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Immersive Spatiotemporal Travel in Virtual Reality

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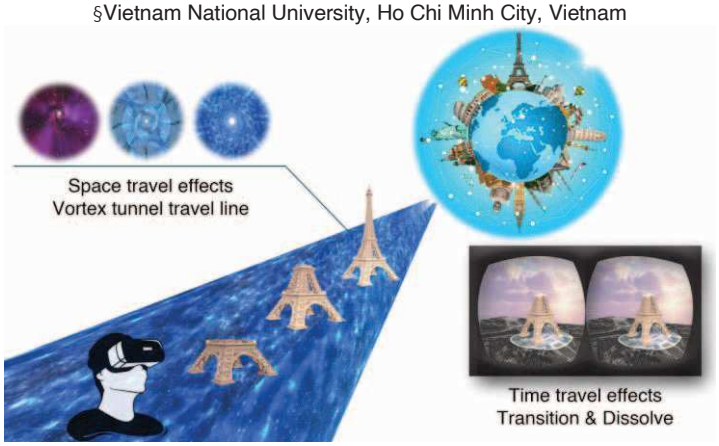

Figure 1: Space and time travel experienced in Virtual Reality

Abstract

Space and Time travel, once confined to science fiction, are now subjects of practical scientific inquiry. However, the practical feasibility of such journeys remains uncertain. This paper aims to investigate and elucidate the effects encountered during simulated space warp and time travel. Specifically, it examines three effects associated with spatial displacement and two effects related to temporal shift, contextualized within the construction phases of five monumental world wonders. Our study, which assesses participants' perceptions while experiencing these effects through virtual reality headsets, provides valuable insight into the potential of immersive space-time travel simulations and could inspire future developments in the field.

Keywords: Time travel, space travel, effect experience, user study.

Index terms: virtual reality, historical visualization.

1 Introduction

Current applications of Space & Time Travel concepts in augmented reality (AR), virtual reality (VR), and mixed reality (MR) primarily focus on the transformations and outcomes across different stages. For instance, the Historical Exploration VRET (Virtual Reality Exhibit Template) system [1] is constructed stage-by-stage, presenting results in various forms, such as 3D terrain construction, 360-degree images, and videos. Another system uses storytelling methods to describe the time travel experience to the past in Bosnia and Herzegovina using VR and AR [2]. Yet, both systems largely overlook and evaluate the development of time travel effects. In reality, Einstein's general theory of relativity is one of the most renowned theories when discussing the concept of time travel. From a first-person perspective, certain symbolic models and images typically associated with this process include cosmic strings, traversable wormholes, and Alcubierre drives [3]. Several movies, comics, and animations have depicted and simulated the effects of space-time travel through various effects, such as in "Doraemon" (1969), "Star Wars" (1997), "The Time Machine" (2002), and "Doctor Strange" (2016). Although these experiences are not genuine or have little basis for accurate simulation, some images of the distinctive characteristics of the time travel process have been speculated and familiarized with many viewers. The visual arts in the animated film "Mr. Peabody & Sherman" [4] demonstrate how to recreate time travel effects using the concept of magical wormholes. This highlights the potential for developing Space and Time effects for VR and MR applications in historical recreation. However, the focus is solely on visual artistry, not on user perspectives and experiences with VR headsets, particularly for reconstruction apps. Therefore, it is entirely feasible to construct and simulate these effects, particularly in VR, to enhance the immersive experience for users, especially in VR applications. This paper develops a Space & Time Travel system to visualize famous landmarks' history and construction processes - the world's wonders. We specifically focus on creating space travel effects during transitions to different locations and time travel effects during the experience of changes in events throughout developmental stages.

2 Proposed Method

Our proposed method for simulating space and time travel involves a detailed process that we will now explain. We simulated the experience of space and time travel by creating a first-person perspective through warping effects on the Meta Quest 2 VR headset. Figure 1 describes the sequence for experiencing our system: participants select a location and spatial warping effect, and then they are transported to the corresponding area with space travel effects, where they can interact with the developmental milestones through time travel effects. The selected landmarks and structures for recreation based on historical information are the Wonders of the World, including Golden Gate Bridge – San Francisco – USA, Eiffel Tower – Paris – France, El Castillo (Kukulkan Pyramid) – Chichen Itza – Mexico, Statue of Liberty –

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New York – USA and Taj Mahal – Agra – India. We chose to present information in three stages of time travel so that it can clearly illustrate the differences between each construction phase and avoid prolonging the construction process excessively between stages, thus minimizing the risk of experiencing cybersickness in VR environments and also guiding visitors towards important details influencing the overall structure of the building. For each structure, the stages are developed according to a common template, following a historical progression typically from bottom to top. Therefore, we have devised the following template for developing 3D models of the structures: foundation stage, development and construction stage, completion and inauguration stage. The surrounding environment of these landmarks is represented in the form of 3D terrain with corresponding height information, overlaid with a texture layer—satellite images of the area—on top to resemble the real surroundings.

Space travel effects, inspired by movies like Star Wars and Doraemon, simulate flying from one space to another with various images and sensations of movement. Achieving this requires creating a perception of speed and acceleration changes over time, similar to the feeling of traveling by car or airplane. Key characteristics include increasing speed (hyperspeed effect), surreal surroundings like galaxies and stars, and a round surrounding structure, often depicted with cylinder and sphere shapes. The implementation idea for this effect is to create a cylinder, stretch it horizontally, apply textures to its inner surface, manipulate these textures to simulate travel, and choose appropriate textures to create desired images during space travel. Finally, place the camera (also the participant's viewpoint) in the center of the cylinder. It not only provides participants with a 360-degree view but also allows movement and interaction within the 3D space inside the cylinder. Due to these reasons, utilizing and customizing Kronnect's Tunnel FX assets are considered for compatibility and various customization options [6]. By choosing and adjusting parameters such as texture, speed, sound, alpha, rotation, twist, and color, we can create 3 space travel effects similar to the ones seen in famous movies such as "Doctor Strange multiverse travel – Star warp", "Star Wars hyper-speed – Space warp", "Doraemon's Time Machine – Time warp" as shown in Fig. 2a, while ensuring it's suitable for VR viewing. Most architectural transformations over time involve continuous disappearance or replacement effects from one timeline to another. For the time travel effects, we chose to develop a transition effect that can dissolve between meshes as we built in 3 stages. We built the experienced effect during the transition, which is replicated within applications using a particle effect system. This effect has been previously observed in the "Star Wars" movie series, where multiple rays of light emanate from the center, expand outward on the front view of the traveler. (Fig. 2b)

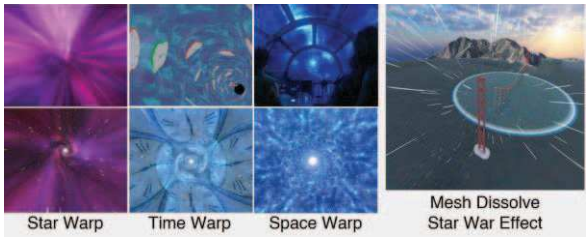

Figure 2: (a) spatial effects (b) temporal effects

3 User Study and Analysis

This study involved 30 participants with an average age of 21.56 years. Participants experienced three space warping effects—Star Warp, Time Warp, and Space Warp—and two time travel effects—Mesh Dissolve and Star War. The survey assessed these effects based on several criteria: immersion, presence, effect smoothness, cinematic comparison, and overall satisfaction. The results in Figure 3 indicated that Space warping effects generally provided a superior user experience compared to Time travel effects across most evaluated criteria. The overwhelmingly positive feedback on space warping effects, particularly the Star Warp, highlights the potential for these effects to offer highly engaging and immersive experiences. The high perceived presence, immersive, smoothness, and cinematic similarity indicate that current VR technologies can effectively replicate and even enhance familiar cinematic experiences. The highly positive responses regarding overall satisfaction suggest a strong foundation for building more sophisticated and compelling VR experiences. Based on the Game Experience Questionnaire [5], we found that the participants felt the experience was rich, impressive, exploratory, imaginative, and aesthetic, and also recommended we integrate more landmarks worldwide.

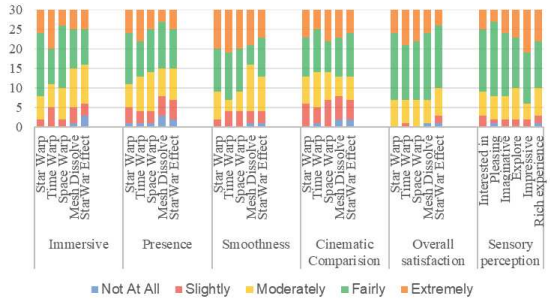

Figure 3: User study survey result

4 Conclusion

In this paper, we investigate spatiotemporal travel in virtual reality and conduct a user study on the effects of space and time travel. Our system received positive feedback from the participants. In the future, we plan to integrate more interactive and visually dynamic elements to elevate the immersive quality of space and time travel experiences further.

ACKNOWLEDGMENT

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