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* Kinematics Geometry and Mechanisms
* Applications of Polyhedra theory
* Fractals
* Computational restitution
* Stereoscopy and Stereography
* Virtual reality

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* Perception and meaning of colors
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* History of geometrical education

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* Multimedia Educational Software Development
* Virtual Reality Educational Systems
* Educational Software Development Tools Research and so on

DEVELOPEMENT OF DIGITAL MODEL OF TERRAIN (DMT) USING AUTOCAD AND SURFING SOFTWARE PACKAGES

Bojan Vujičić[165]
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Marija Obradović[167]

RESUME

This paper considers a problem of developing a digital model of topographic surface (terrain) which, as an empirical surface, requires a specific approach in 3D modeling. The solution is found by using two software packages: AutoCAD, used in classes of Computational Geometry, and Surfing, used as an educational tool in several subjects at the department of Survey, on the Faculty of Civil Engineering in Belgrade. We compared these two techniques of DTM development, in order to determine the advantages and deficiencies of both. Through creating different digital models and comparing the obtained results, our goal was to contribute upgrading the techniques of processing topographic surfaces, as an important segment of planning that connects Computational Geometry and Surveying.

Key words: digital model of terrain, AutoCAD, Surfing.

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1. INTRODUCTION

From the ancient times, man has tried to record the informations about the form and the surface of the terrain on the ground, and to present them in various ways. Some of the first methods were the drawings which are the forerunner of today's maps, and had very low accuracy. As mankind progressed, the technology in this field of science has reached an enviable level.

Horizontal projection was once the only way of showing the terrain's topography. It shows buildings in only one, the first orthogonal projection, ie. *top view*. Because just one projection (orthogonal or oblique) does not specify the location of a point, or any element in space, it is necessary to assign an additional coordinate next to the first projection of each point. The height coordinates expressed in numerical value are called the elevation.

Today, the representation and analysis of terrain are performed using the technology of digital terrain modeling.

Digital terrain modeling is made possible by the rapid development of computer technology. The digital terrain model - DTM[168] is one of the most widely used products in areas such as planning, construction, geology, ecology, telecommunications, transport, geodesy, cartography, and others. The main advantages of DMT in comparison to analogue models (maps) are:

- Simple data analysis
- No loss of accuracy over time

[168] The introduction of the term Digital Terrain Models is attributed to two American engineers from Massachusetts Institute of Technology (MIT). The definition they gave in the late fifties states as follows (Miller 1958): Digital terrain model - DMT is a simple statistical representation of continuous surface soil over a large number of selected points with known X, Y and Z coordinates in any coordinate system.

- Easier management and updating
- Wider range of accuracy and level of detail precision, depending on current needs.

1.1. Digital Terrain Modeling

Process of terrain modeling in digital form consists of several stages, as follows:

- Collecting data (X, Y, Z coordinates of sampled field's points)
- Creating the digital terrain models
- Data Management of the terrain models (updating, distribution)
- Various analysis of the model.

All these stages are dependent on each other and within themselves contain some conditioned operations and disciplines. In the phase of data collection, the most represented are disciplines such as geodesy, Cartography, Photogrammetry and Remote Detection.

During the phase of forming DMT- the mostly represented disciplines are Geosciences, but there are also Computational Geometry, Computer Graphics and Digital Imaging, as well.

In the phase of DMT data management, we use the knowledge and technology related to the Spatial Database, data structuring techniques, web technology, Computer Graphics and other.

In DMT analysis and application, there are included all the Geosciences (Geodesy, Photogrammetry, Cartography, Geography, etc.).

The basic idea of this paper is to show some methods of forming a digital terrain model - more precisely: to compare two techniques for software development on DMT commonly used in the studies of Geodesy. The software packages that will be discussed in this paper are Auto Cad and Surfing. It should be noted that only the input data for creating the models, ie. the collected data, are equal for the both software. Data collection was carried out by photogrammetric methods in the ratio of ***1:2500*** for the area KO Bubanj Potok.

2. AUTO CAD

Auto Cad is one of the most popular computer programs for computer designing. Author of the program and many software tools' add-ons is Auto Desk company.

The main program - AutoCAD - is a sophisticated designing tool of a wide, practically - the universal purpose, that supports both two-dimensional design, which virtually replaces the classical designing on paper or drawing board, compass and ruler, and three-dimensional modeling of complex objects in a model space. It can arbitrarily zoom, incline, turn, present the projections, views and cross sections from all the directions, with perspective effect or without them, to arbitrarily illuminate and render, so that three-dimensional virtually displayed image imitates the object that exists only in computer memory.

Using software package Auto Cad 2008, the exercises in Computational Geometry were performed, at Faculty of Civil Engineering, University of Belgrade, Department of Geodesy and Geoinformatics.

2.1. Preparation of DMT in Auto Cad

Our input data were the points taken with their ***X, Y*** and ***Z*** coordinates, of the State Coordinate System. The points imported in Auto Cad can be seen in the following **figure 1**:

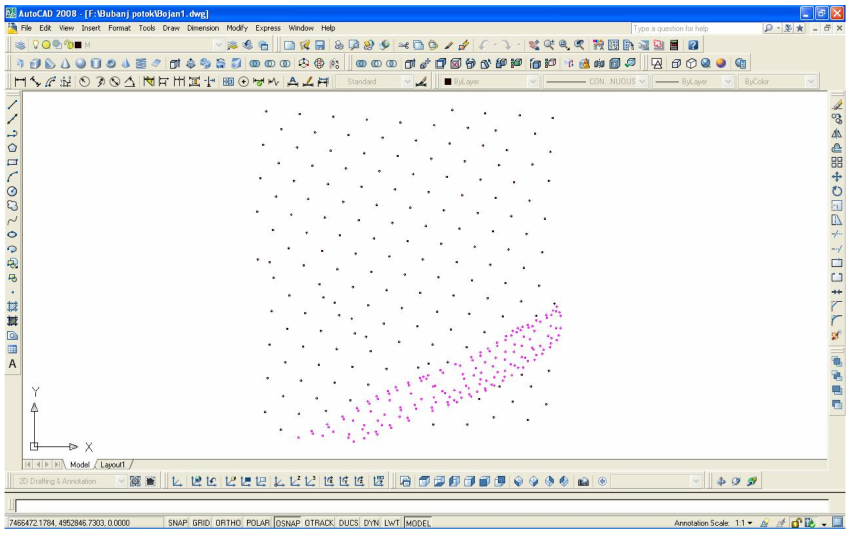

Figure 1: *The Input Data for Producing The DMT*

In addition to the characteristic points of the terrain in our area of recording, there are also the points of a draining ditch (the ditch's characteristic points are given in purple).

With such defined points, it is necessary to perform interpolation, in order to obtain the isohypses of the terrain. Determining the position of isohypses' points was conducted by the proportion between the points (***Figure 2***).

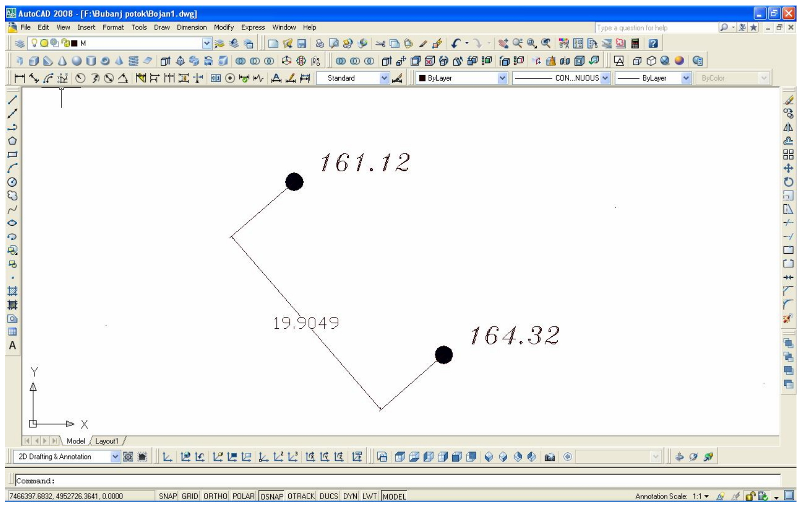

Figure 2: *The Interpolation of an Isohypse (Only the Interpolation Method)*

(H2-H1):D=(He-H1):X

This proportions results the distance ***X***, ie. the length to be applied from ***1*** to ***2*** to obtain the passage of the isohypse I. Tracing the isohypses is performed by the command ***DRAW - Spline*** and after these steps, the drawing is displayed as in the **Figure 3**.

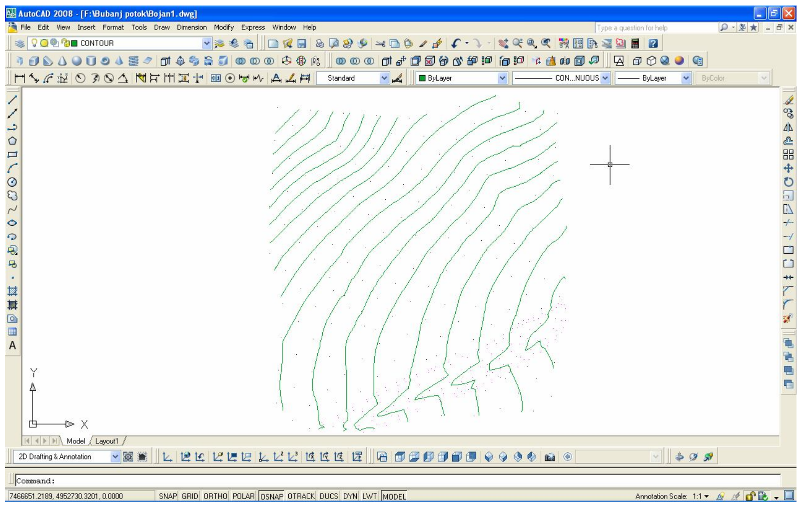

Figure 3: *The Isohypses of the Terrain Assigned By Elevation Points*

The isohypses are located at their elevations, so we do the production of the model by operation **DRAW** → **MODELING** → **LOFT**, which merges the lines assigned in the different (horizontal) levels into a single model (**Figure 4**). If we would use the closed splines, obtained by polylines, the result would be a solid that can be processed with Boolean operators further on.

It should be noted that the entire terrain model is made as integer unit, in the sense that there were not separated the characteristics of the fields points from the characteristics of the ditch's points. So we get the true isohypse for the entire area, for the outside of the ditch, as well as in it, and thus the generating of the model was unique.

There is a possibility of a total separation from the field and later joining the channel (as the intersection of two models, using Boolean operators) but in this case we avoided such an option, because of the large amounts of data and the priorities in making the entire digital terrain models.

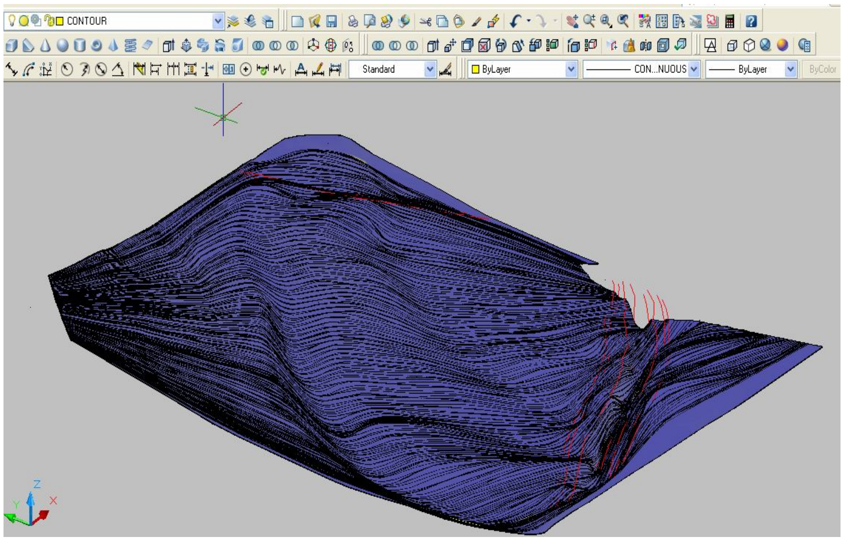

Figure 4: *The Final Digital Model of Terrain of the location Bubanj Potok*

In addition to the previously mentioned features ***LOFT***, this software package contains even some more abilities for modeling the terrain. One of the methods of generating the surface assigned by points – is 3D mesh, a feature that also exists in AutoCAD, in the menu ***DRAW, MODELING***. In order to perform the desired operation and to model a surface with the given points, we need to do the following steps:

We define the number of points within a roughly rectangular matrix of MxN points.

We start the command → ***3DMESH***. At the same time (as shown in **Figure 5**.) we take care in which order we enter the points.

Command: 3DMESH
Enter size of mesh in M direction: 3
Enter size of mesh in N direction: 4
Specify location for vertex (0, 0):
Specify location for vertex (0, 1):
Specify location for vertex (0, 2):
Specify location for vertex (0, 3):
Specify location for vertex (1, 0):

Specify location for vertex (1, 1):
Specify location for vertex (1, 2):
Specify location for vertex (1, 3):
Specify location for vertex (2, 0):
Specify location for vertex (2, 1):
Specify location for vertex (2, 2):
Specify location for vertex (2, 3):

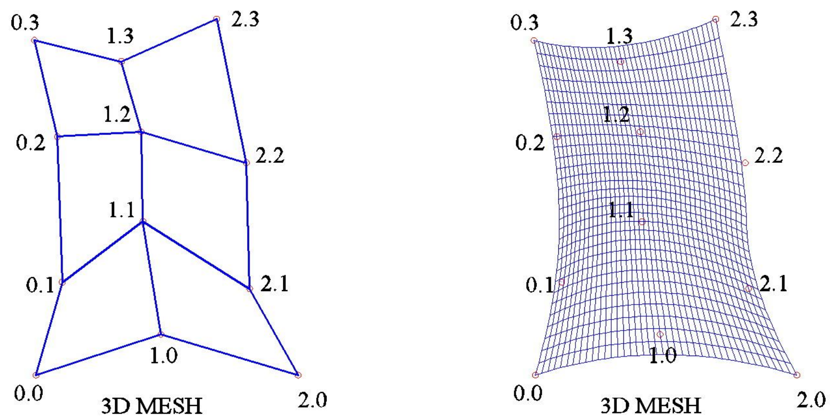

Figure 5: *Forming The Surface With The Assigned Points - 3D MESH And Its Conversion Into A Smooth Surface*

Then, we can turn the resulting surface, which will consist of warped tetralatherals, into a smooth surface, so that such a MESH polygon will be converged to a surface with a larger number of polygons, i.e. isolines that bound them, by changing the properties in the table ***PROPERTIES: Misc***, - instead of ***None*** - we choose ***Quadratic*** or ***Bezier*** (to convert cubic splines into Bezier's). The result is a smooth surface, which can be observed in the **Figure 6**.

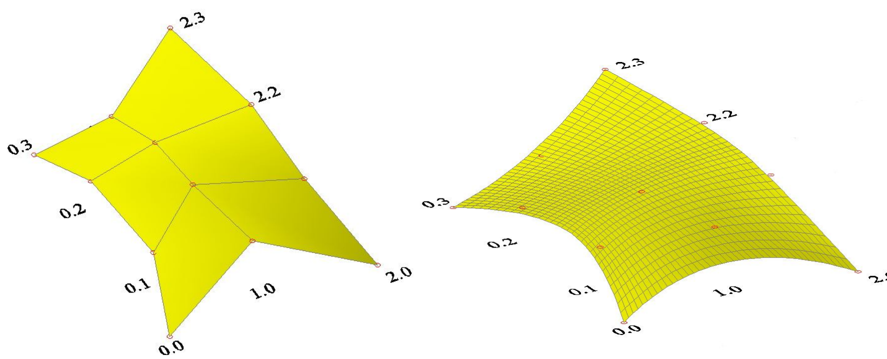

Figure 6: *The Surface Assigned By Points - 3D MESH And its Conversion Into A Smooth Surface Via Option Quadratic, Given In Realistic Visual Style*

3. SURFING

Surfing is a program created by Doc. Dr. Zeljko Cvijetinović Dipl.Geod. Eng. Professor or Civil Engineering, University of Belgrade. This software was designed exclusively for production and analysis of digital terrain models. The software package Surfing is used in exercises in the subject of *Digital Modeling of Terrain* in the department of Surveying and Geoinformatics, at the Faculty of Civil Engineering, Belgrade. Some of the basic characteristics of Surfing are:

- Surfing works on all Windows platforms
- Easy to use, flexible menu
- Provides sophisticated algorithms for the high quality of the terrain surface
- Use Bezier splines
- Very good visualization and 3D
- Quick interpolation of unknown points' heights (elevations)
- Combined with software MapSoft, the leading cadastre software in Serbia.

The overview of the software package **Surfing** is given in the

Figure 7.

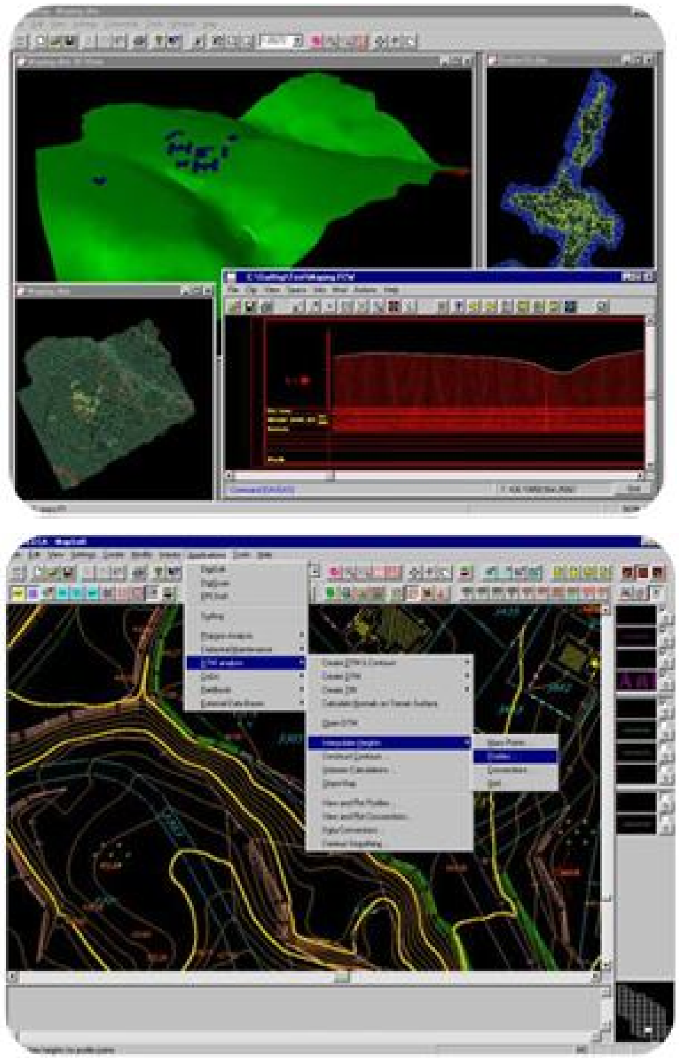

Figure 7*: The Overview of The Program Package Surfing*

3.1. Making DMT in Surfing

Input data for the DMT made in the Surfing program package, are exactly the same as in AutoCAD, ie. there are the points with their ***X***, ***Y*** and ***Z*** coordinates, given in the coordinate system of the Republic of Serbia. After we launch **Surfing**, we load the given data and produce DMT.

Making terrain models is done by command:
Command:_Surfing project.

As we can see in the **Figure 8**, the same points of the terrain, as were assigned in Auto Cad, are now assigned in Surfing.

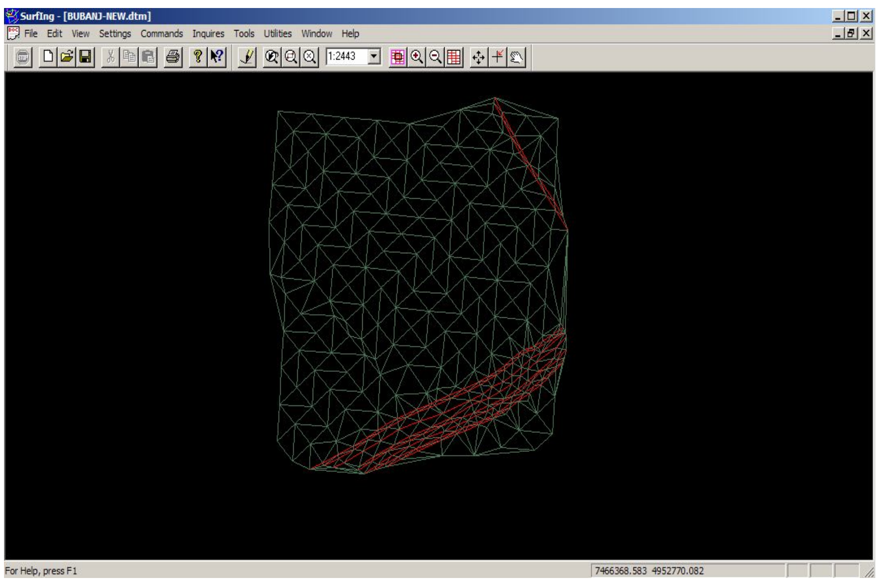

Figure 8: *Producing the Digital Model of Terrain in the Surfing Program Package*

By the command: **Surfing - View - 3D View**, we do the 3D visualization of the model, as shown in the **Figure 9.**

This is followed by smoothing the resulting terrain, which gives a very good interpretation of the ground topology, which can also be seen at the **Figure 10.**

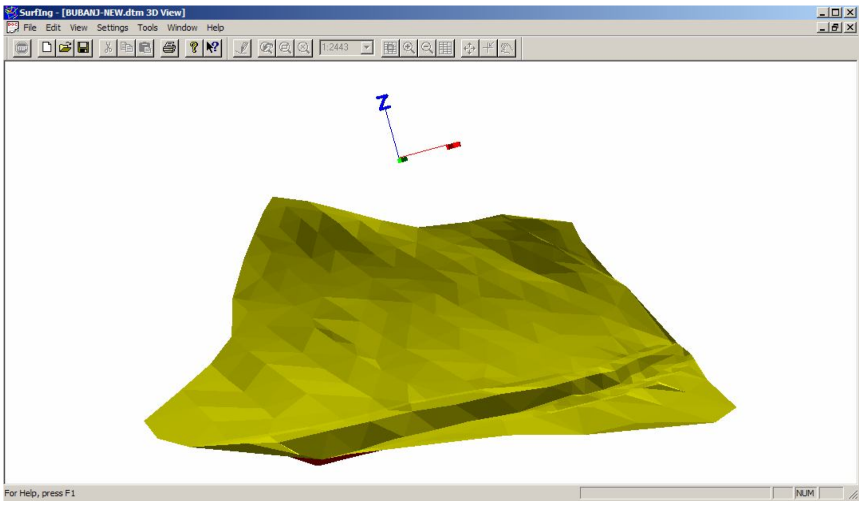

Figure 9: *The DMT with 3D Visualization*

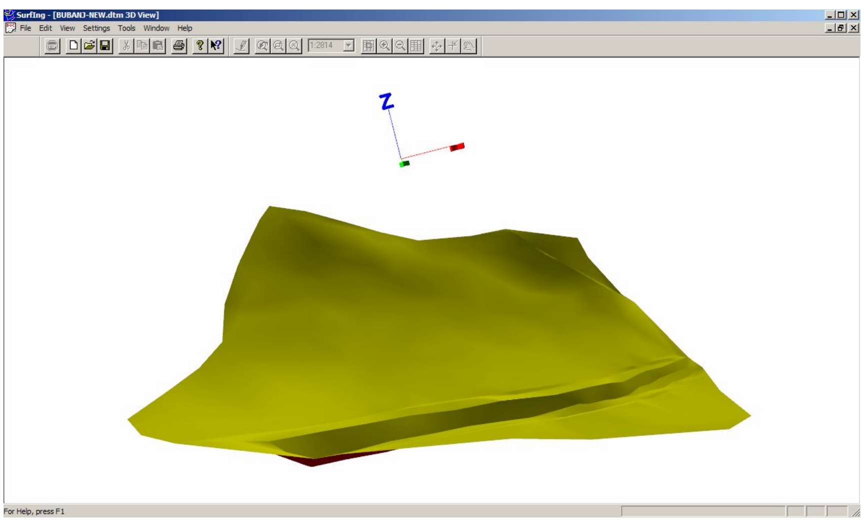

Figure 10: *The Smooth DMT with 3D Visualization*

Conveniences of working with the software package Surfing are: very simple utilization and excellent results.

4. USING AUTOCAD AND SURFING

One of the key advantages of AutoCad is a distribution of the software and universality, broad and massive use, not only in Geodesy and Computational Geometry, but also in other related technical sciences. It is very accurate and has a lot of serviceable features for the terrain modeling as a continuous surface, in digital form. Making a model as illustrated in the given figures, takes about an hour, whereat isohypses' interpolation takes up time. It is quite complicated to interpolate the unknown height points. But, it should be noted that basic Auto Cad is not designed with intention to solve specific problems of modeling topographic surfaces. Furthermore, the more advanced 3D modeling tools have been developed only recently, since version 2006. Nevertheless, there is possibility of upgrading it with additional plug-ins (AutoCad Survey) or just turn to a special program (Terrain CAD) which is specially designed for solving the problems of modeling topographic surfaces.

Benefits of Surfing are numerous. Let's start from the fact that this software package is designed specially for the purpose of terrain modeling. Time needed for the model is measured in minutes. For 10-15 minutes, the terrain (concerned in the examples) is modeled, which continuous surface is created using Bezier splines. As for the interpolation of the unknown height points, it is done in Surfing by a very simple function: **surfing command_interpolate heights** even in several possible ways. In terms of accuracy, this software package has a satisfactory accuracy which can match the accuracy of AutoCAD. Distribution package is much smaller compared to AutoCAD, which does not diminish the value itself.

	Surfing	AutoCad
Processing time	+	-
Model Accuracy	+	+
Interpolation	+	-
Surface Intersections	+	+
Distribution	-	+
Use in studies	+	+

Table 1: *Comparative Review of Two Softwares*

The comparative overview of the advantages and disadvantages of the considered softwares is given in **Table 1.**

5. CONCLUSIONS

From the all above, it can be concluded that the Surfing program is more appropriately equipped for **digital terrain modeling**, but that AutoCad is also very useful and desirable software for particular requirements.

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