MODELLING OF SURFACES IN ORDER TO PROTECT THEM

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Abstract: *The digital model of an object or phenomenon is constituted of a data collection systematically stocked (data base) that describe a tri-dimensional system of coordinates, arbitrary or particularly can form the object features or states/accomplishments of the phenomenon (conversion as a digital image) and allow by calculation programs, deducting the object or states shape and features for the phenomenon in new points. Modeling the areas is the process for representing graphically a natural or artificial area by using one or more mathematical equations. Modeling the terrestrial area is a particular case for modeling an area where we should take into account the specific problems for representing the Earth or some of its parts. From the fields where the digital model can have an immediate applicability are as follows: analyze of telecommunication systems, designing the pipe networks (water pipes), command and control of different systems, as in all other fields where it is necessary to know the altitude information in different points of an area. The term of „digital terrain model" was used for the first time in 1958 by Miller and Laflamme who defined it as "a statistic representation of continuous area by using a great number of points whose horizontal coordinates (x, y) together with the altitude (z) are known and this representation is made in an arbitrary coordinates system". The digital terrain model represents an informatics' instrument composed by terrain data and software that represent a basic component of a GIS. The digital terrain model (DTM) is composed by 3 sub-systems: **1.** Digital elevation model- DEM contains altitudes, slopes, curves, etc. **2.** Digital planimetric model – DPM contains planimetric data and elements. **3.** Digital model of objects nature – DEN contains pedologic, geologic, hydrologic data etc. Generating the DTM refers to the way of data acquisition, to making the model by using different interposing methods and also choosing the structure of data representation (raster or TIN)*

Key words: *sustainable development, Environmental protection, G.I.S., modeling, digital terrain model*

INTRODUCTION

For elaborating a digital terrain model and using it in the future has the following stages:

1. **GENERATING A DTM** that consists in supplying initial data and building the digital model. This stage represents an important phase because the existence of the errors introduced in the stage of supplying the data will exist also in DTM and will commit the whole process of spatial analyze.

2. **MANIPULATING THE DTM**: correcting the errors and updating the model, filtrating operations, combining more models come from different sources or periods, transforming the model structure (TIN – raster and vice versa);

3. **INTERPRETING THE DTM**: analyzing the model and extracting the useful information;

4. **VISUALISING THE DTM**: graphic presentation of DTM (2D and 3D representation)

5. **EXPLOITING THE DTM**: developing the specific applications for the wanted field.

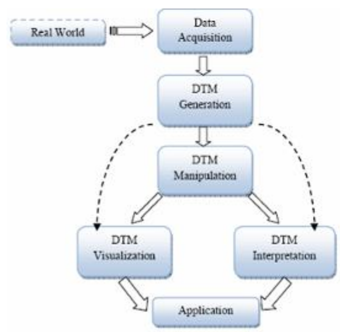

Figure 1 Principle of accomplishing a DTM

MATERIAL AND METHODS

Generating the DTM refers to **the way of data acquisition**, to making the model by using different **interposing methods** and also **choosing the structure of data representation (raster or TIN)**.

Data acquisition represents one of the most important process because are a lot of methods to acquire data from an exterior source of GIS and transforming them in a specific digital form. It can be met three main groups of **data acquisition methods** as follows:

✓ **Photogrammetric methods** (Fig. 2) based on using the analogical equipments and digital photogram metric stations. There are used for the great/average scale projects. The error increases once with fragmenting the relief and with the slope.

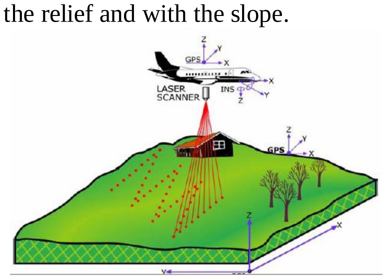

Figure 2 Data acquisition using Photogrammetric methods

✓ **Topographic methods** (Fig. 3) based on using total stations. They are used for small scale projects. This method cannot be applied for very difficult areas.

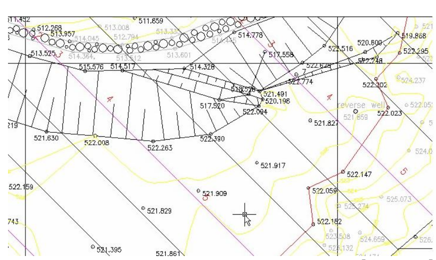

Figure 3 Data acquisition using Topographic methods

✓ **Digitising methods** (Fig. 4) of the cartographic products where the level curves on the maps and plans are transformed in files of planimetric coordinates (x,y) and altitudes (z).

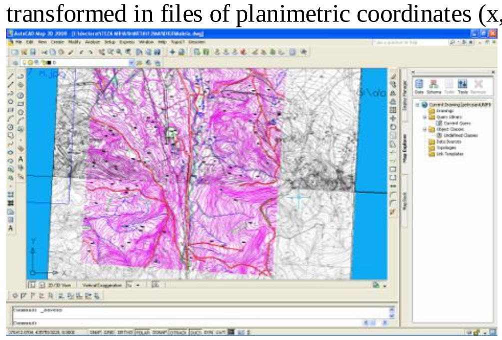

Figure 4 Data acquisition using Digitising methods

Building the model consists in creating a continuous area by using the interpolation method starting with the data collected from the field by using one of the above mentioned methods. **There are no universal algorithm of interpolation** good for all applications and each method has a series of advantages and disadvantages.

Many times the user is forced to choose a method taking into account the methods put under his disposal by the GIS manufacturer.

Classification of interpolation methods

- **Depending on the grade of altering the initial data:**
- **exact** (when the obtained model keeps the values of initial data);
- **inexact** (when the initial values are altered).
- **Depending on the number of values taking into calculation:**
- **global,** which use all the values simultaneously;
- **local** when in order to calculate the new values there are used only the known values from the neighborhood.

The algorithms of interpolation used for generating a DTM are usually exact and local. Linear interpolation is one of the methods commonly used to obtain a raster DTM type starting from the level curves of a topographic map. The quality of this model has evident errors. The histogram of such model has a laced surface, with many picks correspondent to the values of the level curves which proves that the data have a greater density along the isolines than in the space between them, this model having the "mark" of initial topographic map.

RESULTS AND DISCUSSIONS

DTM GENERATING

A *contour plot* (Fig. 5) connects points having some features (climatic, geographic, economic, etc.) in common. These are also known as *isolines*, *isograms or isopleths*. Mathematically, a contour connects two points where a function has the same value for both the points i.e. given a value *z*, the contour plot connects the point *x*, *y* provided the *z*-value occurs at both. This can be used for 2D representation of 3-D surfaces.

The interpolation methods type triangulation one after whom it is obtained a TIN structure **(Triangular Irregular Network)** (Fig. 6)**,** are also multiple.

Interpolation methods such as triangulations, when it is obtain a TIN (**Triangular Irregular Network**) (Fig. 6) are also multiple. The best one is ***Delaunay Interpolation*** that allows to be obtained some perfect triangles inside a circle so the distance between the points from the picks of the triangle is always minim. For each triangle there are memorized the coordinates and attributes of the three picks, topology and slope and declination direction of the triangle surface.

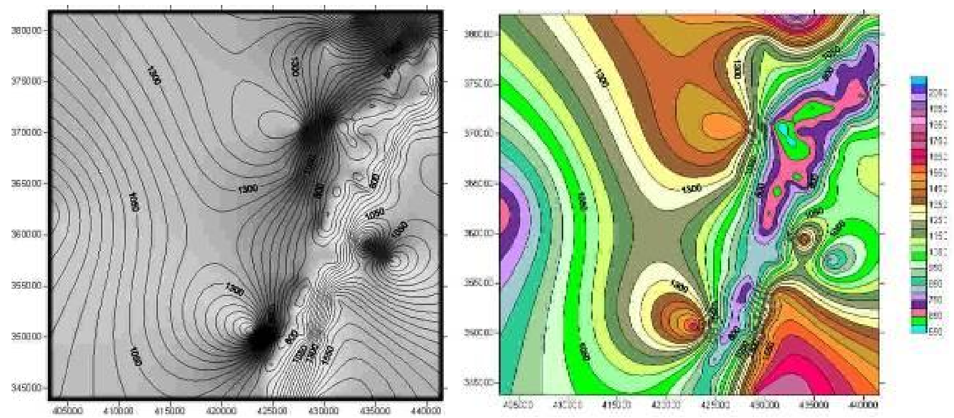

Figure 5 The Site-level curves

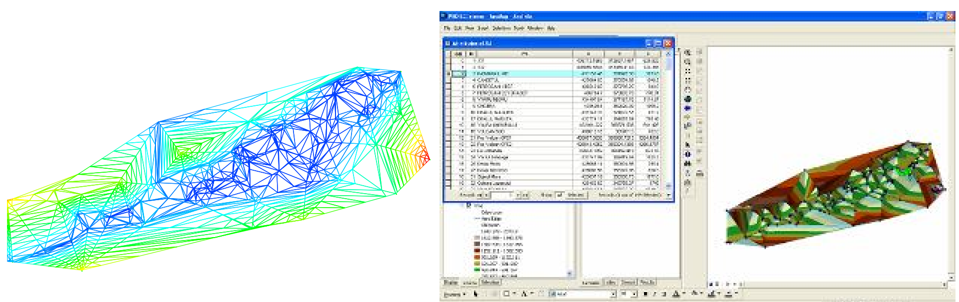

Figure 6 Elaboration of TIN structure

3D visualization (Fig. 7) is the preferred way of visualization to comprehend the actual terrain of any place. This can be achieved by techniques using wire frame models or rendering from a 3-D plane to a 2-D plane. For added realism, image based information is added to the rendered primitives. This kind of texture mapping serves to increase the visual appeal and increase the vivid detail. This is popularly known as *draping*, and leads to a greater understanding of patterns in the image and how they relate to the shape of the earth's surface.

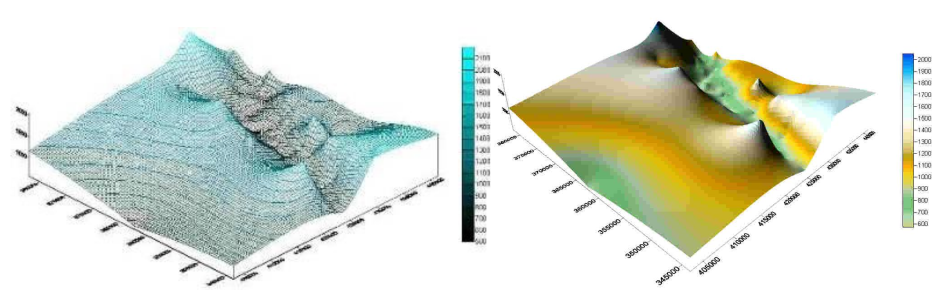

Figure 7 The 3D model (Wireframe model and Surface model)

DTM INTERPRETATION

The analysis of DTM's to extract terrain parameters is termed **DTM interpretation**. The extraction can be performed by either visual analysis or quantitative analysis (interpretation). The analysis can be grouped into *general geo-morphometry* or *specific geo-morphometry*. General geo-morphometry deals with quantification of general surface characteristics such as **slope, gradient or aspect**.

The concept of measuring **slope** from a topographic map is a familiar one for most professionals in the landscape planning/surveying professions. Slope is a measurement of how steep the ground surface is. The steeper the surface the greater the slope. Slope (Fig. 8) is measured by calculating the tangent of the surface. The tangent is calculated by dividing the vertical change in elevation by the horizontal distance. If we view the surface in cross section we can visualize a right angle triangle:

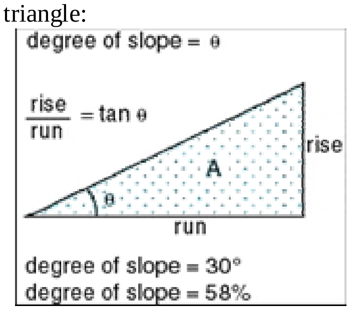

Figure 8 Slope

Percent Slope = Height / Base * 100

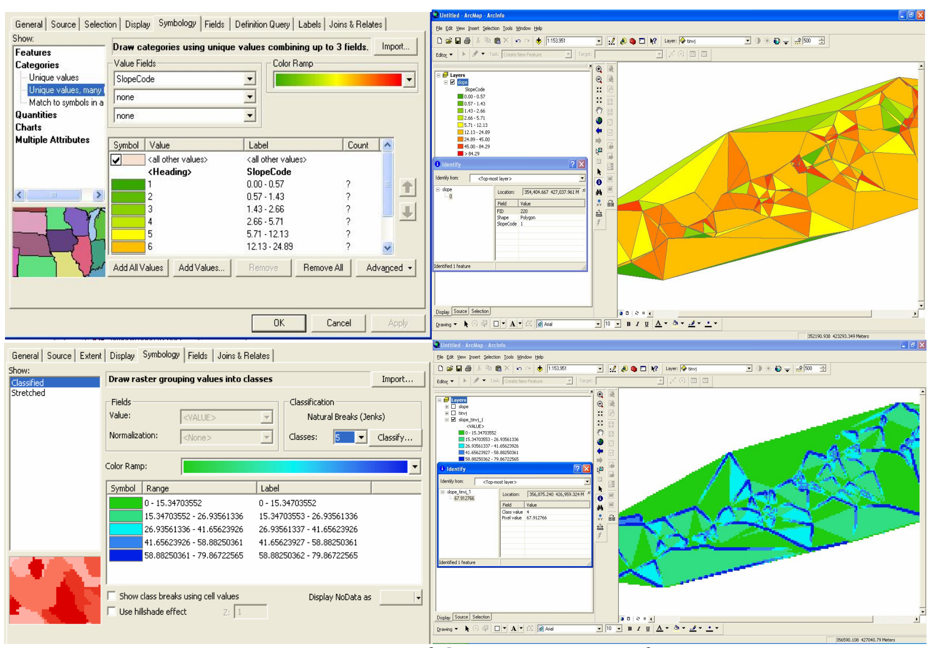

Figure 9 Measuring of slope using ArcGIS software

Slope is normally expressed in planning as a percent slope which is the tangent (slope) multiplied by 100 :

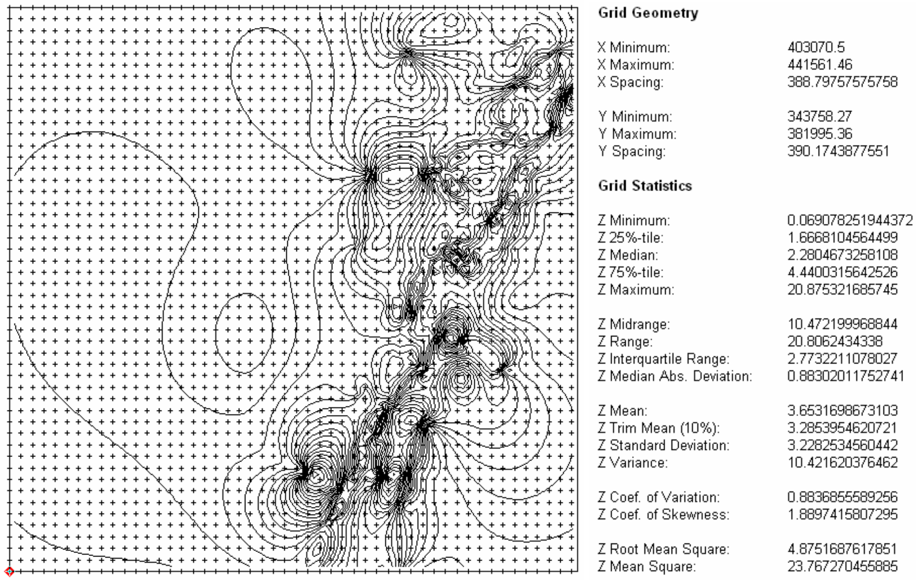

Figure 10 The map of Slope and Grid Information using Surfer Software

S*lope* is an attribute to define surface and comprises **gradient** and **aspect**. When written in the form of a mathematical equation g*radient* (usually calculated in degrees) refers to the first vertical derivative of altitude and represents the rate of change in its magnitude over distance. Similarly a*spect* is the first horizontal derivative of the altitude and represents the direction of the slope. The **curvature** (convexity / concavity) of the terrain can be determined by the second order derivatives. Curvature of the surface helps define the movement of masses. The formulae for calculation are mentioned below:

$$Gradient = \sqrt{\left(\frac{\Delta z_x}{\Delta x}\right)^2 + \left(\frac{\Delta z_y}{\Delta y}\right)^2} \;\; / \;\; Aspect = \tan^{-1}\left(\frac{\frac{\partial f}{\partial x}}{\frac{\partial f}{\partial y}}\right) \;\; / \;\; Curvature = \sqrt{\left(\frac{\partial^2 f}{\partial x^2}\right)^2 + \left(\frac{\partial^2 f}{\partial y^2}\right)^2}$$

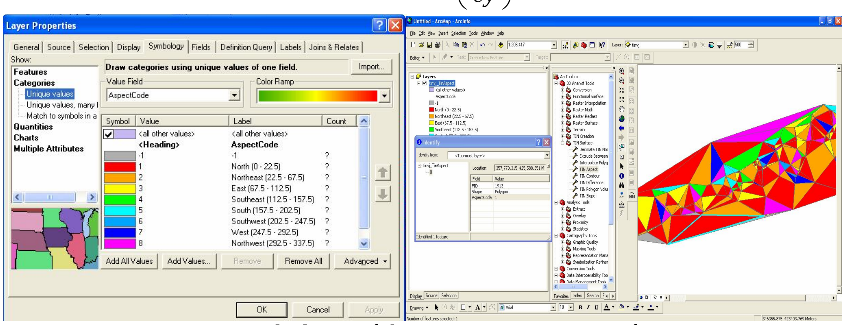

Figure 11 Calculation of the aspect using ArcGIS software

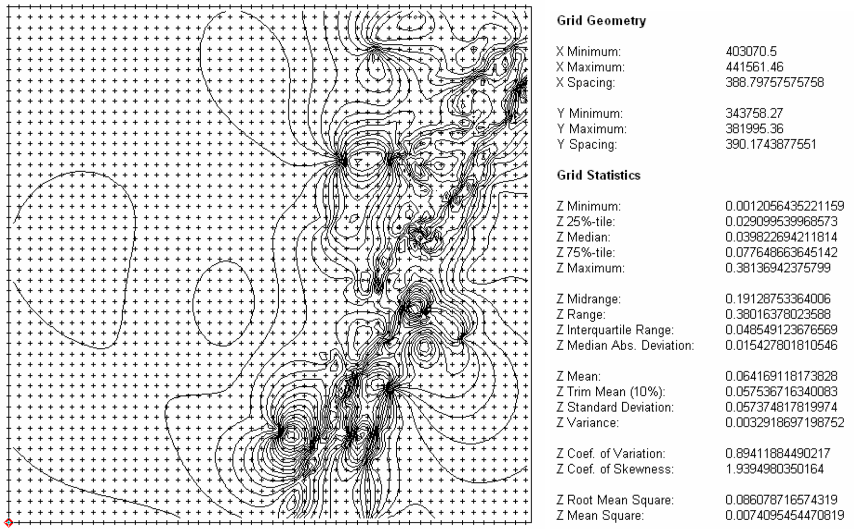

Figure 12 The map of Gradient and Grid Information using Surfer Software

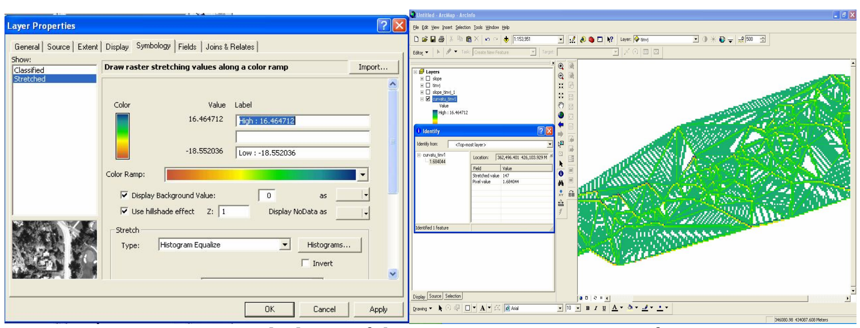

Figure 13 Calculation of the curvature using ArcGIS software

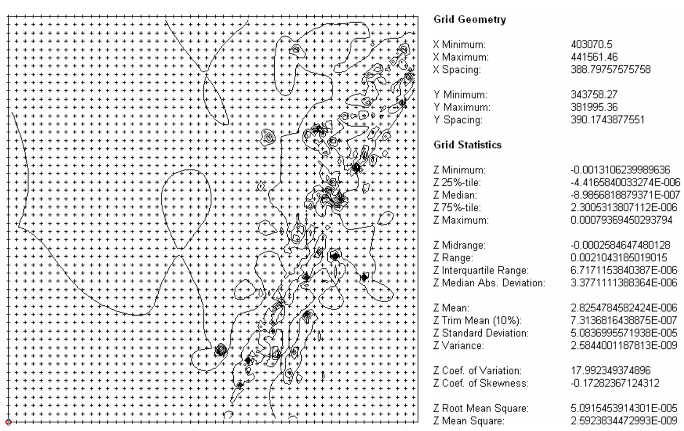

Figure 14 The map of Curvature and Grid Information using Surfer Software

CONCLUSIONS

Many of the uses of DTMs are implicit in their modeling and interpretation techniques. DTM's find wide use in ecological and hydrological applications, such as the computation of hydrological parameters to model water flow in a terrain. A *watershed* is used for this purpose in order to determine the catchments area, by identifying the steepest downhill path extending from an area of interest. Other common applications are the development of soil erosion models, glacial modeling, landslide prediction, catchment's and drainage network analysis. Risk assessment of avalanche and fires are other highly critical applications in which DTMs are can be used. Identifying areas having a high risk of fire by also take into consideration various conditions such as wind direction, amount and type of vegetation and steepness of slopes. Civil engineering applications of DTMs include highway and railway design. Other than these, they are also used in military applications, flight simulators and interactive computer games.

BIBLIOGRAPHY

1. DAVIS, D., - „GIS for Everyone", ESRI, 1999
2. IONESCU, I. – "Engineering Photogrammetry", Ed. Matrixrom, Bucuresti, 2004
3. HERBEI, M., - "Performing a Geographic Information System into the areas affected by the mining exploitations by using modern techniques and technologies" - Doctorate thesis, Petrosani, 2009