Protection of Ethnic Cultural Value: A Case Study of VR Scene Construction in Basha Village

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Digitizing ethnic villages through VR technology is helpful for putting limited resources into the most urgent protection projects at this stage. In this paper, Basha village in western Hunan of China is selected as the carrier, and VR technology is used to simulate its virtual village scene. In this paper, ArcGIS is used to show the distribution of villages, through SketchUp software, 3D modeling of the buildings in the village is carried out, which is imported into Lumion platform and optimized, and finally the VR scene of Basha village is established. Through professional analysis tools, accurate reduction scale, and rational analysis and decision-making, it can not only open up a new situation for the protection of national history and culture, but also better promote the construction and renewal of new countryside.

1. Introduction

As a traditional agricultural country, China has a large number of ethnic villages, most of which still retain complete ancient buildings and primitive ecological culture, with unique regional cultural characteristics and important cultural values [1, 2]. Because it is relatively less disturbed by the outside world, most ancient villages in China have rich folk culture, ancient residential buildings, simple folk customs, and beautiful landscape scenery, which can reflect the historicity and tradition of social culture [3–5].

VR technology is a high-tech which is widely used in the world [6]. Using VR technology to establish digital archives is helpful for the protection and research of ethnic villages, which provides technical support for the restoration and reconstruction of buildings, enables more people to learn ethnic buildings, and accurately identifies the authenticity of buildings, so as to play a positive role in spreading the culture of ethnic villages [7–9]. For example, through the establishment of digital virtual scene roaming, users can visit and study the individual buildings and groups of ethnic minorities at any time and space. In addition, data analysis of buildings can be carried out, including the environmental elements, structural elements, elements of disaster prevention ability, and the vulnerability degree under various conditions. Moreover, we can compare and analyze buildings in different historical periods and different types of buildings by observing the development process and characteristics of them and analyzing the development process of buildings in combination with their own production and lifestyle, which is meaningful to the protection of minority cultures.

Creating a digital virtual space and separating the building information from the entity can realize the fundamental continuation of the building and protect the ancient villages [10]. With the continuous development of digital technology, taking VR as a platform, reshaping the architectural entity, surrounding environment and spatial details of historical buildings has brought about great changes in the perception of historical buildings and the experience of cultural connotation.

Through the improvement of collection of historical building information, 3D model making, VR system building, and the supplement of historical building information database in ethnic villages, the digital virtual space of historical buildings can be created, which enriches people’s experience and interaction and encourages public participation. This has a positive impact on the protection of ancient villages and the continuation of cultural connotations [11, 12].
2. Theoretical Basis of VR Technology in the Research of Folk Villages

VR technology is developed on the basis of graphics, simulation technology, and multimedia technology, which provides a new method for the research of village spatial form and spatial cognition. VR space cognitive experiment simulates people’s behaviors and scenes in real space with the help of computer programs and VR hardware devices, whose purpose is to study people’s spatial cognition and wayfinding from the perspective of the first person and obtain the trajectory data of people’s spatial position in the process of space roaming and wayfinding at the target point, so as to help users better experience their cultural connotation [13].

As shown in Figure 1, the basic principles of VR experiment include the following.

1. The environmental simulation technology: the real village scene in the real world is restored and reconstructed in the laboratory, and 3D objects and spaces with surface materials and colors are generated by computer calculation.

2. Technology of spatial positioning and motion capture: by connecting locators, the spatial position of helmet and handle can be identified, and the basic movements of human body including gestures can be captured.

The process of VR experiment mainly includes [14] the following.

2.1. Field Investigation and Scene Modeling. On-the-spot investigation of traditional ethnic village and image recording of real scene spatial information are applied. Then, Sketchup software is used to reconstruct the three-dimensional space scene of the real village environment.

2.2. Development of VR Game Environment. Based on the game engine Unity3D, a game environment for developing VR experiments can be created, which ensures the smooth operation and fluency of the system, so as to provide users with an immersive experience.

3. Cultural Value and Experience of Ethnic Villages under VR Technology

As a kind of rural settlements, ethnic villages not only have the basic conditions of rural settlements, but also have the characteristics of profound historical and cultural connotations, which witnessed a period of precious historical development in a specific time and reflected the evolution process of the village’s regional culture, artistic aesthetic value, and philosophical value [15].

3.1. Cultural Values. The ethnic village formed by religion has actually become a living community with strong internal cohesion, which has become a spiritual creed that dominates the behavior and lifestyle of the villagers and inherits the village culture.

As shown in Figure 2, its cultural value includes the following four aspects [16, 17].

3.1.1. The Value of Classical Aesthetics. Because of their appropriate scale, humanized residential design, traditional architectural features, and intangible cultural relics, ancient villages have excellent aesthetic qualities and convey many unachievable connotations such as space beauty, architectural beauty, scenery beauty, artistic beauty, and nostalgia beauty. Taking architectural beauty as an example, it is highlighted as a landscape deliberately designed and created by human.

3.1.2. Harmonious Ecological Value. Historical and regional differences have created ancient villages with different temperament. For example, the images of ancient villages in the south of the Yangtze River are generally elegant and beautiful, while those in the north show profound and vigorous characteristics. These ancient villages are formed in the course of historical development which are the products of people’s adaptation to the natural environment, reflecting the distinct harmony between man and nature and the unique regional characteristics of the region. Therefore, the harmonious development of ancient villages and the natural environment are regarded as the key criterion for identifying ancient villages.

3.1.3. Historical Heritage Value. The ancient village history and culture gradually formed over time, which vividly narrates our history and forms the basis for understanding the times we live in. The heritage value of ethnic villages is a cultural feature inherited by many factors and a symbolic system representing the image of the whole city, including tangible architectural art, folk art, production tools, and daily necessities, as well as intangible local conditions and customs, living customs, etc.

To sum up, the cultural values of ancient villages are diversified. How to handle the balance among ecological value, historical value, aesthetic value, and emotional value through VR technology is the key to cultural protection of ethnic villages.

3.2. Cultural Experience. The purpose of this paper is to show the artistic value, rural culture, and humanistic environment of ethnic villages through digital virtualization, so that users can meet high-level psychological needs in the process of participating in the experience, which is meaningful for the spread of traditional culture. As shown in Figure 3, the cultural experience of ethnic villages based on VR technology can be divided into the following three levels.

3.2.1. Authenticity. Virtual space mainly gives immediate feedback to people’s behavior through multisensory synesthesis, which makes people have a real sense of experience.
Sensory stimulation of digital system mainly includes intuitive responses of vision, hearing, and touch, and the experience of these three senses is directly related to the authenticity of users’ experience in the virtual system of ancient villages.

In VR technology, the authenticity of ethnic village scenes is roughly determined by four aspects, including the visual sense of modeling, the texture of materials, the degree of color simulation, and the appearance of shadows. In addition to focusing on the building itself, the surrounding environment should be laid out accordingly, which is also an important part of the virtualization of ancient villages. For example, in the system of Virtual Ancient Village, the authenticity of the whole scene can be greatly improved by relying on the building environment with mountains and water.

3.2.2. Interactivity. In the VR system, to realize the interactivity, two aspects should be considered: on one hand, how to establish the virtual scene; on the other hand, how to build a VR operating platform. For example, when users enter the virtual roaming system of an ethnic village, they can run freely and experience the strong village culture through a variety of local folk activities in ancient villages, which gets the perception of information through a very natural way rather than dogmatic text interpretation.

3.2.3. Immersion. Due to the difference of people’s knowledge and culture level, the immersion based on interactivity and authenticity will be affected. Therefore, to ensure that users can fully integrate into a virtual scene, it is never enough to pay attention to the level of interaction and authenticity. Therefore, some dynamic elements should be added to the virtual scene, such as high hanging red lanterns, small bridges and flowing water, curling smoke from cooking, and old carriages at home, so that users can better place themselves in the virtual scene.
4. Realization of Virtual Scene in Xiangxi Village

In this paper, Xiangxi Ethnic Village is taken as an example to arrange the virtual scene of the village. Hunan Province has been the birthplace of multicultural and multiethnic gathering since ancient times. Huxiang culture is a unique regional culture formed by the combination of Miao man culture, Bachu culture, and Han culture. At the same time, the distribution of traditional villages has also formed two categories: the West Hunan minority village settlement and the southern Hunan Han clan village settlement.

4.1. Sample Selection

4.1.1. Selection of Village Area. ArcGIS is used to display the urban distribution of villages. It can be seen from Figure 4 that the distribution of traditional villages in various regions of Hunan Province is unbalanced. Combined with the actual situation, the topography of western Hunan is complex, surrounded by hills, showing a closed and independent natural geographical environment. Xiangxi and Huaihua City are the most concentrated areas of traditional minority villages. In addition, Chenzhou and Yongzhou, which pass through the Wuling Mountains, belong to the concentrated areas with more Han villages in southern Hunan. However, the terrain in northern and central Hunan is open and flat, and the distribution of traditional villages will be relatively less.

In this paper, Basha village is selected to design the virtual scene which covers an area of 13.7 square kilometers, with a high terrain in the south and a low terrain in the north, surrounded by mountains and rivers. As shown in Figure 5, the streets and lanes formed by its natural development are winding and rise and fall with the terrain, which constitutes the main spatial pattern of the village. The streets and lanes in the core area are well preserved and rich in historical relics, where numerous historical buildings such as ancient dwellings, temples, and pavilions are scattered among them.

4.1.2. Collection Village Information. On the one hand, the track of volunteers’ pathfinding position is collected by the system program, and on the other hand, the space pathfinding vision of volunteers is recorded. The pathfinding process can be decomposed into “starting position-path-target point,” and the initial position, target point, and pathfinding process of volunteers are recorded.

(1) Pathfinding trajectory

Route-finding and straight going at the known target point: volunteers continue to go straight along the current direction of travel. Turn: When there is a fork in the space, volunteers choose to adjust the direction of travel and turn to other streets. U-turn: in the process of pathfinding, volunteers choose to give up the current direction of travel and walk in the opposite direction.

(2) Cognitive map

Cognitive map is an intuitive reflection of volunteers’ spatial memory of ancient villages. After the experiment, volunteers were asked to draw a cognitive map of streets and alleys by means of spatial memory. The basic elements include target points, roads (paths), and buildings. Finally, the cognitive maps drawn by volunteers are compared and analyzed.

4.2. Implementation Process of VR Scene

4.2.1. Scene Construction. Scene construction is divided into on-site information acquisition and 3D software modeling. Firstly, building and street information within the research scope was collected, including image shooting and mapping, and street elevation image database was established by sorting and numbering. Then, the 3D space modeling software SketchUp was used to build the street and lane space model of the village. The walls, windows, roofs, doors, steps, and other buildings and their components were built and the materials were given afterwards; plants, sky, and other environmental elements were inserted to restore the original village space environment to the maximum extent in principle. After the modeling is completed, it needs to be checked to ensure that there is no damaged surface in the model, and the spatial scale is consistent with the real conditions.

4.2.2. Platform Parameters. After the scene is built, the experimental platform of VR space is built which consists of hardware and software. The hardware is HTC VIVE, including helmet, gamepad, and graphics workstation software, and the game engine Unity3D is used as the software platform for VR experiment running [18].

In Unity3D, the parameters such as eye height and pace are adjusted to determine the walking range, and the boundary is processed, so as to simulate people’s pathfinding in the real village environment. After the platform is built, debug the equipment to ensure the fluency of the system.

4.3. Building Model Establishment. In the process of functional design and development of SketchUp modeling software, the requirements of rapid modeling of 3D software are integrated, and the development concept of VR is also introduced. Based on the development of modeling function, SketchUp software simplifies the details and accuracy of the model in the modeling stage, emphasizing the modeling speed and convenience of operation [19]. The simple operation interface and function settings greatly improve the modeling efficiency and reduce the computing burden of the computer.

Through careful investigation and investigation, combined with previous data mapping and field investigation, a large number of address and location information data are collected, which is an important basis for 3D modeling. The workflow of 3D modeling of ancient building is shown in Figure 6.
(1) Comprehensively investigate the real pictures and surveying and mapping data in the process of modeling.

(2) Combined with the size of CAD drawings, implement auxiliary modeling, proofread the ratio of the model to the real scene, adjust the gap between the model and the scene as much as possible, and reduce errors in the process of rectification and protection.

(3) On the basis of the completion of the modeling work, adjust the scale and structure of the model several times, explain the structural relationship of the model as clearly as possible, and restore the connection mode of building construction.

(4) Compare the real photos in the original appearance of the village and attach materials to the white film to restore the authenticity of the houses.

After the above steps, the manufactured model is shown in Figure 7.

Through effect preview and postrendering, the visual effect presented by the model greatly restores the live scene. The volume and proportion of the model are close to the scene on the spot. In the process of repeated proofreading
4.4. Optimization of Virtual Village Scene. Lumion, as a VR platform, has rich operability and practical functions. Through the editing of VR scenes, the authenticity of digital virtual scenes in ancient villages can be further improved. In the process of interacting with the VR scene of ancient villages, users can not only visit and observe the whole scene of ancient villages, but also realize the dynamic simulation of the renovation and protection of ancient villages through secondary editing.

High-quality objects and realistic materials are embedded in Lumion library to construct fine scenes. In this way, conservators can make full use of Lumion software to repeatedly review and modify the building structure, and the software fully considers the compatibility problem. The mainstream visual software has rich interfaces and is compatible with a variety of system platforms, which is convenient for users to use.

4.4.1. Optimization Method of Scenario Model. There are two ways to modify and edit the scene model in Lumion platform: on the one hand, it can be directly introduced into the VR scene in the form of imported model components, and as an added component, it can be edited in the VR scene. Its editing logic is restricted by Lumion software itself; that is, the material is the basic selection unit, and there is no precise size control for placement. On the other hand, the VR scene can be modified by modifying the scene model of SketchUp and updating the import in Lumion. This method is complicated, and its editing logic is not restricted by Lumion software, but only complies with the logic of SketchUp software platform, so accurate size operation can be better performed. Combining these two methods can achieve perfect dynamic simulation of ancient village renovation.

4.4.2. Addition of Detail Elements. SketchUp files can be compatible with Lumion software, while Act-3D adds more than 330 new objects such as furniture, flying flags, and new vehicles. The existing character set is also expanded to several high-quality 3D animated characters. In addition, the number of postprocessing effects, such as weather and artistic painting effects, is greatly increased. In addition, Lumion platform comes with a rich dynamic plant library. These plants are provided by SpeedTree, which are lifelike and dynamic. In addition to its own library, more plants from SpeedTree can also be directly made and imported for editing and use. The plant reservoir area of Lumion platform is divided into specific plant species, which greatly facilitates the plant configuration in the scene and also plays a good auxiliary role in site greening design. The optimized village scene is shown in Figure 8.

Through the editing of VR, the real scenes of ancient villages can be greatly restored, and through this interactive control process, the detailed scenes and the overall environment of ancient villages can be visited.

5. System Test

5.1. Server Resource Occupancy. A total of 130 test cases are written in the system. After detailed testing, 130 test cases are finally executed, of which 102 are successful, and 28 test cases are not executed correctly. After analysis, it is concluded that, in the test process of these 28 test cases, several are caused by system function flow design errors, and some...
are caused by system page link errors; some of them are caused by data format validation without judgment.

In the system performance test, it mainly tests the average transaction response time, transaction response number, throughput, CPU time consumed by database operation, CPU utilization, and other indicators. Through the analysis and statistics of the records in the whole test process, the performance test results are shown in Table 1.

The results show that the response time of the system is low, and the CPU consumption time and average utilization can meet the actual needs.

The concurrent access of the system does not mean to accept the access of so many users at one time, but these users are constantly joining. In the specific test link, the interval time is set to be 10 m; that is, 20 concurrent users will be automatically added every 10 minutes to record the changes of system performance parameters. The test results of server occupancy are shown in Figure 9.

The maximum CPU utilization is 13.189%, less than the standard value of 80%. The maximum number of pages read or written to the hard disk is 0.332 and the minimum value is 0.000, which meets the standard range of 00 ~ 20, indicating that there is no bottleneck in the hardware of the real environment of the system.

In the test script, 5 concurrent access users are added every 10 seconds, so that all concurrent users can operate a certain function of the platform at the same time, and the performance parameters of the application server are recorded with the increasing number of concurrent users. The actual number of concurrent users on the platform will not exceed 300. When testing the performance of the system, in order to ensure that the system has certain scalability, 500 concurrent access users are tested without considering think time.

The average access time of the system is less than 2.959 s, and the maximum response time is less than 5 s, which meets

| Test items                                      | Result               |
|------------------------------------------------|----------------------|
| Average transaction response time              | 64.834 s             |
| Number of transactions processed by the system per second | 60                   |
| CPU consumption time                            | 70.93%               |
| Average CPU utilization                         | 15.625%              |
| Remaining available memory                      | 30%                  |
| Network throughput                              | 685                  |

Figure 8: Optimized village scene.

Figure 9: Test results of server resource occupancy.
the actual needs. When concurrent users request a large number of data, the CPU utilization rate of the system reaches 57.553%, but the average calculation is less than 12.626%, which is in line with the conventional requirements. The results show that the average memory utilization rate of the whole concurrent access process is 680 m, which is within the control range and meets the actual requirements.

5.2. Loading Efficiency. In the scene roaming process around 45, the changes of data load request, real-time data load, and scheduling time of Web scene were recorded with the slow and no long distance jump movement of viewpoints, as shown in Table 2.

It can be seen from Table 2 that, with the start of the first frame, all data in the buffer is empty before real-time loading, and the amount of data loaded in real time is equal to the amount of data requested to be loaded. Data scheduling takes the longest time in the first frame of scene scheduling, because there is little change between the requested loading data and the real-time loading data during the slow movement of the viewpoint. At the same time, the amount of data loaded in real time determines the scheduling time. Compared with the average scheduling time of frames after the first frame, the average scheduling time is 0.161 s, while the persistence time of human vision is 0.05–0.2 s. Therefore, the systematic scene in this paper can achieve smooth roaming conditions.

6. Conclusion

This paper analyzes the foundation of VR technology in the research of ethnic villages and summarizes the classification of cultural value and cultural experience of ethnic villages under VR technology. The virtual scene of village is realized by selecting Basha village in western Hunan of China. Through SketchUp software, 3D modeling of the buildings in the village is implemented, which is imported into Lumion platform and optimized, and finally the VR scene of Basha village is established. It is helpful to promote tourism and cultural propaganda services of ethnic villages and improve the accuracy of protective planning and design of ancient villages. Further research will be devoted to applying the research results of this paper to promote the construction and renewal of new countryside.

Table 2: Test results of loading efficiency.

| Frames | Request load data volume | Real-time load data | Scheduling time |
|--------|--------------------------|--------------------|-----------------|
| 1      | 136.234                  | 55.566             | 2.293           |
| 122    | 135.234                  | 53.845             | 0.157           |
| 267    | 135.873                  | 57.432             | 0.158           |
| 357    | 136.835                  | 52.241             | 0.169           |
| 698    | 137.286                  | 50.948             | 0.174           |
| 846    | 135.486                  | 54.142             | 0.150           |
| 1080   | 136.094                  | 56.124             | 0.142           |

Data Availability

The dataset can be accessed upon request from the corresponding author.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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