Accelerating Human Reaction in Virtual Reality Using Electrical Muscle Stimulation

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Electric Muscle Stimulation (EMS) has been actively explored as a solution for muscle recovery in medicine, sports, and physiotherapy. It can provide rich opportunities for human-computer interaction nowadays. It can provide tactile and kinesthetic feedback of haptic interaction. This work aims to explore the application using EMS in VR.

This work proposes Pre-Stimuli, a force-feedback approach for accelerating human reaction using EMS and maintaining a sense of control in VR, which is developed based on previous work of Preemptive Action. According to the human processor model, the user needs a specific reaction time to react to an event in some situations. If the user is stimulated at an appropriate time before the user responds, the user can complete the action through the EMS method, which can improve the users reaction speed while maintaining a sense of agency (control). This approach has positive effects on immersion in VR.

In order to verify the effectiveness of Pre-stimuli on immersion in VR, two main experiments were conducted in this study, the preliminary study and the user study. In the preliminary experiment, we measured the participants' average reaction time and explored the Pre-Stimuli for the system engineered for the user study.

In the user study, we used Pre-Stimuli in combination with three different feedback to investigate the effects of Pre-Stimuli combined with various forms of feedback. Pre-Stimuli was the independent variable in three controlled experiments. The user study asked participants to join three controlled experiments (two trials in each experiment, a total of six trials). The participants are asked to fill out a questionnaire modified from the IGroup Presence Questionnaire (IPQ) after each trial. The IPQ is a scale for measuring the sense of presence experienced in a virtual environment (VE). The results of IPQ show that the experimental group using Pre-Stimuli outperforms the control group without Pre-Stimuli on all subscales.

In conclusion, the contribution of this work has two sides:

(1) We adopted the previous work of Preemptive Action in VR environments.

(2) We applied this approach to different kinds of feedback

It is verified that the proposed Pre-Stimuli systems can enhance immersion in VR.