3D MODELLING USING LASER SCANNING TECHNIQUE

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ABSTRACT
The three techniques used in the collection of elevation data for digital terrain modelling: ground survey methods, photogrammetric methods and graphics digitizing methods are adds one: data acquisition using laser scanning technique. This article discusses the stages for three-dimensional modelling using laser scanning technique.

Keywords: terrain modelling, laser scanner, DTM, three-dimensional modelling

INTRODUCTION
Digital terrain modelling is a particular form of computer surface modelling which deals with the specific problems of numerically representing the surface of the Earth. The initial concept of a digital terrain model (DTM) originated in the USA during the late 1950s. Since then, considerable advances have been achieved, particularly in the methods of acquiring and processing terrain information. The term DTM originally referred to the use of cross-sectional height data to describe the terrain. Nowadays, however, the definition is more general and includes both gridded and non-gridded data sets. Several other terms are also used to describe essentially the same process. Among the more common are Digital Elevation Model (DEM), Digital Height Model (DHM), Digital Ground Model (DGM), and Digital Terrain Elevation Model (DTED).

MATERIALS AND METHODS
1. Data acquisition
Since data acquisition is so important to all practitioners of terrain modelling, this immediately poses the question as to which techniques should be considered for use in the collection of elevation data. The four main methods which can be used to acquire elevation data are:

1. Ground survey methods normally using total stations
2. Photogrammetric methods based on the use of stereoplotting instruments
3. Graphics digitizing methods by which the contours shown on existing topographic maps are converted to strings of digital coordinate data and the required elevations derived from them.
4. Laser scanning technique.

Nowadays, terrestrial laser scanning has become an additional technique for geodetic applications. The use of laser scanners is continuously increasing. Different laser scanners of several companies are available.

The measurement result is represented by a set of points, called point cloud. Usual steps taken to collect data (point cloud) to geometrical model of the surface or manually constructing primitives are:

- Data acquisition: measuring the point cloud;
- Referencing: defining a reference coordinate system and converting all data sets in the system (in photogrammetry, the process is called orientation);
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- Calibration: eliminating systematic errors;
- Minimizing noise measurement: the process is called filtering or smoothing;
- Surface modelling: estimating surface terrain using Triangulated Irregular Network or estimation of free surfaces.

3D modeling is the process of developing a mathematical representation of a three-dimensional surface of an object via specialized software, aimed at studying the properties and transformation of the respective object. The product obtained is called a 3D model. It can be displayed as a two-dimensional image, following a process called 3D rendering or used in computer simulation of physical phenomena.

2. Three-dimensional modelling steps

The main methods for creating 3D models are:

1. **Polygonal modelling** - most models used in games and movies are polygonal models. This method developed 3D surfaces from a large number of polygons, grouped in a network. These models are very flexible and can be rendered by computer very quickly. The disadvantage is that the surfaces cannot be created very smoothly [1].

2. **Parametric modelling** - this method uses parameters to specify properties of the object.

3. **3D solid modelling** - in this method, basic geometric objects such as cubes, cylinders, cones, and spheres, are used to build more complex models. This modelling technique is simple and fast.

4. **NURBS modelling** (Non-Uniform Rational B-Spline), as opposed to polygonal surfaces modelling, allow to create smooth curves, but the rendering is slower [2].

5. **Modelling based on Spline curves or Patch type surfaces** - is similar with NURBS modelling, except that the surfaces are made of curved lines, which are their edges.

3. Three-dimensional modelling using cyclone software

Step 1. Filtering data

The first operation in the process of post-processing of point cloud data is filtering the results, which implies to eliminate the points that are not subject of the scanned area, removing items containing noise generated by: wind influence, poor reflection on the scanned surface, obstacles, moving people, scanning resolution, etc. (Fig. 1).

![Fig.1. Raw point cloud (unfiltered)](image-url)
It is recommended that additional items taken by the instrument to be removed manually by the operator, which can identify them easily by analyzing the scanned area (Fig. 2). In the study case of this article, the removed items were the points taken from more than 50 m from the tunnel entrance and exit, points representing the crowns of trees, bushes on the side of the track. These operations were performed with the commands "Polygonal Fence Mode" and "Rectangle Fence Mode", benefiting from the program viewing modes that allow top view, front view, left, right, forward or orthographic views [3].

Another filter, automatic this time, was made to eliminate very close points. The instrument is set to start scanning for scan resolution at a certain distance (10 cm to 50 m). During the scan the instrument collects a large amount of points at close distances that define generally the same object. They are useless and slows work and information management.

Operation for removal from density of the points can be implemented with the five standard modes in the command "Point Cloud Density": without reduction, minimum reduction, average reduction, high reduction and very high reduction. In this case, the points are random reduced by different percentages from 0% to 75%, depending on the chosen reduction. The procedure is recommended for scanning short distances when the density of points is uniform in the point cloud.

After filtering and setting these operations it can proceed to data modelling based on final desired / required products.

Step 2. Obtaining TIN model (Triangulated Irregular Network)

Another important milestone is the creation of digital terrain model DEM (Digital Elevation Model) and contours lines. The software uses TIN model (Triangulated Irregular Network), which is a network of triangles that are created as a Delaunay algorithm (Fig. 3).

In practice, for obtaining a digital terrain model are used modelling functions or geometrical models (Grid, contours and TIN). Compared with other models, TIN model has a lot of advantages and best expresses the surface, with the triangle modeling unit. The TIN model reduce redundant data from Grid model, especially in regions where land is kneaded and sudden changes appears. TIN model accuracy is higher than other models of the terrain representation because this model uses 3D triangles to generate the surface [4].
TIN generation is done from the menu "Tools"/"Mesh"/"Create mesh". This operation can take a long time depending on the complexity of the surface and the number of points. It is recommended that for complex objects, the generation of TIN model to carry on portions (Fig. 4).

Step 3. Correct model imperfections
To correct inherent imperfections: gaps or peaks (Fig. 5), occurring in creating TIN model, the software provides tools for editing the model. These imperfections are due to the low density of points in some areas, due to shadows when scanning, due to faulty points caused by moving objects when scanning.
Elimination of peaks is done by marking the area and delete them using the "Tools"/"Mesh"/"Delete" section. To fill gaps the routine used is "Tools"/"Mesh"/"Fill selected hole" through which gaps are filled by interpolating triangles located closest to the fault zone. In Fig. 6 are shown the effects of the two routines implemented in the fault zone from Fig. 5.

The final result of three-dimensional modelling can be seen in Fig. 7 in which all the steps above are covered.
CONCLUSIONS
The number of points acquired by terrestrial laser scanning, in a short time, leads to a very accurate interpretation of the terrain. Processing software for both registration and analysis and interpretation are modular and does not require special resources. Filtering the resulting data (point cloud) which involves removing items that are not subject of the scanned area, removing items containing noise generated by: the wind influence, poor reflection on the scanned surface, obstacles or people in motion, scanning resolution, the elimination of too close points, is automatically done at user-defined parameters. Creating digital terrain model DEM (Digital Elevation Model) based on TIN model (Triangulated Irregular Network) is relatively easy and simple, and subsequent it can automatically calculate, based on a reference level, volumes, sections, filling and excavation volumes, etc. The software provides a wide range of possibilities for exporting and importing data in different formats. This allows the use of products resulting from scanning in other softwares for various applications, especially for modeling and rendering applications.

REFERENCES