

Simulated Reference Frame Effects on Steering, Jumping and Sliding

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ABSTRACT

In this paper, we investigated the impact of an egocentric simulated frame of reference, the so-called *simulated CAVE*, on three type of travel techniques: *Steering*, *Jumping* and *Sliding*. Contrary to suggestions from previous work, no significant differences were found regarding spatial awareness between all techniques with or without the *simulated CAVE*. Our first results also showed a negative effect of the *simulated CAVE* on participants' motion sickness for every technique, while confirming that the *Jumping* is eliciting less motion sickness with or without it.

Index Terms: Human-centered computing—Human computer interaction (HCI)—Interaction paradigms—Virtual reality H.5.2 [Interfaces and Presentation]: User Interfaces—

1 INTRODUCTION

Traveling techniques are one of the crucial components of Virtual Reality (VR). They have a direct effect on user experience in terms of effort, enjoyment, frustration, motion sickness and presence [1]. Among techniques demonstrated to reduce traveling discomfort are real walking [3], the use of treadmills [6], and reduction of the field of view (FOV) [5]. However, the decreased FOV may increase misjudgement in critical tasks as well as reduce presence [4].

One other way to reduce motion sickness is through the use of rest frames. For instance, environmental geometry can be used as an orientation cue [7]. Both egocentric and allocentric reference frames are known to enhance spatial orientation [9]. Cao et al. [2] showed that static or dynamic rest frames can reduce motion sickness. Dynamic rest frame disappears when the user stop moving. Their results show that a static or dynamic rest frame allowed users to travel through more waypoints before stopping due to discomfort compared to a virtual environment without a rest frame. However, participants actually preferred the static rest frame to the dynamic one. Recently Nguyen et al. [12] demonstrated that simulated reference frames can improve spatial orientation. They compared two types of simulated reference frames: i) a *simulated Room*, which is fixed a wireframe cube surrounding a user (simulating the corners and edges of a room), and ii) a *simulated CAVE* which is like a *simulated Room* but following the user's movement (Figure 2). They demonstrated their positive effect in a navigational search task within a landmark-free virtual environment.

In this paper we thus investigate the possible benefits of the *simulated CAVE* technique within a virtual environment including landmarks (i.e. a street) and with three types of VR travel techniques: *Steering*, *Jumping*, *Sliding*.

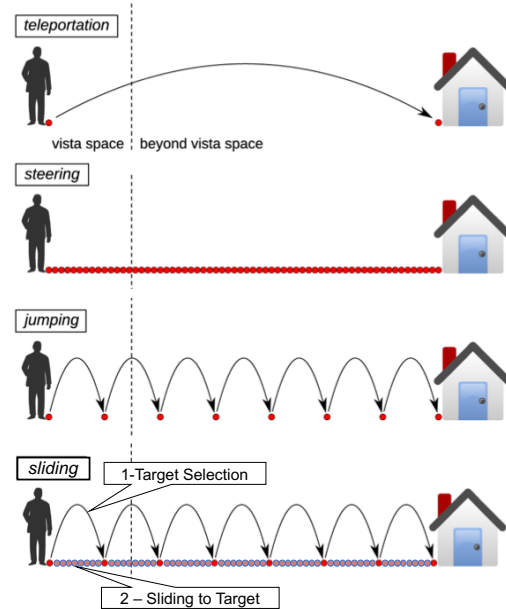


Figure 1: VR Traveling Techniques Differences - Adapted from [13]

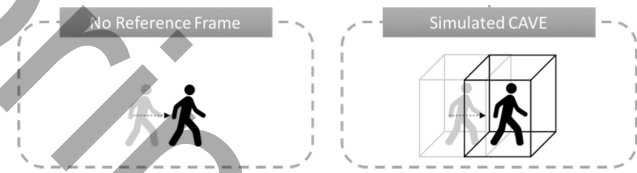


Figure 2: Investigated Improvement: The Simulated CAVE - Adapted Figure from [12]

2 EXPERIMENT

We performed a user study adopting a 3x2 between-subject factorial design, with two categorical independent variables:

1. **Travel Techniques** with three levels: *Steering*, *Jumping*, *Sliding* as represented in Figure 1.
2. **Simulated Reference Frame** with two levels: with or without *simulated CAVE* as represented in Figure 2

We measured the effects of the independent variables in terms of:

1. **Spatial Awareness** with a "point-to-origin" task [13] via a question presented in VR when reaching final destination: *Point with your right hand in the direction of your starting point.*
2. **Motion Sickness** with the Fast Motion Sickness Scale (FMS) [8] via a question in VR: *How sick do you feel right now?*

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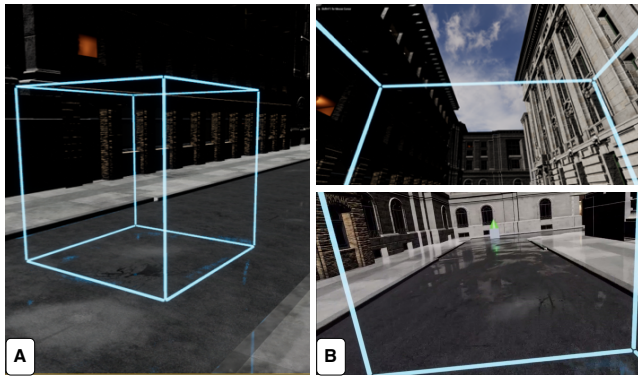


Figure 3: Simulated CAVE - A wireframe cube following the user's position. A) Third Person Perspective B) First Person Perspectives

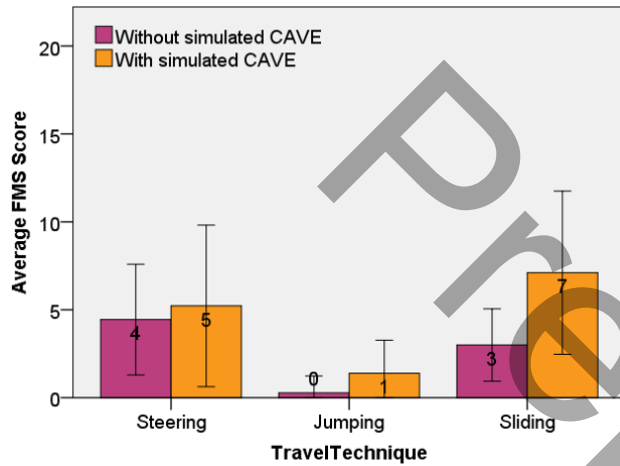


Figure 4: Average Sickness Scores (with Standard Deviation)

The *Steering* technique is based on continuous control and movement of the view point by manipulating the orientation of a tracking device attached to body parts. We implemented a hand-directed steering [11]. In this variation, the user indicates the travel direction by hand pointing and controlling the travel speed via an analogue stick.

The *Jumping* technique is a teleportation but limited to a location you can see [13]. It is using a parabolic ray for target indication and implicit orientation specification (i.e. orientation is determined by user's head orientation).

The *Sliding* is an *manipulation-based* technique combining the advantageous parts of steering and jumping: *Steering* maintains the spatial awareness better than *Jumping*, while *Jumping* induces less simulator sickness than *steering*. This technique is based on view-point manipulation with fixed-object. User initiates the movement and its speed by a short grabbing-releasing hand movement similar to pulling oneself along an elastic rope. This inspired by the *rope metaphor* [10] whereby the users can pull themselves through the environment hand-over-hand, like climbing a rope. However, here the overall effect is to move like sliding inside a water slide.

The virtual environment and task is a replication of Weissker et al. experiment [13]. The experimental task simply required participants to travel along a given route (i.e. a single street) and point to its origin after they have reached the terminal location. Each participant performed the task three times. First, with a very small route (the baseline), then two times with a longer route (first and second trial).

3 RESULTS

Overall 36 participants participated in the study (six per condition) with 20 males and 16 females ($M_{age} = 25.36$, $SD_{age} = 8.48$). This study used an Oculus Rift Consumer Version with a three-sensor room scale tracking setup and the *Oculus Touch* controllers. The system used the Unreal Engine 4 and its *Robo Recall Modkit*.

- *Spatial Awareness*: A two-way ANOVA revealed no significant difference point-to-origin error angles between all conditions.
- *Motion Sickness*: As visible on figure 4, the addition of a *simulated CAVE* tended to increase sickness for every technique. The *Jumping* produced significantly lower scores ($M = 0.5$, $SD = .798$) with or without simulated CAVE ($F(2, 30) = 7.77$, $p = .002$, $d = 0.323$) compared to *Sliding* ($M = 5.17$, $SD = 4.38$, $p = .003$), and *Steering* ($M = 4.67$, $SD = 3.86$, $p = .01$).

4 CONCLUSION

In this paper we measured the effects of adding a simulated frame of references to *Steering*, *Jumping* and *Sliding* techniques. No significant differences were found regarding spatial awareness between all techniques with or without a simulated frame of reference. Our preliminary results showed negative impact of the *Simulated-CAVE* on motion sickness for every technique, while showing lower sickness scores for the *Jumping*. Our future work will verify our results with a larger participant sample, and different navigation tasks.

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