Drone-Steering: A Novel VR Traveling Technique

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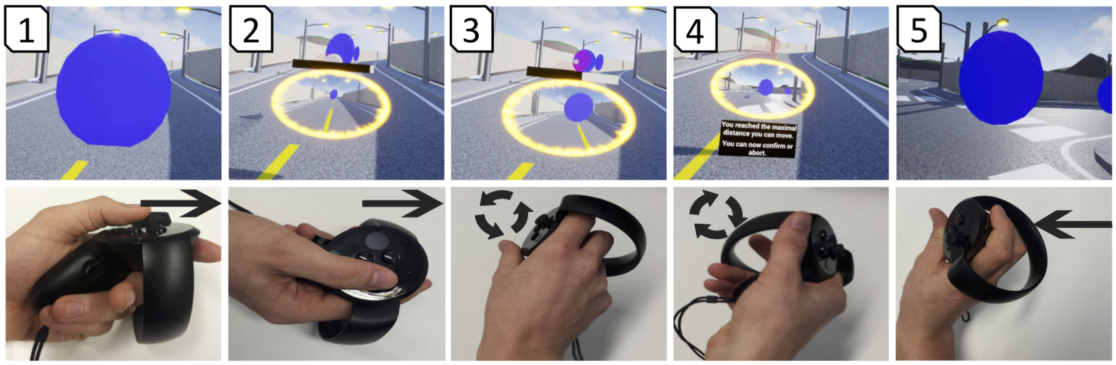

Figure 1: *Drone-Steering* Overview - 1) Initiating travel by pushing the thumb-stick forward. 2) A *photoportal* appears in front of the user covering 60-degree FOV. It acts as the screen of the drone's camera and creates a *Tunneling* effect while keeping an awareness of the surrounding. 3) Piloting the drone by pushing forward/backward and rotating the controller like a steering wheel. 4) A maximum travel distance limitation (indicated by a progress bar above the portal) is forcing the user to move to a point in the vista space (i.e., visible from the starting point). 5) Pressing the trigger to confirm the teleportation to the current drone position and direction or aborting with the grid button. The actual teleportation is represented by the portal wrapping the user (It is maximized covering the whole user's FOV). When completed, the user is at the new location.

ABSTRACT

This paper presents a novel technique of navigation in Virtual Reality (VR) called *Drone-Steering*. This technique has been designed to facilitate path learning and traveling in VR by reducing both cybersickness and disorientation. We compared this technique to traditional *Hand-Steering* in a landmark-free environment. Our first experiment confirmed a significantly lower level of cybersickness during traveling and significantly better path learning. We believe that our technique constitutes a promising alternative to current VR navigation techniques, and will especially interest researchers and developers targeting large VR environments.

KEYWORDS

Virtual Reality, Travel, Path Learning, Sickness

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1 INTRODUCTION

Traveling in Virtual Reality (VR) without physically moving is considered as one of the main sources of *cybersickness* [7]. Symptoms occurring due to cybersickness are headaches, stomach awareness, nausea, vomiting, pallor, sweating, fatigue, drowsiness, and disorientation [7]. This is especially critical for learning and finding a path in VR, as cybersickness has an impact on environmental spatial knowledge acquisition [1].

In this paper, we evaluate a novel hybrid traveling technique called *Drone-Steering*, which is combining the beneficial aspects of the widely used travel techniques *Jumping* and *Steering* to further reduce cybersickness while preserving path learning and finding. Our *Droning-Steering* technique is divided into two main phases: The *steering phase* where the user is piloting the *drone*, and the *jumping* phase, where the user is teleported to the drone location. In addition, we integrated features to reduce cybersickness and disorientation: i) *FOV reduction* [3], ii) *Rest frame* [2], iii) *Photoportal* [6] and iv) *Tunneling* [4]. The integration of all of these techniques into our *Drone-Steering* is illustrated in Figure 1. As our technique has a large steering phase, our preliminary evaluation specifically investigated differences in terms of cybersickness and path replication in comparison with the *Hand-Steering* technique.

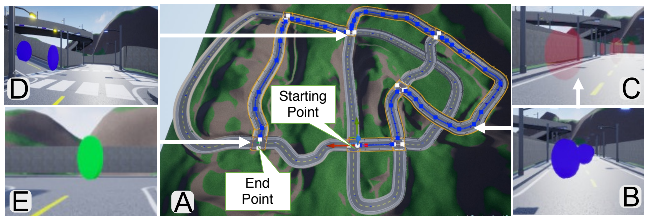

Figure 2: A) Task and Environment - Path to learn and replicate is indicated in blue. B) The starting point of the task . C) After passing a coin it turns red. D) The white dots indicate a crossroad. E) The green coin indicates the final destination

2 PRELIMINARY EVALUATION

We defined a simple navigational task in which subjects are asked to learn and replicate a particular path in a VR environment. As illustrated in Figure 2, the environment is composed of eleven road segments without any landmarks (i.e., no distinguishable buildings, or signs). It prevents participants from using alternative strategies to learn the path. The path to follow had a length equivalent to 800 meters. We measured the participants' ability to replicate the path as well as their degree of cybersickness. The experiment was performed using a *between-subjects* design, where each participant used only one of the traveling techniques. After a training phase, participants learned the path to replicate by collecting coins (*Guided* condition). After reaching the path end, they were teleported back to the start and had to replicate the path (*Unguided* condition). We used an Oculus Rift Consumer Version Head-mounted display (HMD) and Touch wireless motion controller within a three-sensor room-scale tracking setup. The participants were in a standing position. A cable management system was attached to the ceiling. The environment was constructed with the Unreal Engine Version 4.19.2 and run at a framerate of 90 Hz.

Overall, 34 participants took part in the study. The mean age of the participants was 23.6 ($SD_{age} = 3.92$), 24 of the 34 were female. All participants were university students.

Cybersickness: Every 100 meters we measured sickness using a one-item measurement in VR, based on the FMS scale [5]*(Fast Motion Sickness* where 0 is for high and 20 is for no sickness), as suggested in studies evaluating steering and cybersickness [3]. We conducted Mann-Whitney-U-Tests to compare the difference in FMS scores (Figure 3). In the guided path phase, the *Drone-Steering* elicited significantly lower sickness ($M = 18.53, SD = 2.07, p < .001$) compared to the *Hand-Steering* ($M = 13.69, SD = 4.24$) with a large effect size ($r = .61$). The same effect was found in the unguided path phase with significantly lower sickness with *Drone-Steering* ($M = 17.84, SD = 2.70$) compared to *Hand-Steering* ($M = 14.78, SD = 4.30, p = .025$), the effect was of medium size ($r = .39$).

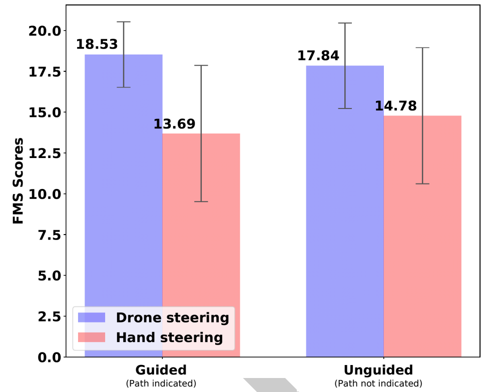

Figure 3: Cybersickness Results with standard deviations

Path Replication: We measured how well participants could follow the path once the coins were no longer displayed, before the task duration elapsed (i.e., 6 minutes). Using a *Fishers* exact test, there was a significant difference ($p = .032$), 14 participants succeeded with *Drone-Steering* and only 7 participants with *Hand-Steering*.

3 CONCLUSION

In this paper, we presented a novel hybrid traveling technique in VR and demonstrated its ability to reduce cybersickness and disorientation in a landmark-free environment. We believe our technique will interest the VR community developing large virtual environments (e.g., city, building or large open worlds). Future work will replicate this experiment with the common *Jumping* technique and with more realistic environments including landmarks (e.g., virtual city).

REFERENCES

[1] John H. Bailey and Bob G. Witmer. 1994. Learning and Transfer of Spatial Knowledge in a Virtual Environment. *Proceedings of the Human Factors and Ergonomics Society Annual Meeting* 38, 18 (oct 1994), 1158–1162. https://doi.org/10.1177/154193129403801803

[2] Z Cao, J Jerald, and R Kopper. 2018. Visually-Induced Motion Sickness Reduction via Static and Dynamic Rest Frames. In *Proceedings of the 25th IEEE Conference on Virtual Reality and 3D User Interfaces.*

[3] Ajoy S Fernandes and Steven K Feiner. 2016. Combating VR sickness through subtle dynamic field-of-view modification. In *3D User Interfaces (3DUI), 2016 IEEE Symposium on.* IEEE, 201–210.

[4] Google-LLC. June 2017. Google Daydream elements, vr guidelines,. https://developers:google:com/vr/elements/overview#locomotion

[5] Behrang Keshavarz and Heiko Hecht. 2011. Validating an efficient method to quantify motion sickness. *Human Factors* 53, 4 (aug 2011), 415–426. https://doi.org/10.1177/0018720811403736

[6] André Kunert, Alexander Kulik, Stephan Beck, and Bernd Froehlich. 2014. Photoportals: shared references in space and time. In *Proceedings of the 17th ACM conference on Computer supported cooperative work & social computing.* ACM, 1388–1399.

[7] Joseph J LaViola. 2000. A discussion of cybersickness in virtual environments. *ACM SIGCHI Bulletin* 32, 1 (jan 2000), 47–56. https://doi.org/10.1145/333329.333344