The Effectiveness of Changing the Field of View in a HMD on the Perceived Self-Motion

Oliver Basting* Arnulph Fuhrmann† Stefan M. Grünvogel‡

TH Köln, Germany

Abstract

The following paper investigates the effect on the intensity of perceived vection by changing the field of view (FOV) using a head-mounted display (HMD) in a virtual environment (VE). For this purpose a study was carried out, where the participants were situated in a vection evoking VE using a HMD. During the experiment, the VE was presented with different FOVs, and a measurement of the felt intensity of vection was performed. The results indicate that a decrease of the FOV invokes a decrease of the intensity of perceived vection.

Keywords: vection; perception; field of view; virtual reality; head-mounted display; user studies.

Index Terms: H.1.2 [Models and Principles]: User/Machine Systems—Human Factors; H.5.1 [Information Interfaces And Presentation]: Multimedia Information Systems—Artificial, augmented, and virtual realities

1 Introduction

Vection is the feeling of self-motion when a person feels their body moving, although no movement is taking place in the real world. It can be experienced in everyday life while sitting in a stationary train and looking out of the train window. If on the other side of the track, at a close range, a different train starts to move the feeling of self-motion may be experienced despite one's own train not having moved at all [10]. In virtual reality this feeling also can be evoked by simulating accelerating movements or rotations of the user in the virtual environment (VE). Thus, vection is an important and relevant factor for the design of VEs (cf. [2]).

For this project we ran an experiment to find out, if the field of view (FOV) in a head-mounted display (HMD) influences the perceived vection of a user.

2 Related Work

Research indicated that a larger FOV induces a higher intensity of vection and that vection appears to be stronger in HMDs [1, 10]. The perceived intensity of vection increases with increasing stimulus size, which means that large FOV displays are more suitable for virtual reality applications [6].

Riecke et al. [9] have compared the effectiveness of different displays in enhancing illusions of self-motion. The results suggests that vection seems to be relatively tolerant towards changes in the display type and the authors suggested to carry out carefully planned research that varies display factors in a controlled manner, in order to systematically investigate how a single parameter influence vection.

*e-mail: oliver.basting@smail.th-koeln.de
†e-mail: arnulph.fuhrmann@th-koeln.de
‡e-mail: stefan.gruenvogel@th-koeln.de

3 Method

A VE application is created to trigger the feeling of self motion, in order to measure the perceived intensity for different FOVs. The VE consists of a simple cylinder to generalize the results.

In order to achieve a suitable experience, a movement straight forward along the rotational axis of the cylinder with a suitable acceleration and velocity is chosen. It is important to ensure a pleseant experience, because it may be possible to mistake a poor feeling with an actual feeling of self-motion [3].

During several pilot studies with single participants and different accelerations, velocities and timings were tested and evaluated to evoke a feeling of self-motion without creating simulator sickness. The final velocity graph is displayed in Figure 3 together with the measurement results, which are further described in section 5.

The main task was to investigate the impact of a change of the FOV within the HMD on the experienced vection. For that reason the FOV is changed during the experiment. To do so, the FOV was limited by overlaying multiple black canvases as in Figure 1.

The participants recorded their perceived subjective intensity of vection with the aid of a simple input device.

Subjective self-report measurement has become the traditional method in vection research [7] and has been used successfully in similiar projects (e.g. using a joystick as input device [5, 9, 11]).

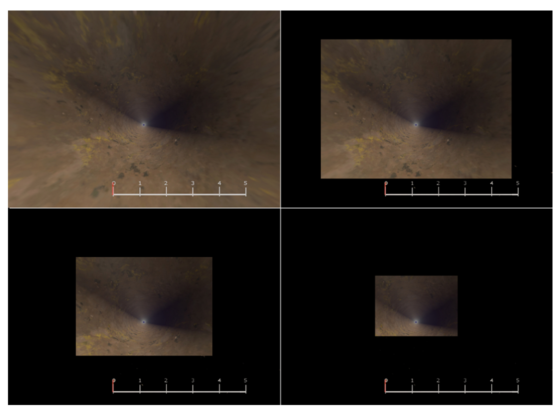

Figure 1: Screenshot of different FOVs at 110°, 77°, 55°, 33°

4 Experiment

An experiment with a participant consists of 4 rounds, each with a different FOV. In order to diminish influence of learning effects during the experiment, the sequence of the rounds was changed for each subject. Since 4 different rounds were presented to each subject, a total of 24 sequencing combinations were possible, one unique combination for each participant.

During the experiment the participants were in a seated position, holding the Vive controller and wearing a HMD being exposed to the above described VE (see Fig. 2). The HTC Vive [4] was used for this study as HMD (cf. [8] for the HTC Vive hardware specification).

Figure 2: Participant wearing the HMD and input controller

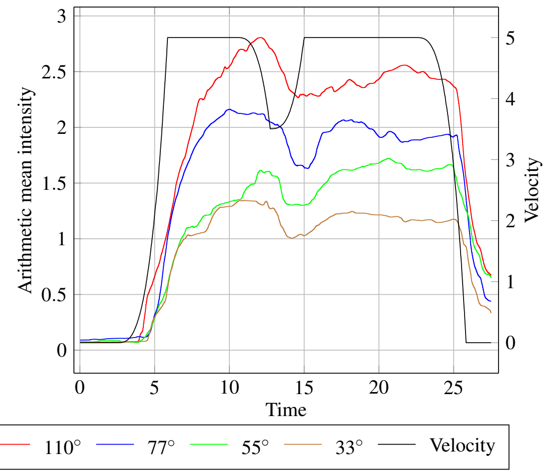

Figure 3: Arithmetic mean of intensity values over all participants per frame.

During each experiment, the participants rated the perceived vection on a scale from 0 to 5 by moving their thumb horizontally on the touchpad. The touch position of the subjects thumb is shown by a red indicator on the scale. A rating of 0 indicates no vection at all, whereas a rating of 5 represents are very high intensity of vection. Those values are not representing an interpersonal absolute value of vection as it is an individual subjective feeling of self-motion of each participant. The scale represents only positive values, because the evaluation of the direction of perceived vection is out of scope.

In addition to that a verbal rating was requested in order to gain more feedback of the actual perceived vection and to validate the measurement data. As described before, each participant repeated the experiment for all 4 FOVs. The participants were instructed to verbally rate the perceived vection in reference to the previous round (stronger, equal, weaker).

5 Results

For each participant and for each reduced FOV (110°, 77°, 55°, 33°) the stream of intensity ratings over 27.5 seconds was recorded. Each rating value lies in the interval $[0,5] \subset \mathbb{R}$. As a first analysis the arithmetic mean over all 24 participants for each reduced FOV was calculated for each frame. In Figure 3 we plotted the corresponding averaged vectors over time. At first glance, there seemed to be a strong correspondence between the FOV and the measured intensity. The more the FOV was restricted, the more the average intensity decreased at each time step. Furthermore, the curves seemed to show, that the acceleration and deceleration of the participant in the VE also influenced the perceived vection intensity.

The verbal ratings of all participants are summed up according to the change in FOV in Table 1. The survey yields that for 31 out of the 36 rounds with increasing FOV the perceived vection were rated as increasing. On the other hand, for 29 out of 36 rounds with decreasing FOV the perceived vection was rated as decreasing. These results support the observations from the intensity measurement.

6 Conclusion

From a first analysis of the raised data it can be stated, that a majority of the participants felt a growth of vection intensity when the FOV getting larger and that most participants felt a reduction of vection intensity when the FOV has decreased in size. These findings also indicate that the size of the FOV in a HMD is related towards the related vection. With the collected data we can assume that a large FOV in a HMD contributes to a stronger feeling of vection and vice versa, a decrease of the FOV contributes to a decrease of vection. In order to confirm the significance of the results further analysis and evaluation has to be performed.

Rated Vection	Increasing FOV	Decreasing FOV
Stronger	31	2
Equal	4	5
Weaker	1	29

Table 1: Verbal Rating Results

References

[1] R. S. Allison, I. P. Howard, and J. E. Zacher. Effect of field size, head motion, and rotational velocity on roll vection and illusory self-tilt in a tumbling room. *Perception*, 28(3):299–306, 1999.

[2] A. Ash and S. Palmisano. Vection during conflicting multisensory information about the axis, magnitude, and direction of self-motion. *Perception*, 41(3):253–267, 2012.

[3] F. Bonato, A. Bubka, and S. Palmisano. Combined Pitch and Roll and Cybersickness in a Virtual Environment. *Aviation, Space, and Environmental Medicine*, 80(11):941–945, Nov. 2009.

[4] H. Cooperation. HTC Vive, Aug. 2016.

[5] B. J. Mohler, W. B. Thompson, B. Riecke, and H. H. Bülthoff. Measuring vection in a large screen virtual environment. page 103. ACM Press, 2005.

[6] S. Nakamura. Effects of stimulus eccentricity on vection reevaluated with a binocularly defined depth. *Japanese Psychological Research*, 50(2):77–86, May 2008.

[7] S. Palmisano, R. S. Allison, M. M. Schira, and R. J. Barry. Future challenges for vection research: definitions, functional significance, measures, and neural bases. *Frontiers in Psychology*, 6, Feb. 2015.

[8] L. Prasuethsut. HTC Vive: Everything you need to know about the SteamVR headset, Feb. 2016.

[9] B. E. Riecke and J. D. Jordan. Comparing the effectiveness of different displays in enhancing illusions of self-movement (vection). *Frontiers in Psychology*, 6, June 2015.

[10] B. E. Riecke and J. Schulte-Pelkum. An Integrative Approach to Presence and Self-Motion Perception Research. In M. Lombard, F. Biocca, J. Freeman, W. IJsselsteijn, and R. J. Schaevitz, editors, *Immersed in Media*, pages 187–235. Springer International Publishing, Cham, 2015.

[11] B. E. Riecke, J. Schulte-Pelkum, M. N. Avraamides, M. V. D. Heyde, and H. H. Bülthoff. Cognitive factors can influence self-motion perception (vection) in virtual reality. *ACM Transactions on Applied Perception*, 3(3):194–216, July 2006.