Methods to Reduce Cybersickness and Enhance Presence for In-Place Navigation Techniques

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ABSTRACT

In previous studies, some factors that ameliorate the cybersickness symptoms for in-place navigation techniques (INAV) based on vection reduction have been found. In this paper, we want to extend such studies in order to analyze both cybersickness and the sense of presence for some INAV techniques. A review of the state of the art shows that there is no agreement if enhancing movement (i.e. reducing the sensory conflicts between mechanical and visual information) or restricting movement (i.e. limiting the postural control) is better to reduce cybersickness. Furthermore, the kind of movement used in an experience has different implications in the sense of presence. Although we did not find statistically significant results from these new studies, we show how techniques that reduce vection promise to reduce cybersickness and their impact to the sense of presence for INAV.

Keywords: Virtual reality, Cybersickness, Presence

Index Terms: I.3.7 [Computer Graphics]: Three-Dimensional Graphics and Realism—Virtual reality

1 INTRODUCTION

In-place Navigation Techniques (INAV) have acquired great interest because they allow users to freely move in VEs without physical translation. However, INAVs generate in users the illusory perception of self-motion (vection), a well-known phenomenon which has different implications in the sense of presence and the occurrence of cybersickness symptoms. In a previous study, we studied the influence of vection reduction to ameliorate the cybersickness symptoms for situations where users are completely stationary [2]. We asked subjects to go up and down stairs inside a realistic VE using an Oculus Rift HMD DK1 and a Gamepad. By adding an invisible ramp over the stairs we manage to reduce vection and the perceived cybersickness effects. In this paper we want to extend this preliminary study on cybersickness with an analysis of the sense of presence in similar INAVs. Whereas physical motion can improve the sense of presence in a VE, we believe that they also increase the perceived vection and therefore the cybersickness effects.

2 RELATED WORK

Our work is related to studies on the relationship between vection and cybersickness, the relationship between sensory feedback and the sense of presence, and INAVs for modern VR environments.

VEs introduce artefacts that causes distortions on perceived motion and enhance cybersickness symptoms. For example, reduced FOV and motion tracking precision limitations, users tend to underestimate their walking speed [8] and the mismatch between mechanical and visual cues increase symptoms [5]. It has been shown that vection changes (i.e. any change in perceived direction and speed) exacerbates cybersickness symptoms ([1]).

There is a wide variety of INAVs. An important set of such techniques is the Walking-In-Place techniques (WIP), which are based on step detection algorithms using traditional motion sensors ([4], [10]). Different researches have shown that WIP techniques provide the necessary vestibular and propioceptive input to enhance presence [9]. The importance of sensory feedback to enhance the sense on presence is well known. Multi-modal sensory feedback has demonstrated to increase the sense of presence in VEs ([7]).

3 METHODOLOGY

This study includes another INAVs in order to study both its cybersickness effects and sense of presence. We decided to include the Shake-Your-Head INAV, which is a WIP interaction method based on head movement that translates head lateral oscillations into virtual steps. We chose the Shake-Your-Head interaction technique because this provides some advantages in comparison to other methods, as follows:

- Step detection algorithm is based on head movements. It allow users stay sit, a condition that has shown good results to reduce cybersickness symptoms. Also, these movements could reduce sensory conflicts in terms of vestibular cues.
- It is an INAV that enhances the sense of presence. It is very simply to implement and does not introduce a great impact in other factors such as latency or calibration problems.

User's head movements were captured with a Microsoft Kinect. We introduce a scaling factor *SF* for the calculated forward speed in Shake-Your-Head technique formula in order to adjust the forward speed to subject's perceived stair step dimensions. This factor acts as a scaling vector for the mapped virtual camera motion in order to reduce the perceived speed underestimation caused by VE simulation. The range was selected based on study [6] and we found an average scaling factor of 1.7 for the perceived natural motion speed.

3.1 User study

We asked subjects to go up and down stairs in the Tuscany Demo application. A set of subjects performed the movement using an INAV technique based on GamePad, while they remain sitting in a comfortable chair. We asked subjects to maintain their heads resting down with the purpose to reduce their head degrees of freedom and as consequence, induce less postural instability. Another set of subjects performed the movement using the Shake-Your-Head interaction technique in a standard chair. It allowed them to have more head motion freedom and thus, help to reduce sensory conflicts. Figure 1 shows the setups for the two implemented interaction techniques. In terms of vection reduction, A set of subjects move on top of the stairs geometry as it comes from the demo scene, and as consequence they perceive more vection changes. Other set of subjects move over an invisible ramp, independently of the interaction technique used (both conditions were balanced among users).

The Simulator Sickness Questionnaire [SSQ] [3] and the Presence Questionnaire [PQ] [11] were used to measure cybersickness

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IEEE Symposium on 3D User Interfaces 2015
23 - 24 March, Arles, France
978-1-4673-6886-5/15/$31.00 ©2015 IEEE

Figure 1: Interaction techniques. Left: GamePad with less postural instability. Right: Shake-Your-Head with head motion freedom.

symptoms severity and the sense of presence respectively. Our hypotheses are the following:

- **H1**: The virtual ramp reduces cybersickness symptoms better than the stairs geometry in both interaction techniques.
- **H2**: The Shake-Your-Head navigation enhances the sense of presence better than the Gamepad in both stair geometries.

3.1.1 Procedure

34 students from our University were recruited for this study, 26 men and 8 women with average age of 23 years old. All signed a letter of consent were they reported normal vision and no mental, psychiatric, heart, vestibular, or stomach problems. We conducted a between-subjects experiment, in which subjects should go up and down the stairs during 6 minutes using each experimental setup: Students were asked to perform the test using an INAV technique either based on GamePad or Shake-Your-Head. Also, we balanced the translation geometry among users, so all subjects test a unique combination of geometry and navigation technique.

3.1.2 Results and Discussion

We performed an analysis of our factors and their influence in cybersickness feeling and sense of presence by means of the SSQ score and PQ score. In terms of cybersickness reduction, ramp geometry tends to have better results than stairs geometry in both interaction techniques, whereas the Gamepad scenario performed best. Figure 2 shows the SSQ score for the four conditions. An one-way ANOVA analysis of the SSQ data was performed. If we take into consideration geometry no matter the interaction technique, we found a tendency that benefit ramp geometry (23.76 ave, SD 16.36) instead of stairs geometry (42.68 ave, SD 42.23) in cybersickness reduction ($p = 0.095$). Considering the interaction technique, We did not find neither statistical significance ($p = 0.49$) about the difference between Shake-Your-Head (29.48 ave, 18.45 SD) and GamePad (36.96 ave, 43.25 SD). However, we found a notably tendency to confirm H1.

In terms of the sense of presence the four conditions got similar results, so we cannot confirm or deny H2. Figure 2 shows the PQ score for the four conditions. Although, we found a slightly tendency to favour Shake-Your-Head (76,62 ave, 11.14 SD) against GamePad (75.59 ave, 6.74 SD) to enhance the sense of presence, the results were not conclusive. We realized that cybersickness feeling have a powerful influence in the user's sense of presence.

4 Conclusions and Future Work

This paper presents a comparative analysis between two INAV techniques, a navigation technique that reduces postural instability with a technique that reduces sensory conflicts enhancing motion. We found that vection changes reduction could be a more effective method to reduce cybersickness symptoms than a interaction technique base on postural instability reduction. Although, we did not find statistically significant results in terms of presence, we realized

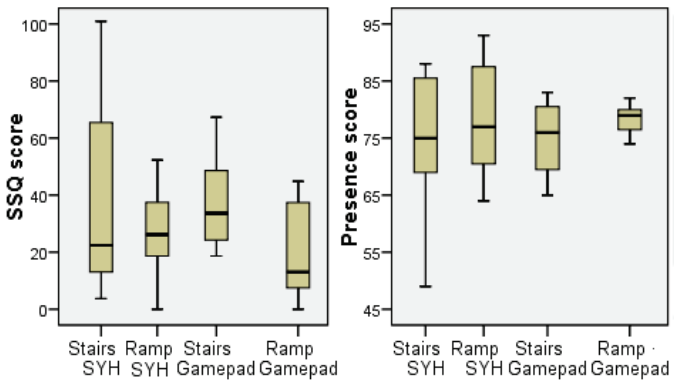

Figure 2: SSQ and PQ scores for the four conditions.

it is particularly difficult to increase the sense of presence without increasing cybersickness symptoms, because mechanical sensory feedback is important to enhance presence but at the same time this introduces artificial cues that increase cybersickness. Considering previous results we need to continue exploring different methods to enhance presence for stairs movement without introduce more cybersickness factors.

Acknowledgements

We thank engineer Alejandro Lovera and the COLIVRI Research Lab staff for their important contributions during tests.

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