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Research on Visual Design of Virtual Reality Based on Eye Tracking Research

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Abstract: *Intangible cultural heritage refers to the manifestations of numerous traditional cultures, as well as connected entities and locations, which are passed down from generation to generation by people of all ethnic groups and are considered part of their cultural legacy. Music, dance, singing, drama, human talents, handicrafts, and other forms of expression are examples. Folk artists learn the inheritance method from the Master, which is how intangible cultural legacy is usually spread. It lacks a steady inheritance process and is on the verge of extinction. The protection situation is projected to deteriorate dramatically. However, it might be challenging for young people to recognize and experience the allure of intangible cultural heritage. As a result, several governments and UNESCO strongly advocate digital intangible cultural heritage conservation, and digital protection has become an essential mechanism of intangible cultural heritage inheritance. As one of the major technologies of digital information, VR (Virtual Reality) may employ digital technology to allow people to experience intangible cultural heritage in a 360-degree immersion and interact with characters and objects in VR to gain a multi-channel perception experience. The use of virtual reality technology to safeguard and restore intangible cultural assets is becoming a hot topic and academic frontier.*

Keywords: *Virtual Reality; Eye Tracking; Visual Design; Immersive experience*

1. Introduction

Mah & Obp (2019)[1] used 3D scanning modeling paired with VR technology to create a virtual tour for a Chinese temple in Singapore, which increased guests' sense of engagement. OndrejMitas (2019) [2]used virtual reality and augmented reality to improve the user's experience of cultural heritage tours. Martin (2020)[3] used virtual reality technology to enhance UNESCO's World Heritage Site in the Canary Islands, Spain, by providing interactive architectural and artistic information in a simulation application that allows users to explore, examine, and engage with cultural heritage places in real time. In the study of VR intangible heritage's temporal portrayal. By incorporating social history into cultural heritage sites and building a narrative-based virtual environment (VE) inside of them, Tuck (2009) [4] improves visitors' knowledge and comprehension of cultural heritage. Kola (2020)[5] proposed this usage of MR for media that tells historical and cultural tales, and she investigated how consumers' psychological states changed as the plot developed. In order to immerse users in a particular setting where historical information can be learned, Cecotti (2020)[6] first proposed the idea of a timeline in cultural VR experience applications. Calandra (2016)[7] employed a modular eye-tracking device to record the gaze of viewers of digital cultural material in order to assess their emotional changes in her study on the visual aspects of the spatio-temporal depiction of VR intangible cultural asset. Eye tracking was utilized by Ross (2019)[8] to identify the primary regions where user vision on digital cultural and creative assets is concentrated. To increase the efficacy and usability of virtual reality museum visits, Pierdicca (2020)[9] suggested a technique for visual attention models drawn from eye-tracking data of digital cultural heritage observers. The portrayal of intangible cultural heritage often combines two aspects of time and place at once, yet in the past, research on VR simulations of intangible heritage has typically solely concentrated on the single dimension of time or space. Additionally, prior studies on the aesthetic qualities of cultural heritage have largely used flat images or films as their experimental medium rather than doing specific visual attention studies for VR settings. The goal of this research is to create a VR experience simulation application of cultural heritage from the two perspectives of time and space, and to specifically investigate the visual characteristics of time and space for the 360 °immersive VR environment.

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2. Virtual Reality and Eye Tracking Theory

2.1. Theory of Virtual Reality

A virtual environment that employs computer simulation to generate a three-dimensional space is called virtual reality, or VR for short. It may make you feel as if you are really in the virtual world and offers users simulations of senses including vision, hearing, and touch. Additionally, this form of immersion is dynamic and may alter depending on what individuals do inside it. The most radical attempt to integrate users with the virtual world is virtual reality technology, which is an advanced form of digital man-machine interface. Users can interact with objects in a virtual environment using a variety of interactive devices, such as a VR helmet, VR glasses, VR handle, etc. Users can experience tactile and auditory feedback in an artificially intelligent environment, resulting in an immersive interactive visual simulation and information exchange.

2.2. Vrtualreality Combined with Eeye Tracking Technology

Eye movement technology's benefits are combined with virtual reality. Eye movement technology is combined with the benefits of virtual reality to enhance user experience. The local rendering of the gaze point using eye tracking technology may enhance virtual reality's immersion and visual realism, as well as regulate external illumination and the user's head position. It can also provide eye tracking that is more accurate and of better quality. It benefits from both the aircraft and in-person eye movement experimental approaches. The portrayed scene is more immersive, eco-effective, affordable, and controlled than the flat one in a VR environment because it retains the three-dimensional depth cues that are inherent in natural vision, where visual stimulation and corresponding aural information function simultaneously. Additionally, in contrast to the actual world, the algorithm can automatically match the original eye movement data with the area of interest, meaning that the experimental setting and human resources are no longer a factor. The study purpose is no longer a constraint on the data's dependability, and sorting data sets requires substantially less labor overall. Diverse desktop or head-mounted eye movement devices are used in eye movement experiments to accommodate different demands. It is capable of impartially assessing and analyzing product designs in the lab that need interaction or don't have any real things.

3. The Development of VR Applications

This essay will choose an exemplary piece of intangible cultural heritage and develop a VR simulation application for it that restores the scene, model, and action.In order to determine whether the user's visual focus in the VR environment is on the critical performance area of intangible cultural heritage and whether it can sustain the user's visual attention, it will design temporal and spatial visual eye tracking experiments in a 360 °environment for VR applications. It will also use VR visual tracking analysis software for visualization and data analysis.A satisfactory user experience in both spatial and temporal visual presentation will be achieved by optimizing and improving the VR experience simulation application of intangible cultural assets based on tests.

3.1. Process of design and research

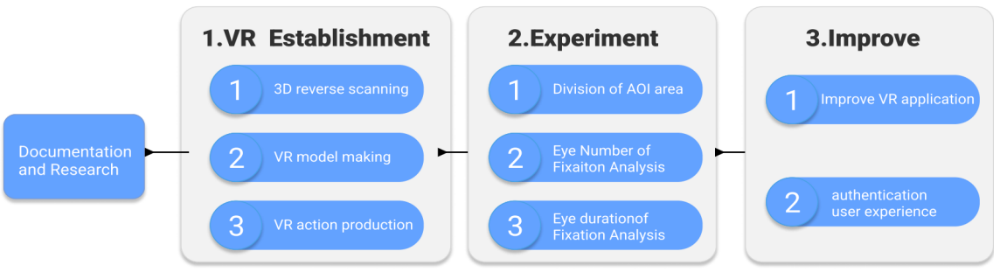

Figure 1: Diagram of the VR scene, model, and action restoration process

Figure 1 depicts the flow chart for the intended study methodology. First, it will create the scene, model, and action restoration to create the intangible cultural heritage VR application. Next, it will design experiments to examine the user's visual attention characteristics of space and time in the intangible cultural heritage VR application. Third, it will improve the application in accordance with the results of the user's eye movement vision experiment, and compile the results.

3.2. The Establishment of Virtual Reality Applications

While most current research on VR intangible cultural heritage focuses on specific technical means or immersive experience in a single dimension, it pays less attention to how to use temporal and spatial representation at the same time to achieve balance and unity. The VR simulation of intangible cultural heritage is typically expressed through two dimensions of time and space. Users may freely observe in a 360-degree immersive environment and even roam around while viewing intangible cultural treasures in virtual reality. Therefore, the study goal of this project is to determine how to determine if the visual attention falls on the key performance area of intangible cultural heritage simulation. Due to the limitations of VR technology, users will be immersed in the VR environment when they are cut off from the outside world, so this project's focus is on whether the simulation can hold users' continuous visual attention. In terms of the VR time representation of intangible cultural heritage. The goal of the design and application research for this project is to create and deliver a VR experience simulation application of intangible cultural heritage with both spatial and temporal representation, and to confirm that it has a satisfactory user experience via the VR eye-tracking test.

Based on the dancing lion tradition in Jieyang, Guangdong, China, a virtual reality application for intangible cultural assets was created. As depicted in Figure 2, It will gather data using a high-precision 3D reverse scanner on the chosen intangible cultural heritage items (dancing lion costumes), combine point cloud processing and 3D modeling software, and gradually complete the modeling of high-precision cultural heritage 3D models and environments in the 3D engine—Unity 3d. In order to create the final motion design simulation, It will deconstruct and gather the character actions from the intangible cultural heritage, edit and arrange them on a timeline, and then input them into the three-dimensional engine Unity 3d. It will utilize Kinect as the motion capture device. In order to provide consumers a genuine experience, It fundamentally insist on conserving intangible cultural heritage action performances from characters and costumes to the fullest degree possible.

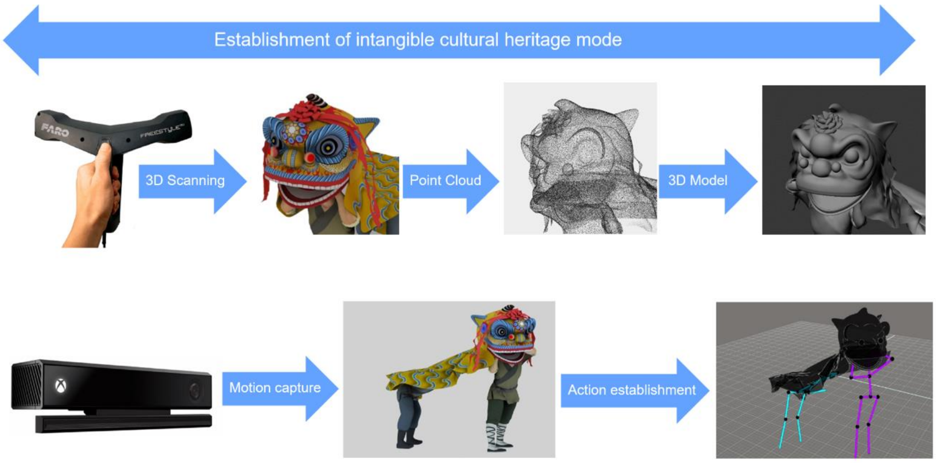

Figure 2: Flow chart of VR scene, model and action restoration establishment

3.3. Overview of Visual Design for Virtual Reality

The virtual reality user interface, as a three-dimensional user interface, needs to fully take into account the factors such as equipment, technology, and environment when designing because the interface is dependent on hardware devices, and the devices are flexible and changeable in addition to having the same functions, contents, vision, etc. as the general two-dimensional user interface. A kind of three-dimensional user interface, as opposed to a two-dimensional one, is the human-computer interaction interface for virtual reality. The most distinctive and essential component of a three-dimensional user interface is a three-dimensional interaction task. The way humans see, comprehend, and utilize space is shaped by their life experiences in three dimensions, which gives us the capacity to move and control things in three dimensions. People can easily perceive and perform three-dimensional interaction thanks to their cognitive and manipulative skills. This technique will also make user experience and habits more consistent with virtual reality human-computer interaction, resulting in a more natural and harmonious interactive experience and boosting immersion. As a result, a major focus of virtual reality HCI research is 3D interaction with geographical information. Dissect the operation job down to its simplest components, then break it down into smaller tasks. Then, using interactive technology, group the broad three-dimensional interactive activities into three categories: selection/manipulation, system control, and navigation. The basic categorization of operational duties, however, cannot be effectively applied to particular jobs in special contexts. Standardizing the processes used to carry out the tasks as well as more thorough interactive task design are required.

The possibility and need to develop an interactive mode distinct from a two-dimensional user interface are both embodied by virtual reality. In the context of three-dimensional space, three-dimensional interaction is formed. People engage with three-dimensional things based on their cognitive and behavioral understanding of three-dimensional space, and via this interaction, they may feel the three-dimensional characteristics of virtual reality, which is the most significant interactive method in VR. To create the simulation and replication of a genuine behavior, designers may build interactive behaviors in accordance with certain actions in a given setting, hence boosting the realism and immersion of the scene. In contrast to the interactive actions of a 2D user interface, designing human-computer interaction for a virtual environment requires taking into account more fundamental, universal factors, such as people's psychological and physiological capabilities, limitations, and prior knowledge and experience. In the shooting scene, for instance, the shooting action that replicates the actual scene is employed for the shooting task, which is advantageous to boost user interest, adapt to users' cognition, and lower the learning cost. The technical method of implementation at the technical and interactive levels must also be taken into account in addition to the specification of channel activity. Natural characteristics provide 3D interaction more degrees of freedom, and task execution complexity is also increased. Numerous interactive realization methods and interface design techniques have emerged from the technological realization in attempt to match this complexity and naturalness[10].

4. Virtual Reality Eye Tracking Experimentation

4.1. Experimental Theory

In this study proposal, I propose to develop two experiments for the spatial and temporal visual aspects of VR, namely the hot spot experiment and trajectory experiment. I'll be using the HTC VIVE Pro Eye Tobii VR eye tracker as the experimental instrument since it inserts an eye-tracking module within the VR glasses and enables researchers to conduct eye-tracking research in a completely regulated 360 °virtual world. The following idea is shown in Figure 3. Tobii Pro VR Analytics was used as the experimental analysis tool in this study because it is effective at obtaining different eye tracking states in the VR environment and outputs data and findings for visual analysis.

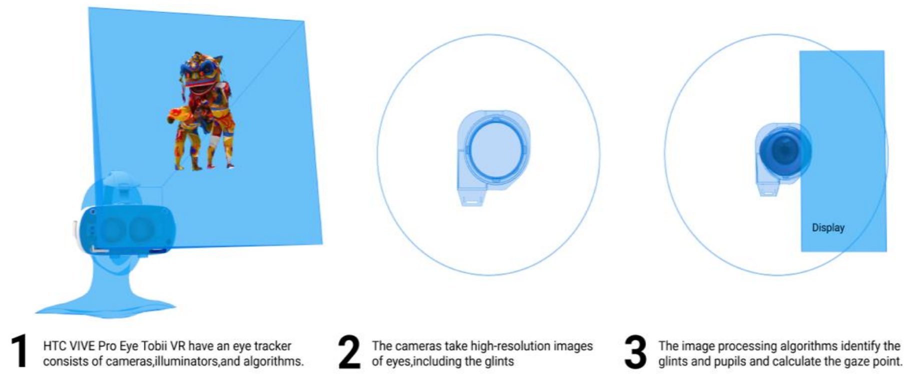

Figure 3: Schematic diagram of data collection method of virtual reality eye tracking equipment

4.2. VR Eye Tracking Hot Spot Experiment

The user's saccade and fixation in the VR environment may be seen in the eye movement heat map for the study on VR visual space features. The procedure for experimental analysis is as follows: To get the visualization results in Figure 4, transfer the user's simulated eye tracking file from the intangible cultural heritage VR into Tobii Pro VR Analytics and use the eye movement hotspot analysis module (schematic diagram). Yellow and green indicate places with less fixation, whereas red indicates areas

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with the highest concentration of browsing and fixation. The ability of the VR simulation model of intangible cultural heritage and the animation design application to draw users' attention can be intuitively assessed using the hot spot analysis of VR eye tracking. This involves determining whether the user's visual focus falls on the key performance area of intangible cultural heritage.

Figure 4: Experiment Map for VR Eye Tracking

4.3. Virtual Reality Time Eye Tracking Experiment

The eye-tracking trajectory graph can display the user's visual fixation position, fixation time, and fixation sequence within a given period of time and generate a fixation sequence from the obtained fixation content, which can be visualized, for the research on the temporal characteristics of VR vision. The procedure for experimental analysis is as follows: Figure 5 may be obtained by importing the user's simulated eye tracking file into the Tobii Pro VR Analytics' intangible cultural heritage VR and using the eye tracking analysis module (schematic diagram). On the fixation trajectory graph, circles of various sizes show the user's observation time. The radius of the dot grows as the stay duration increases, as does the level of attentiveness. The fixation sequence, which is often depicted by numbers (1, 2, 3, 4...) on a circle, is the order of observation. It might reflect the visual attraction of the surroundings and the direction of the visual search. This makes it feasible to determine which simulation elements can hold the user's ongoing attention when they are fully engaged in the VR experience.

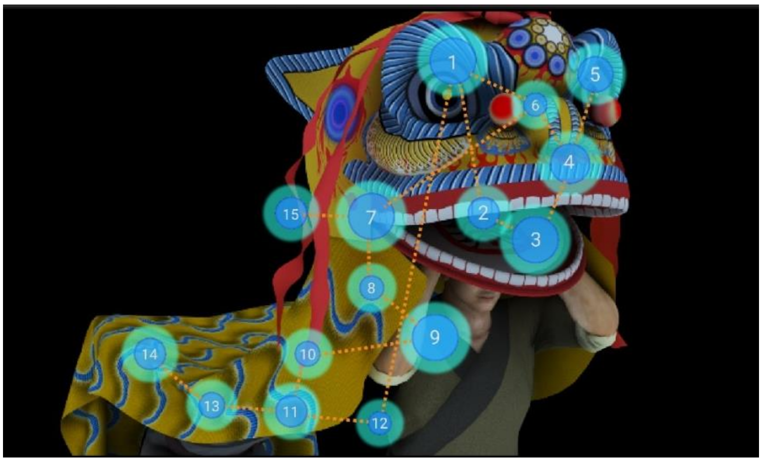

Figure 5: Analysis of VR Eye Tracking Trajectory in Time

The model and action segment that most appeals to the user's vision will be found, its characteristics and causes will be examined, and the details of VR simulation applications will be improved in a targeted manner. This will create a VR experience simulation application of intangible cultural heritage with the excellent spatial and temporal presentation.

The testing findings indicate that the following work should be carried out to guarantee the highest visual performance of 3D animation: establishing the animation scene and character models for 3D animation is the first step; by merging contemporary VR technology, a 3D animation scene with virtualization and authenticity can be formed, which is very convenient for users' applications; In order to use the most efficient 3D animation production processes and create planned 3D animation that is more fluid and flexible in visual presentation, it is crucial to improve one's grasp of different technologies and 3D animation imitation while utilizing VR technology. Thirdly, in order to create a 3D animation that includes both character and visual features, the necessary components for the model must first be incorporated before searching for and including pertinent animation data. Fourth, effectively use VR technology to accurately represent 3D animation, and based on mastering the theoretical understanding of action production, intensify practice and raise the bar for 3D animation creation. By monitoring the object system throughout the creation of 3D animation, VR technology can completely comprehend how the medium really works. It can then synthesize an appropriate 3D animation tracking system door based on the information required for 3D animation state tracking. In addition, the VR technique should be used to complete 3D state tracking so that viewers can more clearly see how the position and angle change when using the V technique. At the same time[11], some shots and pictures that are challenging to realize in 3D animation should be constantly adjusted and corrected.

5. Conclusions

In this essay, theoretically, this will result in a novel visual eye movement heat map and eye movement trajectory map for a 360° immersive VR environment and intuitively analyze the visual characteristics of the user's two spatial dimensions, offering a fresh concept for a subsequent intangible cultural VR experience and user test. Inadequacy and follow-up In this study, visual perspective analysis is the only method used to study how space and time appear visually in a virtual reality environment. Future reliable eye tracking data collection will need us to integrate Tobii Pro VR Analytics' quantitative data output with statistical tools for a more precise analysis. A set of straightforward and effective design techniques for VR sceneries, models, and action restorations will be created for the intangible cultural heritage with narrative and character action kinds.

The importance of the application is by establishing a 360-degree immersive VR experience program of intangible cultural heritage, it will overcome the limitations of conventional digital methods, such as single performances and repetitive interaction situations, and be more able to evoke the audience's emotional resonance. It may increase the given intangible cultural heritage's capacity for distribution and support the growth of regional intangible cultural exhibits, tourism, and the commercialization of regional cultural derivative goods. It will provide fresh research and design concepts for the creation of VR experiences that safeguard and apply comparable intangible cultural property.

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