Tangible Tabletop Interface that Supports Cooperative Learning in Face-to-face Environment

Koichiro Watanabe[a], Tatsushi Takeuchi[a], Tomoo Inoue[b], Ken-ichi Okada[a]
[a]*Graduate School of Science and Technology, Keio University, Japan*
[b]*Graduate School of Library, Information and Media Studies, University of Tsukuba, Japan*
watanabe@mos.ics.keio.ac.jp

Abstract: In this paper, we propose a tangible tabletop interface that can identify individual users using digital and physical objects. In environments in which multiple users are participating, the system can provide user-adaptive information regarding both digital and physical objects, and can record and utilize the operation history for individual users. Using this system, users can perform cooperative learning and share their ideas with each other. We implemented a petrology application using our proposed system.

Keywords: CSCW, CSCL, tabletop interface, tangible interface, operation history

Introduction

There is research available on tabletop interfaces[1] that can reflect the needs of computer media use by multiple persons. Use of computing in a physical world such as the digital desk came much earlier[2].

We have been studying a tabletop interface that enables users to collaborative work or learn efficiently. In environments where users surround the tabletop display and learn together, it is necessary to support not only multi-user work, but also individual work.

In this paper, we propose methods to display digital and physical objects on the tabletop display appropriately. We have constructed a face-to-face collaboration system that can identify who is using objects in order to support the easy viewing of digital contents. The system uses DiamondTouch[3] and a radio-frequency identification (RFID) system. We implemented the “LogBar” to display an operation history that indicates who has checked the objects on the tabletop display. We also implemented a method that can change the size of contents automatically according to the frequency of user access.

We also describe implementations using our proposed system.

1. Face-to-face Collaboration and Problems

Typical face-to-face groupware includes a system supporting face-to-face meetings, such as Colab [4] or CaptureLab [5]. Recently, there has been an increase in research focused on interfaces because methods to operate computers have diversified and become more sophisticated. Studies on interfaces in face-to-face environments include the tabletop interface. For example, Koike proposed a tabletop system that recognizes a human hand by the difference of temperature between the human body and the desk using a far infrared ray camera [6]. In addition, Rekimoto proposed a system that recognizes hand positions by the change of capacitance [7]. Sugimoto proposed a group learning support system in which the physical world and the virtual world were combined [8].

However, these interfaces have some problems. For example, these systems cannot identify both which point the users are touching on the tabletop interface and what kind of physical object they are holding. If it cannot identify them, it is difficult to appropriately support individual users and makes the system troublesome to use, for example, requiring manual changes of the orientation of contents and waiting for other users to finish working. And in an environment where users surround the shared display, they each look at the display from different orientations. Therefore there are users who have difficulty viewing the contents, and cooperative learning becomes inefficient. Although solutions for the orientation of digital objects have been proposed, such as DiamondSpin[9] and Lumisight table[10], these studies did not address physical objects.

2. System Design

In order to solve the above-mentioned problems, we propose a system that can identify a user handling digital and physical objects. In a typical environment, it is difficult to support individual users or analyze multiple users' operation history simultaneously in a collaborative learning environment. We believe that the system needs to support individual users by presenting information to specific users or by changing the orientation of objects according to how they are accessed.

Therefore, we use DiamondTouch and an RFID system together in our research. Our use of these technologies means that the system easily and automatically identifies the operators of digital and physical objects. For example, it gives users high visibility, such as the ability to view automatically digital contents according to each user's orientation, so it is easy to understand and share information. In other words, it enables users to avoid extra trouble, and the system can make cooperative learning more natural in multi-user environments like a tabletop interface.

In addition, it is possible to record each user's operation history at any time, and to utilize it by identifying each user's work with digital and physical objects. The operation history supports the sharing of users' work and ideas. It makes it easy to find objects that have yet to be checked by users by visualizing the operation history, and anticipating other user's actions and requests of the other users.

3. Implementation

3.1 System configuration

Figure 1 shows the system configuration. The touch-sensitive display, DiamondTouch, is laid down on the table and the image is projected on it. It allows multiple users to surround the display and to place items on top of it, as they would with a table. Physical objects with RFID tags are recognized by touching them with a glove containing a RFID reader. Users can handle both digital objects and physical objects with their hands on the display. The system is implemented using Java.

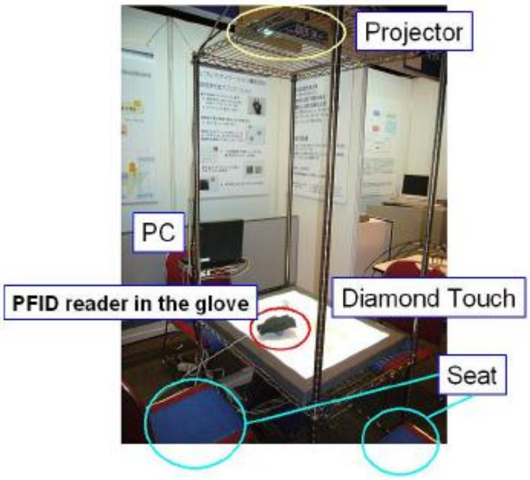

Figure 1. System overview


Figure 2. RFID system

3.2 Identifying operators of digital objects

Our system is constructed with DiamondTouch[11], a front-projected tabletop display that can be handled by up to 4 users. The most remarkable feature of DiamondTouch is that it can identify the user who is touching the surface. With this feature, the system can identify and support each user of the digital objects.

When a user touches the surface, antennas near the touch point couple an extremely small signal through the user's body to the receiver. This unique touch technology supports multiple touches by a single user and distinguishes between simultaneous inputs from multiple users. The blue sheet in Figure 1 is the receiver.

3.3 Identifying operators of physical objects

Our system uses passive RFID tags and readers (PhidgetsRFID system [12]) to recognize physical objects. In our system, users wear a glove containing the RFID reader (Figure 2). When they operate tagged physical objects with the glove, the system can identify what kind of object they are operating. Each reader has a unique ID number and the system stores the ID number in relation to the user. Therefore, the system can recognize which user is operating which physical object.

3.4 Application of learning petrology

In our research, we implemented an application that enables users to learn petrology with physical objects（real rocks）collaboratively on the proposed system. Figure 3 shows a sample image displayed on DiamondTouch. Users can access the digital and physical objects by touching them on the display. There are personal spaces in front of each user where detailed information of the digital object or physical object is displayed according to each user's orientation. Detailed information, including the name type and features of the rock are displayed. In this system, a popup menu is displayed by clicking the Menu button, which is beside the personal space, and users can display the explanation about the classification of the operating object, and expand or eliminate images. Moreover, the dashed line drawn between the pictures of rocks in Figure 3 indicates objects with similar classifications. The system automatically connects objects that have similar classifications with a dashed line, and the more similar the classifications are, the thicker the dashed line becomes.

In addition, we will now describe some functions that make use of the proposed system.

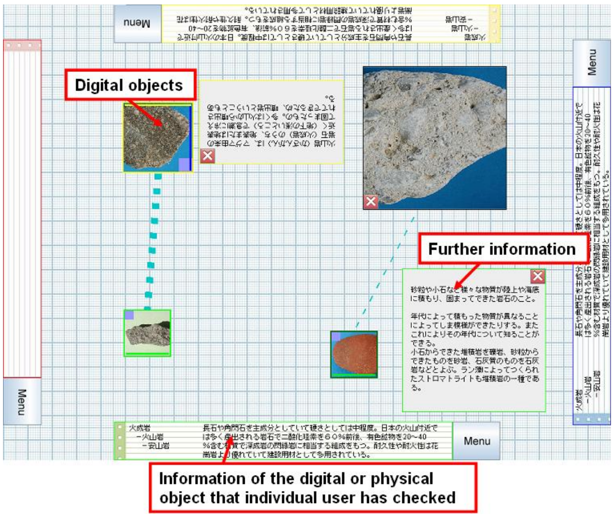

Figure 3. Sample image

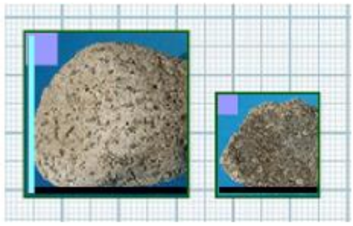

Figure 4. LogBar

3.4.1 Visualization of the operation history

In order to enable users to identify the objects that they have not yet checked among many objects, we implemented a function that visualizes the operation history.

The system displays a colored bar at the edge of the digital object when a user touches it. We call this bar the “LogBar”. The LogBar indicates which users have accessed the object. Figure 4 shows the LogBar. In that figure, the colored bars on the left side of the picture indicate that 2 users who sit at the orientation at which the LogBars are displayed have accessed that object, and a colored bar indicates that 1 user has accessed the object.

With this function, each user can glance through his operation history and the operation history of other users, so it is easier to find and access objects that have yet to be checked. This function is also useful to prevent the same object from being read unnecessarily many times, so users can access multiple objects efficiently.

3.4.2 Dealing with users of a light workload

Our system can identify each user’s operations. Therefore it can support individual users. Specifically, the system gives messages to users who infrequently check objects after a certain period of time. The message prompts the user to check objects and learn about their contents. We implemented this function because in collaborative learning it is undesirable if some users do not participate.

3.4.3 Orientation and size of digital objects

We implemented a function that enables users to see digital objects and related information from the correct orientation for each user in a cooperative learning environment, including the tabletop display. The system automatically changes the orientation of digital objects and information to an easily viewable orientation for each user by identifying operators. This solves the problem of it being difficult to read pictures and texts due to the objects’ orientations in relation to the user.

In addition, the system automatically analyzes the operation history of all the users, and changes the size of digital objects displayed on the tabletop according to the operation history. We define the number of users’ accesses to the object as the users’ focus on the object. Therefore, the sizes of the digital objects become larger with an increasing number of accesses. On the other hand, the size of the digital objects becomes smaller if there are no accesses for a given period of time after all users have accessed the object once.

4. Conclusion

Problems regarding individual user support and visibility of shared information in conventional collaborative face-to-face environments are well known. In this study, we constructed a system that can identify the users who operate digital objects and physical objects. This system can record and use the operation history to support individual users. Specifically we implemented a function that automatically changes the orientation of digital objects for each user, and also changes the size of the objects based on the attention received from users. We also implemented a function to visualize the operation history (LogBar). With these functions, our proposed system enables users to identify the object and its operation state more easily in an environment where there are many objects and multiple users working collaboratively. It is also possible to perform cooperative learning while taking other users' intentions into consideration without interfering with each others' work.

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