Tactile-Audio User Interface for Blind Persons

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Abstract. We are developing a communication media for blind persons which enables blind persons to represent diagrams freely using only their tactile and auditory senses. We conducted psychological experiments in which blind students used and evaluated our prototype system, tactile-audio display (TAD). As a result, some problems on the user interface for blind persons were revealed. These included "troublesome keyboard operations", "rasping voice menu" and "difficulty in simultaneous use by three or more persons". We considered how to resolve such problems.

1. Introduction

Diagrams are very useful media that can support our thinking, communication with others, and so on. However, blind persons can not use visually represented diagrams. There are thus few means by which blind persons may obtain diagrammatical information.

In daily life, blind persons use tactile diagrams (plastic sheets) in which figure elements such as lines are embossed by foaming ink. However, it is difficult for blind persons to recognize diagrams only with the tactile sense because the tactile sense has lower resolution than the visual sense.

In recent years, tactual and auditory representation of diagrams has been proposed and used in some systems [1], [2]. The idea is that coarse information of diagrams is represented by the tactile sense, and fine information, by the auditory sense. In NOMAD [1], auditory information (voice data) is stored and linked to each location on the tactile diagram in advance. Users touch the tactile diagram and hear fine information describing the detail of objects by selecting a location on the diagram. In this way, users can interpret diagrams by integrating information obtained through the auditory and tactile senses. With this system, users can read diagrams, but they can not write diagrams by themselves.

Our aim is to develop a communication media for blind persons by which blind persons can represent diagrams freely using their tactile and auditory senses. In this paper, we consider the possibility of our system, especially its user interface.

2. Tactile–Audio Display (TAD)

2.1 Hardware

The system consists of a tactile display with digitizer, a voice recorder, a voice synthesizer, a keyboard, a disk unit and a personal computer [2] (see Fig. 1).

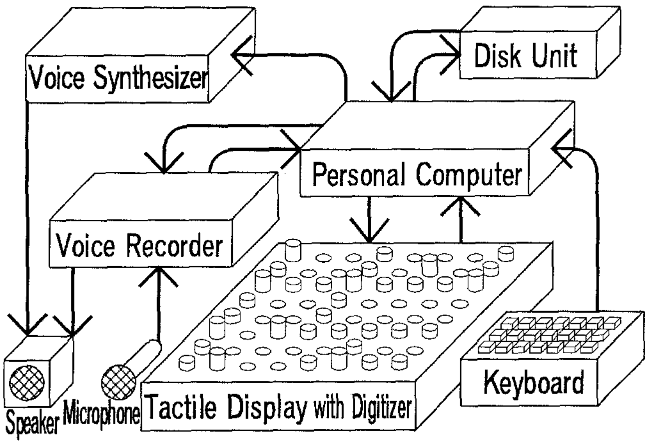

Fig. 1. Tactile–Audio Display (TAD)

The tactile display has an 8x8 pin matrix, and each pin can take one of three states. Furthermore, the display can detect the position of the user's finger because a small switch is embedded in the top of each pin.

The voice recorder is used for recording voice data from a microphone. The data can be played back from a speaker whenever users need. The voice synthesizer transforms the character data to audible voice data.

The keyboard is used for inputting commands, and the disk unit saves diagrams.

All devices are controlled by the personal computer.

2.2 Software

Blind persons can represent diagrams using only their tactile and auditory senses. That is, blind users can set each pin's height and link voice data to a specified pin on the tactile display. Each diagram is saved with a voice label with which users can recall saved diagrams.

A voice menu enables for users to select such data as voice data and diagrams with voice labels. Users can easily operate the voice menu by such simple commands as "listen to the previous term", "listen to the next term", and "select this term". The voice menu is also used to input commands for system operations.

3. Evaluation by Blind Students

We conducted out psychological experiments at the Nagoya School for the Blind. Subjects are seven blind students (nine to twelve years old). We asked subjects to use our prototype system in their classroom work. We describe below the observed behaviors of the subjects and their subjective impressions.

•**Keyboard operation** While using TAD, subjects had to move their hands frequently between the tactile display and keyboard because their hands must do two different jobs, recognize tactile patterns and operate the keyboard. They thus sometimes made mistakes in repositioning their hands on the tactile display or the keyboard.

•**Voice menu** Subjects said that the voice menu for command input was easy for novice users to operate TAD, but repeated messages were rasping and unpleasant for users accustomed to TAD. The reason is, we think, that they can memorize the order of menu items while they repeat operations. While using TAD, subjects recorded their voice into the system as voice data and eventually stored more than 20 voice items. It therefore took much time for users to select desired data because they had to sequentially search a menu of voice data with more than 20 items.

•**Auditory noise** The subjects seemed to be very sensitive to slight sounds. For example, they could perceive faint noises in the voice data recording phase, and could understand the system status based on this auditory noise. From this unexpected fact, we can conclude that even noise is very important feedback for blind users.

•Hand-in-hand instruction When a sighted teacher instructed a blind student, the teacher usually held the student's hand and guided it on the tactile display or keyboard. Such hand-in-hand instruction was observed between two blind students as well. Such operation seems to be a basic behavior for communicating among blind persons. However, when four blind students attempted to use TAD together, it was difficult for each student to understand the information represented on the tactile display because of interruption by other students' hands. To prevent hand collisions, we tried another approach, in which the location selected by a student was reported to the other students by voice message. However, we found that this was more difficult for them to understand than hand-in-hand instruction.

4. TAD User Interface

4.1 Command Input

Blind persons use their hands not only to obtain tactile information, but also to manipulate the TAD; that is, their hands are an input-and-output device. To increase tactile performance in recognition, it is necessary to reduce keyboard operation loads.

Using a speech recognition device is one solution for the above problem, but there are reliability problems.

Users' feet are another motor organ available for command input. That is, the user steps on foot switches to input commands while touching the tactile display. It is difficult to input complex commands with foot switches, but a standard or braille keyboard may be used in such situations.

A voice menu is an important blind users' interface, however, as the number of menu items increases, it becomes more difficult to locate the desired item. A hierarchical structure with submenus may be an effective means of coping with the above problem. However, there are many problems in implementing such a structure, so this is a subject for future study.

It may also be useful to present the menu on the tactile display. The merit of this is that the user can memorize the items associated with the two-dimensional location.

4.2 Auditory Output

Voice messages are useful for conveying information to blind persons. Even novice users can use our system by relying on voice messages. However, when the users become accustomed to TAD operations, monotonous, tedious messages become unpleasant and rasping. It is thus necessary to reduce tedious output according to users' experience.

Earcon [3], a menu of natural sounds such as cries of animals or sounds of machines, can be used to reduce voice messages. Moreover, this may enhance users' motivation for learning.

Artificial sounds such as synthesized music can also be used to reduce voice messages. Human hearing, especially blind persons' hearing, is very sensitive to slight changes of sound. Expert users may operate TAD rapidly relying on just a short music menu.

A problem related to earcon and music menus is how to associate each function with earcon or music.

4.3 Tactile Output

In blind persons' communication, hand-in-hand instruction is very important. One person can guide the other's hand to a specific location or path on a map. In non-contact communication, it is difficult to instruct location or path. However, it is difficult for three or more persons to touch one tactile display at a time in contact communication. If many displays are linked with computer networks, all persons can access the tactile display simultaneously. This is, however, non-contact communication, and presents a paradox.
It is interesting to note that human-computer communication is also non-contact communication. The need for blind persons to instruct location or path in non-contact communication presents an interface problem.

Our tactile display can change the displayed pattern according to the situation. It is thus possible to direct users' attention to a specific location or path by repeating on and off cycles. However, how to simulate "hand-in-hand" communication by this method remains a problem.

5. Concluding Remarks

We considered the possibility of a tactile-audio user interface based on some knowledge obtained by a preliminary field test in a school for the blind. There are many problems to be overcome before we can realize our aim. User interfaces for blind persons have many problems which differ from those of visual user interfaces. We must establish the foundation of a user interface for blind persons based on the blind users' advice.

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