Application of LiDAR technology in power line inspection

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Abstract: Airborne Light Detection and Ranging (LiDAR) technology brought a new reformation for measurement technology, and the airborne LiDAR technology provides a new way for power line inspection. Compared with the traditional measurement system, airborne LiDAR measurement system has its unique technical advantages, which can directly obtain the power line corridor point cloud and get the high precision of 3D spatial information, then obtain the whole information of the 3D power lines corridor. Relative to the high input cost and high risk of helicopter LiDAR in power line inspection, UAV LiDAR technology has been a great success, which promote the development of the UAV’s LiDAR integration technology. The UAV obtain high-precision 3D point cloud data which is equipped with LiDAR system, and then carry out line model reconstruction and hazard detection. The application of LiDAR technology in power line inspection is greatly promoted.

1. Introduction
The power line inspection in china is mainly through maintenance personnel using ground transportation tools or hiking, or using hand-held devices (such as telescopes, digital cameras, infrared thermography, etc.) or the naked eye to inspect facilities for equipment defects. This way not only has high labor intensity, but also has low working efficiency. And at the new era, the way is not suitable for the development and safe operation of modern power grid.

Airborne LiDAR technology firstly made a breakthrough in manned helicopter, and as a relatively mature inspection technology, it has been popularized and applied in China's power grid. However, there are various problems with helicopter power line inspection, such as large cost of one-time investment, high inspection cost, high safety risk of airborne personnel and high airspace control, etc. However, there are still some inspection requirements that cannot meet different conditions, such as different voltage grades, complicated terrain conditions and various special disaster conditions. With the rise of drone technology, the uav power line inspection has opened up a new way for the development of the power sector inspection technology. The uav power line inspection has many advantages, such as small investment in equipment, low inspection cost, automation, intelligence, etc. It can solve the problems such as safety, high technical requirement and high labor intensity of manual inspection under complex geographical conditions.

Airborne lidar measurement technology makes up for the shortage of traditional inspection methods. It detects defects in time and eliminates trouble spots and realize the automatic detection of dangerous area. It improves the efficiency of inspection and saves the cost of inspection greatly. Its direct and potential economic benefits are considerable after using the UAV, it can greatly improve the management technology level and efficiency of power line.
2. LiDAR system power line inspection

2.1 Working principle of LiDAR system
Airborne LiDAR measurement system usually adopts pulse ranging method, and the precision of measurement can reach millimeter. The laser ranging system includes a single-beam narrow-band laser emitter and a photoelectric receiver. A pulse transmitted by a laser transmitter hits an object, and the reflected pulse is picked up by a photoelectric receiver. Depending on the speed of light, you can calculate the distance. If the frequency of the oscillator is f, the distance formula is follow.

\[ L = \frac{c \times n}{2f} \]

Formula 1

The working process of the LiDAR system is a repeated laser point cloud emission and receiving process. The result of the measurement system for the target object is the spatial discrete point cloud with X, Y and Z attribute information. In addition, the LiDAR system can record multiple reflections of the same pulse, producing a point record of multiple returns, and then get the cloud data. The working principle is following figure 1. The P coordinate formula is follow.

\[ X_p = S \cos \beta \cos \alpha \]
\[ Y_p = S \cos \beta \cos \alpha \]
\[ Z_p = S \cos \beta \]

Formula 2

Fig. 1 The working principle of LiDAR system

2.2 Point cloud data processing
After the airborne LiDAR system has scanned the ground, the raw data obtained has time data. However, these raw data do not have coordinates and spatial information, so the 3d coordinate values should be integrated to enable them to share a coordinate system. And removed the noise and isolation points data after the coordinate system is integrated which appear because of the circuit, birds and so on. The entire process from data acquisition to data processing is shown in figure 2.
2.3 The data processing and analysis

After the data collection was completed, GPS data processing and point cloud data preprocessing were performed on the site, we confirm the reliability of the data obtained. We will automatically classify the point cloud and the electric line of the electric pole. We get the result shown in figure 3 and figure 4.

2.4 Application of laser radar technology in power inspection

At present, the use of uav power line inspection is mainly divided into two aspects, which are the track corridor monitoring and the tower parts condition monitoring. The corridor monitoring mainly includes the inspection of the overhanging trees in the corridor, the illegal dangerous buildings, the tilt and collapse of the tower, and the existence of the bird's nest and other routes. Because of the extensive, wide-range, long-range inspection of the route, it requires the uav to have a relatively fast flight speed and long endurance and can fly autonomously. Tower parts condition monitoring is mainly to monitor the local state, such as Self-detonation, damage and flashover trace of insulator string, various kinds of wire clips and anti-vibration hammer damage, defect, deformation movement and damage of lightning protection facilities. So, the UAV is required to be stable and accurate, and it can be used to collect high-quality image information near the tower.

Through the uav power line inspection, it will realize the detection of dangerous ground objects, the fine measurement of distance between power lines, 3D visual management of transmission lines, detection of landform and geomorphologic changes in the corridor, capacity analysis of transmission lines and other inspection work.
lines, and tree cutting assessment and management.

3. Conclusion
In this paper, we introduce the working principle and application of LiDAR system in power line inspection. LiDAR system's advantage is that can accurately restore the 3D spatial information of line corridors, and then we can get along the more accurate and more comprehensive information of the line and route area, which greatly improve the operation ability of the helicopter patrol.

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