditions, including the development of a new interaction system realized by adding entities. Our system is an ambient human interface system, which materializes as a friendly advisor that gives users natural awareness through making real images via a network to follow users. We would like to work toward realizing such an ambient human interface system of user-oriented ubiquitous computing through implementing this system.

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