ATLANTIS PRESS
*Atlantis Highlights in Material Sciences and Technology (AHMST), volume 1*
International Symposium "Engineering and Earth Sciences: Applied and Fundamental Research" (ISEES 2019)

# Classification and Automatisation of Laser Reflection Points Processing in the Detection of Vegetation

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***Abstract* – The article touches upon the issue of automatic recognition and subsequent processing of data on natural and industrial objects of the world. The obtained data is a result of laser scanning. For data analysis in 2018 a research group, consisting of specialists from Kuban State Technological University, Kuban State University, Kuban State Agrarian University and Aerogeomatics Company, conducted a joint research on the decoding of forest cover based on the data of airborne laser scanning under various landscape conditions. The analysis of existing software was performed through the comparison of various methods of automated decoding and the subsequent decoding of points on the basis of airborne laser scanning. Various research results on this topic, including foreign studies, are analyzed. The authors made the conclusions about the quality and reliability of the information provided by each of the products and the level of development of this software segment as a whole. The alternative development options for this industry based on the use of neural networks are given.**

***Keywords – laser scanning; classification of cloud of laser points; neural networks.***

## I. INTRODUCTION

Technical progress in the field of equipment for engineering and geodesy survey is rapidly developing. The technology of three-dimensional laser scanning is increasingly being introduced into our lives. Nowadays laser scanning is perhaps the fastest and most effective way to obtain high-precision three-dimensional models of various natural and anthropogenic forms and objects.

Due to the high performance and precision of air, ground and mobile laser scanners are used in various areas of industry, engineering surveys, design, construction and architecture, buildings and structures monitoring, in state and municipal administration, road transport infrastructure, land surveying and cadastral works, forestry and water management, oil and gas industry, survey work, environmental monitoring and documentation of emergency situations. In addition it is necessary to note that there are pilot studies on the creation of spatial models of compact parts of complex forms for the development of working construction documentation through the use of ground laser scanning, which indicates high precision of the resulting model and demonstrates the possibility of using ground laser scanning (GLS) technology for production purposes [1].

Nevertheless, despite such an extensive scope of usage, there is no reason to say that the technology of 3D laser scanning is widely used in these industries. It is necessary to note that the software of the scanners themselves is annually improved, thereby simplifying the method of conducting field measurements and reducing the time for performing geodetic surveys. However, the resources of the software intended for the subsequent processing of information are often insufficient for the rapid modeling of the situation on the ground, obtained as a result of field survey. The main reason for this problem is that office work is conducted manually, often taking up a significant part of the time working with a laser scanner. At the moment, there are simply no valid algorithms capable of properly automating the processing of laser reflection points obtained as a result of field survey.

## II. Methods and Materials

In order to analyze this problem in 2018 a research group, consisting of specialists from Kuban State Technological University, Kuban State University, Kuban State Agrarian University and Aerogeomatics Company, conducted a joint research on the decoding of forest cover based on the data of airborne laser scanning under various landscape conditions. This article presents a comparative analysis of automated point decoding techniques based on airborne laser scanning data: Microstation (Terrasolid); a technique using the Global mapper + LIDAR module; a technique based on combining LIDAR data and a raster image; a technique using the MATLAB application package; techniques implemented in ArcGIS.

The algorithms of these software solutions allow partially automating the processing of laser reflection points obtained as a result of laser scanning. The study was carried out according to airborne laser scanning (ALS) of forest area of the Aralar Natural Park, Spain.

## III. Comparative Analysis of Automatic Methods for Forest Cover Decoding According to Air Laser Scanning Data

Microstation (Terrasolid) Method

Microstation Bentley Connect 10 software and Terrasolid package are used for this method.

In the Terrascan settings, a new type of trees is created and the following settings are made: the minimum and maximum tree height, the variation of the crown width of trees, the name of a tree, and it is possible to select the "Height" block created earlier [2]. Before the determination of trees, it is necessary to normalize the surface in order to get the best result, since surface imperfections play an essential role in the determination of the heights of trees. The function of Transform loaded points is used for normalization. At the final stage, using the Detect trees function, the crowns and heights of trees are detected. This function also allows selecting the type of tree, the storage location of blocks of crowns and heights, and the "more trees" method. As a result of calculations, the trees with heights and crown radius are obtained.

The advantages of the method:

- High percentage of the detection of trees (83-95%);
- Good determination of height and crown (98% and higher);
- Minimal data loss in the course of block partitioning used in this and subsequent methods for data verification.

The disadvantages of the method:

- It is necessary to manually select the type of tree for each study area, as there are many types of trees, and they are different in their configuration;
- The method not always correctly determines the total number of trees with a low density of points;
- The detection of trees is difficult with a high density of vegetation;
- The program needs fine adjustment of the parameters.

Global mapper + LIDAR module using method

Global mapper with LIDAR plugin was used for this method.

LIDAR data is loaded into the program, but in order to improve the detection quality, Las data should be loaded only with vegetation, and only with a normalized surface [3]. It is also necessary to take into account the geographical projection of the data, because without precise information about the projection, the accuracy of the data will be very low.

It is necessary to open the Extract Vector Features tab and select LAS file. In the *extract tree* section, the minimum height, longitudinal and transverse line of the crown [3] is set. In *resolution* it is necessary to choose the best resolution for this file.

The obtained data is exported to * .shp. and imported into Microstation. After it the assessment of the determination of the crowns and heights of the trees is made.

The advantages of the method:

- Good determination of the number of trees (from 65 to 78%);
- The method is independent of wood type;
- Excellent height detection (98% or more).

The disadvantages of the method:

- It is necessary to select the resolution by trial and error in order to obtain high quality;
- There are problems with the detection of crowns with high density of vegetation.

LIDAR data and a raster image based image.

This method uses a raster image of the territory and the LIDAR data itself. In the future, LIDAR data, the ArcGIS, a high-quality aerial image and the Trees from Lidar and NAIP tool [4] are also used.

Initially, a Las Dataset is created in which the Las file will be located. Then the Trees from Lidar and NAIP tool opens, and the desired Las Dataset is selected, the average interpoint distance is set, by default, the buffer from the building, 1 channel and 2 raster channel are selected. The method itself uses about 40 operations. Using a raster, the tops of trees and their heights are found; with the help of LIDAR data, the crown radius of a tree is found.

The tool runs several dozen operations in order to obtain the final data. At the initial stage, the statistics for * .las files are calculated and NDVIplus and NDVIminus are calculated for rasters. Then the points go through the processing chain with Negate - Flow Direction - Sink tools, and then the highest places are selected from the raster, which are eventually converted into point objects with information about tree height [4].

In order to obtain information about the crown, the raster NDVIplus and NDVIminus rasters are used, after which the final file passes the function Focal Statistic, Flow Direction, Flow Accumulation, to which information about tree heights, crown sizes, etc. is added to the output.

Using the *buffer function*, a tree crown polygon is created, and the data is exported to Microstation, where the accuracy of crown and tree heights is assessed.

The advantages of the method:

- Relatively good determination of trees at low density of - 62–63%;
- Perfectly determines height and crowns;
- Small difference in 4 blocks of verification, which indicates the high quality of the method.

The disadvantages of the method:

- The method is not very useful in case of high density of vegetation;
- Often the location of the tree is not determined correctly (at the edge of the crown).

MATLAB (APP) software package

The MATLAB, MATLAB scripts, SAGA GIS, ArcGIS, and nDSM surface software are used for this method. The basis for this method is the study of Tyson Swetnam, Doctor of Geography and the local maximum algorithm with a variable zone [5].

In order to add data to MATLAB, it is necessary to convert the raster image into ASCII format using the additional SAGA GIS program.

The next stage uses the following code: vlm_output_raster = vlm (raster, 0.6, 30). This code specifies 2 factors: the ratio of the width and height of a tree and the value of anisotropic 2D blur raster (Blur) [6]. The value of the ratio of the width and height of a tree is taken from the Microstation data for this area, but in order to improve the quality of the obtained data, an empirical method is used. It is visually assessed how the crown of a tree describes the polygon. The *blur* coefficient is responsible for the number of trees found.

Using the export_vlm_output = export_utm (vim_output_raster, raster) code, the received data is transferred to the Matlab table. Then the data is copied to the Excel file. Then the rows with the value of NaN and those columns that are not needed and have extra information are deleted. The final file contains 5 columns: id, x, y, height, radius.

Using the *Add function*, an excel file is added to ArcGIS. Using the buffer function, according to the radius column, the models of crowns are built and exported to Microstation, where a visual assessment of the quality of crowns and tree heights is carried out.

The advantages of the method:

- Good performance in the number of found trees 68.8–76.13%;
- Good detection of a crown.

The disadvantages of the method:

- Inadequate detection of a crown;
- False detection of a crown.

Similar research was conducted by other research teams. In particular, the effect of point density on the accuracy of automatic detection of objects was studied.

The table 1 shows the accuracy of the selection of individual trees in an automatic way. According to the presented data it can be seen that the lower the density of cloud of laser points, the lower the reliability of selection of individual trees [7].

TABLE I. RELIABILITY OF IDENTIFICATION OF SEPARATE TREES DEPENDING ON THE DENSITY OF CLOUD OF LASER POINTS

| Density of cloud of laser points (point/m2 ) | Number of selected trees | Data reliability, % |
|---|---|---|
| 67,9 | 33 | 73,3 |
| 33,8 | 32 | 71,1 |
| 16,9 | 31 | 68,9 |
| 8,5 | 28 | 62,2 |
| 4,2 | 22 | 48,9 |
| 2,1 | 15 | 33,3 |

In addition some of the studies are aimed at the comparison and possible combination techniques that allow obtaining information about the territory using satellite images and aerial laser scanning [8, 9]. It is concluded that the data obtained from the satellite may be suitable for specific tasks of the forest resource inventory, for example, regular monitoring of the state of the forests, however, they have less accuracy in comparison with airborne laser scanning.

It is necessary to mention the problem of factors limiting the accuracy and applicability of laser scanning, such as: shadow zones, dramatic changes in the coefficient of reflection, hotspot, transparent surfaces and geometric features of the surface of the scanned or measured object (sharp edges, steps) [10]. As a result, some of the points of laser reflections are not in their place or simply absent, so noises or empty spaces may appear in point clouds. They complicate the process of automatic processing of laser scanning data and require the manual elimination of these errors. At the moment, there are generally accepted and original methods of restoring surfaces with different specifics of use, but there are no automated algorithms among them [10].

## IV. RESULTS

In accordance with the presented study, it can be concluded that the algorithms of existing software solutions, such as Terrasolid, Global mapper, MATLAB, and others do not always guarantee high quality results, and often do not have adequate universality for all types of territories. Moreover, research groups from other countries [11–13] faced the same problem. In their scientific works, they offer their own methods of decoding laser points of reflections [11–14].

However, it leads to the inconsistency of methods of obtaining and processing information. It is necessary to create unified and more sophisticated software that can satisfy modern requirements for processing the results of laser scanning [15, 16]. The solutions based on artificial neural networks (ANN), which show high results in detection of high-precision images including the results of airborne laser scanning may present one of the possible variants of such software systems. By encapsulating modules on the classification and detection of high-precision images based on the INN in relation to the tasks of forest inventory into existing software solutions, it is possible to achieve higher confidence in the detection of individual trees depending on the density of the cloud of laser points.

## V. CONCLUSION

Modern laser scanning systems have a huge performance potential. They are able to carry out up to 1 million measurements per second, thereby covering vast areas of territory. This gives a huge array of data on the points of laser reflections obtained on the basis of a scan. However, the performance of software designed to process the received information does not allow using the full potential of this technology and slowing down the production process. Obviously, in order to continue the development and, most importantly, to increase the efficiency of using 3D laser scanning technology, it is necessary to improve the software algorithms for processing field measurement data, which is possible with the use of INN-based image classification and detection methods.

It is also important to note that among the existing application programs there are no products developed in Russia, therefore the creation of such solutions in our country is promising not only in terms of the financial benefits of specific companies, but also for strengthening the economy of our country and supporting the process of its digitalization, which is one of main vectors of development of Russia.

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