Effects of Speed and Transitions on Target-based Travel Techniques

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Abstract

Travel on Virtual Environments is the simple action where a user moves from a starting point A to a target point B. Choosing an incorrect type of technique could compromise the Virtual Reality experience and cause side effects such as spatial disorientation, fatigue and cybersickness. The design of effective travelling techniques demands to be as natural as possible, thus real walking techniques presents better results, despite their physical limitations. Approaches to surpass these limitations employ techniques that provide an indirect travel metaphor such as point-steering and target-based. In fact, target-based techniques evince a reduction in fatigue and cybersickness against the point-steering techniques, even though providing less control. In this paper we investigate further effects of speed and transition on target-based techniques on factors such as comfort and cybersickness using a Head-Mounted Display setup.

Keywords: Virtual reality, travel techniques, navigation, cybersickness

Concepts: •**Human-centered computing** → **Usability testing;**

1 Introduction

Emerging new technologies in the Virtual Reality (VR) facilitate a rapid development of techniques and applications for travel in immersive virtual environments (IVE). Travel plays an essential part on the VR experience, where the user moves from a starting point A to a target point B. We also can divide travel in two subcategories. On *Explore* tasks the user moves freely on the VE without a predetermined goal and *Search*, where he/she has to reach a specific checkpoint. The choice of the travel technique can influence the user and cause severe side effects, essentially cybersickness [LaViola Jr 2000], reduced presence and disorientation [Smith and Marsh 2004]. The more natural the technique, the more efficiently users can perform travelling tasks on VEs [Suma et al. 2010], especially on Explore tasks. However, constraints such as fatigue and limitations of the physical space can make it unsuitable to some situations. Indirect methods such as Target-based and Steering techniques [Bowman et al. 2004] can overcome this problem by providing an approach to travel while still providing a favorable spatial orientation on VEs.

Some causes of cybersickness in VR-systems include graphical realism of the environment [Davis et al. 2015], field of view [Fernandes and Feiner 2016] and navigation speed [So et al. 2001]. Although steering techniques can provide an improved spatial understanding of virtual surroundings, target-based approaches can reliably overcome unwanted symptoms on inexperienced users of immersive systems [Ragan et al. 2012]. In this work we aim to further investigate the effects of speed and transition in Target-based techniques, by comparing three different methods and how they impact the VR experience in key aspects such as comfort and cybersickness.

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2 Travel Techniques

We implemented three different techniques for travel in IVEs, as depicted in Figure 1:

Teleport Technique (TP) This technique [Bowman et al. 2004], also known as infinite velocity, translates a person instantaneously from their current position to the next checkpoint.

Linear Motion (LM) This technique consists of moving the user along a linear path for two seconds with a constant velocity, until the next checkpoint.The velocity choice is based on previous work [So et al. 2001] and varies between 30 m/s and 50 m/s depending on the checkpoint distance.

Animated Teleport Box (AT) We developed the Animated Teleport Box technique with the objective to combat the negative effects of the Teleport technique. Two 1.5 second animations were played when a user was being translated from their current position to next checkpoint. The first one animated the Box to rise up and surround the user, and the second one executed the same animation but in the inverse direction. The box has 2.3 meters on each side so that users would not feel too claustrophobic when travelling. It was developed with the intention of not showing users that they were being moved, as a mean of decreasing the disorientation that might be felt after being teleported.

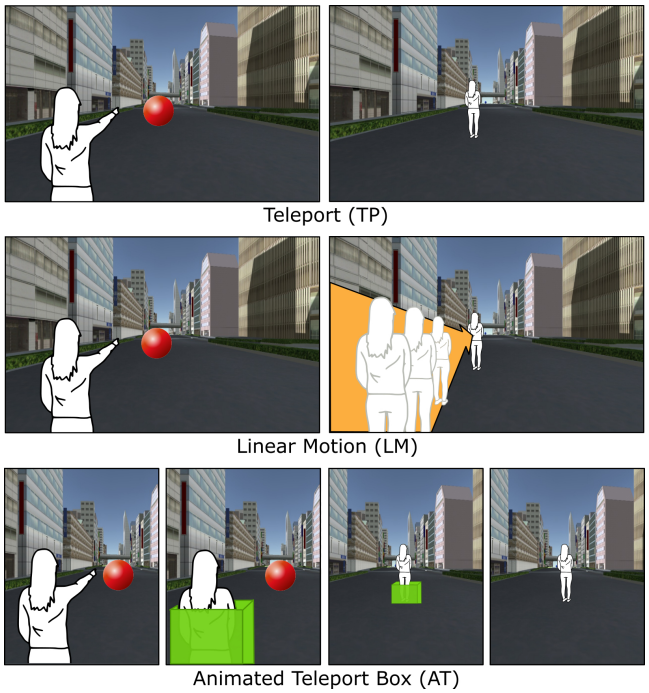

Figure 1: *Implemented Travel techniques.*

3 Task Design

To validate the techniques described above, we completed a user evaluation. Our aim was to understand which of the techniques were preferred and the impact of cybersickness on users. We tested the techniques in our laboratory in a controlled environment, using a Samsung GearVR HMD with a Samsung Galaxy S7 smartphone. Users were able to freely rotate their head within the VE. 20 participants (2 females) completed the user evaluation, with ages ranging from 19 to 31 years old (mean = 24) and 7 participants already had previous experience in VR. Each user evaluation session adopted the same protocol, starting the initial briefing with a quick explanation to the experiment and also with a description of the techniques. To avoid biased results from users becoming familiarised with the techniques and used to the environment, the techniques were presented in a partial random order, so all permutations were exhausted.

The virtual environment was a model of the city of Osaka, Japan (visible in Figure 1), which was populated with six spherical checkpoints to where the users would be travelling to. During each travel, the users were told where the next checkpoint would be (to their left or right) and were also instructed to point to said checkpoint before traveling using of the techniques. The user had no control over the path that he would take, and would only be in charge of pointing to the checkpoints. We allowed the users an adjustment period to the environment, before travelling to the first checkpoint, to make sure they knew where they were and where they were being moved to. Each session took on average thirty minutes, which ended with a brief questionnaire about their experience.

4 Results

Throughout data analysis, we first conducted a Shapiro-Wilk which showed that not all samples followed a normal distribution. We then used a Friedman non-parametric test to look for statistical significance between the three tested techniques. When statistical differences were found, we conducted a Wilcoxon Signed-Ranks Test to look for statistical significance on each pair of techniques with an additional Bonferroni correction. For a better comparison regarding task performance, we subtracted the animation times from the total time following the formula : $T' = T - \alpha \times (n-1)$, where T is the total time, α the path time (3 seconds in AT, 2 in LM, and zero in TP) and n the number of travels (6 in our case). Looking at Figure 2, we can notice a slightly better performance with AT, but without statistical significance. Because of that we can state that efficiency is similar in all the tested techniques.

Regarding questionnaires' data (Table 1) we found that users felt more physical discomfort using LM (Z=-2.699, $p < 0.01$ against AT and Z=-2.386, p=0.017 against TP). Despite the discomfort caused by LM, participants stated it as their favourite technique in most cases, Due to the similarity between user preferences on both AT and TP we conducted an additional test on the total times of the test task. This test confirms a better result on such condition with TP as it does not need additional time among the movement between positions (Z=-3.114, $p < 0.01$ between AT and Z=-2.578, p=0.01 against LM).

Question	AT	LM	TP
It was easy	5 (1)	5 (1)	5 (1)
I was satisfied	4 (2)	4.5 (2)	4 (2)
I felt physical discomfort*	1 (1)	2 (3)	1 (1)
I felt visual discomfort	1 (1)	2 (2)	1 (1)

Table 1: *User preferences: Median (Interquartile Range). * indicates statistical significance.*

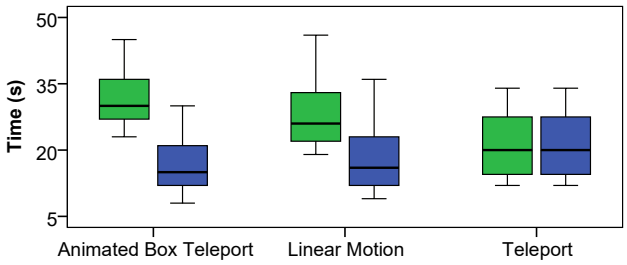

Figure 2: *Time elapsed on each task. Green boxplots represent total time, and blue the time excluding techniques' animations.*

5 Conclusion

In this work we investigate the effects of target-based techniques regarding travel time, speed and transitions. We propose three different techniques based on previous work by varying said parameters. Through user evaluation, we found that Infinite Velocity techniques cause less discomfort. We also found that using transition effects in conjunction with these techniques does not affect either performance or cybersickness.

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