GazeSphere: Navigating 360-Degree-Video Environments in VR Using Head Rotation and Eye Gaze

Yun Suen Pai
Keio University Graduate School of Media Design,
Yokohama, Japan 223-8526
yspai1412@gmail.com

Benjamin I. Outram
Keio University Graduate School of Media Design,
Yokohama, Japan 223-8526
benjamin.outram@gmail.com

Benjamin Tag
Keio University Graduate School of Media Design,
Yokohama, Japan 223-8526
tagbenja@kmd.keio.ac.jp

Megumi Isogai
NTT Media Intelligence Laboratories
Japan
isogai.megumi@lab.ntt.co.jp

Daisuke Ochi
NTT Media Intelligence Laboratories
Japan
ochi.daisuke@lab.ntt.co.jp

Kai Kunze
Keio University Graduate School of Media Design,
Yokohama, Japan 223-8526
kai.kunze@gmail.com

Figure 1: (a) Installed eye trackers on the HTC Vive, (b) GazeSphere system using head rotation for navigation, and (c) scene during navigation with virtual cue and semi-transparent rendered video

ABSTRACT

Viewing 360-degree-images and videos through head-mounted displays (HMDs) currently lacks a compelling interface to transition between them. We propose GazeSphere; a navigation system that provides a seamless transition between 360-degree-video environment locations through the use of orbit-like motion, via head rotation and eye gaze tracking. The significance of this approach is threefold: 1) It allows navigation and transition through spatially continuous 360-video environments, 2) It leverages the human's proprioceptive sense of rotation for locomotion that is intuitive and negates motion sickness, and 3) it uses eye tracking for a completely seamless, hands-free, and unobtrusive interaction. The proposed method uses an orbital motion technique for navigation in virtual space, which we demonstrate in applications such as navigation and interaction in computer aided design (CAD), data visualization, as a game mechanic, and for virtual tours.

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CCS CONCEPTS

• **Computing methodologies** → **Virtual reality**; • **Hardware** → *Sensor devices and platforms*;

KEYWORDS

Virtual reality, 360-degree-video, eye tracking, orbital navigation

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1 INTRODUCTION

Current 360-degree image and video use-cases do not allow for a smooth transition between several environments, often resulting in a jarring experience. Teleportation, though effective, has two fundamental problems; it is unrealistic and breaks the sense of immersion, and it requires a physical input such as a mouse click to move to the next point. The second issue is often solved using 'dwell time'which works well for allowing the viewing of the environment in virtual reality (VR) while also providing a hands-free solution that is unobtrusive and subtle [Pai 2016]. However, herein also lies a new challenge; given a smooth transition between two points is possible, then the ability to stop at any point to view the environment during the transition is also favorable. One of the more popular solutions right now is eye tracking in VR. For example, Transparent Reality [Pai et al. 2016a] and GazeSim [Pai et al. 2016b] utilized eye tracking in VR as an input modality by computing the focus depth of the eye gaze to transition between layers of information and for foveal rendering respectively. Layered Telepresence [Saraiji et al. 2016] also shows the promise of eye tracking for use in simultaneous multi-presence using multiple telepresence robots. In terms of transitions in virtual environments, an interesting method was proposed in AnyOrbit [Outram et al. 2016] that uses head rotation and exocentric rotation for locomotion that minimizes motion sickness. However, this method required a separate mouse input to allow user control of the center of rotation.

2 SYSTEM DESCRIPTION

The GazeSphere system was developed with several goals in mind, one of which was to limit the overall input devices and create a hands-free solution to navigation between stationary positions represented to the user through 360-degree video. To achieve this, we used the Pupil Labs' eye-tracking infrared camera system to calibrate the user's gaze point.

Our implementation utilizes head rotation for transitioning from one point to another [Outram et al. 2016]. The system uses 360-degree videos taken at two stationary locations, and a 360-degree video shot continuously between these two locations.We then seek this transitioning video using head rotation, where rotation of the head left and right is coupled to seeking forward or backward in the video. The head rotation angle A is coupled to position p between transition start and end points a and b by the relation

$$p = a + (b - a)sin^2(A/2)$$

where $A = 0$ when the user is facing in the direction $b - a$. This allows a more orbit-like sensation and intuitive understanding of the beginning and end points of the transition. To maintain hands-free interaction and allow the user to select from among multiple possible transition directions, we employ real-time eye tracking as input. If the user looks at the virtual cue, the transition is initiated and the user can navigate toward that direction using their head rotation. During this phase, we employ AnyOrbit's torus-based orbit algorithm, which produces a self-correcting orbital path of the user around the cue object, and enhances the orbital motion metaphor that is very intuitive to users. While transitioning, the user can, at anytime, deactivate orbital motion by looking away from the cue object, thus returning to a stationary egocentric rotation view. Figure 2 illustrates the arc of the orbital motion.

3 USER EXPERIENCE

Initial studies and demonstrations have shown that users were able to quickly adapt to this motion without any noticeable motion sickness. For example, most users were able to master a related navigation technique in 5 minutes [Outram et al. 2016].

The proposed system can redefine navigation mechanics in HMDs for 3D content as well. For example, Figure 3 shows the navigation mechanic being used for CAD modelling, sports viewing, data visualization, and gaming. Orbital navigation allows intuitive

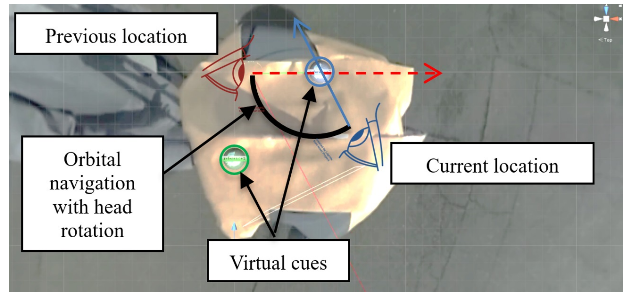

Figure 2: System overview during navigation

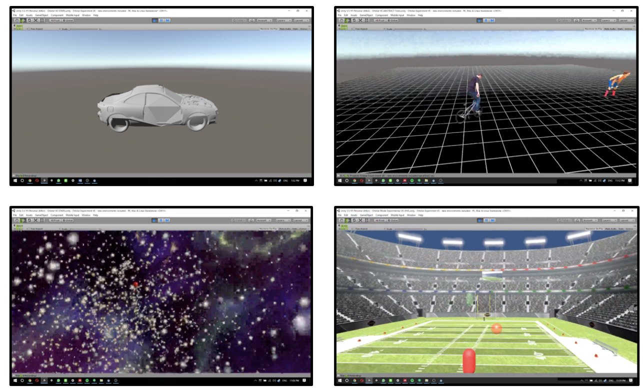

Figure 3: GazeSphere used in 3D content like (a) CAD modelling, (b) sports viewing, (c) data visualization, and (d) gaming

viewpoint selection to allow, for example, freedom to observe particular sports plays in sport, or particular data points in 3D data visualizations.

4 CONCLUSIONS

GazeSphere provides the user with an intuitive and unique method of transitioning between 360-degree environments through the use of head rotation and eye gaze. It provides a seamless experience of movement without relying on external tracking devices.

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