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UAV Remote Sensing Applications in Large-scale Mapping in the Hilly Region of Tibetan Plateau

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Abstract

UVA (unmanned aerial vehicle) remote sensing has a big advantage over the large-scale mapping with flexibility, efficiency and low operating cost. In this paper, a practical application that UVAs are used to map the hilly region in the eastern of Tibetan Plateau, 25 square kilometers, with the scale of 1:1000 is taken as an example to demonstrate the feasibility of UVA data processing.

Keywords: *UVA; aerial triangulation; DEM; DOM; DLG*

1. Introduction

The main body of unmanned flying platform is to protect the payload and power. The shape of fixed-wing UVA, generally used for aerial survey, is similar to the manned aerial vehicle, consisting of the main fuselage, wings (including main wing and aileron), empennage and landing gear. UVAs, an important way of aerial remote sensing, have been widely used in various fields with the unique technological advantages such as flexibility, convenience and low cost. In addition, UVAs have significant advantages over quickly obtaining high-resolution images in small areas or flying difficultly regions, which also have increasingly become a major method of spatial data acquisition. However, compared to traditional aerial photography, the flight attitude of UVAs is not ideal, and the aerial coverage is small. UVA mainly comes to rapid puzzles; little involves the basic large-scale topographic mapping tasks.

In this paper, taking the application of UVA remote sensing technology in topographic map production with the scale of 1:1000 as an example, the successful case that UVA remote sensing platform is applied in large-scale topographic mapping is introduced. Moreover, the improvement direction of UVA remote sensing platform in terms of large-scale topographic mapping is proposed.

2. Survey Area

The survey area is located in the eastern Tibet Plateau, four kilometers long from north to south, east-west width of seven kilometers. The northeast, a hilly region, is slightly lower with the altitude of 2566-2804 meters.

3. Brief of the UVA System

3.1. UVA Hardware System

UVA hardware system includes a wireless remote control UVA, a flight control autopilot, an airborne communication equipment, payloads and so on. The fixed-wing UVAs are used

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for the UVA aerial assignments in this paper, and the relevant parameters for UVA flight platform can be seen in Table 1.

Table 1. The Parameters for UVA Flight Platform

Wingspan	Length of aircraft	Empty weight	Payloads	Cruising speed	Ceiling	Material quality	Rate of climb
3.1m	2.05m	15kg	7kg	110km/h	6000m	Glass steel	15m/s
Operating radius	Takeoff mode	Recovery mode	Endurance	Air-range	Communication distance	Camera model	Power system
100km	Slide/Ejection	Slide/Parachute	2.5h	250km	20km	Canon 5 II	Gasoline engine

3.2 The Software System of Remote Sensing Image Processing

PixelGrid UVA module from Chinese Academy of Sciences is adopted for aerial data processing. PixelGrid is a new generation of remote sensing image data processing software, based on the theory of full digital photogrammetry and remote sensing, using few control area network adjustment of remote sensing images, on account of the techniques including automatic matching of multi-baseline and multiple-matching high-precision digital elevation model, the production of high-precision image map and mosaic. This system can comprehensively conduct UVA photogrammetric processing over multi high-resolution satellite images and aerial images, build cluster distributed network. Moreover, through computer multi core parallel processing and the combining mode of automation and manual editing, the system also can complete the production tasks of DEM and DOM of remote sensing images from aerial triangulation to large scale.

4. Photography Scale and Ground Resolution

Traditional film cameras use photographic scale during operations. The so-called photographic scale is calculated by dividing the flight height by the focal length. Take the photographic scale as the starting point when using film camera for aerial photography. First, use the map scale to determine the photographic scale. Then the flight height can be determined by photographic scale and focal length, and the photographic baseline and lateral spacing can be determined by photographic scale. Due to the much smaller nominal focal length of digital cameras compared to film cameras, the photographic scale calculated by dividing the flight height by the focal length is also very small, that is not comparable with the film, often misleading. Take ground resolution as the starting point for route design when using digital cameras for aerial photography. First, determine the ground resolution by the map scale, and then determine the flight height.

5. Acquisition of Image Data

Same as the traditional aerial photography, the steps such as route design, aerial flight, quality inspection, fly up or go-around and measurement on images control should be implemented for UVA digital aerial photography. The differences are that the changes of earth's curvature are not considered in the route design of UVA aerial photography due to the small size; quality inspection for aerial photography can be completed in the aerial site without prints.

(1)Select the datum of photography

According to the situation of perturbation region, the highest and lowest height of perturbation region can be statistics, and then the datum of perturbation region can be determined. In general, the datum of perturbation region is the average value of the maximum and minimum height.

(2)Select the appropriate degrees of course and lateral overlap

The mapping desired degrees of course and lateral overlap should be selected. Usually, the degree of course can be set to 65%, and the degree of lateral overlap can be set to 40%.

(3)Calculate the degrees of course and lateral overlap of the highest point of perturbation region

(4)Calculate the ground resolution of the lowest point in perturbation region

The minimum ground resolution in perturbation area＝（datum elevation－elevation of the lowest point＋relative flying height）／camera focal length×single pixel size of camera

The overlapping degree of the highest point in perturbation area＝[（the elevation of the highest point－datum elevation）／relative flying height] ／[1－（the elevation of the highest point－datum elevation）／relative flying height]

(5)Adjust the ground resolution and recalculate the overlapping degree

When the minimum ground resolution in perturbation area goes beyond the mapping required resolution, or when the overlapping degree of the highest in perturbation region is smaller than the mapping request, the ground resolution must be adjusted, and the relative flying height, ground resolution of the lowest point and the overlapping degree of the highest point should be recalculated until meeting the requirements.

(6)Calculate the coordinates of exposure points

According to the ground resolution and overlapping degree, calculate the coordinates of exposure points and statistic the aerial photographic parameters such as the number of routes, the number of photos, the length of baseline, lateral spacing and the total distance and so on.

The weather is sunny on the aerial photographic day with high visibility, and the wind speed is about 1~2 grade. During the aerial photograph, 900 high-resolution aerial photos are obtained; 14 routes are designed; the degree of course is set to 65%; the lateral overlapping degree is set to 40%; the resolution is better than 0.1m; the size of perturbation region is about 25 square kilometers; aerial relative flying height is 300 meters. The design parameters of aerial photography can be seen in Table 2.

Table 2. The Design Parameters of Aerial Photography

Absolute flying height	Camera focal length	Camera pixel	Ground resolution	Overlapping degree of course	Lateral overlapping degree
2900m	24mm	5616*3744	Better than 0.1m	65%	40%

Figure 1 is the diagram of aerial photography, where the black irregular region is the DLG mapping area, and the DOM is manufactured within the coverage of aerial routes. In this paper, the mapping accuracy in DLG region is emphatically discussed.

Figure 1. The Diagram of the Aerial Photographic Route

Note: △ means the image control point; ● means the point of aerial photography.

6. Collect the Image Control Points and the Checking Points

6.1. Collect the Image Control Point

After the completion of flight, according to the actual distribution of aerial images, near the center line of outside the aerial region and lateral overlap inside mapping area, every 4-5 baselines progressive in the overlapping degrees of 5-6, operators can collect the coordinates of clear objects through RTK in the field, and point on the original image in a portable tablet computer. 230 horizontal control points are collected in this survey. The horizontal control points collected by operators are all located on the relatively smooth surface or roof, which satisfy the conditions of large contrast of color and easy to identify.

6.2. Collect the Checking Points

Collecting the coordinates of image control points, meanwhile, operators have uniformly collected 323 horizontal control points in the mapping region in order to check the accuracy of the integrated adjustment of the area network.

7. The Encryption Calculation and Result Analysis of Air Three

Before encryption calculation of air three, the distortion correction of original images according to the camera calibration parameters should be done by using UAV module in Pixel Grid software. Pixel Grid Intelligent air three modules are based on matching feature points of the same name automatically after distortion of the image by the topological order of aerial POS point. As the turning point is completed, remove the error point gradually by free bundle adjustment function in Pixel Grid, when the free net adjustment is less than two pixels, join the control and inspection points form field collection for regional network integrated adjustment. The encryption process of air three can be seen in Figure2.

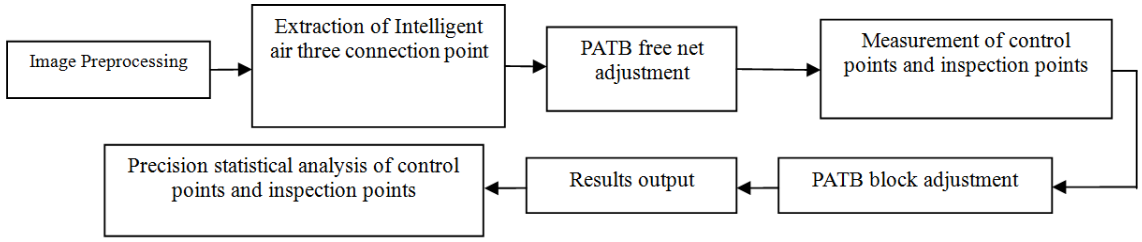

Figure 2. Encryption Process of Air Three

The statistical results of the residual could be seen in Table 3.

Table 3. The Elevation Error Statistics of Control Points and Inspection Points

Control point error /x	Control point error /y	Control point error /h	inspection point error /x	inspection point error /x	inspection point error /h
0.195	0.183	0.234	0.243	0.231	0.223

Table 3 shows that the results accuracy of air three in survey area meet the precision demand.

8. Topographic map collection

The three-dimensional data acquisition in digital photogrammetric workstation, the encryption results stereo images directly into the air three, and the directional accuracy should be checked before mapping by workers. The data acquisition should be based on stereo images of objects like structure and geometric characteristics formation and physical properties, such as shape size, color, shadow and mutual relationship, to identify and determine the content and nature of objects, and then the contour characteristic of the measured object. Data editing using dedicated digital mapping software for data processing, graphics edition, which satisfies the requirements of digitization. The acquisition of topographic vector data is based on the space vision digital photogrammetry system. Completion of the vector data collection of 79 maps 1:1000 DLG in national standard subdivision.

9. Field Mapping

The qualitative investigation for surface building industry of internal gathering, such as housing level, building materials, the level and trend of electric power line was carried out in the 1:1000 range, which included in Attribute annotation, geographical names injection and so on. The new added features got after aerial photography, cannot be sentenced without image, which need supplement measurement outside. Due to part of the feature in the shadows, vegetation, high-rise buildings feature video projection difference glands or other reasons, some objects cannot be sentenced, and individual leak testing feature because of workers' omissions need supplement measurement outside. Field mapping should be seriously and carefully.

10. Mapping Accuracy Inspection

In order to check the reliability of the results, the accuracy of the results detected by topographic map of RTK network data acquisition, random uniform sample of10images within the scope of the survey area for elevation accuracy testing, detection results shown in Table 4. And the accuracy of the plane and elevation data is fully meet the standard requirements.

Table 4. Statistics of Plane and Elevation Accuracy Detection

Image Number	Point Error	Elevation Error	Image Number	Point Error	Elevation Error
1	0.47	0.38	6	0.43	0.45
2	0.52	0.39	7	0.44	0.43
3	0.42	0.42	8	0.52	0.39
4	0.49	0.37	9	0.39	0.42
5	0.51	0.46	10	0.47	0.44

11. Conclusion

Due to low altitude UAV photogrammetry with maneuver, fast, economic and other advantages, while digital camera can adjust the sensitivity of the ISO by changing the aperture, shutter and fog on color, contrast, brightness through the software, which make it possible to obtain a color image in cloudy or mist day. It is easy to get 4D mapping products by the full digital photogrammetric workstation. Low altitude UAV digital aerial photograph is an important content of the real-time data information system mapping technology in access system which is a powerful complement of existing aerospace aviation image acquisition system, the important means to deal with emergency surveying and mapping service, the basic tool for key areas of monitoring geographic conditions and an important way to fast update of geographic information. The 4D mapping products and 3D landscape models produced by using unmanned aircraft aerial system will play an important role in emergency rescue, reconstruction, new rural construction, construction of digital cities, monitoring of geographic conditions, construction and many other areas. Through the practice of Surveying and mapping in Tibetan Plateau hilly areas the production technology of UAV remote sensing images used in large area 1:1000 topographic mapping is formed, UAV remote sensing images can meet the large hilly area topographic mapping, the completion of a basic1: 1000scale topographic map have been attempts to make the UAV remote sensing images become an efficient mean of mapping technology. With the continuous development of sensor technology, UAV technology, communication technology and constantly improvement of data processing software, UAV aerial system will be more widely used in large-scale topographic mapping areas. UAV photogrammetry technology can also be widely used in the national ecological environmental protection, mineral resources exploration, marine environment monitoring, land use investigation, water resources development, crop growth monitoring and yield estimation, agricultural operations, natural disaster monitoring and assessment, city planning and municipal management, forest pest and disease protection and monitoring, public safety, national defense, digital earth and advertising photography, etc. This has a broad market demand.

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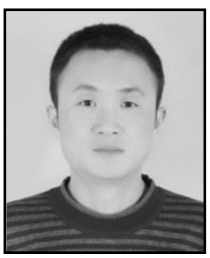

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