Usability Evaluation and Interface Design, Volume1, pp.445-449,Human-Computer Interaction (HCI), New Orleans, 2001.8.

Supporting Individual and Cooperative Work Using Scalable Pen Interfaces

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Abstract
This paper describes prototyping of a computer-supported system for preparing schools' newspaper, it is a typical example of computer-based environments for supporting creative learning for both individual children and groups of children in primary and secondary schools. Learning is trained through individual creative thinking and communication among individuals. To support this, information processing, more intuitive user interfaces, and seamless coupling of individual work and group work, are all necessary. We have employed pen-based user interfaces for both individual work and group work and designed the groupware so that individual and group works are combined seamlessly. Namely, the materials are prepared by each individual on a display-integrated tablet with an electronic pen, and then they are collected, edited, and merged into the schools' newspaper by electronic markers while being displayed for a group of children on an interactive electronic whiteboard. This paper presents the design, implementation and preliminary evaluation. We hope to clarify the requirements for this type of systems, including their realizations, by the revision at the end of this paper.

1. Introduction

To learn Information Technology (IT) and to utilize IT for learning is indispensable in the information society in the 21 century. There are many problems, however, when children are to use computers. One of the biggest problems is the heavy burden when they have to use a keyboard while thinking or learning. For creative learning, more natural user interfaces are essential so that they are not bothered by the way they interact with computers. We employ pen-interfaces for both individual workspace and cooperative shared workspace. Each child works on a display-integrated tablet with an electronic pen and then collaborates on an electronic whiteboard using electronic markers and erasers. According to the terminology of cognitive psychology, handwriting is so-called “automated” for us since we have been writing by pen since our childhood so that we can concentrate our attention on thinking without being annoyed by how to use a pen. Moreover, we can express our feeling or emotion by our handwriting.

The main reason why we have been working on handwriting-based user interfaces is that thinking is not interrupted by the actions for writing. Thinking and writing form a positive feedback loop system allowing and clarify one’s idea. This nature of writing is suited for creative work rather than labor-intensive tasks [1)]. Our research also extends to systems using PDAs, desktop tablets, and large electronic whiteboards, which are useful for computerized classroom education [2)]. We have been developing several educational applications for the latter system [3)].

In primary and secondary education, however, group learning and individual learning are also important as well as classroom learning. Group learning activates discussions among school children, helps themselves share and understand common problems and leads them to the solutions effectively based on their confidential relationship. The research area that group learning belongs to, liberated from physical restrictions and enhanced by computers, is called CSCL (Computer Supported Collaborative Learning).

This paper describes an initial attempt to employ our pen interface resources in order to support creative learning for both individual learning and group learning. Out target is a computer-supported system for preparing school's newspaper in primary and secondary schools. The school’s newspaper preparation is a typical example of creative work made by individual children collaborating with each other. Our aim to develop this system is to realize an environment where each individual children and groups of children can creatively learn.

2. Basic Design of the School's Newspaper Preparation System

2.1. Handwriting-based user interface

This system is for school children. We must assume that the users are not well prepared for using a computer and

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typing a keyboard. Many educational software products require skills for them to use a computer and a keyboard. This is hard even for less creative work. For creative work, this is a much harder problem for children. Therefore, we employ pen interface instead of a keyboard and a mouse. The pen interface can be commonly employed for PDAs, desktop tablets and electronic whiteboards. Thus, it is scalable to the size of the target. It is natural to the users so that creative thinking is not restricted. We expect school children to be able to use it like a sheet of paper with pen and like a blackboard with a piece of chalk.

2.2. Individual work and group work

The process of preparing school's newspaper is divided into individual work and group work. In the individual work, each child collects articles to be used for school's newspaper, and prepares manuscripts for them. In the group work, the group edits the school's newspaper using materials presented by the members. Here, a desktop PC or one of the desktop tablets that the members are working with does not fit the group work. A screen cannot be simultaneously seen from all the members and articles cannot be manipulated by all members. One solution to this problem is to share a large surface virtually and view and access it through each workspace. Another solution is to share the common area physically. We prefer the latter method since the full awareness is shared among all the members: Each child works on a display-integrated tablet with an electronic pen and then collaborate with other children on an electronic whiteboard, which is 70 inches large, using electronic markers and erasers.

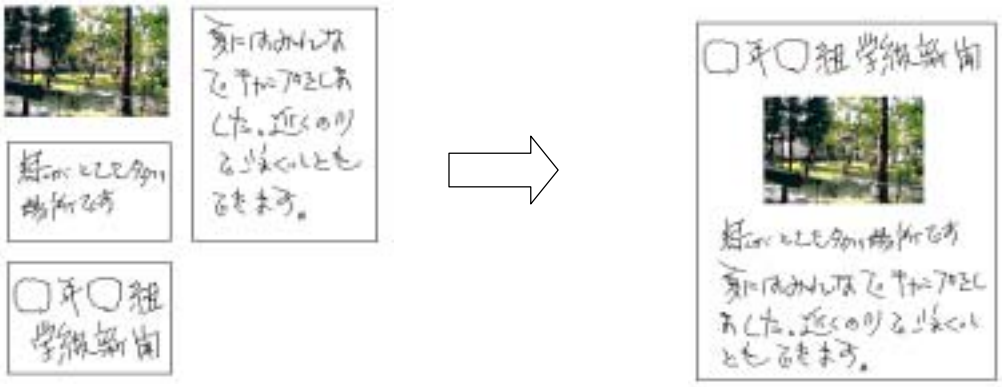
3. System for Preparing Schools' Newspaper

This system is composed of desktop environment and electronic whiteboard environment, where the desktop environment with pen input is used by each individual for preparing materials while the electronic whiteboard environment is used for children for collecting, editing and arranging materials into the school's newspaper. Therefore, two functions corresponding to the two environments are necessary that must be seamlessly coherent so that children can use them as if they would prepare materials on a sheet of paper and then discuss them on a blackboard. Fig.1 shows preparation of schools' newspaper using our system.

3.1 Material Preparation Function

The material preparation function is to prepare materials for articles in school's newspaper using a display-integrated tablet with an electronic pen. Fig. 2 shows the screen of this function.

In the material preparation function, there are two modes, one for input handwritten text and the other for correcting segmentation points between characters so that handwritten text can be laid out according to any column width.



An Individual prepares materials for an article.
(Material Preparation Function)

Group members edit articles using the materials prepared in the last step.
(Article Editing Function)

Fig.1 Preparation of schools' newspaper on our system.

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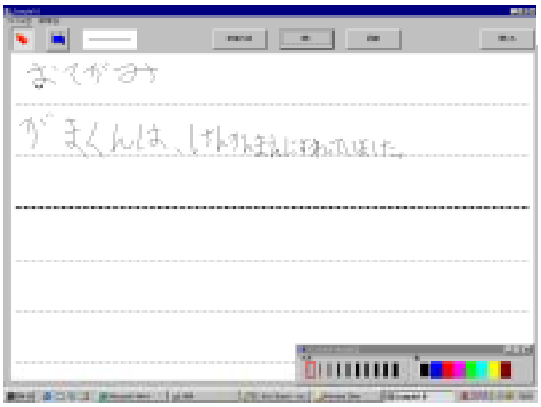

Fig. 2 The screen of the material preparation function.

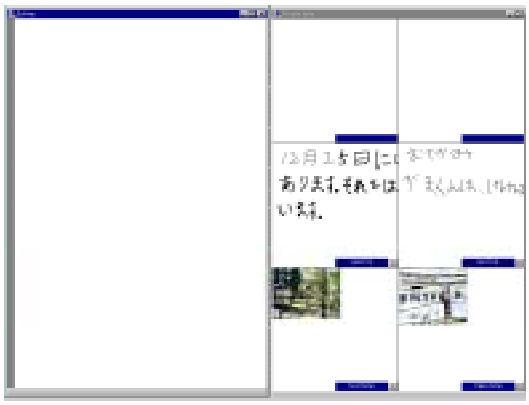

Fig. 3 The screen of the article editing function.

In the handwriting input mode, a child can write text on horizontal gridlines displayed on a display-integrated tablet. The user can also erase text, select the thickness of the electronic ink and change its color. Then, the system segments characters using handwriting recognition technology developed at our laboratory [4]. Here, it is important that the system employs handwriting recognition in order to segment handwritten characters rather than replacing handwriting by character font. When the user changes from the handwriting mode to the segmentation modification mode, the system determines character segmentation points automatically. In the segmentation modification mode, the writer can correct mis-recognized character segmentation points.

3.2 Article Editing Function

The article editing function arranges materials that users have prepared using the material preparation function to form a school's newspaper on the electronic whiteboard. The materials include handwritten text, photographs, pictures, figures, voice clips, animations etc. Fig. 3 shows the screen of this function.

This function is used on the electronic whiteboard with surface far bigger than that of tablets. Therefore, it is very important that the user interface doesn't depend on the user's height and standpoint. New scroll bars placed at both sides of the electronic whiteboard solve the problem of the user's height. Fig. 4 shows a general scroll bar and the scroll bar for the electronic whiteboard. The screen can be freely scrolled by tapping the electronic marker anywhere in the scroll bar and dragging it to the direction that the user wants to show.

When the bottom part of the surface is tapped, a menu appears where the user can select functions such as "open a file" or "save to a file " and so on. This arrangement enables even a small child to operate the menu regardless of the standing position. Fig. 5 shows the bottom part after the menu has appeared.

Fig. 4 A general scroll bar (left) and a scroll bar for the electronic whiteboard (right).

Fig.5 The menu bar for the article editing function.

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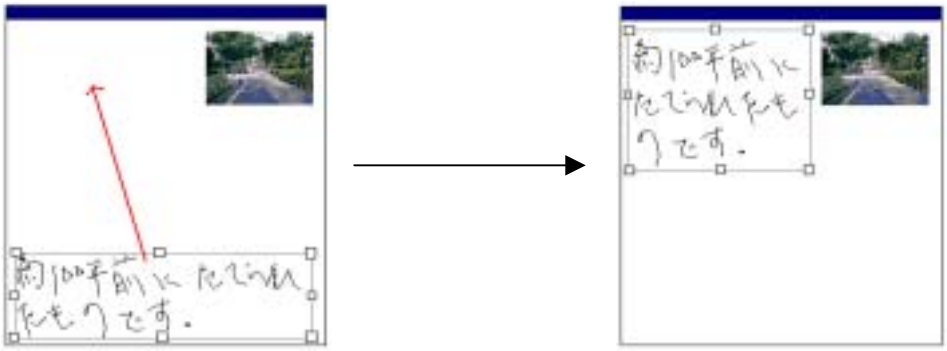

A handwritten text is specified and moved.

A system judges the column width automatically and handles line-feeds automatically.

Fig. 6 Automatic line-feed.

When materials are moved, enlarged, reduced or deleted from the newspaper, the column width needed to layout each material is recomputed, and the handwritten text is split into lines (automatic line-feed) at appropriate segmentation points. This is possible because handwritten text has been segmented between characters . Fig. 6 shows how this looks like.

4. Evaluation experiment

We made preliminary evaluations in order to judge the usefulness of each function, clarify problems in the user interface and test whether this system can support creative work. The first evaluation was made to test the material preparation function, and the second evaluation was made to test the entire system for preparing schools' newspaper.

4.1 First evaluation experiment

We invited six children from the second grade to the sixth grade in an elementary school and asked them to use the material preparation function. Fig. 7 shows how they are working using this function.

4.2 Second evaluation experiment

We invited ten children from the first grade to the fifth grade in an elementary school and asked them to use the entire system for preparing schools' newspaper. Fig. 8 shows a scene where they are using the article editing function.

Fig. 7 A snapshot from the first evaluation experiment.

Fig. 8 A snapshot from the second evaluation experiment.

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4.3 Opinion of subjects

The school children who used this system gave the following opinions:

- Handwriting is easy to prepare materials.
- Gridlines are useful when inputting sentences.

Moreover, we have observed the following children's behaviors:

- Intervals between handwritten characters get narrower during writing, as shown in Fig. 2, which makes automatic segmentation difficult.
- By passing an electronic marker from a child to another, they can smoothly turn the role of editing to each other.
- Vertical writing is easier than horizontal writing since Japanese children are more familiarized with the former in the Japanese language lessons.
- Automatic character segmentation is not easy for children's handwriting and it takes a certain amount of time to output the result.

The last two problems are being revised. After the revision, usability and effectiveness of the system for making creative learning are evaluated again.

5. Consideration and future work

This paper described prototyping of a computer-supported system for preparing schools' newspaper. It supports creative learning made for individual children and groups in primary and secondary schools.

In the material preparation function, a child can write characters on horizontal gridlines and the system recognizes character segmentation points automatically. However, children's handwriting has narrow intervals between characters. For this reason, automatic segmentation is difficult and correction work by the user is increased. Moreover, since automatic segmentation takes some time, children likely lose their concentrations. For children, lines of character writing boxes rather than just gridlines are much better. They are accustomed to them since they write essays using this type of manuscript papers. Moreover, this dispenses with automatic segmentation and the segmentation modification mode so that children are not annoyed by the delay of processing and they do not have to correct mis-segmentations.

For children, vertical writing is easier than horizontal writing since Japanese children are more familiarized with the former in the Japanese language lessons. The use of this system within a lesson of a primary school is scheduled. We are going to create the input screen for vertical writing so that there is no inconsistency with the language lessons in a primary school.

Acknowledgments

We are thankful to all the people who have cooperated in the evaluation experiment of our system for preparing school's newspaper.

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