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Airflow Presentation Method for Turning Motion Feedback in VR Environment

Yujin Suzuki†[1], Vibol Yem[1], Koichi Hirota[2], Tomohiro Amemiya[3], Michiteru Kitazaki[4] and Yasushi Ikei[1]

[1] Tokyo Metropolitan University, Japan
[2] The University of Electro – Communications, Japan
[3] The University of Tokyo, Japan
[4] Toyohashi University of Technology, Japan

Abstract

This paper describes the effectiveness of airflow presentation to reduce VR sickness and induce vection during turning motion. Five airflow displays were placed surrounding the face and the angle interval of each display was 45 °. Each has 0.6 m distant from the face. Two directions of turning motion: left and right, were visually presented. Result showed that airflow from any direction could reduce VR sickness. Moreover, we confirmed that the airflow presented in 45 ° from in front direction to the turning direction (left or right) enhanced the perception of vection.

CCS Concepts

• ***Human-centered computing*** → Human computer interaction (HCI) → Interaction paradigms → Virtual reality;

1. Introduction

To immerse virtual reality, cutaneous vibration sensation has been widely studied. Some of these aimed to reproduce touch feedback sensation. Other studies have developed motion platform to induce vection of body motion. On the other hand, only few studies have focused on airflow perception [MSO*14] [R14]. We usually perceive airflow sensation on the skin of face or arm when walking or running. In this study, we aimed to investigate the effects of airflow feedback and airflow direction on VR sickness and vection during walking with turning motion in VR environment.

Previous study has used airflow to induce motion sensation when riding an exercise machine that refers to a horse in VR environment. This study reported that the cutaneous sensory simulated by the wind enhanced sensation of body movement to forward direction [MSO*14]. Another study used airflow to enhance the sensation of bird-like flying [R14]. However, all of these did not investigated the effect of airflow direction on VR sickness and vection during turning motion.

2. Experiment

VR environment shown on HMD need to be rotated as a visual feedback for turning motion. Such a visual presentation easily provides VR sickness. The purpose of this experiment is to investigate whether airflow can reduce VR sickness or not during turning walking. The vection was also observed to confirm the necessary of airflow presentation.

2.1 Airflow Display

Airflow Display (Fig. 1) composed of a circulator to generate an airflow (KJ-D992W, Twinbird) blades with diameter of 16 cm, and a rectifier grille with a speed control driver (BXSD120-A, Oriental Motor). The maximum air speed is about 7.0m / s at a distance of front 0.6m.

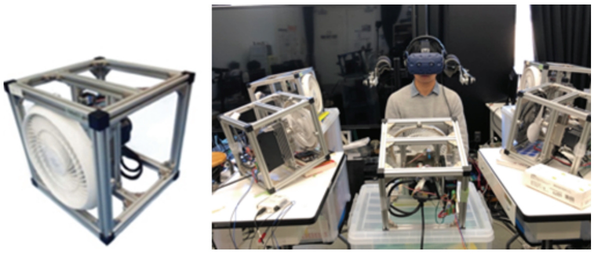

Figure 1: *Airflow display (left) and overview of the experiment (right).*

2.2 Participant and stimulation condition

Ten hospital university students with average age of 22.7 participated this experiment.

We developed a 3D virtual environment of turning motion for visual feedback. As Fig. 2 shows, there were two cylindrical walls: inner and outer walls. The radius of inner wall

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was 0.7 and that of outer wall was 1.3 in VR unit. There were two types of motion feedback: left turning and right turning (Fig. 2). The distant of each airflow display was 0.6 m from the face. There were six conditions of stimuli presentation: no airflow, left 90 °, left 45 °, center, right 45 °, right 90 °. Center presents the airflow direction from the in front of the face. There were two directions of turning motion: turn left and right. Therefore, there were 12 conditions in total. Each stimulation time was 15 s. White noise was played in the headphones to cut off the outside noise.

Figure 2: *Visual feedback of walking sensation for left turning (left) and right turning (right).*

SSQ[KLB*93] was used to evaluate the level of VR sickness, and visual analog scale for vection (0: no motion sensation ~ 100: the same as actual motion). And for turning sensation (0: no turning sensation ~ 100: the same as actual turning walking).

2.3 Results

Figure 3, 4 and 5 show the average level of VR sickness, vection and turning sensation, respectively. ANOVA was conducted for each data analysis. Each main effect of VR sickness, vection and turning sensation was observed ($p < 0.01$ for VR section and vection, $p < 0.05$ for turning sensation). For VR sickness, there were significant differences between no airflow with the other conditions of airflow direction ($p < 0.01$ for all). For vection, the significant difference between no airflow with the airflow presented from 45° of the same turning direction (45° from the center to left or right) ($p < 0.01$). For turning sensation, it was similar to vection, there was the significant difference between no airflow with the airflow presented from 45° of the same turning direction ($p < 0.05$ for left and $p < 0.01$ for right turning).

3. Conclusions

We investigated the effect of airflow and its stimulation directions to the face on VR sickness, vection, turning sensation for turning walking feedback. We found that airflow contributes to reduce VR sickness regardless of its presentation direction. Moreover, airflow presented from 45° of the same turning direction enhanced vection and turning sensation.

4. Acknowledgements

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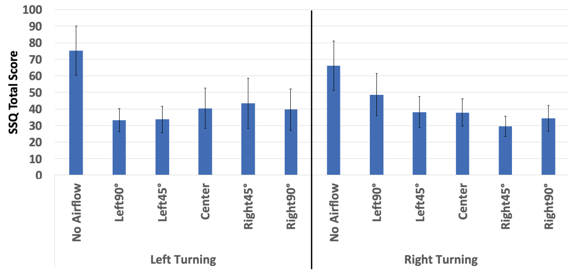

Figure 3: *VR sickness for each stimulation condition.*

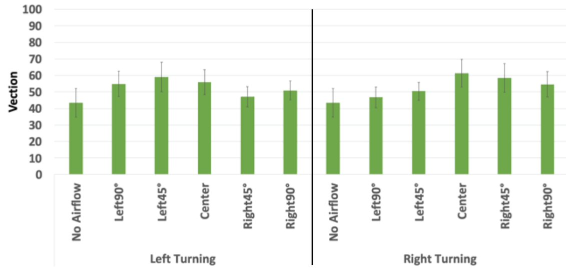

Figure 4: *Vection perception level for each condition.*

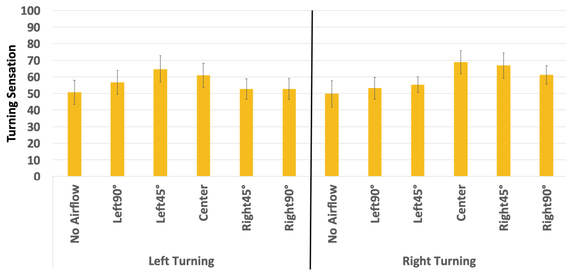

Figure 5: *Turning perception level for each condition.*

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