Reconstructing Land's Appearance

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Abstract

An important and largely area of computer image generation is that related with geographic information. Geographic data can be used for analysis, design and evaluation in natural-resource assessment, regional planning, and large-area landscape design.

While Geographic Information Systems (GIS) has focused on delivering traditional cartographic representations, some people demands others aspects be covered: the use of "appropiate" representations to help viewers to understand the information. This is the case of the visualization of the land's topography and how the changes on it affect its appearance.

Strangely, the combination of GIS and visualization area still remains unexplored. The fields seem to complement on another, yet they have developed in parallel and the interaction between them is important in providing usable interactive systems.

This paper presents a visualization approach of a topographic surface spatially interpolated from Topographic Reliefs. We hope this will help people with no background in scientific visualization orient themselves to the image.

Categories and Subject Descriptors: [**Computer Graphics**]: Picture and Image Generation−*display algorithms*; Computational Geometry and Object Modeling−*boundary representations, curve, surface and object representations, geometric algorithms.*
Keywords: Geographic Information Systems, Topographic Maps, Topographic Reliefs, Scientific Visualization, Interpolation Functions.

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1 Introduction

Scientists generally record geographic data as a regular array of values of one o more observations over some area. Nevertheless they gather it with different remote sensing platforms (typically satellite or airborne methods), the aim had been to get graphic representations showing the interaction between surfaces and spatial lines which own, by convention, a particular geological meaning; in other words, a *Topographical Map* [1].
In GIS scientists generally represents data containing information about one aspect of the geographic area depicted, such as *land cover* or *elevation*. Making maps involves to show the relationship between a point, its cartesian coordinates and the corresponding altitude value. One frequently used method of recording a continuous surface is by means of the *Isometric Lines* (Contour Lines) that describe it [2].

For many years, computer graphics researchers and practitioners have been grappling with the problem of using this information for creating images that have a worn appearance [3][4]. A visualization technique creates pictorial presentations of data that are critical for interpreting the measurements. As visualizations, data maps can bring into view subtle relationships that might otherwise go unnoticed. Maps can also point out areas where data analysis should be reconceptualized.

There exists different surface rendering techniques that make posible to get a digital elevation model of a certain relief [3][4][5][6][7]. Even this, some viewers still suffer from acute difficulties in visualizing and representing relationships among data and so, in distinguishing and communicating which are the most meaningful. It is difficult to extract meaning from a single global measure because data uncertainty will almost always vary spatially across the elevation surface [6][8]. Usually the spatial variation is influenced not only by the topography being modeled but also by the algorithm that produces the elevation model.

This work reviews the different methods existing for generating elevation models and shows how a low-end inexpensive viewing technique can be used as a "quick trick" to produce many of the same effects as high-end techniques, by means of a functional composition via **Topographic Reliefs**. Finally, there is a discussion about its advantages and limitations.

2 Background

Scientists frequently want to see multiple data sets or data variables displayed in the same visualization. Visualize the data help to support a fuller understanding of the site's uniqueness, that is, to assess its particular geological values. Generally data are organized as a set of polygons representing each one the several altitudes existing in the analysed region (*Isometric lines*), that is, the projections over an horizontal plane of the emerging lines from the intersection of land surface and different horizontal planes (See Fig. 1).

Graphics can serve as representations of particular data features that researchers wish to communicate. Making pictures of relationships among data is not new; there is a long history of methods to create images from scattered data points. The following discussion only pretends a very brief introduction to the topic. In it each method changes the data and introduces artifacts that must be understood because they will carry to the actual visualization.

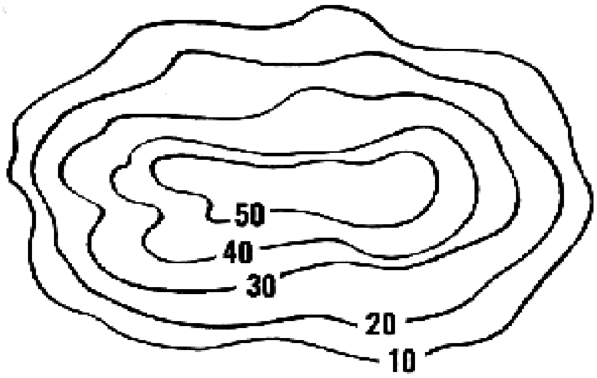


Figure 1: Isometric Lines of a Region.

The simplest and quickest approach to display digital elevation data is to associate each elevation with a color and display the colored surface (*2D Rendering*). This involves grouping elevation values into discrete color bands, and the overall effects shows solid, colored contour lines along the boundaries between color changes.
The resulting image broadly indicates topography and might also indicate mistakes in the elevation model. This is not a discriminating method of visualizing elevation data because relatively large changes in elevation values can result in similar looking images (See Fig. 2)..

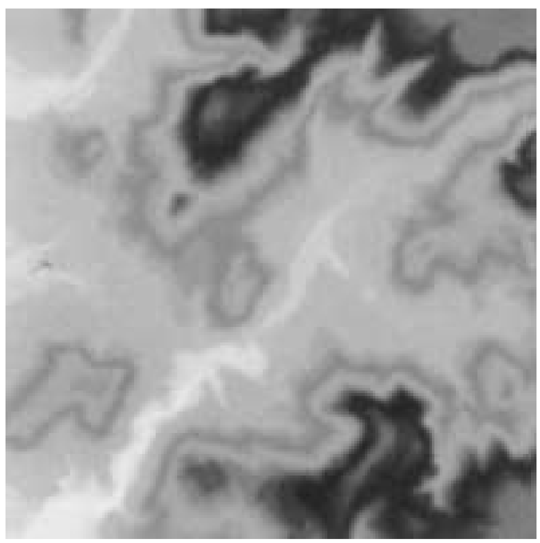


Figure 2: 2D Rendering of elevation data.

An alternate approach is *Pseudo-3D projection*. In this, the surface topography is represented by two sets of orthogonal lines that follow the shape of the surface. This produces a vaguely realistic rendering of the elevation model surface and does not suffer from the quantization of elevation into bands (which is apparent with colored contour maps).
3D projections offer more intuitive views than 2D rendering, but changes in parameters like viewing distance, field of view, and vertical exaggeration can be misleading. Also, parts of the elevation model might obscure others, resulting in a selective rendition of the surface (See Fig. 3).

The last frequently used method of producing a continuos surface is interpolating the isometric lines that describe it, usually named *Shaded Relief Maps*. The effectiveness of this

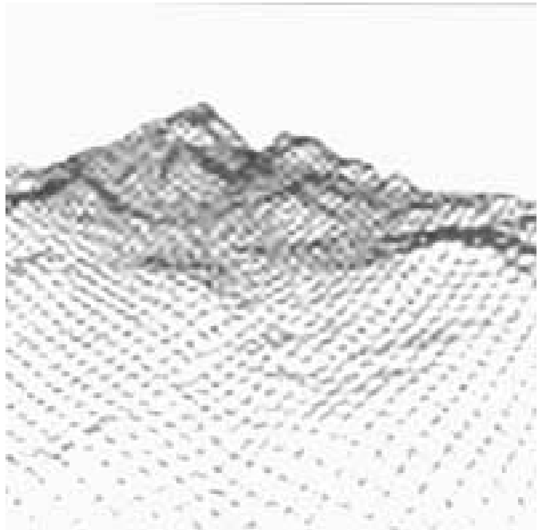


Figure 3: Pseudo 3D Projection of a land surface.

kind of visualization depends on the used interpolation method. An assortment of different algorithms exist with varying sofistication (*Inverse Distance Weighting, Contour Flood Filling, Simultaneous Over-Relaxation, etc.*) but generally the simpler (often less realistic) method that only use local neighborhoods highlight interpolation accuracy best.
With this method, several new features become salient, nevertheless these features are related to the distribution of contour lines used to represent the surface. Since the arrangement of contours lines is arbitrary, such results would be not desirable.
Moreover shaded relief maps can be improved by increasing the grayscale contrast between adjacent pixels. This further emphasizes local pixel variation at the expense of smaller scale comparison and, manipulating the color table associated with data lets us selectively highlight different aspects of a data set (See Fig. 4).

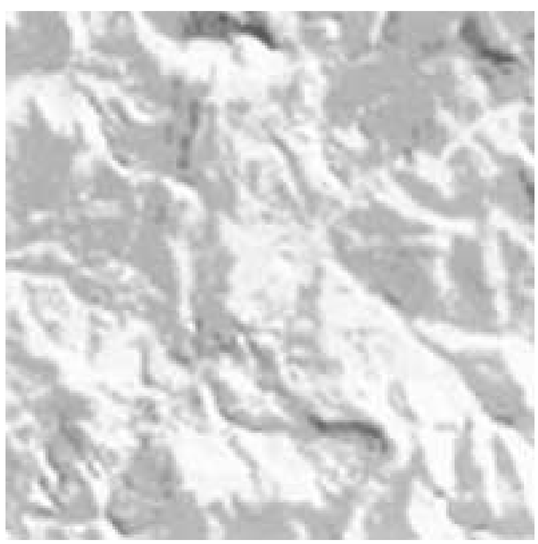
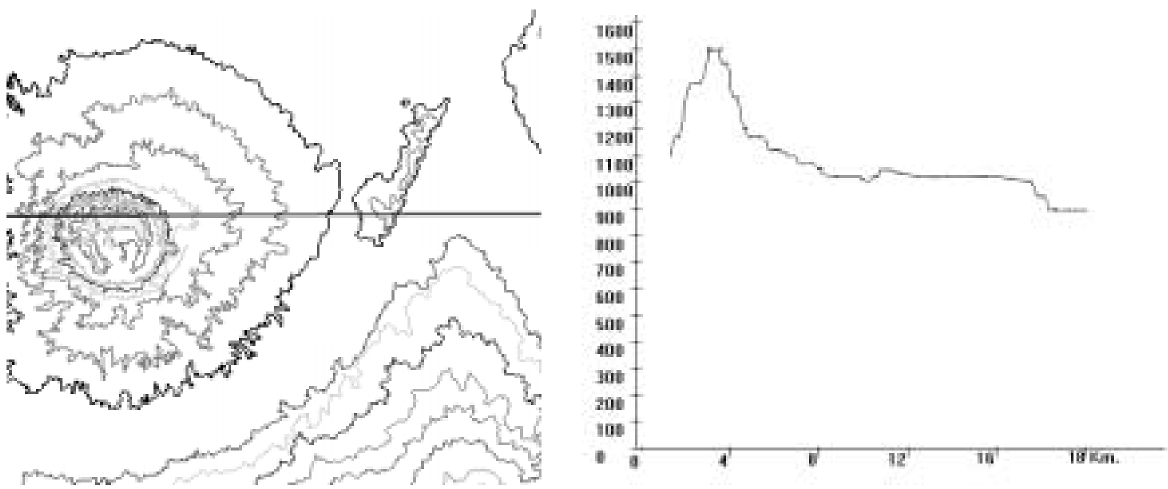


Figure 4: Shaded Relief Map.

However, new techniques of data collections and analysis stimulate researchers to convey their work into view in more simple ways, perhaps never before attempted.

3 The Experimental Model

If a particular intersecting trace through the isometric lines is drawn, it coult be viewed as a vertical plane cutting the land surface. Interpolating the isometric lines involved by cutting, a *Surface's Topographic Relief* arise [1][7].
Surface's topographic relief is a graphic representation showing the information of the geographic area lying across the cutting plane, determining the contour line's points that it touches and joining them [9]. Joining data can be made by either lines or interpolation (bilinear interpolation, bicubic interpolation, etc.) [10][11] (See Fig. 5).



(a) (b)

Figure 5: Topographic Relief of the Countor Lines shown in a).

It might seem probably that we can assess the land's surface by calculating various topographic reliefs horizontal (or vertical) extending over the entire surface. Visualizing all toghether the independent topographic reliefs, gives an intuitive understandable land presentation.
A more sophisticated rendering can be obtained by arranging one image over the 3D projection of elevation. In this way, two independent groups of topographic reliefs (horizontal and vertical extending) are showed together without overloading the image with too much information (See Fig. 6).

In considering two dimensions, with a rectilinear reliefs grid, a topological primitive (cell) is generated. The cell could be a rectangle of various sizes depending on the regarded reliefs distribution over the surface.
Primitive cells gives a base to a more accurate and simple elevation model. They gather in its four corner points the information (altitude) of the neighboring contour lines controlling them; and these four altitudes will allow to generate a sub-grid of control points. The new mesh structure qualifies for a surface's reconstruction by using implicit surface algorithms (interpolated or blended functions: spline, B-spline, NURBS, etc.) [10][11]. As each cell surface is reconstructed they are showed all toghether in the resulting image and the entire land surface is generated.

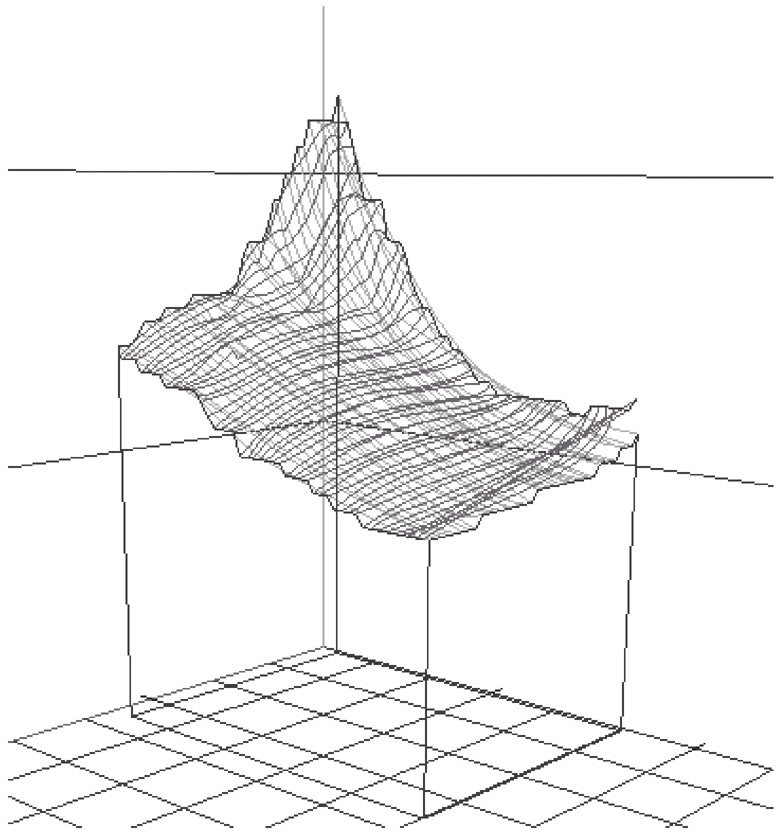
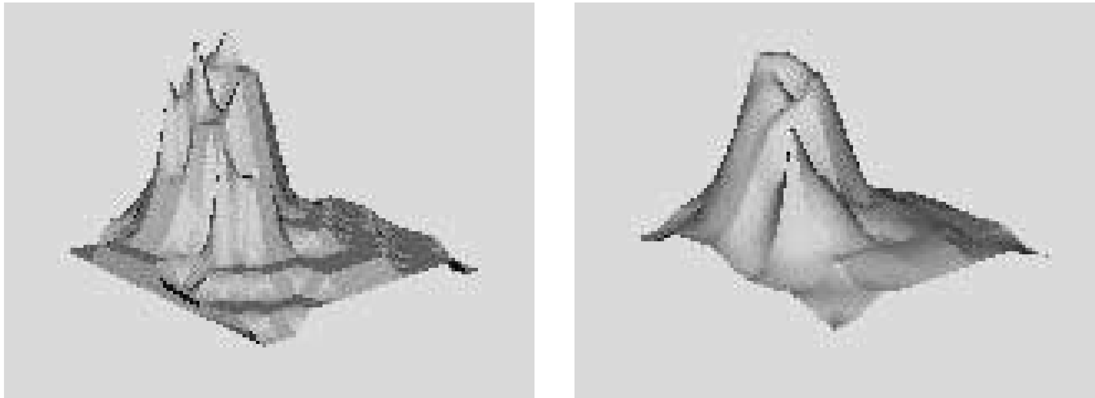


Figure 6: Extended Topographic Relief of the contour lines shown in Fig. 5.

4 Results

The area presented as an example of the preceding method is located in the north-eastern of San Luis Province. The topography corresponds to a mountain named *El Morro*. Data consist of 1:100.000 digitized contours at 2,5 kilometers vertical interval.
The results of the interpolated surface algorithms appear in Figure 7. The two maps refers to an inherit property from the concept of primitive cell, that is, *Blocking cells*. When visualizing, cells can be blocked and then the corresponding interpolation algorithm be applied. Figure 7a, corresponds to a visualization with no blocking and primitive cell sizes of 4 points (2x2 matrix), the other one corresponds to a visualization of a blocking of 9 cells, that is a resulting cell size of 16 points (4x4 matrix).

The surface algorithms used to interpolate the cell surface are based on spline functions family. A property of any spline curves is that neighboring elements of a profile are smoothly joined, without the discontinuities existing in some other methods. In particular, a used basic spline function, will honors all corner data points of a cell and can be regarded as an exact interpolator of them.
Is because this last mentioned characteristic that in Fig. 7a the control points at the cell border, and specially the corners, will not match the corresponding border data of its neighbours, then localized spurious peaks and pits arise in the elevation model.
This technique implies that relative magnitude of surface variation and global height information be lost. While using this kind of blocking, a more discriminating way of looking at local (neighbour) variation in elevation should be needed.



(a) (b)

Figure 7: Interpolated surfaces with two different blocking ratio for Fig. 6.

Looking at Fig. 7a, we can argue that, given the error likely in contour data, exact interpolation is not necessarily desirable. In Fig. 7b blocking cells tries with relative ease, to produce profiles with a more continuous surface which do not necessarily honor all input points (by replacing the spline-fitting function with any existing blending function). By constraining the nature of the profiles in this way, we eliminate sharp breaks in slope, which are relatively uncommon in natural landscapes.

From the two analyzed figures we can conclude that, nevertheless no blocking represents particular information corresponding to any cell interpolated, when the cells are joined the general aspect of the region might confuse the viewer. By other side, while blocking no honors exactly the gathered data points, when cells are joined a more intuttive and straightforward global information is sketched.

5 Summary and Discussion

Visualization software is widely used in scientific, academic and engineering areas; but computed visualizations can be very misleading.
While working with multiple data sets, not all the information is always interesting enough to show. And of the interesting data, presenting all of it in one image might confuse the viewer. An audience with no scientific background in the data needs a simple presentation, one they can understand quickly, easily, and intuitively. Thus for each forecast visualization, you must carefully decide the data of interest and what to show in one presentation.

Here we focused on rendering multiple data sets while preserving their salient characteristics. We shouldn't limit visualization to the use of visualization packages, nor should we restrict it just to the rendering of images. Visualization is a descriptive and analytical methodology. It does not start with the display of data, but includes the preceding steps used to create those data. Consequently, simple display techniques can be part of a complex visualization process.

For many users, the underlying function that the sampled data represents is not known, and the "isosurface" produced is at best a good guess.

Although our method depends largely on the frequency of the Topographic Reliefs used to map the surface, it can offer ideas for new measurements and facilitate qualitative data interpretation. Moreover, this can be adopted as a good artifact of the warping of the original rectilinear data onto a continuous surface, welding the discontinuity in the data's provided form.

Actually, work continues on the analytical steps that must be taken before rendering the joined singles cells pointing out to avoid spurious peaks and pits. In the next, studies about the benefits of using stereoviewing as an easy to view and effective way of generate intuitive understandable presentations will be done.

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