Research on Gene Extraction and Activation of Architectural Style of a Thousand-Year Traditional Village in Luquan Enabled by Smart Rural Technology

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ABSTRACT

This paper is devoted to the gene extraction and activation of architectural style of a thousand-year traditional village in Luquan District, Shijiazhuang City, Hebei Province, to deal with the problems of architectural aging and cultural fault in the process of modernization. Through the application of digital technology and smart rural technology, the project aims to realize the protection, inheritance and activation of traditional villages. The research uses UAV 3D scanning modeling, GIS, AR/VR and other technologies to accurately measure and data record village layout, residential buildings, production and life style and public space, so as to realize the virtual reproduction of architectural styles. At the same time, the smart village based on Unity and UE5 platforms will build a digital management platform, develop the smart APP of Shuiyu Village, and apply the smart technology to agriculture, environment, tourism, cultural and creative fields, so as to improve the efficiency of village management and the quality of life of residents. In addition, the project also uses Touchdesigner and 3DMapping software platforms, combined with interactive art installation, to provide tourists with immersive art experience and enhance cultural identity. The research results will provide new ideas for the protection and activation of traditional villages in Luquan District, promote the development of local cultural tourism, and realize the organic integration of tradition and modernity.

Key words: smart village; digital protection; building activation; culture and tourism development

I. Introduction

With the acceleration of the modernization process, the traditional villages are faced with severe challenges such as architectural aging and cultural fault. Shuiyu Village, a thousand-year-old traditional village in Luquan District, Shijiazhuang City, Hebei Province, is a precious heritage of agricultural civilization in North China, and its unique architectural style and profound cultural heritage urgently need to be protected and activated. Through the comprehensive use of various digital technologies and intelligent rural technologies, this paper explores how to effectively extract and activate the architectural style genes of Shuiyu Village, so as to provide a new path for the sustainable development of traditional villages.

(1) Research background

1. Current situation and challenges of traditional villages

In the wave of globalization and urbanization, the traditional villages are facing an unprecedented impact. A large number of rural people have poured into the cities, leading to the imbalance of the population structure of the traditional villages, the shortage of labor force, and the gradual weakening of the vitality and vitality of the villages. At the same time, the introduction of modern architectural concept and technology makes

many traditional buildings lose their original features and characteristics in the process of transformation and new construction. In addition, the infrastructure of traditional villages is often relatively backward, and the public services are insufficient, making it difficult to meet the needs of modern life, which further aggravates the decline of villages.

2. Unique value of Shuiyu Village

Shuiyu Village, located at the eastern foot of Taihang Mountain, is a traditional village with a history of thousands of years. Its unique geographical environment gives birth to a rich variety of architectural styles and cultural connotations. The buildings in the village cleverly adapt to the terrain and are built on the mountain, forming a unique layout of harmonious coexistence with the natural environment. (as shown in Figure 1, Figure 2)

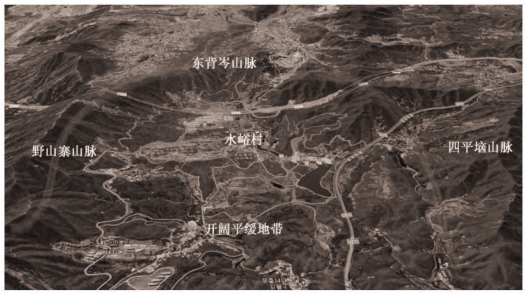

Figure 1 Topographic map of Luquan Shuiyu Village mountains

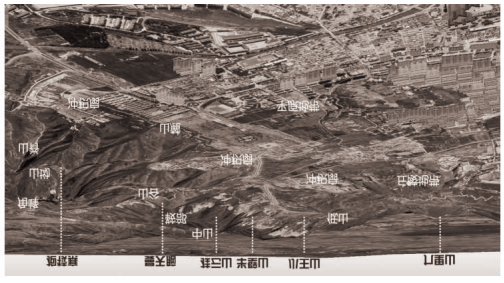

Figure 2 Aerial view of Shuiyu Village's mountain, hills and plain of in Luquan

Traditional red stone buildings, unique cave forms and rich folk culture are all the precious material and intangible cultural heritage of Shuiyu Village, bearing the profound historical memory and national emotion, and have a high research and protection value. (as shown in Figure 3)

Figure 3 Villager residence building of Shuiyu Village in Luquan

3. Technology-enabling opportunities

The rise of digital technology and the concept of smart village has brought new opportunities for the protection and development of traditional villages. 3D scanning, GIS, AR/VR and other technologies can accurately record and reproduce the details and overall style of traditional architecture, which provides a solid scientific basis for the protection of architectural style. At the same time, smart rural technology can improve the management level of villages and the quality of life of residents, inject new vitality into the activation of traditional villages, and make them shine new luster in modern society. (Figure 4)

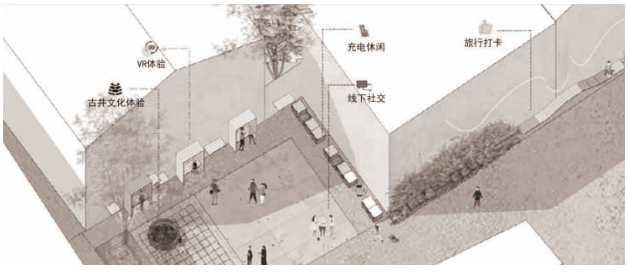

Figure 4 Concept drawing of architectural style design of a thousand-year traditional village in Luquan enabled by smart rural technology (1)

(2) Research purpose

This study focuses on the thousand-year-old traditional village in Luquan District, Shijiazhuang City, Hebei Province, taking Shuiyu Village as a typical example, and deeply excavates its spatial morphology characteristics and constituent elements. The aim is to fully understand the spatial layout, architectural style and cultural inheritance of Luquan traditional villages,

evaluate their protection and development challenges, and explore the protection and activation strategies in the new era. Through careful analysis, it provides scientific basis and practical guidance for the protection, inheritance and innovation of traditional villages, and promotes their sustainable development. The research uses 3D scanning, GIS, AR/VR and other digital technologies to accurately record architectural styles, realize virtual reproduction, combined with the concept of smart villag, use the Internet of Things and big data to develop digital management platform, improve the village management and living quality of residents, and provide technical support and innovation path for the protection and activation of traditional villages.

(3) Research significance

This study has great practical significance and historical value for the protection and activation of traditional villages in Luquan District, Shijiazhuang City, Hebei Province. In the process of modernization, the traditional villages are facing the dual challenges of aging buildings and cultural fault.

Through in-depth study of the spatial form of traditional villages in Luquan District, it provides scientific basis and innovative strategies for protection and inheritance, and maintains its historical and cultural and other values. The introduction of digital technology, the use of 3D scanning, GIS, AR/VR, etc., to conduct accurate digital recording and virtual reproduction of villages, not only contributes to the preservation of cultural heritage, but also can expand the scope of cultural communication and enhance the public awareness of protection. In combination with the concept of "smart village", information technologies such as the Internet of Things and big data are used to develop a digital management platform, improve the efficiency of village management and the quality of life of residents, and promote the effective protection and activation of traditional villages. This has improved the living environment of the villagers, provided technical support for the local economic development and sustainable development, promoted the development of local cultural tourism, and enhanced the identifiability and memory of the traditional villages. By protecting and activating traditional villages, we will attract more tourists, promote the development of tourism, let more people deeply understand and experience China's farming civilization and traditional culture, and enhance their confidence in national culture. In short, this study plays a key role in inheriting and developing the excellent traditional Chinese culture and displaying the unique charm of Chinese farming civilization. (Figure 5)

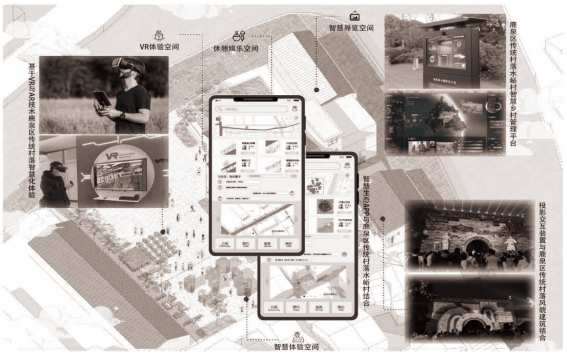

Figure 5 Concept drawing of architectural style design of a thousand-year traditional village in Luquan enabled by smart rural technology (2)

II. Definition of the relevant concepts

(1) The development of smart villages

Smart village is a new model combining modern science and technology with rural development. Rural production, living and management levels are improved through the Internet of Things, big data and other technologies. Its core is to use modern information technology to realize the efficient management and reasonable allocation of resources, promote the sustainable economic development and the improvement of residents' quality of life. Smart villages not only focus on agricultural agriculture, but also cover governance, environmental protection, tourism, cultural inheritance and other aspects.

By constructing digital management platform, it can accurately manage agriculture and improve crop yield and quality; improve life convenience and public service efficiency; digital means can help protect and

activate traditional villages and promote cultural tourism and traditional culture. At the same time, smart villages emphasize harmonious coexistence with nature, use science and technology to monitor and protect the ecological environment, promote green development, and strengthen exchanges and cooperation among villagers through information technology to enhance the cohesion of rural areas.

In this paper, the concept of smart village is integrated into the protection and activation of traditional villages in Luquan District. With the help of digital technology and intelligent management, new vitality is injected into traditional villages, and the organic combination of tradition and modernity is realized. It is hoped that through the construction of smart villages, the traditional villages in Luquan District will become the display window of agricultural civilization in North China, contribute to the inheritance of excellent traditional Chinese culture and creating a better rural life.

(2)The application of digital technology

Digital technology brings new opportunities for the protection and activation of traditional villages. In terms of the protection of traditional villages, digital technology can accurately record the architectural style, spatial layout and other details of traditional villages, and realize the digital archiving and display of cultural heritage through 3D scanning, GIS, AR/VR and other technologies. In the protection of the millennium traditional villages in Luquan District, these technologies help the construction of smart villages and improve the village management level and the quality of life of residents. This study combines digital technology with the protection of traditional villages, through in-depth research and practice, provides new ideas for the protection and activation of traditional villages in Luquan District, promotes the development of local cultural tourism, and realizes the organic integration of tradition and modernity.

III. Gene extraction of architectural style of a thousand-Year traditional village in Luquan enabled by smart rural technology

(1) Gene extraction of street style

The streets and alleys have clear spatial levels and flexible layout, which are well combined with the local terrain. The street space is mainly divided into four levels of roads, respectively: the main roads connecting inside and outside the village, the main roads for villagers in the village, the roadway connecting the multi-family dwellings, and the roadway entering the entrance of the residential residents. The villagers' main activity road is like branches inserted in the main road, extending to the surrounding areas. The main road is connected to the roadway, and the roadway is connected to the household roadway, so that the inner street space in Shuiyu Village is rich and hierarchical. The bottom interface of the street space is the basic space of People's Daily life, which mainly includes the change of the road laying material and the ground. The road material is made of local materials, the main road is laid with cement, and the secondary road uses the Taihang Mountain body stone and soil as raw materials.(Figure 6)

Figure 6 Material laying of street roads in Shuiyu Village

(2) Gene extraction of architectural style

The residential buildings of Shuiyu Village are not only closely connected with the spatial form of the village, but also deeply reflect the residents' lifestyle, cultural practices, and religious beliefs. These buildings are cleverly laid out along the contours and the terrain elevation differences, and use the local unique iron-rich shale and sandstone as building materials, to build a unique local characteristics of the redstone construction. Influenced by the style of Shanxi cave dwelling, combined with the rich local stone resources, these buildings skillfully make use of the fluctuation of the terrain along the contour line layout, choose the local iron-rich shale and sandstone as the main building materials, and build the red stone dwellings with unique local characteristics by hand. (Figure 7)

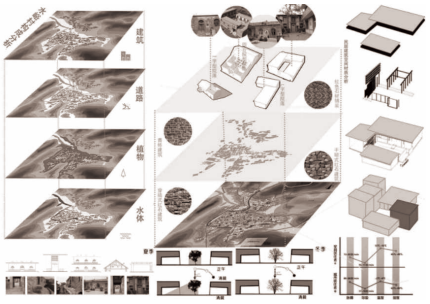

Figure 7 Analysis of the landscape buildings and constituent elements of Shuiyu Village

IV. Research on activation of architectural style of a thousand-year traditional village in Luquan enabled by smart rural sechnology

(1) Application of digital technology

Unmanned Aerial Vehicle (UAV) 3d scanning modeling: using UAV equipped with high-precision scanning equipment to carry out comprehensive aerial photogrammetry in Shuiyu Village. Through professional modeling software, the collected large amount of point cloud data is transformed into accurate 3D models, truly restoring the architectural form, street layout and landform of the village, and providing detailed basic data for the subsequent analysis and research.

Using large DJI K350 professional mapping drones to Shuiyu Village 45° tilt photography, software version for DJI Zhitu V4.0.10, through the scene exploration, communicate with the local departments and reference to the existing geographic information, accurately define Shuiyu village surveying and mapping area, determine the flight altitude between 100 and 150 meters, flight speed adjustment to the maximum, the ground resolution of 1.918cm/px, real projections like map covering area of 1.206531 square kilometers, the specific parameters by DJI K350 professional surveying and mapping uav. (Figure 8)

Figure 8 Luquan Shuiyu Village Data mapped by DJI K350 professional UAV (1)

According to the quality report of air-three reconstruction, the number of connected areas is 1, the maximum number of connected areas is 16555, the number of connected points is 36936793, the connection points are 4153732, the reprojection error RMS is 1.118 pixels, and the root mean square error of geographic registration is 0.057 meters. The reconstruction parameters include single machine calculation, high feature point density, subject distance of 100 meters, and XML is no. The RTK state shows a fixed solution of 17980, floating, single point and others as 0. (Figure 9)

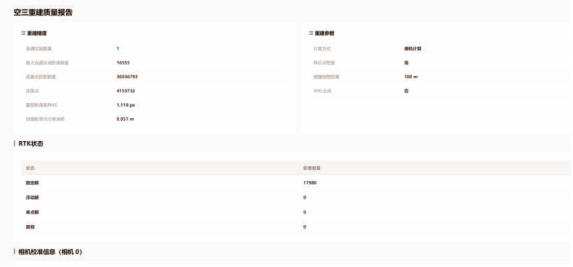

Figure 9 Luquan Shuiyu Village Data mapped by DJI K350 professional UAV (2)

This surveying and mapping task obtained high-quality image data, and the accuracy of air-three reconstruction and two-dimensional reconstruction was high, which can meet the protection and research needs of traditional villages in Shuiyu Village. The parameter optimization and error analysis of the camera show that the calibration state of the camera is good, which can ensure the geometric accuracy and color accuracy of the image. The whole data processing process takes a long time, so it is suggested that the time and resources should be arranged reasonably in the future tasks to improve the processing efficiency. The mapping results are applied to the 3D modeling, terrain analysis, cultural relics protection and other aspects of Shuiyu Village, to provide a scientific basis for the protection and sustainable development of traditional villages. (Figure 10)

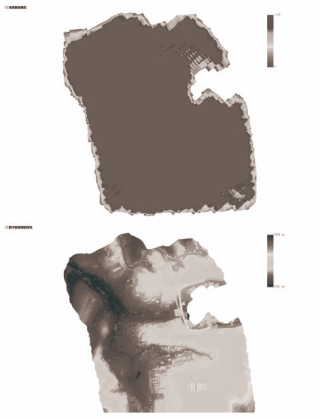

Figure 10 Luquan Shuiyu Village Data mapped by DJI K350 professional UAV (3)

(2) Application of GIS technology

Shuiyu Village, located in Luquan District, Shijiazhuang City, Hebei Province, is a thousand-year-old traditional village with rich historical and cultural heritage. In order to better protect and study the architectural style of Shuiyu Village and its relationship with the natural environment, this study uses GIS technology to draw the boundary of the survey area, mark the key areas, and build a geographic information system platform, and combine the 3D scanning data for further analysis. The basic geographic information data such as topographic map and satellite image of Shuiyu Village and its surrounding areas, as well as historical documents and field research data related to the history, culture and architecture of the village are are collected. The collected data are sorted out and analyzed, and the useful information is extracted to provide a basis for drawing the boundary of the test area.

Combined with the collected data and field investigation, according to the natural geographical scope and research needs of Shuiyu Village, the mapping tool of GIS software was used to accurately draw the boundary of the survey area on the digital topographic map and satellite images. Survey area boundary drawing should fully consider the integrity of the village, the geographical characteristics and representative and the relevance of the surrounding environment, ensure covers all important areas, Shuiyu village, including ancient buildings, historical sites, traditional dwellings, etc., also to consider the surrounding natural environment, such as mountains, rivers, forests, etc., in order to comprehensive analysis of the relationship between villages and the environment. (Figure11)

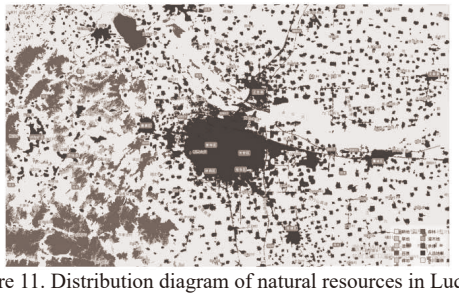

Figure 11. Distribution diagram of natural resources in Luquan

Detailed investigation and registration of the ancient buildings and historical relics in Shuiyu Village, including its name, location, age, architectural style, protection status and other information. On the GIS platform, the graphical elements such as points, lines and surfaces are combined with the attribute data to annotate these key areas. For example, for ancient buildings, you can use polytools to map the area range and record the corresponding information in the attribute table. For historical sites, such as ancient Wells, ancient monuments, you can mark with point elements and add attribute fields to describe their type, age and other features. In addition to the ancient buildings and historical relics, other areas in Shuiyu Village can also be marked according to the research purpose and actual needs, such as the concentrated distribution area of traditional dwellings, public activity space, religious places, etc. The labeling of these areas contributes to a deeper understanding of the social structure, cultural inheritance and lifestyle of the village. (Figure12, Figure 13, Figure 14)

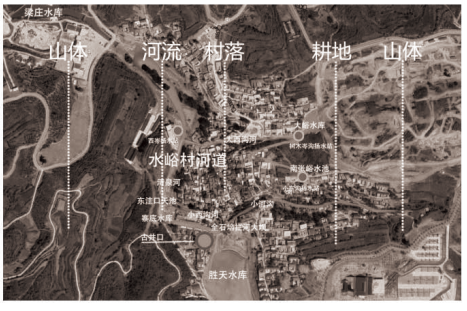

Figure 12. Distribution diagram of mountain and river channels in Shuiyu Village

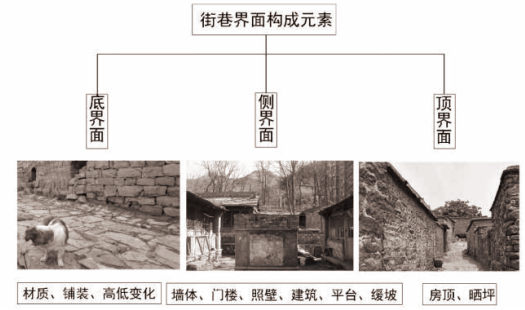

Figure 13 Analysis diagram of street interface elements in Shuiyu Village

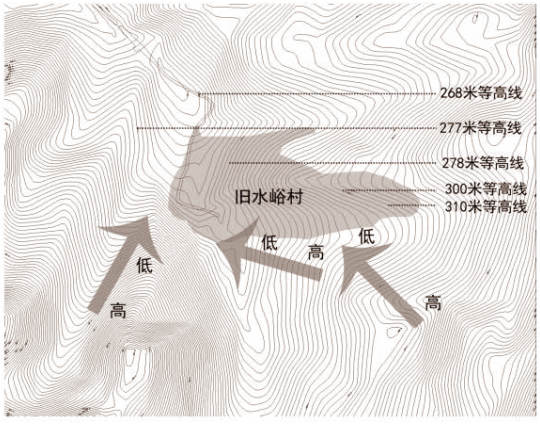

Figure 14 Distribution of the 1-meter elevation difference contour line in Shuiyu Village

(3) Construction of the geographic information system platform

1. Platform construction

The professional photogrammetry software ContextCaptur was selected to process the collected images to generate the 3D point cloud, mesh model, and texture map. Import and integrate the tilt photography data, and import the previously drawn test area boundary, marked key area data, and other related geographic information data (such as topographic data, image data, etc.) into the GIS platform. Integration and processing of data from different sources and in different formats, so as to realize unified management and visual display on the platform.

2. Fusion of the 3D scanning data

In order to preprocess the building data of Shuiyu Village through ContextCaptur, including data format conversion, noise removal, point cloud data extraction, to improve the data quality and processing efficiency.

The preprocessed 3D scan data were combined with the geospatial information. The 3D analysis function of GIS software can be used to stack the 3D model data on the two-dimensional map of the GGIS platform to realize the integration and display of 3D model and geospatial information. The coordinate model and the geospatial data in location and scale are ensured by setting the appropriate coordinate system and projection mode.

The topographic data on the GIS platform is used to generate the topographic map of Shuiyu Village and its surrounding areas, including contour map, slope map, slope map, etc. By analyzing these topographic elements, the relationship between the location and topography of Shuiyu Village is studied. For example, observe whether the village is located in the intermountain basin, hillside land or valley zone, analyze its site location combined with the geological survey data, and analyze the geological conditions of the site selection of Shuiyu Village on the GIS platform, including stratigraphic lithology, geological structure, hidden dangers of geological disasters, etc. To understand whether the geological stability factors are taken into account, such as avoiding seismic fault zone and landslide areas, to ensure living safety. On the platform, the land use status of Shuiyu Village is classified and counted, including different types of construction land, farmland, woodland, water area and so on.

Through UE5's construction of the smart village platform in Shuiyu Village, Luquan, the interface design should fully consider the characteristics of tourism demand and smart village technology. A simple and clear village overview display area is set at the top of the interface, with a high-resolution panoramic 3D model map of Shuiyu Village as the core, and the model is accurately constructed according to the real terrain and architectural layout. Tourists can zoom and rotate freely. With a brief text introduction, covering the village history, geographical location, cultural characteristics and other key information, such as "Shuiyu Village, located at the eastern foot of Taihang Mountain, was built in the late Sui

dynasty and early Tang dynasties, has a unique red stone architectural style and rich farming culture". At the same time, real-time weather, temperature, tourist flow and other basic information are displayed to facilitate tourists to plan their trips.

An independent architectural style browsing area is set up to present different types of buildings in the form of classified list, such as dwellings, public buildings, religious places, etc. Click on the specific building, and pop up the detailed information card, including the 3D model of the building, historical evolution, architectural style analysis, internal structure display, etc. For example, for a typical red stone kiln building, show an animation demonstration of the whole process from site selection to construction, as well as high-definition pictures and text descriptions of the interior spatial layout and decorative details, so that tourists can have an in-depth understanding of the cultural connotation behind the building.

A tourism service area is set up in a prominent position on the interface, integrating traffic guide, accommodation recommendation, catering information, shopping guide and other functions. The traffic guide provides a variety of transportation suggestions from surrounding cities to Shuiyu Village, including self-driving routes, public transportation shifts, etc.; the recommendation of distribution, room type, price range and reservation; the catering information lists the location, pictures, introduction and business hours, etc.; the shopping guide recommends the information of handicrafts and agricultural products with local characteristics, supporting online purchasing function to provide one-stop service for tourists.

Create an immersive cultural experience area, using virtual reality (VR) and augmented reality (AR) technology to allow tourists to experience traditional folk activities and handicraft production process online. For example, through VR equipment, tourists seem to be in the traditional temple fair in Shuiyu Village, feel the lively atmosphere; with the AR function, tourists can use mobile phones to scan real scenes, see the virtual historical figures interpreting local legends, enhance cultural identity and tourism interest.

An ecological protection exhibition area will be opened up to introduce the natural ecological environment, the achievements of biodiversity protection and the sustainable development measures of Shuiyu Village. Display the information of forest coverage rate, water resources status, rare animal and plant species in the form of dynamic charts and videos of the village, publicize the concept of ecological tourism, guide tourists to travel in a civilized way, and jointly maintain a better environment.

It provides the background management interface for the village managers, and integrates the monitoring data of the Internet of Things equipment, such as water quality monitoring, air quality monitoring, security monitoring, etc., to present the operation status of the villages in real time with visual charts. At the same time, it has the functions of tourist flow analysis, facility maintenance reminder, emergency command and dispatch, to help managers make efficient decisions efficiently, improve the intelligent level of village management, and ensure the orderly development of tourism activities and the safety protection of cultural heritage.

Through the careful design of the above modules, Shuiyu Village ’s digital twin platform interface of Luquan will provide tourists with a comprehensive, convenient and in-depth tourism experience, and provide strong support for the protection and development of the village, so as to realize the perfect integration of tradition and modernity. (Figure 15, Figure 16, Figure 17)

Figure 15 Smart village management platform of Shuiyu Village in Luquan (1)

Figure 16 Smart village management platform of Shuiyu Village in Luquan (2)

Figure 17 Construction interface of the smart village management platform of Shuiyu Village in Luquan

(4) Combination of interactive art installations

As a powerful visual programming tool, Touchdesigner can realize complex graphics processing and interactive control. Combined with 3DMapping technology, the architectural elements of Shuiyu Village, such as roof and wall, are used as projection carriers to design and produce exquisite dynamic visual content. Through the projection of mapping, the surface of the building presents a gorgeous light and shadow effect, showing the historical story, folk culture and natural scenery of the village.

Multiple interactive art installation points are set up in the public space of Shuiyu Village. For example, a large 3DMapping device is set up in the entrance square of the village as the projection screen to show the overall style and historical and cultural context of the village; a small interactive device is set up beside the characteristic dwellings, allowing tourists to interact with the architectural elements and have a deep understanding of the cultural connotation behind the building. These interactive art installations not only provide tourists with a new cultural experience, but also enhance their sense of identity and memory of Shuiyu Village culture. (Figure 18)

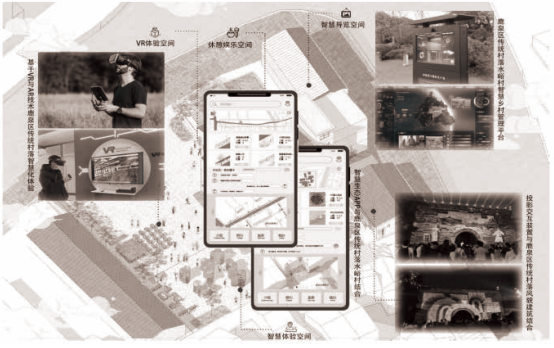

Figure 18 Concept diagram of smart village art installation interaction in Luquan Village

V. Conclusions and innovation points

Through the in-depth study of Shuiyu Village, Luquan District, Shijiazhuang City, Hebei Province, this paper comprehensively explores the application of smart village technology in the gene extraction and activation of traditional villages. Through UAV 3D scanning modeling, GIS, AR/VR and other technologies, the street style and architectural style genes of Shuiyu Village are extracted, and the UAV 3D scanning modeling technology is used to provide high-precision 3D modeling, which truly restores the architectural form, street layout and landform of the village. GIS technology is used to draw the boundary of the survey area, mark the key areas, build a geographic information system platform, and conduct in-depth analysis combined with 3D scanning data. Based on the smart village digital management platform built by Unity and UE5 platform, the smart APP of Shuiyu Village is developed, and the smart technology is applied in agriculture, environment, tourism, cultural and creative fields, which helps to improve the efficiency of village management and the living quality of life of residents. The interactive art installation combines Touchdesigner and 3DMapping technology to provide tourists with

an immersive cultural experience and enhance their cultural identity. The research results provide a new idea for the protection and activation of traditional villages in Luquan District, promote the development of local cultural tourism, and realize the organic integration of tradition and modernity. Through the protection and activation of traditional villages, it has attracted more tourists, promoted the development of tourism, enabled more people to deeply understand and experience China's farming civilization and traditional culture, and enhanced their confidence in national culture.

This study has remarkable innovations in technology application, platform construction and cultural experience. First, the integration of multiple technologies is one of the core innovations of this study. The research innovatively combines a variety of digital technologies and intelligent rural technologies, realizing the comprehensive recording, analysis and activation of traditional village architectural styles. The comprehensive application of this multi-technology not only improves the accuracy and reliability of the data, but also provides a new technical path for the protection and activation of traditional villages. Secondly, the construction of the smart rural digital management platform is another important innovation point. The smart rural digital management platform built based on Unity and UE5 platform provides convenient services and rich experience for residents and tourists. In addition, the application of interactive art installations is also a major highlight of this study. Using Touchdesigner and 3DMapping technology, combined with interactive art installations, it provides tourists with an immersive cultural experience.

This study is not only innovative in theory, but also operable and popularized in practice, providing valuable reference for the protection and activation of other traditional villages. In the future, with the continuous progress and innovation of technology, smart rural technology will play a more important role in the protection and development of traditional villages, and make positive contributions to the inheritance of excellent traditional Chinese culture and the comprehensive revitalization of rural areas.

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