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Analysis of 3D Model's Measurable Data Without Control Points Based on Consumer UAV

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Abstract. This article uses the DJI phantom 4 which is consumer grade drone to capture images of the survey area, and uses ContextCapture software for interior processing to obtain a realistic 3D model of the survey area. The 3D model without control points and the 3D model with control points are compared and analyzed to obtain measurable data of the 3D model without control points

Keywords: consumer grade drone, photogrammetry, control point

1. Introduction

With the rapid development of surveying and mapping technology and corresponding software and hardware technologies, unmanned aerial vehicle (UAV) low altitude photogrammetry systems are increasingly widely used in surveying and mapping work, and have become an important technical branch of the surveying and mapping industry[1]. The drone low altitude photogrammetry system can quickly obtain ground image data information. By using post processing software, products such as DOM, DSM（DEM）, DRG, and DLG with production accuracy can be obtained. However, professional surveying drones are not only expensive and difficult to apply for route airspace, but also require high technical quality of operators, making it difficult for professional drones to meet the small and medium-sized surveying market due to their high cost, long cycle, and low economic benefits in photogrammetry[2]. With the rapid development of technology, the various hardware sensors and software carried by consumer drones have become more advanced, which can already meet the accuracy requirements of surveying and mapping. At the same time, due to the convenience of low-cost consumer drones in carrying and being not limited by takeoff sites, it is easier to apply for flight routes and is increasingly widely used in surveying and mapping work[3].

In addition, for areas with complex terrain, the measurement of image control points in field work also has certain difficulties. Therefore, this article focuses on the measurability of 3D model data without control points produced by low altitude photogrammetry based on consumer grade drone platforms. Generate a three-dimensional model without control points and a three-dimensional model with control points data for obtaining aerial images, and analyze the measurable spatial information of these two models to obtain the measurable analysis of the spatial information data of the model without control points finally.

2. Acquisition of UAV image data

Before starting data collection, corresponding preparations need to be made to ensure the safety of personnel and instruments during the field collection period, and to ensure the smooth progress of flight operations.

2.1. Site survey and image control points measurement

Field survey refers to the organization of personnel to conduct on-site inspections of the operating area and surrounding environment before the official start of construction operations, familiarize themselves with the flight airspace conditions of the survey area, and understand the main geological and geomorphological characteristics within the survey area. This paper first collects the data of the survey area to understand the

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terrain, surface features and whether there is a no-fly zone around the survey area. There are no signal sources such as airports or high-voltage towers near the flight area, and the weather conditions in the survey area are good, meeting the requirements of this test[4].

In order to better analyze the measurability of 3D models without control points, 11 image control points were deployed according to relevant specifications, and their plane coordinates and elevations were measured using a single base station network GPS-RTK positioning technology.

2.2. Field aviation flight

This article first collected and analyzed the parameters of consumer grade drones with certain surveying accuracy on the market, as well as the applications of drones on the market. According to the surveying operation requirements, the Phantom 4Pro V2 was selected. Based on the site survey and relevant specifications of aerial photogrammetry, design parameter information such as relative altitude, overlap, and route on the ground station software. Finally, the field flight was conducted on a a time period with good weather, appropriate lighting, and wind speed, and 474 images were obtained. After inspection, all the captured images covered the shooting area without relative or absolute flaws, and all the images were rich in layers, bright colors, saturated colors, and moderate contrast, which can be used for the production of 3D models in the later stage.

3. 3D modeling of ContextCapture software

ContextCapture software is developed by France's Acte 3D company. Its working principle is to systematically analyze multi view images or point cloud data, automatically detect and identify the same ground object point in different multi view images or point cloud data, calculate external orientation elements through intelligent algorithms, and generate a high-resolution 3D model of the ground object[5].

After importing image data using ContextCapture software, first perform aerial triangulation, and after completing aerial triangulation calculation, check the 3D view. After checking and confirming that the point cloud model is correct, create a new reconstruction project and submit a new production project for model production, generating a 3D model without control points, partial 3D model as shown in Figure 1; Mark the specific position of the image control points in the calculated image of the aerial triangulation. After the thorns are completed, check the 3D view and confirm that the relative position relationship between the point cloud model and the image control points is correct. Then, submit a second aerial triangulation measurement. Then, create a new reconstruction project and submit a new production project for model production, generating a 3D model with rich texture and vivid details, partial 3D model as shown in Figure 2.

Fig. 1: Partial 3D model without control points

Fig. 2: Partial 3D model with control points

4. Comparison of spatial information data

According to the principles of photogrammetry, whether it is dual image photogrammetry or aerial triangulation, when there are no ground control points, aerial images can generate a three-dimensional model. At this point, the relative orientation of the model points is correct, the model size is not equal to the actual size, and the absolute orientation of the model points is incorrect.

4.1. Coordinate data comparison

Randomly select 24 feature points from the two generated 3D models, and treat the coordinates of the feature points in the spiked model as true values. The calculated coordinate difference is the feature point model error of the 3D model without control points.

Table 1: Model error of 3D model feature point

Point number	|ΔX|（m）	|ΔY|（m）	|ΔZ|（m）
1	1.9	1.51	78.09
2	1.92	1.47	78.04
3	1.84	2.06	78.13
4	1.64	2.14	77.87
5	2.68	1.82	78.23
6	2.59	1.72	78.3
7	3.02	1.59	78.07
8	3.07	1.6	78.05
…	3.22	1.13	77.78
24	3.57	1.54	77.25
Max value	4.84	2.33	78.3
Min value	1.29	0.96	73.41
average value	3.11	1.57	77.04

It can be found that the coordinate differences of the selected feature points between the 3D model with control points and the 3D model without control points, the maximum absolute values in the X, Y, and Z directions are 4.84m, 2.33m, and 78.3m. The minimum absolute values are 1.29m, 0.96m, and 73.41m. The average absolute values are 3.11m, 1.57m, and 77.04m.

4.2. Relative data comparison

Randomly select 24 feature points from the two generated 3D models, measure their line segment lengths and height differences in the two 3D models, and calculate their differences and ratios. As shown in Tables 2, 3, and 4, they are the comparison tables for horizontal distance, elevation difference, and oblique distance.

Table 2: Comparison of horizontal distance

Point number	HD of model with control points（m）	HD of model without control points（m）	Difference（m）	ratio
1	12.90	12.94	-0.04	0.997
2	35.15	35.33	-0.18	0.995
3	22.94	23.06	-0.12	0.995
4	8.25	8.29	-0.04	0.996

5	16.56	16.79	-0.23	0.987
6	18.60	18.65	-0.05	0.997
7	10.02	10.10	-0.08	0.993
8	76.57	76.98	-0.41	0.995
9	58.12	58.30	-0.18	0.997
14	76.40	76.91	-0.51	0.993
11	101.88	102.51	-0.63	0.994
12	120.91	121.63	-0.72	0.994
absolute maximum			0.72	0.997
absolute minimum			0.04	0.987
average value			0.27	0.994

Table 3: Comparison of elevation

Point numbe	Elevation of model with control points（m）	Elevation of model without control points （m）	Difference （m）	ratio
1	-0.04	-0.09	0.05	0.444
2	1.19	0.93	0.26	1.280
3	2.84	2.91	-0.07	0.976
4	-0.16	-0.18	0.02	0.889
5	-2.95	-3.1	0.15	0.952
6	-5.25	-5.36	0.11	0.980
7	0.1	0.28	-0.18	0.357
8	4.35	5.08	-0.73	0.856
9	-6.67	-6.66	-0.01	1.002
14	-5.37	-6.14	0.77	0.875
11	3.36	5.42	-2.06	0.620
12	16.64	17.75	-1.11	0.938
absolute maximum			2.06	1.280
absolute minimum			0.01	0.357
average value			0.46	0.847

Table 4: Comparison of oblique distance

Point numbe	oblique distance of model with control points （m）	oblique distance of model without control points（m）	Difference （m）	ratio
1	12.90	12.94	-0.04	0.997
2	35.17	35.34	-0.17	0.995
3	23.11	23.24	-0.13	0.995
4	8.25	8.29	-0.04	0.996
5	16.83	17.07	-0.24	0.986
6	19.33	19.41	-0.08	0.996
7	10.02	10.10	-0.08	0.992
8	76.69	77.15	-0.46	0.994
9	58.51	58.68	-0.17	0.997
14	76.59	77.16	-0.57	0.993
11	101.94	102.65	-0.71	0.993
12	122.05	122.92	-0.87	0.993
absolute maximum			0.87	0.997
absolute minimum			0.04	0.986
average value			0.30	0.994

According to the data in Tables 2, 3, and 4, it can be seen that the horizontal distance difference between the 3D model without control points and the 3D model with control points is relatively small. The maximum absolute value is 0.72m, the minimum value is 0.04m, the average value is 0.27m,and their symbols are the same, the ratio is between 0.997 and 0.987, with an average value of 0.994m.

The height difference between the 3D model without control points and the 3D model with control points is significant, with a Maximum absolute value of 2.06m and a minimum absolute value of 0.01m. Moreover, with different symbols, the ratio of height difference changes greatly, ranging from 0.357 to 1.280; Due to the influence of height difference, the corresponding slant distance difference and ratio between the 3D model without control points are greater than that of the 3D model with control points and the 3D model without control points,the maximum difference value is 0.87m, the minimum value is 0.04m, and the symbols are the same. The ratio is between 0.997 and 0.886, with an average value of 0.994m.

Based on the above data analysis, it can be concluded that the difference of coordinate data between the 3D model with control points and the 3D model without control points obtained by the DJI phantom 4 drone is significant, and the difference in height and ratio is significant. However, the distance difference and ratio are both small, and can be directly measured if precision allows.If the requirement of accuracy is higher,The measured value can be multiplied by an empirical ratio data to obtain the result data.

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