

# ASPECTS OF DATA MODELING OF FUSED SURFACES WITH PLANIMETRIC DATA IN A TOPOGRAPHIC GEODATABASE

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### ABSTRACT:

As a result of building a topological surfaced geodatabase for the test area, the paper discusses the investigation of modeling 3D surface data, and its fusion with other planimetric modeled data, and storing it in a geodatabase, maintaining the special relationships of the data, its retrieval and representation methods, taking into consideration the quality aspects of the surface data, its validity, and its structured properties.

In older days geographic, topographic, cadastral and thematic maps were produced to represent special information to the user, these maps in many cases contained surface information, using for example contour lines with specific thickness, interval, and collected with a special accuracy, coinciding with the grade of goodness of extracting these elements from the maps.

Now a days maps still play an important roll in the information technology world, with an exceptional event of form and nature variation, altogether with its flexibility they became dynamically created by the GIS user from a distance through networks, to suit her/his or the client's requirements, thus creating digital thematic maps and reports, which means the source of this information (Geodatabase) has to be prepared with an up to date information , composing planimetric data and surface data altogether with their relationships stored, which shall regulate the way of retrieval, presentation and updating of the data and information, as well as quality aspects.

A particular example is chosen for investigation, which uses an internet GIS application software that provides the user with online raster images, combined with the particular vector data selected from the map composer or using the inquiry system, retrieved from a Geodatabase.

So what happens when the users requires surface information to be combined with their maps; this shall rise up the following investigation facts, and others:

What kind of data categories complies with which surface style it can be shown.

(Vector, Raster, contours, spot heights, 3D modeled surface, ..etc )

What are the viewing aspects that shall be considered when adding these surfaces.

(Scales, transparency, colors, thickness, interactions with other data, ..etc )

Should the quality of the surface be indicated.

(In many cases the accurate height information demanded, the quality may deceive)

What is the validity of the information.

(time of acquisition, changes happened in a particular area, ..etc)

What are the relationships of the data, the surfaces should maintain in the Geodatabase

## 1. INTRODUCTION :

Maps of a particular scale falls under a category of geographic, topographic or cadastral, each of which has its own way of representing and showing surface topography on their margins which was traditionally expressed by the isometric curved lines (contours). The height difference between successive contour lines depends on the scale of the map among other factors; which limitations is a function of the smallest readable element from the map and the steepness of the surface. In comparison with conventional mapping techniques GIS presents surfaces in many ways one of which is the contour lines, which is unique among other surface presenting formats due to its capability to be contributed to final digital two dimensional planimetric details without covering it, but the rules of representing the surface upon the

planimetric data within GIS platforms are of importance for showing the accurate information for decision making and should be taken care of through modeling rules and tools of geodatabases.

These rules should be designed and invented to solve the representation of the surfaced data, taking into consideration the type of data, its accuracy, its degree of goodness to express the surface when combined with different categories of planimetric data, and the cartographic rules such as exaggeration, generalization and other rendering rules.

Different data structure types of surfaces contribute to a certain accuracy, depending on the sources of the data and its accumulating errors due to processing and interpolation. This accuracy can not be realized by the end user just by looking

into the data and using it, the matter which may lead to incorrectness of decisions made depending on it, as much as to inaccuracies of designs, for instance if a planner is to set a sloping of a sewage network to an accuracy of half a meter based on a terrain model which may reach an error of one meter at some areas, due to the lack of knowledge concerning the accuracy and validity of the DTM an error may occur, the matter which necessitate planners to have a full information concerning the goodness of the data used .

Some surfaces change rapidly and some times drastically due to artificial urban development, as much as due to tectonic natural phenomenon, which means an up to date should be following to keep its validity, again this fact can not be realized by simply using the data.

As an example of showing the importance of rules defining the relationships of the surface data, is that a contour can not cross an other, a blunder which is still being created by interpolating software while smoothing lines or fitting surfaces, other than that is the density of contours in steeper areas or the discreteness of the contours among others.

The paper discusses these facts and more for the different surface structures, showing the advantages and disadvantages of the different structures, and the rules should be encountered in the geodatabases concentrating the quality of the surfaced data and its effect on the result.

## 2. METHODS OF PRESENTATION & DATA QUALITY

For expressing the quality of the data, some information should be tabulated in such a manner that it can be viewed with the data itself expressing its accuracy, even if the accuracy of the data is changing from one part to the other, the stored accuracy information in the geodatabase should be able to discriminate between areas of different accuracies using specific annotations.

With a similar way as storing the topology and networks in the geodatabase accuracy can be a part of the geodatabase or when storing spot heights or contours the accuracy can be added to it as a property of the layer or the class.

With out keeping records of the data accuracy and expressing it with the data, the operator has to extract the knowledge of the data accuracy from reports or records, and the end users may use the data in a wrong manner effecting the quality of designs based upon this data.

### 2-1 Quality of Surfaced data

Generally speaking the quality of all the surfaced topographic data depend on the following factors:

Source of the data,  
Method of Data Collection,  
Density of the Data,  
Interpolation and processing methods,  
Digital Format or Structure of the Data,

**Source of The Data:** The source plays a major roll in the quality aspects, different data requisition methods are available choosing among which results in a certain quality measures, since the source can be using field survey measurements for instance directly from the ground or can be from photogrammetric stereo image pairs where the variation of the scale means a variation in quality as much as the overlapping areas between the images.

Other sources can be satellite stereo images, also radar data became an important source or data collected using laser beam technology, an other source can also be old and existing digitized maps or stored data.

Thus the quality measures begin at this point, where propagation and accumulation of errors begin, in case of the data collected using field surveying measurements, starting by the quality of the existing height control network, its reference, its projection, its adjustment and its density, followed by the type of instruments used, the methods of data collection, certainly a very important factor is the experience of the surveyors in collecting such types of data, and finally the processing of the data, altogether with the interpolation methods, and the representing structure.

**Method of Data Collection:** Talking about the effect of the data collection methods on the quality of surfaced data, we are to supply an example of using the most usual methods of data collection, the Regular networks and irregular scattered, If the data is collected directly from the field taking into consideration the steepness would provide closer surface to the reality than collecting the data using a regular spaced network, the type of instrument used such as plane table or using a total station or GPS would certainly effect the quality of the data. On the other hand if the data is collected using photogrammetric workstations, then factors such as the length of the base with depend on the overlapping areas, the scale of the photography, results of the triangulation and adjustment, manual data collection in urban areas, and automatic data collection would certainly effect the quality of the surface.

**Density of the Data:** As matter of fact the density of the data should have a limit that complies with the final data format and accuracy to be reached, flat areas demand less density than others, designing the density should be economically worthy. Raster data for example has a regular and equal density every where, which means that flat areas are accurate while hilly areas may lack the required accuracy.

For solving this particular problem of data to be collected using field survey or manually from stereo pairs should be designed with a certain surface modeling factor, this modeling factor will determine the number of pints to be collected within an area. Because the surface modeling factor has an influence on the time and price of data, we should consider total quality measures for designing such a factor, some of these measures are:

- what kind of implementations the data shall be created for ?
- How often the data is updated?
- Is it economically worth it, to go for such an accuracy?
- Is there a probability of using this data for other aspects in the future?
- What shall be the structure of the data, and what kind of limitations may the structure nature cause to the data.

Considering these factors and others, a certain surface modeling factor is selected such as, collect data if the height difference tends to a certain limits, in other words height difference between successive mass points should be limited to a certain measure, when ever it is possible (Buildings or such obstacles may intrude such a process).

This can be one modeling rule which regulates the quality of the data collected or measured, another rule which if combined with the surface modeling factor rule can be the maximum horizontal distance between the successive mass

points; thus when ever the surface modeling factor is not reached and there are no obstacles, data are to be collected in a regular network format. Implementing such rule shall density mass points even if the areas are almost horizontal, a fact which may be useful when it comes to some types of surface interpolation methods.

Surface modeling factor rule can be defined as follows:

$$Sd = Md / \sin \text{ alfa} \quad (1)$$

$$Hd = Md / \tan \text{ alfa} \quad (2)$$

Where  $Sd$  = Maximum slope distance between successive. Points  
 $Md$  = Surface modeling Factor represented by the maximum height difference between successive points.  
 $\text{Alfa}$  = slope angle between the successive points.  
 $Hd$  = horizontal distance between successive points.

Supposing that the suggested grid distance is  $Gd$ , the horizontal distance between successive measured points shall be  $Hd$  where the slope is steep, but shall not exceed  $Gd$  for less sloppy areas. If these rules are implemented then a certain quality can be reached. For example if I require my data to be measured with a grid distance of 10m and my surface modeling factor to be 1 meter, the I shall assure that my model dose not deviate from the real surface by an error grater than 50 cm which is the maximum expected interpolating error between successive points taken as half the height difference value between the successive points.

**Data collected Using existing Maps:** When digitizing existing maps, we are to consider some more errors depending on the digitizing method, the scale of the map, the interval of the contours, and the validity of the data, so that an assessment of quality can be made. This method shall obviously present an accumulation of errors, and overshooting contours shall create an error depending on the steepness of that particular segment.

**Interpolation and processing methods:** A very effective part of quality aspect of the surface data is interpolation, and that is because we are seeking to represent the infinitely continuous surface using the limited collected surface information, so the interpolation method is very hectic and depends on how many neighbor points it considers and with what kind of weighting rules, the distance to the nearest points, the density of the data, the roughness of the terrain, and others such as surface fitting.

**Digital Format or Structure of the Data:** The digital format on the other hand shows the final result, it makes a big difference if data is collected with a certain accuracy and represented with a less accurate method or visa versa, both situations shall mislead the operator in a way or other, and some digital structure formats are more convenient and legible to be used for representing the surface fused with planimetric data. For example contours can give a pleasant looking when superimposed on planimetric data to express the surface, although TIN data are far more accurate, raster data on the other hand provide a general impression about the terrain.

Then choosing between the different Surface structures shall dominantly depend on the purpose the data should be used for, it can be one type or a combination of several structures.

**Total accuracy of data:** If we suppose that the total deviation from the truth height at a certain point on the surface is equal to the sum of deviations resulted due to the accumulation of errors, then

$$dz = Sn + Sm + Si + So \quad (3)$$

Where  $dz$  = total deviation of the z value of a surface point  
 $Sn$  = error due to the control network used  
 $Sm$  = error due to the measurement method  
 $Si$  = error due to interpolation  
 $So$  = other accumulation errors

Thus when planning data collection methods and modeling aspects the sum of these errors has to be taken into consideration and the result should be reflected with the data to overcome problems accruing due to misleading visual representations of the terrain models.

Other errors can be such as the incompleteness of measured break lines.

## 2-2 Representing Quality of the data

Among other aspects the quality and validity information should be encountered with the data. Some proposed methods are for example creating a buffer around contours in a separate layer showing the maximum deviation of the values of the contours, creating error ellipses around measured points, and registering meta data of the feature classes showing the validity of the data such as date of measurement, source of data, assessed accuracy, interpolation method, etc.

## 3. Modeling Rules

Rules should be set for height data in a geodatabase, in such a manner as topology rules, implementing topology rules for parcels as an example such as parcels must not overlap, shall insure a certain quality of the planimetric data, a rule that data can be validated for. If we design similar useful rules for height data we shall be able to insure a certain quality and cleanness.

A simple rule is not to allow contours to cross, may show the effected blunders created by certain DTM software when interpolating and smoothing of the contours.

A rule setting the maximum surface modeling factor  $Md$  as in equation (1) to be 2m, shall validate all model points to be within this range.

Setting a rule for changing the contour interval as a function of the displaying scale and average steepness of the zoomed area, shall insure a pleasant representation without covering the planimetric details under the data .

Other rules which can filter TIN structures, such as maximum triangle side length.

Considering such modeling rules and others such as color and thickness of contours in certain areas depending on the background, shall prevent many errors that can not be seen other wise without checking the whole data against those rule, it shall provide a certain limit of automation, and comicality.

## **Conclusions**

The surfaced data should be accomplished with accuracy measures information, and validity information to prevent misleading designs of GIS based on this data. Before using height data assessment should be made and accuracy measures should be encountered in the geodatabase in away or an other, also total quality aspects should be considered before data collection to set a surface modeling factor.

Encountering modeling rules in a geodatabase shall benefit users by insuring data quality and cleanness against these rules. Further investigations are to be made for implementing such rules and others with the different terrain data modeling structures.

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