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GazeTance Guidance: Gaze and Distance-Based Content Presentation for Virtual Museum

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Abstract

The increasing popularity of virtual reality provides new opportunities for online exhibitions, especially for fragile artwork in museums. However, the limited guidance approaches of virtual museums might hinder the acquisition of knowledge. In this paper, a novel interaction concept is proposed named GazeTance Guidance, which leverages the user's gaze point and interact-distance towards the region of interest (ROI) and helps users appreciate artworks more organized. We conducted a series of comprehension tasks on several long scroll paintings and verified the necessity of guidance. Comparing with no-guidance mechanisms, participants showed a better memory performance on the ROIs without compromising presence and user experience.

Index Terms: Human-centered computing—Human computer interaction (HCI)—Interaction paradigms—Virtual reality; Human-centered computing—Human computer interaction (HCI)—HCI design and evaluation methods—Usability testing;

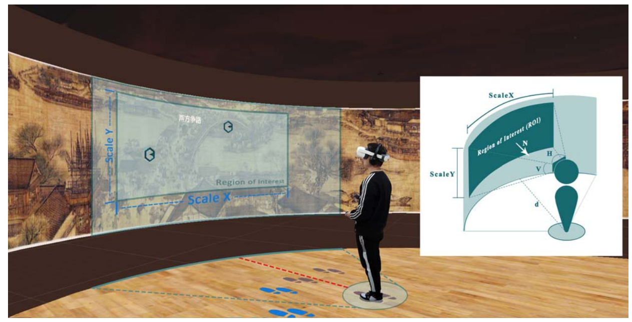

Figure 1: A user is looking at an informative plane with gaze and distance guidance in a virtual museum tour. The footprints indicate suitable positions for observation while the flickering cursors marked the center of ROI as recommended gaze point.

1 Introduction

The concept of the virtual museum has rapidly evolved through the development of Virtual Reality (VR). Previous research has shown that mechanisms for guiding a user's visual attention to a particular ROI play a significant role in xR-based education. These techniques include visual effects [1], intensive flickering [5], implicit guide with audios [3] and so on. In addition, the position of observation between user and content is also discussed [2]. These works help us to understand and design immersive experiences.An evident challenge is how to organize fragmented information with higher DoF. When establishing virtual museums, artworks and corresponding commentaries are supposed to be connected tightly, and user behavior requires more accurate guidance, especially for exhibits with massive information.

This paper proposes a novel two-tier interaction mechanism in room-scale VR system, namely *GazeTance Guidance*, which presents information through guidance on the user's gaze point and interact-distance towards the ROI (see Figure 1). Comparing with two ordinary interaction mechanisms, including museum showcase and ROI marked with cursor triggered by the VR controller, proposed *GazeTance Guidance* can provide a better memory performance on the ROIs without compromising presence and user experience.

2 GazeTance Guidance

GazeTance Guidance aims at helping users to understand and memorize complex information in virtual museums. This mechanism contains two kinds of interactive elements: flickering cursors and footprints, which correspond to gaze and distance guidance respectively. Cursors were pinned on painting by setting their position coincided with ROIs' center. Footprints were placed on the floor with position more carefully calculated (See right side of Figure 1). suitable position P to observe the ROI is calculated as follows:

$$P = \begin{cases} P_{ROI} + N * \frac{ScaleX}{tan(H)} & , \quad if \frac{ScaleX}{ScaleY} >= k \\ P_{ROI} + N * \frac{ScaleY}{tan(V)} & , \quad others \end{cases} \tag{1}$$

where P_{ROI} is the position and N is the normal vector of the ROI plane. H and V are the human viewport angles in the horizontal and vertical direction. We set $H = 94^\circ$, $V = 32^\circ$ as suggested by IBM[1]. $k = \frac{tan(H)}{tan(V)}$ is the parameter which determines the dominant scale axis of ROI. Besides, the footprint was rotated to let the tiptoes point to the ROI, helping the user find the cursor easily.

The cursor for each ROI would be active only if the user moved next to (less than 0.3m) the corresponding footprint. A gaze pointer follows the user's head rotation and locates at the center of the viewport. If the pointer collided with any active ROI and stayed for a period of time (temporarily set to 1.5 seconds), the system would play audio commentary and show a keyword.

3 User Study

We conducted a user study with 24 participants (16 males and 8 females) to evaluate the effect of *GazeTance Guidance*. The study aimed to measure user experience [4] (UEQ), presence [6] (IPQ), and user's memory and comprehension of ROI related contents.

The Pico Neo 2 headset was used to immerse the user into virtual museum tours. Three long scroll Chinese paintings were selected to surround the virtual space, including *Luoshen Appraisal Painting (LAP)*, *A Thousand Li of Rivers and Mountains (ATLRM)* and *Along the River during the Qingming Festival (ARQF)*. The paintings are both of historical value and rather difficult to memorize and understand in detail for non-professionals, so they are helpful for us to carry out comparative experiments.

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[1] https://www.ibm.com/design/v1/language/experience/vrar/user-comfort/working-zone/

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In each of the virtual museum tours, participants are supported by one of three different ways of explaining the contents of the scroll. Figure 2 shows illustrations of the three interaction mechanisms we are comparing called *Showcase* (SC, which simulates the traditional museum layout without gaze or distance guidance, and the keywords are written on textboards below the ROIs), *ROI Cursor* (RC, which includes cursor for guidance, keywords and audio commentary, but does not restrict the user's gaze angle and position), and *GazeTance Guidance* (GTG, ours). Each tour's audio commentary starts with a description of the current painting, followed by 18 to 31 short descriptions correspond to ROIs. The total audio length for each painting is approximately 5 minutes (see video[2] for more details).

Figure 2: Showcase, ROI Cursors, and GazeTance Guidance

In the within-subject design we used, participants were equally divided into 6 groups to ensure that each interaction mechanism of each content is experienced the same number of times. The experiment consists of the following steps:

1) Participants were given a general introduction and filled in a basic information sheet. 2) Participants learned to use the system by watching on a screencast and operating in an empty virtual room with sample interactive ROIs. 3) Then they wandered in a virtual museum, and were told to traverse all ROIs. In other words, participants needed to go through all textboards in SC, or click all cursors in RC (with VR controllers), or step on all footprints with cursors being gazed in GTG. 4) They filled out IPQ, UEQ, and an ROI-related questionnaire immediately after each tour. 5) Steps (3) and (4) were repeated three times with different interaction mechanisms. The order of 3 paintings and 3 interaction modes were random.

The ROI-related questionnaire includes 4 image captures for content restatement (memory task, MT) and four descriptions for true/false judgment (comprehension task, CT). Each capture contains 1 to 3 *keywords* (ROIs) to restate. The final score consists of the keywords hit in restatement and the number of correct judgments. It is worth mention that the full score in MT and CT are normalized to 10 and 4 for each painting respectively.

4 Results and Discussion

The results were analyzed based on 72 trials over 24 participants. The left side of Figure 3 shows the distribution of content-related score in each trial, where darker colors represent for MT score. The GTG mechanism (MT: 8.3 ± 1.7, CT: 2.8 ± 1.0) shows a distinct advantage when compared with RC (MT: 7.1 ± 2.0, CT: 2.4 ± 0.8) and SC (MT: 7.4 ± 1.7, CT: 2.2 ± 1.0). A one-way ANOVA on MT score also revealed an evidently main effect for the painting content ($F_{2,70} = 28.17$, $p < .001$).

The UEQ results are illustrated in the middle of Figure 3. In general, a trend can be observed in which the conditions with guidance cursors (RC and GTG) are distinctly higher compared to the conditions without guidance cursors (SC). We conducted a 3 (painting) x 3 (mechanism) mixed factorial ANOVA on the normalized UEQ scores. Results revealed a significant main effect for the interaction mechanism ($F_{2,142} = 37.71$, $p < .001$). In our IPQ results (shown as the right side in Figure 3), a two-way ANOVA revealed that there

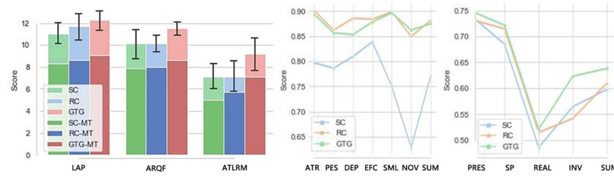

Figure 3: Content-related score(± total score standard error); comparison of UEQ factors; comparison of IPQ factors

are no significant differences in the sense of presence between SC, RC and GTG ($F_{2,94} = .72$, $p = .490$).

Overall, results from this study show that the content-related score in content restatement and description judgment with GTG are significantly better than SC and RC. Participants can memorize and comprehend the content in the painting much better with the help of gaze and distance-based guidance.

5 Conclusion and Outlook

In this paper, a gaze and distance-based interaction mechanism, namely *GazeTance Guidance*, is introduced that enables virtual museums to provide a more comprehensible exhibition. In conducted user studies, we investigated how *GazeTance Guidance* affects information acquisition, user experience and sense of presence. Results show that *GazeTance Guidance* enhances users' memorization and comprehension of exhibits, and negligibly interfering with the user experience.

Moreover, *GazeTance Guidance* can adapt quickly to a virtual museum experience, when there are large works that require the observation of multiple details to ensure understanding. There are some possible directions for future work. More granularity of user behaviors, such as eye-movement tracking and gesture recognition, is expected to generate a better interactive guidance system with more accurate perception.

Acknowledgments

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