ASSISTING SYSTEM OF VISUALLY IMPAIRED IN TOUCH PANEL OPERATION USING STEREO CAMERA

Atsushi Yamashita, So Kuno, and Toru Kaneko

Shizuoka University, Japan

ABSTRACT

In this paper, we propose an assisting system of touch panel operation for people with visual disability. In the system, a user specifies the target button on the panel by verbal input. The system detects the button and user's fingertip by analyzing images obtained through stereo camera. Navigation is made by indicating the direction of the fingertip on the panel through headphones with sound. To construct an efficient navigation method, comparisons were made experimentally concerning to indication of the finger motion direction, choice of navigation sound, and indication of the distance. The effectiveness of the proposed method was verified through experiments.

Index Terms— stereo vision; wearable sensors; user interfaces; touch panel; visually impaired

1. INTRODUCTION

In this paper, we propose an assisting system of touch panel operation for people with visual disability.

There are a lot of cases in which visually impaired people feel inconvenience in everyday life. Therefore, there are studies of the use of image processing for supporting them [1–4].

In recent years, touch panels have been extensively used as input devices in various equipments. A touch panel is a flat screen containing images of buttons. Therefore, it is impossible for visually impaired people to operate the equipment since they cannot recognize the buttons. To solve this problem, an automated teller machine (ATM) having a handset with a specially designed numeric keypad and an interphone system has been developed [5]. However, such ATMs are few in number because of their high cost.

Sound presentation methods for the visually impaired in operating a touch panel are also proposed [6, 7]. However, a fixed-camera and markers on touch panel are needed. In other words, a special device must be attached to the touch panel system itself.

The aim of our research is to construct a system that can be used to simplify touch panel operation. This system can be attached to a user (wearable device) and does not require ATMs to be equipped with a special device.

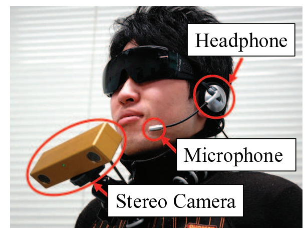


Fig. 1. Assisting system in touch panel operation.

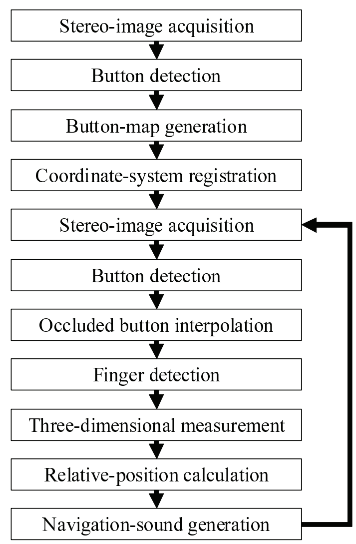


Fig. 2. Processing flow.

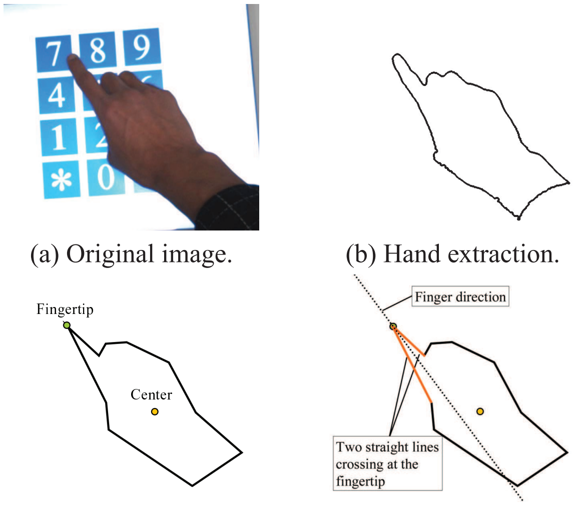
2. PROCEDURE OUTLINE

The system components are shown in Fig. 1. The user wears a stereo camera for image acquisition, a microphone for verbal input, headphones for receiving instructions, and a computer.

The processing flow is shown in Fig. 2.

Before navigation, a map that contains information on the arrangement of buttons on the panel is generated. Positions of occluded buttons in touch panel operation can be estimated

This research was partially supported by KAKENHI, Grant-in-Aid for Scientific Research (C), 21500164.



(a) Original image. (b) Hand extraction.

(c) Hand profile. (d) Finger direction.

Fig. 3. Detection method of finger direction.

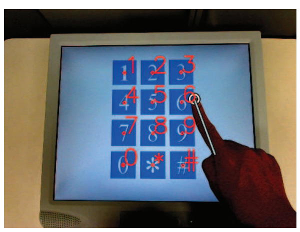


Fig. 4. Recognition result of buttons and finger direction.

by using the generated map. The direction recognized by the system is also adjusted automatically to correspond to that recognized by the user before navigation.

First, the name of the button on the touch panel that is to be pressed is specified through the microphone. The voice recognition engine recognizes the user's command.

Next, stereo images are acquired through the stereo camera. From the images, the system extracts areas, each of which has a characteristic aspect ratio and density. The character recognition process is executed for the extracted areas to determine button positions on the touch panel.

Simultaneously, the hand is extracted from the images by investigating the color components and examining if they are those of the flesh (Fig. 3(b)). Then, the profile of the hand is acquired as a polyline approximating the boundary of the hand (Fig. 3(c)). The intersection of the line pair forming an acute angle at the furthest position from the center of gravity of the hand area is determined as the fingertip (Fig. 3(d)). Figure 4 shows an example of recognition result of buttons and finger direction.

Three-dimensional (3D) coordinates of the button and the fingertip are calculated by triangulation (Fig. 5). The relative positions of the input button and the fingertip are obtained from the 3D coordinates, and the navigation sound that in-

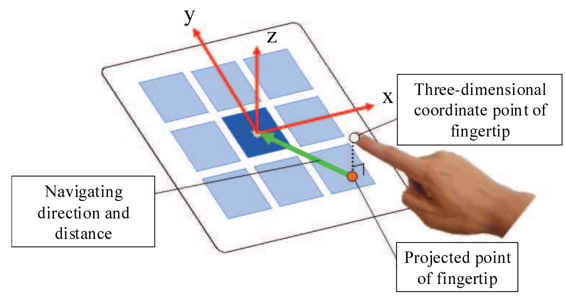
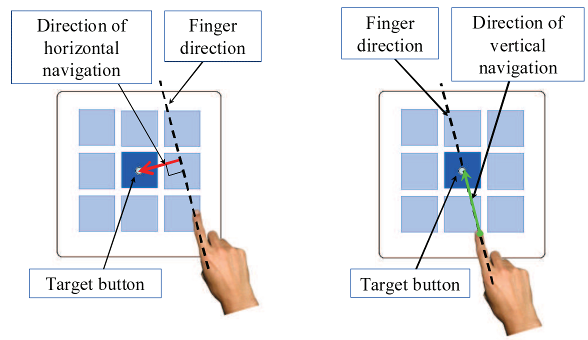


Fig. 5. 3D measurement of buttons and fingertip.



(a) Horizontal navigation. (b) Vertical navigation.

Fig. 6. Two-stage navigation.

dicates the direction in which the fingertip is to proceed is generated to be outputted to the user through the headphones. If the distance between the fingertip and the touch panel is too small in vertical direction, the system informs the users by warning sound not to touch the panel before the finger reaches the target button.

The processes from image acquisition to navigation-sound output are repeated until the user touches the right button.

3. DEVELOPMENT OF NAVIGATION METHOD

To devise an efficient navigation method, ways to indicate the direction of motion of the finger, different types of navigation sounds, and ways to indicate the distance between the finger and the panel are considered.

3.1. Direction Indication

As to the direction indication, we develop two methods; two-stage navigation (Fig. 6), and eight-direction navigation (Fig. 7).

Two-stage navigation consists of two steps; horizontal navigation and vertical navigation. The system gives the information whether the target button is in left side or right side at first (horizontal navigation, Fig. 6(a)). Then, it gives

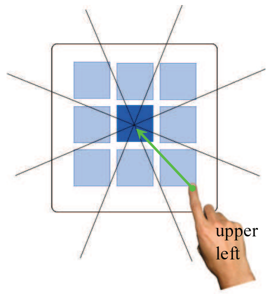


Fig. 7. Eight-direction navigation.

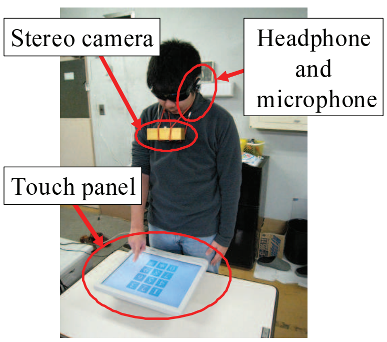


Fig. 8. Experiment.

vertical information to the user until the positions of the target button and the fingertip coincide with each other (vertical navigation, Fig. 6(b)).

Eight-direction navigation gives the direction of the target button directly in resolution of 8 directions (Fig. 7).

3.2. Navigation Sound

We use two navigation sound methods; signal sound and synthesized voice.

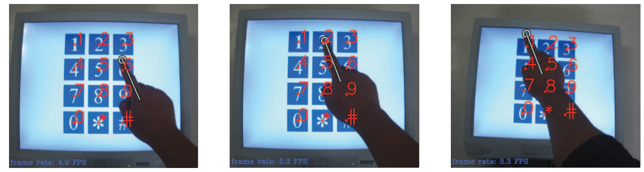
In signal sound navigation, the balance of loudness of left and right sound (stereo effects) indicates the direction of the target button (left or right). Tone pitch of the sound indicates the relative positional relationship between the target button and the finger (front side or far side).

In synthesized voice navigation, the system vocalize the direction of the target button such as “upper left” and “right”.

3.3. Distance Indication

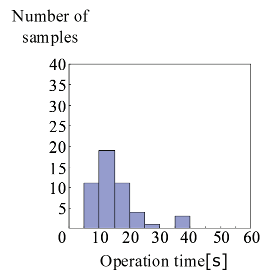
The distance between the finger and the target button is indicated by three methods; interval of output, volume, and distance.

In interval of output method, changes of interval of output means the change of distance. First tempo sound means that the distance is close. In volume method, loud sound means that the distance is close. In distance method, the system vocalize the distance directly such as “3cm”.

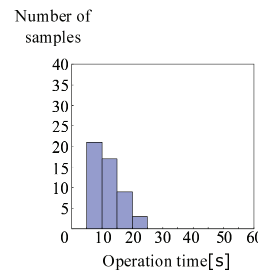


(a) (b) (c)

Fig. 9. Navigation result for occluded buttons.



(a) Two-stage.



(b) Eight-direction.

Fig. 10. Histogram of operation time of direction indication.

4. EXPERIMENT

In the experiment, the assisting system consisted of Point Grey Research Bumblebee2 stereo camera (1024×768pixel, 20fps), a normal headphone and microphone set, and a PC (Intel Core2Quad 2.83GHz, Memory 4GB) (Fig. 8). We used NET Framework SDK2.0 System Speech Recognition as the voice recognition engine and Aques Talk as the voice synthesis engine. The character recognition engine was constructed by ourselves. Average computation time was 5fps.

In the experiment, we obtained data on navigation time and views about the usability (ease) of the method by considering 10 blindfolded able-bodied subjects. Five trials were carried out on each subject.

Figure 9 shows an example of navigation result for occluded buttons. The system could stably navigate finger to the target button, although a large part of buttons were occluded by the user’s hand, especially in Fig. 9(c).

Table 1 and Fig. 10 show the comparison result on direction indication and histogram of operation time of direction indication, respectively. From these results, it is verified that the operation time of eight-direction method is faster and has good usability.

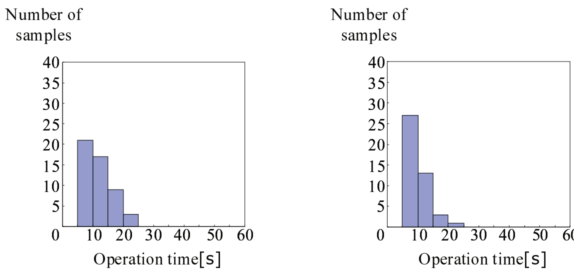
Table 2 and Fig. 11 show the comparison result on navi-

Table 1. Comparison on direction indication.

Navigation	Operation time	Usability
Two-stage	16.8s	0 vote
Eight-direction	12.4s	10 votes

Table 2. Comparison on navigation sound.

Navigation sound	Operation time	Usability
Signal sound	12.4s	0 vote
Synthesized voice	10.5s	10 votes



(a) Signal sound. (b) Synthesized voice.

Fig. 11. Histogram of operation time of navigation sound.

gation sound. From these results, it is verified that the operation time of synthesized voice method is faster and has good usability.

Table 3 and Fig. 12 show the comparison result on distance indication. From these results, it is verified that the operation time of volume method is faster and has good usability.

To sum up, the combination of eight-direction, synthesized voice, and volume navavigation was most efficient. The experiment showed the effectiveness of the proposed system where the average navigation time for the most efficient method was 9.7 seconds.

5. CONCLUSION

In this paper, we propose a touch panel operation assisting system for people with visual disability. The system recognizes buttons and a finger in the stereo images and then guides the finger to the target button. Experimental results show the effectiveness of the proposed method.

6. REFERENCES

[1] Nicholas Molton, Stephen Se, David Lee, Penny Probert and Michael Brady: "Robotic Sensing for the Guidance of the Visually Impaired," *Proceedings of the International Conference on Field and Service Robotics*, pp.236–243, 1997.

[2] Duane J. Jacques, Ranga Rodrigo, Kenneth A. McIsaac and Jagath Samarabandu: "An Object Tracking and Visual Servoing System for the Visually Impaired," *Proceedings of the 2005 IEEE International Conference on Robotics and Automation*, pp.3510–3515, 2005.

[3] Sylvain Cardin, Daniel Thalmann and Frédéric Vexo: "Wearable System for Mobility Improvement of Visually Impaired People," *Visual Computer Journal*, Vol.23, pp.109–118, 2006.

[4] Atsushi Yamashita, Rie Miyaki and Toru Kaneko: "Color Information Presentation for Color Vision Defective by Using a Projector Camera System," *Proceedings of the ACCV2010 Workshop on Application of Computer Vision for Mixed and Augmented Reality*, 2010.

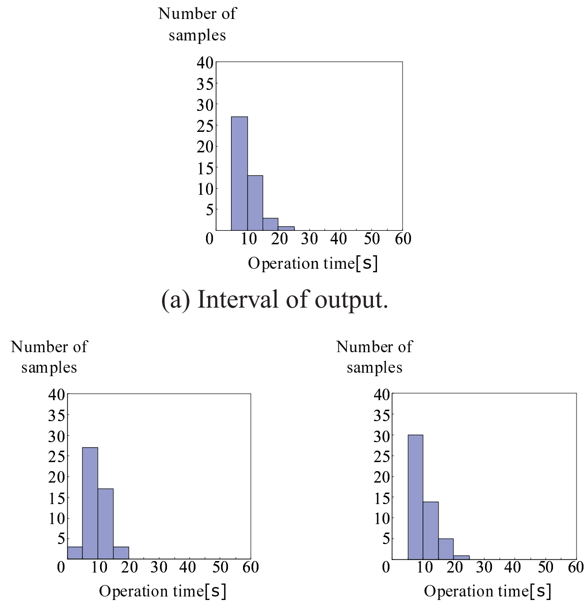
[5] Takao Asawa, Akinori Ohta and Taku Ando: "Promoting Universal Design of Automated Teller Machines," *FUJITSU Scientific & Technical Journal*, Vol.41, No.1, pp.86–96, 2005.

[6] Masamitsu Watanabe, Yoshinori Takeuchi, Tetsuya Masamoto, Hiroaki Kudo and Noboru Ohnishi: "A Finger Navigation Method for the Visually Impaired in Operating a Touch Panel," *IEICE Technical Report*, Vol.108, No.435, pp.53–58, 2009.

[7] Keijiro Usui, Masamitsu Takano and Ikuko E. Yairi: "Sound Presentation Method for Touch Panel Regarding the Use of Visually Impaired People," *Proceedings of SICE Annual Conference 2010*, pp.2992–2998, 2010.

Table 3. Comparison on distance indication.

Navigation	Operation time	Usability
Interval of output	10.5s	1 vote
Volume	9.7s	6 votes
Distance	10.7s	3 votes



(b) Volume. (c) Distance.

Fig. 12. Histogram of operation time of distance presentation.