

# Application of UAV 3D Tilt Photography Technology in Mine Monitoring

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**Abstract:** Three-dimensional tilt photography technology of UAV is a new technology for the development of new era. It not only successfully solves the shortcomings of traditional measurement technology, but also improves the resolution, accuracy and imaging effect. Therefore, this paper will take UAV three-dimensional tilt photography technology as the main object, and analyze its monitoring application in mine engineering, so as to improve the market value of the technology, highlight the application characteristics of the technology, and promote the development of the technology in environmental protection and on-site supervision of mine engineering.

**Keywords:** UAV; 3D oblique photography; Mine engineering

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## 1. Introduction

As an important input element in production activities, mineral resources play an important strategic role in the development of China's modernization and industrialization. However, for a long time in the development and utilization of mineral resources, there have been many problems such as safety, management, environment and technology<sup>[1]</sup>. Due to the backward mining technology and the lack of environmental protection planning, the development of mineral resources will inevitably bring certain damage to the environment, such as mudslides and solid waste piles indirectly caused by the development.

From the perspective of enterprises, mine surveying and mapping promotes the efficiency of mining resources and enhances the economic benefits of enterprises by providing technical and management guidance for mine development. From the perspective of government supervision, the supervision department needs to regularly supervise the existence of cross-border development, illegal mining, environmental damage and other methods of mining enterprises, and it is faced with the choice of labor input, monitoring cycle, and supervision accuracy<sup>[2]</sup>. UAV photography technology has the advantages of speed, efficiency, and high precision, which can provide strong technical support for mining area supervision.

As one of the most convenient means of aerial photogrammetry and remote sensing, UAV remote sensing has been widely used in the fields of land change, crop yield estimation, field operation, ecological environment evaluation and so on. Using remote sensing technology such as UAV to realize the continuous monitoring of the surface will help to strengthen the understanding of the geological background of the mine, such as formation lithology and geological structure, and promote the management of the development and utilization of occupied land and the distribution of mine geological disasters.

## 2. Overview of UAV Tilt Photography

UAV refers to the aircraft with autonomous driving ability. Generally, it is controlled by wireless remote sensing equipment to collect and transmit the information in the specified area, and the information is received by the ground receiving equipment. Through the analysis, confirmation and screening of the information, it can finally collect the spatial and all-round information of the measured area. Tilt photography technology collects images synchronously through one vertical, four tilts and five different perspectives, so as to obtain richer and clearer data. This technology is a new technology developed in the field of international surveying and mapping. It breaks the

traditional shooting limitations and completes the image acquisition by one flight platform and multiple sensors. Tilt photography technology can not only truly reflect the features and landforms of the measured area and ensure the accuracy of the measured object information, but also build a three-dimensional urban model based on positioning, modeling and other technologies, which will bring people clearer and intuitive images. UAV tilt photogrammetry technology can record the image information and three-dimensional coordinate information at any angle of the surface of the measured area at the moment of photography. It has the characteristics of high precision, high resolution and high efficiency. It can reflect the actual situation of the terrain, features and surrounding environment of the measured area, and has irreplaceable advantages in the measurement work<sup>[3]</sup>.

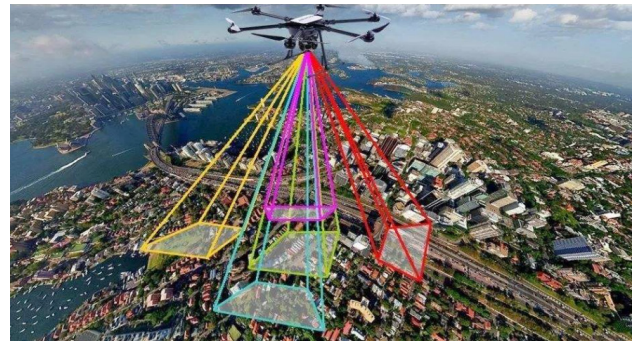
### 3. Basic Contents of UAV 3D Photography Technology

UAV usually refers to unmanned aircraft or other aircraft with autopilot capability. It uses wireless remote sensing equipment to control, gradually realize the observation and information collection of relevant areas, and timely transmit the collected information back to the ground receiving equipment, and then confirm and screen the information in combination with certain data processing, so as to realize all-round Spatial geological and topographic information collection<sup>[4]</sup>. Therefore, UAV has many advantages, such as flexibility, portability, high economic benefits, low cost and good available conditions, and realizes high-efficiency utilization in aerial photography, mining, geological terrain, agriculture, rivers, disaster areas, wildlife areas, rainforest areas and infectious disease monitoring.

In terms of the system composition of UAV, it usually includes: ① flight platform, which is mainly responsible for the observation, acquisition and monitoring of flight and related data information; ② The control system is usually based on remote sensing technology, combined with flight control technology and equipment management technology, and realizes the overall control of UAV with the cooperation of self driving and positioning; ③ The photographic sensor system is mainly a kind of photographic sensor. During the flight of UAV, it realizes three-dimensional ground information photography through fixed-point exposure control of shutter, focusing fixation and camera locking; ④ The ground receiving system is mainly used to receive the information collected by the aircraft, process, classify and summarize the data, and then obtain the specific information of the observed area, so as to ensure the accuracy, authenticity and reliability of

the information in the whole process.

Tilt photography technology is a new photogrammetry technology gradually developed on the basis of high and new technology. It can realize synchronous information collection in vertical angle, four tilt angles and other directions, especially in the observation process of buildings, which greatly increases the authenticity, objectivity and reliability of observation data<sup>[5]</sup>. The working diagram of UAV 3D tilt photography is shown in Figure 1.



**Figure 1.** Schematic diagram of UAV 3D tilt photography

In view of the above situation, the UAVs circulating in the market basically have the following advantages in the observation process of mine engineering: ① they can realize all-round and whole process real-time monitoring and ensure the safety of the whole mine engineering Mining; ② It can realize the information collection of multiple observation angles such as vertical and tilt, and can accurately reflect the specific situation of the measured area; ③ It can ensure the authenticity and clarity of information in the observation area, the observability of texture and the credibility of data; ④ It can realize the measurement of single image in oblique photographic image; ⑤ The amount of observation data is small and the transmission process is simple, which is conducive to data sharing<sup>[6]</sup>.

### 4. UAV Tilt Photography Technology

Tilt photography technology: mainly includes tilt image data acquisition and tilt image data processing. Tilt image data acquisition is to obtain topographic information from multiple angles by carrying multiple sensors on the same flight platform. Usually, five cameras are used. The lens perpendicular to the ground becomes a positive film, and the others at a certain angle with the ground are oblique films. Tilt image data processing generates a real 3D model based on "all elements and all textures" through the process of multi view joint adjustment, image dense matching and 3D texture mapping of positive and oblique images. UAV tilt photogrammetry system is mainly composed of UAV system, mission load system, data processing system and so on.

## 4.1 UAV System

As a remote sensing aerial survey flight platform, UAV system needs to carry and install mission equipment with certain weight and volume; First, it should have sufficient safety and reliability. At the same time, the altitude and flight path control accuracy should meet the basic requirements of photogrammetry. According to the specific environment of the project and the scope of the operation area, select the aerial camera UAV with specific specifications and models.

## 4.2 Mission Load System

It mainly includes tilt camera, synchronous control device, stable PTZ, etc. Among them, tilt camera and multi angle synchronization control device are necessary components for image synchronization acquisition; The configuration of stabilized pan tilt, position and attitude acquisition system can improve the image acquisition accuracy and the effect of 3D modeling<sup>[7]</sup>.

## 4.3 Data Processing System

Data processing system is also an important part of tilt photogrammetry. It usually adopts three-dimensional distributed computer system and has the ability of massive data processing. Through tilt photographing three-dimensional software and continuous two-dimensional images, the real scene three-dimensional model can be restored.

# 5. Application Analysis of UAV 3D Tilt Photography Technology in Mine Monitoring

## 5.1 Workflow

UAV tilt photography technology can complete multi angle shooting of mine terrain, record the real situation of terrain, and display information completely and clearly. The technology collects mine surveying and mapping through large-scale high-altitude photography.

The data information of mountain texture and texture is displayed in the form of three-dimensional model. The main work includes the following aspects: ① preliminary investigation and research. In order to ensure the effectiveness of measurement data, certain preparations should be made before UAV aerial photography, that is, preliminary investigation and research of the mine. Through this work, the specific situation of the mine is understood. The main contents include: determining the shooting range of the mine, determining and adjusting the resolution of photographic images, etc. ② Determine the shooting route. After completing the preliminary research work, the data and information obtained shall be sorted out and studied

in time. Through a series of integration work, digitize all information, adjust the image resolution in combination with the control software of UAV, and add various parameters of aerial height picture, so as to plan and determine the route of aerial photography. ③ Aerial photography and processing stage of internal and external industry. Before aerial photography, it is necessary to build the flight platform and adjust each sensor, so that they can work uniformly and effectively. In the process of UAV tilt technology shooting, it is necessary to record all kinds of relevant data and information of the mine, and conduct unified sorting and analysis<sup>[8]</sup>. After completing the UAV tilt photography of the mine, professionals should analyze and process the photographed information with the help of some system software, and finally establish a three-dimensional model image. In terms of UAV tilt photography technology, it can not only realize the real-time transmission of on-site information, but also accurately display the geographical location and relevant data of the mine, so as to ensure the integrity and reliability of mine topographic mapping information. ④ Analyze and evaluate the measurement results. Whether the results of check points are accurate or not affects the evaluation of mine topographic survey results. Therefore, it is necessary to strictly inspect the inspection points of mine terrain and the qualification and completion of inspection items. In particular, check in detail whether there are obvious splicing traces in the mine terrain shooting picture, so as to ensure the accuracy of photographic data to a certain extent.

## 5.2 Real Time Monitoring of Mining Area

In general, UAV 3D tilt photography technology is used to monitor the mining situation of the mine in the open air. In the actual monitoring process, UAV 3D tilt photography technology can present high-resolution images and data information and truly reflect the mining situation of the mine<sup>[9]</sup>. The obtained images can reflect the topography of the mining area. The three-dimensional model generated by this technology can restore the situation of the mine, reflect the mining progress and steps, and reduce the work tasks of mine survey workers and the workload of monitoring managers to a certain extent.

## 5.3 Analysis of Application Results

In the mining monitoring of mine engineering, the application achievements of UAV 3D tilt photography are as follows: ① the acquisition of high-resolution doim data and the establishment of high-resolution 3D tilt stereo data model realize the real-time monitoring of the whole mine engineering observation area and ensure the safe de-



velopment of the whole project; ② The multi-directional measurement of inclined three-dimensional model and the actual measurement of earthwork are realized, which improves the intuitiveness, accuracy, timeliness and effectiveness of mine observation area; ③ It truly reflects the mining situation of mine engineering, improves the on-site management and control efficiency, reduces labor consumption, and ensures the high efficiency, high quality and high quantity of mining production scheduling, project progress and various auxiliary projects (drainage and drainage works, environmental protection works, etc.

## 6. Other Applications and Example Analysis of UAV Tilt Photogrammetry Technology

### 6.1 Other Applications of UAV Tilt Photogrammetry Technology

Due to the advantages of UAV tilt measurement technology and three-dimensional real scene model, it has been widely used in surveying and mapping. The application of this technology mainly includes the following aspects: first, in terms of urban planning, the urban three-dimensional real scene model formed by UAV tilt mapping technology can realize the virtual presentation of urban landscape and scenic spots, and browse the whole city through the network, which provides some help for urban planning; Second, in terms of mine monitoring, UAV tilt photogrammetry can flexibly and quickly obtain the images of the measured area, complete the production and update of topographic map, and carry out completion survey<sup>[10]</sup>; Third, in terms of power planning, power is an important guarantee for China's economic development. The three-dimensional environment of the line corridor can be quickly established through UAV tilt photogrammetry technology, so as to accurately obtain the relevant information of the strip area of the power line; Fourth, the technology also provides high-precision 3D geographic information services based on 3D virtual reality for land and resources, public security, environmental protection and other industries.

### 6.2 Application Example Analysis of UAV 3D Tilt Technology in Mine Monitoring

The area to be measured is a part of Jiuquan Iron Copper Polymetallic mining area in Gansu Province. The mine monitoring is carried out by using UAV three-dimensional tilt technology, mainly including the following aspects: Determination of shooting range, route design, layout of control points and image data processing. The relevant parameters of aerial photography are: the flight area is 10m<sup>2</sup>, the flight altitude is 500m, and the camera used is

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Route design: divide the flight zone according to the change of kappa angle. The planned routes are 11 routes for vertical photography and 22 routes for tilt angle photography. Layout of control points: according to the division of routes and the actual situation of the mining area, control points are arranged around it, and about 300 control points are arranged. Image data processing: the process flow is automatic image matching → ground control point measurement → image matching encryption and extraction of DEM → Dom and panorama production. The three-dimensional tilt technology of UAV can monitor the situation of the mine in real time, and monitor the terrain and geology of the mining area, which is of great significance to geological disaster prevention and control and environmental protection.

## 7. Conclusions

In short, the application of UAV 3D tilt photography technology to mine monitoring can ensure the reliability of mining data and the authenticity of information; Realize the whole process and all-round real-time monitoring of mine mining, and ensure the safety of the whole mine project. The advantages of measurement and three-dimensional model of this technology make it applied to various fields and further promote the development of this technology.

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