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Informatics Society

Aims and Scope

The purpose of this journal is to provide an open forum to publish high quality research papers in the areas of informatics and related fields to promote the exchange of research ideas, experiences and results.

Informatics is the systematic study of Information and the application of research methods to study Information systems and services. It deals primarily with human aspects of information, such as its quality and value as a resource. Informatics also referred to as Information science, studies the structure, algorithms, behavior, and interactions of natural and artificial systems that store, process, access and communicate information. It also develops its own conceptual and theoretical foundations and utilizes foundations developed in other fields. The advent of computers, its ubiquity and ease to use has led to the study of informatics that has computational, cognitive and social aspects, including study of the social impact of information technologies.

The characteristic of informatics' context is amalgamation of technologies. For creating an informatics product, it is necessary to integrate many technologies, such as mathematics, linguistics, engineering and other emerging new fields.

Guest Editor's Message

Jun Munemori
Guest Editor of the Fourth Issue of International Journal of Informatics Society

We are delighted to have the fifth and special of the International Journal of Informatics Society (IJIS) published. This issue includes selected paper from the Third International Workshop on Informatics (IWIN2009), which was held in Honolulu, Hawaii, USA, Sep 11-17, 2009. The workshop was held at Hawaii Tokai International College (HTIC). This workshop was the third event for the Informatics Society, and was intended to bring together researchers and practitioners to share and exchange their experiences, discuss challenges and present original ideas in all aspects of informatics and computer networks. In the workshop, 27 papers were presented at 4 technical sessions. The workshop was complete in success. It highlighted the latest research results in the area of networking, business systems, education systems, design methodology, groupware and social systems.

Each IWIN2009 paper was reviewed in terms of technical content and scientific rigor, novelty, originality and quality of presentation by at least two reviewers. From those reviews, 14 papers are selected for publication candidates of IJIS Journal. Among those 14 papers, 5 papers are related to groupware. This fifth issue focuses on groupware and includes those selected five papers. The selected papers have been reviewed from their original IWIN papers and accepted as publication of IJIS. The papers were improved based on reviewers' comments.

We hope that the issue would be of interest to many researchers as well as engineers and practitioners in this area.

We publish the journal in print as well as in an electronic form over the Internet. This way, the paper will be available on a global basis.

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AR Chemistry : Building up Augmented Reality for Learning Chemical Experiment

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Abstract - Learning is changing behavior and ideas by storing experiences and acquiring knowledge. We focus attention on Chemistry in various learning. This paper describes a learning assist system for chemical experiments "ARChemistry" which is used in augmented reality and tabletop interface for combining physical papers and digital content.

In this system, tabletop interface shows needed related information on tabletop interface. Augmented reality enables us to show chemical reactions by using a virtual model. The user's history is stored for the feedback of the experiment. ARChemistry's feedback function enable us realize mistakes that are made in the "Which procedure", "Who", and "What operation" aspects of the experiment.There are no methods to catch mistakes on traditional experiment.

Through experimental use, the results showed that an augmented reality interface system worked appropriately.

Keywords: tabletop, augmented reality, collaborative work, multi user, chemistry

1 Introduction

Learning is to change thinking and actions by experience and storing knowledge, for example, remembering how to get to a new office, making a presentation or memorizing new words.

In this research, we focus on academic learning. There are many different types of learning. Collaborative learning is one type, in which, several people work together to achieve a common goal. Collaborative learning often takes place in chemistry courses during group learning experiments. We decided that this is one effective way of learning[1][2].

Many researchers have studied collaborative learning systems that use a tabletop interface or tangible device. Recently systems have been developed with large displays that allow two or more users to intuitively operate the device[3][4][5]. These systems allow users interact with physical objects and retrieve relevant digital information. This paper will propose "ARChemistry" should be used in introductory chemistry courses. The system assists the chemical experiment learning by using augmented reality (AR) and physical objects. The system has an experiment study space with the tabletop interface, and we apply that to chemical experiment. When students use the AR loupe for an experiment they will be able to use physical objects view 3D animations and retrieve any needed information like moving ion, chemical reactions. Augmented Reality offers a way to merge virtual graphics with the real world in real time[4]. Users will be able to see invisible objects with the system.

By Storing history information the system allows users to search for and find their mistakes in the "Which procedure", "Who", and "What operation" aspects of the experiment. With the conventional experiment it is impossible to refer to history information to find mistakes. It was impossible to refer the history information, but our system enables us to get the feedback. It is important for student to identify and isolate their mistakes. To confirm the utility of this system, an assessment experiment and user discussion were done.

2 Related Work

Learning is our ordinaries of life and it influences our operation afterward. Everyone has done it regardless of conscious or unconscious consideration. There are many different types of learning and an Academic learning is a conscious learning.

It falls into two general categories of learning that one is to learn from a textbook and a reference book or that another is to learn from the out-of-door activity and experiment.We focus on the experiment learning of the experience type[5].

2.1 Experiment Learning

We view the experiment learning as a collaborative learning that some facing people work jointly at the same time. The second learning style is class room learning that teacher stands in front of students. Learners often achieve high result with the collaborative learning more than with classroom study[1].

In this case, important points are evaluation to group and personal responsibility. Evaluation to group has all learners in group effects in aiming to achieve high level. Working in them responsibility, learners have a great awareness and get a high result. Because two factors are direct motivations for learning. Based on these factors, we focus on the chemical experiment that many students do it at the same time and that chemical reaction is very impressive.

2.2 Problem of Experiment Learning

In this research, we make the virtual chemical experiment to assist chemical learning on the tabletop interface. In view of the following factors, we designed the system in order to do such the experiment as actual experiment.

- Cooperation with text study
- Experiment accident
- Experimenter's error in operation
- Experimental environment

First, it is difficult for people to always put all studied information in the head while experiment. But students need many chemical information in experiment to understand invisible reaction. For example, combining ion and electoron/other ions , features of cation, how to use instrument and so on. As a result, students often refer to the text or just do without right information.

Second, chemical accident and user's mistake will be caused even if we pay very attention to them.

Third, chemical experiment needs equipment mostly which is not enough at home.

3 ARChemistry

ARChemistry is a supporting system for chemical experiment study. The system applies 3DCG to virtual experiment space on tabletop. If the above-mentioned problem is based, it becomes an important point in the following four points.

- Visalization by AR
- Display related information in experiment
- The experimenter's identification
- Record of experiment procedure

At first, movement of ion and electron is ordinarily invisible but it becomes visible by AR. Visualization by AR adds the understanding more than an actual experiment[8][9]. Repeating is important in study. But the repeating in experiment needs many kinds of chemicals and needs experimental instruments which we don't have usually at home. Visualization allows us using chemicals and instruments in a repetitive manner. For example HCl or H2S in chemicals and the gas burner etc can be used. These reduce cost and risks. Additionally, this system leverages not only AR but also physical objects. It becomes possible not to lose the experiment feeling by operating physical objects like beakers.

Second, if we access an object, system displays some related information on tabletop. Mainly the information displays ionization tendency or contents of beakers and so on. This operation bridges the gap between text study and experiment study.

Third, identification and record allow users to search for and find mistakes. Correcting work is difficult in an actual experiment though some chance of study are ruined when the experiment is finished while not correcting a mistake. However, warning and feedback became possible by recording each user's record. Warning is to inform them of the thing that causing to the accident when keeping experimenting or the experiment cannot be correctly ended while working on the tabletop interface. Feedback is to be able to confirm and isolate whether it made a mistake in "Who", "Which procedure", and "What operation" because the procedure and the user's correspondence are made the text sentences after working, it was not possible to do by an actual experiment.

We aspire achievement of construction that virtual experiment system has four necessary elements.

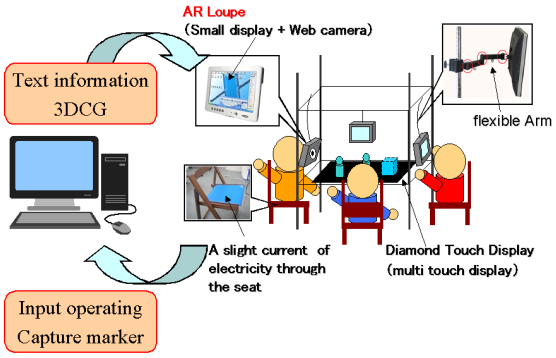

Figure 1: Hardware Construction

3.1 Implementation

This system keeps the horizontal and arranges a large-scale touch sensor display （DiamondTouch[6][7]） as shown in Figure 1. The electronic information is projected from the top of the rack, and the physical objects are on the display. We links the information and physical objects with tabletop interface. When user operates a beaker , the system displays beaker's contents information. In addition, we built up the AR loupe which has the Web camera behind a small display. We install the AR loupe by each user's left side. When AR loupe captured an AR markers, AR loupe will display some 3DCG about experiment which are images or some 3D animation. The system progresses order by order in the following three parts.

- operation physical object
- display AR
- operation with tabletop interface

It explains details and the manner of operation of these three parts in order.

3.1.1 Operation Physical Object

In this system, user can recognize the beakers as a lab ware. The experiment feeling is not ruined because we move the physical object on the touch sensor display, and the system can recognize it.

To recognize the physical object with the system, the copperplate and the copper wire with high conductance are put as shown in Figure 2.

Figure 2: Overview of Physical Object With Copperplate

A slight current of electricity from DiamondTouch passes the user's body when they operate a physical object, and it is read in the system[6][7]. DiamondTouch is the multi touch sensor display which can recognize the multi point and who use the system. Moreover DiamondTouch can distinguish the physical object according to the size of the sheet copper.

By using this function we can mix contents of the beakers virtually . As Figure 3, user grips the beaker firmly for eliminating a gap between hand and beakers. When we down the beaker on the tabletop , it was recognized. If the operation was correctly, included information would be shown on your space at Figure 4. And user select blending button when last two beakers have been recognized to the system. A marker includes text information and 3D animation, appears with sound effects. User can check the chemical reaction with AR loupe and text about experiment on tabletop.

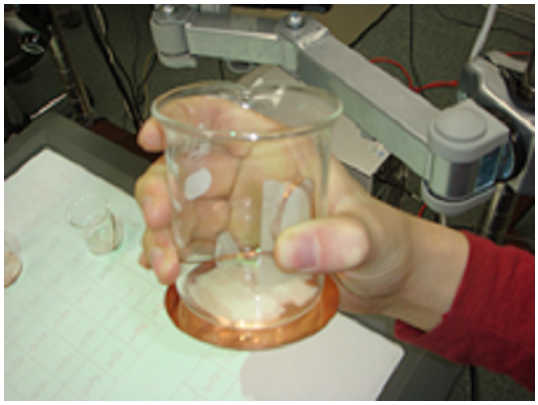

Figure 3: Gripping Physical Object

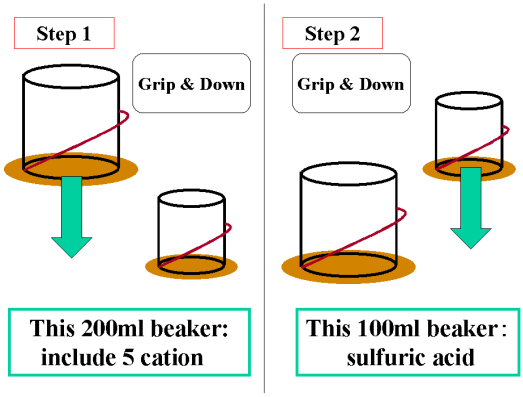

Figure 4: Physical Object Recognition

3.1.2 Display AR

We can use AR loupe for viewing virtual objects. As Figure 5, AR loupe is constructed by a 9 inch display and Web camera（Qcam Pro for Notebooks）. AR loupes are arranged for all three user's left side. Flexible arm fixes them strongly.

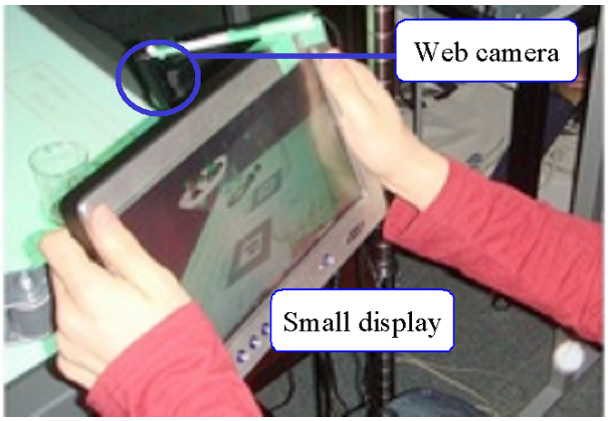

Figure 5: Operating AR Loupe

AR loupe distinguishes the presence of the AR marker through the image which Web camera captured. When the AR marker exists, loupe's display shows 3DCG on the marker after distinguish the shape. Moreover, because the AR marker has been linked not only 3DCG but also chemical information, textual information is shown on the tabletop and 3DCG is possible to display in loupe's display.

Because the AR loupe can be freely moved by using the arm as shown in Figure 5, it is possible to operate the system without closing both hands on the touch sensor display.

When users want to see 3DCG, they can pull AR loupe and peer into the screen of own small display. The display shows some animation. For example flame reaction or a precipitate by uniting ion and so on.

3.1.3 Operation with Tabletop Interface

We perform procedure chiefly by using the touch sensor display. Figure 6shows an actual operation screen.

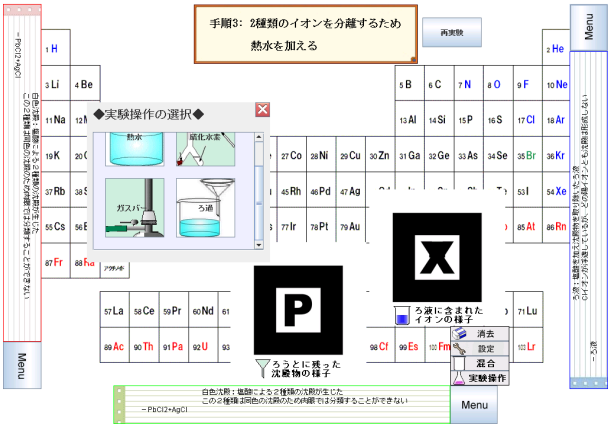

Figure 6: An Operation Screen on Tabletop Interface

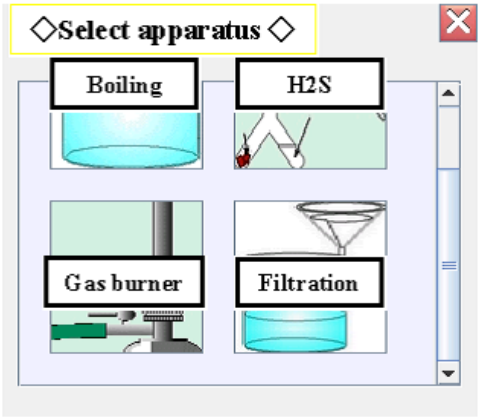

Figure 7: Overview of Apparatus Panel

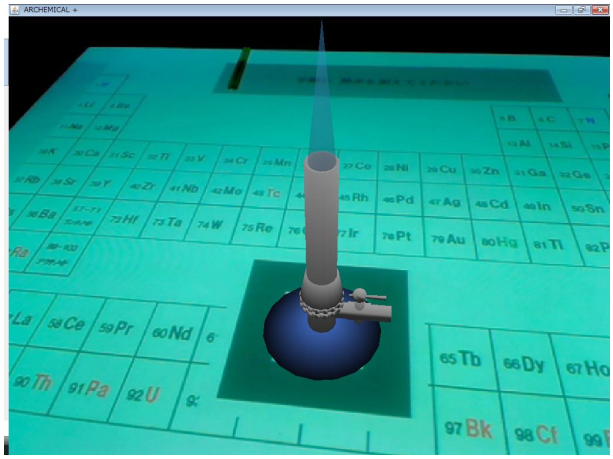

Figure 8: Apparatus：A Gas Burner for Flame Reaction

It is possible to operate the system intuitively with touch sensor display. Additionally, We innovate a way to use menu list like a usual PC for handling so operating system is more easily. There are some panels to play the system on tabletop display. In figure 6, there are ”menu list” at upper blue menu panel and ”AR panel” which has an alphabet on black square.

1. an individual note pad panel
   When user operates the system, chemical information of operated object is shown to each user’s front panel. The information will be shown in touching AR panel, in gripping a beaker, and after chemical reaction.

2. an indication panel
   This panel shows what you must do next. If you mistake the procedure, the system alerts that you are wrong with warning tone and message.

3. hiding button in menu list
   It hides the marker which user feels obstructive at operating it.

4. log button in menu list
   When this button is pushed, select panel appears. And on that panel, user decides whether they log or not, and what log file name is.

5. blending button in menu list
   As shown in Figure 4, system memorize informations of two beakers. When the indication panel says that you must blend two beakers, this button is possible to use. At blending, AR panel shows 3D animation of chemical reaction process.

6. apparatus button in menu list
   In touching apparatus button, chemical apparatus panel appears as shown Figure 7. When user touches icon in this panel, system shows paired AR marker which corresponds to each operation such as lab wares and a reagent.Figure 8 seemed to select a gas burner icon, and to have looked into the marker with the AR loupe. When user touch again ,the gas burner reacts another flame color of the classified ion and user confirms whether it is a specific ion.

There are filtration, to pour heated water, the outbreak of the hydrogen sulfide as well as a gas burner.

3.2 Record

When we do the experiment operation , our system records not only the operation but also a physical object and an operator. In a word, Users can confirm ”Which procedure”, ”Who”, and ”What operation” aspects with the historical information whether they made a mistake. As a result, in actual experiments it was difficult to specify a mistake of procedure but our system allow users to discover a critical point in the experiment. And the system allow users to be able to prevent the accident before happens in real experiment because they are taught by warning message which shows that you must fail if you keep to do your operation.

4 User Study

4.1 Overview

We conducted a user study to clarify the effects of ARChemistry on users. The objective of this study was to observe how the system would affect the users' chemical experiment, and how users would interact with the system. Eighteen university participants aged 21 to 24 years (14 men and 4 females) were asked to participate in this experiment. The participants worked in pairs during the experiment. All of the participants were inexperienced in regards to chemical activity, and were novice users of the interface that we developed.

We used HMD in order to compare ARloupe to a system with HMD. The participants received an explanation of how to use each system before starting the experiment ? cation analysis. The participants were asked to accomplish chemical experiment without a time restriction using each system. The experiment had the following two system setup: DiamondTouch and ARloupe, and DiamondTouch and HMD.

- ARloupe: Participants had a small display to capture markers and to show 3DCG. They were able to change display's positions freely anytime so they can see both surface of DiamondTouch and ARloupe separately.

- HMD: Similarly participants used a HMD to display 3DCG. HMDs were eMagin Z800 3D Visor and i-visor FX601 - SVGA 800 $\times$ 600. We placed a web cam to HMD in order to use it by video see-through type.

We wanted to understand how ARChemistry would allow participants inexperienced in chemical experiment to accomplish cation analysis. We observed the user interaction in each setup, and analyzed whether ARChemistry supported user activities related to chemical experience even if the users had little or no experience in chemical. After accomplishing the cation analysis, we asked participants to fill the questionnaire (ten stage evaluation and free description column).

4.2 Result

Through this experiment, we were able to confirm some practical advantages of ARChemistry in the process of accomplishing the cation analysis. The Table 1 shows the average time and standard deviation to finish the experiment. Participants with ARloupe finished more fast than with HMD. The considerable factor of this difference is visibility. User with HMD said that he had been surprised at suddenly user's hand had broken into his sight while he had focused on the task at hand. And another said that it had been difficult for him to read text on surface by image degradation through the HMD. This is why watching at text on surface of DiamondTouch with HMD is smudgy. Users with ARloupe can watch at the text by naked eyes and check 3DCG in small display so they can have broad eyeshot.

The Table 2 shows the outcome of a questionnaire. When the summary is seen, the high reputation value is obtained for the question No.1, No.5, No.8 that we emphasized these

Table 1: Average Time and Standard Deviation to Accomplish The Experiment

Method	Average Time	Standard Deviation
ARloupe	479.4	102.3
HMD	751.8	155.2

Table 2: Summary of Questionnaire Response.

No.	Question	Average
1.	I found easy to manipulate table top	8.0
2.	I found it intuitive to use beakers	7.2
3.	I performed AR Loupe as intended	7.4
4.	I imagined the actual chemical	7.5
5.	I found it supporting experiment to use 3D or text information	8.1
6.	I feel fun to use this system	8.7
7.	I found Chemistry of interest	6.5
8.	I found easy to understand chemical reaction	8.1
9.	I found the system available for review and preparation	7.7

themes when we made the system. It says that the participants were able to use the system easily by touching the tabletop screen or using physical objects (beakers) or ARloupe. Responses say that ARChemistry's operation was easy because it was a very simple operation. About No.5, No.8, they say that 3DCG improves users understanding. In comparison with text learning, virtual chemical reactions are so clear that users see how some ions react.

In addition, the question No.6, No.9 was the high reputation values too. These comments are that this experiment was so fun because we had been speaking each other while operating and that it was possible to operate the system without getting tired. Participants seemed to actively interact with ARChemistry while communicating with each other and to provide understanding of chemical experiment. Efficiency goes up to study enjoying it, so this evaluation backs up the utility of this system that these evaluations.

On the other hand, No 7 is lower score than other question. This is why participants who were not interest in chemical from the beginning didn't get their interest from the system a short time later even if that operating is fun and easy to understand.

5 Conclusion

There are styles of the learning now for many divergences. Interaction methods with AR and a touch sensor display increased slowly in that. The system "ARChemistry" used AR and tabletop interface and put a focus for the chemical experiment learning. In this system, tabletop interface can show needed related chemical information on tabletop and how you push forward operation. Augmented reality allow us to show chemical reaction by using a virtual model. And the feedback of the experiment is enabled by storing user's history. The

feedback is able to realize us the mistakes made ”Which procedure”, ”Who”, and ”What operation” aspects.They are new method to combine text study and experiment one in chemical. Through evaluation experiment, the results showed that the system of an augmented reality interface worked appropriately and is interesting in learning and discussion each other.

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Visualizing the Liveliness of Discussions and Reply Relationships on Online Discussion Boards

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Abstract - This paper proposes a technique to interactively visualize the liveliness of discussions and the reply relationships of messages on online discussion boards, and describes prototype software that visualizes the liveliness of any topic thread on 2channel (Ni Channeru) [1], Japan's largest online discussion site. This visualization is based on a line graph of the number of postings versus time. To show reply relationships on the same chart, this visualization utilizes the technique of Thread Arcs [14], which show reply relationships as semicircular arcs that connect message plots. Furthermore, for users to know the length of each message, the visualization can plot a message as a pair of small bar graphs on the same line graph.

Keywords: liveliness of discussion, visualization of discussion structure, online discussion boards, 2channel (2ch.net), Thread Arcs

1 INTRODUCTION

An enormous amount of information is exchanged every day in online discussion boards or Web forums on the Internet. Although such sites are mixtures of various information, some lively discussions in which many people participate would include valuable, interesting, or entertaining information. However, conventional discussion boards provide only user interfaces in which users need to read messages one by one from the beginning of each thread, even if they are looking for only the lively parts of the discussion.

Therefore, this paper proposes a technique to interactively visualize the liveliness of discussions and the reply relationships of messages on online discussion boards. It also describes prototype software that visualizes the liveliness of any topic thread on 2channel (Ni Channeru) [1], Japan's (and probably the world's) largest online discussion site. Although the "liveliness" of a discussion can relate to various factors of the discussion, this paper roughly defines liveliness as "the number of posted messages per unit time". The number of replies per message and other statistical data are used as secondary information.

The 2channel consists of many Web discussion boards on different themes, and each board allows a user to make a new "thread" for every new topic. In each thread, posted messages are displayed sequentially from 1 up to 1000 message numbers. On each board, the display order of its threads is determined by floating the thread with a new posting at the top. At the same time, the user can use the "sage" (down) command to keep the thread from floating.

In addition, 2channel features anonymity[1], that is, users are not required to provide any registration or contact information. Actually, most of the postings are contributed by "anonymous". However, to reduce the negative effects of anonymity, many boards have recently appended a string called "ID", which is apparently a random string to each message for identifying the user. The ID string is calculated with a one-way hash function from both the posting IP address and the posting date, thus it remains the same when the user posts any message from the same address on the same day.

2 RELATED WORK

2.1 Analysis of Online Discussion Boards

As for the liveliness of online discussion boards, Matsumura et al. [2], [3] collected and analyzed log data from all discussion boards in 2channel to propose the quantification of characteristics of each discussion thread according to the following eight indices:

Contents (C) The average size of a message in bytes (except for the following AA and V).
Activity (A) The average number of messages per thread.
Interactions (I) The average number of replies per message.
Speed (S) The average number of messages per day.
Vocabulary (V) The byte ratio of "2channel words".
ASCII Art (AA) The byte ratio of text arts.
Nameless (N) The ratio of messages posted by anonymous ("nanashi-san").
ABON The ratio of messages deleted[2] by administrators.

Researchers calculated these indices by the category of which discussion boards they belonged to, and showed the rough trends of discussions in each category by analyzing the relation of these indices with the method of covariance structure analysis. Then, they proposed a statistical model to show the overall dynamism of 2channel with the cause-effect relationships of the three trends: the discussion divergence trend (A and S are large), the discussion deepening trend (C and I are large), and the stylized expression trend (V and AA are large).

In addition, Matsumura et al. [5] also performed statistical analysis for the dynamism of Yahoo! Japan Message Board [4], which requires a user's registration unlike 2channel. They used a weighted, directed graph representing the relation of users to analyze reply relationships and their influences in

[1] Indeed, it is not so anonymous, because the servers maintain the log data of all connections.

[2] "Abon" is the system message indicating deletion of the message.

the discussion. Then, they focused on the role of users and classified discussions in Yahoo! Japan Message Boards into three types: leader-driven communication, leader-follower-collaborative communication, and follower-driven communication.

These researchers investigated users' collective behavior in online discussions from a macro perspective by quantifying a discussion with several index values. Therefore, the techniques can be significant in the fields of sociology, mass psychology, etc. However, they are not directly useful for general users reading online discussion boards.

2.2 Time-Series Analysis of Discussion

From the users' viewpoint, discussion boards with a greater number of postings are considered more worth reading, because such boards usually hold lively and active discussions and contain abundant fresh information. As for 2channel, the degree of discussion liveliness is often called "ikioi" (momentum) or "nobi" (growth) [3]. These words roughly signify the number of postings per unit time ("growth" also means the total number of postings).

For users to find such lively and interesting discussions, some software [6], [7] and Web sites [8], [9] for reading online discussion boards display the value called "ikioi" (momentum), or the posting speed per hour, for every discussion thread, which is the average number of postings per time. In addition, some boards show ranking lists of the values.

Furthermore, there is software called V2C [10] that can visualize the time variation of the value on a chart. V2C draws a thread in a line graph using the x-axis for time and y-axis for message number (i.e., the number of postings). Therefore, the graph slope represents the number of postings per time or the momentum.

Matsumura et al. [11] extended the research previously mentioned [2] and attempted a time series analysis of the liveliness of a discussion in 2channel with the following six new indices: the posting interval rate (the average interval between postings), the interaction rate (the average number of replies per message), the anonymous rate (the rate of anonymous postings), the 2channel word rate (the rate of jargon per message bytes), the ASCII arts rate (the ratio of characters often used in text arts), and the new information rate (the rate of new nouns per message).

2.3 Visualization of the Discussion Structure

Visualizations of discussion structures for character-based online communication have been developed and used conventionally. Most of the software for e-mail and Netnews (Usenet) enables users to gather a related discussion and view relationships of messages in a tree structure by using the messages' headers such as "Subject" and "References". This method visualizes a lively discussion in Netnews as a complicated tree structure because of its message format such as e-mail.

[3] Moreover, the state of extremely lively discussion is sometimes called "matsuri" (festival), where users join the discussion and post many messages in the aim of liveliness itself.

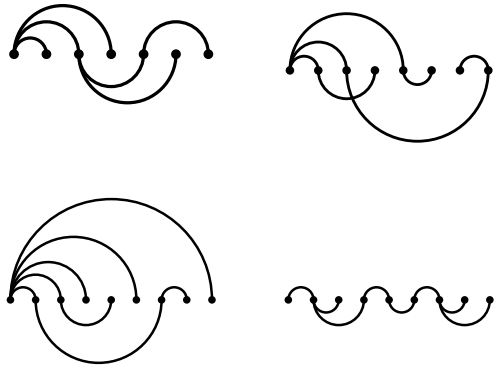

Figure 1: Thread Arcs (B. Kerr, IBM Research).

In the CSCW (computer-supported cooperative work) field, many discussion systems [13] with visualization interfaces have been proposed traditionally. Most of such systems show that the discussion flows with branching and merging as directed graph structures on a two-dimensional plane. For example, Matsumura et al. [12] proposed the analysis method and the visualization of the discussion structure on their online discussion board as a kind of directed graph.

On the other hand, this paper refers to the research of Thread Arcs [14], which is a visualization of e-mail reply relationships in a personal mailbox. As Figure 1 shows, the Thread Arcs visualization can show reference relationships among messages placed on a straight line, by drawing semi-circular arcs connecting replying and replied messages. As a result, a compact visualization is realized that does not need two-dimensional layouts.

3 INFORMATION TO BE VISUALIZED

As suggested by the words "ikioi" (momentum) and "nobi" (growth), it is considered that users' feelings about the liveliness of an online discussion are greatly affected by the passage of time. Therefore, this research uses visualization based on a statistical graph with a time axis to display the following information:

The cumulative number of postings Visualizing this is the most basic view for the liveliness of a discussion over time. A line graph such as V2C is used. It relates Matsumura's A and S indices.

Postings by the same ID (user) Messages posted by the same ID (as currently focused by the user) are highlighted in the view.

The cumulative number of unique IDs If this is small, it means that few users perform many postings.

Postings with "sage" command Posting messages with the "sage" (down) command prevents the thread from floating to the top of the board.

Size of every message The visualization can show the size of each message, excluding symbols and spaces.

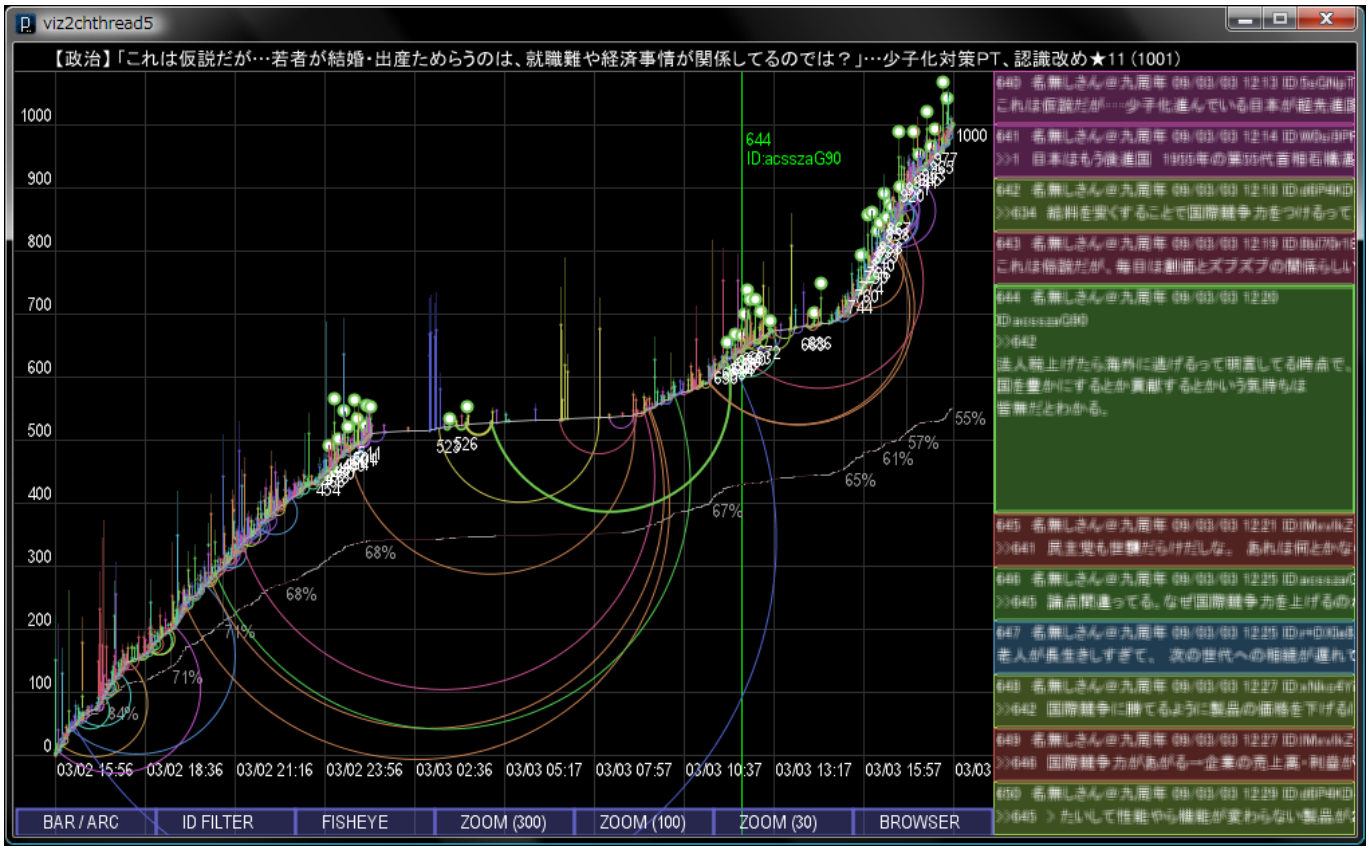

Figure 2: The visualization overview (the left area is for visualization, the right area is for messaeg texts).

Reply relationships between messages Every reply in the thread is visualized. It relates to Matsumura's I index.

The cumulative number of replies It also relates to Matsumura's I index.

For now, there are no metrics corresponding to the number of 2channel words (V), the rate of anonymous postings (N), and the number of deletions by administrators (ABON) in Matsumura's indices [2], [11]. The author considers that these are less important for the interactive visualization of a single thread, because most new jargon is used frequently only for short periods of time, and the number of signed postings and message deletions is small in a thread.

On the other hand, this research uses information about the ID and "sage" (down), although this is not included in Matsumura's indices. These are considered useful to characterize each thread, because the number of IDs can be a useful index for the number of unique posters, and "sage" postings are commonly seen in threads that are little changed by the participating users.

In addition, this research does not count replies to the first message, which presents the topic of the entire thread, as effective replies.

4 VISUALIZATION TECHNIQUE

This section describes the visualization technique in detail. The prototype software has been developed with Processing [15], a programming language that is suitable for dynamic graphics. When a user drag-and-drops the log file or the URL of the thread, which is saved by a 2channel browser like Open Jane [6] or displayed on a Web browser like Firefox, onto the window of the visualization, the screen is displayed as shown in Figure 2 [16], [17].

4.1 Line Graph for Discussion Liveliness

This visualization technique is based on a line graph of the cumulative number of postings versus time. By using this technique, users can read the total number of postings up until a certain point in time, and view by the slope, the progress of making the discussion lively. If the graph slope is extreme at some point in time, the discussion at that time is very lively. On the other hand, if the slope is small, the discussion is not so lively.

Each posted message is plotted with a different color (hue) calculated from its ID on the graph. When a user selects a message to investigate its relationships, the messages posted by the same ID are highlighted on the chart with particularly large plots (Figure 3 and 4). These features enable users to determine the posting tendencies of other participants.

4.2 Line Graph for the Number of Users

The software also visualizes the cumulative number of unique IDs as a line graph, which shares the vertical axis with the number of postings, and shows the percentage of unique IDs for all postings in digits, every hundred messages. If

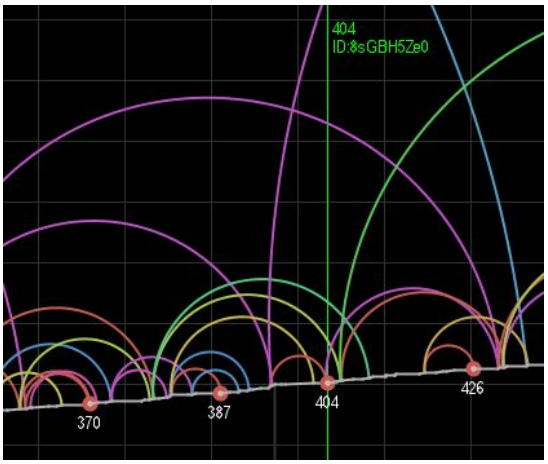

Figure 3: Arcs for reply relationships and coloring for IDs.

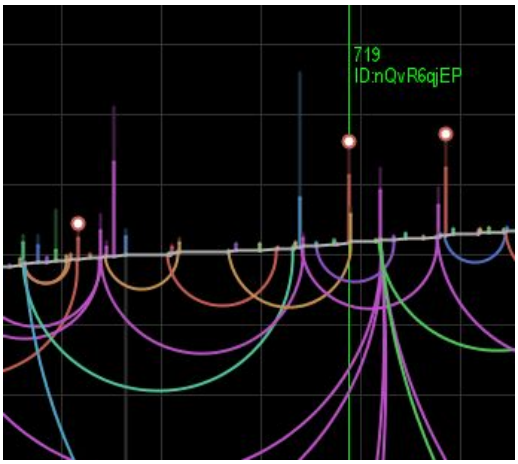

Figure 4: Small bar graphs for the amount of information.

the percentage is small, some regular users are continuously posting in the thread. On the other hand, if the percentage is large, many new posters are participating constantly.

Furthermore, the parts of the graph where messages are posted by "sage" (down) commands are drawn in a lighter color. Usually, threads that are sinking in this manner are hard for newcomers on the discussion boards to discover.

4.3 Small Bar Graphs for Message Size

The software can visualize the approximate amount of information contained in each message using the two small bar graphs at a position of each plot on the line graph of the number of postings (Figure 4). These two graphs represent the length of each message in bytes and the length excluding symbols and spaces in bytes, respectively. The latter's bar is drawn more thinly than that of the former's.

If the lengths of the pair of bars on a plot are very different, the corresponding message contains many symbol characters. Therefore, this feature enables a user to estimate the effective size of every message except for text arts, formatting spaces, etc. Although Matsumura removed text arts with the dictionary for calculating the effective size of every message, this interactive visualization enables users to determine the amount of information visually from the bar graphs.

4.4 Arcs for Reference Relationships

A feature of this interactive visualization is to display reply relationships of messages in semicircular arcs on the same line graph of the number of postings by using the technique of Thread Arcs (Figure 3). As a result, a user can investigate the tendency of replies in the entire thread, find the messages that have particularly many replies, and read the sequences where the discussion becomes much livelier with many replies.

Applying the technique of Thread Arcs to an existing monotone increasing graph enables us to visualize the relationships of data as additional information on the same graph, because the technique visualizes connections between two plots on one dimension.

The arcs are shown on the upper side of the line graph when the small bar graphs are not drawn, and on the other side when the bar graphs are drawn to avoid visual overlapping. Their colors are the same as the plots of the corresponding reply messages.

In addition, the cumulative number of replies is also visualized as a line graph like the number of postings and the number of unique IDs. This number often increases when some users in the thread have opposite views, because their lively debate elicits many replies.

4.5 Partial Zooming and Fisheye View

The time axis of the graph ranges from the thread creation to the latest post. The vertical axis ranges from 1 to 1000 message numbers. Plotting up to a thousand messages in a chart can make the visualization too dense and occluded, so the zooming feature is provided to show the range between the last ten and the next ten messages around the one that the user has selected.

However, some reply relationships connect temporally separated messages in a thread, so only clipping and zooming a part of a chart can be insufficient for a user to view relationships in detail. Therefore, the visualization provides a typical fisheye view with the graphical fisheye view technique [18] (Figure 5). It is also possible to apply simple zooming at the same time.

When you select a message in the fisheye view mode, the x-coordinate is recalculated interactively by the formula,

$$x_{feye} = \frac{(d+1)\, x_{max}\, x}{dx + |x_{max}|},$$

where x is the x-coordinate before the transformation when the x-coordinate of the focus is zero, x_{feye} is the x-coordinate after the transformation, x_{max} is the x-coordinate of the display limit in the zooming direction (depending on the sign of x), and the d is the zooming parameter ($d = 8$ in the figure).

By this technique, a user can overview the entire thread and detail around the selected message, and roughly know the destination point of arcs representing reference relationships.

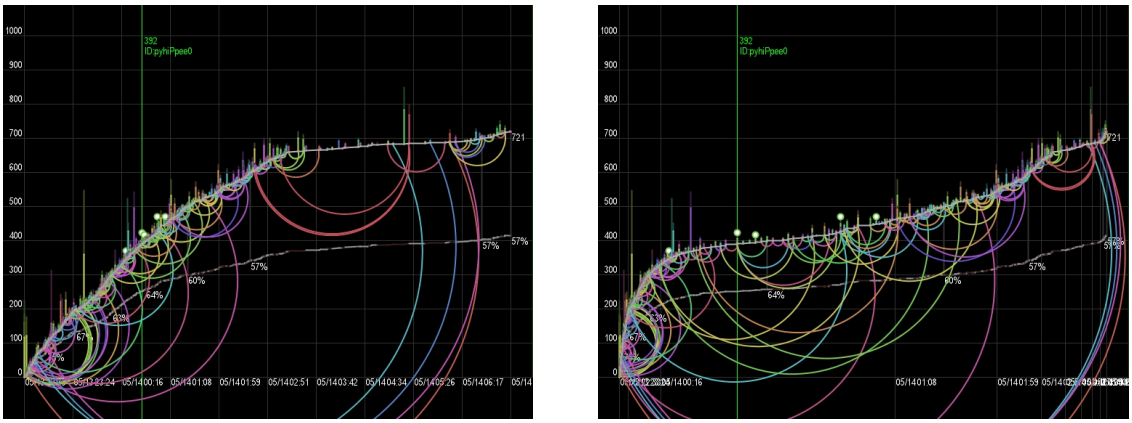

Figure 5: Nonlinear zooming with fisheye view, on the left is before applying and on the right is after applying.

5 APPLICATION AND DISCUSSION

This technique enables users to visually understand tendencies of individual threads in a temporal view, although Matsumura et al. clarified the tendencies of online discussions in a macro perspective with several quantified indices.

This section discusses the characteristic tendencies of threads found by the visualization in three perspectives: thread on event vs. thread on theme, thread with impressions vs. thread with debate, and thread for open discussion vs. thread for members. These were found by applying this visualization to various types of threads in 2channel.

5.1 Thread on Event vs. Thread on Theme

By observing the time variations of liveliness on many different threads from creation to end, some threads become most lively at their early stage from creation then gradually decay over time, and others become lively at random times regardless of their creation and end.

Such a phenomenon may relate to the purpose of each thread or the reason for its creation. The former type is often seen when a kind of event triggers a user to create a thread for discussion. The latter type is often seen when the thread is continuously maintained by some theme, such as a local area or sports team.

For example, the right-hand side of Figure 6 is the thread of breaking news about the national debt balance (over the course of a day). The left-hand side of the figure is a different thread on the topic of the Kingdom of Thailand (over the course of three years). The latter has been maintained in a variety of topics related to Thailand, but the tremendous surge of the coup d'etat is shown in comparison to before or after it.

5.2 Threads with Impressions vs. Threads with Debates

In many threads, some are lively on some level in the number of postings, even though there are very few replies in the thread. In contrast, some are not that lively and the increase of postings is slow, but discussion is actively performed with long messages and many replies.

One of the factors causing these differences can be whether or not the topic of the thread is easy to debate. For some kinds of news, there is not much room for debate among users other than reported in the first message, so the discussions do not become so interactive even if people post many messages of impression such as surprise and repulsion.

Moreover, when the first message reports shocking news, occasionally a number of messages without any replying comments are posted much more rapidly, for example, simple messages of surprise, praise, opinion, and agreement with the first message. It depends on the readers to deem such communication as lively and important.

On the other hand, social problems, historical issues, and topics involving users often expand discussions in various directions and accelerate lively communications among users. It enlarges the number of replies in the thread.

For example, Figure 7 shows two visualizations of threads, both in the newsflash board. On the left is news of Prime minister's remarks; on the right is news of the exhibition of the Dead Sea Scroll. The number of postings is not much different, but the number of replies is contrasting: the former is 15% of the number of postings, the latter is 48%.

5.3 Threads for Open Discussion vs. Threads for Regular Members

It can be said that threads with a high percentage of unique IDs are open for discussion, and various users are continuously participating and immediately leaving. On the contrary, threads with a low percentage of unique IDs are for regular members, and a relatively small number of participants continue to post messages.

The threads for regular members often continue to progress with "sage" (down) postings, because such threads are not very interesting for other people. Although there is a small number of new participants in such thread, sometimes the discussion becomes very lively, as in an explosion. It is often triggered by the news of an event related to the topic of the thread, such as result of sports match, and indicates that the number of postings per member is increasing.

For example, the left-hand side of Figure 8 shows a thread on certain local news of a city, and the right-hand side is

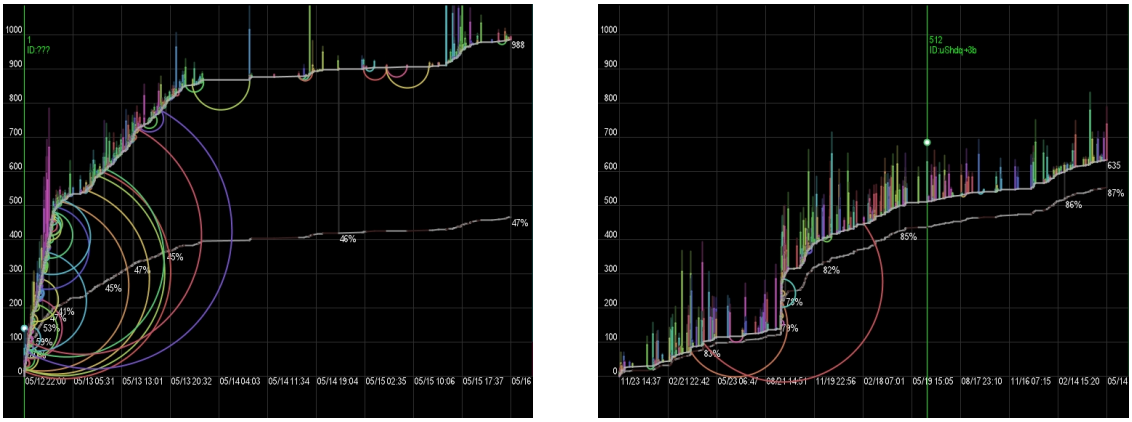

Figure 6: Visualizations of the threads on an event (left) and on a theme (right).

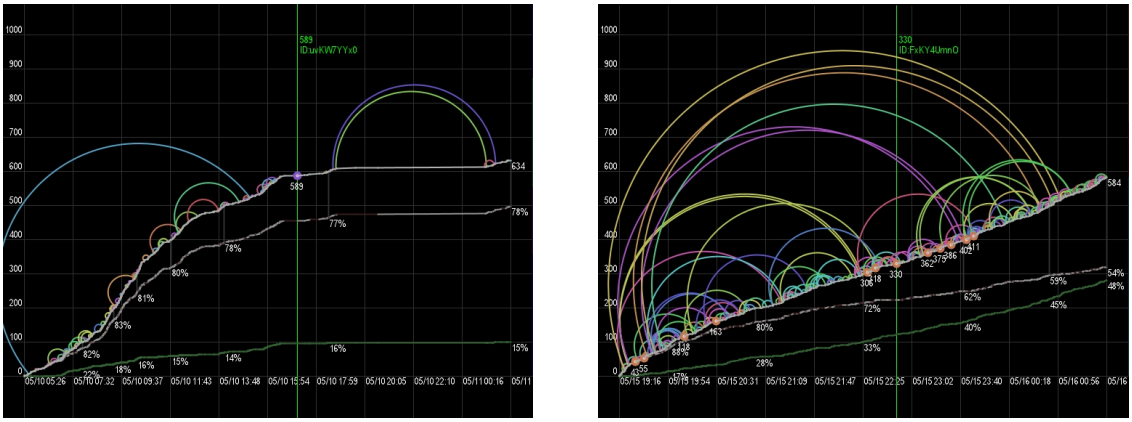

Figure 7: Visualizations of the threads with impressions (left) and with debates (right).

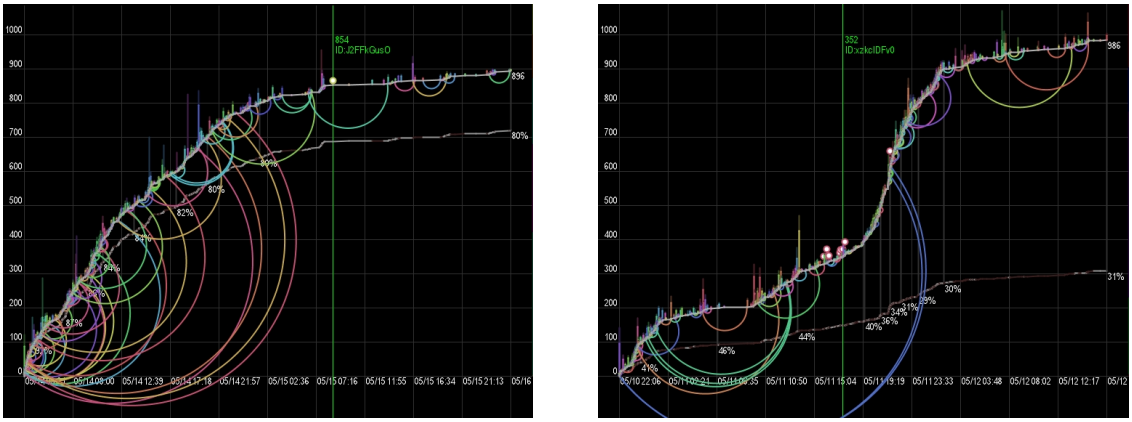

Figure 8: Visualizations of the threads for open discussion (left) and for regular members (right).

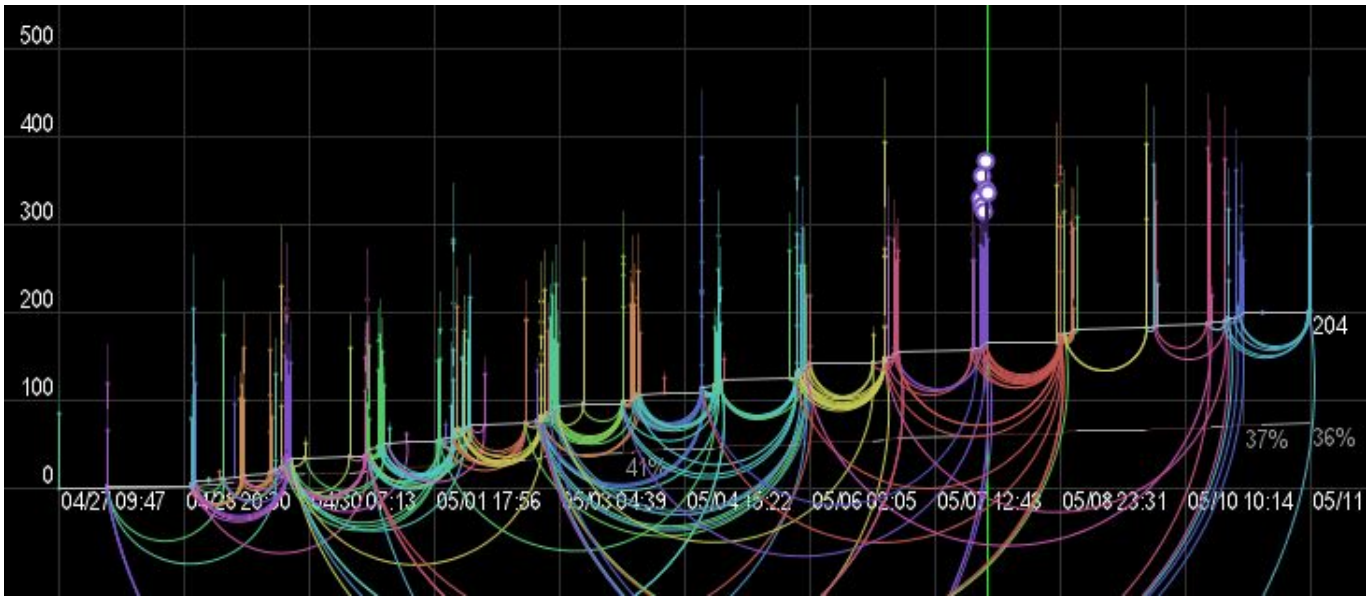

Figure 9: An example of very high correlation between discussion liveliness and time of day.

a thread for fans of a specific professional baseball team. The former indicates over 80% unique IDs, while the latter indicates 31%, in keeping with floating with "sage" progress.

6 SUMMARY

In this paper, the author has proposed a technique to interactively visualize the liveliness of a discussion and the reply relationships of messages on online discussion boards. This visualization consists of a line graph of the cumulative number of postings versus time to visualize the liveliness of discussion, and semicircular arcs connecting replying pairs of messages on the same graph.

In other words, this research extends the technique of Thread Arcs to visualize relationships of two points on a monotone increasing polygonal line or curve, although originally it can visualize only on a straight line. Therefore, this visualization is considered applicable to other existing line graphs to visualize additional information among data.

The author applied the method to the real threads in 2channel, and then the various characteristics in different threads were found. The author then discussed them in three perspectives: thread on event vs. thread on theme, thread with impressions vs. thread with debate, and thread for open discussion vs. thread for regular members.

Some topics are considered for future work, such as experimental evaluation, visualization with the effect of time of day, and feedback to the technique to statistical analysis. Three-dimensional visualization such as the Natto View [19] may also be useful to provide visual interaction on a chart.

Many threads are affected by human life rhythm regarding the effect of time of day, so it is known that the number of the postings decreases from midnight until the next morning [16]. Furthermore, there are threads that have a very high correlation between their liveliness and time; Figure 9 shows such a thread, where many messages are posted at the same time every day.

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WCR: A Wearable Communication Recorder Triggered by Voice for Impromptu Communication

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Abstract - Everyday communication is not always planned in advance. There is a type of communication called "opportunistic communication" or "impromptu communication" that happens unintended in any place and in any moment. The conventional video recording equipment cannot capture this type of communication because it has to be set up in advance. This paper presents the development of a wearable communication recorder (WCR) for impromptu communication. To cope with a problematic issue of dealing with a large amount of video data in life log systems, the proposed wearable recorder records interpersonal communication selectively. It gets the recording cue from the first utterance of the user in a conversation and records the communication by video and audio as far back as some 30 seconds of the utterance. This can reduce useless recording and can record whole communication session at the same time. From the analysis of interpersonal communication, 10 seconds of backward recording is suggested to be acceptable. The performance of WCR was also examined in terms of the proper recognition of communication, which indicated over 90% of the recall rate.

Keywords: Wearable computing, Communication Research, Impromptu Communication, Nonverbal, Multimodal.

1 INTRODUCTION

Research on interpersonal communication has been actively conducted since 1950's, and its major progress was brought by the video recording technology. Observation was almost the only way for a researcher to study interpersonal communication which never happens again before the use of the video recording technology. The video recording technology allowed a researcher to investigate a piece of communication activity repetitively and to analyze it in fine time sequence by frame-by-frame observation. In other words, detailed communication analysis cannot be achieved without video-recorded communication.

It is well known that there are two types of interpersonal communication. One occurs at predetermined time and place while the other occurs opportunistically without prior appointment. Interpersonal communication that has been analyzed so far by video data falls into the former. Conventional video recording cannot capture the latter type of communication because the video recording equipment should be set up before the communication starts.

However, the video recording equipment has progressed. Wearable video recording equipment can be found recently partly owing to the wearable computing. It has been used in the life log research, for example.

We propose a wearable communication recorder to get the video data of the latter type of communication, or impromptu communication, due to the importance of the video recording of the communication when studying it. Impromptu communication can be recorded by using such a wearable video equipment. A problem is how to deal with a huge amount of recorded video when the video is always on. This is one of the major research issues in life log. Our approach is to record impromptu communication alone automatically.

The rest of the chapters are composed as follows. The related research is explained in Chapter 2. Our recorder is proposed in Chapter 3. The implementation of the recorder is described in Chapter 4. Daily informal communication is examined for the design of the recorder in Chapter 5. The initial investigation of impromptu communication is reported in Chapter 6, and the basic performance of the recorder is validated in Chapter 7. Conclusion is given in Chapter 8.

2 RELATED RESEARCH

2.1 Impromptu Communication

Impromptu communication is a type of informal communication. Informal communication is known to be important to keep and nurture human relationships and to facilitate group work. Because of this importance, there are many systems to support informal communication. VideoWindow is an early research system to support informal communication between distributed office rooms by the audio and video links [1]. Cruiser is an early research system to support informal communication between distributed desktops [2].

There are many other systems to support informal communication since then. However they are not for recording impromptu communication.

2.2 Communication Recording

Video recordings of communication have been made frequently for communication analysis.

Examples of such video use are the analysis of multi-party conversation by video recordings [3] and the analysis of body movement synchrony in psychotherapeutic counseling by video [4]. The video is recorded manually in these cases. The video recording of multi-party conversation in a meet-

ing with the automatic speaker identification has been realized recently [5]. However, all these are for communication which is scheduled in advance and which takes place at a fixed location.

There are systems to record communication in a limited area.

The Active Badge system is an early system to know the locations of the entire users. The user wears an infra-red transmitter named Active Badge. The networked sensor that is installed one or more in each room detects the Active Badge thus tells the location [6]. From the closeness of two or more badges, the system user is able to know the meeting of the people.

The Bat system is a subsequent of the Active Badge system. Ultrasound is emitted from the transmitter that the user wears and a number of receivers are installed on the ceiling, which makes high precision of locating possible [7].

Interactions between the user and the object can be recorded automatically using the infra-red markers on the objects and the infra-red receivers worn on the users in the limited area which the system is installed [8].

All these can record interactions more or less, but the markers are necessary. This means that the recording area is limited within the marker area.

Because impromptu communication occurs at any place, we cannot apply these systems to record impromptu communication.

2.3 Life Log Research

A life log system is an always-on recorder of various events, user's behavior, and operated objects. Some of them take the video logs. They can be very large data because of the always-on feature of the life log systems. Dealing with very large data is not easy. Additionally, most of the data is useless when the user would like the video of a specific event. Thus information search or retrieval from this very large data is a major topic of research. Because of this, it may not be the best to record everything when the type of information to be needed is known. Our research is different from generic life log research and is focused on the recording of interpersonal communication.

Mixture of the video and sensor information has also been researched because image processing alone is not always enough to recognize objects in the video or to understand the context. Sensor information can be the annotation to the video recordings. Interpersonal communication has not been focused on in this type of research.

3 PROPOSAL OF A WEARABLE COMMUNICATION RECORDER

We propose a wearable communication recorder (WCR) to get the video data of impromptu communication. Because impromptu communication does not happen at a fixed place, conventional video recording equipment cannot fulfill the requirement of mobility. People also do not know when impromptu communication occurs because it happens without appointment. Typical impromptu communication is a short talk when two people come across in the hallway. Accordingly, the recording equipment should record interpersonal communication without the limitation of time and place. To fulfill this requirement, wearable equipment is applied.

Recording everything like a life log system may cause a problem of dealing with a large amount of video data although it is easy to do so. Recording communication alone is an option to avoid this problem. However it is disturbing for the user to turn on and off of recording manually every time communication happens. It is desirable that the system automatically turn on and off.

One of the important issues for the recording of interpersonal communication is the detection of initiation of communication and completion of communication. For the automatic recording of communication, utterance can be thought of the good candidate of the recording cue. However, it is not so simple to start recording when detecting the user's voice and to stop the recording when detecting the end of the voice. It is known that communication usually starts before the first utterance by eye contact or salutation [9]. In accordance with this, the recorder should record nonverbal cues which occur before the verbal utterance. Detecting these nonverbal cues robustly is not very easy in itself, and it needs measuring instruments that are not easy to wear.

To cope with this issue, our recorder applies the mechanism of a driving recorder. The driving recorder is a device commonly used in the business cars such as taxis and trucks. It records the video around the car as the evidence when it detects an impact by car accident or sudden braking. Because it is not good for the evidence video to start recording from the time of the impact, the video data is always buffered about a minute. The buffered data is then saved when the impact is detected by the accelerometer sensor.

The recording of interpersonal communication is thought to be possible by the voice detection and the mechanism similar to the recording mechanism of the driving recorder. The voice detection can be the trigger of saving buffered video data that include nonverbal cues which arise before verbal utterance. For completing the recording, it is also thought to be possible by extending the recording some more time after detecting the end of the voice.

With this explained mechanism, WCR is presumably able to record the whole communication session in any time and place while reducing the useless data.

4 IMPLEMENTATION OF THE WEARABLE COMMUNICATION RECORDER

4.1 Equipment

A USB camera for video communication (Microsoft LifeCam VX-6000) is used for the video recording. It has the 1.3 million pixel CMOS sensor that gives clear image. The view angle is 71 degree. It is with automatic adjustment of white balance that responds to the brightness. It is with directional noise-canceling microphone.

The built-in directional microphone of the USB camera is used for recording communication. Another throat microphone is used for assuring the detection of the user's utterance.

Figure 1: Appearance when wearing the system.

These are connected to the small laptop PC (Fujitsu LOOX P70-XN), which records the input information.

Figure 1 shows the appearance of the user when wearing the equipment.

4.2 Software

The operating system of the PC is Windows XP Professional. The program is written in C++. OpenCV 1.0 is used for video processing. Windows Multimedia API is used for audio processing.

WCR keeps detecting audio signal from the throat microphone. The video from the USB camera and the audio from the built-in microphone of the camera are buffered for some 30 seconds. When the audio from the throat microphone becomes bigger than a certain threshold, it is recognized as the utterance of the user of the system. Then the buffered video and audio is saved to the file, which is supposed to be the recording of the nonverbal communication before the utterance. On the other hand, when the audio from the throat microphone becomes and keeps less than a certain threshold after detecting the utterance, it is recognized as the completion of the utterance. The recording stops after a certain period of time from the completion.

The video is encoded in real time and saved as MotionJPEG with the resolution of QVGA. The each audio is saved as 8 bit monaural RIFF with 22kHz sampling rate.

Figure 2: Devices used for recording daily informal communication: Omnidirectional camera (left) and a conference microphone (right).

5 INVESTIGATION OF DAILY INFORMAL COMMUNICATION

5.1 Aim

To know the appropriate buffering time in WCR, communication was investigated. Although the actual target of WCR is impromptu communication, daily informal communication was investigated because the targeted communication cannot be captured without a wearable continuous recording system such as our system and because daily informal communication is thought to be more similar to impromptu communication than other types of communication.

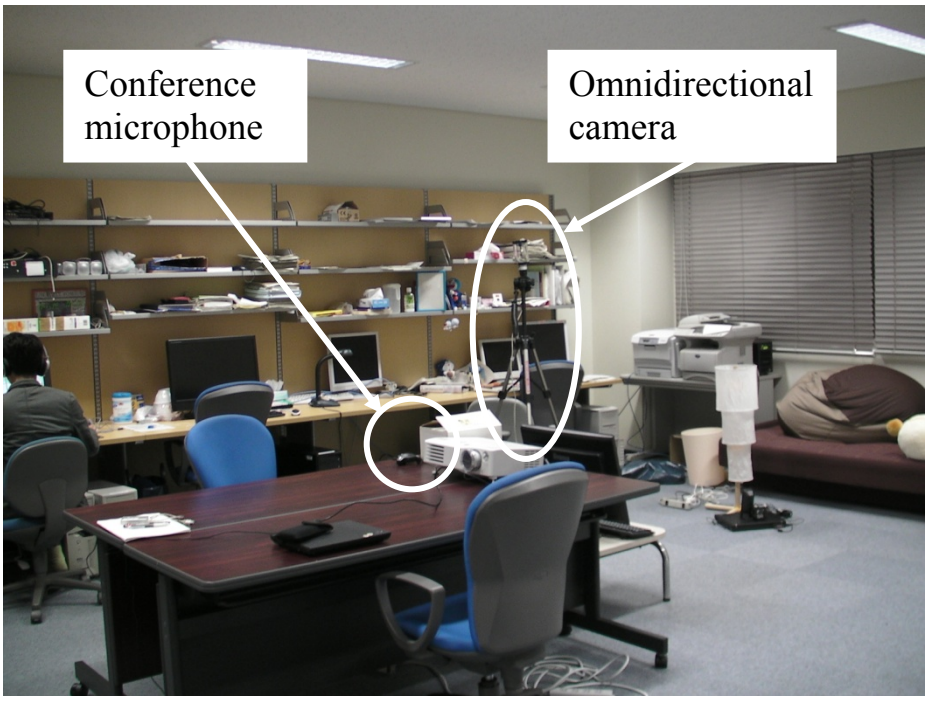

Figure 3: Recording environment of daily informal communication.

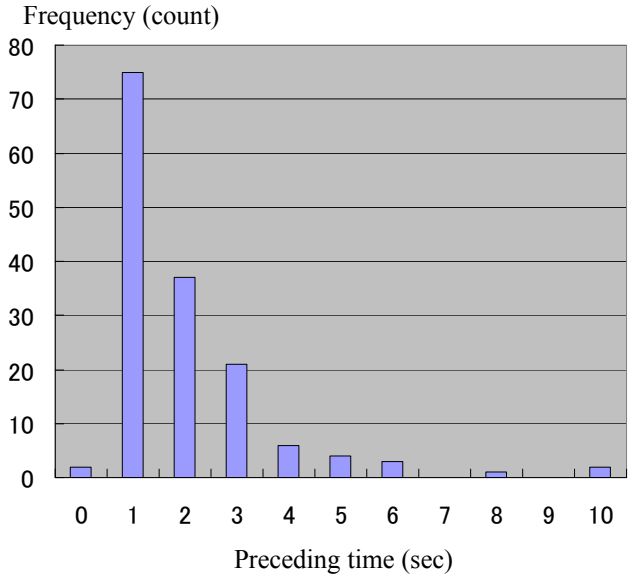

Figure 4: Preceding time of communication behavior before the first utterance.

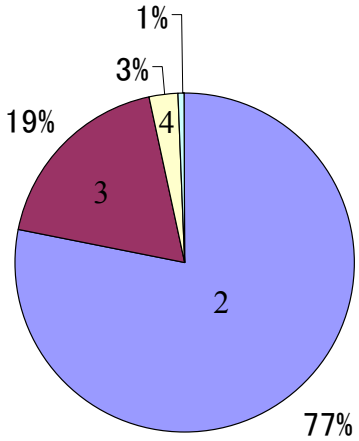

Figure 5: Number of participants in the communication.

5.2 Method

The omnidirectional camera (VSTONE VS-C42U-300-TK) and the conference microphone (BUFFALO BSKP-CU201) (Figure 2) were set up at the room which is approximately 9 m x 6 m (Figure 3). Communication in the room was recorded 27.5 hours in 5 days. The video was recorded in 2048 x 1536 (QXGA) with 6 fps. The elevation angle of the camera view is approximately 15 degree and the depression angle is approximately 60 degree. The microphone is omnidirectional with the noise reduction.

5.3 Result

For the every communication, the time of communication behavior before the first utterance was clocked. The result is shown in Figure 4. The total number of communication was 151. The average time of communication behavior before the first utterance was 2 seconds. The first utterance came less than 3 seconds from the beginning in nearly 90% of communication. The longest interval between the beginning of communication and the first utterance was 10 seconds. It

Table 1: Time between the initiation of communication and the first utterance of the user

communication ID	1	2	3	4	5	6	7	8	9
time (sec.)	1.5	0.0	4.6	3.7	3.0	4.1	2.8	0.7	2.5
communication ID	10	11	12	13	14	15	16	17	
time (sec.)	4.0	0.0	3.2	1.2	4.4	2.0	1.8	1.4	

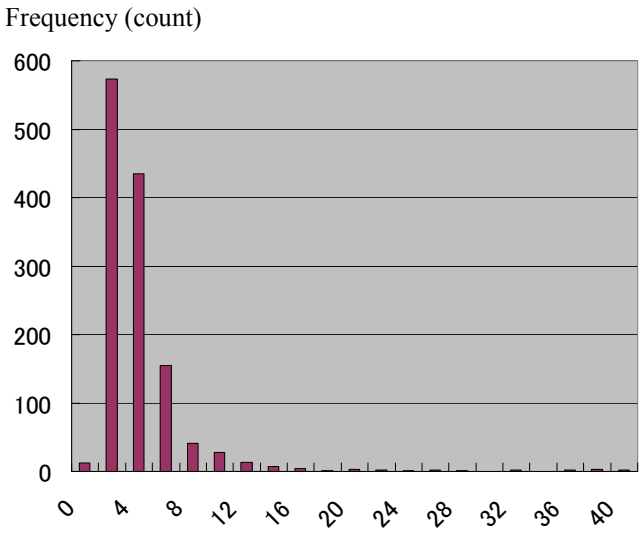

Figure 6: Intervals between the utterances.

seems to be reasonable that the buffering time of the WCR is 10 seconds.

Additionally, the number of participants in the communication is shown in Figure 5. Dyadic communication occupies over 3 out of 4 communications, and most of the rest was triadic communication.

6 INITIAL USE OF THE WEARABLE COMMUNICATION RECORDER

6.1 Aim and Method

To examine the feasibility of the system, we used it on trial. The buffering time was set 30 seconds. This means that the video and audio were recorded from 30 seconds back before the trigger of the first utterance. From the trial data, it was examined how long initiation of communication come before the first utterance of the user. The duration between the utterances was also examined to get the clue of the completion of communication.

The trial user was one male university student. He wore WCR a day from 10am to 10pm. He communicated with others as same as everyday.

6.2 Result

The total recording time was 73 minutes. The speaker and the time of utterance, initiated time of communication by observation were annotated to the video and audio data. This was done by the video annotation software named CIAO.

The communication occurred 17 times in the data. The moment the user became aware of the communication target was regarded as the initiation of communication. The time between the initiation of communication and the first utterance of the user is shown in Table 1. Because the sample number is small, its distribution should not be concluded. But it is suggested that most utterance began within 5 seconds from the initiation of communication from Table 1. All the communications were dyad. The time may become longer in the communication by more than 3 people. It is suggested that preparation of 30 seconds of buffering time is long enough and probably could be shorter, which is easy to implement.

Then intervals between utterances were examined. It is shown in Figure 6 with the scale of 2 seconds for X axis. The most frequent interval was between 2 to 4 seconds. Over 90% was within 8 seconds and over 98% was within 16 seconds. There were data over 30 seconds, but they were about different topics or talking himself. The longest interval in a sequence of conversation was 20.2 seconds. It is suggested that the recording can stop about 20 seconds after the completion of the last utterance.

Although this initial use is not enough to give the detailed data about communication, feasibility of the system was confirmed.

7 PERFORMANCE EVALUATION OF THE WEARABLE COMMUNICATION RECORDER

7.1 Aim and Method

The reliability of the automatic recording of WCR was examined in terms of the recognition of communication.

A female university student wore WCR in a room 13 hours in 2days. The room and the setup were the same with what was described in Section 5. All communication in the room was recorded by the fixed camera and the conference microphone. This recording became the reference to know the communication in the room. The recording by WCR was matched with the reference recording. An example of the fixed camera recording and WCR recording is shown in Figure 7. The reliability of WCR was evaluated this way. The buffering time was set to 10 seconds. The recording stopped automatically after 30 seconds from the last utterance.

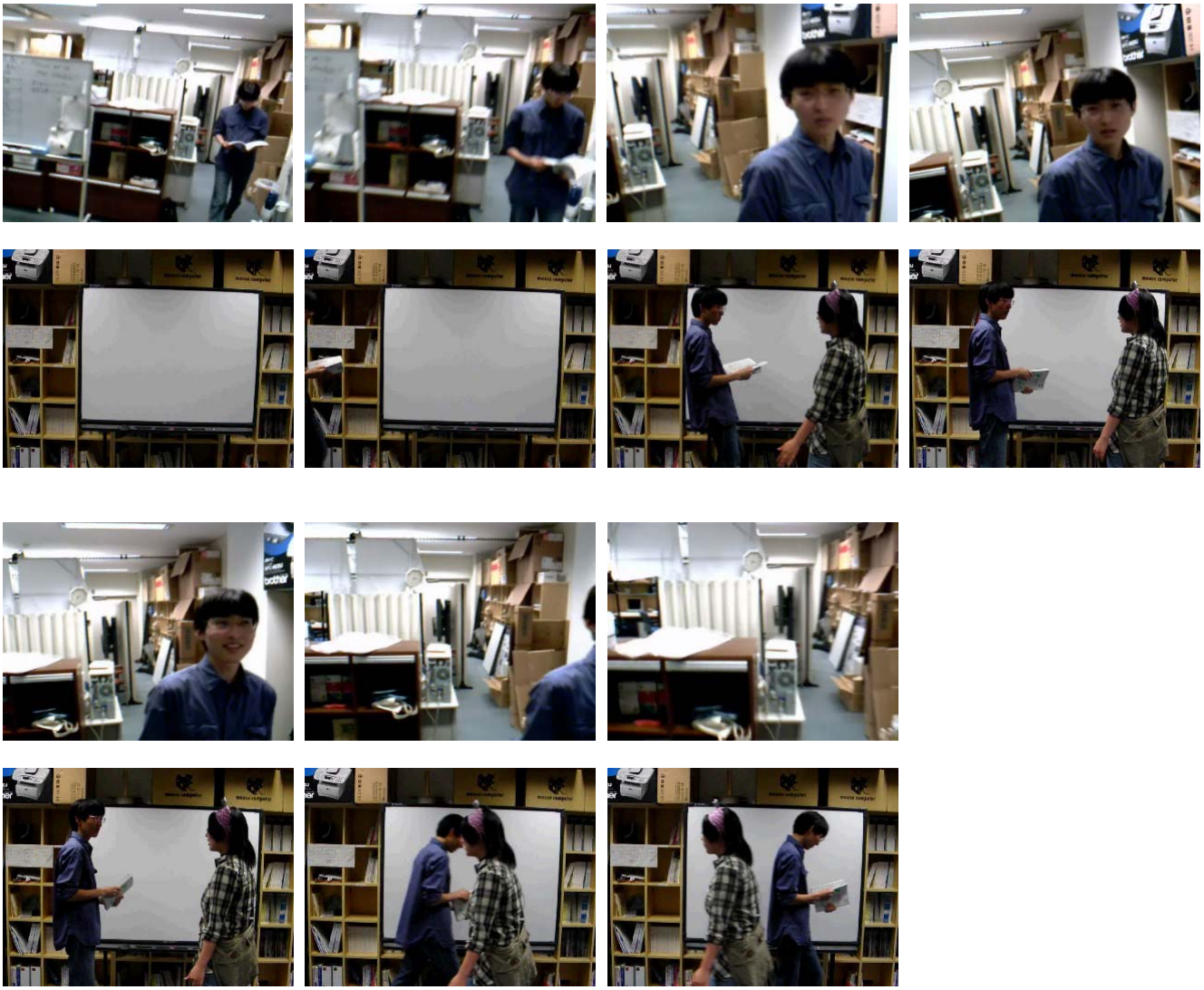

Figure 7: Example of WCR recording and the fixed camera recording (Top: WCR recording, Bottom: fixed camera recording. Time-line from left to right).

7.2 Result

The number of the communication with the user was 32. The number of the recordings by WCR was 39, which means WCR recognized these recordings as communication occurrences. Among these 39, the number of communications that were recorded properly was 30.

This shows that WCR could record 30 out of 32, i.e. 94 % of the communication events properly. The rate is known as the recall rate. One of the two communications that WCR failed to pick up was because of the too small voice of the user. The utterance volume was under the detection threshold. The other communication that WCR failed to record properly included the utterance interval over 30 seconds. WCR recognized this communication as two different communications.

WCR also sometimes mistakenly recognized the noise event as communication. The rate of the properly recorded communication among all the recordings was 30 out of 39, i.e. 77 %. The rate is known as the precision rate. WCR applies the throat microphone for the user's voice detection. The recording is controlled by this voice detection. Because the throat microphone does not pick up the environmental noise, the environmental noise hardly effect to the result. The number of people in the room was seven at a maximum. The recognition errors were due to the sound the user made such as sneezing and cough.

8 CONCLUSION

We proposed and implemented the wearable communication recorder (WCR) to get the video data of impromptu communication. Different from other life log recorder or conventional video recording equipment, WCR focuses on recording impromptu communication efficiently. The video recording has played an important role in communication analysis but has been applied to the limited communication setup. The significance of WCR is to expand its target. Al-

though current prototype has points to be improved such as its appearance or the functions as a wearable computer, it is expected to advance the analysis of impromptu communication.

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Remote Kenken: An Exertainment Support System using Hopping

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Abstract - Games that use sensors and the physical body have become widespread. However, existing games have a problem that the playing position is fixed. In this study, we propose a system, "remote kenken," by which one can really move their body, and can exercise. We have overcome the limitation on body movement by arranging sensors in the same way as "kenken". In addition, a moderate exercise load was realized by repeating the game five times. We performed a comparison between the proposed system and a kenken game, in which a subject jumped over the same place. The proposed system was evaluated highly in the sense of reality.

Keywords: pressure sensor, exercise, game, entertainment, kenken

1 INTRODUCTION

TV games are one of the forms of entertainments that can easily be enjoyed within the family. Most of them mainly use a controller, but there are few sensor operating systems. There are some games for exercise and entertainment, which we call "exertainment". Physical exercise is recommended for senior citizens [1]. It is expected to become one of the future exercise methods. However, one's position is fixed in these games, and there is the problem that movement is limited. In other words, it is only a simulation of exercise.

We have proposed an exertainment support system, "remote kenken," which overcomes this limitation on movement. We simulate kenken by the proposed system using pressure sensors[1].

2 EXISTING SYSTEMS

Wiifit [2] is popular software developed for the game console "Wii," released by Nintendo. Wiifit is a game aimed at doing exercise within the family. It is attached to a balance Wii board as a peripheral device. A balance Wii board is shown in Figure 1. Plural sensors are put on this balance Wii board and can sense careful movement such as weight movement.

Family trainer [3] is software developed for "Wii," and is designed for exercise. A mat controller (shown in Figure 2) is attached as a peripheral device. It is simple structure. This system does not use a special sensor like a balance Wii board. "Kenken step" is included to perform hopping on the spot. Like Wiifit, Family trainer is limited to exercise on the mat controller.

[1] The work reported in the paper was partially supported by Japan Society for the Promotion of Science (JSPS), Grant-in-Aid for Scientific Research (B) 20300047, 2008.

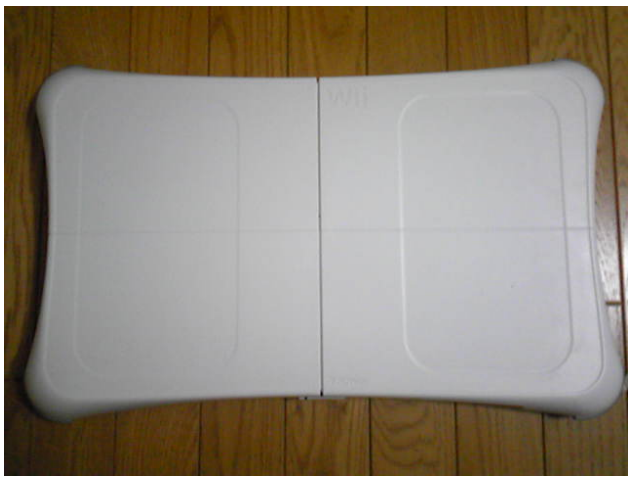

Figure 1: Balance Wii board.

Figure 2: Mat controller.

The differences between remote kenken and kenken step are shown in Table 1.

Table 1: Differences between remote kenken and kenken step

	Remote kenken	Kenken step
Moves	Jumps in the same way as in reality.	Jumps only on the spot.
Score	Step precisely on pressure sensors. + Playing time.	There is no indication of the score. Time should be fast. The player must jump as displayed on a screen.

3 REMOTE KENKEN

3.1 Design policy

This system is performed in the same way as conventional kenken. We raise the sense of reality and aim at exercise. Therefore we use pressure sensors. We get the analog value of the position of a foot by pressure sensors. The system aims at exercise and entertainment.

3.2 Development environment

The system was developed by Visual C#. The program is about 1,800 lines of a client application, and about 600 lines in a server application. The circuit of the pressure sensor uses a PIC. 16F873-20/SP was used for processing data from a pressure sensor. The program is about 60 lines. The pressure sensor uses FlexiForce [4].

3.3 System constitution

This system consists of a PC (server and client) and pressure sensors (max 8). The circuit of the pressure sensor is shown in Figure 3, and a pressure sensor with acrylic board in Figure 4. Eight pressure sensors in a board are shown in Figure 5. The client manages the score. Two players are enabled by using a server application. The total constitution of this system is shown in Figure 6.

3.4 Calculation method of the score

As for the score, it is calculated by data from sensors. When a player steps on the center of the pressure sensor, two points are awarded. When a player steps any place other than the center of the pressure sensor, one point is awarded.

The normal mode is 32 points by stepping forward on the sensors. Furthermore, the score by playing time is expressed at 8 points. Total score is 40 points in maximum (8 points + 32 points). The five round trips mode is 160 points by stepping forward on the sensors. A score by playing time is expressed at 40 points out of a total of 200 points, which is a perfect score. The ratio of the score is 4:1. We put weight on

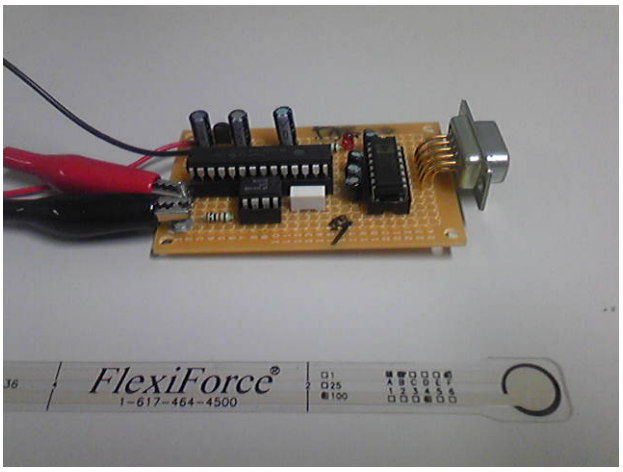

Figure 3: The circuit of the pressure sensor.

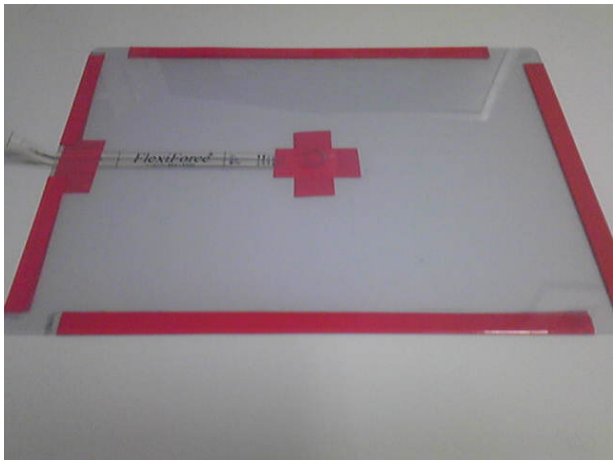

Figure 4: A sensor with acrylic board.

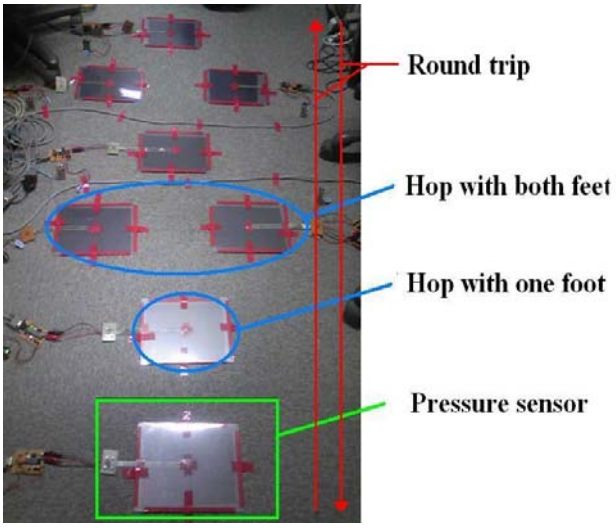

Figure 5: The pressure sensors on the floor.

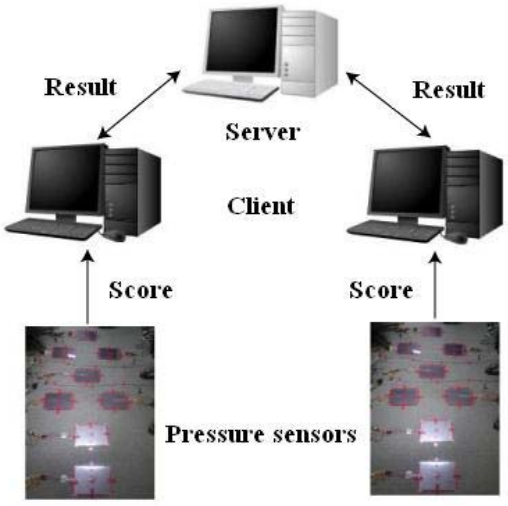

Figure 6: Total constitution of the system.

the accuracy of steps.

Remote kenken usually performs this with eight pressure sensors connected.

The score of the player becomes 0 when a player didn't step on any pressure sensors. It is imperative that the player step on the first and the last sensor, otherwise the game cannot proceed.

As an example of the normal mode, a player got 20 points with the pressure sensor. When the playing time was 10 seconds, 2 points were added. The total score becomes 22 points in this.

3.5 Sound effects at the time of the play

Seven kinds of sound effects are used in the system. This is because a player can grasp present status even without watching the screen. When a player gets a point, we use two kinds of sound effects, so the player comes to understand whether he placed his foot on the center or not.

4 EXPERIMENTS AND RESULTS

4.1 Experiment summary

We carried out the experiment into whether it was useful as exercise. Subjects measured their pulse before and after playing the game. We assumed two players in the game simultaneously and compared the score of the game with partner.

4.2 Experiment environment

Subjects were eight persons at Wakayama University. A scene of the experiment is shown in Figure 7.

A subject pushes the standby button after having been connected to the server. The game starts. Subjects performed five round trips. Subjects step on the pressure sensor. Subjects repeated "kenken" five times from the starting point.

Figure 7: A scene of the experiment.

4.3 Results of application experiment

The results of the experiment are shown below.

The scores and pulse rates of the subjects are shown in Table 2. The average time of playing is 42.5 seconds. (Reference: The average of "kenken step" was 33.9 seconds). The average score was 129.6 / 200. The pulse rate rose 20.6 per one minute after the game. The average of "exercise strength" became 17.6%. "Exercise strength" is shown below.

Exercise strength (%) = (The pulse rate while exercising - The pulse rate at the time of rest) / (The best pulse rate - The pulse rate at the time of rest) × 100

Table 2: The score and pulse rates of the subjects

Playing time (seconds)	Score	Pulse rate per minute	
		before	after
33.2	128	99	115
38.1	131	82	108
60.7	134	65	82
42.4	112	86	108
44.5	122	80	95
37.8	127	87	116
38.4	127	87	112
44.9	156	77	92

The results of the questionnaire are shown in Table 3 (1: very poor, 3: neither good nor poor 5: very good).

The description part of the questionnaire is as follows.

(1) Is the score reasonable?

・The ratio of weight for playing time and score from sensor is reasonable.

・If I can't step on the sensor, I think zero score is reasonable.

・The parameters of playing time are reasonable.

(2) Concerning others opinion and impression.

・I enjoyed it. There should be several variations about the kenken.

・I was worried about the delay of the sound.

・It is hard to understand the lap now.

・There should be comments from the system depending on your score. By getting a point, it should say "do your best!"

4.4 Consideration of the experiment

The results of the questionnaire on "remote kenken" and "kenken step" shown in Table 4. We shall next discuss the results of experiments based on Tables 3 and 4.

Table 3: Questionnaire results of experiments

Questions	Evaluation average
As for playing time, was it reasonable?	4.5
Were you able to understand the rules?	4.9
Were you able to step well?	3.4
Did you understand whether you were able to place your foot by sound?	4.4
Was it like real hopping (kenken)?	4.5
Do you feel it was "exercise"?	4.4
Were you motivated more by a result of victory or defeat?	4.5
Do you think the setting of the score is reasonable?	4.1
Were you interested	4.6

Table 4: Comparison with kenken step

Questions	Remote kenken	Kenken step
As for playing time, was it reasonable?	4.5	3.9
Were you able to understand the rules?	4.9	3.7
Were you able to step well?	3.4	2
Was it like real hopping (kenken)?	4.5	2.1
Do you feel it was "exercise"?	4.4	3.6
Were you interested?	4.6	3.9

(1) Concerning playing time and the understanding of the rules.

Average playing time for remote kenken took 42.5 seconds. The evaluation was 4.5. The length of playing time can be said to be reasonable. It took 33.9 seconds in average playing time for kenken step. Because the average of evaluation was 3.9, we thought that playing time of around 40 seconds is reasonable.

The average evaluation was 4.9 for understanding of the rules. That evaluation is higher than kenken step. Five round trips was easy to understand.

(2) Concerning sensors and sound effects.

The evaluation of "Did you understand whether you were able to place your foot by sound?" was high (4.4 / 5.0). But, pressure sensor sometimes sent incorrect data, and the players misunderstood their situation. A variety of sounds related to the lap is needed.

(3) On hopping sense and exercise.

The evaluation of the sense of reality was high (4.5 / 5.0).The evaluation of sense of reality was higher than kenken step (2.1 / 5.0).

The evaluation of "exercise" became 4.4. There were many people who felt it was "exercise". As for the pulse rate, an average of 20.6 per one minute increased. Remote kenken seems to be exercise.

(4) The score and victory or defeat indication.

Victory or defeat indication added motivation to the game. It was highly evaluated (4.5 / 5.0).

There were answers such as "the parameters of playing time were reasonable" for a description questionnaire. It was popular to get numerous points from pressure sensors.

(5) Concerning fun.

Evaluation of whether it was "interesting" was 4.6 which were higher than that of kenken step. There were opinions of "I enjoyed it. There should be several variations of kenken". By this experiment, we fixed the position of the pressure sensor. The sense of reality was kept in the system. If sound effects are added, the evaluation might go up.

5 CONCLUSION

In this paper, we proposed an exertainment support system named "remote kenken".

Remote kenken is a system in which players can jump around in the same way as real hopping by stepping on pressure sensors on the floor. We experimented 8 times (8 people) using the system.

The results of the application experiment are as follows.

(1) The sense of hopping seems to be highly evaluated in comparison with "kenken step," which simulates hopping.
(2) Around 40 seconds were judged to be reasonable in playing time. Because "kenken step" is thought to be reasonable at around 40 seconds, we thought such a small amount of time was reasonable for "kenken".
(3) After each experiment, pulse rates rose, so its value as exercise was accepted.
(4) Displaying victory or defeat by the score was evaluated as fun.

Sense of reality was high in this system. In the future, we will improve the system for exertainment and perform experiments between remote players.

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Proposal and Practice of Exchange Learning through Quiz Creation and Peer Review

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Abstract - In this paper, we propose a method of learning that includes interactively reviewing and taking quizzes created by learners of different classes. First, we describe a brief outline of the CollabTest system that we have developed and evaluated. Next, we describe the proposed method of learning exchange between classes, including the details of quiz creation, mutual review, and taking quizzes using the CollabTest system. We discuss the expected effects of the proposed method on learners. In addition, we implement the CollabTest system so that learners can study using the proposed learning method. A trial study was conducted in the semester beginning in April 2009, and as a result of these experiments, we determined the requirements and effectiveness of learning through collaboratively creating and taking quizzes created by learners in different classes.

Keywords: Exchange Learning, Problem Posing, Quiz Creation, Peer Review, Online Test.

1 INTRODUCTION

We studied a web-based learning system named "CollabTest" that enables learners to acquire knowledge by creating quizzes and sharing them with peers [1, 2]. The learning procedure when using CollabTest is as follows.

I. Learners in a class create multiple-choice quizzes with explanations of the content.
II. They review the quizzes collaboratively in a group.
III. They submit the quizzes to their teacher.
IV. Learners take student- or teacher-created quizzes to confirm their comprehension levels.

We have developed the CollabTest system to enable students to perform the above-mentioned tasks on the Web. Moreover, we have continually used this system since 2002 at schools of various levels, including a university, high school, elementary school, and vocational training school. In 2003, we developed a point system in which students can earn points by performing tasks such as submitting a quiz or posting a comment. Furthermore, we allowed learners to compete among individuals or among groups via a point-ranking function. We have used this system in a total of 104 classes over 6 years. As a result, 5083 learners have used the system, 14456 quizzes have been created by learners, and 40652 comments have been posted by learners. These results show that CollabTest can help resolve issues such as the lack of e-Learning materials and the lack of student-student and teacher-student interactions.

Exchange learning, which involves exchanging information between regional schools via the Internet and a video conference system, has been actively studied at junior high and elementary schools in recent years [3-9]. However, practical studies of exchange learning through quiz creation and peer review have not yet been reported. In addition, practical studies of question-posing and peer-assessment via web-based systems that facilitate learning between classes have not been reported in related studies on learning systems [10-13]. Exchange learning using a system such as CollabTest requires neither preparation of learning materials nor scheduling, as is the case when using a video conference system, as the environment of CollabTest is asynchronous. Thus, we can expect that exchange learning between classes can be conducted more easily than other methods of exchange learning. Moreover, we expect to observe considerable effects due to communicating between classes in addition to those of CollabTest [1, 2].

For these reasons, CollabTest is thought to be an effective system for exchange learning; however, we have used it only in a closed environment, for example, at a particular university. We have considered expanding the usage environment of CollabTest to include an open environment such as the World Wide Web where various learners could participate. With this in mind we apply CollabTest to exchange learning in order to expand its versatility and create new value. In this paper, we consider learning methods for exchange learning using CollabTest and their effects. We then clarify the functionality that is necessary for exchange learning and report the results of using one learning methods that we considered[1].

2 COLLABTEST

We have developed CollabTest as a Web application using JSP (Java Server Pages) and Java servlets. The system provides a group management function that can divide students into groups, a quiz entry function that is used by not only teachers but also learners, and an online test function that can deliver tests based on the quizzes created by the students and teachers [1]. A noteworthy feature of this system is the collaborative environment for quiz

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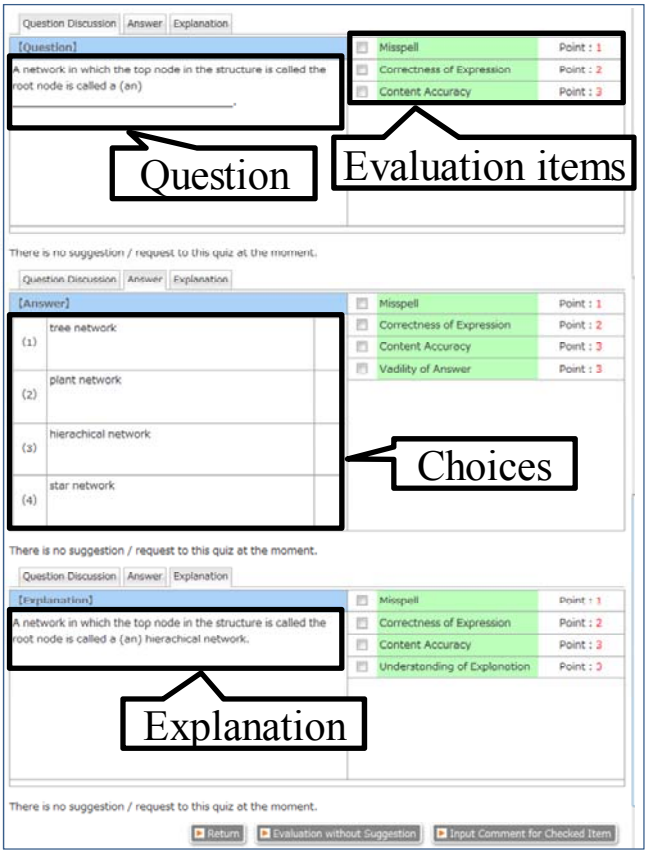

Figure 1: Review page for a quiz.

creation [14]. The environment provides a peer-review function that shares a learner's quiz with their group and allows group members to interactively assess the quiz. As shown in Figure 1, learners can assess quizzes created by group members according to review items displayed in the system. In addition to these functions, it provides a point system in which learners accumulate points through the use of the system, as well as a point-ranking function that allows competition between individual learners or groups [2].

3 EXCHANGE LEARNING USING COLLABTEST

3.1 CollabTest and Exchange Learning

Many case studies on exchange learning have been reported in recent years. Although the learning methods and contents of learning reported in these case studies were different, common points were reported regarding the information exchanged between classes. Based on these common points, exchange learning between classes is defined here as a learning method that involves sharing the knowledge of learners in different classes and exchanging comments or feedback on their respective knowledge. Since the classes are different, the learners gain access to different teachers, schools, cultures, and grade levels, as well as the different specialties, knowledge, and experiences of their peers. In CollabTest, sharing knowledge between classes occurs when taking quizzes and the exchange of information occurs when posting of comments on quizzes. In the

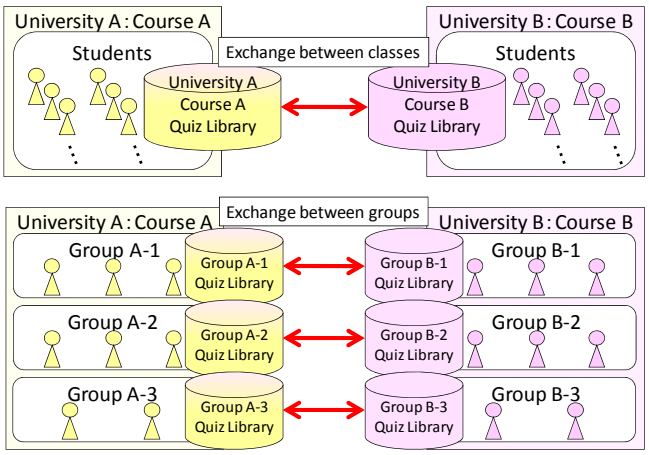

Figure 2: Methods for combining learners.

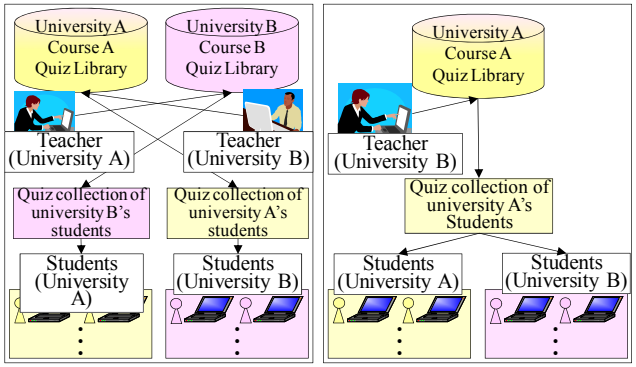

Figure 3: Method for creating a test.

following, learning is classified into two steps: evaluating quizzes interactively and taking the quizzes. Then, an example of an implementation of this learning method and the expected effects of the exchange using this system are described.

3.2 Exchange Method

(1) Learning exchange through Peer review

In one peer-review activity of CollabTest, a learner shares his/her quizzes with members of the same group. If the learners share quizzes with learners in a different class, they can share not only knowledge but also exchange comments on their quizzes.

As shown in Figure 2, we considered two methods of learning exchange through the peer review. The first method is an exchange between classes. The second method is an exchange between groups. In the case of reviewing interactively with other classes, learners can browse all quizzes created in the other class. As a result, a learner who is interested in the quizzes created in the other class has considerable opportunities for learning exchange. However, there is a possibility that an unmotivated learner who is not interested in the quizzes will not participate fully, especially if there are a large number of quizzes and the learner does not understand what should be done.

In the case of reviewing interactively between groups, a learner who is not interested in the quizzes can likely begin to learn more easily since the number of quizzes that they can browse is limited, thus making the material more

Table 1: Examples of differing class attributes.

No	Difference of class attribute (-: same, ✓: different)					Example
	Learners	Teacher	School	Grade or amount of knowledge	Specialty	
1	✓	-	-	-	-	● Exchange between classes that have the same course name and the same teacher at the same university.
2	✓	✓	-	-	-	● Exchange between classes that have the same course name and different teachers at the same university.
3	✓	✓	✓	-	-	● Exchange between classes at different universities that have the same or similar course names.
4	✓	✓	-	✓	-	● Exchange between fifth graders and sixth graders.
5	✓	✓	✓	✓	-	● Exchange between elementary school students and junior high school students. ● Exchange between junior high school students and high school students. ● Exchange between high school students and undergraduate students. ● Exchange between undergraduate students and graduate students.
6	✓	✓	- or ✓	✓	✓	● Exchange between economics class for students specializing in economics and economics class for students specializing in other fields.

accessible. On the other hand, a motivated learner will likely feel that the material is not sufficiently challenging. For these reasons, it is necessary to develop a function that enables learners to choose whether to learn between classes or groups depending on the number of learners, their motivation, and the particular circumstances of the classes.

(2) Exchange through Taking Online Tests

In online tests, learners take quizzes created by peers in the same class, quizzes created by past classes, and quizzes created by the teacher. Learners can post comments such as their questions about and impression of each quiz using the online test function of our system. If the learner takes an online quiz created a different class, the learners can mutually share knowledge and have the opportunity to post comments on the quiz after its completion.

As shown in Figure 3, we considered two methods of using quizzes created by learners in different classes. In the first method (left of Figure 3), the teacher composes the test by selecting questions from quizzes created by learners. In the second method (right of Figure 3), the teacher composes a test using quizzes created in his/her class and shares it with the other class. In the first method, the teacher can use the quizzes that he/she wants to use, although this requires a commitment of time from the teacher. In the second method, the teacher can administer the test without using a large amount of time for test preparation. However, a teacher should be able to confirm and edit the test contents before administering it to the learners as there is the possibility of including quizzes at an inappropriate level or containing inappropriate content for the class.

3.3 Expected Effects

In exchange learning using CollabTest, quizzes created by learners on the course content are used as learning materials. For this reason, different classes with similar course content can learn in collaboration. Moreover, a video conference system has been used to exchange comments in the related study on exchange learning. However, for this system, learners use a BBS (Bulletin Board System) in order to exchange comments, thereby it is not necessary to adjust the course schedules of the classes and the learning exchange can be implemented easily.

The expected effects of learning interactively between classes using CollabTest will be affected by the attributes of the classes participating in the learning exchange. These attributes include the teacher, school, and grade level, as well as the specialties, knowledge, and experiences of the learners. Table 1 shows an example of differing class attributes. The common effects of using CollabTest are expected to be as follows.

- The learners will participate in a class more actively as a result of their awareness of learners in the other class.
- The motivation for the class will improve as a result of taking quizzes created by the other class and receiving comments from learners of the other class.
- Communication skill will improve as a result of exchanging information with learners with whom they are not acquainted.

As class attributes become increasingly different, these effects are expected to become larger. Moreover, we expect that the more comments the learners exchange, the larger these effects will become. We expect the following effects when there is a difference in the grade level or amount of knowledge between classes participating in the exchange learning (Table 1, No. 4–6).

- The learners in the lower grades will be able to receive more advanced and specialized comments and suggestions.
- The learners in the higher grades or with the higher amount of knowledge will be able to improve their explanatory and descriptive skills since they must post

easy-to-understand comments for learners with incomplete understanding of the learning contents.

4 FUNCTION ENHANCEMENT

It was necessary to develop new functions to enable mutual learning between classes using CollabTest. We considered the following to be necessary functions.

- Registering courses to initiate the exchange learning.
- Reviewing quizzes interactively between classes.
- Delivering quizzes interactively between classes.

For this study, we developed the first two functions list above.

4.1 Administrative Functions for Exchange Learning

The administrative functions for the exchange learning system are provided by an administrator or teacher mode. Figure 4 shows the user interface of the function to register courses. An administrator or teacher can access the function after logging on and accessing a course page. This page displays a list of the courses that start in the same semester as the accessed course. The list displays categories describing the course content and course information such as the course name and the teacher's name. The category items correspond to the scope and learning units of quizzes. Learners consult this list when they create a quiz [2]. In CollabTest, learners must select a category item registered by their teacher when they create a quiz. Consulting this list provides the administrator or teacher with an outline of each course.

When the teacher or administrator clicks the registration button displayed next to the course information, he/she can access the initializing page where he/she can set up the start and end dates of the exchange learning. Figure 5 shows the user interface of the initializing page for exchange learning. On this page, after the teacher or administrator sets up the start and end date of the learning, he/she selects the category items that can be accessed mutually during peer review between classes from the above-mentioned category list. Learners learn collaboratively through the peer-review system using the quizzes registered in the selected category items.

4.2 Peer-review Function for Exchange Learning

We developed a function, referred to as the "interspace management function", in order to bring together learners in different classes. We developed the interspace as a space to assess quizzes between groups in different classes. Figure 6 shows the interspace management function provided in administrator or teacher mode. The left side of Figure 6 displays groups that are not assigned to the interspace among the groups that the teacher registered in the course. The right side of Figure 6 displays the groups that are being assigned to each interspace. We can assign more than one group to an interspace. Each teacher assigns groups from his/her course to any of the interspaces. If the teacher

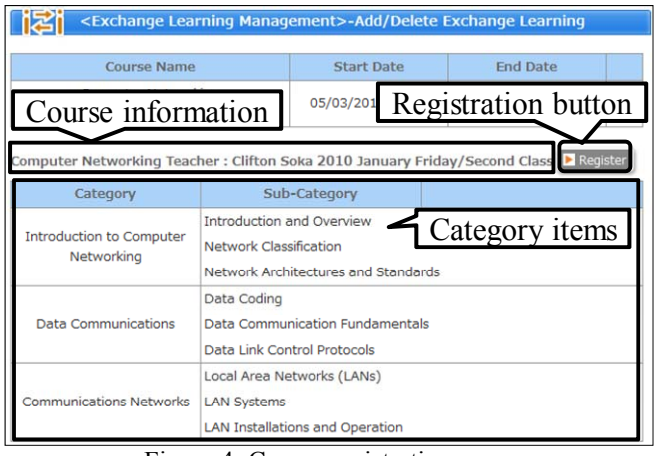

Figure 4: Course registration page.

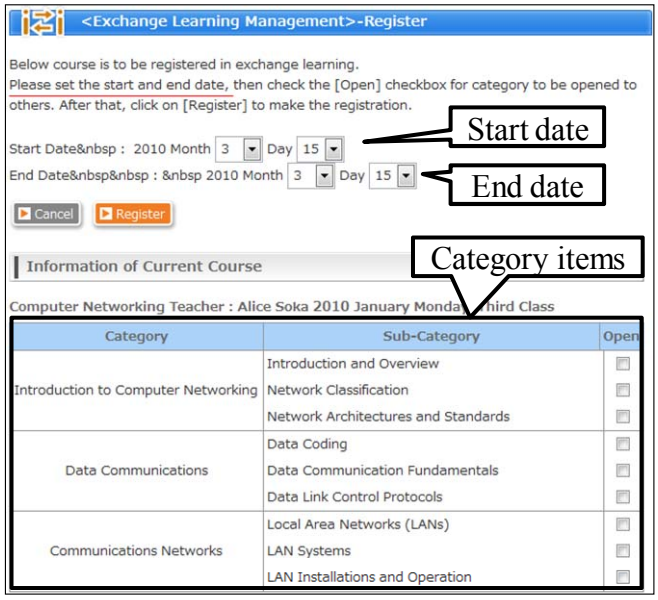

Figure 5: Initializing page for the exchange learning.

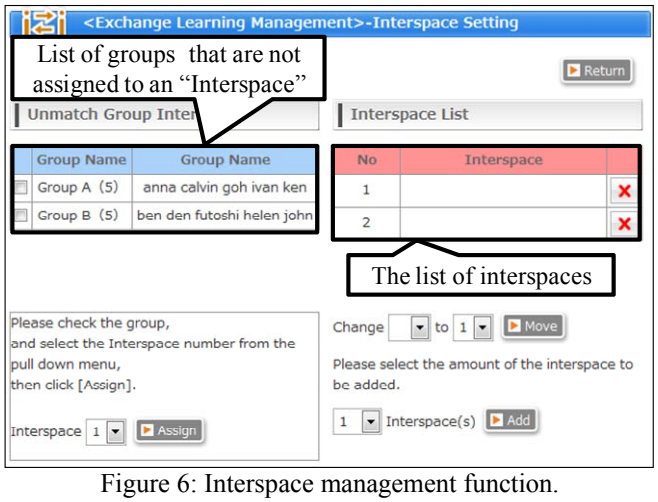

Figure 6: Interspace management function.

assigns all groups to same interspace, the learners can learn between classes as shown in Figure 2. When the teacher assigns each group to separate interspaces, the learners can access quizzes created by members of the group assigned to the same interspace and post comments on the quizzes. Figure 7 shows a function for displaying the list of quizzes

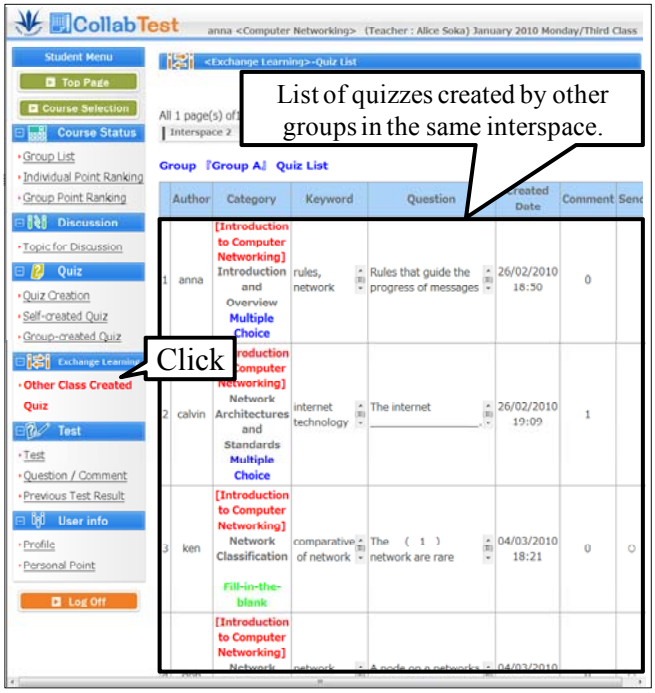

Figure 7: Function for displaying quizzes created by other class.

created by other groups assigned to the same interspace.

5 EXPERIMENTS

5.1 Overview of Experiments

We conducted two experiments in the beginning in April 2009 in order to investigate the effects of exchange learning between classes using CollabTest. Experiment 1 was conducted for two class of the same course, Programming Practice 1, which was taught by two different teachers at Soka University. In addition, Experiment 2 was conducted for two similar courses, Introduction to Computer Networks, which were taught by two different teachers at Soka University and Aichi Prefectural University. Table 2 shows an overview of these courses.

Programming Practice 1 (referred to as Prog. 1 and Prog. 2) is a beginners' class for the C programming language, and Prog. 1 and Prog. 2 (see Table 2) used the same textbook. Experiment 1 corresponds to No. 2 shown in Table 1. Introduction of Computer Networks (referred to as Network 1 and Network 2) is a course on topics such as the history of the Internet, OSI reference models, and TCP/IP. In addition, Network 1 and Network 2 (see Table 2) used the same textbook. Experiment 2 corresponds to No. 3 shown in Table 1. All teachers taught class for 90 minutes once a week.

In the first half of the semester, each teacher used CollabTest only in their class as it has been used in the past. Then, CollabTest was used for exchange learning between classes in the second half of the semester. In Experiment 1, there were two opportunities for exchange through peer review and taking quizzes, as described in Section 3.2. In the exchange through peer review, we assigned all groups to

Table 2: Course overviews.

No	Course ID	University	The number of Students	Experimental Period
1	Prog. 1	Soka University	46	2 months
	Prog. 2	Soka University	49	
2	Network 1	Soka University	102	2 weeks
	Network 2	Aichi Prefectural University	9	

Table 3: Results of exchange through peer review.

Course ID	Quizzes (*1)	Comments	Students-1 (*2)	Students-2 (*3)
Porg. 1	49	7	3	21
Prog. 2	61	33	2	4

*1: Number of shared quizzes
*2: Number of students that posted comments
*3: Number of students that received comments

Table 4: Results of exchange through taking online tests.

Course ID	Quizzes (*1)	Students-3 (*2)	Frequency (*3)		Comments
			Average	SD	
Prog-1	12	27 (58.7%)	1.4	1.4	0
Prog-2	9	25 (51.0%)	1.6	2.0	0
Network-1	7	61 (59.8%)	1.4	1.3	4
Network-2	10	5 (55.6%)	1.2	1.2	0

*1: Number of quizzes included in the online test
*2: Number of students that took the test
*3: Frequency at which students took the online test

one interspace, thereby all learners were able to access all quizzes created by the two classes. In the Experiment 2, we conducted the exchange only through taking online tests since the experimental period was short and there was a large difference in the number of students in each class.

5.2 Result of System Usage

Table 3 shows the results of exchange through peer review. Students taking Prog. 1 created 49 quizzes that were shared with students taking Prog. 2, and 61 quizzes were created by students taking Prog. 2, which were shared with students in Prog. 1. However, there were only two or three students who posted comments about quizzes created by students of the other class. Moreover, 4 out of 7 comments posted in Prog. 1 and 26 out of 33 comments posted in Prog. 2 were posted after the last class.

Table 4 shows the result for learning between classes through taking an online test. From this result we confirmed that more than half the students in each course had taken the quizzes created by learners in the other class. On the other hand, in Network 1, only four comments were posted after taking the online tests. In the other classes, there were no

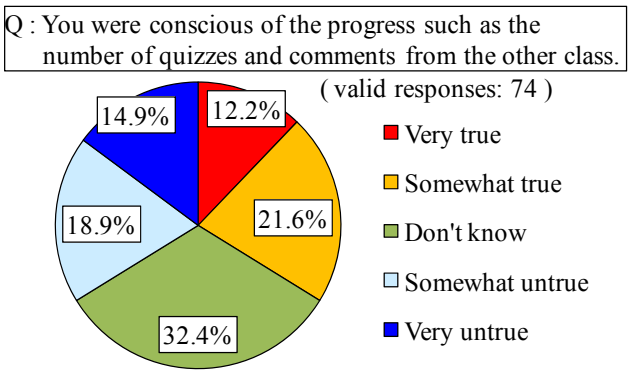

Figure 8: Results of questionnaire 1 (Experiment 1).

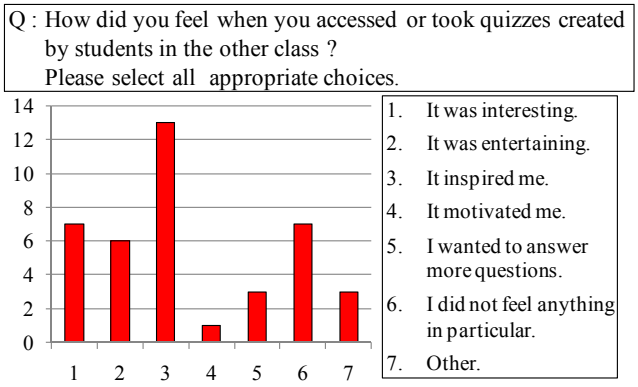

Figure 9: Results of questionnaire 2 (Experiment 1).

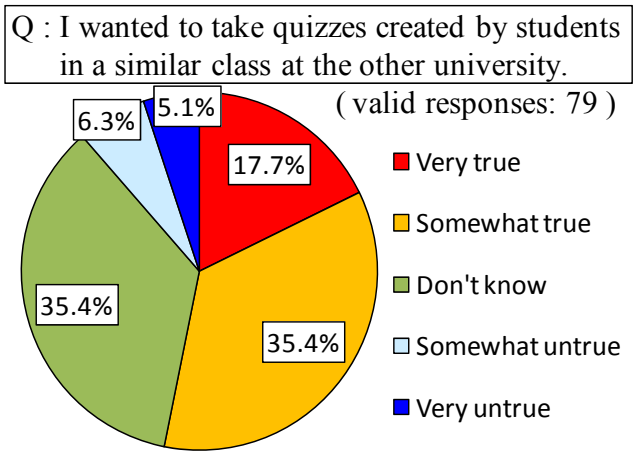

Figure 10: Results of questionnaire 3 (Experiment 1).

comments. These results show that the learners shared only their knowledge not their opinions in these experiments. This result may be due to not having sufficient time to take and assess the quizzes created by the other class during class time.

5.3 Questionnaire

(1) Experiment 1

Figures 8-10 show the results of a questionnaire given to students of Prog. 1 and Prog. 2. As shown in Figure 8, only 34% of students responded that they had been conscious of the progress of the exchange, such as the number of quizzes created and comments posted by other class. In Experiment

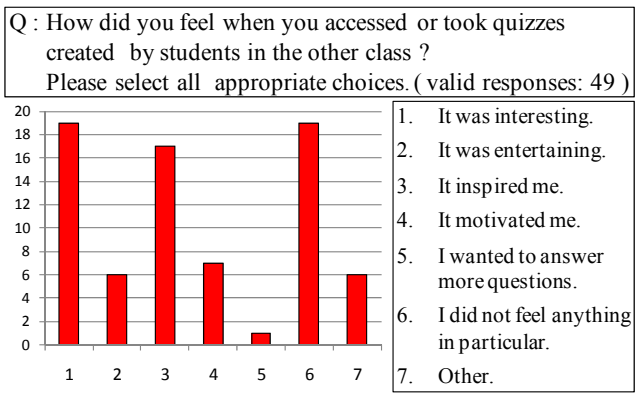

Figure 11: Questionnaire result-4 (Experiment-2).

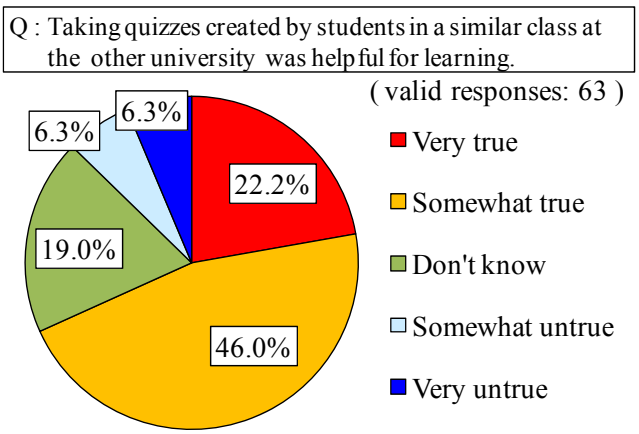

Figure 12: Results of questionnaire 5 (Experiment 2).

1, there was little opportunity to be conscious of learners in the other class since the few opinions were exchanged between the classes. It is possible that the results shown in Figure 8 are attributable to this. Figure 9 shows the results for a questionnaire given to students who had accessed or taken the quizzes created by students in the other class. As a result, 46.4% of students responded that they had been inspired by accessing or taking the quizzes. In the results of the questionnaire shown in Figure 10, more than half of the students responded that they wanted to take quizzes created by students in a similar class at another university. From these results, we confirmed the requirements for learning through mutually taking quizzes that were shared between universities for students in a related class.

(2) Experiment 2

Figures 11-12 show the results of questionnaires given to students who took Network 1 and Network 2. The questionnaire in Figure 11 was given to students who had accessed or taken the quizzes created by students in the other class. Many students responded that they had been inspired by accessing or taking the quizzes. On the other hand, there were also many students who had responded that they had not felt anything in particular when they had accessed or took the quizzes. In the result of questionnaire shown in Figure 12, 65.5% of students responded that taking the quizzes had been helpful for learning. From these results, we confirmed the effectiveness of learning through mutually taking the quizzes created by students taking similar classes at different universities.

6 CONCLUSIONS

In this study, we proposed a method of learning through mutually assessing and taking quizzes created by learners in different classes. Moreover, we defined exchange learning between classes as follows.

- Learning through sharing knowledge with learners in a different class.
- Learning through mutually exchanging opinions about their knowledge.

Furthermore, we considered a method of exchange that included peer review and a method of exchange that included taking online tests. In addition, we evaluated the effects of these methods.

In experiments conducted at two universities, more than half of the students took quizzes created by students in the other class, and knowledge was shared between classes. In the results of questionnaires, we confirmed the requirements and effectiveness of learning through mutually taking quizzes created by learners in different classes, although only 34% of students responded that they had been conscious of the progress of other class. However, there were only two or three students who exchanged comments between classes. Unless students post comments actively during peer review or after taking online test, they will not be able to achieve the expected effects described in 3.3.

Therefore, in the future, a comprehensive evaluation of the experimentation environment and manner of operation will be needed to ensure the active exchange of views between classes. For example, we will clarify the purpose or intention of the exchange learning in each class, and we will provide time to post comments and take the quizzes created by the other class during class time. If we can make them actively exchange comments between classes, we are going to evaluate how much the system can achieve the effects.

In addition, we will verify the utility of proposed methods by repeating the experiment on various cases in the future. We currently plan to conduct exchange learning between a university in Japan and a university in the United States as well as between classes with attributes other than No. 2 and No. 3 shown in Table 1.

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