Proposal of a Direction Guidance System for Evacuation

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Abstract. In this paper, we propose a device that indicates the direction to evacuate. Our proposed system, which would present the direction through the tactile sensation of the head, could be used in no visibility environment such as filled smoke. This paper describes a feasibility of our proposed system and indicates problems to be solved.

Keywords: Evacuation, Smoke, Direction, Guidance, Tactile sensation.

1 Introduction

Generally speaking, there is an electrical sign to escape in case of fire at a hotel. However, if there is a massive poll of smoke we will not able to see the sign and we will feel fearful while evacuation. Moreover, if the sign can not be seen or is turned off because of flat battery during night time we will not be able to know which way we have to go in the dark. In such this environmental condition, the sighted person will become similar to a blind person because visual information can not be available.

Incidentally, we went about to develop a new device which presented the visually impaired person with the obstacles direction and distance. As for direction, we proposed a new method to present the direction of obstacle by tactile stimulation and revealed its effectiveness [1]. If using our experimental results, we hypothesize a person would know easily an escape direction by tactile stimulation. Also, we hypothesize a person will be able to escape without using visual information while smoky dark environment. However, our previous experimental results [1] were obtained under the condition in which subjects were fixed on a chair and they were not allowed to walk.

Then, in this paper, we investigated whether or not subjects were guided by tactile stimulation to a designated direction while walking and we reported feasibility of our system to help evacuation.

2 Direction Displaying Method

Figure 1 shows one of experimental results when our direction displaying method was used. In this experiment, first tactile stimulation was presented, next the subjects were

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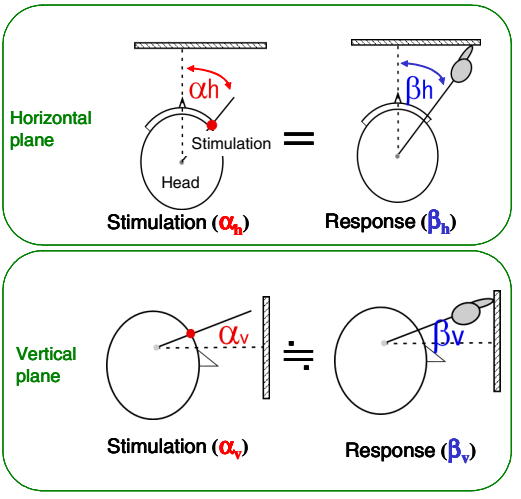


Fig. 1. Direction displaying method [1]

asked to imagine the direction of stimulated point, lastly the subjects were asked to point the direction with their fingers. In this experiment, we used an air stimulation as tactile stimulation because that the air stimulation did not cause uncomfortableness.

Left figure shows the angle between tactile stimulation and face forward direction (alfa), and right shows the angle between pointed direction and face forward direction (beta).

From the upper figures, alfa is equal to beta. That is, if there is an obstacle at 30 degrees rightward for example, tactile stimulation should be presented 30 degrees right on the head. Therefore, the blind person will be able to imagine where the obstacle is. Or, if you intend to guide the blind person to the 30 degrees rightward, tactile stimulation should be presented 30 degrees right on the head.

However, these results were obtained when the head of subjects were fixed, that is to say, it was not known whether or not these results applied to the condition in which the head moved while walking. Then, we investigated a feasibility.

3 Feasibility Study

In order to present a designated direction, tactile stimulation point should be changed according to the movement/rotation of head while walking.

Firstly, we made a head movement measuring unit by combining gyro sensor and digital magnetic compass. The gyro sensor and digital magnetic compass was small and light weight, so the unit does not become obstructive to evacuate. On the basis of the head movement speed, optimal gyro sensor and compass were selected.

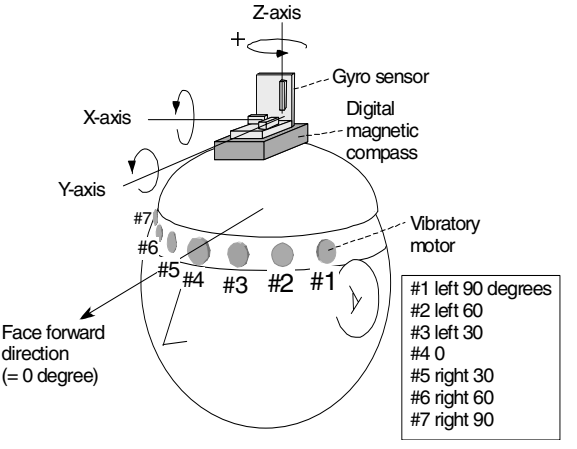


Fig. 2. Our guidance system

Next, air stimulation was used as tactile stimulation in previous experiment. However, it is impossible to carry the experimental setup which includes an air compressor and electrical valves because of its heaviness and big size. And we think the experimental results are applicable to any tactile stimulation such as vibration. Then, we used vibration caused by vibratory motor because a vibratory motor was light weight and easy to control. From the preliminary psychophysiological experiment, the arrangement of vibratory motors on the head was decided.

Then, we have made a system by combining vibratory motors, gyro sensors and digital magnetic compass. The outline of our system was shown in figure 2. In this system, seven vibratory motors were arranged in every 30 degrees on the head and three gyro sensors and a compass were put on the head.

Guided walking experiment was done in order to investigate whether or not the subjects could be guided to a designated direction. In this experiment, the four

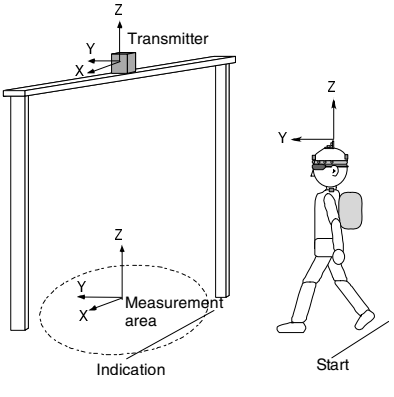


Fig. 3. Experimental setup

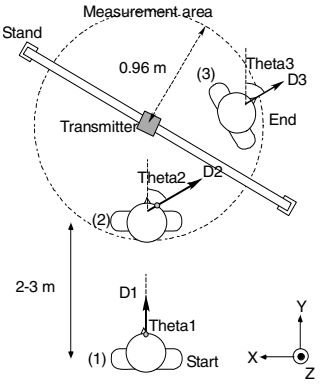


Fig. 4. Experimental protocol

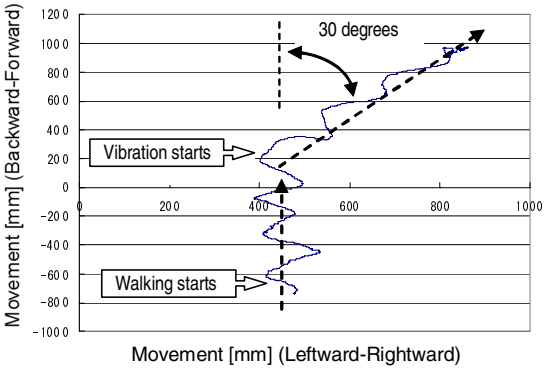
subjects who wore blindfold were asked to walk to the direction which was pointed out by vibration of a vibratory motor.

Figure 3 shows experimental setup. The head position while walking was measured by a magnetic three-dimensional positioning sensor(Fastrak). A transmitter of Fastrak was put on a wooden frame and two receivers were put on the front and back of the head so that head center was calculated. A subject was asked to walk following a vibration on the head.

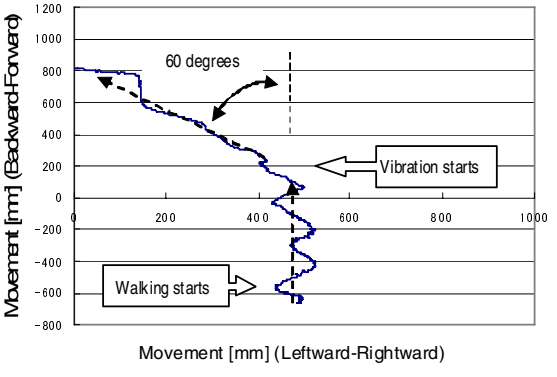
Figure 4 shows the experimental protocol. First the subject started to walk at the start position(indicated by (1) in figure 4 and indicated by start in figure 3). At this time, #4-vibratory motor was vibrating, that is to say, vibration was added to the forehead center and the subject walked to the forward direction. After walking for about 2 or 3 meters, another vibratory motor started to vibrate((2) in figure 4 and indication in figure 3). The subject was asked to turn to the direction which the vibration indicated. In other words, the subject was asked to turn until vibration moved to the forehead center. Before executing experiment, the subjects were not trained at all.

Figure 5 shows one result. These graphs show overhead view of track of head position. Vertical axis shows the head movement in backward and forward direction, whereas horizontal axis shows the movement in leftward and rightward direction. After starting the experiment, the center motor(#4) vibrated so the subjects went straight ahead and the track moved from the bottom to the center of the graphs. Next, in graph (a), #5-motor which was set at right 30 degrees vibrated. After the motor vibrated, the subject turned to the rightward. The graph shows that the direction of track changed and the angle change was about 30 degrees. Similar results were obtained for 60 and 90 degrees and were obtained for other subjects.

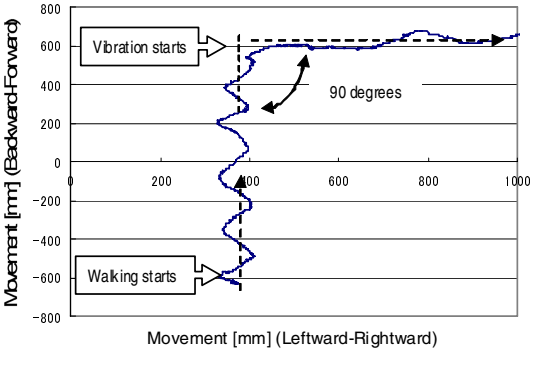
From these results, we thought that our system could guide the subject to the designated direction in this experimental condition.



(a) 30 degrees rotation



(b) 60 degrees rotation



(c) 90 degrees rotation

Fig. 5. Track of guided walking

4 Problems to Be Solved

The experimental results showed a possibility that our system could guide a person to the designated direction without training. However, an integral error would become problem if the head moved complicatedly. For example, figure 6 shows the angle difference between an angle measured by our head movement measuring unit and an angle obtained by two Fastrak receivers which were put on the front and back of head. Figure 6 shows one result when a subject walked with his/her intention for 30 seconds. The value changed for positive or negative but maximum value was about 50 degrees. Nevertheless to say, this angle difference depended on the walking condition, but it was difficult to imagine there was no angle difference. Then, we have to make a method which will decrease the angle difference.

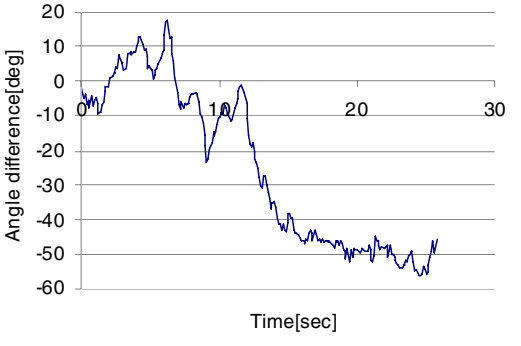


Fig. 6. Change of angle difference while walking

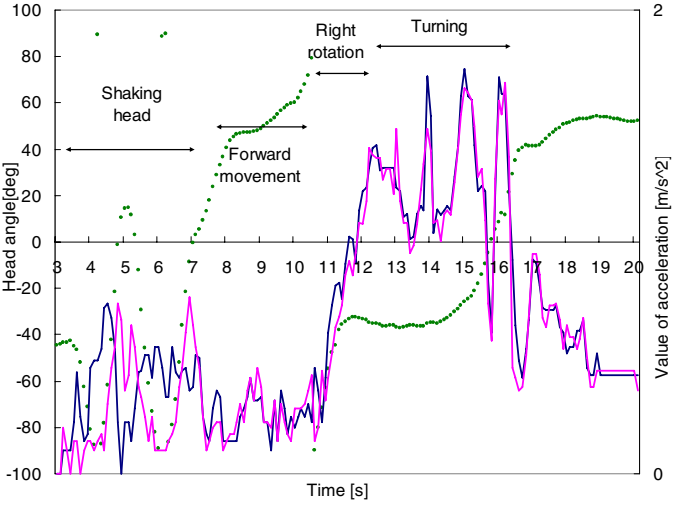


Fig. 7. Head movement and change of acceleration value

The reason why the angle difference was occurred is thought to be accumulation of integral calculation error of gyro sensor. If small change of head movement such as head shaking which is not related to walking is avoided, the angle difference may become small. Then, we investigated whether or not small head movement could be detected by using two acceleration sensors which were put on both head sides. A subject executed the following four actions; shaking head, walking forward, rotating rightward and turning right. Figure 7 shows a result. Dots indicate head direction while two lines indicate values of two acceleration sensors which were put on left/right of head. This graph indicates that neither acceleration values changed much for the forward movement, though they did change in a similar way for the rightward rotation and in a similar way periodically for the right turn, and there was no relationship between them for the head shaking. Then, we thought small head movement during the forward movement might be detected, but more researches are necessary.

5 Conclusion

In order to evacuate in no visibility environment, we proposed a method which present direction by tactile sensation. Our results showed the possibility of our proposition but showed problems to be solved. We would like to solve the problems and make a useful evacuation system in the near future.

Reference

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