2022 IEEE Conference on Virtual Reality and 3D User Interfaces Abstracts and Workshops (VRW) | 978-1-6654-8402-2/22/$31.00 ©2022 IEEE | DOI: 10.1109/VRW55335.2022.00263

Touch the History in Virtuality: Combine Passive Haptic with 360° Videos in History Learning

Yanxiang Zhang* Yingna Wang† Qingqin Liu ‡

University of Science and Technology of China

Abstract

History learning can help learners understand changes and establish identity. 360° videos can display complex history scenes, but limited to the visual and auditory. Passive haptic can provide tactile feedback by matching physical props to virtual counterparts. Utilizing passive haptic in 360° videos can create a diverse and rich experience but face matching problems because of perspective distortion. We propose using high-fidelity models and mapping videos to a cube space to solve this problem. The results of a 28 participants user study show that combining passive haptic with 360° videos enhances users' presence in historical experience.

Keywords: 360° videos, passive haptic, history learning, space match.

Index Terms: [Systems, Man, and Cybernetics]: Human Computer Interaction—Immersive Experience; [Computers and Information Processing]: Haptic Interfaces;

1 Introduction

History can help learners understand people, societies, changes, and how the society we live in came to be. Studying history is essential for good citizenship and establishing identity because history learning can train the abilities to assess evidence and conflicting interpretations[1]. Using 360° videos in history learning can train students effectively and efficiently and promote them to foster a sense of responsibility to safeguard more cultural heritage [2]. 360° videos can display complex history scenes with high-fidelity, but the experience is mainly limited to the visual and auditory. The user's core ability to move autonomously and interact with elements within the virtual world is limited to choosing an angle within the environment from which to view the scene in 360° video [3]. Passive haptic can provide tactile feedback according to user actions by matching physical props to virtual counterparts[4]. Passive haptics has been proven to significantly enhance virtual environments, especially the sense of presence[5] [6]. Previous studies mainly use passive haptic in computer-generated modeling environments, which will take great efforts to simulate the real history sceneries. In this work, we combine passive haptic with 360° videos to create an immersive virtual historical experience. We hypothesize that this combination can enhance users' presence than simply watching the video and using a 28 participants user study to verify it.

Utilizing passive haptic in 360° videos can create a diverse and rich experience while maintaining a high degree of visual realism. It can not only be used in history teaching in school but also in cultural tourism and personal history learning and experience.

* petrel@ustc.edu.cn
† wynnewang@mail.ustc.edu.cn
‡ neoluxqq@mail.ustc.edu.cn

2 Experimental Setup

Using passive haptic in 360° videos faces matching problems different from computer-generated environments. The perspective distortion of 360° videos changes the scale and position of the objects, especially those close to the camera. Combing 360° video environments and high-fidelity models by scanning or modeling is more suitable for utilizing passive haptic in 360° videos. Since the 360° video environment is not a modeling environment, it is difficult to locate and match the modeled objects in it. We created a cube space considering one side as the ground, making it easier for the designer to find the coordinate, especially in indoor scenes when matching the virtual to reality.

2.1 The Problem of Matching objects in 360° videos

We shot a 360° video with the resolution of 7680*3840@30fps 8bit at the former residences of a famous local historical figure using the QooCam 8K with the lens of F2.0 and 200° FOV. Since we want the participants to experience the video while sitting, the camera's height is 120cm. An Oculus Quest 1 is used to display an immersive experience. 360° videos provide the freedom of viewing in all directions but are limited by the camera position. Passive haptic provides tactile feedback based on the user's touch movements. So, it's vital to match objects close to the camera in the shooting video. However, we found that objects close to the camera are severely distorted when watching with HMD. Perspective distortion is apparent when shooting scenery closely using wide-angle lenses, which are widely equipped for panoramic shooting. Shoot at wide angles, and short distances resulting in extended distances, that is, objects close to the lens appear abnormally large while the distant appear abnormally small [7]. In addition to the size, the distance and height of the objects close to the camera don't match reality either.

2.2 Map 360° videos to Cube Space

We shot another 10-minute 360° video without objects relatively close to the camera. Then we chose to model a high-fidelity table with a calligraphy work and a scanned Chinese brush on it. We also fixed a brush and unfolded rice paper on a table. After mapping the video to a unity sphere, we find the matching process requires many adjustment steps and higher space perception cause the reality we perceive is not spherical.

Figure 1: Match the table in sphere (left) and in cube (right) in Unity

Since it is not a modeling environment, it is difficult to locate and match the table, brush, and rice paper in 360° videos. We envisioned constructing a hexahedral space considering one side as the ground to map the virtual objects in 360° videos in Unity. The 360° video is divided into six squares and projected into the cube's six sides. We used the camera's processing software QooCam Studio to adjust the view of 360° video by changing the Yaw, Pitch and Roll parameters in Reframe mode, and exported six square-shape videos. After mapping the videos to the cube faces, we imported and adjusted the models in the cube according to the real objects. We found the models can be accurately and easily adjusted in the 360° video cube environment like in a 3d computer-generated environment. The whole procedure took about 34 minutes.

3 User Study

To verify our hypothesis that utilizing passive haptic in 360° videos can enhance users' presence than watching the video alone, undergraduate and postgraduate students ($N = 28$; 15 females and 13 males) volunteered by convenient sampling to participate in the experiment. The age of the participants ranges from 20 to 28 ($M = 25.3$, $SD = 1.93$).

All participants signed written informed consent and filled out an online background information questionnaire. Participants were randomly assigned to either the "passive haptic group" (G_P) or the "360° video group" (G_V) with 14 participants each. The G_P sat at the table, and on the table was placed a brush and unfolded rice paper that had all been matched to the virtuality and fixed on the table. The G_V sat on the same chair without other objects around. The background sound in the video first introduces the objects in the scene, then introduces the owner of the room, and finally uses historical images and videos to assist in conveying the information.

Figure 2: User experiencing scenes (the left is G_P with paper and a brush on the table, the right is G_V without haptic passive).

After watching, the user completed an online Presence Questionnaire (PQ) by Witmer and Singer[8] using a Likert scale with seven answer options and a semi-structured interview. The KMO value of PQ is .86 and p of Bartlett's test is 0.000<0.01, so it's appropriate for exploratory factor analysis (EFA). The results of EFA indicate the validity of PQ. The Cronbach's α is .82, so the reliability of PQ in this experiment is also acceptable. The presence of G_P is significantly higher than G_V, $F(1, 26) = 48.6$, $p < .01$. Both groups' participants inflected that their identity of the history figure improved (11/14 in G_P and 12/14 in G_V). Their knowledge of the local history increased (all in GP and G_V) after the experience. Participants (8/14) in the G_P said that when they first touched the brush and the paper that matched the virtual environment on the table, they felt moved from the space where they were into the virtual historical scene, and this feeling was incredible. Participants in both groups (10/14 in G_P, 7/14 in G_V) expressed interest in the historical scene. Some of them (4/14 in G_P, 2/14 in G_V) even said that they wanted to go to the former residences in person offline after the experiment.

4 Conclusion

In this work, we proposed the idea of utilizing passive haptic in 360° videos to create an immersive and authentic virtual historical experience. However, using passive haptic in 360° videos faces matching problems different from computer-generated environments because of the perspective distortion. Using high-fidelity models by scanning or modeling can achieve the models in the virtual space to have the same shape as the real objects. Mapping 360° videos to a cube space with one side as the ground is easier to locate and match the models in 360° video environments. The results of the user study show that combining passive haptic and 360° video can enhance users' presence and history learning interest than 360° video alone.

360° video environments can realistically present historical scenes and cultural heritages, but the experience is limited visual and auditory. Passive haptic can bridge the virtual and reality with spatially-registered physical models, and low-fidelity props constructed from cheap, convenient materials such as plywood and particleboard can increase users' realism, immersion, and presence [4]. The cube space we proposed reduces the space perception and adjustment steps when matching models to objects. With the development of 360° video shooting cameras and processing software along with consumer-level virtual reality (VR) devices, the difficulty and cost of 360° video production based on passive haptic are not high, which means that it can be applied on many occasions, such as in the classroom of history learning, the VR experience in historical relics, and the personal historical tour of private space like home.

5 Limitation and Future Work

The video in this work is shot at a fixed position and the passive haptic interaction method we used is realized by matching the fixed objects, which is relatively simple. More complex interactions such as real-time tracking and other tactile feelings need to be studied in future work.

Acknowledgements

This paper is supported by National Social Science Foundation of China, under grand number: 21VSZ124.

References

[1] P. N. Stearns, "Why study history," *American Historical Association,* pp. 1-7, 1998.

[2] R. Abidin and N. Suryani, "Students' Perceptions of 360° Degree Virtual Tour-Based Historical Learning About the Cultural Heritage Area of the Kapitan and Al-Munawar Villages in Palembang City," *International Journal of Social Sciences and Management,* vol. 7, no. 3, pp. 105-112, 2020.

[3] J. Mateer, "Directing for Cinematic Virtual Reality: how the traditional film director's craft applies to immersive environments and notions of presence," *Journal of Media Practice,* vol. 18, no. 1, pp. 14-25, 2017.

[4] B. E. Insko, *Passive haptics significantly enhances virtual environments*. The University of North Carolina at Chapel Hill, 2001.

[5] R. Viciana-Abad, A. R. Lecuona, and M. Poyade, "The influence of passive haptic feedback and difference interaction metaphors on presence and task performance," *Presence,* vol. 19, no. 3, pp. 197-212, 2010.

[6] M. Meehan, B. Insko, M. Whitton, and F. P. Brooks Jr, "Physiological measures of presence in stressful virtual environments," *Acm transactions on graphics (tog),* vol. 21, no. 3, pp. 645-652, 2002.

[7] M. Galer, *Photography Foundations for Art and Design: The creative photography handbook*. Routledge, 2012.

[8] B. G. Witmer and M. J. Singer, "Measuring presence in virtual environments: A presence questionnaire," *Presence,* vol. 7, no. 3, pp. 225-240, 1998.