GVS RIDE: Providing a Novel Experience Using a Head Mounted Display and Four-pole Galvanic Vestibular Stimulation

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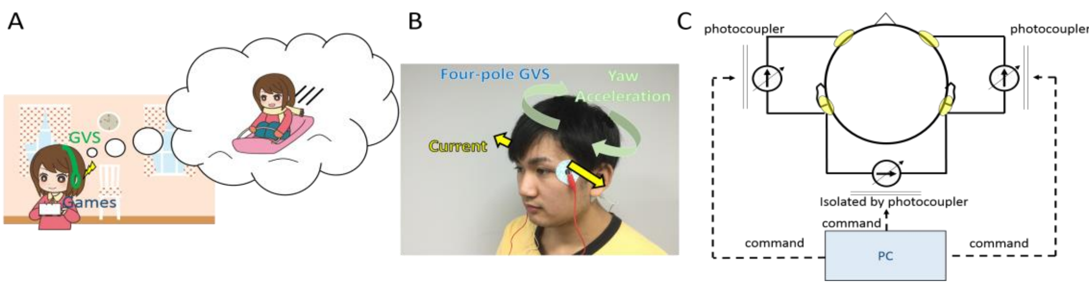

Figure 1: Use of Galvanic vestibular stimulus (GVS) for a virtual acceleration display and its composition.

ABSTRACT

Galvanic Vestibular Stimulation (GVS) is a technique that induces virtual acceleration (or virtual head motion) by the application of current to electrodes placed on the bilateral mastoids. Since the vestibular sensation closely resembles real-life sensation, it is a promising technique for virtual reality (VR) systems for presenting a highly realistic experience. However, the effect of conventional GVS is very weak. Moreover, GVS cannot induce lateral and anteroposterior directional acceleration. Thus, we invented methods to induce tri-directional acceleration (i.e., lateral, anteroposterior, and yaw rotation) to enhance virtual acceleration. The result is a new application named "GVS RIDE," which gives a highly realistic experience using four-pole GVS and a Head Mounted Display (HMD) in synchronization. This paper and our demo introduce our novel GVS method and an application using GVS with HMD.

CCS CONCEPTS

• **Human-centered computing → Interaction paradigms → Virtual reality**

KEYWORDS

galvanic vestibular stimulation, virtual head motion, multi direction, GVS RIDE.

SIGGRAPH '17 Emerging Technologies, July 30 - August 03, 2017, Los Angeles, CA, USA
ACM 978-1-4503-5012-9/17/07.
http://dx.doi.org/10.1145/3084822.3084840

1 INTRODUCTION

Galvanic Vestibular Stimulation (GVS) is a technique that induces virtual acceleration (or virtual head motion) by the application of current to electrodes placed on the bilateral mastoids. While GVS has historically been used to diagnose vestibular diseases, the technique is now adopted in virtual reality (VR) systems. Since the vestibular sensation closely resembles real-life sensation, GVS is a key technique for providing highly realistic experiences.

Conventionally, VR systems use mechanical stimulation, e.g., motion chairs, for vestibule-sensory display. Since mechanical stimulation devices are large, heavy, and expensive, they are not suitable for personal use. This is one of the reasons for applying GVS to VR systems.

Even though GVS is promising, conventional GVS presents a challenge. It can induce the acceleration sensation in only two directions. Previous works have revealed that there are two types of conventional GVS, i.e., two-pole GVS with electrodes on bilateral mastoids and three-electrode GVS with an additional electrode on the forehead [George 2011, Sever 2000]. Since a current circuit is used in both the GVS methods, these are equal for two-pole GVS. These methods induce lateral and anteroposterior directional acceleration sensation, respectively. Considering that there are six directions in actual vestibular sensation, conventional GVS lacks degrees of freedom for VR applications.

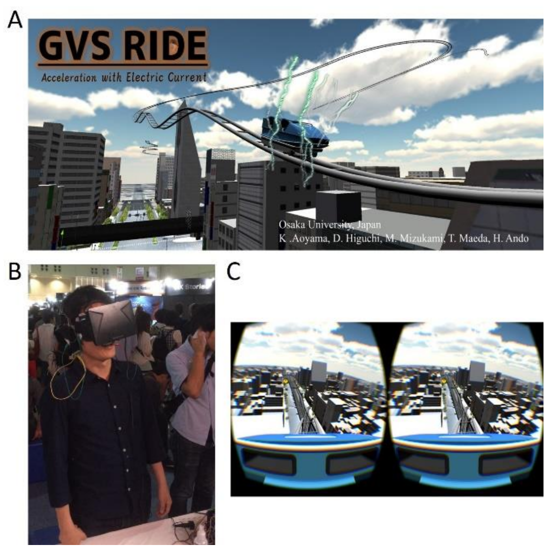

Figure 2: Application of four-pole GVS. The Poster of the GVS RIDE (A). The look of the GVS RIDE demonstration (B). The first-person view of the participant. (C).

2 EXPERIMENTAL AND COMPUTATIONAL DETAILS

Previous studies indicate that lateral directional acceleration is induced by applying a lateral directional current to the head and anteroposterior directional acceleration is induced by applying an anteroposterior directional current to the head. From these studies, we can consider that an opposite directional anteroposterior current to each side of the head induces yaw directional acceleration. To realize such stimulation, we developed a four-pole GVS. Four-pole GVS consists of three isolated bi-polar current stimulators. Each stimulator is connected to either the bilateral mastoids or the temple and the mastoid on one side [Aoyama 2015].

Our previous study showed that this method successfully induces a three-directional virtual acceleration sensation. However, the study also showed that the intensity of the anteroposterior and yaw rotational accelerations is weaker than that of the lateral directional acceleration.

3 CONCLUSIONS

We will perform a demonstration using four-pole GVS and HMD, named GVS RIDE. With our demonstration, users watch first person view video that they are riding on a roller coaster. Then they will experience two scenarios, i.e., video without GVS and video with GVS.

In the scenario of watching video without GVS, users will experience conventional VR experience where their field of view is in motion while the vestibular sensation is stable. In the second scenario of watching video with GVS, users will perceive a higher sense of presence in the virtual world.

In our demonstration, the current strength was limited to 3 mA for safety. Before the demonstration, we asked the users to sign a letter of consent. This limitation and procedure complies with the safety standards approved by the local ethics research committee at the Graduate School of Information Science and Technology, Osaka University, Japan or School of Interdisciplinary Mathematical Sciences, Meiji University. Furthermore, the experiments were explained to all participants when they signed the letter of consent. The study and demonstration protocol was performed according to the ethical standards described in the Declaration of Helsinki.

4 ACKNOWLEDGEMTS

This work was supported by JSPS KAKENHI Grant-in-Aid for Young Scientists (A) Grant Number 17H04690.

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