Application of UAV Oblique Photograph Modeling Technology in Mountain Tourism Planning

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Abstract: In recent years, with the development and popularization of small unmanned aerial vehicles (UAV), it has become a trend of using UAV oblique photograph modeling to assistant planning. Taking Wanling Village in Dujiangyan, Sichuan Province as an example, this paper carries out the three-dimensional modeling of some areas in this region through oblique photography. It provides an intuitive model for tourism planning and tourism product design, and explores the application value of this technique in mountain tourism planning.

1. Introduction

Tourism resources are the basis of tourism development. Traditionally, the foundation of tourism plan and product design is the location theory, the tourism lifecycle theory and the sustainable development theory. Methods of investigating tourist resources include visiting, field observation, testing, recording, drawing, photographing, as well as sampling and indoor analysis when necessary. Tourism planning usually needs many rounds of field surveys and investigations, as well as analyses on the GOOGLE EARTH and topographic maps. Meanwhile, the CAD software is needed in the map drawing process. The process of field survey consumes a lot of manpower and material resources. Meanwhile, tourism surveys in mountainous areas are uncertain and dangerous sometimes.

In recent years, some new modern technical means have been widely introduced in the planning process. The three-dimensional modeling technology based on oblique photograph of small UAV is one of the new modern surveying and mapping technologies. It can serve the planning process, especially the tourism planning in mountainous and shallow hilly areas, as well as the design and development of tourism products.

Unmanned aerial vehicle (UAV) is a kind of unmanned vehicle with power, controllability and reusability. The vehicle can carry some facilitates. In recent years, civil UAVs have developed rapidly in China. The small-scale consumer UAVs released by DJI-Innovations, ZERO TECH and other manufacturers are favored by the global market. In the field of civil use, UAV low-altitude aerial survey plays an important role in marketing, resource survey, planning and mapping because of its advantages of low cost, timeliness, high-resolution and convenience. However, few people have explored how to realize the oblique photograph modeling process through small UAVs and how to apply the technology to the design of mountain tourism products. Therefore, the author takes Wanling Village of Guankou Town in Dujiangyan City, Sichuan Province as an example, and uses PHANTOM 4 UAV produced by DJI for oblique photograph and fast three-dimensional modeling to assist the tourism planning of this area, in order to explore the application of small UAV oblique photograph modeling technology in mountain tourism planning.

2. Overview of the Research Area

The planned area is Wanling Village, Dujiangyan City of Sichuan Province. Wanling Village of Dujiangyan City is located in the northwest edge of Chengdu Plain. The territory is high in the northwest and low in the southeast. The elevation span is from 700 meters to 1400 meters, and the total distance from the village committee at the foot of the mountain to the observation platform at the top of the mountain is about 6 kilometers, with a relative height difference of more than 700

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meters. Standing on the top of the mountain, you can overlook the whole picture of Dujiangyan. It is a unique geographical advantage of this region. At present, cement-hardened road is paved from the city to the mountain top of Wanling Village; gravel road is used in the Baisha section from Wanling to Hongkou. The construction purpose is to build high-standard cross-country routes. At the same time, Wanling Village put forward its planning objectives of building a new recreational and leisure base with comprehensive functions of ecological environment, leisure and vacation, outdoor sports, rural tourism as well as health maintenance. With the total investment of about 3 billion yuan, the village plans to build “one belt, two bases and three parks“ (a wild luxury hotel community belt; two bases of bamboo industry and traditional Chinese medicine industry; three parks of cloud platform, path and ultimate experience). At the same time, the plan takes “people“ as the foundation. Through the building of beautiful countryside, we can support and promote farmers, help farmers to earn more money and build a sport and leisure countryside with Sichuan characteristics. It can be seen that the region is rich in tourism resources and has good prospects for development. It is one of the representative destinations for the implementation of tourism projects in mountainous and rural areas.

Figure 1 Reality images of Wanling village, Dujiangyan city

However, this area has a typical low and middle altitude mountain landform. Because of its geographical features, vegetation and wildlife characteristics, climate traits, hardware settings as well as the tourism management situations, this area has more insecurity factors than the plain area. The main manifestations are as follows.

1) Traffic safety. In this area, the topographic relief is large; the vertical and horizontal gullies and the continuous cliffs increase the risks of tourism traffic. At the same time, the safety of roads is closely related to the weather condition. If there is rain, snow or fog, the safety factors will be further reduced.

2) The influence of geological conditions. The specific geological conditions in this area, such as rock-fall, landslide, flood, debris flow and other occasional geological disasters, can endanger the safety of tourists. Especially in the rainy season from July to September, security issues are more prominent in extreme weather conditions.

3) Effects of vegetation and wildlife. There are some poisonous animals and plants in the mountainous scenic area. If the isolation is not appropriate, they will affect the safety of tourists.

4) Forest fire prevention and other natural factors may also cause harm to tourists.

3. Key Technologies

3.1 Basic parameters of the UAV

Oblique photos of the research area were collected by using the PHANTOM4 UAV produced by the DJI Company. The UAV carried IMU and GPS sensors to acquire image positions, altitudes, depths and other information. At the same time, it also carried an image sensor camera equipped with a 1/2.3 inch CMOS with the effective pixel of 12.4 million and FOV 94° 20 mm (35 mm format equivalent). It was very suitable for the three-dimensional modeling through oblique photography. After the on-site investigation, the UAV oblique photograph was carried out at four locations; more than 300 maps were taken in total. About 5KM^2 three-dimensional models were completed in the later three-dimensional modeling.

3.2 The aerial triangulation

The three-dimensional modeling of oblique photograph was carried out based on the aerial triangulation. According to the mathematical model, the technique can be divided into the airstrip method, the independent model method and the beam method. The basic mathematical model for analyzing aerial triangulation is the collinear equation, which is the most basic and important relationship in photogrammetry. The so-called collinear equation refers to the image equation of the central projection. In the process of photographic imaging, the three points of the photographic center S, the image point a and the corresponding ground store A are located in a straight line. At this time, the object space coordinates (X_S,Y_S,Z_S) of the S point in the photographic center, the photo coordinates (X, Y) of the image point a and the object space coordinates (X_A,Y_A,Z_A) of the corresponding ground point A satisfy the following condition,

$$\begin{cases} X - X_0 = -f\dfrac{a_1(X_A - X_S) + b_1(Y_A - Y_S) + c_1(Z_A - Z_S)}{a_3(X_A - X_S) + b_3(Y_A - Y_S) + c_3(Z_A - Z_S)} \\ Y - Y_0 = -f\dfrac{a_2(X_A - X_S) + b_2(Y_A - Y_S) + c_2(Z_A - Z_S)}{a_3(X_A - X_S) + b_3(Y_A - Y_S) + c_3(Z_A - Z_S)} \end{cases}$$

3.3 The 3-D modeling process of oblique photographs

At present in China, popular software used in the calculation of aerial photo space-three includes Pix4DMapper produced by Pix4D Company in Switzerland, Erdas Imagine produced by Erdas Company in the United States, and Context Capture produced by the Acute3D Company in France. In this case, we use Context Capture Master produced by the Acute3D Company to model and calculate the aerial space-three quickly. In the process of rapid modeling, parameters need to be set up first, which mainly includes following contents:

1) Image sensor parameters. Currently, popular UAVs in the mainstream market can directly write information about the sizes, the lens aperture, the lens focal length and other parameters of the image sensor into the EXIF attribute of each image. The software can read the information directly. If the captured image does not have EXIF attributes, then sensor sizes, focal lengths and other parameters need to be input.

2) Spatial reference frame parameters. In this case, the default WGS84 spatial reference system is selected directly

3) Setting and checking control points. The control points are mainly used to determine the range of the stitching area. In this case, the UAV wrote the GPS position information into the EXIF attribute of pictures. The software can read the position automatically, so the position information was read directly from the image by default. But if the ordinary camera of UAV does not write the GPS information into the image while taking pictures, the control points should be selected to determine the shooting range. Otherwise, in the process of splicing and modeling, the splicing dislocation will easily lead to model distortion.

In the process of shooting, the coincidence rate between images should be about 90%. Under the condition of high consistency, UAV should be controlled to take photos from the directions of X and Y through translation; the area to be surveyed should be fully covered. The UAV produced by DJI can cooperate with DJI GS PRO to plan the routes of navigation, so as to cover the whole surveying and mapping area. But in this case, the terrain difference is large. In order to ensure flight safety, the way of manual control method was used for image acquisition for the majority of time. In relatively flat areas such as the hilltop platforms, the central point was located in the core area of surveying; the radius was designed big enough to cover the whole area that needs to be modeled. Then the UAV flew around the points several times to collect images. With the help of ContextCapture Master, we could get the DSM (Digital Surface Model), the 3D POINT CLOUD (Three-dimensional Point Cloud) and the MESH model data from the output options. On this basis, we could extract different planning maps according to the research contents to meet the diversified needs, and use the required attribute information for further analysis. In this case, we directly output the 3D MESH model data. The format model provided basic spatial location, intuitive

three-dimensional terrain, mapping and other information. At the same time, it can be applied to more three-dimensional editing software through format conversion. So the method is very suitable for tourism planning.

Finally, by comparing the corrected three-dimensional model with the original GOOGLE EARTH satellite map, it can be seen that the UAV low altitude oblique model has the characteristics of high resolution, strong timeliness and more accurate data. Through the analysis, we can obtain necessary information clearly, which has a rare advantage in mountain tourism planning and tourism product design. The fast modeling process based on oblique photos of the area can help us to observe the spatial distance, the area and the height difference of different locations more intuitively, and measure the volume more accurately. Especially in mountainous areas where geological hazards such as landslides and debris flows usually happen, the model can help us to clearly detect these hidden hazards. Therefore, the model can be used to plan suitable travel routes. Combined with the field survey afterwards, the model can help us to plan relevant routes in the most effective way and with the least human and material resources consumption. At the same time, it can also facilitate the management work afterwards.

Figure 2 On the left is the model of the top area built by aerial photographs; on the right is the model of the same area in GOOGLE EARTH.

4. Conclusions and Analysis

Through practice, we have sorted out a more efficient planning process. Firstly, the planning area and research content are determined. Then, UAV is used to collect oblique images and build three-dimensional models. Then, data acquisition and analysis are carried out. All kinds of spatial information should be concerned in this process. Therefore, in the process of data extraction, spatial information such as the location, the area, the elevation and the elevation difference should be focused. According to the obtained three-dimensional model, the corresponding tourism planning and product designing could be achieved through measuring tools in the software of Acute3D Viewer. Finally, the rationality of the plan should be analyzed through another process of UAV oblique photograph modeling.

According to the analysis of the UAV oblique photograph model, following aspects in the scenic spot need to be improved.

The mountaintop area, as the core scenic platform, has a limited area. There are some problems in parking. The southeast part of the platform is steep with some potential safety hazards.

There is a large gap in the northwest gravel section. If mountainous cycling projects are carried out, there will be a great risk. At the same time, some sections have potential geological hazards and suspected landslides.

Some sections are too narrow that two vehicles from different directions cannot pass at the same time. There are too many twists and elevation differences.

There are not enough recreational sites along the southeastern section of the road.

In view of these shortcomings, following suggestions for improvement are put forward.

The mountaintop viewing platform should be expanded to provide enough space and a better

viewing perspective.

The gravel section (Wanling-Baisha) in the Northwest direction should be prolonged; the existing grade must be brought down to avoiding potential danger.

Passing entrance should be increased to ensure traffic safety.

Rest pavilions should be built to meet the needs of hikers.

Figure 3 The survey shows that the existing platform area is 868M^2, which should be expanded and become a viewing platform.

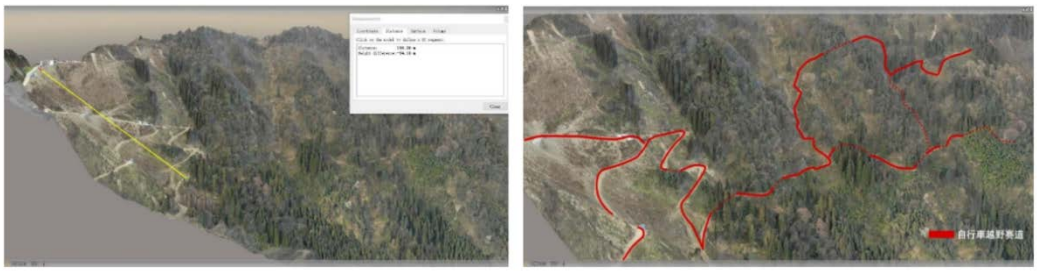

Figure 4 The existing gravel section has a height difference of 94M. The road can be extended and transformed into a cross-country bike road.

However, there are some problems in the use of UAV oblique photograph modeling. Affected by equipment continuity as well as related policies and regulations, at present, there are certain restrictions on the flight area and altitude of small UAVs. At present, the mainstream UAVs usually control the relative flight altitude within 500 meters, flight distance within 7 kilometers, and flight duration about 30 minutes (effective working time is about 20 minutes). So it is impossible to carry out aerial photography in a large area. Therefore, the current application of small UAV oblique photograph modeling in tourism planning usually uses Google Earth or other electronic maps for overall data acquisition; UAV is responsible for data supplement and verification of sub-areas. The field survey is also necessary in further data acquisition and verification. Nevertheless, compared with the traditional surveying and mapping methods, the UAV technology is worth learning and applying. In future research, UAV oblique photogrammetry will improve its endurance and environmental adaptability to adapt to more complex situation and the wider range of survey. How to use UAV aerial survey in a more efficient and convenient way is the research focus. With the progress and development of small consumer grade UAVs and related aerial survey software, as well as the clarity of UAV related policies, the cost and technical threshold will be further reduced. In the future, it will be possible to apply UAV oblique photograph modeling technology to tourism planning teaching, which will greatly improve the cognitive and working ability of students majoring in tourism management as well as urban and rural planning.

To sum up, the method of oblique photograph modeling through small UAV will inevitably be introduced into all kinds of planning projects, since it makes the tourism planning, especially the mountain tourism planning more efficient, reasonable and scientific. It can take aerial photographs fast and convenient, which provides a more reliable technical support for the collection of pre-tourism planning data. At the same time, by acquiring the image and photo data from all directions of the research area and automating the modeling process, the three-dimensional model of the research area can be completed and provide effective data support as well as the intuitive scene model for tourism planning and related tourism product design. Thus, it is of great practical

significance to explore the oblique photograph modeling technology of small UAVs in mountain tourism planning and tourism product development.

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