DIGITAL TERRAIN MODEL IN MINING TOPOGRAPHY APLICATIONS

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Abstract: *The digital terrain model is a real relief representation in three-dimensional space, taking into account the planimetric coordinates N, E and the H elevation. The studied terrain topography is approximated through a mathematical surface achieved by interpolating the measured elevation in the terrain and with the help of the contour. This article approaches the creation of the digital model of the the terrain in several ways and solving specifical mining topographycal problems based on this.*

Keywords: *Digital terrain model, digital model of the deposit, mining topography, TIN, geostatic.*

1. General dates

The digital terrain model, D.T.M., represents a mathematical modelation of the surface, an approximation of it, given that the natural relief has a complex form it is approximated through a continuous function H=f(N,E), in a three-dimensional system where the position of a point is described through the N, E and H coordinates, or, in a local system, through the x, y, z coordinates.

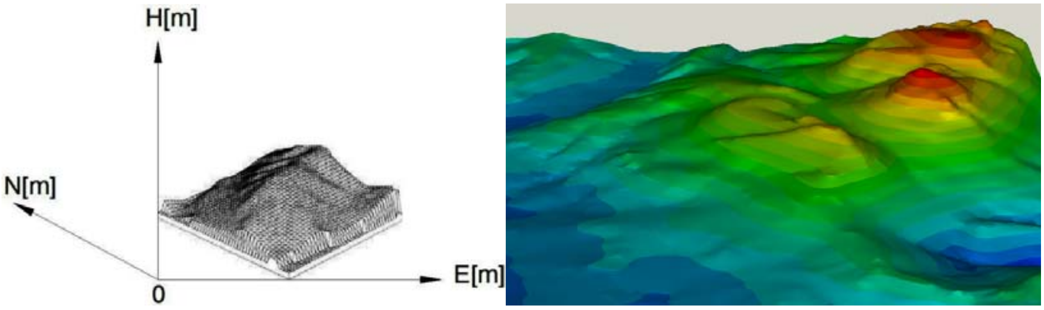

Figure 1 – a) Digital terrain model within a 3D coordinates system – N, E, H
b) Digital terrain model for the Mateiaș Huilei-Hill quarry

The digital terrain model has been intoroduced as terminology by Charles Leslie Miller and Robert Arthur Laflamme in "The digital terrain model – theory & application" work, published by M.I.T., Photogrammetry Laboratory, in 1958. In several sources, the digital terrain model – D.T.M. is named also altimetric terrain model, numerical terrain model, digital elevation model, digital altimetric model. These names define the same mathematically modelated surface, namely that of the terrain, but the digital terrain model should not be confused with the digital surface model which contains also any antropical or natural details situated on the terestrial surface, such as vegetation, buildings etc.

The complex form of the terrain can be mathematically modelated with the help of the known elevation points and the contour, lines that unite the points having the same elevation, named also izohipse.

2. Information retrieval sources that stands to the basis of creating the digital terrain model

The digital terrain model is obtained from several sources, sometimes as a main product, its realisation beeing a purpose, other times indirectly from photogrammetrical processing by "filtrating" the surface model.

Sources from which the digital terrain model can be created are:

- Satelitary sensors;
- Airborn sensors – the use of the stereoscopical method;
- Classical topographycal measurements or with the help of the G.N.S.S. technology;
- Terrestrial laser scanning;
- Conversion of the cartographical products form the raster form into vector format and after that, based on the altimetrical elements from it, create the digital terrain model.

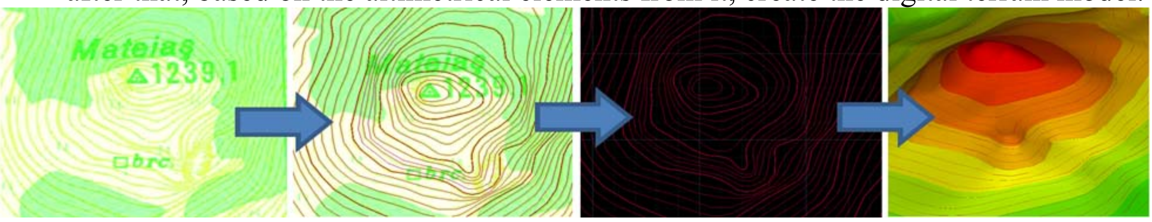

Figure 2 - Obtaining digital terrain model from old cartographic source, raster-vector conversion and subsequent creation of digital terrain model

Regarding Romania, the digital terrain model has been done for small surfaces, for certain interest zones such as carriers, gravel pits, sterile dumps, several objectives of local economical interests, or regionally, for the hidrografical basins, in the floods risk study, in some cases by flights attended by the Military Topographic Direcorate, withs data also from A.N.C.P.I., having coverage from several sources for the entire country, but with no clearly defined qualitative indices or an homogenous quality. Allso, the digital terrain model national coverage is done by digitalising old maps to the scale 1:25000 made by the Military Topographic Directorate, with a reduced precision though and from an unsure source, the aplication of these dates being limitated given the fact that the maps are not updated for over 20 years.

A problem of the digital terrain model achieved from multiple source, with different sensors, different temporary taking over, having scratchy precision features on the entire country, is the data fusion into only one model, having many solutions and approaches.

Chart 1 – different precisions of the digital terrain model according to its source, data source [5]

The data source used in the process of the generation of the digital terrain model	**Digital terrain model precision [m]**			
	Relative		**Absolute**	
	Horizontal	**Vertical**	**Horizontal**	**Vertical**
Military topographic map, scale 1:25000	-	-	10	5
Photogrammetical recordings	-	0,1	0,9	0,9
LiDAR	0,1	0,1	0,2	0,3

3. Methods in realising the digital terrain model

The digital terrain model is obtained by processing, using specialized programs and electronic computer, through different methods of the geostatics.

Triangulation method, T.I.N - Triangulated Iregular Network

An often used method in software programs of obtaining the digital terrain model because of its simplicity and easiness in programming is the triangulation method TIN. Practically, the complex form of the terrain is described by a lots of elementray triangles; each triangle defines a plan, the triangle being the superior face of a right prism, having the inferior face in the orrigin of plan H. The cota of any point inside the triangle is defined by linear interpolation to the cota of the three points of the triangle tops.

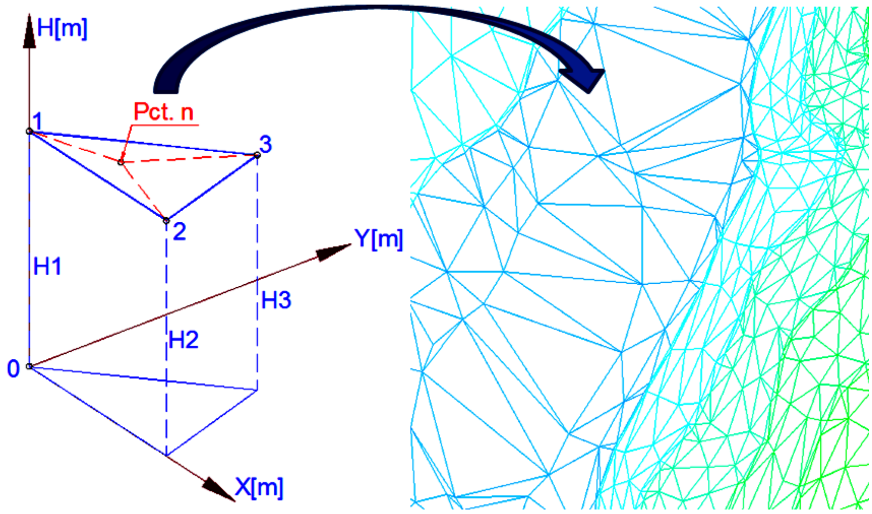

Figure 3 – The interpolation method of the H elevation for a point n in TIN

TIN surface representation method has been discovered in the '70s and the first applications have not been lounched untill the '80s.TIN is practically a vectorial description of the natural relief, through interconected lines and points with the help of the triangles, TINs points getting the characteristics of some **vertexes,** with known H cota, some interpolated, and the triangle sides can contain information regarding the ramp between the points. A disadvantage of the TIN method is that not all tipes of the relief can be represented through triangles, a pronounced thing in high scales, such as glaciar relief.

Consecrated methods of the H elevation or of the z coordinate interpolation in local system are:

- *Modified Shepard method* – is based on the interpolation through the smallest squares according to the invers of the distance, the interpolated values are determined using the weighted average with the distance. The error equations come from the chosen quadric function, an error equation for every proximity point is written, the equation weight is the invers of the distance to the considered point, the proximity dimension is given by the number of proximity points, idealy a circle but most of the times an ellipse.
- *Kriging interpolation method* – has itself many ways, simple Kriging method, usual Kriging method, Co-Kriging and other. It is based on using the varigrama, which represents an instrument used in the identification of the structural model of a

regionalised phenomenon through structural analysis, in our case, the regionalised phenomenon is the form of the natural terrain.
- *Nearest Neighbour method* – as it is called, the closest neighbour point dates are used for interpolation to determinate the elevation of a point; this method is usefull in compleeting the areas of deprivation, extrapolations can not be done on the elevation H.
- *Regular spline with tension method* – this method helps in determing also the elevation but other topographic parameters too such as inclination (ramp), the curvature, saved in raster format.

4. Solving some mining topographical problems with the help of the digital terrain model

Regarding the usage of the digital terrain model in solving mining topographical problems, we can name, for the surface mining exploatatinos, the next products obtained by using specifical software programs:

- Realising situation plans, elevations plans with izohipse;

This thing is realised for big surfaces by using photogrammety means, U.A.V. systems, and for small surfaces by using terrestrial laser scanning or even the G.N.S.S. technology, for punctual work zones.

- Images of the horison, sections through the landform

Images of the horison are obtained using specialised software programs, for a better view over the topography of the terrain and realising a judicious management of the surface mining exploatation. Also, using the digital model, sections, transverse or longitudinal profiles can be seen for studying the terrain topography.

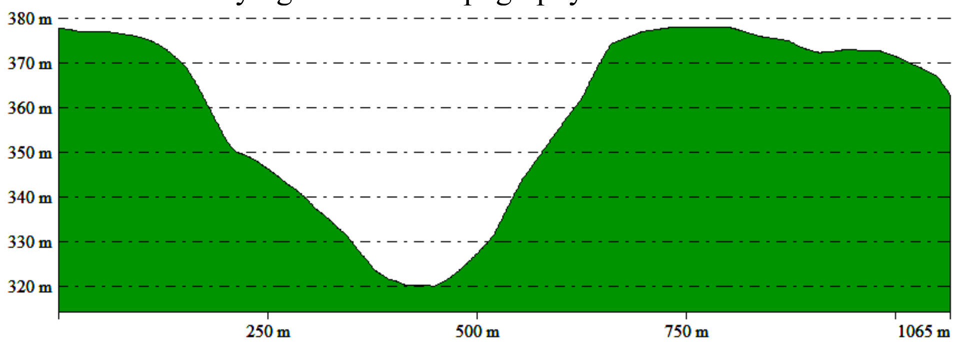

Figure 4 – Product resulted from the exploatation of the digital terrain model, transvere profile viewing a major river bed

- The determination of the uncovered land and the exploited material;

The digital terrain model has a big applicability in calculating the volume regarding the uncovered and exploited material between certain period of time, by comparing two digital terrain models realised in different periods, but regarding the same work front.

- Several plans and temathical maps.

Here we cand mention plans and maps of the planet, convexities, concavities, the line with the biggest ramp, watershed etc.

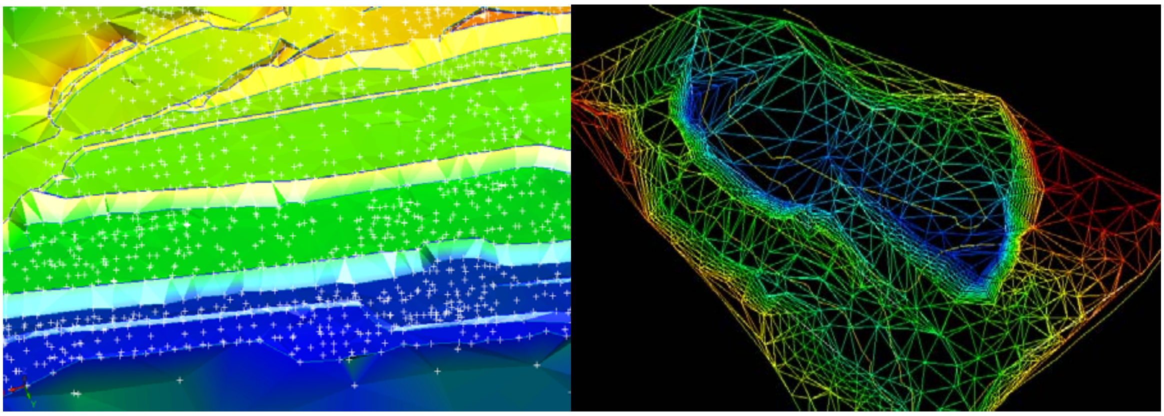

Figure 5 – a) Digital terrain model with the forced ramp changing lines;
b) TIN related to the digital terrain model

By far the greater use of digital terrain model in a surface mining is to determine volumes. Prisms method is used in many cases and calculations expeditivity recommends this method.

For the gypsum quarry Boteni, Arges county, we determined the volume of material uncovered and exploited using the digital terrain model for the second quarter in June 2016 and the third quarter in September 2016. To obtain the digital model, measurements were performed simultaneously with two G.N.S.S. recivers Hemisphere S321 type, in R.T.K. mode. We measured characteristic points of active fronts, up slope, down slope, forced change of slope lines, proximity elevation in the quarry step. With the help of measured points on the field we created a digital terrain model in the software Topko 2009, this software uses the in calculations TIN triangulation method.

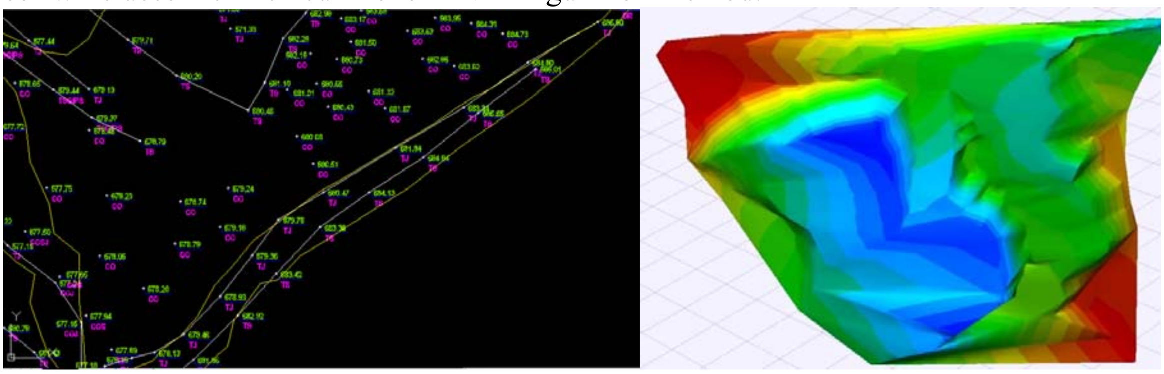

Figure 6 - a) G.N.S.S. measurements for determing D.T.M.
b) M.D.T. achieved in the third quarter of 2016 for active fronts in Boteni quarry, Arges county

By substracting the two digital models the volume of the uncovered and exploited material in the quarry can be practically determined. In normal conditions the digging volume has a certain n value, and the filling one tends toward zero.

For the mining exploitations, besides the digital terrain model, another important product is the digital deposit model. To botain it, it is necessary to use geological data, obtained through drillings. The geological cores describe the litographic and statigrafic column recovered from drilling. Of interest are the superior area of the deposit, named roof and also the inferior one, the shellter, these practically defining, deliming, the deposit from the rest of the material. The digital deposit model is done with specialised software programs, for example the Surpac program, produced by Geovia, ex Gemcom.

5. Conclusions

The models that form the basis for the interpolation of the digital terrain model have to be chosen according to the data, not vice versa.

The digital terrain model form the basis for the modern calculations of the volumes exploited in mining units from the surface, expeditious of the calculations recommends using it.

The accuracy of the digital terrain model is directly correlated with the number of the points that formed the basis of its creation and the distance between them. As the points taken from the terrain are more, the better the digital terrain model will approximate the reality from the terrain.

The realization of an ommogen digital terrain model for the entire country is a current problem and its solution should be found by the states authorities (gouvernment). Of interest is also the fusion of the existing digital models, reliable and quality methods exist so the wish of solving these aspects should also exist.

6. Acknowledgements

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