Practical use of interactive tactile graphic display system at a school for the blind (2)*

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The basic function of the interactive tactile graphic display system is that it enables blind persons to draw and erase tactile graphics directly on the tactile surface with the stylus. Besides that, the system can be used to play tactile games, which cannot be achieved by the use of current static tactile graphics, such as embossed print or swell paper.

Keywords tactile graphic display; blind student; good practice

1. Introduction

The interactive tactile display system was originally devised to make drawing enjoyable for blind persons. Its distinctive feature is that it enables them not only to draw, but to erase raised lines simply by moving the stylus on the tactile display surface in the same way that sighted people use a pencil and eraser on a sheet of paper [1]. The user can also draw "blinking" lines and blocks so as to attract the receiver's attention to the blinking point without taking the receiver's hands. In addition, auditory information, including speech, can be given according to the user's actions.

These features of real-time feedback of tactile and auditory information allow the system to be utilized as an interactive multimodal display system, rather than merely a drawing system. We have partially confirmed its potential by developing a Kanji (Chinese characters) learning system and tactile games [2]. Since 2003, we have used this system in a class at a school for the blind and proved its practicability. In this report, we demonstrate our good practices and summarize the effect of using the interactive tactile graphics system on education.

2. System description

2.1 Configuration

We configured a new system setup using commercially available devices so as to increase its durability to rough handling in the class. The system consists of a tactile display device (GD-8x6B and DV-1, KGS Corporation), a three-dimensional digitizer (MicroScribe G2, Immersion Corporation) and a tablet PC (Dynabook SS 3500, Toshiba Corporation). The tactile surface of GD-8x6B measures 192 mm x 144 mm and has 3,072 pins arranged in a matrix of 64 columns and 48 rows with interpin spaces of 3 mm. The tactile surface of DV-1 is half as long as GD-8x6B both vertically and horizontally and has 768 pins. These pins can be raised and lowered individually by our original control program. MicroScribe can measure the three-dimensional location of the stylus tip with a maximum degree of precision of 0.38 mm. The tactile display and the digitizer are connected to the PC via a serial port and a USB port, respectively.

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2.2 Drawing program

Users can draw or erase raised lines by moving the stylus along the tactile surface. Because a tablet PC is used, sighted users can make drawings directly on the tablet as well. Users can select one mode at a time among drawing solid lines, drawing blinking lines and erasing by pressing the mode-switching button at the lower right to the tactile surface. Pressing the clear button, at the upper right, lowers all the tactile pins. Sound effects and speech output help users understand the change of modes and the ongoing operation [1].

2.3 Page flipping tactile animation and tactile games

To use “page flipping” tactile animation, the user (presenter) prepares a series of drawings with each page slightly different from the previous page. These drawings are then displayed in sequential order at periodic intervals. The system can handle a maximum of twenty pages.

Two tactile games are available. They are whack-a-mole and tic-tac-toe.

3. Utilization at the school

From 2003 to 2005, the interactive tactile display system was utilized at the Fukushima prefectural school for the blind. In the following, two lessons in an eighth-grade class where the system was used are described. The class had one blind male student and one female student with low vision, and the system was used mostly by the blind student. Also described are the tactile games; how to play and comments given by both students and teachers after playing them.

3.1 In a geography lesson

Geography lessons use many maps. Although there are some tactile maps available and teachers can have blind students touch them, they cannot be sure of students’ understanding simply by their verbal and physical responses. With this in mind, the drawing system was used so that the blind student could draw the images he had built up after exploring the tactile teaching materials.

The subject in the lesson was terrestrial latitudes and longitudes. The teacher explained the subject using a handmade terrestrial globe, the diameter of which was about 178 mm. The globe had tangible latitudes and longitudes, made of kite strings, around it every 45 degrees. In addition, two bowls were used to show what the cross-sectional views would be like if the globe were to be split into halves. The cross sections also had a tangible equator, axis of geographic poles and latitude lines every 30 degrees.

After the blind student tactually explored these teaching materials, he was asked to reproduce the cross section using the tactile drawing system. He first drew a circle as the circumference of the globe. However, he was not satisfied with the work he had done. He then erased it and drew it again. He repeated these actions several times until he was content with the circle he had drawn. Secondly, he drew the equator, the axis of the poles and the latitude lines. He tried to draw straight lines several times. After a few trials he reproduced the cross section, which was mostly the same as the one he had explored with his hands. The page-flipping animation was then used to show these lines in the order of the axis of poles, lat. 60 deg. N, lat. 30 deg. N, the equator, lat. 30 deg. S, lat. 60 deg. S. This style of presentation seemed to promote his understanding of the subject. Of course, the teacher was able to confirm his understanding by looking at his drawing.

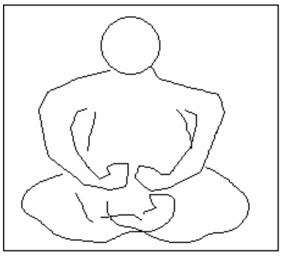
3.2 In a history lesson

The subject in the lesson was the introduction of new schools of Buddhism into Japan in the thirteenth century. To deeply understand it, the teacher thought that remembering the names of famous historical people, events and their ages was not sufficient and that it was important to provide multimodal information through images and moving pictures, including sound and speech. For the sake of the blind student, tactile graphics, a tactile animation, a replica of a Buddha statue, and a multiple line braille presentation were prepared.

Building up a 3D pose out of 2D graphics. A famous sitting Buddha statue in Kyoto was illustrated by the teacher onto the tactile surface of the system. Because of the low resolution of the tactile display, the pose of the hands could not be depicted precisely in the picture of the whole statue (Fig. 1 a)). Therefore this part was outlined in blinking lines to indicate that more detailed information was to be shown on the next page (Fig. 1 b)). After exploring these graphics, the student was asked to imitate the hands of the statue and was able to make a pose of the original statue perfectly, as shown in Fig. 1 c).

Tactile animation. In Kyoto there is a Buddhist temple called hououdou, which was named after a mythical bird, houou, the Asian phoenix. To enrich the student's imagination of that bird, the teacher prepared a series of graphics depicting the bird flapping its wings (Fig 2 a)). Graphics were sequentially presented with an interval of one second, because tactual exploration requires time. The animation was played repeatedly. Meanwhile, the teacher asked the student to imitate the motion of the bird, which he performed correctly as shown in Fig. 2 b).

Producing 2D graphics after exploring 3D sculpture. The purpose of this hands-on lesson was to help the student understand the relation between a three-dimensional object and its two-dimensional depiction. After the student examined the replica of the Buddha sculpture with both hands (Fig. 3 a)), he was then asked to reproduce it onto the tactile surface by himself. At the beginning, he had trouble in balancing the sizes of the picture and the canvas. However, after a few trials, where he drew the outline and erased it altogether, he managed to make suitable-sized picture. Also, he became quickly accustomed to using the system and was able to erase wrong or unsatisfactory lines partially, as soon as he found them, so that he could redraw them. Fig. 3 b) shows the student drawing his picture. Furthermore, he invented a method of expressing important parts in blinking lines and blocks.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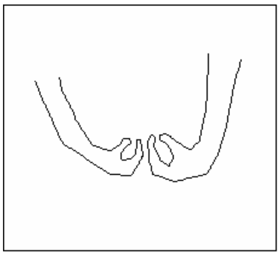
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c)

Fig. 1 *Building up a 3D pose out of 2D graphics.* Illustration of a sitting Buddha statue on the tactile surface; a) the whole statue and b) pose of the hands. c) shows the blind student imitating the pose of Buddha.

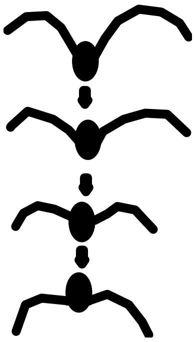
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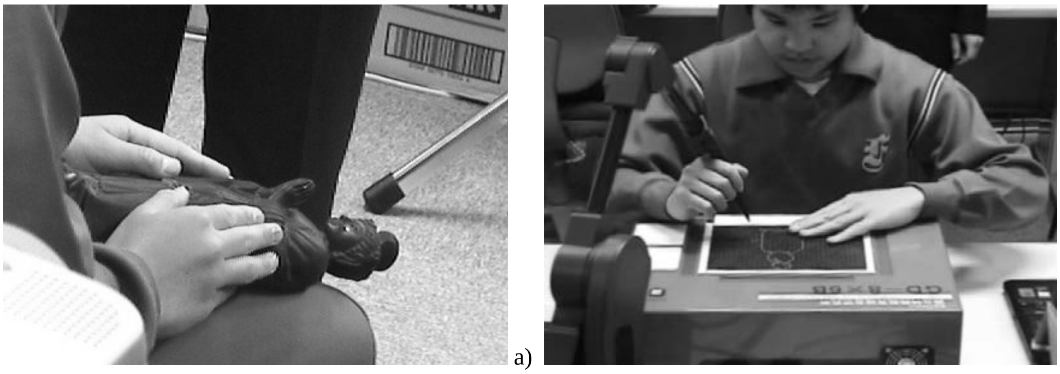
Fig. 2 Tactile animation of a bird flapping its wings, (a) and the blind student imitating its movement, (b).



a) b)

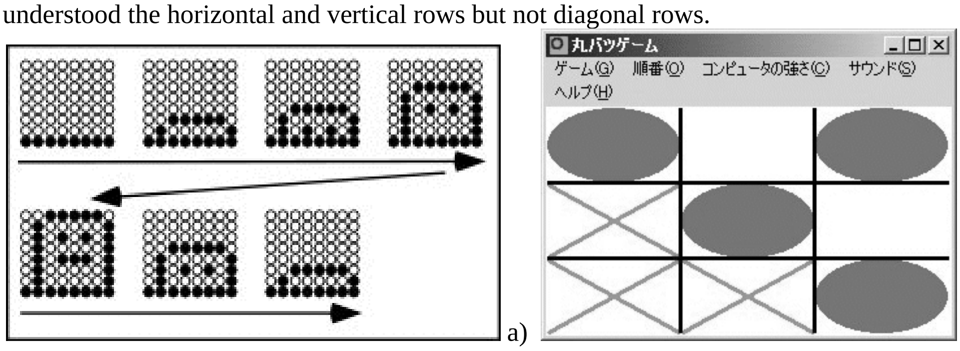
Fig. 3 Producing a 2D graphics after exploring a 3D sculpture. After examining the sculpture (a), the bind student reproduced it onto the tactile surface (b).

3.3 Tactile games

Whack-a-Mole. When the game starts, moles pop up at different places on the tactile surface at random. The player has to find the moles tactually and bash them with the stylus before they disappear. Moles are expressed as a set of temporally changing raised pins as shown in Fig. 4 a). The player's score is the number of moles whacked in 30 seconds. To get higher scores, the manual skill of quickly finding tactile objects and the hand-control skill of moveing his/her hand to where the other hand is placed must be developed. Whereas blind teachers appeared to be uninterested in it and scored only a few points, younger children enjoyed playing this game and scored 10 to 20 points even in their first trial.

Tic-Tac-Toe. At the beginning, all the squares in a 3 x 3 grid are vacant. The first player, either the human or the computer, plays "O" and the other plays "X." Players place their symbols (O or X) in turn at any position. The human player can select the position by pointing to it with the stylus. The first player to get their own symbols in a row either horizontally, vertically or diagonally wins (see Fig. 4 b)).

The rules were easy for the students to understand and they enjoyed playing it. When the computer was too weak compared with the human player, the level was increased from the menu bar. Children easily understood the horizontal and vertical rows but not diagonal rows.



a) b)

Fig. 4 Tactile games. a): Whack-a-mole. b): Tic-Tac-Toe.

4. Discussion

The effective points of the system in the lessons are summarized below.

Simple and easy to draw and modify tactile drawings. The teacher was able to make pictures as an explanation when required during the class. Drawing by the blind student made the teacher certain of student's understanding, and his understanding seemed to become substantial as well. Both the student and the teacher could easily get down to drawing since the system allows repetitive modification.

Tactile Animation. It was proved that properly prepared tactile animation can show the blind student how a bird is flapping its wings. This is especially important when explaining objects that are usually intangible, such as falling leaves and flames.

Blinking lines. Blinking lines are useful in setting importance thereon. Interestingly, the blind student used the same strategy without being taught to do so.

Tactile games. In the games, interactivity with moving tactile objects was achieved and it was observed that blind children enjoyed this very much.

These effects are not achievable with commonly-used static tactile graphics such as embossed graphics, swell paper and thermoform. They have been first realized with our interactive tactile display system. We expect that researchers who are interested in the issues of blind people and drawing (e.g., [3]) will gain new perspectives using this kind of interactive tactile display system.

At the same time, we are aware of the drawbacks of the present system. The use in the lessons showed that it was difficult for the blind student to draw “perfect” circles or “straight” lines. This problem will be solved by improving the software in two ways. One is automatic modification after each stroke. The other is a function of making straight lines by selecting the starting and ending points, and for circles, the center and radius. These points can be either pointed to with the stylus or, for greater precision, inputted from the keyboard.

The low density of the tactile pin array (interpin spaces of 3 mm) is a continual and considerable problem. In 2004, KGS Corporation released a new version of the tactile graphic display named DV-2 with interpin spaces of 2.4 mm. We assume that we can spur technology development in this field by expressing the importance of interactive tactile teaching materials such as these.

However, the high prices of components remains the biggest problem in disseminating the use of interactive tactile systems.

5. Conclusion

Effective usage of the interactive tactile display system in classes with a blind student was reported. It was demonstrated that the functions we provided expanded the potential of the system in the education for blind students.

In late 2003, we developed a new system using an ultrasonic pen (InkLink Handwriting System, Seiko Instruments USA Inc.) [4]. This system setup eliminates not only the use of a large digitizer but also its cost. The second author explains how to make this system on his Web site [5]. We hope that many researchers and practitioners visit the site and make it by themselves.

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