

Guidance Method Using Color-Changing Markers for Historical-Site Exploration in Virtual Reality: A Preliminary Study

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Abstract—Virtual reality (VR) technologies have been widely adopted in diverse fields over the past few decades, including the field of historical site exhibitions and cultural heritage education. In real-world exhibitions, content providers often employ various navigation strategies to help visitors understand and explore the presented content effectively. Similarly, in VR environments, previous studies have proposed guidance methods using visual signs and animated agents, to direct users toward intended locations. However, VR content providers and exhibition staff may need a guidance approach that encourages users to follow an intended route while allowing them to move freely and observe the environment. Moreover, guidance cues must also remain visually distinct from reconstructed historical structures. Therefore, we developed a flexible guidance method using color-changing markers that identify locations offering audio narration and explanatory text. Each marker changes color after users access the associated narration. The markers were placed throughout a virtual historical site, enabling users to locate narration points and identify those they had already visited. The color changes also encouraged users to proceed naturally to subsequent locations. In a preliminary evaluation, participants could visit the marked locations and access the associated audio narration as intended. These findings suggest that the proposed method can guide users through a virtual historical site while preserving free exploration. They also indicate that future versions should guide both user movement and visual attention. The method may be applicable to other virtual historical sites.

I. INTRODUCTION

Virtual reality (VR) technologies have been widely employed in recent decades for tourism and education [1, 2], and applied to historical site exhibitions and cultural heritage education [3, 4]. Through VR-based reproduction of historical sites and cultural assets, learners can experience culture and history effectively and conveniently without visiting the actual locations. Such experiences can also lead to an increased interest in culture and history.

In particular, it is valuable to reproduce historical buildings and sites that have been destroyed by fire or deteriorated over time and to experience them virtually. Fig. 1 shows an example of a lost ancient temple reproduced by Nakashita et al. [4] and a scene from the corresponding VR experience. The building was manually reconstructed using 3D modeling software based on historical blueprints and excavation results from the site.

Moreover, in real-world museums or historical sites, content providers may have a way to present their content for

visitors to learn effectively. For example, a viewing order may be set in advance, and guidance and explanations (audio narrations, signs, or other explanatory materials along the route). Similarly, a guidance method in VR is required. Previous studies have proposed the use of effective signs (arrows [5]) and animated agents instead of human guides [6]. Tsai et al. proposed a semi-limited guidance method that partially constrains the user's range of activity in VR [7].

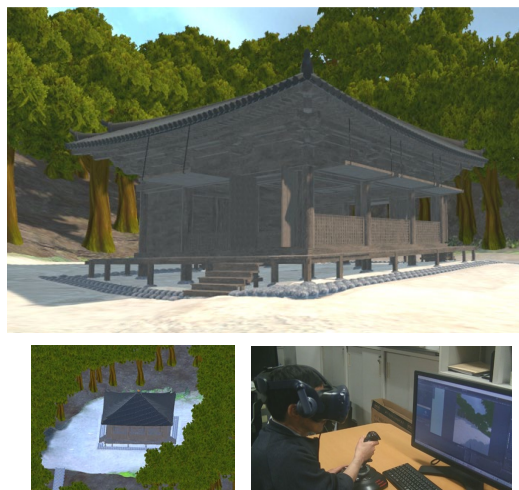


Fig. 1. Production of VR content "Hojo Yoshitoki Hokkedo" [4] and a scene from the corresponding VR experience.

However, VR content providers and exhibition staff may have specific design requirements. In particular, a guidance system may need to encourage users to follow an intended route without preventing them from moving freely and observing the environment. Guidance signs should also be clearly distinguishable from reconstructed historical buildings.

To address these requirements, we propose a flexible guidance method using color-changing markers. Each marker identifies a location where users can access audio narration and explanatory text, and its color changes after they access the narration. Because the markers are visually distinct from the historical buildings, they satisfy the requirement for clearly visible guidance cues. We implemented the method in a virtual historical site and conducted a preliminary evaluation of its suitability.

II. OVERVIEW OF THE GUIDANCE METHODS

We implemented a marker-based method for guiding users through a virtual historical site. Fig. 2 illustrates the proposed

method and the marker color changes. Animated circular markers were placed throughout the site. When users located a marker, they could access the audio narration and explanatory text associated with that location. After they listened to the narration, the marker changed color, enabling them to distinguish visited narration points from unvisited ones and helping them visit all designated locations.

The markers had three color states. Cyan indicated a narration point that had not been accessed, orange indicated the recommended next marker, and purple indicated that the associated narration had been accessed. This color-coding scheme made the markers easy to locate, identified the next destination, and encouraged users to proceed naturally between locations. Nevertheless, users remained free to move through the historical site and observe it from different positions.

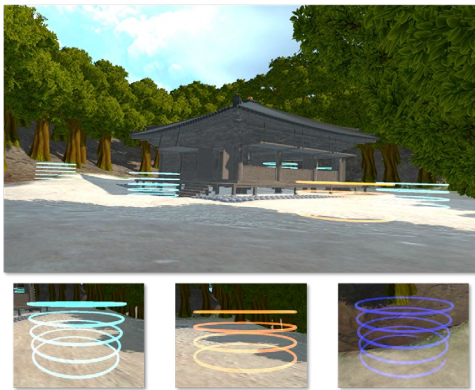


Fig. 2. Color-changing marker states: left, cyan (narration not yet accessed); center, orange (recommended next marker); right, purple (narration accessed).

III. PRELIMINARY EVALUATION AND DISCUSSION

We conducted a preliminary evaluation at the virtual historical site. Six markers identified locations where users could listen to audio narration, read explanatory text, and learn about the site's history. Participants wore an HTC VIVE Pro head-mounted display (HMD) while exploring the virtual environment. They were instructed to visit the markers, listen to the audio narration, and read the accompanying explanatory text.

Fourteen participants took part in the evaluation. Of these participants, 12 visited the markers and accessed the audio narration as intended. The other two missed several narration points, apparently because of their viewing direction. This observation suggests that the guidance method should direct not only users' movement but also their visual attention.

Accordingly, we developed a tool to track users' gaze in VR and plan to use it in future eye-tracking experiments, as illustrated in Fig. 3. The tool uses Unity's Raycast function to identify positions and virtual objects intersected by a ray projected in the user's gaze direction. These objects may include buildings, trees, and statues within the virtual environment.

Overall, the proposed method encouraged users to follow an intended route while allowing them to move freely and

observe the environment. The approach may therefore be applicable to other virtual historical sites. However, further evaluations with larger samples and comparisons with alternative guidance methods are needed.

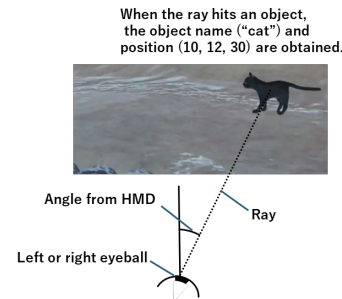


Fig. 3. Determination of gaze positions using rays and angles from the HMD. Unity's Raycast function was used to identify the positions and virtual objects toward which users directed their gaze.

IV. CONCLUSIONS

This study introduced a guidance method that encourages users to follow an intended route while preserving their freedom to move through and observe a virtual historical site. The preliminary results indicated that the method functioned as intended for most participants and met the content providers' design requirements. Further studies should include larger participant samples, comparisons with alternative guidance methods, and gaze-aware support for directing users' visual attention and improving their understanding of historical sites in VR. The proposed method may also be applicable to other virtual historical-site experiences.

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