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Retraction

Retracted: Application of Multimedia Tilt Photogrammetry Technology Based on Unmanned Aerial Vehicle in Geological Survey

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This article has been retracted by Hindawi, as publisher, following an investigation undertaken by the publisher [1]. This investigation has uncovered evidence of systematic manipulation of the publication and peer-review process. We cannot, therefore, vouch for the reliability or integrity of this article.

Please note that this notice is intended solely to alert readers that the peer-review process of this article has been compromised.

Wiley and Hindawi regret that the usual quality checks did not identify these issues before publication and have since put additional measures in place to safeguard research integrity.

We wish to credit our Research Integrity and Research Publishing teams and anonymous and named external researchers and research integrity experts for contributing to this investigation.

The corresponding author, as the representative of all authors, has been given the opportunity to register their agreement or disagreement to this retraction. We have kept a record of any response received.

References

[1] W. Li, "Application of Multimedia Tilt Photogrammetry Technology Based on Unmanned Aerial Vehicle in Geological Survey," *Mathematical Problems in Engineering*, vol. 2022, Article ID 4616119, 6 pages, 2022.

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Research Article

Application of Multimedia Tilt Photogrammetry Technology Based on Unmanned Aerial Vehicle in Geological Survey

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In order to better investigate the geological research, a tilt photogrammetry technology based on the unmanned aerial vehicle is proposed. This paper makes use of UAV tilt photogrammetry technology to make geological macroscopic analysis and establishes 3d color digital ground model, forming a set of technical methods for geological survey assisted by UAV. The experimental results show that the coordinate calculation is significantly improved, and the root mean square error of plane coordinates reaches 0.2 m, which can meet the requirements of later cartography and spatial measurement. The feasibility and efficiency of carrying out a geological survey based on the unmanned aerial vehicle are verified by the practical application in landslide hazard geological survey. It is proved that DEM and DOM data obtained based on oblique photogrammetry data can form various thematic maps by superimposing them with vector GIS data, which will provide a basic data model for subsequent engineering investigation, site management, and image display.

1. Introduction

The UAV tilt photography technology refers to the images obtained by the UAV shooting at a certain angle. By installing multiple sensors on the UAV, data information is collected from different angles, and relatively clear and complete ground object information is obtained [1]. The most useful data images are mainly satellite images with the smallest inclination angle and vertical angle. However, the information from these two angles can only get local information, and the whole physical model and scene cannot be constructed. Inclination photography is an airborne photography monitoring technology taken from multiple angles, which perfectly combines aerial photography technology of unmanned aerial vehicles with data and information collection technology on the ground. Information images of the ground are collected from different angles by multiple sensors on the same platform. This technology changes the limitation that the traditional aerial photography technology can only shoot from the vertical direction and can more clearly reflect the actual situation of real objects on the ground. UAV tilt photography technology can truly reflect the situation of the photographed target. With the support of advanced positioning technology, rich image data can be obtained, and the photography process does not consume a lot of manpower and material resources [2]. The UAV oblique photography can detect the situation of the measured area from multiple angles, truly reflect the local actual situation, and make up for the shortcomings of traditional photogrammetry. In addition, the UAV tilt photography technology can analyze a single image through corresponding software. The length, height, area, and other information of the photographed target are inferred. The UAV tilt photography technology can combine the image data from various angles to build a 3D real scene model, which can not only improve the comprehensiveness and systematicness of data information but also effectively reduce the aerial photography cost. UAV tilt photography technology has the advantages of flexibility, unlimited flight, and low aerial photography cost. Especially, the advantage of being able to build a three-dimensional real-life model has greatly expanded the application range of this technology, making this technology have a very broad development prospect [3].

With the development of unmanned aerial vehicle (UAV) and real-time positioning technology, tilt photogrammetry technology is becoming more and more mature. It can obtain high-resolution all-element geographic information in the survey area by taking photos at low altitude by UAV, can quickly and efficiently obtain the side and top information of the target object, and generate a real 3D model by combining real-time positioning technology and 3D reconstruction technology. In recent years, this technology has been widely used in land, water conservancy, urban planning, and other industries and achieved remarkable results [4]. Moon et al. [5] studied the method of building damage assessment based on UAV tilt photography [5]. Xu et al. [6] applied oblique photogrammetry to waterway engineering and put forward the operation flow of UAV spatial data acquisition for waterway engineering [6]. The feasibility of oblique photogrammetry technology in the application of waterway engineering is verified. Yang et al. [7] explored the influence of oblique photogrammetry on traditional cadastral management and its improved technology and pointed out that oblique photogrammetry technology can significantly reduce the cost of geographic information collection and promote the transformation of urban land management from 2D to 3D [7]. With the growth of computer computing power and UAV performance, inclination photogrammetry technology is bound to play a more and more important role in the planning and construction of various types of projects. Therefore, the application of UAV tilt photogrammetry technology in the geological survey is put forward. Three-dimensional reconstruction of various ground features and landforms on the construction site is realized by using oblique photogrammetry technology. On this basis, a standardized process of spatial information collection that can meet the management needs of the construction site is established, and a set of technical methods for assisting geological survey with unmanned aerial vehicles are formed. This method can not only obtain the image data of the survey area but also obtain the geological information which is more concerned by the geological survey through geological interpretation and analysis. Real-time images of the disaster area are carried out through the oblique photogrammetry technology of drones. After filming, it will be transmitted to the commander, which will help to formulate preventive measures against geological disasters. At the same time, because of the advantages of portable, fast maneuvering, and low risk, the small UAV has obvious advantages in the rapid emergency geological survey under extremely complex terrain conditions, extremely poor traffic conditions, and extremely dangerous environment [8].

2. Image Data Acquisition

Aerial survey image data of UAV are obtained by field flight shooting in the investigation area. Through a series of work, such as investigation task analysis and research, field reconnaissance, UAV type selection, flight altitude and flight path design, ground image control point planning, equipment parameter setting, aerial photography of field flight operations, result inspection and corresponding supplementary measurement, aerial photogrammetry covering the whole investigation area with certain overlap rate, high pixel, high resolution, and high definition is obtained [9]. The workflow of image data acquisition in field aerial survey is shown in Figure 1.

3. Image Data Postprocessing

The aerial survey image data obtained from the aerial survey of unmanned aerial vehicles in the field and POS information of air routes combined with a proper amount of ground image control point measurement results can be used to form DEM (digital elevation model), DOM (digital orthophoto map), DLG (digital line map), and other basic products through postprocessing software (such as Pix4D-mapper and photoscan). At the same time, it can also form three-dimensional color surface models and Google tiles which are composed of polygonal Mesh nets in the whole survey area. The result of UAV postprocessing is to integrate multiple debris images, and the resulting image becomes a part of the observation area image. It reflects all the information in a topographic map, a picture, or a model, so that geological investigators can understand the overall macro information of the survey area and further analyze the work [10].

4. Geological Interpretation and Geological Information Elements Collection Methods

The traditional topographic map surveying and mapping requires a large amount of investment to ensure the operation of complex and diverse disaster forms. Compared with the established scale map, the UAV performs aerial photography through multiple angles and completes the multidirectional aerial map setting according to the actual needs, thereby providing a guarantee for the investigation of disasters.

As shown in Figure 2, geological interpretation and collection of geological information are mainly to identify, measure, analyze, and collect the coordinate information, spatial geometric parameters, and geological information of geological objects such as geological points, lines, planes, and bodies concerned in the geological survey by means of indoor interpretation and preliminary geological analysis of UAV-related products. It mainly includes the spatial position coordinates of various geological objects, formation lithology, geological boundary, joint and plane occurrence, plane distribution range of geological bodies, spreading area, volume, feasibility, and key points, so as to provide more comprehensive and abundant geological information for the fieldwork of geological survey and geological analysis [11].

Geological interpretation and geological information collection are mainly based on field aerial photographs combined with image control points to form a three-dimensional color surface model of the investigation area through postprocessing in the industry. This model is used as the basis of the information collection platform, and the image, color, and texture of the model are combined with

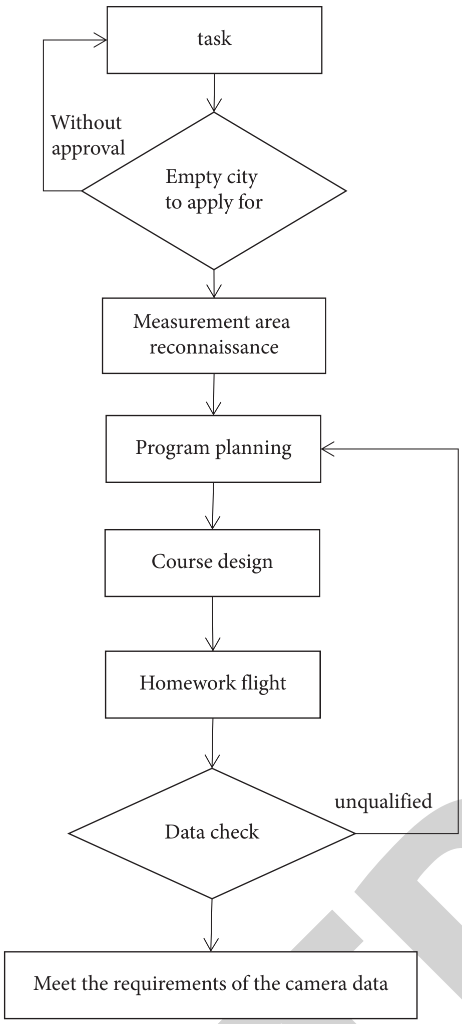

Figure 1: Aerial photography process of UAV.

vector coordinate information and three-dimensional relative position information of the model. Interpreting and identifying the position coordinates, formation lithology, geological boundary, joint and plane occurrence, plane distribution range, spreading area, and volume of the geological body involved in the geological survey and obtained information [12].

4.1. Selection of Geological Information Collection Platform. Through the comparison of UAV-related achievements, the 3D color surface model is a 3D vectorized digital model, which contains not only spatial coordinate information but also real and rich color information, landform, and ground object information. It can not only reproduce the scene of the field work target area but also help geological engineers deepen their observation and understanding of the investigation site. At the same time, it can also preliminarily identify and interpret geological information such as rock and soil characteristics, foundation covering boundary, boundary of unfavorable geological body, surface cracks, joint structure, and hydrology based on surface color change and image information [13]. Meanwhile, the 3D surface model is editable, searchable, and open. It can realize the editing of any concerned geological object in the model, such as identification and convenient outline, and can use its query function to quickly obtain the coordinate information and geometric parameter information of geological objects. The openness of the model also ensures that the obtained information is stored in a common general format of geological work, which is convenient for further analysis and operation in the later period. Therefore, the three-dimensional surface model can be selected as the working platform for geological information collection to realize a series of functions such as capturing, identifying, collecting, analyzing, judging, and storing the information of geological objects of interest [14].

4.2. Geological Point Information Collection Method. Geological point information mainly includes the coordinate information of the geological point and the relevant geological information of the position where the geological point is located. The traditional method is to select the key parts of the survey work area as geological points for on-site recording through a field geological survey. The workflow of collecting geological point information by UAV is mainly divided into several steps. First, the locations where important geological phenomena are exposed are marked and numbered on the 3D surface model to form identification points, and then, the locations of geological points are accurately checked from multiple angles with the help of functions such as model rotation and amplification, and corresponding adjustments are made, so that the selected identification points are taken as indoor preliminary geological points; second, the coordinates and elevation information of geological points are automatically extracted by using the spatial coordinate information contained in the three-dimensional vectorized surface model with the help of related postprocessing software; third, according to the surface color and image information restored by the high-altitude scene combined with geological experience, preliminary indoor analysis is carried out to extract relevant geological attribute information such as topography, stratum lithology, structural characteristics, hydrological characteristics, physical geological phenomena, adverse geological phenomena, and the like of geological points. Finally, obtaining the working conditions, traffic conditions, safety conditions, investigation routes, and investigation priorities of the site where the geological points are located, then forming the comprehensive information of the geological points, intercept 3D models from different perspectives instead of plane photos and section photos, and achieving the preliminary indoor analysis results based on aerial survey geological points [15].

4.3. Geological Boundary Identification and Information Collection Methods. Identification and collection of geological boundaries are mainly to identify and outline linear geological objects such as lithologic boundary, structural trace, geological hazard boundary, hazard zoning boundary,

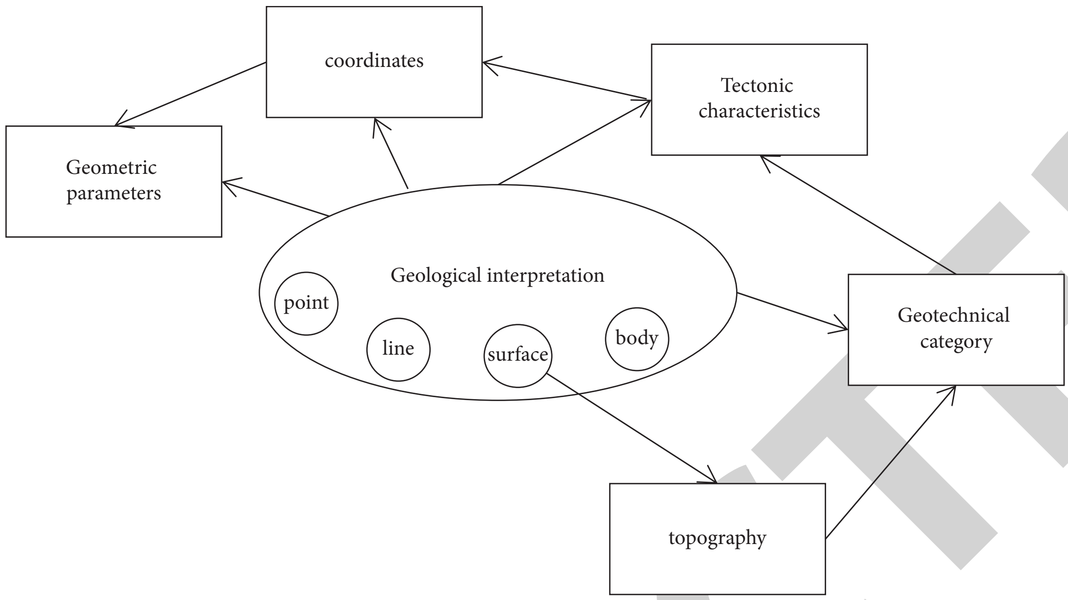

Figure 2: Composition of information elements.

and surface cracks. The analysis and data collection of geological boundary by 3D models are usually based on the changes of surface area, color data, and images. Geological information is confirmed through analysis. In the model, lines are manually described and sketched along the distribution trace of linear geological objects [1].

4.4. Collection Method of Geological Interface Information. The geological interface information mainly includes the geological attribute, undulation, surface adhesion, and distribution occurrence of the interface. Due to the limitation of resolution and clarity of aerial photos and models, information can only be obtained from geological interfaces with large exposure scales and good air conditions.

The geological interface information collection based on the 3D surface model formed by UAV is mainly based on the color, image, and texture development characteristics of the geological interface, combined with geological experience to judge the geological attributes, undulation, and surface attached materials of the interface. The acquisition and calculation method of its distribution occurrence is mainly obtained by using the spatial analytic geometry knowledge on the basis of obtaining the coordinates of more than three points on the interface. The calculation process can be realized by programming [16].

4.5. Geological Body Information Collection Method. The collection of geological body information mainly includes the distribution location, plane area, section shape, thickness estimation, and volume calculation of different types of geological bodies.

First, the boundary of the geological body can be identified in the 3D surface model, and the boundary distribution coordinates and plane distribution area can be obtained by using the calculation function of the software. Then, the plane position information and elevation distribution range can be obtained after the coordinate statistics. The section shape can be drawn in any part of the model, and the surface relief characteristics of the section line can be easily obtained. On the basis of obtaining the profile shape, the thickness can be estimated according to the profile shape combined with geological analysis or by using the relevant exploration data. Combined with the plane distribution area information, the volume of the geological body is estimated [17].

5. Application Cases

Among the selected hillsides, a large number of residents, houses, and cultivated land are distributed on the landslide mass, and township governments, schools, and gas stations are distributed on the opposite bank. The landslide has caused great potential safety hazards to life and property safety. Due to its large scale and sensitive hazard objects, the landslide has been listed as a key investigation project by the land and resources department. Considering the tight time, heavy task, difficult field operation, high safety risk, and no topographic map and other basic data, the geological survey was carried out with UAV in this project. Based on this requirement, the aerial photography equipment is selected as follows: Dajiang T600 UAV "Wu" series products. The model of carrying lens is fc350, with a total pixel of 12.76 million and an effective pixel of 12.4 million. The maximum resolution of the image is 4000×3000 pixels. In the field test, 4 sorties were flown, and 23 routes were photographed. The working base station was the GPS CORS positioning base station in Xinyi, Jiangsu Province. The coordinate system is the national geodetic coordinate system 2000 (CGCs 2000), the relative flight height of the flight line is 35 m, the down-looking resolution is 0.05 m, and the focal length is

20 mm. The effective area of aerial photography is about 0.3 km^2, 15 control points are set in the area, and the mean square error of the plane is 0.199 M. After data collection, in order to keep consistent with the existing GIS platform, the data were transformed into Xi'an 80 coordinate system [3].

As shown in Table 1, Smart 3D capture software was used to realize automatic and rapid modeling of test data. It mainly includes four stages: data preprocessing, aerial triangulation, 3D modeling, and accuracy evaluation. The detection control points are set in the field, and the accuracy of the model is evaluated by GPS coordinates.

In this paper, the measurement of spatial geometric parameters of the geological body is mainly introduced by taking the volume estimation of the landslide as an example. First, on the basis of landslide boundary delineation, the boundary coordinates, perimeter, and distribution area of the landslide are directly obtained by using the software query function. The perimeter of the landslide is about 2 km, and the plane distribution area is about $23\,km \times 104\,m^2$. Then, the section shape of the landslide is obtained. The thickness of the landslide is preliminarily estimated by using the profile morphology and geological knowledge. As shown in Figure 3, through the analysis of the profile morphology and the preliminary geological judgment, the thickness of the landslide mass is about 50 m. Finally, the volume of the landslide is estimated, and the initially estimated landslide volume is about $1000 \times 10^4\,m^3$.

By synthesizing the above preliminary geological interpretation information and reflecting it in the form of mapping, the preliminary engineering geological plan sketch can be generated, which can be used as the preliminary results of a geological survey. At the same time, combined with the macro and microdetailed images, the final analysis is carried out to form the preliminary geological comprehensive analysis conclusion of the survey area. With the help of the UAV, the sketch of the geological plan was formed rapidly in the landslide of the ladder groove. At the same time, it is concluded that the landslide is a large overburden high landslide, mainly distributed in the relatively gentle slope between 2475 m and 2100 m, with an area of about $23 \times 10^4\,m^2$ and with a volume of about $1000 \times 10^4\,m^3$. Surface cracks appeared in the back edge, and local shear failure deformation occurred in the front edge. The stability of the landslide is poor.

Compared with the review results in a later stage, the plane position and elevation of the landslide boundary based on the UAV survey are basically consistent with the actual boundary. The plane error is only cm decimeter level, and the elevation error is in meter level. The occurrence error is within 5°. The error is less than 10%. The main reason is that it is difficult to accurately judge the landslide thickness based on the terrain profile characteristics and geological experience by using the UAV aerial survey results, which often lags behind the actual exploration results, resulting in the error of volume estimation. But it fully meets the accuracy requirements of the preliminary survey [18].

Table 1: Calculation quality results of space three.

	Point	15
Before air three solution	Average reprojection error	2.72
	Root mean square error of reprojection	19.46
	Root mean square error of three-dimensional coordinates	0.3
	Root mean square error of horizontal coordinates	0.2
	Root mean square error of vertical coordinate	0.002
After air three solution	Average retransmission error	5.88
	Root mean square error of reprojection	18.22
	Root mean square error of three-dimensional coordinates	0.2
	Root mean square error of horizontal coordinates	0.2
	Root mean square error of vertical coordinate	0.01

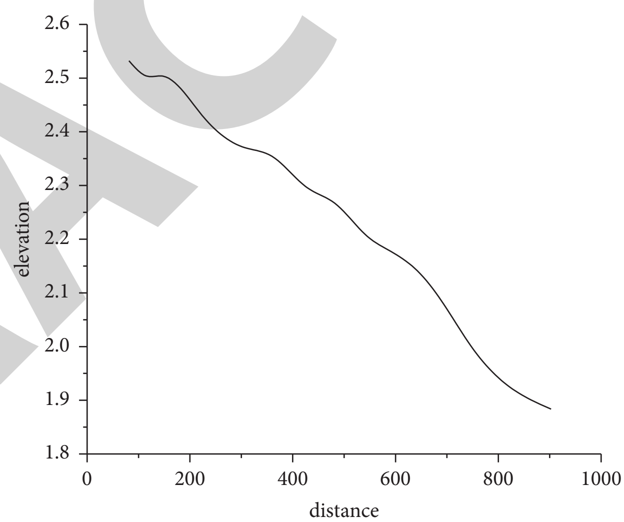

Figure 3: Section shape and thickness estimation.

6. Conclusion

In this paper, UAV can be used to obtain the whole and microimage data needed for geological survey, which can provide reliable data for geological survey and geological analysis, especially in the case of few people, extremely complex terrain conditions and extremely bad natural environment. The use of UAV can further obtain the geological information and spatial position information of geological objects such as geological points, lines, planes, and bodies, which can provide more powerful help for field investigation. The practical application shows that the UAV tilt photogrammetry technology is feasible in the construction site and has a significant guiding role for the field survey. Through reasonable and standard UAV field information collection and internal data processing calculation process, it can be rapidly applied in different project departments of engineering construction enterprises. Combined with 3 s technology to establish an efficient geographic information service platform and introduce GIS spatial analysis tools, the acquisition of geological information can make UAV-assisted geological survey work more systematic and obtain more comprehensive information, and the comprehensive judgment is more accurate.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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