

# Application of High-precision 3D Technology in Transmission Line Measurement

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**Abstract:** 2D measurement technology is gradually replaced by 3D measurement technology, which increases the amount of measurement information, improves the accuracy and optimizes the imaging effect. Taking the electric power industry as an example, 3D laser radar technology plays an effective role in transmission line measurement. Timely detection of transmission line corridor hazards and accurate measurement of the distance between power lines can bring the ideal 3D visualization imaging effect, and guarantee the safe operation of transmission lines. This work mainly discussed the application of 3D laser radar technology in transmission line measurement based on discussing the development process and measurement flow of 3D laser radar technology, expecting to provide some reference for scientific measurement of transmission lines and scientific supervision of power lines.

## 1. Introduction

As a representative of high-precision 3D measurement technology, 3D laser radar technology has been widely used in transmission line measurement. It provides accurate and efficient measurement, improves the practical effect of measurement operations, and overcomes the limitations of multi-spectral and infrared measurement technology that cannot carry out spatial positioning and measurement of altitude, therefore, it can more accurately judge the corridor features and transmission line distance, and guide the transmission line operation and maintenance management [1]. After special processing, the color information point cloud data can be obtained, which has large point cloud density with high accuracy, so that it can support fine modeling of fine ground features and has a strong sense of hierarchy.

## 2. Research Process of 3D Radar Measurement Technology

### 2.1. Foreign research process

In the 1960s, laser was used as remote sensing technology for data measurement. During this period, the United States and the Soviet Union applied laser remote sensing technology to the field of earth science and technology and planetary exploration for the first time, and gradually formed a mature conclusion through accurate analysis and induction of a large number of experimental data. In the 1980s, NASA developed the atmospheric ocean radar system and airborne topographic survey equipment, which promoted the rapid development of laser radar technology. At the same time, Japan, the Netherlands and other countries have also used laser radar measurement technology to extract terrain information and carried out researches and experiments related to airborne laser radar system in the past ten years [2]. GAH, a Berlin electric power company, is one of the most mature companies in the research and application of 3D laser radar technology for power transmission lines around the world. Its laser radar system mainly uses unmanned or manned small aircraft as the measurement platform, which integrates a series of equipment, such as laser scanner, GPS system, camera, and inertial navigation. The pod-borne CLARA laser radar, developed jointly by Marconi company and Dassault company, is capable of detecting obstacles such as rivers and rocks and mapping the terrain around the target area in real time. At present, this system and

operation mode have been widely used in the operation and maintenance of many national power grids abroad.

## **2.2. Domestic research processes**

Compared with foreign countries, the research of laser radar measurement technology in China is relatively late. In the 1990s, the Chinese Academy of Sciences completed the development of airborne laser scanning range-imaging system. In recent years, the research of laser radar measurement technology has been supported by the government. Some companies have independently carried out engineering flights and related tests based on introducing high performance airborne small spot laser radar system from abroad. In 2007, Zhangjiakou Power Supply Company in Hebei Province first measured the distance between power lines using laser radar technology. Then electric power departments in Chongqing, Beijing and several other cities began to use laser radar technology, and the application range of 3D laser radar measurement technology is further expanded. The application of laser radar technology in power transmission lines can effectively optimize the route and the row of poles, effectively reduce vegetation damage, farmland occupation and a series of problems, and then improve economic indicators significantly, so that it can promote the development of national economy and society, and provide strong evidence for related scientific research [3].

## **3. Measurement Process of High-precision 3D Radar Measurement Technology**

3D laser measurement technology is an advanced active remote sensing technology. 3D laser measurement system is mainly composed of laser scanner, aerial measurement platform, high-resolution digital camera, IMU, GPS and related computer software and equipment, so that the system has initiative, non-contact, penetration, and high precision characteristics. It mainly uses vertical take-off and landing fixed-wing UAV to carry laser radar to collect data of transmission lines, so as to obtain 3D data of all features of transmission lines. There are seven steps to analyze its measurement process.

The first step is to obtain the original flight data effectively. The 3D radar ranging system flies along the line corridor and records the position data of transmission line space in real time, including laser scanning data, inertial navigation system data, and original digital image.

The second step is to reconstruct air lines. Air lines reconstruction is mainly to splice the later stage of the air lines, and provide effective data support.

The third step is to eliminate errors and anomalies in laser data systems. The errors and anomalies in the laser data system can be eliminated when the original laser data is obtained and processed.

The fourth step is to calculate the 3D coordinates of laser points and calculate the 3D coordinate data of each measuring point.

The fifth step is to splice air lines. The implementation of air lines splicing can enhance the accuracy of the data in the overlapping area and improve the consistency of the connecting features.

The sixth step is to identify and fit the lines. Part of the circuit is extracted to effectively connect the missing part of the spatial circuit by using software filtering and classification algorithm.

The seventh step is to edit artificial interaction. Artificial interaction editing is adopted to eliminate the invalid laser points in the automatic algorithm, as well as the incorrectly classified laser points and incorrectly filtered laser points.

The eighth step is to measure the distance between the line and the ground. The artificial interaction editing and automatic algorithm can be used to measure the distance between the line and the ground, and display the warning results.

3D laser radar technology plays an important role in power grid construction as well as management and maintenance, which is another technological revolution in remote sensing surveying and mapping after GPS. The 3D laser radar technology can understand and master the operation of the line in time and provide the basis for effective decision-making.

## **4. Application of 3D Laser Radar Measurement Technology in Transmission Line Measurement**

### **4.1. Effective detection of corridor hazards**

When inspecting the line, it is necessary to strictly check the distance between the wire and various ground objects in the line corridor to ensure that the distance between the two meets the safety distance standard. When measuring the distance of dangerous objects in the corridor of the line, the laser points are firstly classified, and the ground, trees, houses and cross areas are mainly classified. The laser points can be classified to accurately find the hanging points between the conductor and the insulator. When fitting the conductor sag, catenary equation can be used to measure the distance between the line and all ground object points. Additionally, when detecting the distance between the line and the object points, the maximum sag can be obtained according to the weather conditions [4]. When establishing the line mode, it is necessary to collect the laser data according to the external temperature, wind speed, temperature, air pressure, sunshine intensity and the current quantity of the line, so as to construct a good line sag model and analyze the sag state effectively.

### **4.2. Accurate measurement of power lines**

Under bad weather conditions, the wire will wave, which will lead to the cross and division of the wire. After the distance of the wire changes, it is easy to cause the short circuit of the line and then cause the discharge phenomenon. When using the laser radar to calculate the distance between the lines, the laser radar will not touch the lines even if the lines are charged, so that the distance between the lines can be accurately measured.

### **4.3. 3D visual management of transmission lines**

The recording 3D laser radar measurement system can be used to measure and restore the terrain, ground features and line sag of the line 3D corridor. After measurement by laser radar, the data can be obtained and processed by relevant software to form digital elevation model DEM and digital orthoimage model DOM. With the support of high-precision DEM and DOM, the terrain and landform of the line corridor can be transformed into a 3D model. At the same time, the ground objects under the line can also be 3D modeled, such as tower. In addition, objects such as houses and trees can be described by laser point cloud, which improves the accuracy of measurement data and reduces the complexity of data processing.

### **4.4. Effective detection of line corridor terrain and landform changes**

Collapse and displacement often occur in the corridor of transmission lines, which are mainly caused by geological changes in the corridor, or by weathering, engineering construction and other factors. 3D laser radar technology is equipped with high-resolution images and laser point clouds. After the terrain of the line corridor changes, the 3D laser radar technology can accurately and intuitively capture the changes of terrain and landform.

### **4.5. Comprehensive analysis of transmission line capacity**

By using 3D laser radar technology, the 3D space of topographic features in line corridors can be effectively scanned and restored. At the same time, computer can be used to simulate the line sag after load, and reasonably detect the safety distance between line sag and ground, which can provide scientific basis for the line current-carrying capacity to a large extent, and improve the safety of line current-carrying capacity.

### **4.6. Assessment and management of deforestation**

When constructing power lines, in the case of woodland, it is often necessary to evaluate the area, height and volume of the line through the woodland first, as well as the construction cost. After the construction of the power line, the spatial information of trees through the lines should be analyzed and calculated. The spatial information mainly includes the annual natural growth rate of forest tree

species, and then the optimal cutting amount of trees can be calculated. By using 3D laser radar technology and laser point cloud, the structural information of forest space can be obtained comprehensively and accurately, and the geometric characteristics such as tree height and crown can also be calculated.

## **5. Summary**

The measurement of transmission line is related to the safety and stability of transmission line, which is affected by many factors, therefore, it is difficult and complex. The advent of high-precision 3D radar measurement technology and its application in transmission line measurement are undoubtedly the technological revolution of power measurement. Compared with other technologies, it has the advantages of obtaining high-precision laser points, high resolution digital image data and combining with geographic information technology, which plays an important role in power grid construction and management and maintenance, therefore, it is worth popularizing.

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