

Effects of Pulling One's Body on Snowboarding Experience in HMD-Based VR

N.H.S.M. Nawarathna, H. Sawada, S. Nomura, and Y. Nishiyama*

Department of Information and Management Systems Engineering, Nagaoka University of Technology, Japan.

*y-nishiyama@kjs.nagaokaut.ac.jp

We conducted indoor experiments to investigate whether the virtual reality experience is affected by pulling the participant's body to the direction of the acceleration vector or inertia force in accordance with a video scene of the viewpoint of snowboarder. Participants viewed the prerecorded 360 video images lasting for 405 seconds via a head-mounted display and performed experiments under three conditions on different days: No pulling (N), Acceleration (A) and Inertia (I) conditions. They wore snowboard boots mounted on wooden board (mimic snowboard) and are equipped with waist belt with ropes that experimenters pulled. We performed psychological measurements (cybersickness, presence, a sense of agency, and subjective time) and behavioral measurements (postural instability). To quantify the postural instability, we calculated fluctuations in center of foot pressure (CoP) throughout the intervention period. The CoPs along a mediolateral axis (x-axis) and an anteroposterior axis (y-axis) were obtained from

$$CoP_x = \frac{-P_{LT} - P_{LH} + P_{RT} + P_{RH}}{P_{LT} + P_{LH} + P_{RT} + P_{RH}} \quad \text{and} \quad CoP_y = \frac{P_{LT} - P_{LH} + P_{RT} - P_{RH}}{P_{LT} + P_{LH} + P_{RT} + P_{RH}}$$

where P is a measured value of pressure sensors (at a rate of 200 Hz) installed on left or right toes and heels. Results of descriptive statistics imply that pulling in either direction alleviates cybersickness (e.g., Nausea subscale in the Simulator Sickness Questionnaire: 44.5 in N, 28.6 in A, 30.0 in I), slightly improves presence (e.g., presence rating: 4.5 in N, 5.0 in A, 4.9 in I), shortens the perception of time (rating: 68.8 in N, 57.5 in A, 51.7 in I), and increases postural instability ($SD(CoP_x)$): 0.09 in N, 0.23 in A, 0.30 in I; $SD(CoP_y)$): 0.13 in N, 0.26 in A, 0.35 in I). Moreover, subscales in cybersickness measure (oculomotor and disorientation symptoms) and the degree of postural instability seems to depend on pulling directions, suggesting that the direction may be one of considerable factors to manipulate user's movements when developing VR training system to acquire motor skills for accelerated locomotion.

Keywords: Virtual Reality, Snowboarding, Accelerated Motion, Inertia Force, Pulling