The application of LiDAR in land resources survey

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Abstract: The biggest problem in land and resource management is the measurement and real-time monitoring of land resources. With the advent of LiDAR technology, this problem has been solved very well. As an emerging field observation technology, UAV lidar is becoming an effective complement compared with traditional aerial survey. Moreover, it plays an irreplaceable role in the field of disaster assessment and early warning, forestry investigation, emergency response, etc. This paper analyzes the application of lidar technology in land and resources management and discusses the development trend of lidar technology in land and resources management.

1. Introduction
Along with the development of the LiDAR technology, the main application in land resources survey is in the following aspects at present, such as Land surveying, censuses, exploration and exploitation of mineral resources, monitoring and early warning of geological disasters, etc. Airborne LiDAR technology has been applied to different degrees in many industries, its application scope includes land surveying and mapping industry, forestry, transportation industry. The application of land surveying and mapping industry involves various fields such as land use and classification, topographic mapping, urban change detection, urban 3D modeling and urban planning and design. The LiDAR technology has solved the difficult problems of traditional measuring method and traditional monitoring accuracy. It is a great significance for the land resources investigation and management.

2. The principle of UAV LiDAR
2.1 The positioning principle
The LiDAR system obtains the instantaneous position information of the laser through the dynamic differential GPS receiver. We will get the attitude data for flight according to the IMU navigation and record the pulse round-trip time through the laser scanning device for the distance between the laser feet and the reference points. Based on the coordinate system and corresponding transformation relation, according to the principle of space triangulation, we will get the 3D coordinate information of the target point. There are involving multiple coordinate systems in the conversion process when we get 3D coordinates of the laser point (target point) through the LiDAR emitter location. The most involved coordinate systems are instantaneous laser scanning coordinate system, inertial navigation coordinate system and wgs-84 coordinate system. The target object coordinate solution is shown in figure 1.

The g-spot is the projection center of the laser scanner, and the location information is provided by differential GPS. The coordinate (ψ, w, κ) is the attitude parameter, which represents pitching, rolling and yaw. So we can get the calculation formula of the target point location solution as formula 1.
Figure 1 The coordinates calculating diagram

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\begin{align*}
X' &= X + \sin \varphi \cos w (d \cos \theta - \frac{d \sin \theta}{\sqrt{1-\beta^2}}) + \cos \varphi \frac{d \sin \theta}{\sqrt{1-\beta^2}} \\
Y' &= Y + \sin \varphi \cos w (d \cos \theta - \frac{d \sin \theta}{\sqrt{1-\beta^2}}) + \cos \varphi \frac{d \sin \theta}{\sqrt{1-\beta^2}} \\
Z' &= Z + \cos \varphi \sin w (d \cos \theta - \frac{d \sin \theta}{\sqrt{1-\beta^2}})
\end{align*}
\]

Formula 1

And, \( b = \sin \varphi \cos w \cos k + \cos w \sin k \). So, we can get the coordinates of the target point M.

2.2 The point cloud data processing

The 3D coordinate information of the point cloud obtained by the UAV LiDAR system is difficult to meet the application purpose, so it is necessary to pre-process the original point cloud data. The early processing of laser point cloud provides a complete and good basic data for the application of late point cloud. It mainly consists of four parts: pre-processing of point cloud data, routine inspection of point cloud after pre-processing, the stitching of point cloud data and noise removal of point cloud data.

2.2.1 The point cloud data preprocessing

We often use the commercial software to complete data preprocessing. Firstly, we will decode the original laser data and orientation date, such as the POS data, DGPS and IMU data. And then we will get the GPS files, IMU files, laser dot files, etc. Then, the airborne POS and ground station GPS are decomposed to obtain precise coordinates. Finally, the standard is obtained by converting the point cloud data into a format. The las format is integrated with the post-processing location orientation data to obtain the ground coordinates. Then, the point cloud data is converted into a standard *.las format, and Integration with post-processing orientation data. Finally, we're going to get the ground coordinates.

2.2.2 The routine inspection of point cloud after pretreatment

After the pre-processing of point cloud data, we need to carry out the routine inspection of point cloud, which including the scope and overlap inspection, point cloud density, precision inspection, and the matching between the navigation bands. We are usually using specialized processing software to perform the routine checks of point cloud data. For example, LiDAR360 software examines the point cloud density.

2.2.3 The splicing of point cloud data

When using the UAV lidar system to carry out the operation, it is often necessary to design multiple routes because of the large range of the measuring area or the occlusion of the target object. However, the overlap between the two adjacent routes is affected by external factors, so the data of overlap may be not completely coincident. This is bound to affect the overall density distribution of point clouds and subsequent use. Therefore, it is necessary to remove the splicing of point cloud data before practical application.

2.2.4 The point cloud data noise removal.

It is inevitable that the use of UAV LiDAR system to obtain the point cloud data will be affected by a variety of factors. It can cause noise (such as impurities and occasional noises), such as the laser scanning ranging system itself or the large areas of water which makes the point cloud data appear hollow.
2.3 The automatic extraction process of weekly elements
In order to obtain the data needed for the project, we should complete the post-processing operation after the preliminary treatment for the original laser point cloud. However, there is not a commercial software which can satisfy the automatic extraction of land resource investigation elements at present. In this paper, we have developed a data processing procedures for automatic extraction of investigation elements. The flow chart is shown in figure 2.

![Flow chart for automatic extraction](image)

Figure 2 The data processing procedures for automatic extraction

3. The application of LiDAR in land resources survey
The LiDAR technology has the characteristics of rich information and short information cycle in obtaining information. Therefore, it plays an important role in the utilization and evaluation of land resources. We can use LiDAR technology to build a land using database. With this database, we can monitor the following information in real time, such as the total data of each land, the land scope, the location and area of land. It is also possible to conduct land change survey, which can be analyzed in real time and reported. It is very useful to establish information system of farmland protection area with LiDAR. The system can monitor the use of farmland in real time and prevent the occurrence of unreasonable utilization of farmland. It is very useful to establish a land use planning system with LiDAR. The system can effectively guide the staff to make reasonable use, monitoring and evaluation of the land, which in order to make real-time correction of unreasonable behavior.

The LiDAR technology is very useful for geological hazard monitoring and early warning. We can use the geospatial data in LiDAR technology to monitor the potential geological hazards in real time and minimize the damage caused by geological disasters. The geological disaster monitoring and warning demonstration station established by the ministry of land and resources has effectively safeguarded people's lives and property.

4. Conclusion
The application research of this paper is still in the exploratory stage. There are still some algorithms and technical problems in the application of airborne LiDAR data. With LiDAR as the data source for land investigation, extensive and in-depth research can be carried out. Combining LiDAR technology with land investigation is a useful and successful attempt. Which is not only enriching the technical means of land survey, but also providing a new method and idea, and it is also a positive practice for the application of LiDAR technology in various fields.

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