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Cultural Collision and Integration of the Traditional Landscape of Ancient Village Architecture in Fuzhou and Modern Media Communication Methods

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Abstract Ancient village architecture, as a special kind of cultural heritage, is the root and soul of the history and civilization of the Chinese nation, and its survival status and protection and utilization in contemporary times have been widely valued and paid attention to by all walks of life. The article establishes a digital conservation model of Fuzhou village architecture based on digital technology, and constructs a digital interactive space of ancient village architecture in Fuzhou based on this model. In order to enhance the interactive experience, the article uses UAV inclined photogrammetry to obtain the point cloud data of ancient village buildings in Fuzhou, and constructs the three-dimensional model of ancient village buildings in Fuzhou by combining the point cloud simplification and denoising algorithm with the ICP point cloud alignment, and optimizes the rendering by using 3Ds MAX software. In order to verify the effect of digital interactive space on spreading the traditional style of ancient village buildings in Fuzhou, the 3D reconstruction effect of ancient village buildings is quantitatively analyzed by taking the ancient villages in Jinxi County as an example, and the interactive experience effect of the digital space of ancient villages is discussed. The average accuracy of the 3D model of ancient villages reaches 92.22%, the fluctuation range of completeness is between 88.78% and 95.83%, the immersion of subjects in the experimental group is extremely significant difference compared with that of the control group ($P<0.01$), and the mean value of the users' scores in the effect of cultural dissemination reaches 4.57 points. Combining the digital technology of modern media communication with the traditional style inheritance of ancient village architecture in Fuzhou helps to realize the living inheritance of ancient villages in Fuzhou.

Index Terms ancient village architecture, Fuzhou, three-dimensional reconstruction, tilt photogrammetry, interactive experience

I. Introduction

Fuzhou ancient villages are a group of ancient villages of the Ming and Qing Dynasties in China with complete protection, concentrated scale, orderly inheritance, unique types, abundant remains, and characterized by the connotation of “Shih, Shang, Confucian, and cultivation”. Fuzhou ancient villages are widely distributed in large numbers, the vast majority of them are well preserved from the Song Dynasty to the present day, no matter the village as a whole or a single dwelling, no matter the composition of the settlement, architectural form, values, living customs are concentrated in the Gandong area of the regional characteristics, showing a distinctive local style, revealing a strong local color [1]-[4]. However, due to the lack of protection, the fate of these ancient villages all over Fuzhou is worrying, the village residents, especially the young people have accepted the new way of life, the old village old houses are left unused and unattended, and the phenomenon of collapses and thefts is very common. Therefore, the collision and integration of ancient village architecture with modern technology has become an important way for its inheritance and development [5]-[8].

Ancient village architecture, as a historical witness of a region, has gathered wisdom and memory for thousands of years. However, with the rapid development of modern society and the wave of globalization, ancient village architecture faces many challenges and impacts. It is in this collision that tradition and modernity intermingle with each other, creating a new sense of beauty [9]-[12]. The development of modern technology has not only brought impact to ancient village architecture, but also injected new elements into it. Through the network and social media, ancient village architecture can be better inherited and promoted to reach more people. At the same time, the development of modern science and technology also allows traditional culture to innovate in new media, such as the application of ancient village architecture in digital art, which makes culture and art have more forms of expression [13]-[16].

Literature [17] took several traditional villages in Jiangxi as the research object, and examined the content of the evaluation and identification system of traditional villages in China. The results of the study show that traditional villages face problems such as the lack of protection concepts, and put forward corresponding protection and development strategies. Literature [18] takes Yichengzi ancient village as an example, points out that the protection of cultural heritage is to transmit historical memory and cultural identity and promote economic and social development, reveals the deficiencies of the traditional cultural heritage protection methods, introduces the cultural heritage protection methods of digital technology, and emphasizes that the protection of technology is conducive to the enhancement of the public's cultural literacy and sense of historical identity. Literature [19] discusses the problems in the cultural construction of ancient villages under the background of big data technology. The method of combining statistical analysis and experimental research was used to study the culture of ancient villages. The results show that the Internet enhances the publicity effect of ancient villages. Literature [20] takes the ancient village of Seven Bridges as the research object, analyzes the current situation of digital protection application of Seven Bridges site and its heritage tourism through field observation and interview, and points out its existing problems. And combined with economic and technical conditions, it provides digital solutions for other traditional villages. Literature [21] emphasizes the important position of ancient villages and introduces the development and innovation of ancient villages in the context of the new era, and puts forward corresponding optimization strategies by exploring the obstacles and working principles of the development and innovation of ancient villages. Literature [22] takes Taoping Qiangzhai as an example and puts forward the conservation method emphasizing the comprehensive utilization of digital technology. It also emphasizes the three conservation steps of landscape identification, data chain establishment and cultural heritage dissemination. The aim is to elaborate the utilization of digital technology so as to provide methods for the sustainable conservation of ancient villages. Literature [23] explores the role of tea tourism in the revitalization of ancient villages by using in-depth interviews and other methods, taking Xiamei as an example. The impact of media and internet marketing on tea culture economy and tourism was emphasized. And the cultural landscape-oriented village revitalization promotes the development of Xiamei in economic, social and cultural aspects. Based on the introduction of Guliukeng Village, literature [24] explored the landscape cultural elements of Guliukeng Village from the perspectives of architecture and feng shui, and put forward the strategy of landscape cultural inheritance, i.e., protection methods such as “comprehensive protection”, and always adhering to the principles of natural originality and wholeness. Literature [25] adopts the method of literature analysis, combined with the theory of media pilgrimage, to analyze the educational practices of Lingnan ancient villages and their value excavation and activation path. By discussing its historical background, cultural value and the intervention of modern media, specific measures are proposed to provide theoretical basis and practical guidance for realizing the protection and inheritance of ancient villages.

This paper mainly obtains the point cloud data of ancient village buildings in Fuzhou through the drone inclined photogrammetry technology, combines the 3D reconstruction software to construct and render the 3D model, and builds the digital interactive space of ancient village buildings in Fuzhou, so as to promote the dissemination effect of the traditional features of ancient village buildings in Fuzhou. The combination of modern media communication methods and the development and utilization of traditional features of ancient village architecture aims to enhance the revitalization and inheritance of ancient village architecture, and helps to expand the dissemination range of ancient village architecture culture. On the basis of combing the architectural features and values of ancient villages in Fuzhou, the article introduces the digital technology of modern media communication to build a digital protection mode of ancient village architecture and establishes a digital interactive space of ancient village architecture. In order to realize the three-dimensional reconstruction of the ancient village buildings in Fuzhou, this paper uses the UAV inclined photogrammetry technology to obtain the point cloud data of the ancient villages, and optimizes the data through point cloud simplification and denoising and combines the ICP algorithm to realize the point cloud alignment. In this way, the three-dimensional model of the ancient village building is constructed, and then combined with the three-dimensional modeling software to optimize its rendering. In view of the effectiveness of the above method, the effect of 3D reconstruction and interactive experience is studied through example analysis, and the communication optimization strategy of ancient village architecture in Fuzhou under the support of modern media communication methods is proposed in this way.

II. Architectural style and value of ancient villages in Fuzhou

The soul of a city lies in its cultural genes and historical memories, which is also the logical starting point of its organic growth. Traditional villages not only carry the memories of people who have lived here for generations, but are also the “genes” for building unique humanistic styles. Fuzhou to tangible and intangible cultural protection of two lines, the traditional architecture of ancient villages, history, culture and other systematic excavation and organization and protection and utilization, so that the ancient villages burst with new vitality.

II. A. Overview and style of ancient village architecture in Fuzhou

II. A. 1) Overview of ancient village architecture in Fuzhou

Fuzhou has more than 200 ancient villages with historical and cultural value, many of which have more than 1,000 years of historical heritage and are one of the important carriers of Linchuan culture. According to the Ministry of Housing and Construction announced the first to the fifth batch of listed in the Chinese traditional villages of the public data statistics, Fuzhou City, 96, located in Jiangxi Province, the first. Jinxi County, Fuzhou City, preserved the pattern of integrity, better historical style, ancient buildings concentrated in pieces of ancient villages have more than 100, in Fuzhou City, ranked first. Ancient villages in Fuzhou are often a village with one family name or dominated by a large family name, and the growth of clans is closely linked to the formation of ancient villages, with which the formation and deepening of clan culture in ancient villages follows. Ancient villages can generally be divided into three types, one is business-oriented, the second is government-oriented, the third is Confucianism and business.

Fuzhou ancient villages pay great attention to site selection, in addition to the safety of the natural and social environment, but also consider the psychological security, many choose to back up to the green hills, facing the open pattern. Bamboo Bridge Ancient Village relies on Houlong Mountain and is located in the north and faces south, with a stream like a belt in front of the village and farmland distributed around the village. Huangfang Village is backed by Linggu Peak and faces the water of Fuhe River. The site of Qishan Ancient Village is built on the mountain and facing the water. Liukeng Ancient Village is surrounded by green mountains and surrounded by the river on three sides, with a beautiful environment. Houlinfang Ancient Village is backed by Houlong Green Mountain, the main gatehouse is in castle style, with a lookout window upstairs, where cannons are placed to ward off foreign invasions.

Fuzhou has a group of ancient villages of the Ming and Qing Dynasties with complete protection, concentrated scale, orderly inheritance, unique type and abundant remains, characterized by the connotations of “Shishi, business, Confucianism and cultivation”, which fully reflects the stable existence of Fuzhou's history, culture and socio-economic structure, and it is an important material for the study of the Jiangwu Wenhua and Linchuan culture. The revitalization of traditional villages and the inheritance and development of native culture provide spiritual impetus and cultural support for rural revitalization. Protecting and utilizing the development of high-quality Fuzhou ancient village resources is of great significance for rural revitalization, inheritance of excellent traditional culture and Linchuan regional culture, and continuation of the historical lineage of the countryside.

II. A. 2) Architectural style of ancient villages in Fuzhou

(1) Building orientation. In China since ancient times on the direction of the house is extremely elaborate, due to the regional environment, national customs and religious beliefs and other differences, the house direction is also different. Fuzhou ancient villages building houses oriented both inherited the characteristics of the Han Chinese people's house orientation, but also a blend of their own characteristics. Since the beginning of the village to the village expansion and then tend to stabilize, the development process has followed the direction of the beginning of the building to maintain consistency, but also according to their own needs and preferences and choose the direction. From the research of the village building direction data can be found, Dongxiang building direction of various types, subject to more factors, mostly for the natural environment, lighting, climate, feng shui, transportation and other one or more factors.

(2) Layout of building plan. Fuzhou ancient village buildings are mostly Gan style but also affected by the neighboring areas, especially Hui architecture, showing many different features in the architectural form. According to the presence or absence of courtyards and the form of courtyards, they can be divided into three major types, namely, courtyard, outer courtyard and one-character style. Among them, the courtyard type is the most common and well-preserved building in traditional villages, and the patio is the symbol of the courtyard type, while the outer courtyard type and the one-character type are relatively fewer in number and have greater differences in form.

(3) Structural characteristics. Fuzhou ancient village traditional building walls in the use of materials, construction methods are reflected in the local materials, according to the characteristics of the local conditions. According to the different materials used, it is divided into four categories: green brick wall, earth brick wall, wooden wall and mixed wall. According to its use of green brick wall, earth brick wall is mainly used for the outer wall, wood wall is mostly for the compartment face wall of the courtyard house, mixed wall is used both inside and outside the wall.

II. B. Value embodiment of ancient village architecture in Fuzhou

II. B. 1) Historical and cultural values

Traditional villages are the valuable historical and cultural heritage left by the Chinese farming civilization to the future generations, and the process of reproduction and development of traditional villages is also the development course of the Chinese farming civilization, which encompasses the knowledge of many disciplines, such as politics, economy, military, history, art, architecture, culture and society, and is of high historical and cultural value.

Just as cultural relics are the carriers of history and culture at the micro level, Fuzhou ancient village buildings are the carriers of history and culture at the meso level, traditional villages, historical and cultural towns and villages are the carriers of memories on a larger scale that have developed since ancient times. Especially, traditional villages contain a lot of historical information from the reasons for building villages, choosing village sites, shaping patterns to building spaces, which are valuable legacies at both material and non-material levels, and are the best windows to look back at history. Moreover, traditional villages are usually the integration of excellent construction methods in ancient China, or the representatives of excellent history and culture, which has a deeper cultural significance.

II. B. 2) Architectural aesthetic value

The layout of the architectural space of ancient villages in Fuzhou is distinctive, reflecting the life and production characteristics of villagers as well as their family structure and living habits. The architectural aesthetic value of ancient villages in Fuzhou involves three aspects: construction techniques, architectural art and architectural environment. The construction technique includes the selection of materials, structure and construction technology of the building space, which reflects the level of economic development of the village, the level of social productivity and the level of development of construction technology. The types, layouts, styles, colors and decorations of the architectural space compounds show the level of architectural art of the village, and the unique construction of building façade materials, rich architectural roofscape, traditional colors and exquisite decorations reflect the architectural art value of the village. Each architectural space compound has its own external environment, including artificial and natural environments, and the architectural space and the village environment are interdependent and affect each other for a long time, and with the constant changes in the villagers' life and production activities, they gradually reach a relatively harmonious state.

III. Protection and dissemination of the traditional features of ancient village architecture in Fuzhou

With the change of modern architectural style, the ancient villages have been destroyed and deserted in the process of human transformation of nature, the ancient villages' residential buildings contain the local people's culture, aesthetics, handicrafts and historical memories, which are valuable tangible and intangible cultural heritage. It is a valuable material and intangible cultural heritage. It is a task of great urgency to fully utilize the modern media communication methods to preserve and disseminate the traditional appearance of Fuzu's ancient village architecture. Using digital technology to take photos, scan and model the traditional features of Fuzhou's ancient villages and buildings, and using media means to disseminate the traditional features of Fuzhou's ancient villages and buildings can provide a realistic basis for the preservation and dissemination of the traditional features of Fuzhou's ancient villages and buildings and the means to do so.

III. A. Digital Space of Ancient Village Architecture in Fuzhou

III. A. 1) Digital Conservation Models for Ancient Buildings

Based on digital technology, combined with the value foundation of traditional features of Fuzhou's ancient villages, the digital protection content and classification standards of traditional features of Fuzhou's ancient villages are constructed from the overall cultural perspective. Figure 1 shows the digital protection mode of Fuzhou ancient villages' architectural traditional features, which is aimed at better preserving the traditional features of Fuzhou ancient villages' architecture, and laying the foundation for the realization of the digital dissemination of the traditional features of Fuzhou ancient villages' architecture.

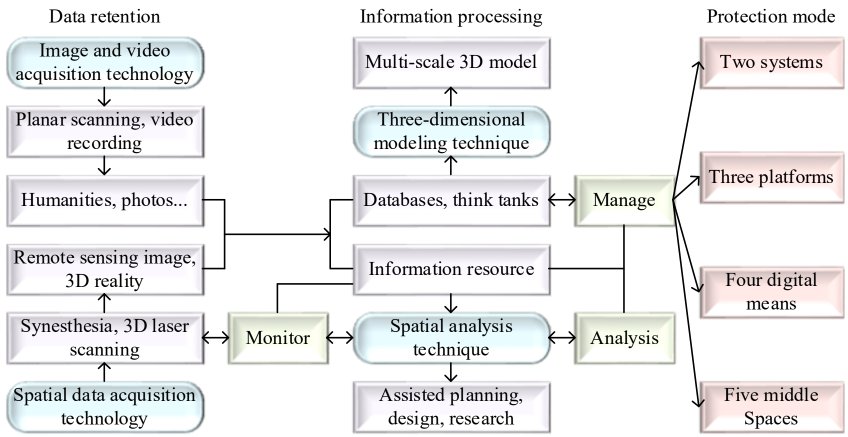


Figure 1: The digital protection mode of the ancient village of Fuzhou

(1) Data retention is mainly based on image and video acquisition technology and spatial data acquisition technology as the core, the collection and storage of information on ancient villages, which is the most basic link in the digital protection and inheritance of ancient villages. Data retention should be classified according to the digitalization standard for the collection of content, using standardized collection methods, relying on digital information acquisition and processing technology, to obtain complete, accurate and true data, and effectively protect traditional villages [26].

(2) Information processing is mainly with the help of information space analysis technology to analyze and monitor the relevant information, with the help of three-dimensional modeling technology for data preprocessing and parameter setting, so as to digitally organize, convert and reproduce the ancient village information.

(3) The digital protection and development of traditional ancient villages require multi-dimensional cultural heritage data information for multiple and hierarchical statistical analysis, storage and display, to provide data service support for the subsequent renovation of the cultural heritage of ancient villages, protection research and development and utilization.

III. A. 2) Digital Interactive Space for Ancient Architecture

Based on the digital protection mode of traditional features of ancient village buildings in Fuzhou, the digital interactive space of ancient village buildings in Fuzhou is established by combining 2D digitization and 3D digitization software, and its specific framework is shown in Fig. 2, which mainly includes the content structure and interactive structure. Its purpose is to enhance the digital interactive effect of Fuzhou ancient village architecture, help people better understand the traditional landscape of Fuzhou ancient village architecture, and help the revitalization and inheritance of the traditional landscape of Fuzhou ancient village architecture.

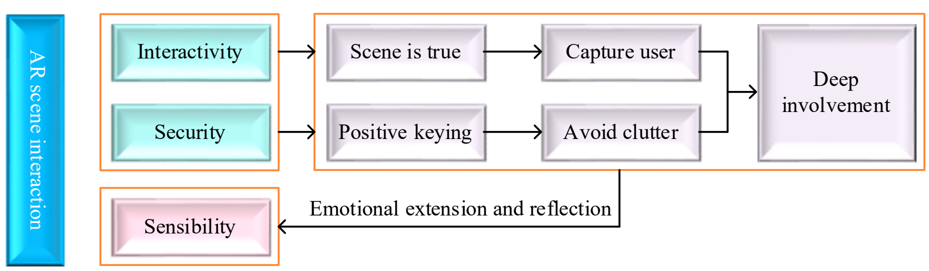


Figure 2: The digital interaction space of the ancient village of Fuzhou

The main hardware equipment for two-dimensional digitization of ancient village digital space development includes plane camera, panoramic camera, aerial drone and other shooting tools, and the main software includes Adobe Photoshop, Substance Painter, etc., and the digital image is acquired through the field collection of scenery, high-definition mapping, etc. by hardware equipment. And through the software for UI design and production, mapping and digital image optimization, etc. [27].

The main software for three-dimensional digitization of digital space development of ancient villages includes Blender, Unreal Engine and so on. The use of Blender modeling software for three-dimensional modeling and animation production, the collected information and design plans through the modeling software into a three-dimensional model. Buildings, streets, alleys and landscapes of ancient villages in Fuzhou are created step by step through drawing, stretching, placing and other operations. During the modeling process, detail sculpting and texture processing are carried out to make the model more realistic and fine, and sculpting tools and texture drawing functions are used to add textures and details to the buildings and landscapes. The character model is animated using skeletal animation and skinning techniques, and the scene is animated using particle system, fluid simulation and other techniques.

III. B. Three-dimensional modeling of ancient village buildings in Fuzhou

III. B. 1) Three-dimensional data acquisition of ancient buildings

In the object 3D modeling, the traditional photogrammetry technology needs to go through the external manual shooting object structure texture combined with digital orthophoto DOM, area vector map to establish the white film and texture mapping, there are modeling efficiency is low, the process is complex, the accuracy is low, and the effect is poor and other issues. Inclined photogrammetry is based on multiple sensors in different viewpoints to obtain more comprehensive information about the front and side of the object, in addition to the traditional 4D products (Digital Orthophoto DOM, Digital Elevation Model DEM, Digital Raster Map DRG, Digital Line Drawing Map DLG), it can also quickly generate a 3D model of the real scene. The 3D reconstruction theoretical system originates from computer vision and photogrammetry, and the imaging law is based on the covariance equation [28]. Namely:

$$\begin{cases} x - x_0 = -f\dfrac{a_1(X_A - X_S) + b_1(Y_A - Y_S) + c_1(Z_A - Z_S)}{a_3(X_A - X_S) + b_3(X_A - Y_S) + c_3(Z_A - Z_S)} \\ y - y_0 = -f\dfrac{a_2(X_A - X_S) + b_2(Y_A - Y_S) + c_2(Z_A - Z_S)}{a_3(X_A - X_S) + b_3(Y_A - Y_S) + c_3(Z_A - Z_S)} \end{cases} \tag{1}$$

where x, y represents the image plane coordinates of the image point, x_0, y_0, f represents the inner azimuthal element of the image, X_S, Y_S, Z_S represents the camera camera center point S in the object coordinate system, X_A, Y_A, Z_A represents any object point in the object coordinate system; a_i, b_i, c_i represents the 9-direction cosine value composed of the three outer azimuthal elements.

Based on the consideration of the architectural layout and the surrounding natural environment of the ancient villages in Fuzhou, this paper selects Jinxi County in Fuzhou City as the 3D reconstruction research object. On the basis of ensuring the completeness of the information of the ancient architectural complex, the flight parameters of this tilt photography are set as follows for the efficiency of UAV image acquisition and the streamlining of post-processing:

Flight altitude 50m, gimbal pitch angle (tilt) 50°, course speed 4.8m/s, course speed (tilt) 5.5m/s, overlap rate of both side and heading 80%, overlap rate of side (tilt) 70%, overlap rate of heading (tilt) 80%, main course angle 78°, and flight margin 20m.

This mapping used DJI Wizard Phantom Pro model for tilt photography image acquisition, set up a total of 10 routes, with a total route length of 25,415m, a total of 120 waypoints, a mapping area of 69,423.5 square meters, and a total of 2,489 photographs.

III. B. 2) Point cloud data simplification and denoising

After obtaining the point cloud data of ancient village buildings in Jinxi County by using inclined photogrammetry, in order to improve the 3D modeling accuracy effect, this paper simplifies and denoises the point cloud data.

(1) Curvature-based point cloud simplification algorithm

The curvature-based point cloud simplification algorithm takes the curvature values of the sampled points and their neighborhoods in the point cloud data as the basic features, and decides whether or not to remove the sampled points by judging the relationship between the curvature and the size of the set threshold. Generally, in the part with large curvature change, more points need to be retained to reflect the three-dimensional features of the point cloud; in the part with small curvature change, indicating that the region is more gentle, only fewer points are needed to reflect the shape of the object. Currently, the spherical fitting method is commonly used to estimate the curvature of the point cloud, and the calculation process is as follows:

Assuming $p_i(x_i, y_i, z_i)(i = 1, 2, 3, \cdots, n)$ is n points on the sphere and the center coordinate is $o(x_o, y_o, z_o)$, the radius of the sphere is:

$$(x - x_o)^2 + (y - y_o)^2 + (z - z_o)^2 = R^2 \tag{2}$$

$$C = x_o^2 + y_o^2 + z_o^2 - R^2 \tag{3}$$

Simplification yields the spherical linear equation as:

$$x^2+y^2+z^2-2(x*x_o+y*y_o+z*z_o)+C=0 \tag{4}$$

The objective function is obtained from the least squares method as:

$$F(x_o,y_o,z_o,C)=\sum_{i=1}^{N}(x_i^2+y_i^2+z_i^2-x*2x_o+2y*y_o+2z*z_o+C^2) \tag{5}$$

Taking p_i as the coordinate origin, the X, Y and Z axis directions are the same as the system direction, the points in the neighborhood of p_i are translated to get their coordinates in the local coordinate system established with p_i as the origin. And the neighboring point coordinate values are brought into the public above equation to find the parameters x_0,y_0,z_0 and C, and the curvature p according to the curvature calculation formula. That is:

$$\rho=\frac{1}{\sqrt{x_o^2+y_o^2+z_o^2-C^2}} \tag{6}$$

On the basis of the curvature, by comparing with the set threshold, it judges whether the sampled points are retained or not, and completes the point cloud simplification after processing all the points.

(2) Point cloud denoising algorithm based on bilateral filtering

The main idea of bilateral filtering is to use the angle of the normal vector of the point cloud and the spatial distance between the point clouds as the basis for judging the filtering of noise points. The algorithm not only considers the distance along the normal direction, but also takes into account the distance from the sampling point to the neighboring points, and there is no restriction on the normal direction.

For a sampled point p in the point cloud data P, the unit normal vector of the point p is first calculated using the point $N_r(p)$ within the neighborhood range r of the point p, and then the position of the point p is updated by the following equation. i.e:

$$p_i^{'}=p_i+\lambda n_i \tag{7}$$

where $p_i^{'}$ is the sampling point p_i after bilateral filtering and λ is the bilateral filtering factor, the specific expression is:

$$\lambda=\frac{\sum_{p_j\in N_k(p_i)}W_c(\|p_j-p_i\|)W_s(\|<n_j,n_i>\|-1)<n_i,p_j-p_i>}{\sum_{p_j\in N_k(p_i)}W_c(\|p_j-p_i\|)W_s(\|<n_j,n_i>\|-1)} \tag{8}$$

$$w_C(x)=e^{-\frac{x^2}{2\sigma_C^2}} \tag{9}$$

$$w_S(y)=e^{\frac{y^2}{2\sigma_S^2}} \tag{10}$$

where n_j is the unit normal vector of the sampling point p_i near neighbor point p_j, and w_C,w_S is the Gaussian kernel function when the standard deviation is σ_C,σ_S. From the formula, it can be seen that when σ_C is larger, the bilateral filter is suitable for smoothing the point cloud, and when σ_S is larger, it can better retain the three-dimensional features of the point cloud data.

III. B. 3) Tilted imagery and data alignment

In order to integrate the tilted image and point cloud data, based on the pre-processed tilted image and point cloud data, the ICP algorithm is used to align the tilted image and point cloud data, and to prepare for the subsequent construction of the 3D model of the ancient buildings.The idea of the ICP algorithm is to iterate until the distance between the tilted image and the point cloud data is less than the set threshold.The distance calculation function of the ICP algorithm is given by:

$$d(P,Q)=\min_{q\in Q}\|q-p\| \tag{11}$$

where P is the set of tilted image data, Q is the set of point cloud data, and p and q are any of the data in the set of tilted image data and the set of point cloud data, respectively.

The steps of aligning the tilted image and point cloud data using the ICP algorithm are as follows:

(1) Calculate the nearest point. Calculate the distance between the tilted image data and the point cloud data according to the above equation, and the point cloud data with the smallest distance is recorded as set $Y_k=\{y_{i,k}\}$, and the formula is:

$$y_{i,k}=\min_{q\neq Q}\left[d(p_{i,k},q)\right] \tag{12}$$

(2) Calculate the parameters. When the error between the rotation matrix and the translation matrix is minimized, the iterative process is completed and the final rotation and translation matrices are solved with Eq:

$$\begin{cases} e(R_k,t_k)=\dfrac{1}{N_p}\sum_{i=1}^{N_p}\|(R_k p_{i,0}+t_k)-y_{i,k}\|^2 \\ e_k=\min_{R_k,t_k}\left[d(R_k,t_k)\right] \end{cases} \tag{13}$$

where, $e(R_k,t_k)$ is the error of the rotation matrix and translation matrix of the ancient architecture data, R_k is the rotation matrix, t_k is the translation matrix, N_p is the total number of the ancient architecture point cloud data, $p_{i,k}$ is the number of the initial tilted image data, and e_k is the distance error of the data with iteration number k.

(3) Alignment. Based on the (R_k,t_k) obtained in step (2), solve for the coordinates of the target point cloud data in the tilted image, and establish the best global alignment matrix, Eq:

$$p_{i,k+1}=R_k\,p_{i,0}+t_k \tag{14}$$

(4) Complete the iteration. Set the iteration termination conditions, if the number of selected generations to reach the maximum value or $e_{k-1}-e_k<\tau$, complete the iteration, the corresponding rotation matrix R_k and translation matrix t_k; if the number of iterations does not reach the maximum value and $e_{k-1}-e_k \geq \tau$, then continue to iterate.

III. B. 4) 3D Model Reconstruction and Rendering

(1) Three-dimensional model reconstruction

Based on the alignment results of the tilted image and point cloud data of the ancient buildings in the previous section, the ICP algorithm combined with the CGA rules for the construction of the three-dimensional model of the ancient buildings, the specific process is as follows:

CGA rule is a kind of computer language that can automatically construct the model and has the characteristics of target description and visualization observation. Nowadays, the CGA rules have been integrated into the CE platform, and the rule program writing is completed in collaboration with the C++ language to realize the construction of 3D model of ancient buildings by the program.

Based on the alignment results of the tilted image and point cloud data of the ancient building, the ICP algorithm is used to further optimize in order to execute the CGA rule commands, namely:

$$g(X_s,Y_s,Z_s)=|f(X_s,Y_s,Z_s)-f(X_s+i,Y_s+j,Z_s+k)| \tag{15}$$

where $f(X_s,Y_s,Z_s)$ is the binarization function, (X_s,Y_s,Z_s) is the three coordinates, and i,j,k is the direction vector.

Through the above formula, the construction of the three-dimensional model of the ancient building is completed, and its expression is:

$$K_{P,Q}=(X_s,Y_s,Z_s)S+Ht-rp_{i,k+1} \tag{16}$$

where S is the image scaling factor, t is the image shift vector, r is the rotation factor, and H is the number of point clouds.

Through the above conversion operation, the construction of three-dimensional model of ancient buildings is completed, which provides a method for solving the contradiction between the opening and protection of ancient buildings, and also provides accurate and complete data support for the management and repair of ancient buildings.

(2) Three-dimensional model rendering

In order to make the model established to achieve realistic, lifelike effect, it is necessary to render the model. At present, there are two main ways of rendering, one is to render through the gradient of color, such as from yellow to blue, indicating the process of change. This approach is often used to represent changes in elevation in DEMs in the earth sciences. The other kind is texture mapping. The second type of rendering is usually used in order to get a landscape model with a strong sense of realism. The point cloud data collected and edited in the previous section are used to complete the visual rendering of the architectural scene of the ancient village in Jinxi County.

The rendering of the 3D model is carried out in 3Ds MAX software, which provides a powerful material production platform, relying on which highly realistic texture and ever-changing material effects can be produced. Mapping is the performance of the material effect of a major means, mapping as a texture is given to the material, so that the material effect is more realistic. The specific steps are as follows:

Step1 In Cyclone, select all the building models of ancient villages in Jinxi County, and export them as *dxf files through Export, which can be read by 3Ds MAX software.

Step2 In 3Ds MAX software, use File/Import command to open the file exported by Cyclone, adjust the coordinates so that its border is parallel to the X and Y axes respectively.

Step3 Edit the wall of the ancient village building. Cut the wall surface to make the shape of the wall conducive to the later mapping work. Then categorize each face, such as roof, steps, windows, walls, etc.

Step4 Mapping Rendering. Select the faces to be mapped from the categories, change to editable mode, click the material editor, and import the traditional style data of the ancient village architecture collected in the previous section to the material sphere. Select the imported texture data, use UVW mapping, and adjust the U-direction tiling, V-direction tiling and W-direction tiling to match the faces to be mapped, so that the mapping effect can be optimized. Then close the material editor, and then get the 3D image of the architectural landscape of the ancient village in Jinxi County after the rendering is completed.

IV. Three-dimensional reconstruction and interactive experience of ancient village architecture in Fuzhou

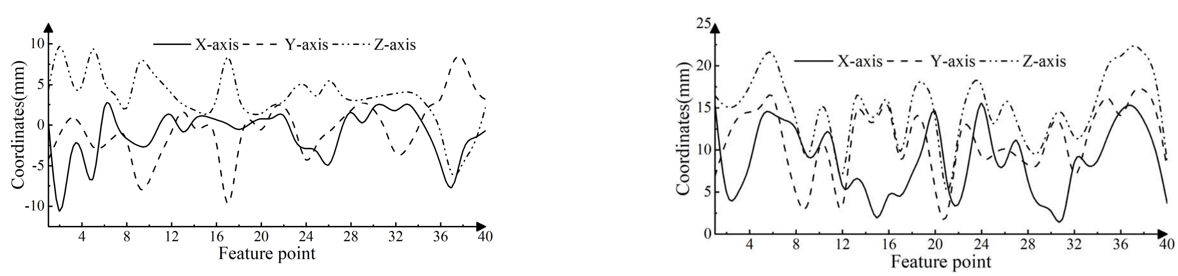
Fuzhou City is one of the regions in China with relatively rich resources of ancient villages. Due to geographic conditions and historical development and other reasons, a large number of ancient villages with mainly Ming and Qing Dynasty buildings are still preserved, which not only have historical and cultural value for the study of Chinese traditional Confucian farming culture and Linchuan culture, but are now becoming a unique and fragile cultural phenomenon and tourism resources. Combined with modern media communication technology, the protection and excavation of ancient village cultural resources into it, accelerate the scientific development and utilization of ancient villages, show the development of ancient villages tourism economic value, this is also the era of ancient villages in Fuzhou given the development of the traditional style of building a good opportunity.

IV. A. Three-dimensional reconstruction effect of ancient village buildings

IV. A. 1) Comparison of point cloud coordinates of ancient villages

In order to verify the validity of the three-dimensional coordinate point cloud data of ancient village buildings in Jinxi County obtained by using the UAV inclined measurement technology in this paper, a total of 40 obvious feature points and characteristic points evenly distributed in Jinxi County are selected, and the corresponding planar coordinate data of the characteristic points are collected by total station, which are compared and analyzed with the corresponding point data extracted from the point cloud. The maximum value, minimum value, mean value and median error of the difference were counted, and Fig. 3 shows the 3D coordinate comparison results of the ancient village point cloud data under different methods. Among them, Fig. 3(a)~(b) shows the coordinate data acquired by UAV inclined measurement and total station, respectively.

As can be seen from the figure, the maximum and minimum values of the difference between the point cloud data of 40 feature points of the ancient villages in Jinxi County acquired by UAV inclined photogrammetry and the measured plane in the X direction are -10.61mm and 0.19mm, respectively, and the maximum and minimum values of the difference in the Y direction are -9.71mm and 0.04mm, respectively.The maximum and minimum values of the difference between the coordinate data of the total station acquired by UAV and the measured plane in the X direction are 15.53mm, 15.53mm and 15.53mm, respectively. The maximum and minimum values of the difference between the coordinate data acquired by the total station and the measured plane in the X direction are 15.53mm and 01.93mm, respectively, and the maximum and minimum values of the difference in the Y direction are 17.13cm and 2.21mm, respectively. It can be seen that the use of UAV inclined measurement technology can acquire more accurate coordinate data of the ancient villages' buildings, and the combination of the ICP point cloud alignment algorithm can further enhance the acquisition of the coordinate data of the point cloud of the buildings of the ancient villages in Jinxi County, which can be the basis for the construction of the The three-dimensional modeling of the digital space of ancient village buildings in Fuzhou provides a reliable data foundation.



(a) Inclined survey technique (b) Full station

Figure 3: Point cloud data coordinates

IV. A. 2) Three-dimensional modeling data of ancient villages

In order to verify the 3D modeling performance of this paper's method in reality, through the construction of 3D models of the overall structure of ancient villages in Jinxi County, Fuzhou City, the accuracy, completeness, and modeling time of the results were counted, and the overall structure of ancient villages in Jinxi County, Fuzhou City was divided into four subsections, i.e., the front section, the corridor, the middle section, and the rear section, and 3D modeling was carried out respectively, in which each subsection was composed of three parts: the foundation of the terrace, the body of the house, and the roof. The results of comparative analysis of various data indicators were obtained as shown in Table 1.

From the table, it can be seen that for the ancient village architectural landscape in Jinxi County, Fuzhou City, no matter which kind of architectural structure, the accuracy of the 3D model established by the method of this paper is very high, with the value ranging from 88.04% to 97.26%, and the average accuracy of the 3D model reaches 92.22%. Thus, it shows that the 3D reconstruction of ancient villages in Jinxi County, Fuzhou City can be realized using the method of this paper, and the reconstruction accuracy is high. In addition, in terms of the completeness of the model construction, the overall data is also relatively satisfactory, with the total fluctuation range within 88.78%~95.83%, and the average completeness of the 3D model construction also reaches 92.09%. At the same time, the time used for 3D modeling of each part of the ancient village buildings is also very short, basically kept below 2.5 hours, and the average time for reconstruction of the ancient village buildings in Jinxi County, Fuzhou City is only 2.04 hours. It further illustrates that using the method of this paper to construct the 3D model of ancient village buildings in Fuzhou City is not only of high quality and speed, but also of accurate location, with excellent modeling performance. Using this model as the basis and applying it in the digital space of ancient villages in Fuzhou, it can better help the audience to feel the traditional appearance of ancient village buildings in Fuzhou in the virtual environment, further expanding the scope of the audience for the dissemination of the traditional appearance of ancient village buildings in Fuzhou.

Table 1: Comparison of 3D modeling data in ancient villages

Contrast data		Accuracy (%)	Complete (%)	Time (h)
Front section	Taichi	89.83	89.51	1.29
	House	89.28	91.03	1.74
	Roof	88.04	88.78	1.45
Corridor	Taichi	95.13	93.28	2.07
	House	89.23	89.52	2.35
	Roof	93.15	89.76	2.28
Middle section	Taichi	92.19	91.89	2.34
	House	93.64	93.83	2.29
	Roof	92.94	95.65	2.17
Posterior section	Taichi	90.55	91.26	2.13
	House	95.34	94.79	2.32
	Roof	97.26	95.83	2.06
Means		92.22	92.09	2.04

IV. A. 3) Efficiency of 3D rendering of ancient villages

In the process of constructing the 3D landscape scene of ancient village architecture in Fuzhou, the terrain, features and other objects are mainly represented by models. The finer the model, the better the visual effect, the larger the amount of data and occupied resources, and the lower the rendering efficiency; on the contrary, the worse the visual effect, the smaller the amount of data and occupied resources, and the higher the rendering efficiency. To address this situation, this paper investigates the relationship between the model data volume and the system resource occupation and rendering efficiency when rendering 3D scenes under 3Ds MAX, as well as the model data volume that the system can carry. And combined with the ancient village architecture field situation in Jinxi County, Fuzhou City, the study develops a 3D scene optimization scheme based on 3Ds MAX. So that the system can meet the visual requirements and run smoothly.

First of all, based on the visual experience during the system operation, through the experiment, research and analyze the relationship between the number of transmitted frames per second (FPS) and the smoothness of system operation under 3Ds MAX, and classify it. That is, when the FPS is greater than 30 it means very smooth, higher than 20 means smooth, greater than 15 is generally smooth, greater than 8 is relatively smooth, and less than 8 means lagging.

Then, the experimental data reflecting the relationship between the number of rendering facets and the rendering efficiency are obtained for each group and graded according to the grading relationship table between FPS and running smoothness. The obtained experimental data are shown in Table 2.

As can be seen from each set of data, the larger the number of rendered slices, the lower the rendering efficiency of the system, and the less smooth the system runs. When the number of rendered slices is less than 121,469, the system can run smoothly, and when the number of rendered slices is between 121,469 and 205,142, the browsing speed is adjusted appropriately by the free browsing function of the system, and the system can reach an acceptable relative smooth operation. When the number of rendered slices is more than 205,142, the system has obviously lagged. Therefore, when the base number of rendered facets is less than 200,000, the system is able to run smoothly. And after the point cloud simplification and denoising in this paper, the number of rendered facets of the 3D model of ancient village buildings in Jinxi County, Fuzhou City is roughly around 180,000 facets. Therefore, the 3D model rendering of ancient villages in Jinxi County, Fuzhou City using 3Ds MAX software has high efficiency, which can give the ancient village buildings a better performance and make them accurately reflect the real-life traditional appearance of ancient villages in Fuzhou in the digital space of the ancient village buildings in Fuzhou.

Table 2: Test data

Render number	Tris	Draw Calls	FPS	Fluency
30214	931.5KB	4925	34.5	Very fluid
121469	1.69MB	11053	15.7	General fluid
205142	2.05MB	15247	8.9	Relative fluid
482481	3.72MB	28601	6.2	Carton
953827	6.14MB	47532	3.4	Serious carton

IV. B. Ancient Village Digital Space Interactive Experience

IV. B. 1) Effectiveness of user immersion experience

Based on the three-dimensional model of the traditional style of Fuzhou ancient village architecture, the digital space of Fuzhou ancient village architecture is constructed by combining with Unity 3D, and it is applied in the dissemination of the traditional style of Fuzhou ancient village architecture. In order to verify the immersive experience effect of users under this digital space, this paper mainly analyzes the data quantitatively by physiological testing method - brain wave experiment monitoring. The subjects of this experiment were all online students of JX Normal University, totaling 30 people, who were randomly divided into an experimental group (EXP) and a control group (CON), with the same number of people in both groups. The experimental group experienced the traditional style of ancient village architecture in Fuzhou through the digital space, while the control group viewed the traditional style of ancient village architecture in Fuzhou through two-dimensional pictures.

This experiment used QUICK dry electrode multi-lead EEG system, a wearable EEG monitoring device made by Company C. The device can collect EEG signals from the frontal lobe (the front part of the brain), parietal lobe (the back top part of the brain), temporal lobe (the outer part of the brain), occipital lobe (the back part of the brain) of the brain according to the different channels, and it mainly collects two kinds of EEG waves of θ and β in the experiment.

After the EEG signals in the experiment were collected and saved, the raw data were imported into the data processing software for processing, and the power values of θ and β waves corresponding to each channel of the subjects in the EXP group and CON group were output, and the data were compared and analyzed to determine whether the digital space of ancient villages in Fuzhou proposed in this paper has a better immersion experience. The ratio of the power of θ wave and β wave, TBR, is used to indicate the degree of concentration of attention, and the smaller value of TBR indicates that the attention is more concentrated, while the larger value indicates that the attention is more distracted. In this paper, only the frontal lobe channels of the subjects were analyzed, including the six channels Fp2, Fz, F3, F4, F7 and F8. The TBR values of each channel in the EXP group and the CON group were counted and a paired-sample t-test was carried out on them, from which the results of the test of differences in the TBR values of each channel of the frontal lobe of the two groups of subjects were obtained as shown in Table 3. In the table, R is the paired-sample correlation coefficient, and *,** indicates significant and extreme differences at the 5% and 1% levels, respectively.

As can be seen from the table, in the paired-sample correlation validation, the correlation between the EXP and CON groups for each frontal lobe channel is greater than 0.7, and their significance is less than 0.01, which demonstrates the correctness of the paired-sample t-test selected to compare the data of the EXP and CON groups. In the results of the paired samples test, between the EXP and CON groups, the Fp2 channel ($T=2.638, P=0.017<0.05$), the Fz channel ($T=2.476, P=0.011<0.05$), the F3 channel ($T=2.635, P=0.016<0.05$), the F4 channel ($T=2.581, P=0.024<0.05$) , the significance values of all four channels were significantly different at 5% level. F7 channel ($T=3.049, P=0.000<0.01$) and F8 channel ($T=3.119, P=0.002<0.01$) between the EXP and CON groups, and the significance values of both channels were highly significantly different at the 1% level. And the TBR value of each channel is different, but the average TBR value of each channel is above 4.5 in CON group, while the EXP group is below 3.95, and the average TBR value of each channel is greater in CON group than in EXP group. Since smaller TBR values indicate more focused attention and larger values indicate more distracted attention. So it shows that the level of attention in the EXP group is higher than the CON group and the difference is statistically significant. That is, it proves that the digital space of ancient village architecture in Fuzhou can make the subjects pay more attention, shows that the digital space of ancient villages created by using digital technology can enhance the immersive experience of the subjects, and verifies the feasibility of this paper's dissemination of the traditional style of ancient village architecture in Fuzhou through modern media communication technology.

Table 3: Test results of different channel TBR values

Channel	EXP	CON	R	T	Sig.(2-tailed)
Fp2	3.72±1.41	4.55±1.86	0.705**	2.638	0.017*
Fz	3.83±1.28	4.52±1.95	0.748**	2.476	0.011*
F3	3.42±1.25	4.59±1.94	0.759**	2.635	0.016*
F4	3.95±1.56	4.59±1.78	0.734**	2.581	0.024*
F7	3.88±1.39	4.57±1.83	0.762**	3.049	0.000**
F8	3.76±1.12	4.56±1.85	0.757**	3.119	0.002**

IV. B. 2) Analysis of the effects of user experience

After analyzing the users' sense of psychological experience of Fuzhou Ancient Village Digital Space, this paper further explores the effect of users' interactive experience of Fuzhou Ancient Village Digital Space. In the experiment, we selected three basic aspects of functional experience, sensory experience and emotional experience as the main dimensions of evaluation, the specific contents of which are shown in Table 4. It was made into a questionnaire, and the Likert five-level scale was mainly adopted to quantify the data, i.e., 1~5 indicated very disapproved to very approved, respectively.

Table 4: Scale of user experience effect

Type	Describe	Code
Sensory experience	Scene aesthetics	GG1
	Scene layout	GG2
	Picture accuracy	GG3
	Interactive nature	GG4
	Immersion	GG5
Emotional experience	Light relaxation	QG1
	Be curious	QG2
	Interest	QG3
	Sense of discovery	QG4
	Scene attraction	QG5
Cultural communication experience	Cultural interest	WH1
	Cultural expression	WH2
	Detail degree	WH3
	Scene quality	WH4
	Popular mode	WH5

Through the form of on-site distribution and guide the 15 students in the experimental group to fill out the questionnaire, after completing the questionnaire data will be collected and organized. After the user's experience evaluation scores were counted, the user's experience evaluation scores for the digital space of Fuzhou ancient village architecture were obtained as shown in Figure 4.

As can be seen from the figure, Fuzhou ancient village architecture digital interactive space in the sensory experience, emotional experience and cultural dissemination effect of the three aspects of the user's high evaluation, its score was 4.18 points, 4.39 points and 4.57 points respectively. Among them, the score of cultural dissemination effect is the highest, which indicates that through the modern medium of digital interactive space, it can help Fuzhou ancient village architecture better realize cultural dissemination, realize the cultural collision between the traditional appearance of ancient village architecture and the modern media dissemination technology, and enhance the dissemination effect of the traditional appearance of ancient village architecture in Fuzhou with the help of its digital dissemination characteristics. In terms of emotional experience, the users have higher evaluation values for exploration, fun and relaxation, but the system has lower satisfaction in the item of “satisfy curiosity”, through communication with the users, we found that the reason is that the content of the picture and sound is not vivid enough, which is also the reason for the low rating of the item of "attractiveness of the scene". This is also the reason for the low rating of "Scene Attraction". It is worth noting that the overall rating of the sensory experience is the lowest, which is mainly due to the gap between modern digital technology and the integration of the traditional appearance of ancient village buildings in Fuzhou, in the follow-up study to guide further exploration of new directions more adaptable to the digital development of ancient village buildings in Fuzhou, through the introduction of expanded technology to enhance the cultural communication effect of ancient village buildings in Fuzhou.

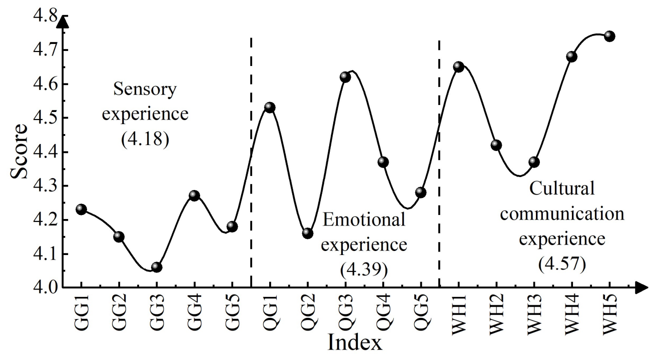


Figure 4: User experience assessment score

IV. C. Communication Optimization Strategies for Ancient Villages in Fuzhou

IV. C. 1) Building a communication platform for ancient villages

In the era of traditional media, the general public was in a passive position in the process of media publicity, but with the progress and development of the Internet, more and more people are dominating the right to use the media. If opinion leaders in villages are given access to sufficient cultural resources, they can combine new media with the inheritance and development of traditional culture, thereby promoting the sustainable development of society as a whole.

In terms of the current social environment, the use of the Internet has been a survival skill of modern people, the Internet provides all kinds of resource platforms for the public, the information of the ancient village tourism can be promoted through the self-media, microblogging, weibo, weibo, jitterbugging and other forms of platforms, coupled with the rapid changes in the development of technology, in the future, the combination of urban and rural planning, new urbanization, and smart tourism, the protection and development of the ancient villages can play a more positive role.

Construct Fuzhou ancient villages digital service platform, form spatial data by collecting architecture and road design of ancient villages, form digital model after collating and analyzing, collect ancient villages' residential, cultural heritage, folk customs, record and integrate related culture, form multi-dimensional database, i.e. Fuzhou ancient villages digital website. Taking the website as a carrier, using digital transmission and induction technology, it establishes a resource database and provides services such as information query, culture and standardized processing. Along with the development of artificial intelligence technology, people can immerse themselves in the virtual scenes of these ancient villages and carry out immersive interactions.

IV. C. 2) Dynamic inheritance of ancient village architecture

(1) Renewal and reconstruction of key buildings in ancient villages in Fuzhou. The principle of combining utilization and maintenance should be adopted for key buildings, giving new vitality to historical buildings and continuing their original functions and uses. After repair and remediation, the buildings of ancient villages can be opened as places for civic activities, and eye-catching architectural introduction signboards should be erected to introduce the history of the attractions to tourists. Refurbish and restore the statues and objects in the ancient villages, set up monuments to introduce their history, restore the original appearance of the ancient villages, and strengthen the function of cultural inheritance.

(2) Drive the development of ancient villages with tourism as a leader. Although the development of modern tourism has brought some negative impacts on many scenic spots and monuments, such as the deteriorating environment, some cultural relics have been destroyed. However, we can't give up eating for fear of choking, let Fuzhou ancient villages long sleep in the remote countryside, can't play its due role in adjusting the human heart, purifying the mind, inheriting the culture and so on. Inheritance of Fuzhou ancient village folk art, but also must start from the development of tourism, the formation of tourism driven village development, village development driven

by the virtuous cycle of folk art heritage. The development of Fuzhou Mountain ancient village cultural tourism project can start from its unique regional cultural characteristics and rich folk art forms, focusing on the national strategy of concentrating on ecological protection and high-quality development, exploring the design of integrated tourism corridors, and creating a landscape and culture complementary, folklore and historical value of the dance of the characteristics of the road of tourism.

V. Conclusion

The article establishes a digital interactive space for ancient village buildings in Fuzhou based on digital technology, acquires 3D point cloud data of ancient villages and realizes their 3D modeling through UAV inclined photogrammetry technology. Taking the ancient village buildings in Jinxi County, Fuzhou City as an example, we analyze the effect of 3D reconstruction and interactive experience. The average accuracy of the 3D model of the ancient village built based on UAV inclined photogrammetry reaches 92.22%, the total fluctuation range of the completeness is between 88.78% and 95.83%, and the average value of the overall modeling time consumed is only 2.04 h. In the interactive experience of the digital space of the ancient village in Fuzhou, there is a highly significant difference in the immersion sense of the experimental group compared to that of the control group ($P<0.01$), and there is a significant difference in the sensory experience, the emotional experience, and the emotional experience between the experimental group and the control group. The mean values of users' scores in sensory experience, emotional experience and cultural communication effect were 4.18, 4.39 and 4.57 respectively. This fully demonstrates that the modern media communication digital technology has synergy with the communication of the traditional style of Fuzhou ancient village architecture, which can significantly improve the communication effect of the traditional style of Fuzhou ancient village architecture. Digital media technology gives Fuzhou ancient village architecture new development opportunities and helps to realize the revitalization and inheritance of ancient villages in Fuzhou.

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