The Method of Buildings Monomer Based on UAV Oblique Photography

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Abstract: Oblique photogrammetry technology is a trend to build 3-dimensional model of the city, and it is always used to build large scene city model, as to get high-precision 3D model of a single building, the traditional method or oblique photogrammetry technology are not so appropriate. In this paper, an improved method about unmanned aerial vehicle (UAV) oblique photography is proposed to solve this problem.

1. Introduction

3D model of the city is the foundation of smart city. Traditional tech to model the city is using CAD, which use 2D information to establish 3D frame first, then paste its texture on the frame by using specialized 3D software such as 3DMAX. The workload of this method is heavy and the labor cost is high.

Oblique photogrammetry technology is a new developed high-tech in international surveying and mapping field, it establishes 3D model by high resolution oblique images with high overlap and real texture of the object, while oblique images are aerial photographs taken at oblique angles to the earth's surface [1-2]. Even it needs special software to model, the whole modeling work is much more efficient, real and lower cost. It has been a hot area of research for several years, and now is widely used in city informatization construction [3].

2. The Principle of UAV Oblique Photogrammetry

Oblique photogrammetry technology consists of an aircraft and several sensors to capture the images from five different angles, one vertical angle and four tilt angles (as show in Figure 1) [3], it changed the traditional aerial photogrammetry which can only take from the vertical angle, and can provides rich geographic information and friendly user experience as well as low cost.

Compared with traditional vertical aerial photogrammetry, it can obtain the façade information of the objects on the ground more effectively and one area is surveyed from different viewpoints many times. It is more suitable for human visual perception, and there are more choices about the aircraft and sensors with the development of technology, above all, the tech is widely used in 3D smart city reconstruction, urban management and planning, homeland security, and mapping services.

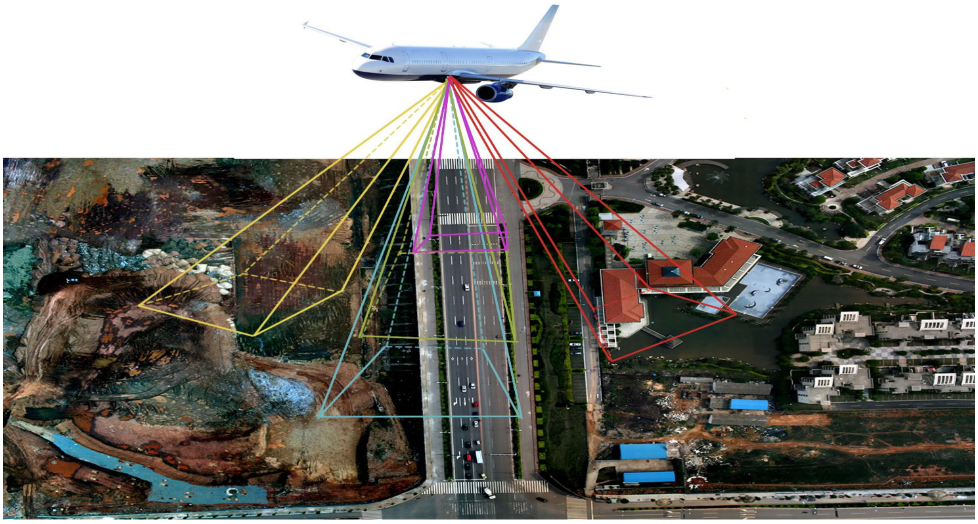

Figure 1: the principle of UAV oblique photogrammetry.

UAV (with fixed wing or rotor) is the most functional aircraft to acquire images, for the low price and the ability to move agile [4]. The most famous UAV supplier is DJI, one example is Yu Mavic 2 pro, the weight of which is less than 1kg and the camera L1D-20c's focal length is 28mm (35mm format equivalent). There are many options for cameras too, such as Hopong, which is a famous professional Chinese supplier for UAV tilt photography, as shown in Figure 2.

Figure 2: YU MAVIC 2 pro and Hopong camera (AP3400R).

UAV oblique photography has been used in big-scale modeling, and the accuracy meets the medium requirement. But how to improve the accuracy of single building's model? This paper discussed how to get the high-precision model of a single building by UAV oblique photography tech.

3. Workflow

3.1.Traditional Flying Parameter

The purpose of traditional aerial photogrammetry is to get aerial images of the particular object in designed scale and degree of overlap. There are several parameters should be taken seriously, for example, flying height (H) which means the vertical distance between centre of the camera to the ground, the principal distance of camera (f), and scale (S) which means the size of a unit on the image divide the actual size, as shown in formula 1. The bigger the scale is, the higher the GSD is.

$$S=f/H \qquad (1)$$

The degree of overlap is also important, while the degree of aerial images is required to satisfy the need of stereo measurement, which contains two kinds, overlap along the flying route (56%-65%) and sideslip (30%-35%).

As to build the model of single building, the principle rules need to be followed. In the other side, to high-precision model means accurate position and comprehensive texture information.

3.2.Improved Method

3.2.1. Workflow

Figure 3 shows the work flow of the method of buildings monomer based on UAV oblique photography, in order to keep the safety of equipment, reduce the cost, and save time, the on-the-spot-survey is necessary. Processing and post-processing are also important to improve the result.

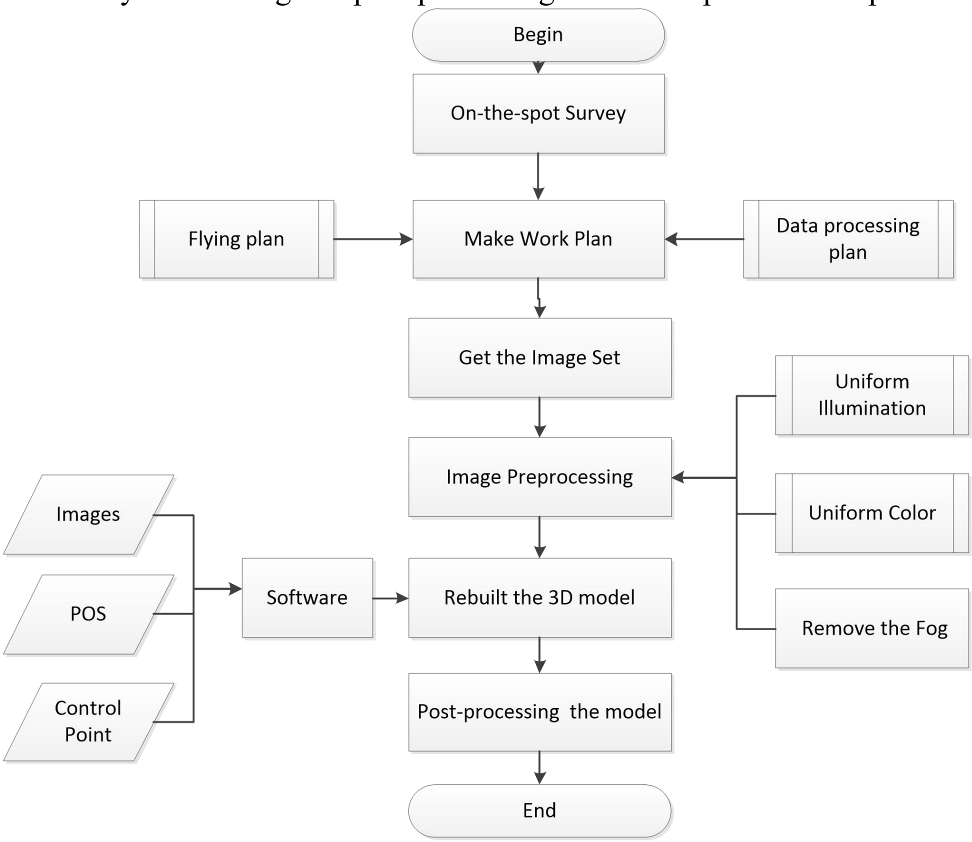

Figure 3: The workflow of 3D model of single building.

3.2.2. Flying Route

In order to get more details of the single building, images from every direction need be shot as much as possible. We classify the flying routes to four kinds.

a. Traditional routes. Make the UAV flying above the building in a typical height, take images as same as the old tech, to get the texture of the top.

b. Surrounding routes. Flying around the single building, and shot images.

c. Flying from far away to near by.

d. Flying from bottom to top.

The rout is shown in Figure 4. When capture images in the four kind of route above, make sure the overlap of your images is enough, and that means the images sets coved every parts of the building.

Figure 4: The surrounding routs.

3.2.3. Flying Equipment

According to the observation conditions, budget and existing conditions, choose appropriate equipment. It contains three parts, the aerial, surveyor and instruments. The aerial is UAV, the instruments contains camera, position and orientation system to record the position and attitude parameter when the camera exposure.

4. Example

4.1.Project Information

The method is test on an ancient building shown in Figure 4, the UAV is DJI M600 pro and the camera is Hopong tilt camera AP3400R, which contains three cameras and can acquire nearly 300 million pixels of images in one exposure period.

4.2.Accuracy Test

According to specification for aerotriangulation of digital aerophotogrammetry (GB/T 23236-2009), specifications for inspection and acceptance of quality of digital surveying and mapping achievements (GB/T 18316-2008), technical code for three dimensional city modeling (CJJ/T 157-2010) and specifications for the digital products of three-dimensional model on geographic information (CH/T 9015-2012), choose check points, common points and height points to inspect positon and attribute accuracy, the number and requirement should follow the four standards above [4-7].

4.2.1. Root Mean Square Error (RMSE)

Compare the coordinate of control points with surveying coordinate, get error in x, y and z direction ($\Delta_x, \Delta_y, \Delta_H$), the mean square error of a point equals $\sqrt{\Delta_x^2 + \Delta_y^2}$, and the RMSE can calculate in formula 2.

$$m = \pm\sqrt{[\Delta\Delta]/n} \qquad (2)$$

Coordinates of control points surveyed by GPS or total station, the number of control points depends on the area of research target, and the points should be distributed symmetrical.

Standards changes for different topography, and the standard for plain is shown in Table 1.

Table 1: Standard of mean square error of a point and mean square error of height for plain.

Scale	Points	Mean square error of a point(m)	Mean square error of height(m)
1:500	exam point	0.13	0.11
	Check point	0.175	0.15
	Public point	0.35	0.3

4.2.2. Accuracy Evaluation Criteria of 3D Model

The accuracy requirements of 3D model are shown in Table 2.

Table 2: The accuracy requirements of 3D model.

Level	I	II	III
Scale	1:500	1:500	1:1000
Accuracy of height	0.5 m	0.8 m	1m
Accuracy of position	0.3 m	0.5 m	0.8 m

For single building, the geographic feature class can be divided to five classes, level I is the main building of urban government, landmark building, example of level II is zone.

5. Conclusions

UAV oblique photography is effective to model wide scale scene, when the research object becomes to be single building, the method in this paper is much more useful. We tested the method on restoration of ancient buildings, and it proved to be realizable.

The point is to get enough images from every direction, so the preparation of the reconnaissance should be take carefully, and the UAV pilot needs to be more skillful. In further research, we will combine UAV oblique photography with three-dimensional laser scanner to build the model of single buildings.

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