Evaluation of Gesture-Command Input Method for Pen-based Group KJ System

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Abstract. The processes involved in carrying out collaborative creative work and the ability to record and circulate the results are important. Previously, we proposed a label-capturing system for the group KJ method that uses anoto-based pens. The system instantly digitizes the positions and contents of labels containing ideas and thoughts, and then generates KJ diagrams for distribution. We also proposed a method for editing the visual properties of KJ diagrams using pen-writing gestures with physical transparent sheets on target labels. However, when the number of functions increases, the management of the physical transparent sheet becomes difficult. In this study, we verified the suitability of the system by introducing a user-defined gesture command framework. This framework increases the flexibility of user operation as well as the number of functions acceptable by the system. We confirmed the suitability through preliminary evaluation of the system with respect to recognition.

Key words: Groupware for Idea Generation, Creativity Support System, KJ Method, Digital Pen, Anoto Paper

1 Introduction

People often use small paper cards or post-it notes to organize their thoughts and ideas. The KJ method proposed by Jiro Kawakita [1] is a technique for organizing diverse opinions and ideas. In the original KJ method, the participants first express their opinions and ideas using small paper labels, which are then organized through grouping and metalabeling processes in the real world.

The emergence of graphical user interfaces (GUIs) and visualization techniques in the 1990s encouraged the development of software tools, such as KJ Editor [2], GUNGEN [3], and D-ABDUCTOR [4], for the KJ method. These tools replaced physical labels with virtual ones and promoted the advantages of managing and sharing labels and diagrams. During the first decade of this century, the concepts of tangible user interfaces (GUIs) and augmented reality (AR) were widely diffused. Using tools based on these concepts, the users could readily
collect virtual data by interacting with physical objects. In another interaction, there have been studies using gestures and speech [6]. Although this study explored true multimodal interaction over a digital table, we value the traditional KJ method style. Using anoto-based digital pens, the group KJ (GKJ) system [7] captured the content and position of notes handwritten on paper labels. The GKJ system adopted the AR concept in the context of the KJ method, which is utilized for the creative process during collaborative group activities. To improve the usability of the GKJ system, we proposed a method that allows the users to edit the representation (Fig. 1) of digitized paper labels by using predefined gestures [8]. However, the predefined gestures restricted the user operations during the editing tasks. Moreover, if a function increases, the number of physical tools needs to be increased. In addition, the users cannot freely set up gesture command patterns. Therefore, in this study, we propose a method in which the number of functions can be easily increased. In addition, we introduce a mechanism that allows the users to register their own gesture patterns for additional operations, thus eliminating the above restrictions. Using this mechanism, the users can define their own gestures and assign them to extra functions. For example, when unfamiliar and unwilling students participate in an activity, the pattern registration task can relieve their uneasiness feeling. When these students freely register new gestures, the group activity is believed to have become more active.

Fig. 1. Decorated idea memo

2 Group KJ System

In this section, we first explain the functions of the former GKJ system and then describe the details of the previously proposed gesture-command input methods.
2.1 What is the group KJ system?

Before explaining our proposed mechanism, we describe our previous GKJ system. The GKJ system utilizes anoto-based digital pens (anoto pens) (Fig. 2) for capturing the position, orientation, and content of paper labels used in the original KJ method. Anoto pens can read the dotted patterns embedded on anoto paper. When a user draws on a label card, the drawing is regarded as being normal handwritten content. When the user draws a single line on the base sheet and label card, the GKJ system determines the position and orientation of the label with respect to the paper boundary. Furthermore, if the user draws a line on more than one label, grouping of the selected label is performed. The GKJ system aims to provide digitized KJ diagrams as soon as the group completes its efforts, so that the results could be rapidly shared and circulated. The pen-based interface is suitable for simultaneous group editing as opposed to editing on a single personal computer (PC).

Fig. 2. Digital pen and anoto paper

2.2 Previously proposed method

In order to add the editing method, we proposed a gesture command method. We used a feature that the anoto pen enables to read anoto paper through a translucent sheet. To simplify the coloring and highlighting operations and to enable all users to participate in the editing of the visual properties, we previously proposed a gesture-command input method [8]. When editing, the users have to trace a predefined pattern. This method provides triggers to edit a card label, both semantically and visually.
3 Problem and Proposal

Here we describe the problem and the proposed solution.

3.1 Problem

The GKJ system provides a function to edit the visual properties of KJ diagrams using a GUI on a PC screen. However, it limits the users who could modify the visual properties. In the traditional KJ method, the coloring and highlighting of the KJ diagrams are performed in a straightforward manner using commonly available colored pens. When a user draws a gesture aligned with a guiding groove, a particular operation corresponding to the gesture pattern is performed. Although this method improves the usability of the GKJ system by providing various functions to edit the visual properties with operations, the former visual editing method has the following several problems.

First, if a function increases, the amount of physical tools needs to be increased and the same amount of pattern sheet has to be prepared. Second, the users cannot configure the mapping between the predefined gestures and the functions. Therefore, the system limits the operations that the users can employ. In fact, according to the comments from the questionnaires completed during the preliminary experiment [8], the users had several opinions. First, they would have liked to have been able to freely write the pattern of a gesture command. Second, they felt that a freehand method that uses a semitransparent sheet with no guiding grooves was a better option than the one that used a gesture with a guiding groove. Finally, the relationship between the predefined pattern shape (for example, an □ R □) and a function (for example, changing the text color to red) was not intuitive.
3.2 Proposal

In this section, we describe a mechanism that allows the users to register their own gesture patterns for additional operations. The proposed mechanism allows the users to freely edit the visual properties of a label; it does not limit the users to predefined gesture-command patterns. By applying the proposed method, the GKJ system can provide extra functions that add capabilities to the user experience. In order to respond to many extensions, we proposed the “gesture registration” method [9]. When the participants emphasize their own ideas, they can use the favorite gesture command (Fig. 4). This method has three merits. First, when users want to emphasize an idea, they can freely edit it using the self-gesture command. Second, the system can provide a user with many functions. Third, the users are required to have only one translucent sheet. When a function increases, it may become that user tends to forget the pattern of a function. But, since a paper used for registration remained at hand, the user can check a function suitably. Therefore we believe that we can develop an easily extendable system.

4 Gesture Registration

In this section, we explain the system design for editing the visual properties of KJ labels.

4.1 Registration mode

In order to make sure that the group members participate as much as possible in collaborative editing during the creative work, the GKJ system should improve
the editing functions that can be performed by each user using anoto-based pens. We have already proposed gesture-command-based operations [8] for that concept. To incorporate this concept, gesture registration functions should be prepared for each participant in order to improve the usability for that individual. Therefore, we prepared gesture registration functions for each participant. Figure 5 shows the menu items that begin the registration process.

This registration process is performed at the beginning of the group work. Although the registration can be performed at any time, we recommend that it is completed before the collaborative work begins. Each member of the group writes his/her own gesture on a normal label card. In this case, the users write a favorite pattern to trigger an editing operation. For convenience, we employed normal label cards.

After the gesture has been inputted, a participant begins registration. The user right-clicks on the displayed gesture on a PC screen. The user then chooses the function button on the pop-up window (Fig.5) to select a function that corresponds with the gesture. The user can assign multiple gestures to a single function. This operation can enable the user to add alternative gestures on a function. When the user register similar multiple gestures on a function, the system can improve the stability of the recognition. If a similar gesture is assigned to another function, it may cause unexpected results. Our system allows the user to freely determine individual gesture sets. Therefore, no limitations on registering personal mapping between gestures and functions. For example, the system accepts the mapping of gesture “R” to “changing color to green” function.

![Fig. 5. Registering gesture pattern to function](image-url)
4.2 Using Registered Gestures

On the basis of the above process, the user can complete the registration step. Next, the user moves to an actual label work activity. When the user wants to emphasize an idea, he/she writes his or her registered gestures on a label card that has been covered by a semitransparent sheet.

Before starting the actual label work activity, one of the user need to change the system’s preference from registration mode to execution mode. In order to distinguish gesture pattern candidates and actual gesture commands, the system should know the current status. When an gesture is written and the gesture is successfully recognized, the user can change the visual property of the label card.

5 Implementation

In this section, we explain how the system stores registered gesture-command patterns, and utilizes the pattern for recognition.

To store a pattern, the system stores the pen’s data and ID obtained by the registration mode. The original drawing with Anoto pens consists of point coordinates \((x, y)\). When a user registers a gesture in the process of 4.1 (Fig. 5), the pen data of the selected sheet is acquired. The system first recalculates the point coordinates for averaging the distance of the points. Then the system calculates the angle between each vector. The detail of the algorithm is described in [8]. Finally the angle data and the pen ID are stored. The pen ID is used to distinguish each individual pattern.

To recognition the gesture, the system must be changed to the execution mode. To change the mode, the user clicks a check box in the menu bar of a window. When the user writes the gesture pattern, the size of the gesture drawing is checked, and only larger drawing is processed as a gesture candidate.

The system calculates the pen data of the gesture candidate as same as the registration mode. Then, the degree of similarity between the candidate and preregistered pattern is calculated [8]. The function with the highest degree of similarity is processed.

The registered patterns are saved to a file, and they are recalled in the next activity. Thus, the users free from registration task for each activity if the same person uses the same pen.

6 Evaluation and Result

In this section, we confirm suitability of the proposed method by an experiment.

6.1 Task

We registered various patterns into the system, and it was confirmed whether it recognizes that the edit operation was actually performed. We assigned 4 to 12 kinds of functions, and measured the recognition accuracy. The registered
gesture patterns were ‘a’, ‘b’, ‘r’, ‘m’, ‘n’, ‘S’, ‘Z’, ‘ ’, ‘ ’, ‘w’, ‘?’, and ‘v’. We evaluated the effectiveness of proposed recognition algorithm. In order to investigate recognition errors with conditions of number of registered pattern, we compared the error rates with 4, 6, 8, 10, and 12 registered patterns. We tried 10 times for each gesture command, and the processing result was observed.

6.2 Result

We measured the percentage of the entire processing that was successful, and also determined the incorrect recognition rate.

Fig. 6 shows the result of recognition test by registered pattern number. Even though the registered pattern number increased, the correct recognition rate is not declined. However, the incorrect recognition rate is slightly increased. Since the recognition accuracy is not high, we analyzed the result in detail.

Fig. 7 shows the result of accuracy for each pattern. We found that the recognition rate is varied by the shape of gesture pattern. The patterns of “a” and “b” were about 90%, but “r”, “m” and “n” incorrectly recognized each other. Especially the most of “o” was failed.

6.3 Consideration

We believe that the recognition accuracy is acceptable. However, we need to attempt to increase the recognition rate. Moreover, there were patterns that were easy to recognize from the results, as well as those that were difficult to recognize. For example, the pattern “o” was not successfully recognized in the current algorithm. A problem for incorrect recognition was also discovered.
Even though there were the recognition problems, we consider that the concept of user-defined gesture is feasible for group work, especially it extended the usability of the system. In the future, we improve the recognition algorithm to fulfill the need for the group label work.

7 Conclusion

In this study, we verified the suitability of the system by introducing a user-defined gesture command framework. This framework increases the flexibility of user operation as well as the number of functions acceptable by the system. The participants can freely and easily edit the visual appearance of KJ diagrams. In a previous study, in order to emphasize a user’s opinion, a method was devised to allow the user to edit the visual properties using gesture-command patterns. The number of editing functions was limited. According to the users’ opinions solicited in a questionnaire, the user thought the use of predefined patterns was inconvenient.

Therefore, we proposed a gesture-command registration method. Using this method, when a user wants to edit a target label card, he/she can freely write down his/her own registered pattern. We considered that the GKJ system is useful, and is improved using our gesture-command registration method. In order to demonstrate added capability improved the users’ experience, we conducted a preliminary experiment for evaluating the recognition accuracy and admissibility. From our experimental results, we found that the recognition rate is varied by the shape of gesture pattern. And we thought that the rate of recognition was low for the specific pattern. Even though there were the recognition problems, we consider that the concept of user-defined gesture is feasible for group work, especially it extended the usability of the system. In the future, we improve the recognition algorithm to fulfill the need for the group label work.
If these problems are solved, we will compare this method with other methods used for editing the visual properties of labels, and will perform a large-scale experiment on the overall system. For example, we may allow the participants to conduct a group session using the primary paper-based KJ method, and then conduct a group session using our proposed enhanced GKJ system. We are considering using the collaborative creative work and class meeting for our experiments. The success of our evaluation will be determined by how favorably the users respond to our method, and whether they consider the meeting outcome as the polished outcome.

Acknowledgment

Our study is partly supported by a grant-in-aid for Scientific Research (20300046, 20680036).

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