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Poster

Electrical Stimulation Method Capable of Presenting Visual Information Outside the Viewing Angle

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Abstract

Galvanic sight stimulation (GSS) is a lightweight and wide-viewing-angle visual information presentation method. In the GSS method, electrodes are placed on the skin around the eyeball to perform noninvasive electrical stimulation, thereby causing a white flash called phosphene. While the viewing angle of a head-mounted display is a maximum of approximately 110°, the extent to which the GSS can present visual information is not known. In this study, we demonstrate the advantages and usefulness of GSS via the quantitative measurement of viewing angle that can be visually presented by GSS, and a comparison with the viewing angle of the existing optical visual presentation method.

Categories and Subject Descriptors (according to ACM CCS): H.5 [Human computer interaction]: Human augmented reality – visual information generation

1. Introduction

Percutaneous electrical stimulation is a technique that can induce various senses using only a lightweight and inexpensive electric stimulation device. Among percutaneous electrical stimulations, galvanic sight stimulation (GSS) is a method for inducing visual information. GSS is a technique that allows you to feel the white flash (phosphene) in the entire field of view by installing electrodes around the eyeball and applying a weak current through them.

Our previous research shows that the phosphene light source is perceived around the stimulation electrode in multi-electrode GSS, and shows the utility of using this light source position change as a marker to guide the head to the target direction [HAA*17]. When we reanalyzed this experimental result, we observed that the light source position changed very broadly in the range of GSS. The presentation angle of view is an important parameter indicating the performance of the display.

By using GSS, it is possible to present vision in a wide range of view. Therefore, we propose the use of GSS instead of HMD or the use of GSS in combination with HMD. It is expected that it will be possible to create a very wide field of view by allowing the GSS to supplement the presentation of visual information in a range that HMD cannot present. However, the range in which the GSS can present vision remains unknown. Therefore, this study aims to measure the spatial presentation range of phosphene caused by multi-electrode GSS and demonstrating the superiority of multi-electrode GSS in terms of range of visual presentation.

2. Method

The subjects were three healthy adult males. This experiment complied with the safety standards approved by the local ethics research committee at Graduate School of Information Science and Technology, Osaka University, Japan, and all participants had the experiments explained to them and signed the letter of consent. The study protocol was performed in accordance with the ethical standards laid down in the Declaration of Helsinki.

The experiment was conducted in a quiet laboratory. As shown in Figure 1, electrodes were placed on the subjects under three conditions. In the first condition (i), five anodal electrodes were arranged at intervals of 3 cm in the horizontal direction from the outer corner of the eye. In the second condition (ii), five electrodes were arranged at intervals of 3 cm in the horizontal upward direction of the eye. In the third condition (iii), as well as the other conditions, five electrodes were installed in the downward direction. Conditions (i)–(iii) were also applied symmetrically to the right side and left side, totaling six conditions. Moreover, for all the conditions, the cathodal electrode was placed behind the neck.

After setting the electrodes, the subject wears an HMD (DK 2, manufactured by Oculus). In the HMD, a virtual space of 20×20×20 [m] was visually presented in a first person view with a white line on a black background. Furthermore, at the center of the field of view of the subject, a blue hollow circle with a diameter of 2 [m] was displayed, and it was made to move following the movement of the head.

The subjects underwent current stimulation from a randomly chosen from anode electrode on the face.

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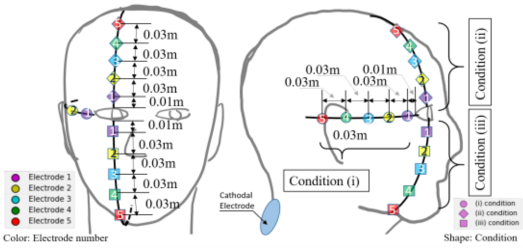

Figure 1: *Illustrations of the head of a human being are used to indicate the condition of electrode placement.*

The stimulation current was a square alternating current with a value of 1.5 [mA], frequency of 10[Hz], and current application time of 4 [s]. Subsequently, the subject answered whether phosphene could be seen or not, and if phosphene could be seen, he was instructed to rotate his head and body such that the place where the light source position of phosphene matched is inside the blue circle. During the stimulation, the subject was standing and was asked to face the front. The angle of phosphene that the subject could see was measured using a motion capture system (V120: Duo, manufactured by Optitrack), the angle of rotation from the front of the head before and after stimulation.

The conditions (i)–(iii) and the right eye side condition and left eye side condition were performed as separate sessions, and a total of 150 trials were carried out by performing five trials of stimulation for each electrode arrangement.

3. Results

In all trials, subjects indicated the position of source of phosphene accordant side with stimulation electrode positon. The graph on the left side of Figure 2 shows the average and variance of the perceived position of phosphene relative to the stimulation electrodes for each of the conditions (i)–(iii). In the case of Figure 2 (i), the absolute value of the yaw angle is shown, and in Figure 2 (ii)-(iii), the average value of pitch angle is shown. The graph on the right side of Figure 2 shows the phosphene occurrence probability relative to the stimulation electrodes for each of the conditions (i)–(iii). For each statistic of the occurrence probability, we obtained the mean and variance for six groups (three subjects and two conditions on the left eye side and right eye side). The asterisk symbol in the figure shows a condition where a significant difference was observed in the group with the occurrence probability of 0% by the Dunnet method.

4. Discussion

From Figure 2, it is shown that the multi-electrode GSS can present visual information in a wide range of visual field; the visual averaged presentation range in maximum condition in the horizontal direction is approximately 120° on one side and approximately 57° on the upper and downwards in the vertical direction. It can be concluded that GSS has a superior point of the viewing able range against conventional HMD.

Moreover, the horizontal viewing angle of 120° obtained in this experiment is wider than 100° on one side, which is the width of the human visual field, and in the case of several

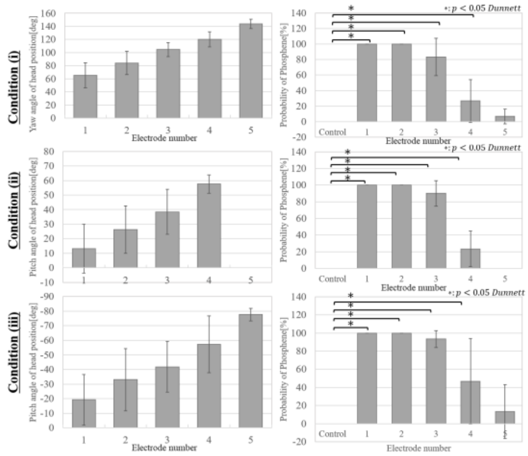

Figure 2: *Experimental result*

stimulation conditions in the vertical direction. This indicates that the multi-electrode GSS can present visual information to a position where a human usually cannot see.

Furthermore, in this study, we will allow the subject answer the light source position of phosphene. Therefore, even if the subject does not see the light source from the spatial pattern of phosphene, there is a possibility that the light source position is presumed. However, in this study, it has been demonstrated that visual information can be presented outside the field of view even though GSS is estimated.

5. Conclusions

In this study, in order to use GSS as a replacement or auxiliary of HMD, we conducted experiments to measure the range where visual information can be presented by GSS. Consequently, the GSS has a presentation angle of visual information of approximately 120° in the horizontal direction and approximately 57° on one side in the vertical direction, which is sufficiently wide compared with the presentation viewing angle of view of the existing HMD and larger than the field of view of a person. In a future work, we will increase the number of subjects to acquire data and aim to clarify the mechanism of visual information presentation by GSS.

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