Augmented Collaborative Card-Based Creative Activity with Digital Pens

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Abstract. Typically, practitioners of the KJ method use paper labels and four-colored ball-point pens to externalize their thoughts and ideas during the process. A similar approach and method is used in group KJ lessons. However, due to the large paper size required, this approach is limited in effective capturing and sharing of outcomes. Considering the merits of the conventional paper–pen approach and the demand for quick sharing of outcomes after the session, we designed and implemented a system to digitize the group KJ session—not just the outcomes but also the details of the creative work processes. We use digital pens to capture position and orientation of labels, as well as their contents, during the session. We confirmed the efficiency of our system with several KJ sessions.

Keywords: CSCW, Creative meeting, Label work, KJ method.

1 Introduction

We often use small paper cards or post-it notes to organize our thoughts and ideas. Organization of paper cards has two advantages: (1) moving the cards by hands is intuitive; (2) groups of users can simultaneously access the cards. Therefore such card-based activity is commonly used for summarizing and organizing ideas. However, digitizing the process of card-based activities must address special concerns. There are several tools that handle virtual cards and post-it notes on a PC, such as the KJ Editor [6], GUNGEN [7], and D-ABDUCTOR [8]. These tools are effective in organizing personal tasks but are not suitable in group work, because they require mouse and keyboard input.

To solve these input limitations, by introducing a natural and augmented reality approach, Klemmer et al. [1] proposed the Designer's outpost system to capture the flow and transition of post-it notes on a wall-size large screen. We also developed a system to relieve the occlusion problem of the outpost system by using glass with controllable transparency [2]. However, the outpost system's large size makes it difficult to move, rendering it inapplicable for digitizing activities in casual meetings usually held in knowledge creating companies and research laboratories.

In this paper, we propose a system to capture the location of the paper cards with a small and simple facility. The captured location is then used to reproduce the card organization process after the session ends.

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2 Capturing Card Locations by Digital Pens

We used Anoto-based pens to store drawings on paper cards and a base sheet. The Anoto-based pen can recognize the position of drawings by scanning special dotted patterns on the paper. Using the unique features in patterns, the system can distinguish between data of the drawings on the cards and those on the base sheet. Using these characteristics, the drawings can be used not only for handwriting notes but also describing the relationships between the paper cards and the base sheet.

When the user draws a line that covers the sheet and a card (Fig. 1 left), the pen recognizes the line as three drawings (Fig. 1 right). If these drawings are generated at almost the same time, we can consider that, at that time, the paper card was placed so as to connect the three drawings. We call this operation *scanning* and the connecting points *joints.*

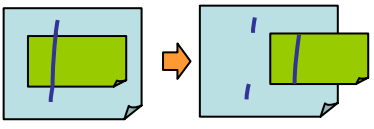

Fig. 1. A line over the card border is separated into three lines

By enhancing the technique, we can recognize orientation and overlapping state of paper cards if two joints are extracted by scanning. (Fig. 2)

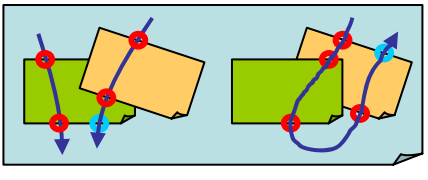

Fig. 2. Recognizing of orientation and overlapping states

To eliminate unnecessary pen drawings on paper for scanning, we can simply use a semi-transparent plastic sheet while scanning (Fig. 3)

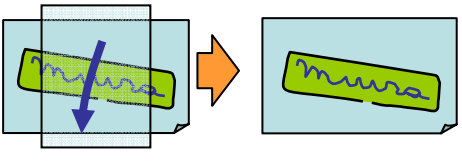

Fig. 3. Using transparent plastic sheet to eliminate drawings

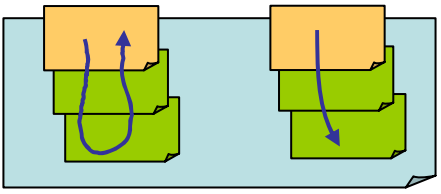

Fig. 4. Grouping (left) and Ungrouping (right) gestures

A similar method was proposed by [3] as research on digitized experiment record notes; however, to edit the card structure, we introduced extra pen gestures called *grouping* and *ungrouping*. Grouping can be performed by a continuous round stroke from the top-level card to the child cards (Fig. 4 left). Ungrouping can be defined by a continuous single stroke from the top-level card to the child cards (Fig. 4 right). These grouping and ungrouping operations can be used for common card-based creative activities, especially for making figures in the KJ method [4, 5].

Of course a digital camera can store the paper sheet status in detail. But reusability of the card content is crucial for creative tasks, and the atomic data should be provided to enhance the process. In particular, an authentic KJ method involves procedures that use repetitive tasks for refinement and deepening.

3 GKJ System

We developed a system named GKJ (Group KJ) that handles scanned handwritten drawings and gestures captured by multiple Anoto pens. The GKJ system consists of (1) Anoto pens, (2) an L-Box Digital Pen Gateway System (DPGW), and (3) a GKJ editor. A system overview is shown in Fig. 5. The L-Box DPGW collects pen data from multiple pens simultaneously, via a Bluetooth connection, and sends it to a MySQL table in a PC. The GKJ editor checks the updated data and handles the data to construct a digital representation of the current paperwork status. For further editing

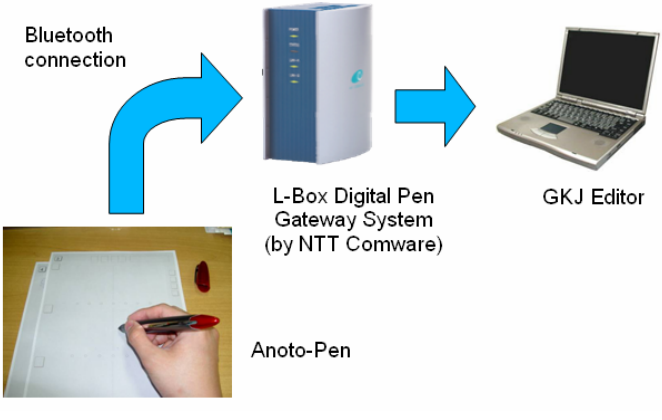

Fig. 5. GKJ system overview and data flow

tasks, the GKJ editor provides functions for organizing the virtual cards, using a mouse and a keyboard as alternative input devices.

4 Usage Scenario

Typically the group KJ method session consists of two stages—card gathering and card unfolding. In the gathering stage, the participants discuss and collect cards with similar meanings or arguments. After that, they add extra cards to those gathered, and write an abstract of the cards on the added cards. Then they clip these cards together with paper clips, considering them as a single card. This is repeated until there are less than 6~9 cards in the stack. In the GKJ editor, the folding operation can be performed by the grouping gesture, and the folded cards are shown in the left of Fig. 6. In the authentic KJ method, the participants are basically prohibited from referring to the child cards during this stage.

Then they proceed to the unfolding stage. Usually the participants extract the cards on the base sheet, but this requires special care to not destroy the constructed structure of piled cards. Also, in the real world, it is difficult to re-organize the unfolded cards because the amount of area necessary for the cards depends on the number of cards and the layout. A high number of cards prevent a trial and error approach. Therefore we recommend that the participants use virtual cards to estimate a preliminary layout. The GKJ editor provides a function for unfolding virtual cards and pre-organizes the extracted virtual cards by dragging the top-level cards. Figure 6 right shows the unfolded virtual card view. Using this function, the participants can effectively layout the cards by considering the relationship between the cards.

After the two stages, the participants obtain a figure (Fig. 7) which represents their issues and viewpoint as an outcome. The participants can review the process by replaying the operations with the GKJ editor. Also they can export the process data or print figures in a PDF format. Incidentally, the curved line in Fig. 7 was constructed by a Bezier curve, whose control points were generated by the convex hull algorithm. The curved lines are automatically recalculated by moving the virtual cards.

As described above, the proposed GKJ system allows freely choosing a proper environment (real or digitized cards) for their task such as review by the digitized log

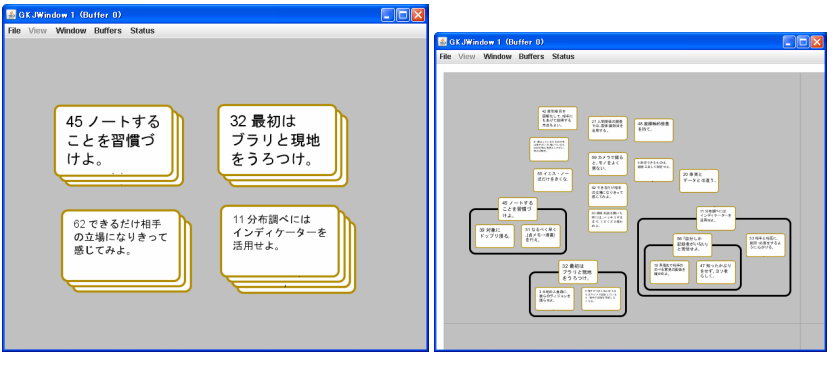

Fig. 6–7. Digitized views of grouping — (left) pile and (right) unfolded view

rollback, and distribution of data. The high portability of the GKJ system makes it useful in a variety of environments. Group sessions with the GKJ system can be held with (1) a base paper sheet, (2) paper cards, (3) digital pens, (4) L-Box, a small Linux box, and (5) a PC.

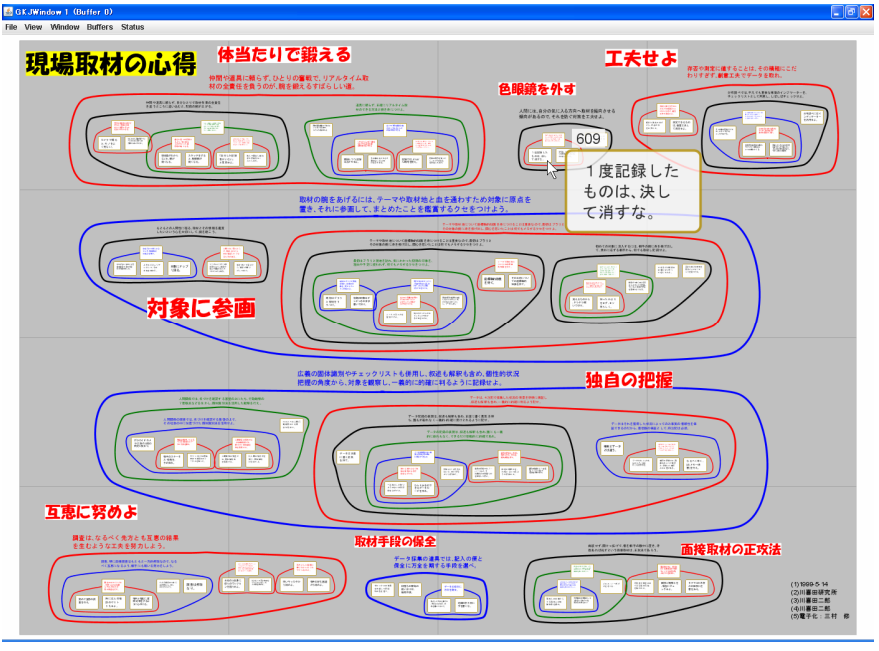

Fig. 8. Final KJ method figure in the GKJ system

4.1 Practice

We operated the GKJ system for small courses of collaborative card-base activity (Fig. 9 shows a class at our institute and Fig 10 shows a lecture course with city hall staff). We used pre-printed cards as material, and the participants positioned the cards spatially to represent their thoughts and considerations. In this case, the system may not enhance the ongoing work, but the participants enjoyed scanning and checking the digitized data. The instructor could conduct the course in the same manner as the conventional courses that use the cards (Fig. 9 left). Since the scanning is intuitive, the instructor could easily capture the card locations. The captured data was utilized to generate PDF files, which represent their layout after the course. The precise transition log of the cards was helpful for retrospection.

In the lecture course at a city hall (Fig. 10), the participants first wrote their thoughts and work related problems on plain paper cards with pens. Then they classified their cards by hand and discussed the issues. After organizing the cards, by putting them on the base sheet, we scanned the card positions.

Fig. 9. Lecture courses with collaborative card-base activity at the university

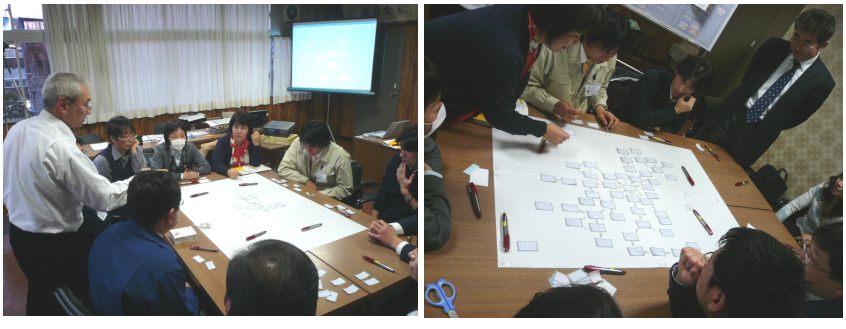

Fig. 10. Lecture course with city hall staffs

We obtained the following findings from observations of the sessions and comments from participants.

(Advantages)

1. Card writing with a pen was straightforward and intuitive for participants.
2. The participants could naturally organize their cards because they could see other people's behavior.
3. The quick distribution of digitized logs and figures (PDF) is effective for reviewing the session and discussion. Incidentally, the instructor had been providing digitized logs and session videos for participants even for the conventional lectures, but it took a few days to digitize the outcomes.
4. The instructor and some participants could master the scanning and enjoyed the operation.
5. The position of the scanned data accurately represented the real figures.

(Drawbacks)

1. Sometimes the scanning failed due to errors. The most frequent mistake was a scanning section error. The GKJ system utilizes four A2 size sheets to compose an A0 sized base sheet. Since the printed dot pattern of the A2 sheet was same, the user needed to specify the section of the base sheet to the system before scanning by tapping a checkbox. Occasionally the user missed the presetting or scanned with

a wrong pen. To reduce this error, we now prepare four preset pens for each A2 sheet section. Even if the error occurs, the user can easily fix the misrecognition by rescanning.
2. Sometimes unnecessary scanning lines appeared on cards and base sheets. The reason was misrecognition during scanning. The misrecognition was caused by weak pen pressure, high scanning speed, and the lack of a gap between cards (less than 1 cm). To solve the issue, we added a "transparent" pen mode, which does not draw unnecessary lines while scanning.
3. Some participants wrote upside down on the cards, because it is difficult to recognize the top and bottom. This caused the card content to be shown wrong side up, and the position was scanned incorrectly. The issue could be solved by implementing a function to automatically detect when the wrong side was up by considering the handwritten note, and handling the card carefully.
4. As we described in points 1 to 3, scanning required skill and know-how. The user needed to understand the characteristics of the pen and the GKJ to operate the system adequately. However, the skill could be easily acquired with a few minutes of training, and a failed scanning could be easily recovered by rescanning.

Even with its drawbacks, the GKJ system has the potential to augment conventional paper based discussion. We also found that most of the drawbacks could be solved by further system refinements.

5 Conclusion

We proposed a method for capturing the location and hierarchical structure of paper cards written with Anoto-based pens. The method enables the participants to record a precise atomic transition log of the cards. We also developed a system for digitizing paper-based card organization tasks instantly, based on the proposed method. Due to simplicity of the pen-based input, the GKJ system is universal; it can be used by office workers and also the elderly and primary school children. We confirmed the effectiveness of the system with several sessions. We applied it to small group learning sessions of up to 10 persons, but this system is applicable for many participants and groups, since the system can handle up to 40+ pens at the same time. We will refine the GKJ system to improve its usability, and it should contribute to the effectiveness of group discussions that include various types of participants, such as town meetings.

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