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ANALYSIS OF LIDAR ELEVATION DATA IN GIS

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Abstract

The paper aimed to present the main delivery format for the LiDAR(Light Detection and Ranging) elevation data and the possibilities to access and use all informations that a vendor provides them. The GIS (Geographic Information Systems) software have extended their capabilities to store and analyse the LiDAR data. For several years there have developed different tools for obtains varied geospatial products based on LiDAR data. The case study uses ArcGIS technology to briefly present several options available to store and visualize the LiDAR data and to combine multiple data source in order to obtain a complete representation of terrain.

***Key words**: geodatabase, analysis, raster, GIS, TIN, LiDAR.*

INTRODUCTION

Light detection and ranging (LiDAR) technology is an optical remote sensing technology that is provide detailed 3D elevation data. LiDAR data become more available and data analysis software offer more dedicated advanced tools to solve complex problems using the elevation data. In general LiDAR data processing has two steps (qcoherent.com, 2013
Data pre-processing: after the data acquisition it is required to filter data for noise. In the pre-processing step are compute the collected point coordinates from the independent parameters such as scanner position, orientation parameters, scanner angular deflection, and the laser pulse time.
Data post-processing: the data can be post processing in order to obtain the final products: Digital Elevation Model (DEM), Digital Terrain Model (DTM), Triangulated Irregular Network (TIN).
Elevation and location information are the most important components of LiDAR data. LiDAR data is also called lidar point cloud data or cloud of points. Lidar point cloud data is delivered as a collection of files in either ASCII (text) or LAS (binary) format(Robert J, 2012).
The ASCII elevation data can be very slow and the file size can be extremely large, even for small amounts of data and they aren't keep all information specific to the lidar data (asprs.org).
LAS files are the most used file formats for lidar data. LAS datasets maintains information specific to the lidar nature of the data like time, intensity value, class code and the three-dimensional positional information that represents latitude, longitude and ellipsoidal height.

x	y	z	i
1667501.45	170602.58	65.46	2.7
1667501.65	170601.92	66.65	2.2
1667501.68	170600.22	50.43	2.5
1667505.69	170602.61	65.04	3.6
1667503.1	170599.2	63.09	2.5
1667500.83	170597.1	54.96	1.1
1667500.6	170588.08	68.6	1.4
1667504.21	170595.75	49.44	0.5
1667506.44	170597.49	59.32	2.2
1667507.43	170599.89	48.96	2.3
1667505.46	170599	34.76	1.4

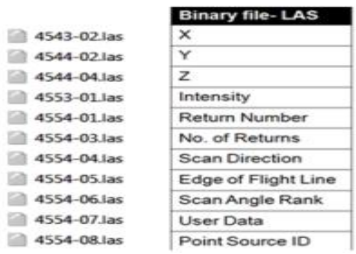

Figure 1. ASCII and LAS files
(Source ESRI.com)

The LAS specification was developed by the American Society for Photogrammetry and Remote Sensing (ASPRS, 2012).

The vendors can supply other processed products such as contours and breaklines(Adams R.S., 2009)

A breakline represents a distinct interruption in the slope of a surface, such as a ridge, road, or stream and defines and controls surface behaviour from smoothness and continuity point of view(Sommer et all., 2006 and esri.com).

Figure 2. Contours and breakelines

LiDAR datasets have large size(several TeraBytes TB) and irregular point density. One file can handle billions of points at the sub-meter point space.

If this data is loaded directly in to a specific format it will be result a large data file.

MATERIALS AND METHODS

In ArcGIS the common way to storage and management the data is Geodatabase format. This format combines „geo"(spatial data) with „database"(datarepository)(esri.com).

Geodatabase stores collection of spatial data, maintains the integrity of data and defines advanced geospatial relational models like topologies or networks(esri.com). There are three tipes of Geodatabase: File, Multiuser and Personal Geodatabase. Personal Geodatabase have a single editor environment and is limited to 2GB in size. File Geodatabase have a single editor environment, stores data in a file systems folder and is limited to 1TB for each dataset. Multiuser Geodatabase supports multiuser editing (except multiuser desktop geodatabase) and has a storage capacity from 10GB to the storage capacity of server.

Because of the constraints, personal geodatabase is not suitable for storing LiDAR data.

In this study case we used the File Geodatabase as a storage environment.

In File Geodatabase the LiDAR file data is storaged as multipoint feature class. One point stored as multipoint stores many LiDAR points using only one database row.

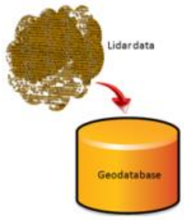

Figure 3. Point cloud data loaded in Geodatabase format (Source ESRI.com)

This format saves space and improves the read-write performance(esri.com). For example Ticleni_Lidar multipoint feature class stored 2025 LiDAR points in one database row(Figure 4).

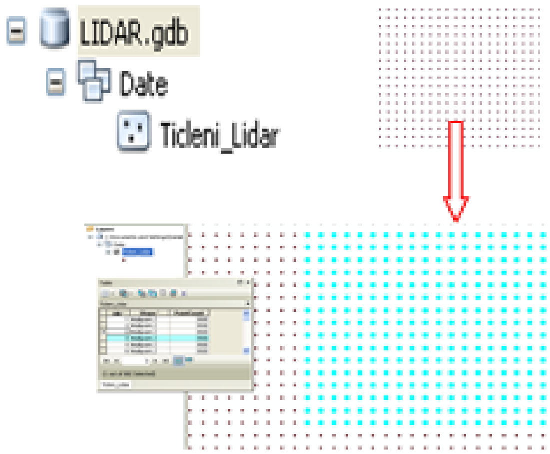

Figure 4. Multipoint feature class

Another way to storage the LiDAR data is Date Terrain format. A terrain dataset uses point cloud LiDAR data to represent a surface. A Terrain Dataset is a multiresolution surface, stored as a TIN based surface. It is built from vector–based feature classes stored in Geodatabase. With Terrain datasets can be better represented a surface and it can be performed many types of 3D analysis. Also is possible to extract TINs and rasters from terrain datasets on a specific area of interest an level of details(esri.com).

The last storage format used in study case was LAS Dataset. A LAS Dataset is not stored in the Geodatabase. It is a binary file created and stored independent on hard-disk. The file extension is *.lasd*. The format allows to study the LAS files in their native format and edit the classification of the LAS points(esri.com).

RESULTS AND DISCUSSIONS

In order to study the main LiDAR data formats and the final products, we have selected a dataset in LAS format that cover the Ticleni region from Gorj county.

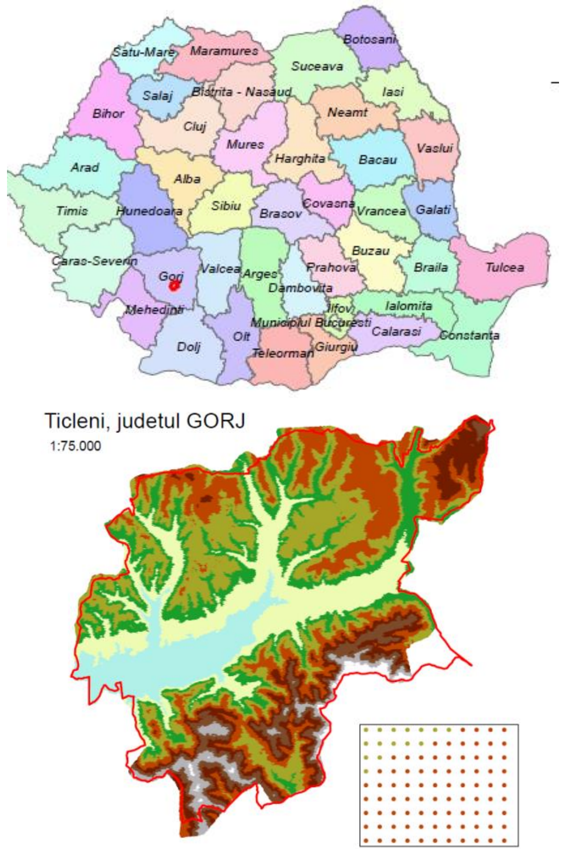

Figure 5. Ţicleni region from Gorj county

The LiDAR dataset datum is national reference systems Krasovski 1942 (S-42) with the Stereographical projection 1970 and the system of normal altitudes for the Black Sea 1975.

After completing the steps of creating File Geodatabase and after using the specific raster analysis tools from ArcToolbox the final results are present in the Figure 6.

1. Multipoint feature class **Ticleni_Lidar**
2.Terrain Dataset **Date_Terrain** based on feature class **Ticleni_Lidar**
3. Feature class(polylines) **Contur**
4. Raster(grid) **Raster_Lidar**
5. Raster **Umbre** (Shadow)
6. Raster **Pante** (Slope)
7. LAS Dataset **LAS.lasd**
8. Triangulated Irregular Network **tin_ticleni**

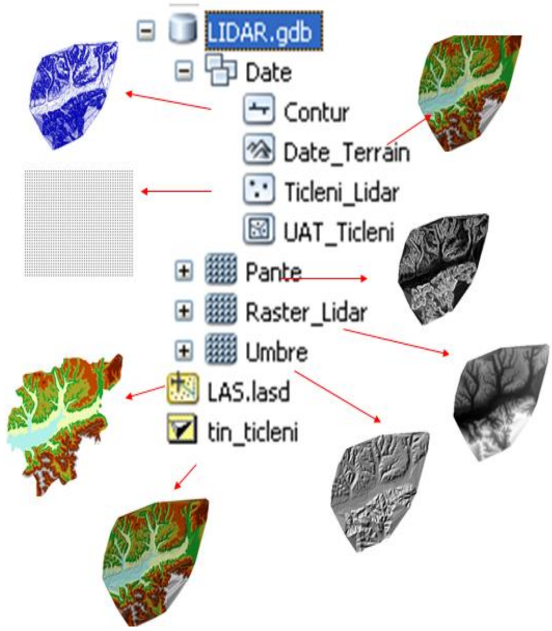

Figure 6. Final products- Vectors, Raster, TIN, LAS Dataset, Terrain Dataset

Base on Terrain Dataset it was performed a line-of-sight analysis using the 3D Analyst toolbar from ArcGIS. A line-of-sight is a line drawn between an origin and a target that shows the parts of the surface along the line that are visible to or hidden from an observer.

This tools determines whether a given point is visible from another point. If the terrain hides the target point, the obstruction can be identified.

There are two cases:

- The origin and the target are on the surface;
- The origin and the target are offset from the surface with 1,8 meter;

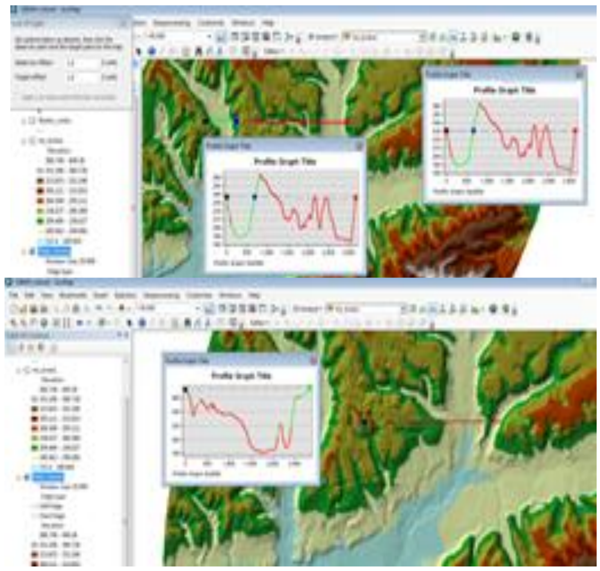

Figure 7. Line of sight and Profile graph

The green lines indicate where the observer can see the ground and the red lines indicate the portions of the ground that are not visible.
To create a graphical representation of the profile it was used the Profile Graph option from 3D Analyst toolbar. The profiles show the change in elevation of a surface along the same two lines used for line-of-sight analysis(esri.com).

CONCLUSIONS

Before using LiDAR data is important to analyse the dataset specifications in order to make the right decision regarding your project needs. Those specifications should compared with the real needs of project:-necessary resouces

- the scop of using data
- the cover area
- necessary point density;

Keep a balance between what the project needs and what data is available.
Use a scalable environment for the large LiDAR dataset.
It is necessary to estimate the size of the Geodatabases.
There isn't practical to keep all data in a single Geodatabase
Is neccesary to use different method to check the accuracy of the data and the final results of the data analysis. Not all errors have significance. Some errors might be acceptable values or without significance and they won't influence the accuracy of the final results.

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