Application of UAV 3D Photogrammetry Model in Disaster Prediction and Geological Mapping

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Abstract: Using traditional methods to predict and investigate geological hazards is a costly work, so we propose to use UAV imaging technology to improve work efficiency and reduce work costs. Unmanned aerial vehicle (UAV) low-altitude photography system can quickly acquire high quality and high resolution remote sensing images, especially in small regions and areas with complex geomorphological and meteorological conditions. The digital elevation model (DEM), the digital orthophoto map (DOM) and the three-dimensional digital model are generated by the data processing of the remote sensing image data obtained from the unmanned aerial vehicle (UAV). Then through the establishment of relevant geohazard interpretation indicators for geological hazards interpretation and disaster background analysis. This not only improves the accuracy of interpretation, but also endows the geological hazard body with measurability. At the same time, it provides the basic data for quantitative research and analysis of geological hazard.

1. Introduction

Through the comprehensive study of the geological hazard investigation and data in the assessment area, as well as the assessment of the present situation and the forecast, It can find out the local geological environment condition and the type, distribution and scale of geological disaster, analyze and evaluate the influence of engineering construction and operation on geological environment, predict the risk of geological disaster that may be induced or aggravated, and evaluate the suitability of the site. The prevention and cure measures are put forward to provide the basis for the criterion and decision of the construction project. However, the traditional geological hazard assessment methods are more expensive and inefficient. At the same time, because of the shortcomings of the traditional technology of spatial analysis, it can only be detected through visual observation, and the evaluation effect is poor. With the advancement of science and the progress of UAV technology, the application of UAV technology is more and more extensive. The application of UAV technology in geological detection has brought great development to the industry, through the effective measurement of the development of geological disasters. Damage caused by disasters can be reduced to a certain extent.

With the continuous improvement of the SFM and MVS algorithms, there are more and more applications of photogrammetry, ranging and modeling techniques based on photographic modeling[1]. Photography modeling can quickly restore the shape of the modeling object, benefiting from its real texture mapping. It greatly reduces the workload of the model after building the model, and makes it possible to fully restore the objects, complex objects, such as geological outcrop and geomorphic phenomenon, appearance and give it real texture. This lays the foundation for the authenticity of the models built from aerial images taken by UAVs.

2. Key Technology

2.1. UAV Remote Sensing Technology and Photogrammetry

Unmanned aerial vehicle remote sensing mainly refers to relying on the UAV as the main information acquisition platform, transmitting the final acquired remote sensing information to the surveying and mapping center through unmanned aerial vehicle airborne remote sensing information acquisition and processing equipment, and forming a 3D digital model through data technology processing to meet the development needs of the industry. During the process of UAV remote sensing operation, in order to obtain clear and accurate images, not only need UAV has stable performance, remote sensing equipment, the degree of specialization is equally important. This technology is a comprehensive perception of the target environment in a large-scale, high-precision and high- definition way, which can intuitively reflect the appearance, location, height and other factors of the complex geographical environment and provide scientific data basis for real and effective geographical mapping[2].

UAV photogrammetry is a digital photogrammetric process used to describe images acquired by a remotely controlled semi-autonomous or autonomously operated airborne platform. Digital photogrammetry is a series of overlapping images taken from different angles to calculate geographic reference and color dense point clouds, DEM and orthophoto images.

2.2. Using UAV to Obtain Geological Information

To understand the geological information, the resolution when we build the model is very important. The ground sampling distance (GSD), which is an important description standard of resolution, refers to the pixel size expressed in ground distance units in digital images. For the lowest aerial photo (camera pointing vertically downward), the GSD can be calculated using the following formula:

$$GSD = \frac{AGL * W_{sensor}}{W_{image} * f}$$

where GSD is the ground sampling distance in meters per pixel, AGL is the altitude above ground level in meters, Wsensor is the physical width of the camera sensor in mm, Wimage is the width of the digital image in pixels and f is the focal length in millimetre.

However, if the spatial resolution is blindly increased, the capture time and internal calculation time will be greatly increased, so in order to better evaluate environmental disasters, we need two different spatial resolutions to determine models of different scales.

Table 1：Scale level and Characteristics.

Scale level	Characteristics	Resolution
Region scale	It can reflect the undulation of the terrain and help determine the scope of influence	About 5cm
Outcrop scale	It can help us to characterize geological information	<1cm

For regional scale objects, we need to use planning route to collect terrain data in the target area by UAV, so that it can reflect the terrain undulation in the target area.

Figure 1: Region scale model and outcrop scale model. In order to fully express the shape of the geological body through the model during UAV aerial photography, we should select the appropriate shooting angle to ensure that the geological information from all angles of the object can be fully expressed. For areas with relatively small topographic relief, the main shooting mode is direct flight, and detailed geological information can be ensured through UAV camera angle.

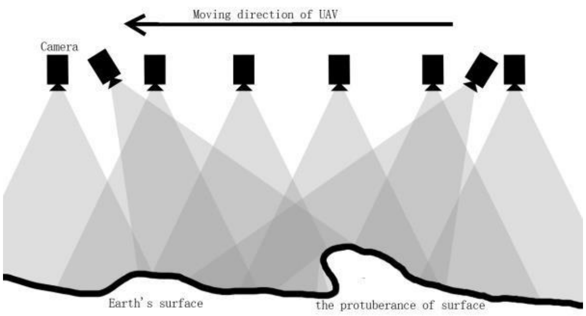

Figure 2: For the shooting of the model.

2.3. Aerial Triangulation

Aerial triangulation is a method of measuring the elevation and plane position of an encrypted point by performing control point encryption indoors based on a small number of field control points in stereophotometry. The specific method for establishing a single three-dimensional model is as shown in the figure below. The image space coordinate system of the first image in the navigation belt is used as a space auxiliary, and the image pairs of the subsequent image pairs are parallel to each other.

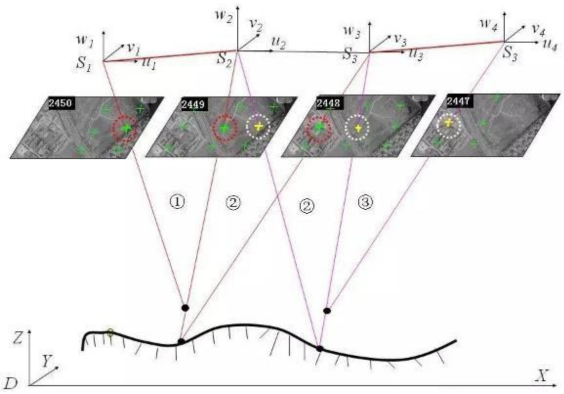

Figure 3: Method of building a single solid model.

2.4. Photography Modeling

The real-world modeling software Context Capture is a product of France's Acute3D company acquired by Bentley in 2015. It is an application that can acquire real-world models through scanning,shooting, etc., and can solve the infrastructure process and transform the realistic model into Application requirements for electronic models.

We use Context Capture software to match the aerial image of the drone, calculate the initial position and azimuth of the camera, and generate a 3D model with texture mapping[3]. On the basis of this model, we conduct disaster assessment and prediction.

3. Application Aspects

The application of UAV remote sensing images to geological hazard surveys is highly feasible, especially in the investigation and monitoring of regional geological hazards. By using the UAV photogrammetry technology, the 3D model of the geological hazard can be established, which breaks through the limitations of the traditional 2D planar remote sensing image interpretation method[4].

The automatic extraction of landslide information by means of tools is of great significance for predicting the possibility of landslides and the areas affected by landslides in the later stages. The use of drones for disaster monitoring not only improves understanding accuracy, but also improves work efficiency and reduces work costs. It also makes catastrophic bodies measurable and provides important basic data for quantitative research and analysis of geological disasters.

Figure 4: This is a orthophoto image created from UAV aerial images. On the map, we can see the scope of the construction impact, and can speculate on the area where the disaster may occur. In addition, the final affected area can be judged according to the gully and the range of water flow after the river is relocated.

For the Beishan area of Gansu, China, we can use aerial drone modeling to determine the area or extent of soil erosion and manage it.

Figure 5: This is a 20 square kilometers orthophoto map based on the effects of UAV aerial photography. In this picture we can clearly observe the specific path and extent of soil erosion. Through the information already known, it is not difficult to take corresponding measures to solve the problem of soil erosion.

For the occurrence of geological disaster areas, using the image information obtained by aerial photography of the drone, we carry out the synthesis processing of the 3D model to obtain the overall picture of the geological disaster. By measuring the geological disaster, we can obtain effective data related to the geological disaster, and adopt the data. Analysis of the information on the location of the space allows for a comprehensive assessment of geological hazards. Detailed investigation of the types of secondary occurrences of geological hazards is carried out in all directions, which is especially important for grading. For the acquisition of the rescue route and the allocation of rescue resources， the later evaluation of geological disasters can generate important reference values.

Because the topography of Beishan is gentle, the vegetation coverage is low, and the lithology is well exposed, the ortho images and models taken by UAV are suitable for the exploration of mapping. Before mapping, we need to combine the existing geological data, geological maps and other information, according to the ortho-image to establish the interpretation mark of geological information, and interpret the local bodies and geological phenomena on the ortho-image.

In the Beishan Research Area, many veins are developed. These veins are distributed among the various rock masses in the study area. Their types, occurrences and forms are different, and there are certain order sequences in the formation time. In the orthophotos obtained by aerial photography of drones, we can find the combination of veins and veins in the relationship between the cutting and cutting, which is convenient for us to explore the relationship between the cuttings and the intrusion of the veins. Granite porphyry veins in the plaque-like granitoids in the northern part of the study area cut through the diabase veins. In the plaque-like granitoids in the northwestern part of the study area, there are phenomena of quartz veins passing through the chopped diorite veins. The granite porphyry veins in the slanted amphibolites in the southeastern part of the study area cut through the older diabase veins, but were also cut by the newer diabase veins. It can be seen that the diabase veins (dark green veins) in the study area can be divided into two phases.

Finally, through the interpretation of the orthophotos in the area, it is found that the veins in the Beishan Research Area are divided into four phases. The first stage is a dark vein dominated by diabase veins. The second stage is the granite porphyry vein. The third stage is a dark vein dominated by diabase veins. The fourth period is quartz vein.

The whole veins in the study area are mainly EW-NEE, followed by NE, NW and near SN. The faults developed in the Beishan area are dominated by NNE, followed by near SN and NW.

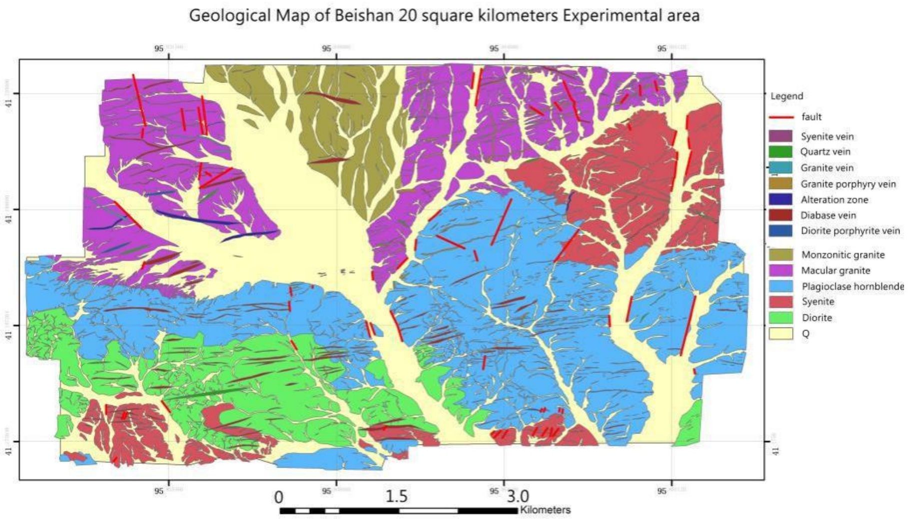

Figure 6: This map is based on the UAV aerial image of 20 square kilometers of ortho image interpretation of the geological map, compared with the traditional geological map, its accuracy is greater, the description of geological information is more detailed and accurate.

The dikes developed in the Beishan area mainly include diabase veins, granite porphyry veins, diorite dykes and quartz veins. The diabase veins are most widely developed and are developed in the syenite, plaque-like, diorite and slanted amphibolites in the study area. Granite porphyry veins are mainly developed in the porphyritic and syenite bodies in the north-northeast of the study area (Figure 6). The diorite dykes are mainly developed in the slanted amphibolites in the south-central part of the study area.

4. Conclusions

In this paper, a method of using UAV to establish 3D model and orthophoto map of research area is proposed.

The possibility of landslide occurrence and the influence area in the later stage of landslide are predicted by establishing the 3D model of Daqiao gold mine in Longnan City, Gansu Province.

Through the establishment of high-definition orthophoto map in Beishan area of Gansu Province to test the large-scale geological mapping, and then complete the high-precision orthophoto map of the area of 20 square kilometers. It is found that the ore veins in Beishan research area can be divided into four stages. The first stage is dark vein, mainly diabase vein. The second stage is granite porphyry vein. The third stage is dark vein, mainly diabase vein. The fourth stage is quartz vein. The whole ore vein in the study area is mainly east-west-northeast, followed by northeast, northwest and nearly north-south direction. The faults developed in Beishan area are mainly NNE trending, followed by nearly NS trending and NW trending faults.

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