

## THE APPLICATION OF UAV OBLIQUE PHOTOGRAMMETRY IN SMART TOURISM: A CASE STUDY OF LONGJI TERRACED SCENIC SPOT IN GUANGXI PROVINCE

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### ABSTRACT:

With the application of UAV Oblique photography, rapid 3D real-time modeling based on aerial image data has become a new technology in the field of 3D modeling. In view of the current poor mapping and inability to reuse the basic surveying and mapping data in the publicity and display, dynamic planning, etc., based on the UAV photogrammetry technology that is used to rapidly and accurately collect image data of the Longji terraced scenic spot in Guilin, Guangxi, this paper develops a platform by 3D real-time modeling technology with the combination of the high-tech such as digital mapping to realize the three-dimensional navigation and smart tourism of the scenic spot. The practical results show that the application can better meet the actual needs of high precision, large scale, wide audience, strong interaction, etc., which effectively alleviates the contradiction between the protection and utilization of cultural resources in cultural tourism, expands the cultural resources audience, and provides high-tech support to the cultural tourism.

### 1. INTRODUCTION

With the continuous improvement of the economic level of our people, traveling has become a part of the lives of many people. According to the results of the National Bureau of Culture and Tourism's 2018 Development Statistics Bulletin, the total income of China's tourism industry was 5.97 trillion in 2018. The tourism industry has entered a period of great development. The comprehensive contribution rate of tourism to China's economy and employment has exceeded 10% (Li et al., 2014). Tourism industry has been an important part of promoting China's economic transition. At present, the international tourism market continues to grow. Due to the late development of China's tourism industry, compared with other developed countries, China's tourism development still lags behind in many aspects. In order to promote the development of China's tourism industry, provide public service functions that are more advantageous to tourists, enhance the promotion of tourist attractions, and promote the magnificent scenery in China, the multi-information fusion technology represented by virtual reality technology has entered people's lives. With the emergence of virtual reality, a new door has been opened for the tourism industry.

Virtual reality is based on computer technology. It is a science that integrates people and information, and comprehensively processes and generates a real digital environment that is highly similar to a certain range of visual, auditory, and tactile sensations (Kong, Li, 2019). Users interact with objects in the digital environment with the necessary equipment. It enables people to immerse themselves in the computer-generated virtual world, and can interact with them in real time through natural ways such as language and gestures, give the experienter an immersive experience and experience.

With the help of virtual reality technology, the UAV tilt photography technology has a new space of development. UAV tilt photogrammetry is a high technology of remote sensing surveying and mapping developed rapidly in recent years. Compared with traditional manual modeling, it has the advantages of real, fast, efficient and automatic. This technology has changed the limitation that aerial photogrammetry can only shoot ground objects from a vertical angle with one camera. That is to say, a multi-angle sensor is carried on the same flight platform, and image is collected from a vertical angle and four inclined angles at the same time. Using the 3D modeling software, a complete, real and high-precision 3D landscape model can be obtained. In the tourist scenic spot, the traditional artificial modeling is difficult to restore a wide range of real natural landscapes. The traditional handcrafting degree does not reach the aesthetic level of the real landscape, and landscape and image use update is not a strong trend. With its high resolution and high realism, UAV tilt photography can truly restore the true natural landscape, which is conducive to the protection of scenic spots, especially the protection of geological relics, the promotion of popular science knowledge and the visual display of natural landscapes, thus attracting Visitors watch, providing users with a more realistic virtual travel method, providing a new way for the scenic spot to display their own image and resources.

To this end, the basic surveying and mapping data of tourist attractions in the aspects of propaganda, display and dynamic planning are not current and cannot be reused (Guan, Sun, 2017). Based on virtual reality and UAV photogrammetry technology, this paper conducts fast and accurate image data collection for Longji terraced scenic spot in Guilin, Guangxi, and generate 3D model through advanced 3D real-time modeling technology, and combines the number based on the model. High-tech such as surveying and mapping, with the

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concept of tourism information retrieval and tourism function services under the digital background, enhances the personalized travel experience of tourists, enabling visitors to browse and experience different virtual tourist landscapes from multiple perspectives in 3D simulation scenarios.

## 2. RELEVANT THEORY AND TECHNICAL SUPPORT OF UAV TILT PHOTOGRAPHY MODELING TECHNOLOGY IN VIRTUAL TOURISM

### 2.1 The role of virtual reality technology in tourism

Virtual reality technology has the virtuality beyond reality. Compared with the real world, it utilizes and integrates high-performance computer hardware and software and various advanced sensors to create an integrated information environment with immersive immersiveness and perfect interactive capabilities. Corresponding feedback on human perception of muscle activity interaction, which allows the user to complete some things in the real world that cannot be experienced, if conditions permit. The role of its virtual tour is also very obvious. The composition of the virtual reality system is shown in Figure 1.

1. Promote the diversification of tourism marketing methods. Visitors participate in the tourism marketing process, immersively experience the scenic spots, have a detailed understanding of the information of the scenic spots before the field travel, stimulate tourism interest, and can become the promoter of tourism marketing.
2. Promote the development of tourist attractions. In today's big data era, there is a lack of a platform that allows visitors and travel planners to interact with each other, visitors reviewing the previous virtual tour experience while traveling in a real scenic spot will increase the fun of their travel process. Visitors experience it as builders. It can provide corresponding feedback to the virtual tourism construction of the scenic spot, and it can increase the interactive experience between tourists and scenic spots.
3. Improve the convenience of tourism planning. At the beginning of the planning of tourist attractions, the planners can create virtual scenes according to the planning requirements, establish corresponding virtual reality systems, judge the advantages and disadvantages of various plans through the individual observation and experience of the planners, check the implementation of the construction, and plan for the plan. The plan serves as an aid. The application of virtual reality technology in tourism planning can better improve the quality of scenic spots planning, speed up the construction of scenic spots, and facilitate the use of the spatial layout of scenic spots to reduce design defects.

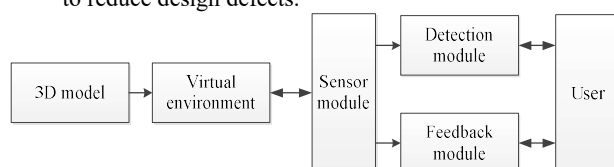


Figure 1. The composition of the virtual reality system

### 2.2 Advantages of UAV's tilt photography modeling technology

Tilt photography is an important data source in virtual cities. UAV tilt photography modeling technology can combine control points encryption from massive image data with a small number of ground control points to obtain accurate external orientation elements. The momentary posture when shooting images. Then, through multi-view image intensive matching to find the connection point, construct a three-dimensional TIN grid white mode, contact the index relationship between the model surface and the oblique image, and based on the triangulation network (TIN) model, each image data is performed. Spatial screening to find the image set that best fits the model. Finally, the image pixel is sampled and read into the model, and the rich texture information is quickly and efficiently obtained, and the texture mapping is automatically completed. This model can truly reflect the objective situation of the ground and generate high-quality 3D scenes to meet the needs of modern society. The more traditional method of urban 3D modeling is to combine the orthophotos, the CAD topographic maps and other data to create an initial white mode, collect photos in the field, then process the photos and map the textures on the white mold. This method consumes a lot of manpower, material resources and financial resources. The emergence of drone tilt photography modeling technology can solve this problem well.

## 3. SYSTEM IMPLEMENTATION

### 3.1 Overall structural design

This paper applies the UAV tilt photography modeling technology to virtual reality. The design system consists of three parts: data layer, logical layer and application layer (or user presentation layer, presentation layer). The data layer consists of two parts, which are the aerial image data of the drone and the ground control point (image control point). The basic data is obtained and processed by third-party software to generate full GPS information, elevation information and surface information of real-life digital three-dimensional model. The logical layer is the use of cloud-based true 3D GIS open platform-DataEarth, DataEarth including three parts: DataEarth Builder, DataEarth Server and DataEarth Web. DataEarth Builder convert the 3D model of the data layer to the DataEarth platform proprietary data type and mounts it through the cloud server of the platform. DataEarth WebSDK is the core business component of the DataEarth virtual earth 3D mapping platform, used to implement the system's GIS functions, for example, layer management, dot-line-surface rendering, object monomer and visual analysis of 3d models and so on. The platform also has multi-level development and development capabilities, and can be used to build SOA application systems and GIS cloud systems through the development of SDKs on the Web. The logical layer is to use a literal translation scripting language JavaScript to write code implementation functions, that is, to implement Web services, the overall structural design is shown in Figure 2.

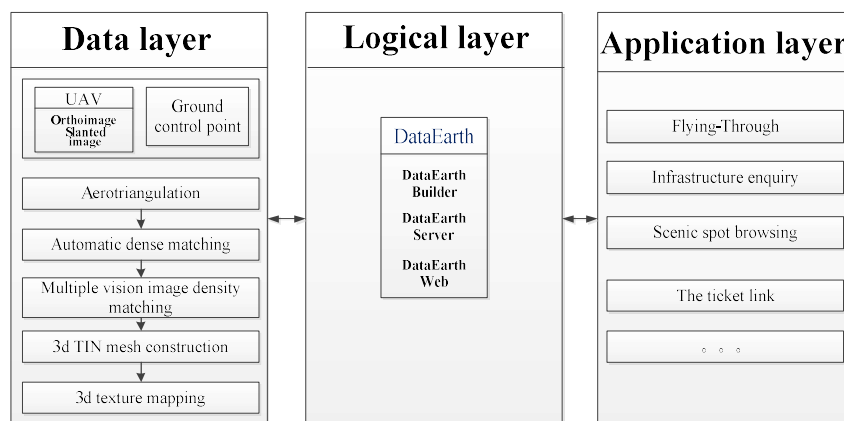


Figure 2. The overall structural design

### 3.2 3D scene modeling

**3.2.1 Field data collection:** The experimental area is Pingan village scenic spot of Longji terrace in Longsheng county, Guangxi Zhuang Autonomous Region. Longji terrace is located in peace township, Longsheng County, Guilin City, Guangxi Zhuang Autonomous Region (east longitude 109°32'~100°14', north latitude 25°35'~ 26°17'). It is 30 kilometers from Longsheng county and 70 kilometers from Guilin city, with an area of 66 square kilometers which among 20 square kilometers available sightseeing. Longji terrace is located at the edge of the ancient land of Jiangnan on the west side of Yuecheng mountain. The exposed stratigraphic are pre-sinian system sandstone, sandy schist and shale. Due to multiple geological structural movements, the landform of high mountain-terrace - valley is formed. The highest elevation is 1,850 meters and the lowest elevation is 300 meters. Most of the terraces are located on slopes between 300 and 1100 meters above sea level. The slopes are mostly between 26°-35° (Chen et al., 2002).

After the field survey of the experimental area, the UAV landing site is selected as the observation platform with flat ground and open view. The observation platform is located in the measurement area. Considering the time required for UVA measurement and the capacity and quantity of batteries, it can avoid wasting too much time in taking off and landing to the measurement area. Therefore, the observation platform is chosen as the takeoff and landing site for UVA tilt photogrammetry. According to the requirements of "field specifications for low-altitude digital aerial photogrammetry", a total of 7 image control points are arranged in this operation. The course overlap degree of the UVA was 85%, and the side overlap degree was 80%. The five-lens UVA was divided into five sorties, and a total of 7,430 photos were collected and stored in five folders.

**3.2.2 Internal data processing:** The 3D modeling software is mainly from abroad. Mainstream software such as street view factory, Smart3D, Pix4DMapper and PhotoScan are widely

used at present. In this study, Smart3D software was used to process the acquired image data. Smart3D software, also known as ContextCapture, is a 3D scene computing software developed by Acute3D Company of France based on graphics computing unit GPU. It was acquired by Bentley software company of America later. It is a revolutionary 3D modeling software. The software is based on photogrammetry, computer vision and computer geometric algorithm, practical, computational models, stability and other aspects reach industrial level. No need for manual intervention, rely on simple continuous image vividly generated and more detailed 3D model, data processing is very efficient and has the advantages such as simple, rapid and automatic, also can output various mutually compatible with general format, convenient imported into different kinds of platform and application software, convenient for later processing. It is widely used in the fields of cartography, homeland security, cultural heritage protection, architectural design, construction and construction (Li et al., 2017). Smart3D software has the world's leading computer vision 3D modeling algorithm, which can accurately solve the external orientation elements only by combining POS data. In using the algorithm based on oblique photographic image redundancy rich advantages for its image matching, and import the field acquisition as control points, choose WGS84 coordinate system, will be as the locus of control precision in image corresponding to the position, the average as the locus of control in six to eight spines point on the image, generated by aerial triangulation points, to obtain high precision matching results, check the accuracy of aerial triangulation, step precision report qualified for the operation. If the accuracy of the report is unqualified, check the problem after prick again, and repeat the above steps, until the precision report qualified (Fang, Li, 2017). The accuracy report of 3D model is shown in Table 1 and Table 2. Due to the large amount of data in the 3d model, the block model was adopted for production. This time, adaptive block cutting was selected and submitted to the computer for automatic data processing. The schematic diagram of 3D model results is shown in Figure 3.

Type	Median reprojection error [px]	Of the reprojection error RMS [px]	Ray distance RMS [m]	Three dimensional error RMS [m]	The level of error RMS[m]	Vertical-error RMS [m]
Control_points	2.25	2.71	0.051	0.061	0.044	0.042
Automatic_tie_points	0.55	0.75	0.019			

Table 1. Before aerotriangulation

Type	Median reprojection error [px]	Of the reprojection error RMS [px]	Ray distance RMS [m]	Three dimensional error RMS [m]	The level of error RMS[m]	Vertical-error RMS [m]
Control_points	0.50	0.48	0.020	0.024	0.017	0.017
Automatic_tie_points	0.45	0.50	0.020			

Table 2. After the aerotriangulation



Figure 3. The schematic diagram of 3D model results

### 3.3 Function implementation

**3.3.1 System functional structure:** According to the specific characteristics of different tourist attractions and planning needs to develop different functional programs, the system construction consists of three parts, namely database, server and front-end pages, of which the database is the OSGB format model produced by Smart3D software. DataEarth Builder is used to convert huge 3D data to DataEarth Server, a high-performance cloud GIS service platform. DataEarth Web can be used for online publishing, management and aggregation of data, and multi-source data integration and diversified display methods. It provides high-performance, high-precision, high-efficiency, easy-to-use platform capabilities and powerful GIS spatial analysis services. Based on this, we have customized secondary development for our travel system (Zheng, 2018).

**3.3.2 Loading and display application of scene data:** The 3D travel system provides 3D visual browsing and powerful search capabilities that are not available in ordinary maps. In addition to the basic real-time 3D model for viewing, the scene data also has a layered display of satellite maps. It can make visitors more intuitive to see the surrounding environment information, and spatial visualization analysis can provide great convenience for travel planners. The following is a demonstration of the various functional modules. Main interface of 3D tourism system is shown in Figure 4. Spatial measurement is shown in Figure 5. Spatial data analysis is shown in Figure 6.

1. Tourist location profile information inquiry. Users can check the geographical location, name and main

- introduction materials of tourist attractions, including pictures, images and other related multimedia information.
- Tourist traffic information inquiry. The specified route can be searched according to the user's query conditions and displayed on the map. It is also possible to calculate the distance between the point and another point, search for the best path and the information along the way, automatically search for information such as the tourist route between any two points, and dynamically display it on the 3D model.
- Panoramic display. It provides a panoramic view of the featured scenic spots, allowing visitors to further understand the features of the scenic spots.
- Coordinate measurement. In a specific tourist attraction, the 3D tourism system can directly calculate the coordinate position of the place. Due to the reality of the 3D model, the resulting coordinate values are quite accurate. With the continuous improvement and further development of the three-dimensional tourism system, the information update of tourist destinations will increase accordingly.
- Distance measurement. In the ordinary tourist scenic line diagram, the length of a line can only be estimated based on visual inspection. This often results in inaccurate results, which wastes the travel time cost of tourists and may also damage the tourists' interest in travel. The distance measurement function provided by the three-dimensional tourism system selects two target points on the real-life 3D model, and accurately calculates the coordinates and elevation of the two target tourist points to obtain a more accurate distance.
- Area measurement. The area measurement function of the three-dimensional tourism system is mainly to serve the tourism planning management department. For the development and planning of the scenic spot, it is necessary to accurately measure the size of the scenic spot in advance. The usual practice is for the tourism planning department to measure in the field, and the tools used are also some conventional measuring tools such as range finder. Because the tourist attractions are not all flat, and the mountains are undulating, the degree of water depth and so on will often affect the actual measurement results. The area measurement function provided by the three-dimensional travel system calculates the area of the surrounding surfaces by selecting the positions of several points on the three-dimensional model.
- Vision analysis. Viewing analysis refers to the topographic analysis of a situation in a certain area by



taking a certain point as an observation point. Use DEM to determine the technical method of whether any two points on the terrain can be seen from each other. By selecting any two points on the three-dimensional real-time map, it is judged whether or not the two points can be viewed.

8. Visual domain analysis. A set of all the points of view in the area is analyzed relative to a certain observation point based on a certain horizontal angle of view, a vertical angle of view, and a specified range radius. Visitors can select the ideal tourist spot in advance when planning their own journey, and there will be no obstacles to the view of mountains or buildings within the scope of this tourist attraction. In addition, for the tourism planning department, this function can help to better plan the tourist attractions, build or demolish some unnecessary buildings. The results of the analysis are indicated by the green area at the observation point and the red area is not visible at the observation point.
9. Profile analysis Profile analysis can be used to analyze elevation changes of three-dimensional real surface. Through cross section analysis, relief section information, positions and elevations of the highest and lowest points, and distance between two points can be obtained. It can help users estimate the difficulty of walking along a path or evaluate the feasibility of laying down a path.
10. Sunshine analysis Sunshine analysis is very useful in tourism planning, such as whether the planned buildings seriously affect the lighting of surrounding scenic spots, how big the affected area is, and how to adjust the height of the buildings so as not to affect the lighting of surrounding buildings.



Figure 4. Main interface of 3D tourism system

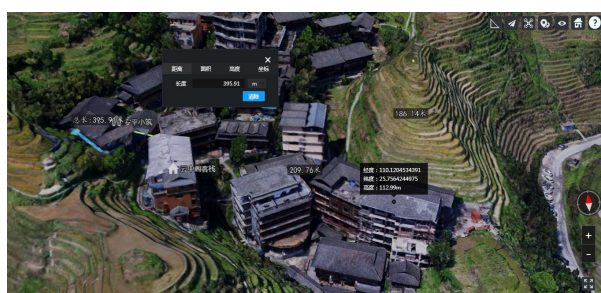


Figure 5. Spatial measurement



Figure 6. Spatial data analysis

## 4. CONCLUSION

This paper designs and achieves the virtual roaming system of Longji terrace scenic spot in Guangxi by combining virtual reality technology and UAV tilting photography technology. The method of using UAV tilting photography technology and powerful image geometric operation software (Smart3D Capture) to produce three dimensional city model is feasible, which can quickly build live 3D scene. Furthermore, in order to achieve the technical route and implementation scheme of virtual roaming, accomplish the virtual scene roaming and displays characteristics of the scenic spot area, the DataEarth platform is applied. The development of the system basically achieves the intended purpose, which not only shows the realistic visual effect of Longji terrace scenic spot in Guangxi, but also conducts human computer interaction in a simple, efficient and intuitive way. The research and implementation of the system has important practical significance for the construction of subsequent virtual tourism projects.

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