Development of a Touch Panel Interface that Provides Tactile Feedback Depending on the Surroundings

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Abstract. We have developed and evaluated a touch panel interface that provides tactile feedback depending on the surroundings. We attempt to provide map information for blind people and make the car navigation system replace the white cane for blind people. In the study, we emphasis on providing tactile feedback for blind users that reflects the surroundings. The design of the interface to tactile feedback is that the touch panel moves up and down with a touch position. Those movements provide the tactile feedback. In order to achieve the tactile feedback method, we have placed four servo motors at the four corners of the touch panel. The motors move up and down the panel. From the evaluation experiments, we have observed that it is possible for a blind user to recognize map information by touching the panel.

Keywords: Tactile feedback, Electric wheelchair, Multi touch panel, Assistive technology.

1 Introduction

Wheelchairs are the major moving apparatus for handicapped people. In the previous paper, we have reported our experiences about an interface that we have designed and implemented for electric wheelchairs that makes users recognize the surrounding circumference so that it prevents accidents. Even though we have implemented a viewer for the user that liberates the user from the constrained perspectives, we assumed that the user can see the display as well as the circumstances. We have not assumed the user of blind people. There are, however, a certain number of blind people who need to use wheelchairs.

Therefore, we have designed and implemented a touch panel interface that provides the wheelchair users tactile feedback over that circumstances. The motivation is an interface device for wheelchairs that provides similar functions of the white canes. The interface consists of a touch panel that moves up and down depending on the existence of any obstacles in front of the wheelchair. The surrounding information can be retrieved through the laser range finder (LRF). We employ usual surface capacitance for the touch panel, because our purpose is providing everyday apparatus and low cost is an important factor.

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2 System Configuration

The touch panel has four servo motors at the four corners that make the panel move up and down at three levels as well as incline the panel so that the user can feel the tactile sensation how far and which direction the obstacle is. The resolution of the touch panel is 512×666 pixels. The distance between the bottom and top position of the panel is 13mm, and it takes 0.085 second to move from bottom to top and vice versa.

By using this touch panel that moves up and down depending on the existence of any obstacle, the user can drives his or her wheelchair as if he or she walk with the white cane. Our first goal has been achieved. However, if we can provide some kind of navigation system for blind people, it should be useful. Our second goal is providing more accurate information than that of the LRF can provides.

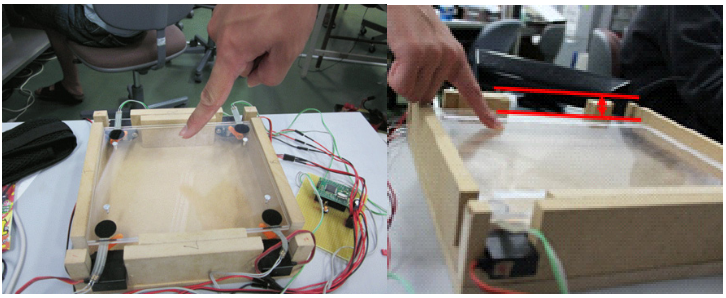

Fig. 1. A touch panel system equipped tactile feedback

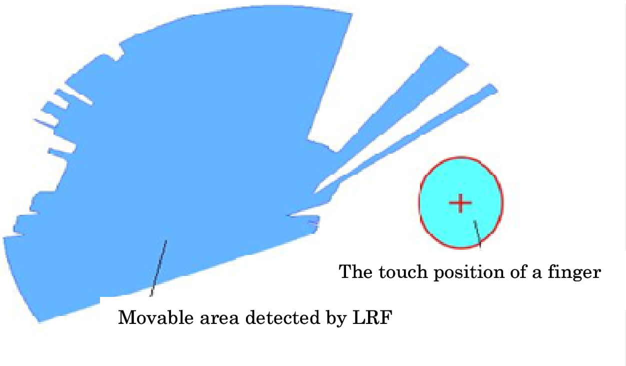

Fig. 2. A touch panel system equipped tactile feedback

Our assumption is that a blind user of the wheelchair would not drive unknown area alone. Therefore we do not need complete navigation system just as car navigation system. We only register the map information of the users' home or work place as well as immediate neighboring area.

The user is expected to touch the panel by using his or her finger, and the coordinates of the position of the fingertip are acquired by the connected microcomputer. The circumstances in front of the user are mapped into the panel so that panel functions as an invisible map of navigation system.

When the user touches a certain point of the surface, the position is calculated and mapped into the hidden map, and if the touched position is blocked by some obstacle, the touch screen rises to make the user sense the obstacle. Therefore, when the user drives his or her wheelchair, and go through a winding aisle, the user can sense the drivable route of the winding aisle on the touch panel. The user also can sense the corner of the aisle as the appearance of an open gap on the wall of the aisle.

3 Experiments for Performance Measurement

From the numerical experiments, we have observed that it is roughly possible for blind users to recognize map information by touching the panel. Even though the recognition accuracy by the tactile sense of this device is depending of the individual sensibility, the device achieved to provide base functionality.

For example, we have used a map in the experiments as shown in Fig. 3.

We acquired the following knowledge by the experiments using this simple map.

(1) It is generally possible the user can sense 16mm (on a panel) width as a route.

(2) It is enough to perceive width of a 12.5 mm up-and-down motion.

(3) For the feedback, the conditions that the high level indicates obstacles, the low level indicates road and the middle level indicates “start” or “goal” points are good enough for recognition.

We have observed that the participants tend to scan the whole panel with a finger first to perceive a route on the map. Thus the subjects have rightly recognized the topology of the graph of the route. Fig. 4 and Fig. 5 show how the subjects recognize the routes represented on the touch panels as the results of the experiments using this system. Fig.4 shows that many subjects have incorrectly recognized the routes. However, when a subject was advised that he should scan the panel beforehand, he could greatly improve the recognition rate (Fig.5).

Fig. 3. Simple maps for experiments

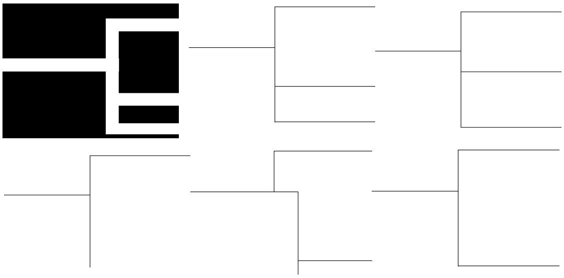

Fig. 4. Examples of result (tracing route)

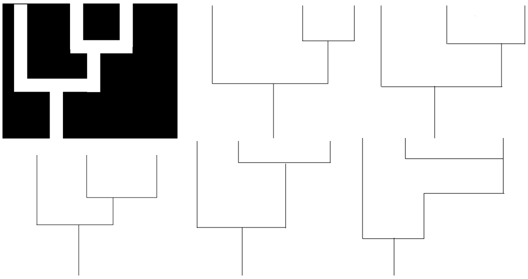

Fig. 5. Examples of result (scanning whole the panel before tracing)

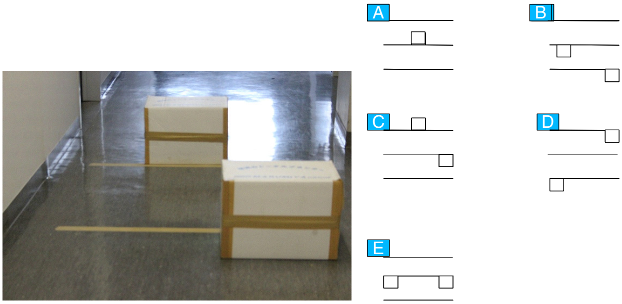

Fig. 6. Obstacles detection

Therefore we can conclude that blind users can drive his or her wheelchairs in well-acquainted places such as home or work place as well as immediate surrounding by using this touch panel navigation system.

In the emergency case, when the user must stop immediately, the panel inclines at maximum steep so that the user can sense the immediate obstacle in front of him or her (Fig. 6). We believe that the combination of the LRF and navigation map widen the activity area of blind people. We have observed, however, that it is hard for the LRF to detect moving obstacle as well as the LRF itself is moving.

We are well aware of the limitation of the touch panel interface. Even though it is very inexpensive, the accuracy is limited. We are planning to design and to implement a new touch panel that is able to provide unevenness so that the user can sense the route by his or her palm or multiple fingers instead of single finger.

In the current design, only a single point can respond by the technique of using the up-and-down motion of a panel. We are currently developing a new system; however, we extend the system that responds two points in the feedback system. The method is to lean the panel combining up-and-down motion of two points. Since leaning the panel as well as moving up and down makes a virtual three-dimensional structure, we have found that a user can easily understand the map by the expansion. Even though the experiments with touching two points and leaning the panel are still in preliminary stage, the new system improves the users' recognition ability, and the subjects give us favorable responses.

4 Conclusion and Discussion

We have proposed and developed a touch panel interface that provides tactile feedback depending on the surroundings. The design of interfaces for the tactile feedback is using a touch panel that moves up and down according to the touched position.

As tactile feedback method, we have placed four servo motors at the four corners of the touch panel. The motors move up and down the panel. The resolution of a touch panel is 512×666 pixels. A panel takes 0.085 second for moving up and down 13mm.

As the result of the experiments, we have found that it is possible for blind users to recognize map information by touching the panel. Feasibility study is now in progress using an electric wheelchair. Even though preliminary experiments suggest favorable results, there is some room for improvement. We are re-designing our interfaces while continuing to conduct the feasibility study to provide more flexibility to the users.

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