Easy digitalization and representation of three-dimensional maps

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Abstract

A software which can digitalize and show in three dimensions cartographic maps has been carried out. From two-dimensional maps a digital model is obtained, this model has the information of co-ordinates and data level. Once the model is done, it can be shown in three dimensions making ease the notion of relief of the land. To make this process, a examination of the cartographic pattern that appear in the maps has to be done, and work with process for the representation of images. The result is a compromise solution between speed and resolution of the model.

1. Introduction

The cartographic area envolves the colection, storage, handing, evaluation and application of the cartographiable information. Moreover, important environmental data have to be generalizated to comply with the scale and with the intention and essential of the user who will use the product. So, graphic design principles have to be applied in order to achieve a understandable cartographic visualization.

The reduction of the time and cost in the generation of maps and graphics are considered as the predominant present tendencies, and in the close future as web. Besides, it is important to consider the quality to improve the communication between the computer and the user, that is to say, the information given by the computer has to be accurate and friendly. The implementation of these goals is possible by means of the Geographic Information Systems (GIS). Nevertheless, the use of this kind of systems means that the user has to improve the traditional methods with new skills.

The Geographic Information Systems are automatic methods to capture, store, check, integrate, operate, analyze and show in a computer screen data which are geographically referenced to the Earth. There are three fundamental components: a data base, a statistic-mathematic algorithm with capacity to analize, and a resource to show the information graphically.

2. Analysis

Maps will be processed according to their type, that is to say, with the kind of representation. Maps are classified by the way of how altitude is represented. We will consider two different methods to indicate what the altitude is in one point of a map:

- by means of isolines or
- of a colour code.

Isolines are drawn in maps by means of continuous lines and with the same colour and wide. Also, those isolines comply with a series of geometrical specifications: isolines can not intersect and each one either has to be close or has to begin or end in the border of a region. Near to the isolines the value of the parameter corresponding to a given isoline is written. These values or numbers are placed in the map with a determined direction in relation to the marked isoline. Usually two kind of isolines are used in maps: mains and supplementaries. The last ones generally have different wide.

Maps whose altitudes are referenced by colours have normally a legend or caption. In this legend, data corresponding to the map and colours used with their meaning are shown. In our case, the legend indicates the relation between colours and altitude. In order to represent three-dimensional maps by means of a software, it is necessary to have the information in vectorial format in relation to the height above sea level. To achieve this goal, a digital process has to be apply to the map. This process will give the information of the surface in vectorial format.

2.1. Digital processing. There is a manual digital process used in GIS applications that makes use of a digitalization board. With this method, the operator traces manually all of the lines of the original map by means of a digital pointer and creates a digital map in the computer that is the same as the original one. Each line is digitalized through a serial of points capture along this isoline.

There is another method similar to the previous one (because of the lines are traced manually) that works directly on the computer screen through an scanned image of the map as background. Once again, the lines have to be drawn manually. But the accurate is higher since the scan process is made with a high resolution; moreover, there are other kind of tools like the zoom, etc.

Other method is the automatic digitalization. Lines are traced automatically over the scanned image of the map by means of image processing and pattern recognition techniques. The aim of the digitalization algorithm is substitute the operator for the computer.

Even though the methods for the digitalization through *manual* tracking of level isolines are direct methods, they require experience and a great quantity of time for their implementation. These methods also require special devices as digital pointers, etc. That implies the project increase its complexity and price. But the actually disadvantage is the low accuracy. It depends on the success of the operator when he or she traces the isolines. In the case of working with the original map (and not with the scanned one), the accuracy is even lower, since in the previous method there are available tools as zoom, etc. to make easier the task in complicated areas.

In the *automatic* digitalization, the tasks that the user has to implement are minimal. The user only has to select the map what will be processed and some other simple decisions like what the colour has the level isoline, etc. It is the computer who is taken charge of implement the rest of the process (tracking of isolines, etc.). But it is normally an hypothetical case, since there are generally identification errors which require user's supervision in order to resolve difficulties. The quid of the question, or the solution, is the complexity of the software (because it require complex algorithm of pattern recognition) and how friendly the program is. On the other hand, the computer is fast enough processing the data map and it is cheaper than methods that need tracking devices.

2.2. 3D Representation. The solution has to be easy to use and friendly. Moreover, the product has to be accurate, reliable and sound. Obviously, the answer speed of the software has to be fast. To resolve these questions a mixture of a visual language (Visual Basic) and API functions has been selected.

3. Implementation

In both of the cases of representation of a map (by isolines or by colour code), the map is previously scanned.

The software is structured in two parts or programs: one correspond to the digital processing of the two-dimensional map (MAP2D3D), and the other one represents in 3D this map (MAP3D).

The first program, MAP2D3D, is implemented based on the interface SDI and the next figure shows its general flow chart.

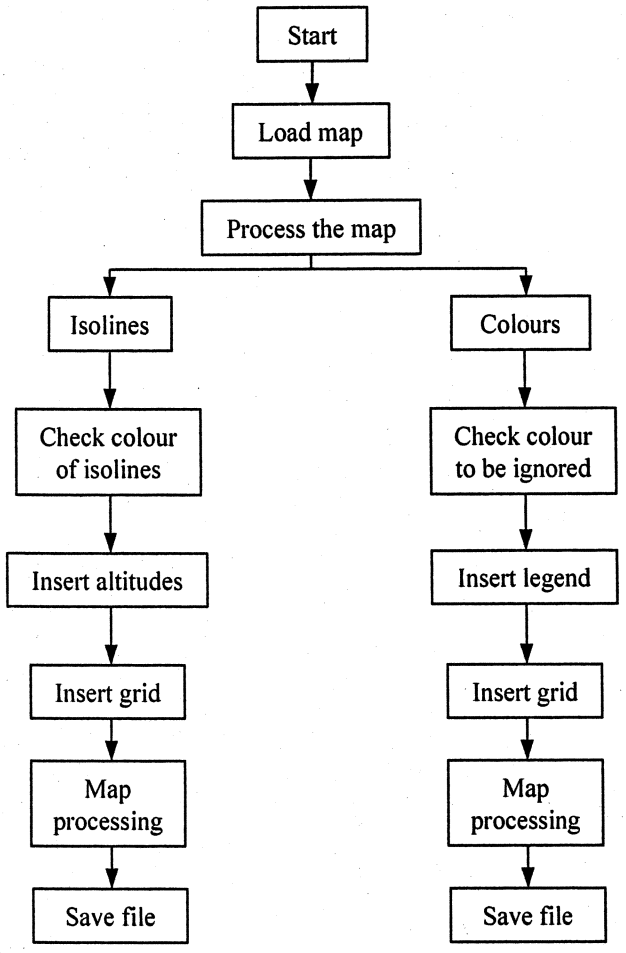

Figure 1: *Flow chart of MAP2D3D program.*

The search of the isolines is based on a colour comparison. Because of the colours introduced by the user when he picks with the mouse in the isolines, the program makes an interval of colours that will be used to find those isolines. When the software finds a pixel which colour is inside the interval, the program allocates a particular colour to this pixel. After that, and if the isoline is completed, altitude of the pixel is allocated. In order to be more clear for the user, and when the previous process is finished, by means of an API function the gap between two isolines is coloured. Besides, in this way the software makes his own legend.

To allocate altitudes to the two-dimensional map, intermediate values between the altitude intervals are taken. In the case of isoline maps, an own legend is made by the software (as we said previously). In the case of colour maps, half value of the altitude interval is taken.
The second program, MAP3D, is implemented based on the interface MDI and the next figure shows its general flow chart.

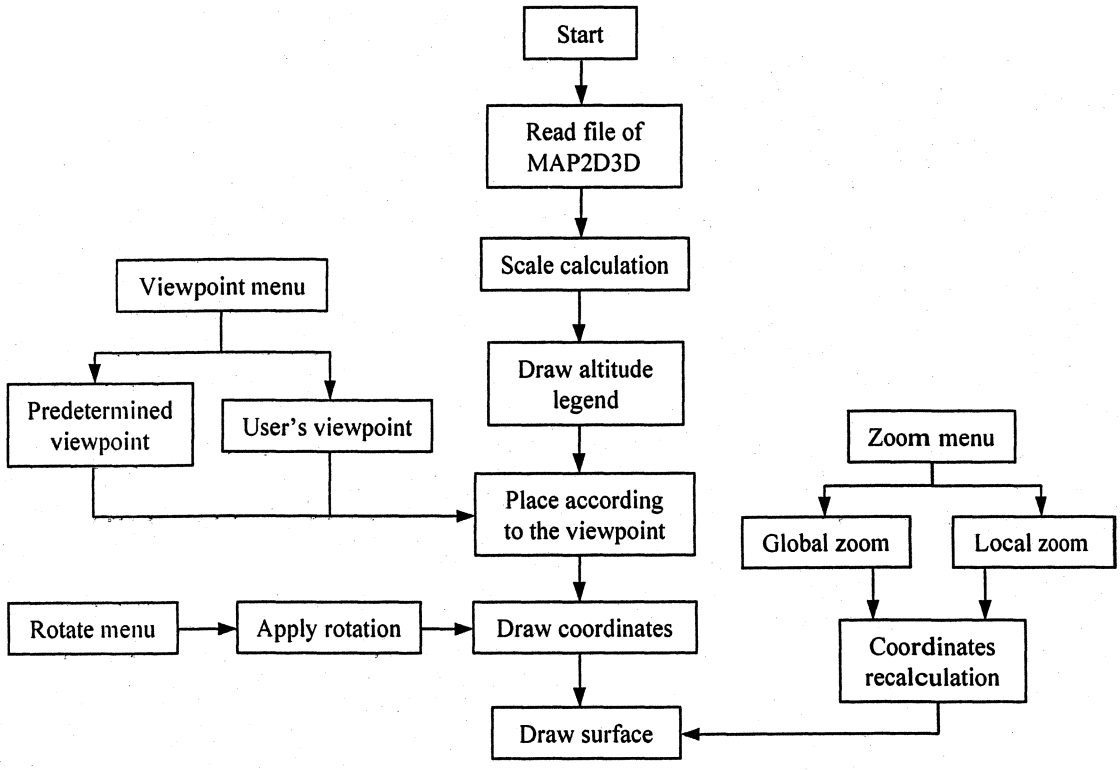

Figure 2: *Flow chart of MAP3D program.*

The way of representating the final three-dimensional surface of the map is by means of triangles in order to give more realism to the representation.

4. Results

4.1. Digital processing. Either if the representation of the map is made by means of isolines or through a colour code, out files are text files, so that they are really easy to use, operate and edit. Data are organized in two parts: one contains all of the nodes in which the surface of the map (in two dimensions) is is separated with their corresponding space coordinates; the other part has the triangular structure that joins the nodes in order to construct the three-dimensional map. These files will be used by the MAP3D program.

We have two posibilities to create this out files. For maps representated with isolines, the software asks the user to indicate which colour the isolines have and the gap (of altitude) between them. With the colour the computer finds the isolines and asks to the user wich is the altitude that corresponds to those isolines. Thus, it creates its own caption. Once the computer has the legend, it takes points in the map (according to the grid that the user selects) and ascribes the altitude that corresponds to each node according to the legend.

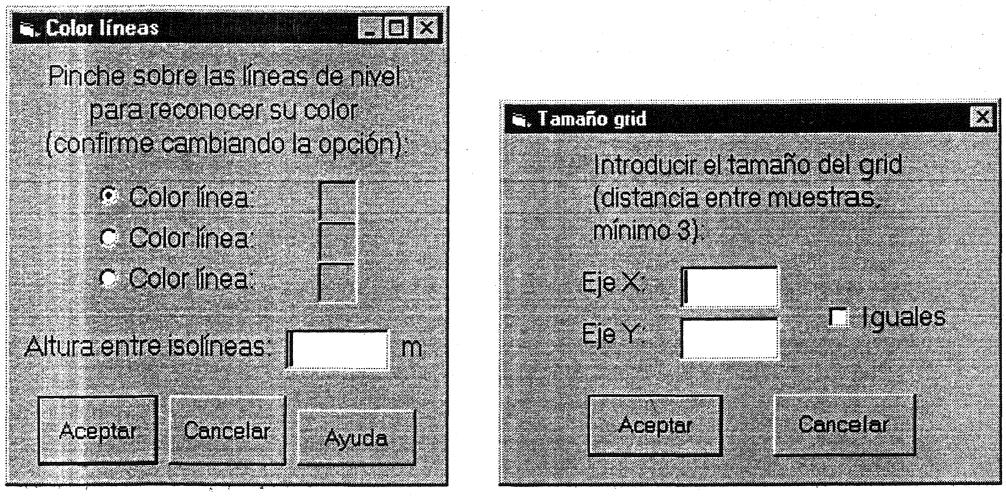

Figure 3: *Colour of isolines and grid size menus.*

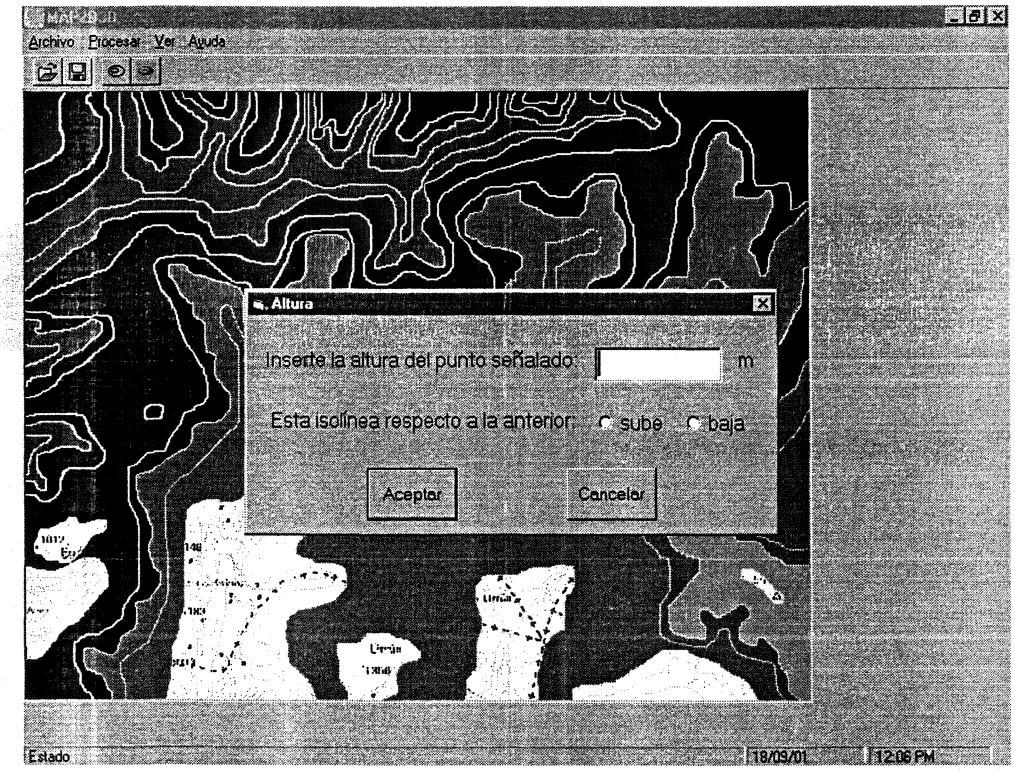

Figure 4: *Isolines drawing and altitude menu.*

For maps represented by means of a colour code, the software asks the predominant colour of the 2D map that has nothing to do with the colours of the caption. Then, the program also asks the legend of the two-dimensional map. The legend links the colour with the altitude that represents. Afterwards, the computer takes again points in the map and ascribes the altitude that corresponds to each node according to the colour code.

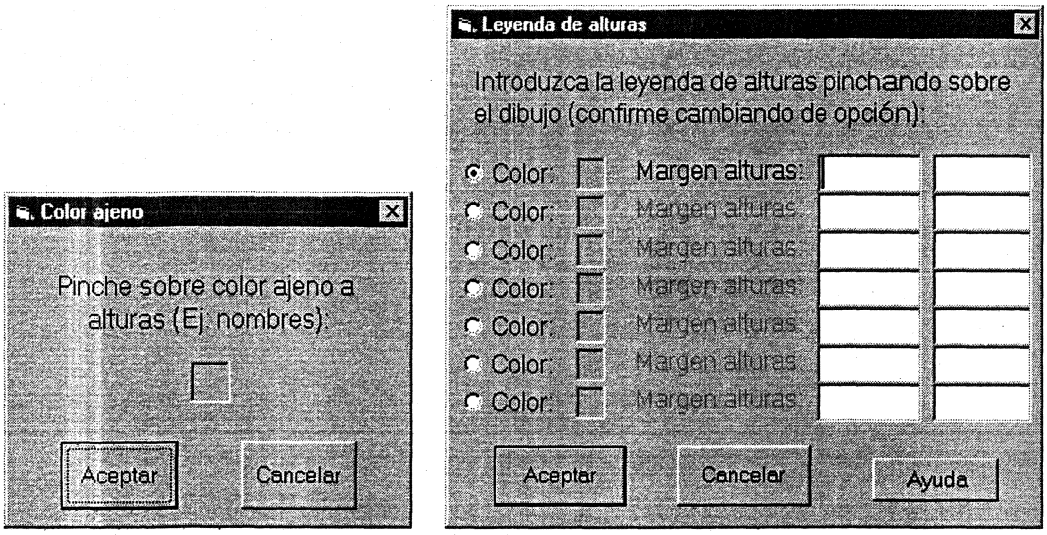

Figure 5: *Different colour and colour questionary menus.*

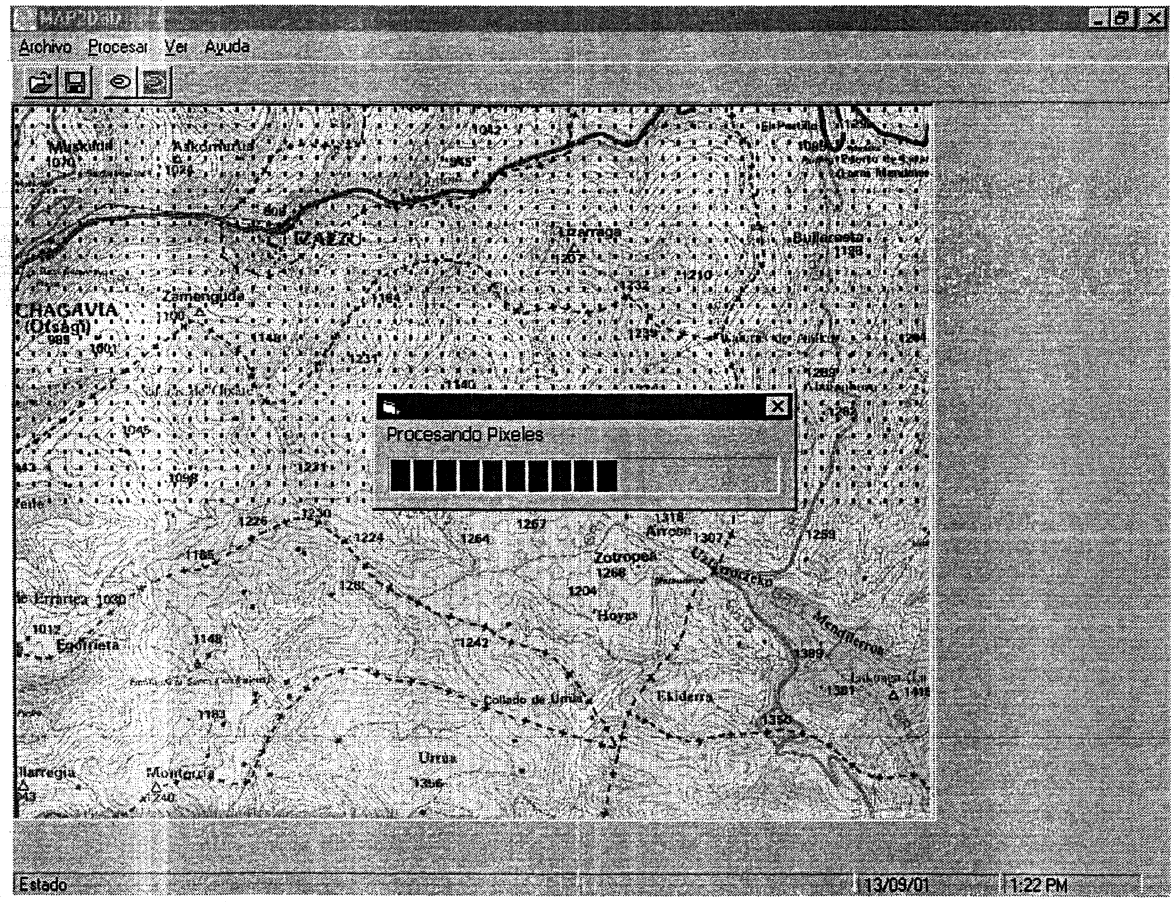

Figure 6: *Processing map based on colour code.*

4.2. 3D Representation. When a map is selected to be represented by the MAP3D program, it always use triangles. It begins with a predetermined viewpoint, together with coordenate axes and a colour scale to show the altitude. The tools that the program can use are tipical zoom,

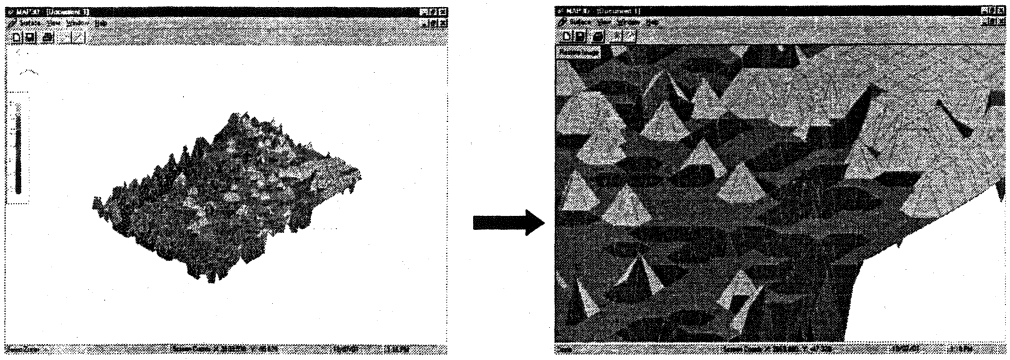

Figure 7: *Local zoom.*

rotation with a user viewpoint or moving the mouse,

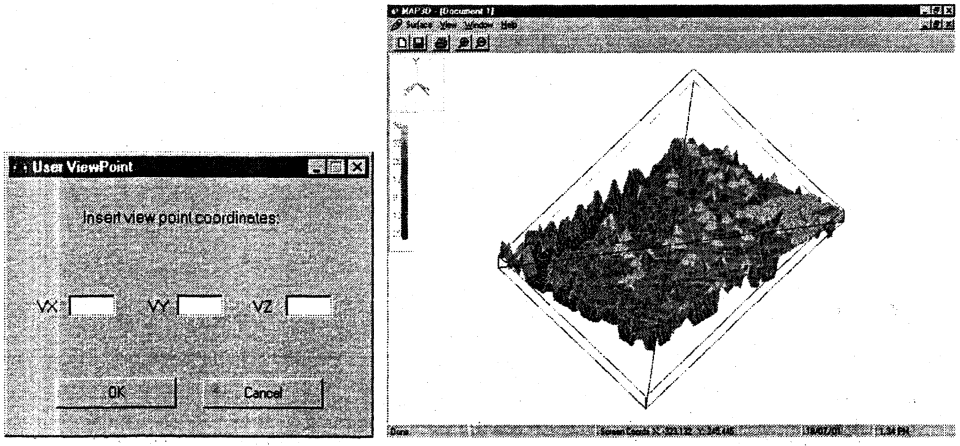

Figure 8: *Rotation process.*

and the node information, which offers the node data used to represent the map (x, y coordenates and altitude).

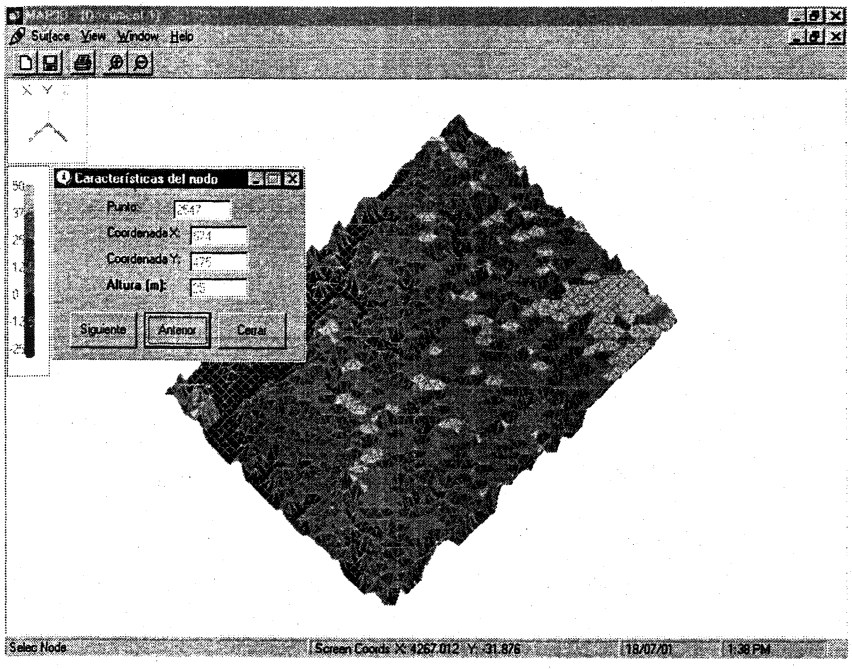

Figure 9: *Node information menu.*

5. Conclusions

A complete digitalization process of cartographic maps includes the acquisition of the map image, a pre-process in order to get data, lines trace, shape recognition, and a topology building. In our case, maps are scanned as the first step. As the scan process distorts the original colours, contrast modification functions and modification functions of pixel colour representation are used.

The pre-process is implemented either by means of isolines tracking, by algorithms guided towards geographical pattern recognition, or through the study of the map legend to recognize the altitudes.

Once the geographical relief, that is to say, areas of the map with different altitude, are identified and digitalized, the three-dimensional representation is implemented. The 3D surface is drawn by a triangular mesh where the basis are squares of a grid that the user has to be selected, in a balance of draw speed and accuracy of the method.

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