WALKING SUPPORT SYSTEM FOR BLIND PEOPLE USING PHOSPHENE

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ABSTRACT

Most of blind people use a white stick for walking. However, the detectable obstacles are only the things nearby that the white stick can touch, hence, not every danger can be avoided. In addition, some of them feel uncomfortable carrying the white stick since it explicitly shows that they have a handicap. In this study, aiming at the safe walking for blind people, a new walking support system using phosphene will be proposed. The phosphene is the phenomenon that a flash of light is recognized in the brain by giving electrical stimuli such as tDCS and tACS to a specified part of the head. In this system, the obstacles within a certain range from the user and their directions will be detected by three ultrasonic sensors attached on the frontal region of the head. Subsequently, the existence of detected obstacles and their directions will be perceived by the user using phospene. These ultrasonic devices are connected to a microcomputer, and then the electrical stimuli can be easily controlled based on the directions of the obstacles. The notable point is that this system enables an intuitive obstacle detection by visual stimulus which cannot be intrinsically provided to blind people. Furthermore, the system device is small enough for the user to carry, that is to say, it can be a wearable device to support the safe walking for blind people instead of the white stick. In this paper, firstly, the research background will be introduced. Continuously, the related work with the pros and cons, and the principle of the proposed system will be described. After that, the system implementation will be thoroughly stated. To show the effectiveness of the proposed system, the preliminary results obtained by the substantiative experiment will be discussed. Finally, the paper will be concluded with the future work.

INTRODUCTION

Blind people cannot obtain the information of visual sensation, and thus they are likely to be exposed to danger when they are walking somewhere. Therefore, it is important for them to safely avert obstacles using a walking support tool. Blind people often use a white stick when they walk outside. In this case, they can detect an obstacle without hitting it since the white stick directly touches the obstacle instead of their bodies. This is an ideal walking support tool due to the safety. However, the white stick has some weak points. For example, when a blind person is using a white stick, one hand that is holding the stick is always busy. If he/she falls down it would be a serious and dangerous accident because it is difficult to fully protect the body with only one hand. In addition, some of blind people feel uncomfortable carrying the white stick since it explicitly shows that they have a handicap. Hence, the following two points are required for the walking support system for blind people: (1) both hands are free, and (2) they look natural with the equipment.

RELATED WORK

Besides the white stick, some walking support systems for blind people have been studied. Lasley Kay et al. developed Sonic Guide using an ultrasonic transmitter and two ultrasonic receivers (Sasaki, 1993). This system detects the distance from the user to an obstacle using the ultrasonic devices and notifies the user of the distance by sounds with different frequencies depending on the distance. However, it uses a pair of earphones to give the sounds to the user, therefore, the user’s audio sensation will not be available to the outside sounds.

Miyuki Saito studied Navi Hat (Saito, 2015). Navi Hat also uses ultrasonic sensors, but the way to inform the position of the obstacle is different. It makes vibrations, when the distance to the obstacle becomes shorter than a certain value. However, it cannot detect diagonal directions and obstacles around the foot. Therefore, Navi Hat cannot be used in a real situation.

To overcome the difficulties mentioned above, a new walking support system for blind people using visual sensation, “phosphine”, will be proposed. This is the most important point in this study since it uses the visual sensation as phosphine even though they are blind.

PHOSPHENE

Phosphene is the phenomenon that a flash of light is recognized in the brain by giving electrical stimuli to a specified part of the head. In this study, a noninvasive device is used to induce the phosphene. There are some studies to induce the phosphine using TMS (Transcranial Magnetic Stimulation) (Alan, 2000) and tACS (transcranial Alternating Current Stimulation) (Ryota, 2008). Both of studies gave the stimuli to the occipital cortex. The former clarified the correlation between the position where the phosphene is observed and the position where the stimulus is given. However, TMS tends to cause side effects such as itchy skin, headache, nausea and convulsions. In addition, TMS device is so large and heavy that it cannot be used for a walking support system. The latter investigated the apposite frequency and electric current value to induce the phosphene. tACS is safer than TMS because there is no side effect, and also it is very light. However, there is no study that discusses the correlation between the position where the phosphene is observed and the position where each electrode is placed. Therefore, this investigation is focused on in this study in order to use the phosphen with tACS for the walking support system.

PROPOSED SYSTEM USING PHOSPHEN

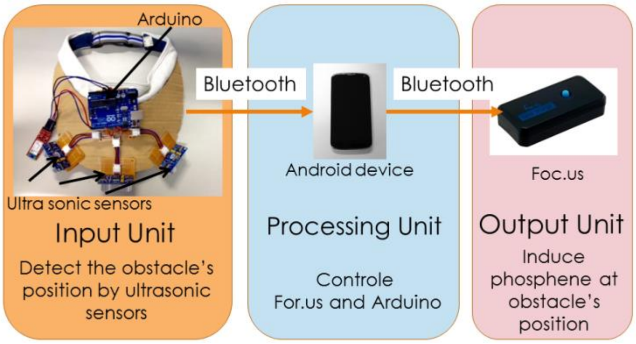

Fig. 1 Schematic block diagram of proposed system

The proposed walking support system for blind people is operated by an android device. The schematic block diagram of this system is shown in Fig.1. The system is divided into three parts: Input Unit, Processing Unit and Output Unit. Input Unit is composed of three ultrasonic sensors and an Arduino system with Bluetooth module. Processing Unit is implemented on the android device which is connected to both Input Unit and Output Unit with Bluetooth. Output Unit is a controller that controls the tACS device. The ultrasonic sensors in Input Unit obtain the distance to an obstacle and the distance data is sent to Processing Unit via the Arduino system with Bluetooth module. Processing Unit monitors the distance data and when the distance to the obstacle becomes shorter than a certain value, a command, which switches on the tACS device, is sent to Output Unit to induce the phosphene.

SYSTEM EVALUATION

To evaluate the proposed system, two types of experiments were conducted. The purpose of the first experiment is to verify whether the phosphene is induced at the intended position or not, by placing the electrodes of the tACS device adequately. The purpose of the second experiment is to clarify the appropriate frequency to induce the phosphene.

Fig. 2 Experimental environment

Figure 2 shows the experimental environment. The subject wears an eye mask. Foc.us has been selected as a tACS device since it is small and light enough to carry. The parameters used to give electrical stimuli is controlled by the application software on android device. Note that Foc.us has many functions to give electrical stimuli such as tDCS (transcranial Direct Current Stimulation), tPCS (transcranial Pulse Current Stimulation), tRNS (transcranial Random Noise Stimulation) as well as tACS, therefore, this device can be useful for further study on the stimuli to induce the phosphene.

Figure 3 presents the electrodes placements that were used in the first experiment. Table 1 shows the predicted positions where the phosphene would be induced.

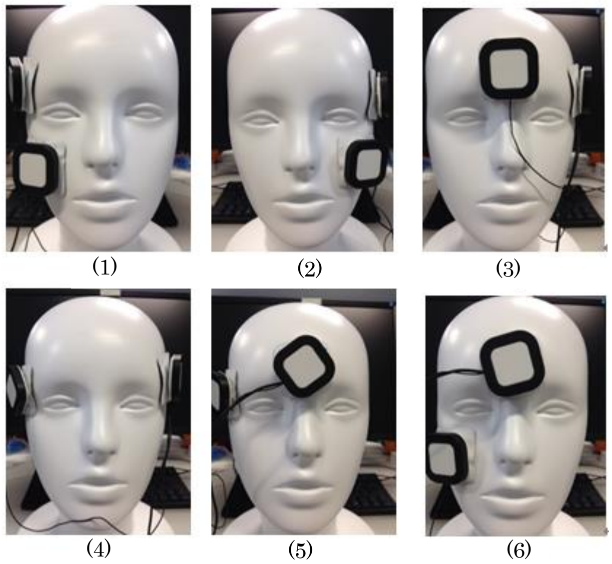

Fig. 3 Electrodes placements

Table 1 Predicted phosphene's positions

No. of placement	Position(s)
(1)	Right
(2)	Left
(3)	Front, Left
(4)	Left, Front, Right
(5)	Front, Right
(6)	Front

For the first experiment, 10 healthy subjects (8 males and 2 females) were selected and they answered where the phosphene was induced in each electrodes placement.

Table 2 shows the result obtained from the subjects. The first column represents each subject A to J. If the phosphene was perceived, "P" is shown in the column corresponding to the perceived positions. Otherwise, "N" is shown in the column. Almost all the answers were consistent with the predictions. Only gray cells in Table 1 indicate the different answers from the predictions. It is noted that all the inconsistent answers occurred when the predicted positions include "Front".

Table 2 Positions where phosphene was perseived

	(1)			(2)			(3)		
direction	left	front	right	left	front	right	left	front	right
predicted	N	N	P	P	N	N	P	P	N
A	N	N	P	P	N	N	P	P	N
B	N	N	P	P	N	N	N	P	N
C	N	N	P	P	N	N	N	P	N
D	N	N	P	P	N	N	P	P	N
E	N	N	P	P	N	N	P	P	N
F	N	N	P	P	N	N	P	P	N
G	N	N	P	P	N	N	P	P	N
H	N	N	P	P	N	N	P	P	N
I	N	N	P	P	N	N	P	P	N
J	N	N	P	P	N	N	P	P	N
	(4)			(5)			(6)		
direction	left	front	right	left	front	right	left	front	right
predicted	P	P	P	N	P	P	N	P	N
A	P	P	P	N	P	P	N	P	N
B	P	P	P	N	P	P	N	P	N
C	P	P	P	N	P	P	P	P	P
D	P	P	P	N	N	P	N	P	N
E	P	P	P	N	P	N	N	P	N
F	P	P	N	N	P	P	N	P	N
G	P	P	P	N	P	P	N	P	N
H	P	P	P	N	P	P	N	P	N
I	P	P	P	N	P	P	N	P	N
J	P	N	P	N	P	P	N	P	N

The reason why it is difficult to perceive the phosphene at the front position must be the current flow. When the phosphene is induced at the front position, the electrodes should be placed across the both retinae from each other. In other words, the electric current flow must be well-balanced to both retinae. Therefore, it is necessary to adjust the parameters of tACS such as electric current, voltage and frequency in order to control the electric flow depending on the subject.

Table 3 Valuation basis in MOS

MOS	Valuation basis
5	Perceived clearly
4	Perceived well
3	Perceived
2	Perceived slightly
1	Not perceived

For the second experiment, 5 healthy subjects (3 males and 2 females) were selected and they answered if the phosphene was perceived or not when the frequency of the tACS was varied from 1Hz to 30Hz. The answer style complies with 5 steps Mean Opinion Score shown in Table 3. The higher the score is, the clearer the phosphene was.

Figure 5 presents the result obtained from the subjects and each subject is denoted as a to e. Fig.5 shows that it was difficult for 4 subjects to perceive the phosphene when the frequency range is from 15Hz to 30Hz. Furthermore, only subject e has a different tendency.

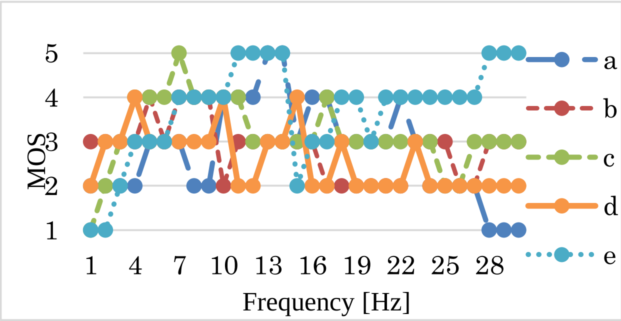

Fig. 5 MOS vs. Frequency

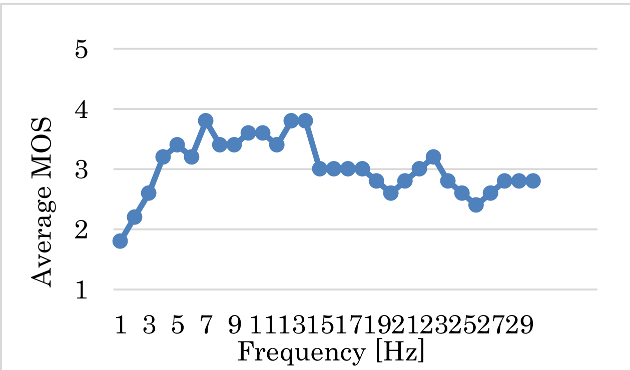

Fig. 6 Average MOS vs. Frequency

Apart from subject e, there is a certain tendency on MOS to the frequency range. To clarify the appropriate frequency to induce the phosphene, the average MOS from all the subjects' results was calculated. Figure 6 shows the graph of the average MOS when the frequency varies. It is obvious that the appropriate frequency rage is from 4Hz to 14Hz. As mentioned before, subject e perceived the phosphene well even though the frequency was more than 15Hz which is a different tendency from the subjects. However, the appropriate frequency range from 4Hz to 14Hz also covers the better condition of subject e. Hence, it is concluded that the above frequency range is appropriate for all the subjects in this experimrnt.

CONCLUSION

I clarified that I could show phosphene to the direction that I aimed at as validation of the output part in the systems of this study. However, it is necessary that the precision of the front direction's phosphene is improved for the safety walking support system. In addition, I clarified that the apposite frequencies to induce the phosphene were 4Hz to 14Hz. Therefore, I'll use the frequencies on future walking support. Will investigate the visual performance of the phosphene by the frequency in future; of the result of subject e investigate the cause.

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Manami Kanamaru is going to receive her B.E. in 2016 from Shibaura Institute of Technology. She currently belongs to Mobile Multimedia Communications Laboratory. Her research interests.

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