Research on Digital Mapping Method Based on Complex Terrain

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Abstract—Based on UAV low-altitude remote sensing technology and tilt photography technology, combined with highway projects, the UAV operating process, quality inspection and accuracy, and positioning accuracy in the mountainous complex terrain conditions are analyzed, and operating experience is summarized for subsequent navigation. The production provides guidance. At the same time, it also provides a reference for the exploration of digital mapping methods, and lays a theoretical foundation for the research of mapping methods. The combination of mapping methods in complex terrain with high technology is highly innovative.

1. INTRODUCTION
Topographic maps are the basic data for the survey and design of major engineering projects, and the current technical means for generating topographic maps of survey areas include aerial photogrammetry technology, drone low-altitude photography technology, aircraft LiDAR and drone LiDAR technology, and all-field survey technology. Compared with LiDAR technology, UAV low-altitude photography technology has the advantages of strong maneuverability, high data acquisition efficiency, and rich texture information. It is currently an important means of topographic map production. With the advancement of UAV manufacturing technology and the development of image matching technology in recent years, UAV low-altitude remote sensing and tilt photography technology began to be vigorously promoted in railway and highway survey and design[1-2]. The task of the experimental project is to complete the 1:2 000 topographic mapping task of a certain expressway project (the working area is 56 km2) and the construction of a three-dimensional real-world model of the interworking area[3-5]. The project is a typical belt-shaped terrain in the transportation industry, which is very representative. On the one hand, because the survey area is located in the mountainous area of Chongqing, the topography is undulating, and the maximum altitude difference of the survey area reaches more than 600m, which is more challenging for UAV mapping.[6-8] On the other hand, because the highway survey specification requires high elevation accuracy of topographic map results, it puts forward higher requirements for both field data collection and internal business mapping. Based on drone low-altitude remote sensing technology and oblique photography technology, combined with a highway project in mountainous areas, this paper analyzes the large-scale mapping operation process, positioning accuracy influencing factors, quality inspection and accuracy under complex conditions in mountainous areas, and summarizes operational experience. The follow-up flight and production provided guidance[9].

Mountain topographic map surveying and mapping mainly uses a piece of zhi white paper fixed on the du chart board to survey the topographic dao map. At the beginning, the chart board must be
oriented. This can be based on the pre-measured geodetic control points as the starting direction. Orientation; in a simple survey map, you can also use the north arrow to orientate. After the drawing board is oriented, it is necessary to determine the location of the surveying point on the drawing[10]. For surveying and mapping included in the national unified basic topographic map, there is a unified and standardized coordinate exhibition point requirement; but for small-area local area surveying and mapping, it can be assumed to be independent From the origin of the rectangular coordinate system of the plane, you can start to determine the plane coordinate position of any other point on the ground by measuring the azimuth and distance. As for the elevation of points, since the National Elevation System has deployed many uniform elevation benchmarks across the country for use, they can generally be measured to the surveying area by leveling, so line-of-sight triangulation is used in surveying. The method can simultaneously determine the position and elevation of any point[11-12].

The advantages of digital topographic map surveying and mapping technology are high accuracy of surveying and mapping. High precision is one of the biggest advantages of digital topographic map surveying and mapping technology. In the past, mapping technology was often applied to optical instruments and line-of-sight measurement. Grading layout was the first principle to be observed in the measurement process, which would lead to the appearance of many levels, and the accuracy of measurement was therefore affected to a certain extent. Manual drawing is the method used in most drawing processes, so its own accuracy cannot be guaranteed. Today, when the level of science and technology is highly developed, the method of total station surveying can play a good role in topographic map surveying and mapping, the accuracy of surveying and mapping is effectively controlled, the control level is appropriately reduced during surveying, and the drawings are deformed. Factors will not affect the surveying and mapping work. Therefore, the digital topographic map surveying and mapping technology has high accuracy. Under normal circumstances, the digital topographic map surveying and mapping technology itself has a relatively high degree of automation, and the labor intensity of related staff is therefore reduced. Traditional mapping technology involves more manual methods and drawing work during the application process, which affects the level and accuracy of mapping, and the labor intensity of the staff is relatively high. Construction personnel can apply digital mapping technology indoors, and the drawing work is highly scientific. The staff can complete most of the mapping work only on the computer. In addition, in order to reduce the number of moving stations, surveying and mapping personnel can also fully use the total station in the topographic mapping process, which can not only expand the monitoring range, but also ensure the normal progress of surveying and mapping. Most total stations have a chip inside, and the data and information obtained from the observation can be effectively stored through the chip, and the workload of measurement records will be reduced.

2. **OPERATION PROCESS OF LARGE-SCALE SURVEYING AND MAPPING IN MOUNTAINOUS AREAS**

Check the status of the equipment, complete various approval procedures before the flight, and report to the local authorities in advance. Collect the existing DOM, control points, leveling points and other data in the survey area, and initially grasp the terrain undulations of the survey area, set up image control points in advance, and select candidate takeoff and landing sites (as shown in Figure 1).
Image control points are divided into two categories: select natural features such as corner points of houses and zebra crossings that are easy to identify in residential areas as image control points; use putty powder or paint to artificially deploy targets in mountainous areas or areas without obvious markings, which can be deployed in the inner corner of the “T” or the center of the “＋”. According to the ground feature recognition resolution, it is twice the image ground resolution, so the width of the artificial target should be at least 2 GSD or more. The experimental project is based on the POS-assisted aerial photography area network point plan, that is, the plane control points are arranged by corner points, and elevation control points are added as needed. The average distance between the control points is about 1 km.

The Pegasus V100 tilt-rotor UAV is used in terrain measurement and control, which includes a single-lens aerial survey module (1×42 million pixels, a focal length of 35 mm, and a pixel size of 4.53 um) and a four-lens tilt module (4×24 million). Pixel, focal length 35 mm, pixel size 3.92 um). The advantages of tilt-rotor UAVs in mountainous areas are reflected in two aspects: On the one hand, because it is difficult to find ideal take-off and landing sites, the characteristics of vertical take-off and landing UAVs reduce the requirements for take-off and landing sites; Compared with multi-rotor UAVs, using fixed-wing mode during operation can greatly improve flight efficiency.

The experimental project uses PhotoScan software to perform air triple encryption of UAV images. The main steps are as follows:

1. New project: Import image data, external orientation elements and control point data. When processing tilted multi-view images, it is necessary to assign images from different cameras to corresponding camera identifications (share the same internal camera parameters). The data of outer bearing elements and control points are given the correct standard deviation (weight). The standard deviation of the external orientation element of the image with network RTK or PPK function is usually set to 0.1～0.m, and the standard deviation of the control point data is usually set to 0.005～0.10 m.

2. Perform free network adjustment: This step performs feature point extraction and matching and incremental reconstruction of all images, and uses external orientation elements to perform weighted observation adjustment. At this time, the relative orientation model between images can be restored. Provide a better prediction coordinate for subsequent thorn points.

3. Image control point puncture point: traverse all the image control points, and complete the puncture point work for each image control point in turn, ignoring the occluded or blurred image of the logo. In the puncture process, the image control points around the periphery of the measurement area can be punctured first, and the adjustment results can be optimized while puncturing the points.
(4) Overall adjustment: After completing all the image control points and stab points, use the control point data as weighted observations to perform overall adjustment to obtain the final adjustment result. The self-checking camera model uses the Australis model (including the following parameters: f, x0, y0, k1, k2, k3, p1, p2, b1, b2) to check whether the overall adjustment results have abnormal precision image control points. If it does, check the reason and adjust again. When performing the tilt image aerial three, you should also check the distribution of the connection points, and remove some gross points (floating in the air or below the surface), so as not to affect the later model reconstruction effect.

3. ANALYSIS OF UAV IMAGE POSITIONING ACCURACY

In the application of large-scale mapping under complex terrain conditions in mountainous areas, the main factors affecting the positioning accuracy of UAVs are as follows:

(1) Image ground resolution. The image ground resolution is the most important factor that affects the large-scale mapping of UAVs. It is the most direct and effective way to improve the positioning accuracy through the image ground resolution. When designing drone routes in mountainous areas, the actual ground resolution of the image is different due to the undulations of the terrain. Therefore, it is necessary to ensure that the lowest ground resolution meets the set requirements.

(2) Degree of overlap. The degree of overlap directly affects the strength of the area network and the construction of the relative model during the aerial three of the UAV image. Normally, the heading overlap of the UAV during flight is more than 80%, and the side overlap is more than 60%. In theory, the greater the overlap, the higher the positioning accuracy. The degree of heading overlap does not affect the operational efficiency of the flight, but only affects the camera exposure interval of the UAV. If conditions permit, the degree of heading overlap can be appropriately increased. The number of sideways overlap image routes. Increasing the sideways overlap will reduce the flight efficiency, so it needs to be properly weighed during flight. When operating in mountainous areas, due to the influence of topographical fluctuations, the degree of overlap gradually decreases with the increase in altitude. Therefore, the influence of topographical fluctuations on the degree of overlap should be taken into consideration when flying in mountainous areas.

(3) Whether with network RTK or PPK differential function. At present, UAVs with network RTK or PPK differential functions on the market can obtain the accuracy of external azimuth line elements of about 10 cm, which can greatly reduce the field image control points and improve the absolute positioning accuracy of UAV images. In the aerial three process of UAV images, it is necessary to give the correct standard deviation (weight) to the high-precision exterior orientation elements to obtain the optimal adjustment result. Because it is difficult to collect field image control points in mountainous areas, it is recommended to use drones with network RTK or PPK differential functions.

(4) The layout and distribution of control points. When the network RTK or PPK differential function and the degree of overlap are large, the improvement effect of the control point on the model becomes weaker and weaker. It is mainly used to complete the absolute orientation of the relative model constructed by the UAV image and improve the absolute orientation accuracy. At this time, UAV image mapping generally adopts the POS-assisted aerial photography area network point solution.

(5) Correction of abnormal elevation. When conducting large-scale UAV mapping or unmanned aerial mapping under complex mountainous terrain conditions, the abnormal elevation changes generally cannot be ignored. In order to further improve the accuracy of the UAV’s large-scale mapping, it is necessary to consider the impact of elevation anomalies. Strictly speaking, it is necessary to first use the geodetic results for aerial three processing of drone images, and then use the elevation anomaly model to convert the orientation results to high-level results.

4. CONCLUSION

The main conclusions of this paper are as follows when carrying out large-scale UAV surveys of complex terrain in mountainous areas:

(1) Choose drones with network RTK function or PPK differential function for operation to improve the positioning accuracy of external orientation elements and reduce the number of field image control
points. When performing tilt photography operations in mountainous areas, you should also choose a longer focal length tilt lens or use a high-altitude flight plan.

(2) In the course of route design, the degree of course overlap and side overlap should be appropriately increased.

(3) In the air triple encryption of UAV images, the correct standard deviation (weights) of the external azimuth elements and control points should be given, and the positioning results of high-precision network RTK or PPK difference shall be fully utilized to improve the accuracy of UAV images. Air three positioning accuracy.

(4) The impact of abnormal elevation should be fully considered. When high-level data is used, block processing can be used to reduce the impact of abnormal elevation. It is also possible to first use the ground height results for air-three encryption, and then use the elevation abnormal correction to transform the results to a higher level.

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