ESTHETICS AND POTENTIAL OF CARTOGRAPHIC VISUALIZATION IN MOUNTAINOUS AREAS

Karel KRIZ
Georg HÄFELE

University of Vienna, Department of Geography
Cartography and GeoInformation
Universitätsstrasse 7
A-1010 Vienna, Austria
E-Mail: kriz@atlas.gis.univie.ac.at
E-Mail: haefele@atlas.gis.univie.ac.at

Abstract

The beauty, clarity and vividness of Beranns' panoramic views of many parts of the world are known and highly regarded by us all. The efficiency and usefulness of GIS to analyze spatial relevant phenomenon is present to every geo-scientist. It is possible to create new and most of all fascinating results combining the powerful tools of GIS with the knowledge of thematic cartography. Visualization is in both cases an important factor for communication. Cartography deals with the basic process of visualizing spatial related information and has the task to communicate and to present itself in an understandable and esthetical way.

1 Introduction

This paper gives an overview of the 3D visualization methods and approaches used at the University of Vienna, Department of Geography, Cartography and GeoInformation. It then deals with the bases needed to achieve such perspectives and the problems that accompany the realization. It is therefore important to understand the different prerequisites needed for such tasks, and the numerous possibilities for cartographic representation. However, the main focus lies in the symbiosis between thematic cartography and the sense of esthetics, explained on the base of a few examples taken from mountainous areas in Austria.

One of the major areas of interest for 3D thematic cartography is in the integration of GIS with cartographic symbology. This can range from combining satellite data, orthophotos or thematic raster images with cartographic phenomena, all the way to integration of quantified object representation in 3D surfaces. It is essential on the one hand to understand the basic tools of cartographic design, such as the use of color, shape, size, texture etc. On the other hand, one must be aware of the functionality and expressiveness of 3D representation. Furthermore, different approaches in the field of computer graphics and multimedia emphasize the importance of thematic cartography in static as well as in dynamic applications. The use of multimedia methods and applications not only in thematic cartography is boosting the art and science of spatial representation into new and fascinating spheres. It is up to us to utilize this media for cartography.

2 Methods and Approaches

One of the main components of a 3D cartographic visualization is the unique representation of the earth's surface. This can be achieved in various ways using different methods and approaches. Traditional cartography has shown us (and still is showing us) how the third dimension is presented in an attractive fashion, using proven methods such as contours, hydrology, ridges, altitude points etc.. A major factor to produce such products is to have high quality data and talented staff.

Modern digital cartography has principally the same prerequisites, the only additional factor is that high-tech devices (such as hardware and software) and know-how are needed. The basic knowledge of cartography should be in both cases the same. Unfortunately, nowadays many map producers and GIS users think that high-tech alone can solve their problems and neglect the two major prior components - data quality and staff quality.

High quality data (either thematic or geometric information) is very important not only for 3D map production and acts as a framework for every successful visualization. Exact and correct geometric representation of the earth's surface is essential for the production of 3D perspectives. The gathering of these basic informations spans a wide field of methods and is used in both traditional and digital cartography. These methods can range from primary data gathering using ground surveys, satellite and GPS surveying, or photgrammetric data capture all the way to secondary information preparation using cartographic data sources such as contour maps or elevation mass points. These methods have all one thing in common. The third dimension is captured and then used to reproduce surface phenomena.

A relatively useful way to reproduce such surfaces in modern cartography is by using digital terrain models (DTMs). A DTM may be understood as a digital representation of a portion of the earth's surface. The main problem however is to get a unique model in an adequate accuracy. It is therefore primarily essential to evaluate the data input quality. Furthermore, one must take into account that the DTM generation and resolution is crucial for a successful representation of the terrain. It is for example doubtful to calculate potential avalanche hazards with a 50m DTM, if a majority of the gullies in the area are not broader then 50m. There again, this model would be sufficient enough for a general overview. It all depends on the scale and quality demands. Unfortunately, reality shows us that quality demands are not always respected. DTMs are used in combination with GIS analysis tools where suddenly rivers flow upstream - and these maps then even win a 1st prize at GIS conferences!

A major aspect of cartographic work besides data acquisition is the capability of combining available information in an attractive fashion. Esthetics in cartography is an important factor although it is very subjective and hard to evaluate. Esthetics deals with the study of rules and principles of art and is concerned with such concepts as beauty and taste. This may go a little too far for cartography, but one must not forget that this science uses many features of art.

Cartography has the assignment to set up the theoretical and practical prerequisites for map production and to give the user an utmost exact conception of the past, present and planed reality. Therefore the cartographer advances to become a graphical translator of spacial information. If one takes the rigid rules of cartography and the flexible components of art one could define cartography as a subjective way of presenting objective spatial relevant phenomena. It uses special methods and specific rules to achieve a synthesis, needing to be informative, comprehensive and most of all esthetic. Cartography is an art with special rules.

In order to achieve a solid and sound representation of the earth's surface using a DTM, one must take into consideration the different ways how such a model can be constructed. As mentioned before, the primary elevation data can be captured in many ways. In Austria we have a full cover 50m elevation model built primarily for orthophoto production and lately transformed for use as a DTM. The quality of this model is reasonable for perspectives and analyzing for a scale of up to 1:75 000. Using this model for larger scales is not advisable.

Furthermore, the Austrian Federal Office of Metrology and Surveying (BEV) has a very detailed contour and hydrology coverage in the scale of 1:50 000. However the degree of generalization is actually for a scale of 1:30 000. Therefore we decided to capture the elevation data using these bases.

Two major data structures were then used to construct the digital terrain models. These are the rectangular grid or elevation matrix and the Triangulated Irregular Network (TIN). In both cases, the elevation data (scanned isolines - raster-vector conversion - attribute assignment) was integrated in the GIS software ARC/INFO.

The crucial point was however to determine which resolution is possible for an accurate and perspective correct representation of the chosen area. Theoretically one could calculate any resolution wanted. The 3D perspective views show however impressively the optical limits of such ventures. Using the contours and hydrology on the pre-condition that they are accurate, one can produce 3D perspectives up to a resolution of 5-10m. After integration, correction and analysis of the DTMs one could now produce perspective views of the area using a raytrace program with the capability of image overlay, object integration and special effects.

2.1 Bases

The quality and resolution of digital terrain models (DTM) play an important role. In our case we first tried to use the DTM of the Austrian Federal Office of Metrology and Surveying (BEV) which is interpolated on a 50m rectangular grid and has a lot of systematic errors. It approved that this DTM is not acceptable in applications with a scale larger than 1:75 000.

The solution was to derive the DTM from the contourlines of the Austrian topographic map 1:50 000. These lines were then vectorized. Missing and incorrect elements had to be edited interactively. With the current version of ARC/INFO there are at least two approaches to generate a DTM out of a contourline coverage:

- Create a TIN (Triangular Irregular Network) and then generate a rectangular grid (GRID).

  With this method the only information that is used in the computing process is the height information of the points. Due to this a lot of terrain information is lost, which is present as the contour map.

  In mountainous regions the TIN data structure has in connection with an excessive sampling rate along the contourlines, a high demand on the physical memory. The time to compute a grid larger than 2000 x 2000 cells lies within the bounds of some hours until a day.

- Create a GRID directly out of the contourlines with the aid of the topogrid module:

  An advantage of this method is the possibility to take a connected drainage structure into consideration. This enables the generation of a hydrologically correct grid. The general shape of the landscape, primarily formed by the erosive force of water, is therefore represented through a high accuracy surface.

To detect classification and geometrical errors there is an option to write out topographic depressions (sinks). The computing time and the storage needs are moderate. A disadvantage is a slight biasing in the interpolation algorithm that causes input contours to have a stronger affect on the output surface at the contour.

2.2 Raytracing

Raytracing provide unlike most GIS, possibilities to overlay the DTM with data and objects, almost with no limitation. Raytracing programs are in general flexible, easy to modify and relatively fast. Here at the Department of Geography we have adapted such a program to work with DTMs originated from a GIS. The possibilities to use different light sources, to add atmospheric effects, textures, objects and text gives the final product a realistic appearance.

The main difficulties were to define the 3D objects in the DTMs coordinate system and to simulate realistic daylight conditions. After a proper rectification of image sources (satellite data, aerial photograph etc.) these were ready to use as overlays.

3 Realization using Raytracing and Overlay

Figure 1: Panoramic view of the Schneeberg in Austria in the province of Lower Austria, south of Vienna. The view point is Puchberg looking towards the south. The base for the DTM are the contourlines captured using photogrammetric analysis at a scale 1:25 000. (Courtesy BEV). The DTM has a resolution of 10m as was calculated using the TIN to GRID method in ARC/INFO. The overlay is a generalized landcover with structural elements. The objects integrated in the foreground show a very simplified version of object integration in Raytrace.

Figure 2: Panoramic view of the Silvretta region in Austria in the province of Vorarlberg. View point is the Radsattel looking towards the south-west at the Silvrettahorn. Base for the DTM is the contour and hydrology cover of the Austrian topographic map scale 1:50 000. (Courtesy of the Austrian Federal Office of Metrology and Surveying BEV). The DTM was calculated for a resolution of 5m using a TIN to GRID conversion with ARC/INFO and overlaid with a digital orthophoto (courtesy BEV) at the same resolution using Raytrace.

References

[1] BERANN, H. C.: *Darstellende Kunst im Panorama*. Karlsruher Geowissenschaftliche Schriften, Reihe A(Band 4):57 – 69, 5 1986.

[2] HERZOG, A. und R. WEIBEL: *Automatische Konstruktion panoramischer Ansichten aus digitalen Geländemodellen*. Nachrichten aus dem Karten- und Vermessungswesen, Reihe I(Band 100):49 – 84, 1988.

[3] HUTCHINSON, M. F.: *A new procedure for gridding elevaton and streamline data with automatic removal of spurious pits*. Journal of Hydrologiy, (106), 1989.

[4] HUTCHINSON, M. F.: *Development of a continent-wide dem with applications to terrain and climate analysis*. In AL, M. F. G. ET (ed.): *Environmental Modeling with GIS*, pp. 392–399. University Press, 1993.

[5] IMHOF, E.: *Kartenverwandte Darstellungen der Erdoberfläche*. Internationales Jahrbuch für Kartographie, S. 54 – 97, 1963.

[6] MUSGRAVE, F. K.: *Grid Tracing: Fast Ray Tracing for Height Fields*. Departement of Mathematics. Yale University, 1990.

[7] WEIBEL, R. and M. HELLER: *Digital terrain modelling*. In MAGUIRE, D., M. GOODCHILD, and D. RHIND (eds.): *Geographical Information Systems*, chap. 2, pp. 269–297. Longman Scientific & Technical, Harlow, 1991.

[8] WOOD, M.: *Panorama maps: the old magic on a new digital plane ?*. In MESENBURG, P. (ed.): *Proceedings of the 16th International Cartographic Conference*, vol. 1, pp. 103 – 113, Köln, 1993. International Cartographic Association, Deutsche Gesellschaft für Kartographie.