Comparative Analysis of New Forest Resources Survey Methods

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Abstract. Traditional fine forest survey methods mainly rely on ground surveys and use remote sensing image to estimate, which has problems such as low efficiency, poor data objectivity, difficult to unify standard control, and low degree of automation. Based on the DEM, DSM, lidar point cloud, and tilt photography model from multiple sources and resolutions, by superimposing high-resolution remote sensing image and selecting eight representative evaluation indicators such as distribution interpretation, species legibility, vegetation penetration ability and parameter extractability, this paper analyzed the advantages and disadvantages of forest resource surveys under these methods and proposed a fast and high-precision method for fine forest resources survey. The results showed that the forest resource survey based on lidar technology can meet the needs of fine forest resources survey and can be used for fine forest resources survey.

1. Introduction
Forest resources survey is an important part of natural resources survey and monitoring, its main work is to ascertain the type, distribution, quantity and quality of forest, and reflect the status of forest resources management in the survey area objectively. The specific task of forest resources survey includes: (1) Find out the type, distribution, quantity and quality of forest resources. (2) Find out the changes about areas, protection and utilization, management property of forest. (3) Analysis and evaluate of forest resources and ecological status and management effectiveness comprehensively, put forward opinions on forest resource cultivation, protection and utilization, and make suggestions for forest ecological security and ecological civilization construction.

The extraction of forest resources structure parameters, such as tree height, DBH, crown width, tree density, and volume, is an important premise for quantifying the structure, pattern, and function of forest resources systems and plays an important role in forest resources management, forest carbon source estimation, biodiversity research and protection, and it is the basic work to complete the task of forest resource survey. Traditional fine forest survey methods mainly rely on ground surveys and remote sensing image estimation. This method has problems such as low measurement efficiency, poor data objectivity, difficult to unify standard control, and low degree of automation[1]. New technologies such as lidar and oblique photogrammetry provide a new technical means for the extraction of forest resource parameters.
2. Data Source and Processing

2.1. Data Source
(1) 30m DEM in Zhongxian, Chongqing. The data comes from Geospatial Data Cloud Network (http://www.gscloud.cn/), Xi'an 80 coordinate system.
(2) 30m DSM in Zhongxian, Chongqing. The data comes from Japan Aerospace Research and Development Agency (https://www.eorc.jaxa.jp), WGS84 coordinate system.
(3) Lidar point cloud data of Zhongxian, Chongqing, WGS84 coordinates system.
(4) UAV tilt photography model of Baozhu Village, Chongqing, Xi'an 80 coordinate system.
(5) 0.5m high-resolution remote sensing image of Zhongxian, Xi'an 80 coordinate system.

2.2. Data Processing
(1) Image Processing. Perform image cropping on 30-meter DEM and DSM according to the point cloud data range, use image process on lidar point cloud to generate a DSM and to perform topographic shading processing on DSM in ArcGIS.
(2) Coordinate transformation. Perform coordinate transformation operations on the data above, and unify the various data coordinate systems to Xi'an 80.

3. Display Effect of These Methods

3.1 30m DEM and Image
Add experimental data in ArcScene, set the cropped 30m DEM as the basic height of remote sensing image, and specify image cell size to (30, 30) to achieve the best display. The display is shown in the figure below.

![3D vertical view](image1)

(a) 3D vertical view  (b) 3D end view

**Figure 1.** 30m Dem and Image

3.2 30m DSM and Image
Add experimental data in ArcScene, set the cropped 30m DSM as the basic height of remote sensing image, and specify image cell size to (0.000278, 0.000278) to achieve the best display which shows in the figure below.
3.3 Point Cloud DSM and Image
Use LAS Dataset to Raster tool in ArcMap to create a high-precision DSM of laser point cloud, then use the hillshade tool to create a landscape shading based on the newly generated DSM. The overlay display is shown in the figure below.

Figure 3. Point cloud DSM
Add point cloud, DSM and remote sensing image in ArcScene, The overlay display and UAV and backpack lidar point cloud is shown in the figure below.

Figure 4. Point cloud
Figure 5. Point cloud DSM and Remote sense image

Figure 6. UAV and Backpack lidar point cloud

3.4 Drone Tilt Photography Model
Add the oblique photography data in LocaSpaceViewer, the display effect is as follows:

(a) Forest stand  (b) Single tree

Figure 7. Drone tilt photography model

4. Comparative Analysis
As we discussed before, the main content of the forest resource survey is to ascertain the types, distribution, quantity and quality of forest resources, and to measure the tree species, tree height, DBH and location, etc. Therefore, this paper mainly selects indicators such as display effect, distribution interpretation, species legibility, vegetation penetration ability, parameter extractability, and data reliability to reflect the advantages and disadvantages of these forest resources survey methods.
Judging from the display effects of the above methods, there is no significant difference in the display effect of the 30m DEM and DSM superimposed on the high-resolution remote sensing image due to the lower resolution. These two methods can judge the distribution of forest resources in general, but the type, quantity, and quality of forest resources cannot be distinguished, and the ability to extract important parameters such as tree height and DBH does not meet the requirements of forest resources survey.

The display effect based on the lidar point cloud technology method is better. Through remote sensing images and dem shading, the distribution of forest resources in the region can be generally judged. Because the laser point cloud has the ability to penetrate vegetation, when the point cloud reaches sufficient accuracy (base station lidar can reach 2mm accuracy, vehicle lidar 2cm accuracy, airborne laser can reach 10cm accuracy), we can use some relevant software to perform single tree segmentation of point cloud data, which can be further analyzed and processed to obtain the biomass, storage volume, canopy height, canopy coverage, canopy / gap ratio, canopy parameters, tree density, and some accurate data such as the location and height of individual trees. Research has showed that the tree height and crown width characteristics of forest trees obtained by airborne lidar data have very high accuracy. Based on the single tree data by actual measured data and airborne lidar, The correlation of the single tree data is analyzed and the single tree parameters are inverted[2]. The average accuracy of the single tree crown width estimation is 88%, the average accuracy of tree height is 89%[3]. If used in conjunction with a vehicle and base station or backpack lidar, the accuracy can be even higher. This fast and high-precision extraction method can meet the needs of fine investigation of forest resources.

Based on the UAV tilt photography technology, a realistic 3D model can be generated with the best forest resource display effect. The distribution, type, quantity and quality of forest resources can be generally judged. It can obtain some tree parameters accurately by analysising and processing of the oblique photography model, such as the tree height and location, and canopy coverage[4]. However, due to the low ability of vegetation penetration, it is impossible to accurately obtain the elevation data such as tree canopy and surface terrain, and leaf area index, forest density and accumulation parameters. Studies have shown that the accuracy of extracting single tree crown widths through an oblique photogrammetry system is 86.43% on average, the average accuracy of single tree height is 92.21%, the single tree volume measurement accuracy can reach 69.78%, and the stand canopy closure accuracy can reach 93.7%, the average precision of stand average crown amplitude is 74.39%, and the average precision of forest stand accumulation is 78.48%[5].

However, the forest resource survey method based on oblique photogrammetry technology is greatly affected by environmental factors. The forest stand survey is not the same as the single tree survey. The forest stand survey based on oblique photogrammetry technology has a large area of obscuration, which cannot be easily and obviously interpreted and make the extraction of some tree parameters less accurate. Therefore, the forest resource survey based on the UAV tilt photogrammetry technology can meet the general needs of the forest resource survey, but cannot meet the fine survey of forest resources.

Table 1. Analysis of advantages and disadvantages

| ID | Indicators                      | 30m DEM | 30m DSM | Lidar point cloud | Tilt photography model |
|----|--------------------------------|---------|---------|-------------------|------------------------|
| 1  | display effect                 | normal  | normal  | good              | excellent              |
| 2  | interpretation of distribution | normal  | normal  | excellent         | good                   |
| 3  | interpretation of species      | low     | low     | excellent         | good                   |
| 4  | vegetation penetrability       | \       | \       | high              | low                    |
| 5  | parameter extractability       | low     | low     | excellent         | good                   |
| 6  | single wood survey             | low     | low     | excellent         | good                   |
| 7  | stand investigation            | low     | low     | excellent         | good                   |
| 8  | extracted data reliability     | low     | low     | excellent         | good                   |
5. Summary
By analyzing advantages and disadvantages of the above methods, we can draw these conclusions: (1) Forest resources survey based on lidar technology can meet the needs of forest resources survey and can be used for fine forest resources survey. (2) Forest resources survey based on oblique photogrammetry technology can meet the general needs of forest resources survey, but cannot meet the fine survey of forest resources. (3) The 30-meter accuracy DEM and DSM superimposed on high-resolution remote sensing images cannot identify the forest resource survey category effectively, and the display effect is average.

Compared with traditional forest resources survey method, the manual measurement has features like low efficiency, poor data objectivity, difficult to unify standard controls, and low automation. The forest resources survey based on lidar technology can choose a suitable lidar mobile platform based on the survey area, terrain conditions, etc., including large airborne lidar systems (applicable to terrains with large working areas and large terrain fluctuations), unmanned airborne lidar systems (moderate working area, small terrain change) and ground lidar system (convenient transportation in the work area and easy access). The three-dimensional lidar point clouds contains a variety of meaningful data information such as forest resource reflection intensity, coordinates, etc., and it can penetrate trees and be less affected by weather, which has advantages that other methods does not have in forest resources investigation and monitoring. This is an important technical support for achieving fine management of natural resources.

By using the combination of lidar, remote sensing image and survey requirements, on the one hand, the detailed information inside the forest can be grasped in time through different remote sensing means, and the distribution status of the forest can be effectively grasped comprehensively, accurately and objectively, on the other hand, in terms of high-precision remote sensing data obtained using lidar technology, it can further analyze and process the biomass, accumulation, canopy height, canopy coverage, canopy / gap ratio, canopy parameters, tree density, even the location and height of the single tree in the forest area. This method can reduce the workload of manual investigation and improve the efficiency and accuracy of forest resource surveys, especially in areas where people are difficult to access, which can improve the survey efficiency greatly and reduce the cost of traditional forest resource survey effectively, and improve the level of forest resource management ultimately.

6. Prospection
On November 3, 2019, China has successfully launched Gaofen-7 satellite, which is the first submeter-scale high-resolution optical transmission three-dimensional mapping satellite, making breakthroughs in the acquisition of high-resolution three-dimensional mapping image data and high-resolution three-dimensional mapping. Gaofen-7 has the three-dimensional imaging capability of forward and backward viewing in the same orbit and the advantage of sub-meter spatial resolution. It can also use the high-precision elevation information obtained by laser altimeter to realize the three-dimensional mapping of satellites with a scale of 1:10000 for civil use in China, which can play an important role in land Surveying, urban and rural construction, natural resources statistical survey and other aspects.

Therefore, we can combine with uav lidar and ground lidar for further research based on the high-precision DSM (2m) produced by Gaofen-7 satellite in the field of detailed investigation of forest resources.

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