A Multimodal Board Game System Interface Using Finger Input for Visually Impaired Computer Users

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Abstract. In this paper, we developed a new board game system on a PC that feels like a real board game. The main improvements of this system are the tactile guide, the finger input interface, and an output method using vibrating stimuli. These improvements allow players to grasp the layout better than previous systems. We evaluate the system using the Othello game. As the result, we see that visually impaired persons can play the Othello game.

Keywords: visually impaired person, tactile guide, speech guide, auditory display, vibrating stimulus.

1 Introduction

Recently, in order to improve the quality of life for visually impaired persons, various communication systems using the personal computer (PC) are studied [1], [2]. As the related study, there are many things that use the hearing and tactile senses like a screen reader [3] and tactile display [4]. Games are one of the communication methods used. Board games are fun not only for sighted persons but also for visually impaired persons. There are two kinds of board games for people with visual impairment: real board games and computer games [5], [6]. The former often use tactile sense, the latter often use hearing. Many board games use an 8 x 8 layout, so we need to grasp the layout of the board. The layout of real boards can be recognized by touching. In contrast, the advantages of computer games are that we can play the game through the Internet and can play against a computer opponent.

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We already reported a board game system for Mini-Go [7]. In this system, the board layout is difficult to grasp because a pen is used as the input device. To improve on this system, we developed a new computer board game system that makes it easier to understand the layout of a game board.

As board games, there is Checkers, Chess, and Othello. In this study, this system uses the Othello game. The Othello game is also known as Reversi [8], and has the advantage that the algorithm of the game is easy. Also, many people play Othello.

We describe a multimodal interface of our system and evaluate playing Othello games using this system.

2 Components of the Board Game System

When we play the Othello game, it is necessary to grasp the layout of the board, planning a strategy of game and putting a piece. So, it is important how to support these movements using our system.

We need to know some information such as the color and arrangement of the piece, the position where we can put a piece, victory or defeat of a game, start and end of game. In these we define the information about position as positional information. Also, we define other information that is necessary for the game as semantic information. In this system, positional information is obtained by touching the board, semantic information about color of a piece is obtained from a vibrating stimulus, and other positional and semantic information is obtained by hearing.

The block diagram of the board game system is shown in Fig.1. This system contains input-output units. The input units are a tactile guide and an input interface attached to a finger. On the other hand, the output units are an auditory display, a speech guide, and vibrating stimuli. The Othello game is played on an 8 x 8 matrix. Therefore, we use a tactile guide which has 8 x 8 = 64 holes with a diameter of about 1 cm to fit the size of a finger. The size of the guide is about 13 cm long and wide and it is fixed to the surface of the tablet. The layout of the board and the input position can be recognized by touching the tactile guide. The input position is converted into auditory information, which is then output through the headphones using a sound (auditory display). Also, a speech guide tells you the positions with a female voice. Furthermore, vibrating motors are attached to several fingers to give the user information about the layout.

The components and transmitted information of the interfaces is shown in Table.1. These are explained below.

Table 1. Components and transmitted information of interface

	Interface	Sense	Positional information	Semantic information
Input	Tactile guide	Tactile sense	○	–
	Input with finger		○	–
Output	Vibrating stimulus	Tactile sense	–	○
	Speech guide	Auditory sense	○	○
	Auditory display		○	–

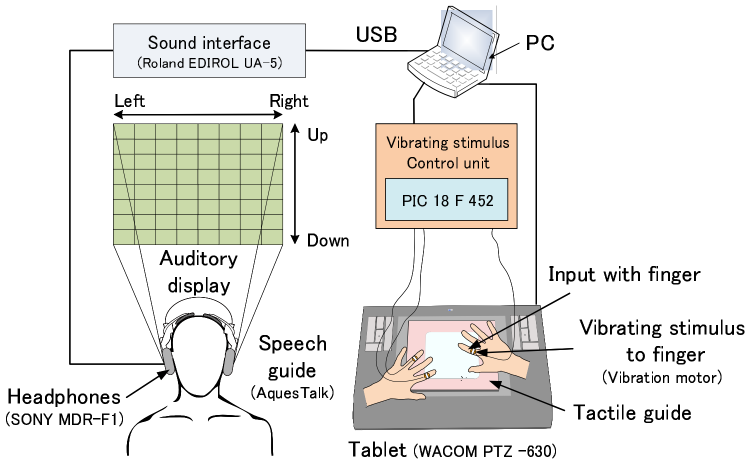

Fig. 1. Block diagram of the board game system

2.1 Tablet and Tactile Guide

In this system, we want to know the layout of the board by touching. Therefore, we introduce a tablet interface from which we can obtain absolute coordinates. Also, we assume the guide (the tactile guide) gives information equivalent to the layout of a board on the tablet. Then, we select the WACOM PTZ-630 tablet, because it has an input area of 203.2mm x 152.4mm, it is an electromagnetic induction type and it detect inputs up to approximately 15mm from the surface.

We cut and create the tactile guide, which is made from an acrylic board, with a machine tool. The thickness of the board is 4mm because the tablet can recognize touches trough an acrylic board with this thickness. Fig.2 shows the layout of the tactile guide for the Othello game. Tactile guide has pointing holes in an 8 x 8 array in order to correspond to the layout of a real board.

The center of the tactile guide is called the center point. The second positional hole in each diagonal direction from the center points an index hole. The index holes show the middle of each direction from the center point. The center point and the index hole have a protuberance in the shape of a cone. Also, taper processing is carried out to the edge of the positional hole and the index hole in order to enable a smooth scan with fingers. On the extension of up and down, left and right of the center point, the four center guides is prepared so that the center of the tactile guide is known. Function holes (Fn holes) are prepared outside of the matrix in order to carry out all setting of the game on the tablet. The eight Fn holes are for future expansion and the top right one has function telling a game mode.

The specification of the tactile guide which described above is shown in Table.2. The various parameters are decided by the psychophysical experiment that evaluated the size and height which is easy to recognize when playing the game for an adult. The top-left pointing hole is the origin (A1). Also, the row and column address of the

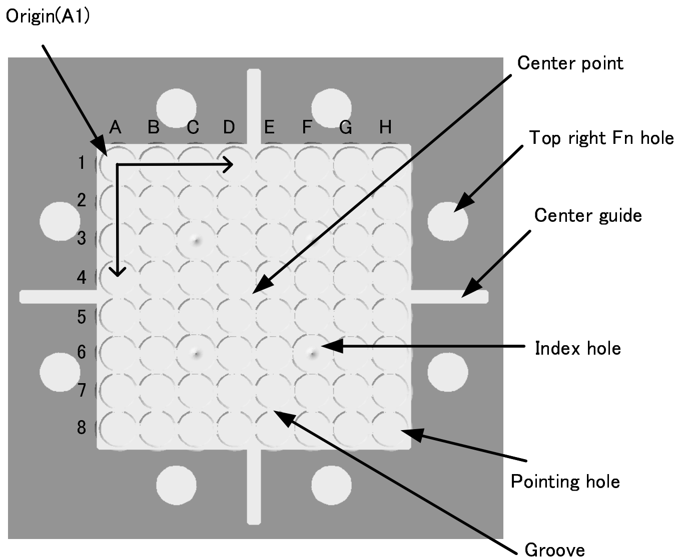

Fig. 2. Layout of tactile guide for the Othello game

Table 2. Main specification of tactile guide

Name	Number	Diameter, width (mm)	Depth (mm)
Fn hole	8	10.5	1.20
Pointing hole	60	9.0	2.50
Index hole	4	10.0	2.50
Center guide	4	3.5	1.25

pointing holes indicate alphabet and numerical number as a coordinate, respectively. In addition, the specifications of the guide such as size and shape and the number of pointing holes can be changed according to a use.

2.2 Finger Input Interface

The input unit attached to a finger is the interface which uses tactile sense, and is made using parts of the mouse that comes with the tablet. An illustration of the instruments which are attached to a finger is shown Fig.3. Because the tablet can detect touches from a height of approximately 15mm, the pointing coil is attached to the first joint of the index finger like a ring. Also, we equip the middle of the second joint and the third joint with button A and B corresponding to the left and the right button of a mouse in the direction of the thumb. The pointing coil is used to let the tablet know buttons and the position of the index finger. Moreover, we can use buttons to determine commands.

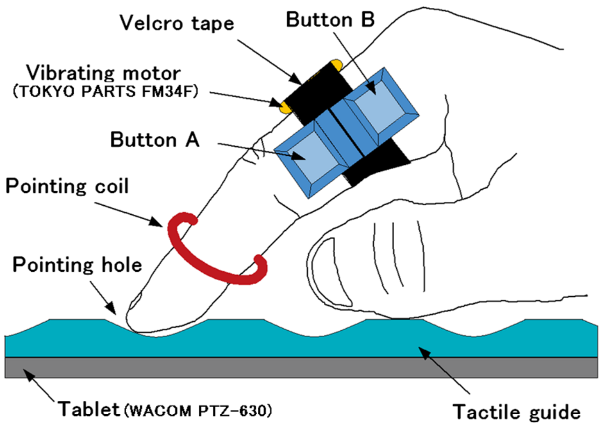

Fig. 3. The appearance of the instruments which attached to a finger

2.3 Vibrating Stimulus

We use a small vibrating motor in order not to disturb input movement. The vibration motor (coin type coreless vibration motor FM34F) is fixed on the index finger of right, the index finger of left, and the ring finger of left as shown in Fig.1. The motor provides the semantic information, such as the point where you can put a virtual piece, white or black. These stimuli are transmitted from the PC to the microprocessor via USB. After the microprocessor (Microchip PIC18F452), which is a vibrating stimulus control unit, processes the information using the Othello game, the information is outputted by carrying out 70 ms operation of about 200Hz vibration that minimize an adaptation effect and maximize sensitivity.

2.4 Speech Guide

A game mode announcement, position coordinates, and choice of various commands are output through the headphones using synthesized speech. The female voice of the AquesTalk is chosen as the synthesized speech for its availability and clear voice. The speech guide has two varieties. Information of game progress such as start or end of game is automatically output, while information of the color of the piece or the coordinates is output on demand by clicking the button A.

2.5 Auditory Display

As an assist of the positional information of the tactile guide, an auditory display is also provided. It is 150 ms white noise convoluted with the HRTFs corresponding to each position of the tactile guide. The sound of each direction corresponding to the tactile guide is generated using the median plane HRTFs obtained by the measurement using a dummy head (KOKEN SAMRAI) and sound source 50 cm distant, and ITD (Interaural Time Difference) and also ILD (Interaural Level Difference) shown in Table.3 below.

Table 3. The direction of sound images vs pointing holes on the tactile guide

			Horizontal (degrees)							
			Left							Right
			−60	−43	−26	−9	9	26	43	60
Vertical (degrees)	Up	60	A1	B1	C1	D1	E1	F1	G1	H1
		43	A2	B2	C2	D2	E2	F2	G2	H2
		26	A3	B3	C3	D3	E3	F3	G3	H3
		9	A4	B4	C4	D4	E4	F4	G4	H4
		−9	A5	B5	C5	D5	E5	F5	G5	H5
		−26	A6	B6	C6	D6	E6	F6	G6	H6
		−43	A7	B7	C7	D7	E7	F7	G7	H7
	Down	−60	A8	B8	C8	D8	E8	F8	G8	H8

3 Evaluation of the Positional Information

It is important to put a piece quickly and accurately on the board when we play the Othello game, so we evaluated effectiveness of the positional information about the tactile guide, the speech guide, and the auditory display.

3.1 Method of the Experiment

Five ordinary persons in their 20's are chosen as the subjects. Subjects wear an eye mask to be a blind artificially. Subjects move their finger toward the target position by voice from the top right Fn hole as the start position and click the button B. The time they spent and the moving process is observed. The 20 coordinates out of 64 points are chosen evenly. We measured 5 times on each condition.

The conditions are as follows: using each interface separately, using two interfaces combined, and using all interfaces at the same time. Also we measured using tactile guide exclusively without an eye mask for comparison.

3.2 Result of the Experiment

The results of experiments are shown as Fig.4, Fig.5. Fig.4 indicates the average time of all subjects per trial. Fig.5 indicates average wrong times per trial. According to Fig.4, it is faster to use the tactile guide, the speech guide, and the auditory display in that order. The variance of the result of the auditory display is great. The time is almost constant except for the condition of the auditory display. Therefore, it is faster when using the tactile guide or the speech guide. Combining interfaces results in a time close to that of sighted condition.

Fig.5 indicates there is little error except the condition of the auditory display. Particularly, there is no error in the condition of the speech guide as well as sighted. Therefore, the accuracy improves when using the speech guide and the tactile guide.

As a result, we find out that subjects can input the target position by using every interface. In addition, all subjects can input the target faster and more accurately by using the tactile guide and the speech guide. Therefore, the tactile guide and the speech guide are useful interfaces to play the board game. Also, it is unnecessary to practice using the interface because the average time is almost constant except the condition of the auditory display.

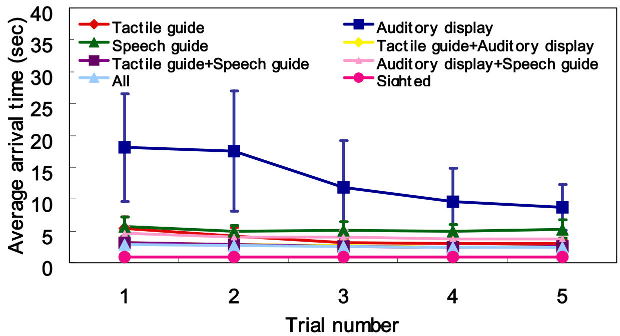

Fig. 4. Comparison of the average arrival time

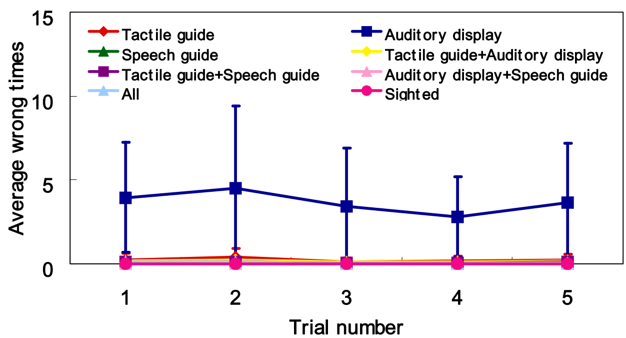

Fig. 5. Comparison of the average wrong times

4 Evaluation of the Game

We considered playing the Othello game using our system. For the game to proceed not only positional information but also semantic information is necessary. Then we carry out the evaluation which focuses attention on the time to place a piece. The situation of the Othello game is shown in Fig.6.

4.1 Method of the Experiment

In the experiments, three subjects play the Othello game on the computer. Also, subjects wear an eye mask. At that time, the behaviors of subjects and the time to put a piece are observed. The procedure of the Othello game is shown bellow.

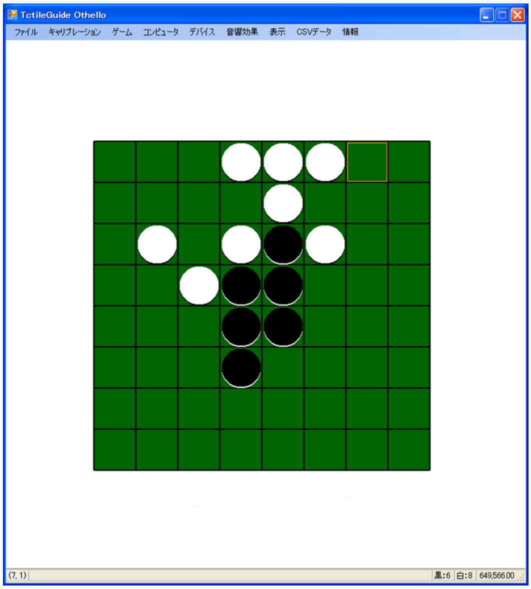

Fig. 6. Situation to the Othello game

First, you can select from the black player or the white player to start the game. If you select the black player, the speech guide tells you that you are the first move, and the game starts. Then, you must put a piece on a place on the board that has at least one straight (horizontal, vertical, or diagonal) occupied line between the new place and another black piece with one or more contiguous white piece. After placing the piece, you can turn over all white pieces lying on a straight line between the new piece and any anchoring preoccupied black piece. This operation is controlled by the PC. Next is the white player's turn. The white player is a computer and this player operates under the same rule as the black player. Players take alternate turns. If one player cannot make a valid move, the turn passes back to the other player. When neither player can move, the game ends. The player with the most pieces on the board at the end of the game wins.

We measured 5 times for each condition. The conditions are as follows: using our system, using our system without an eye mask, using the Othello board for the blind. When using our system, the computer has three techniques shown below [9].

Level 1: Check the board from top to bottom, for a place to put a piece.
Level 2: Check the four corners, and does the same as Level 1 when the four corners cannot be used.
Level 3: Check the four corners. If the four corners cannot be used put a piece on a place that does not allow your opponent to put a place on a corner.

4.2 Result of the Experiment

The result of subject A is shown as Fig.7. Each condition shown in Fig.7 wins the game. The horizontal axis and the vertical axis of Fig.7 indicate the number of moves and the input time of putting a piece.

As the result, all subjects can play the Othello game by using this system. It shows that the input time of the level 1 is shorter than the Othello board for the blind on the whole. When use the Othello board, we grasp the layout on the board at first, put the piece after planning the strategy. However, our system instantly indicates a place where a piece can be placed by the vibrating stimulus. It is thought that this time difference occurs because of this stimulus.

We compare the difference of the level in our system next. It is generally thought that a strategy becomes difficult with the rise of the level. Moreover, it is remind to expect the situation on the board next turn and do not put at the corner. Especially, the result that wins the level 3 is said that we put a piece after having considered the strategy. Therefore, we see that visually impaired persons can play the Othello game.

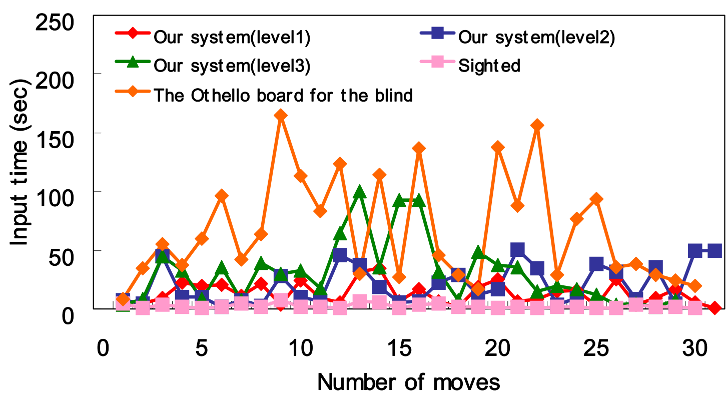

Fig. 7. The time of putting a piece

5 Conclusion

In order to develop a useful interface using the auditory and tactile feedback for visually impaired persons, we perform experiments by using a board game. To obtain positional information, a tactile guide and a speech guide are useful interfaces to play the board game. In the evaluation of the game, we found that our system allows visually impaired computer users to play the Othello game.

In the future, we will make a co-operative system and a system that can get closer to the level of play of Othello by a sighted person. Moreover, we will apply this system to other board games such as the Mini-Go and the Checkers game.

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