Comparative Analysis of Image Shooting Methods Based on UAV Photogrammetry

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Abstract. Inclined photogrammetry technology is increasingly used in the transmission line inspection business, which is a basic work to build a "digital grid." In this paper, we compare the different shooting modes of photogrammetry. By analyzing the data indicators of different shooting modes, we can get the shooting index that is most suitable for the power grid inspection requirements, and carry out flight test on the same line to verify the accuracy of the field. Patrol provides optimal data collection solutions and indicators.

1. Introduction

With the rapid development of the domestic power line network, the natural environment is harsh, geological disasters occur frequently, and the difficulty of patrolling the transmission line corridors is increasing. The traditional manual measurement method is used to patrol the transmission line corridors, which has a large workload, low efficiency and high cost, and it is difficult to meet the inspection requirements of the power grid. With the development of drones and the rise of tilt photogrammetry technology, Using the tilt photography technology to carry out the three-dimensional modeling of the real scene, the rapid three-bit reconstruction of the transmission line corridor can effectively improve the inspection efficiency of the transmission line, discover potential hidden dangers of the transmission line in time, and ensure the safe and stable operation of the transmission line.[1]

Tilt photography is based on traditional photogrammetry techniques. The traditional vertical shooting method can only obtain the top information of the subject, and cannot obtain the side information of the subject; tilt photogrammetry is a new technical method in recent years, which is not limited to the traditional orthophoto only from the vertical angle. The way to shoot is to collect images from multiple angles by mounting multiple sensors on the same flight platform[2]. Among them, vertical shooting images can be processed by traditional aerial photogrammetry technology to produce 4D (DEM, DOM, DLG and DRG) products; other oblique photographic images can be used to obtain rich texture information on the side of the object..

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2. Comparative analysis of tilt photography and vertical aerial photography

Tilt photography is a new high-tech development in the field of international mapping and remote sensing. It combines traditional aerial photography and close-range measurement technology, which subverts the limitations of previous orthophotos that can only be taken from a vertical angle.

From the point of view of data collection, the traditional image is the image data obtained by continuously taking photos on the ground through the aerial camera mounted on the aircraft, and then the image data obtained through a series of internal processing. The obtained results are only the angle of view of the object, that is, the angle of view is perpendicular to the ground. The tilt photogrammetry test uses 5 cameras mounted by airplane or drone to shoot the ground object from the front, back, left, right, and vertical directions, and then passes the geometric correction, adjustment, multi-view image matching, etc. The series of processed data obtained with all-round information of the features. The simple understanding is that the object on the image is in a plane, and the tilted photogrammetric object has a true height.

For the purpose of traditional aerial photography to obtain orthophotos, a photographic method with a film inclination of less than 2-3° is called vertical aerial photography. This method facilitates subsequent ortho-correction and stereo mapping processing, but will lose the lateral façade details of the object. In fact, oblique photography can also obtain orthophotos, but when the tilt angle is too large, orthorectification requires a higher degree of image overlap, the projection difference will be larger, the accuracy will decrease, and the acquisition cost will increase. However, in recent years, the development of multi-lens aerial camera has overcome the accuracy problem well, and at the same time, the modeling and texture acquisition of the top and side façades of the object have been realized, which makes the tilting aerial photography perform in the large-scale three-dimensional modeling. Outstanding ability. Tilt photography can acquire tens of kilometers of transmission lines and terrain models at one time, with fast modeling speed and strong texture authenticity. At the same time, tilt aerial photography can also obtain orthophoto and digital elevation models in addition to modeling.

Tilt photogrammetry is based on traditional vertical photogrammetry. The traditional vertical photogrammetry has the advantage that the camera is vertically photographed, and the distortion of the image is small. After the stereoscopic three-dimensional reconstruction, the top view information of the object can be well reflected, and the plane accuracy of the measurement is also relatively accurate, but the side image information cannot be obtained, and the three-dimensional model obtained from the vertically photographed image is easy to form a large number of voids on the side due to the lack of side texture information, and the details of the model are not perfect, and it is easy to lack the details when dealing with the situation of the terrain fluctuation and the water surface. Therefore, traditional vertical photogrammetry is suitable for making a true image. The emerging tilt photography technology captures more abundant side image information through multi-camera shooting, which can enrich and improve the detailed information when performing stereoscopic 3D modeling. The side and detail points are more abundant, especially in processing. When the equipment and tree vegetation are hollowed out, good modeling results can be obtained, and the elevation accuracy of the measurement is also accurate.

This paper analyzes the traditional vertical photography and tilt photography, and determines the flight tilt angle and image overlap that are most suitable for the transmission line inspection.

3. Experiment and analysis

The project first collected a line in Foshan, Guangdong Province, with a total length of about 30 km. The whole survey area is dominated by mountain terraces, with complex landforms, numerous vegetation and crops, and good visibility. The flight mode is to collect image data and POS data once along each side of the transmission line channel.

3.1. Image data acquisition and processing

3.1.1. Data acquisition scheme design.
The aerial survey data acquisition of this project is carried out by a fixed-wing UAV equipped with a full-frame camera ILCE-7RM2 at a time interval of two seconds. The focal length of the lens is fixed at 35mm; the photo size is 7952x5304; the shooting area contains the rolling hills and the gentle plain. The average flight altitude is about 200m, and the drone patrol flight speed is 100km/h.

The data collection work of this project is carried out in two batches. The first batch of data acquisition is a comparison of the vertical reconstruction and tilt photography on the three-dimensional reconstruction effect and accuracy of a line in Foshan City using traditional vertical shooting and 15°C tilt angle. The second batch of data The acquisition is based on a series of tilt angles and three sets of overlap degrees for a certain line in Qingyuan City. A total of nine sets of image data and precise positioning data of the same line are taken for comparative analysis.

The effect of three-way reconstruction in two ways is shown in Figure 1:

![Tilt photography 3D modeling screenshot](image1.png) ![Orthophoto image 3D modeling screenshot](image2.png)

Figure 1 3D reconstruction renderings

From the comparison of the above two figures, it can be seen that from the perspective of the effect of three-dimensional modeling, the image modeling effect obtained by tilt photography is better, the image detail reduction is more rich and delicate, and the texture is more clear after restoration. The density of point clouds and the quality of point clouds obtained by tilt photography are better, and where it is difficult to restore such as ponds and towers, oblique image processing is better.

3.2. Comparative analysis of 3D models

From the perspective of the rendering of the 3D model, the restoration of the oblique image is more realistic and delicate, and this section analyzes the reasons that affect the deeper level of 3D reconstruction through data comparison. This paper analyzes the number of connection points, the degree of overlap, the accuracy, and the processing efficiency.

3.2.1. Number of connection points

In the process of three-dimensional reconstruction of stereo photography, the number of connection points is an important indicator affecting the effect of the three-dimensional model, and is an important link in quality control. The number of connection points directly reflects the result of image matching. Image-intensive matching refers to the matching of the same name for the calculation of the terrain of each object in the measurement area when the DSM/DEM is produced. The result is directly related to the effect of 3D reconstruction.

In order to compare the number of connection points of image data collected by two different shooting modes, this paper first analyzes the average number of image connection points of different shooting modes in this project, and then selects ten consecutive images, and connects the statistical images. The number of points. In this paper, the average number of connection points per image of the oblique image is 34754, and the average number of connection points per vertical image is 28836, which is significantly smaller than the oblique image. On the left and right two navigation belts, the number of connection points in the oblique image is obviously more than the number of joints in the orthophoto image, and the mean of the number of joints is much larger than the mean of the orthophotos.

From the index of the number of image connection points, the tilt image is also better than the vertical image, which can match more points with the same name, which is more conducive to improving the effect and accuracy of the three-bit reconstruction.
3.2.2. Overlap analysis
When shooting at the same altitude, the positive and oblique shooting modes are directly related to the ground span of the image, which affects the overlap of the images. Excessive overlap will make the work inefficiency and data volume increase, greatly increasing the post-data. The workload of the processing, and too small overlap can not meet the operational requirements of the three reconstruction of the transmission line, seriously affecting the quality of the three reconstruction models.

The span of the oblique image is much larger than the span of the orthophoto image, and the imaging area of the oblique image is also much larger than that of the orthophoto image. The local flight span is shown in Figure 2 below:  

For the same location of the same location, this paper selects the span of the road in the section. After measuring, the length of the road in the inclined image is 1261 meters, and the length of the road in the positive image is 661 meters. The ground span of the inclined image is much larger than that of the orthophoto. By measuring the span of multiple locations, the ground of the inclined image The area with the smallest span also reaches 1000 meters, and the maximum span can reach nearly 2000 meters. The excessive span will lead to insufficient side overlap and excessive peripheral redundancy information, which will reduce the efficiency of work and affect the data. The speed of post processing.

The overlap of the measurement areas is shown in the figure below to analyze the effect of the two shooting modes on the overlap.  

It can be seen from the above two figures that most of the overlap between the oblique image and the orthophoto image can meet the production needs of the engineering practice; the main difference lies in the edge of the image shooting. Because the tilted image has a large span, only a small amount of image is captured to the edge zone, resulting in a small overlap of the edge zones, and the farther away from the center position, the more the image overlap is less likely to meet the production requirements, the lower the overlap, and The distortion of the image will also be larger. Therefore, the farther away from the center position, the worse the 3D modeling effect, the easier the model is to create voids, the easier it is to deform, and the less accurate the engineering needs.

3.2.3. Precision analysis
In the analysis of the accuracy of the two shooting modes, we manually collect the coordinate information of the two vertices and one tower foot of the crossarm. Calculate the plane accuracy by calculating the length of the crossarm; calculate the tower height to analyze the elevation accuracy.

This paper analyzes the plane and elevation information of the two towers to analyze the impact of different shooting modes on accuracy. The statistical accuracy information is shown in Figure 3 below:
According to the statistical information, it can be seen that the difference between the two is not obvious. The tilt image and the orthophoto have little error in the plane information and the elevation information. The plane error is basically in the centimeter level, and the elevation error is also about 0.1 m. The above analysis shows that the shooting mode is not the main factor for the accuracy of the three-dimensional reconstruction of the image, and the oblique image, especially the larger tilt angle, still has a large distortion, and a certain image will be generated for the accuracy. The good tilt angle minimizes image distortion while satisfying texture mapping.

3.2.4. Production efficiency comparison

This paper also compares the post-processing efficiency of image data obtained by different shooting methods. Image data is collected in different ways using the same sensor device, and the image is post-processed and analyzed by the same hardware device and software. The relevant parameters of the final processing are shown in Table 1:

|                      | Tilt image | Positive photography |
|----------------------|------------|-----------------------|
| Number of photos     | 296        | 321                   |
| Line coverage area   | 3.2582km^2 | 1.7554km^2            |
| Initialization time  | 28m:45s    | 26m:24s               |
| Point cloud classification time | 02h:06m:40s | 02h:09m:23s |
| 3D modeling time     | 25m:21s    | 21m:47s               |
| CPU                  | E5-2630    | E5-2630               |
| RAM                  | 32G        | 32G                   |
| GPU system           | 1080Ti     | 1080Ti                |

It can be seen from the above comparison that under the same hardware facilities and software systems, the same amount of image data is processed, and the drones fly the same distance, even if the image coverage area is different, the processing efficiency of the oblique image and the orthophoto image not much differences. Therefore, different shooting methods have little effect on the efficiency of data processing.

4. Summary

This paper compares the oblique photography with the vertical shooting method to analyze the most suitable operation mode for the three-way reconstruction of the transmission line. In summary, the application of tilt photography to the three-dimensional reconstruction of transmission lines is innovative and advanced. The solid-state 3D model texture map constructed by tilt photography is more clear, and the model has fewer noises and holes, and the precision is higher. Compared with the vertical shooting mode, the number of connecting points of the tilted image is significantly larger than that of the vertically photographed image, the number of point clouds is more dense, and the modeling effect is more abundant and delicate. At present, the three-dimensional model produced by tilt
photogrammetry still has some defects, mainly reflected in: in the densely populated area, the cavity and deformation are caused by the occlusion of the vegetation; when the angle of inclination and the yaw angle are too large, the matching connection between the images The point is less likely to cause the model to be missing; the smooth surface such as the water surface lacks texture features, and it is impossible to match the feature points to generate model holes\cite{5}. In the future, the optimal camera tilt angle and flight parameters can be studied, and the ground 3D laser scan data and oblique photographic data can be studied. Combine, repair and perfect the 3D model. With the rapid development and maturity of tilt photography, it will play an increasingly important role in the three-dimensional modeling of transmission lines, bringing great convenience to the inspection and stable operation of transmission lines.

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