A Fundamental Study of Mid-air Haptics through Galvanic Vestibular Stimulation for Enhancing Whole-body Force Perception

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Virtual Reality (VR) technology has the potential to provide users with immersive and interactive experiences. However, the limitations of current VR systems, particularly in terms of trade off between device weight and the force of haptic feedback. This study aimed to investigate the potential of using galvanic vestibular stimulation (GVS) to enhance force perception in VR environments. This study had three prototype systems. Experiences with the first prototype were discussed. A pilot study was conducted using the second prototype to investigate the user's perception of the combination of GVS and mid-air haptic sensation. The results suggested that a fan or focused ultrasound waves provided more force perception than an air cannon. Two experiments were conducted using the third prototype. This system used air cannon because of its workspace and output force limitations. Experiment 1 focused on determining whether GVS enhances an air tactile sensation and experiment 2 focused on determining whether GVS provides the enhancing effect in multiple hit areas on the user's body. The results of both experiments supported the hypothesis that GVS-induced proprioception enhances the air tactile sensation and provides the enhancing effect in multiple body areas. These results demonstrate that GVS can be used as an effective tool to enhance tactile sensation in VR environments and suggest that further research is needed to optimize the use of GVS in this context.

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