Creation of the Anamorphoses-Based 3D-Pyramidal Block-Diagrams

Nikita Bogomolov, Ilya Rylskiy, and Vladimir Tikunov

Moscow State University, Moscow 119899 Russia, Phone 7-095-936-14-98, Fax 7-095-932-88-36, Tikunov@geogr.msu.su

Abstract

This paper reports on work undertaken to create a 3D image, which displays as many indices as possible (thematic attributes) on a map. A new method has been developed for displaying the information. It resembles the classical method of the block-diagrams (prism maps), but it has more advantages and the efficiency is much greater. In addiltion, this method can be used simultaneously with anamorphosing. The technique of 3D anamorphoses (cartograms) compilation is outlined. Accordingly, algorithms for dynamic anamorphoses compilation for multi-dimensional images and multi-dynamic animations are discussed.
Keywords: 3D images, anamorphoses, multifaceted pyramids, multi-dynamic animations, algorithms

1 Anamorphoses

The main objective of the work reported here was to create 3D images that display as many indices as possible (thematic attributes) on the map. As is generally recognised, classical cartography offers a vast array of methods to display data, such as using colour, hatching, symbols and so on. For example, in creating a map of administrative units, there are a number of indices that should be shown. The usage of widespread methods - like column diagrams - allows us to show a number of indices - perhaps as many as 30-40 different ones. The cartographic legibility of such a map decreases greatly, and the quality of the information presentation becomes in some ways, almost equal to the presentation of the data table, on which the map is based. As a result, different methods of presentation are important if the map message is to be effectively communicated. The efficiency of the method is also very important. The colour used in a map presentation is one of the more effective methods, while point symbols, hatching,

diagrams, and others can also be extremely effective. Anamorphosing is also very efficient, but varies from the other methods greatly.

Anamorphoses could be defined as graphic images that are derived from traditional maps, with varying scales according to the values of parameters taken from the original map. The English-speaking world uses such terms as *transformed maps, pseudo-cartograms, topological cartograms* and other terms for anamorphoses. We prefer to use the term 'anamorphoses'. The process of their compilation should be referred to as anamorphosing (from the Greek "anamorphoo"), which means to display the essence of transformation of the image proportions. In addition, it should be noted that these terms are widely used in a number of countries, especially in Eastern Europe. Anamorphoses could be classified into linear, areal and volumetric characteristics. In this paper only volumetric anamorphoses will be addressed.

In this context, a new method of displaying map information has been created and described in the following sections. It resembles the classical method of the block-diagrams (prism maps), but it has more advantages and its efficiency is much greater. Using this method simultaneously to anamorphosing, is entirely possible.

2 3D Anamorphoses

The main purpose in presenting this method is as follows. We have two indices (thematic attributes) to be mapped: for example, the first one is the real GNP of the country; while the second one is the total population of the country. Both values are from 1996 and cover the whole world.

Real GNP is the gross national product converted to 'international' dollars using purchasing power parity (PPP) rates. An 'international dollar' has the same purchasing power over GNP as the U.S. dollar in the United States. Real GNPs of developing countries tend to substantially exceed their conventional GNPs and reflect more accurately the average welfare level of their population. On the contrary the interaction potential of the PPP measured GNP continues to be determined by official exchange rates, and therefore in developing countries it is usually smaller than the values of the real GNP.

First of all, the anamorphoses is produced according to the total population and real GNP of the countries (Gusein-Zade, Tikunov, 1992, 1993). The results are 2D images as shown in Figs. 1 and 2.
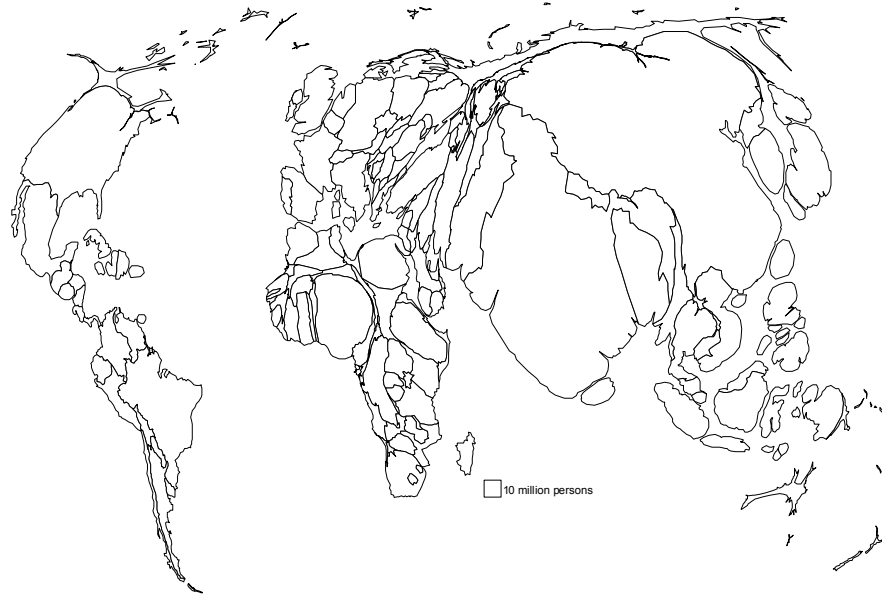
Fig. 1. Population, 1996 midyear estimates
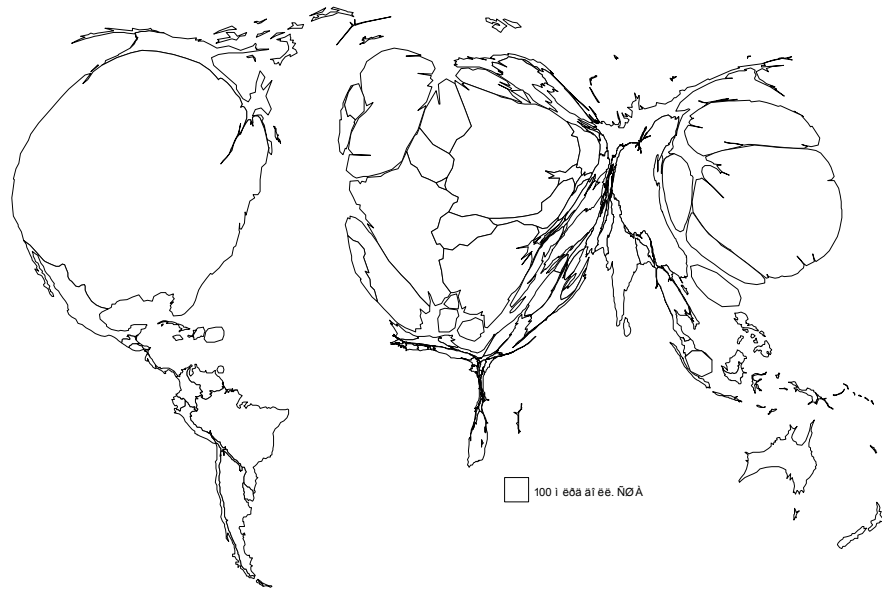
**Fig. 2.** Gross national product, 1996 midyear estimates

Following this presentation, the centre point for each country is used. In case a country is divided into two or more polygons – e.g., Indonesia, Philippines, etc. – the centre point of each polygon is used. The centre points are chosen "on-sight", but the main condition for these points is to be inside the contour of the country. We define centre points of the polygons in the Cartesian coordinate system (XY), according to the anamorphoted image of the population of the countries. All of the points of the country boundaries are given the Z value equal to 0 (zero), and all of the centre points of the countries – equal to the value of the second index expected to show (GNP per person). If we build the 3D surface according to these points (using the linear interpolation of Z value), then we have a number of the multifaceted pyramids. Their bases will have just the same form as the country itself, and the number of faces will be equal to the number of the node points in the polygon of this country.

The anamorphoses of the world according to the total population have a good property. The area of the country here is proportional to the population. The height of the pyramid we built is proportional to the GNP. As is generally known, the volume of the pyramid is: $V = S*H/3$, where S is the square of the basement, H is the height. Consequently the volume of pyramids we compiled is proportional to the GNP of the countries.

It is necessary to mention that comparison of the GNP values of different countries is difficult because of the different shapes of the countries.

The resulting image is very spectacular, and this is one of the most positive features of this method. The comparison of the values of GNP per person and total population becomes very easy. Here two indices are shown, however, the more common methods of displaying the data were not used and were kept in reserve. All information about these two indices is shown in the described manner.

Of course, it is possible to build the block diagrams (prism maps) based on the anamorphoses, but the result will be somewhat worse since the columns cover one another. In addition, it would not be able to see the country with a low value of GNP per person, if neighbours with greater values surround it - it looks like a hole. The zero level is invisible, and it makes the comparison very difficult. The 3D-pyramidal block-diagrams are free from these bad features. They ensure showing the zero level for each country, and provide a good overview (Fig. 3).
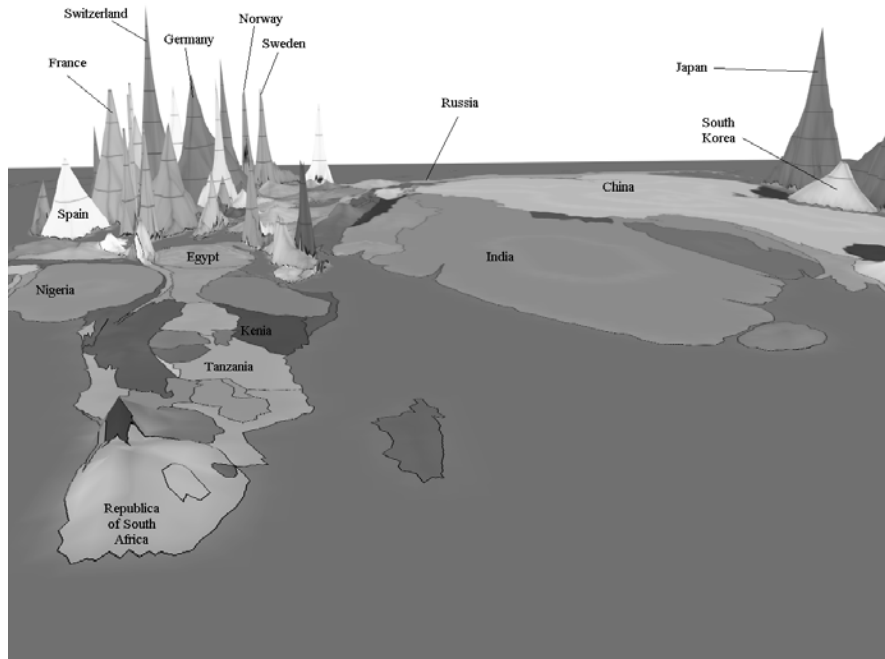
Fig. 3. 3D-pyramidal block-diagram of GNP per person based on population anomorphose

2.1 Technology and Building Methods

Let us consider the technology of producing the images in detail. The base data consist of the political map of the world, the data about the total population of the countries and about the real GNP in each country in 1996.

1. The initial world map was transformed into the anamorphose using the program and mathematical transformation that were developed specifically for generating such images. The resulting data (the files with the XY-coordinates of nodes and the object's topology) was converted into the ArcView 3.2 data format (*.SHP).
2. Centroids were extracted from polygons using X-TOOLS (ArcView 3.2 additional program module) into single point theme. After extracting the position of each centroid, they were checked and in case of an incorrect location, the centroid was manually removed. The new field for the value of GNP per person has been added, and values were given for each centroid. The polygon theme has been converted into a line theme (also using X-TOOLS), and the Z value equal to 0 was given to all lines.
3. Two sets of geometries (centroids and lines) were converted into ArcInfo coverages using ArcInfo 7.5. Following this, a grid surface was built from the

coverages using the ArcInfo TOPOGRID tool (using line point, and additional polygon data for borders of the resulting grid).

4. Additional thematic data has been prepared in ArcView Layout and exported into *.JPG (raster) file in high resolution.
5. Additional thematic raster data has been draped over the grid (surface) using the GEOMETRIC CORRECTION tool from Erdas Imagine 8.3.1 (we used polynomial approximation).
6. Units and projection information has been applied to the grid (surface) and thematic raster. In addition, an annotation file in Erdas Imagine (centers of annotations were linked to centroids of countries).
7. Using VIRTUAL GIS (an Erdas Imagine module) we combined the grid (surface) with thematic raster, and annotations were added. The resulting scene has been saved in Virtual GIS project and rendered from different points of view. The interactive virtual flight through the scene is also possible.

The resulting surface is smooth, though the algorithm intended to produce triangular faces. There are two reasons for this:

– the surface is a regular grid, and raster cells cannot form pure triangles,
– the method of 3D-scene rendering in ERDAS IMAGINE Virtual GIS smoothes all surfaces for "soft imaging". It seems to be impossible to disable this function.

These images we produced for visually analysing the results. Visual analysis is not very precise, and some deviations are allowed. As far as we calculated, the smoothed surfaces differ from the triangular ones only about 0.2-2.5 percent.

3 Dynamic Anamorphoses

Undoubtedly, the anamorphoses are one of the most impressive types of images. They have, however, some negative features: in case of great disparity of the country's area and the value of the displaying index, the contour of the polygon can be deformed greatly (just squashed), and the quality of perception of the information decreases rapidly. The identification of the countries in greatly deformed regions can be made easier by using the dynamic anamorphoses.

In addition, the animation of the anamorphoses must be very interesting, showy and impressive, especially in case of displaying the dynamics of the same values (for example, the growth of the population in the world during the last 10 years).

We produced the program module, which allows us to build the dynamic anamorphoses interactively. Building the intermediate phases requires the interpolation of X,Y coordinates of nodes. We use the linear interpolation. The user can generate the intermediate phases between two images: it can be phases between the original map and anamorphose, or between two anamorphoses. It is

possible to build them in real-time mode (25 frames per second, fps) and to see the animation in both directions.

The user can carry out following operations:

1. He can see the generated maps during the building of the <u>anamophosis</u>, scale it, resize it, and save it into raster (*.BMP) or vector (*.SHP, for ArcView GIS 3.0) file.
2. He can name two files with maps with the same topology, and build all of the phases of morphing from one image to another. These two images can be anamorphosed.
3. The user can watch the intermediate phases automatically (25 fps animation) or interactively (by mouse dragging). If automatically play is selected, then the duration of the animation can be defined.
4. The results of the automatic interpolation can be saved in .BMP frames (the number of frames can be set) or ArcView GIS shape files (*.SHP). In case of choosing raster export, the size of the raster can be set. It is also possible to resize and scale any part of the image.

Using this program module for the dynamic visualization of the anamorphoses, makes it easier to identify the contours through the animation. In addition, generating an animation between two anamorphoses seems to be very useful, since identification without this method is difficult.

4 Multidimensional and Multidynamic Anamorphoses

We are using cartographic images very often. We also use 3D images – like surfaces and block-diagrams, and others. After the introduction of multimedia, when it became possible for personal computers to show the full-screen video, the possibility of the displaying objects in their dynamics (thereby increasing its dimensions by 1). For example, animated 2D maps are 3D in fact (here time is the third dimension), and animated surfaces are 4D objects (<u>Berlyant</u>, 1996)..

In economic geography, we frequently use a number of dynamic rows of indices that are interesting to show on the map. Therefore, we can produce a series of dynamic 2D images – one animation according to the dynamics of one index. It will be easy to analyse each of these films. It will be very difficult, however, to make any correlation between them and to fully understand the significance. As we can see, there is a problem of displaying two or more dynamic indices in one image simultaneously, without building dynamic maps of correlation.

Let us solve this task for three dynamic indices, namely, the total population of the country, the GNP per person, and the expected average duration of life. We have these three values for each country in the world for every year from a period of the last 30 years.

1. Displaying the population. For every year, an anamorphose can be produced to illustrate population characteristics of all countries. All of the images must be

raster in order to drape them over the grid surface. In case of creating the animation using these images, we would be able to see 2D deformations and distortions of the country's shapes. Because the animated anamorphose is so expressive, one can readily see the object dynamics throughout their changing form.

Following this process a central point for each country's polygon must be selected. Let us define their X,Y coordinates. All of these points can be chosen "on sight", or by using any criteria – it does not matter. In case the country consists of several polygons, we must choose a central point for each polygon. This point must be immovable, and it must stay inside of the polygon during all period of animation.

2. Expected average duration of life. Its dynamics can be shown by using colours. Let's make multi-grade colour scale (for example, 100 different grades) to display each level of the showing index by separate colour. Therefore, if we paint each country polygon corresponding to its expected average duration of life colour, and if we do it 30 times – one time per one year, then we see crudely changing colours of the countries.

3. GNP per person. For this characteristic, the method of 3D-pyramidal block-diagrams, which were mentioned earlier, will be used. Here the 2D anamorphose, as mentioned in section 1 are used. All points of the country's contours have their X,Y coordinates, while the Z coordinate is equal to 0. The centres of the polygons, (as defined by the authors), also have their X,Y coordinates, however, their Z coordinate must be equal to the GNP per person for each country in one particular year. Thus an array of points is produced with their XYZ coordinates, and it is now possible to build a surface using them as reference.

Finally, if all of these methods are combined, a surface with "hills" and "planes" can be built, where the height of the hill is proportional to the average GNP per person in this country in one year; the form of its base and the base's area are equal to the population of this country in the same year; and the colour of this hill corresponds with their expected average duration of life (also in the same year). We can build one object like this for every year for the period or interest. Further, if they are animated the dynamic surface characteristics can be seen, where the hills are changing their shape, size, height, and colour.

It is also possible to show horizontals on these "hills", and so these images become metric and quite comprehensible.

This animated image has many dimensions: it includes the 3D surface, and here we have shown 3 dynamic processes.

5 Conclusion

The development of computer technologies enables new methods for displaying data of different kinds in one map using such methods like: 3D-anamorphosing,

dynamic 3D-anamorphosing, multidimensional and multidynamic anamorphosing. All these methods allow us to show the data using the shape of the object (in addition to colour, hatching, and other traditional methods). The animated shape of the object can clearly illustrate the geographic statistics in a dynamic and effective way. Finally, these methods allow map users to visualise several different static or dynamic characteristics (attributes) in one image simultaneously.

References

Berlyant AM (1996) Geoiconics. Astreya Press, Moscow, (in Russian).

Gusein-Zade SM, Tikunov VS (1992) New methods of compilation of anamorphoses and their using. In: Proceedings 5th International Symposium on Spatial Data Handling, vol.1. August 3-7, 1992, Charleston, South Carolina, USA, pp 51-62

Gusein-Zade SM, Tikunov VS (1993) A New Technique for Constructing Continuous Cartograms. Cartography and Geographic Information Systems 20(3):167-173