Problem of Optimum Visualization of Electronic Maps on the Display with Use Variable-Scale of Projections

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ABSTRACT

It is necessary to provide electronic maps and plans displayed on the screen with smooth nonlinear change of scale both on one and on several directions, with the necessary software for regulation of size of increase / reduction of scale in separate places for reception of more detailed information about concrete objects with preservation of visibility of other part of the cartographic image. This reception conditionally named « an electronic lens » most full will allow realizing the inconsistent requirements of visibility and detail of the cartographic image.

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The modern status of development of a society is connected to constant reception and processing of the supercargo volumes of the information. In the field of sciences about the Earth and the surrounding space the problem of adequate perception by a human of the large volumes of the information at acceptance of those or other decisions has been traditionally solved by cartographic representation of various spatially adhered information spatially related to a certain projection system and symbols.

The demand in routine representation of changeable data and the advent of new computer technologies designed to make maps has brought to life new types of cartographic products which are different from traditional maps and atlases. Use of computer technologies in cartography is not only new means for designing maps, but also new means of representation of an area picture, representation of cartographic information jointly with special data not only in a traditional polygraphic kind, but also as electronic maps.

The maps in modern GIS are not only initial information for performance of settlement works, but also source of reception of the information for a human accepting decision by results of accounts. It is necessary to note, that redundancy of the information in a map, put on the screen, not less than its lack complicates acceptance of the correct decision. Normally, when the map representation scale is reduced, the objects are reduced in size or disappear because the monitor resolution does not make it possible to represent them. It is caused by the fact that the problem of automatic generalization still is not solved, though the certain works in this direction are conducted. Some modern GIS allow to show additional information when the picture scale is increased, and to remove it when the picture scale is reduced. However, the problem of showing an optimum body of information represented on the display at a time taking into account its perceptibility by a human has not been solved completely.

Both cartographic and traditional computer technologies have the following common principles of making maps and maps' peculiarities related to their human perception: visual demonstration, visibility and information content.

Cartographic computer technologies make it possible to create maps with an increased informational capacity in comparison with traditional maps. Psycho- physiological abilities of visual perception (size, color, a number of objects) of a cartographic picture should be taken into consideration while maps are being made because the total body of information contained on a map might not be visually perceived by a human. This raises the question of the selection of maximum permissible body of information to be located per area unit of a cartographic picture on the display [1,6].

Computer technologies allow to produce not only continuous picture of large areas (in various directions) on the screens of colored graphic display and to change the scale of this picture and the parameters of the mathematical background, i.e. the picture projection can be easily changed [3, 4].

The software of many geoinformation systems allows now to display on the display an electronic map with smooth increase/reduction of scale. Thus the various ways generalization of the image are used, elementary of which is the inclusion/ denergizing of the images of objects depending on scale of screen display of a map.

Electronic maps and plans represented on the screen with smooth non-linear change of the scale both in one and several directions should be provided with the necessary software to control the increase/reduction value of the scale in some individual places to get more detailed information of some particular objects and keep the remaining part of the cartographic picture in view. This reception conditionally named " an electronic lens " most full will allow realizing the inconsistent requirements of visibility and detail of the cartographic image.

Let's consider opportunities of computer technologies on an example of display of a fragment of the plan of city with smooth non-linear change of the scale in one direction [6]. The initial cartographic image in scale m1 with system of coordinates (x, y) will be transformed to derivative with the help of special functions with smooth transition from one scale m1 to another m2 with system of coordinates (X, Y) (Fig. 1).

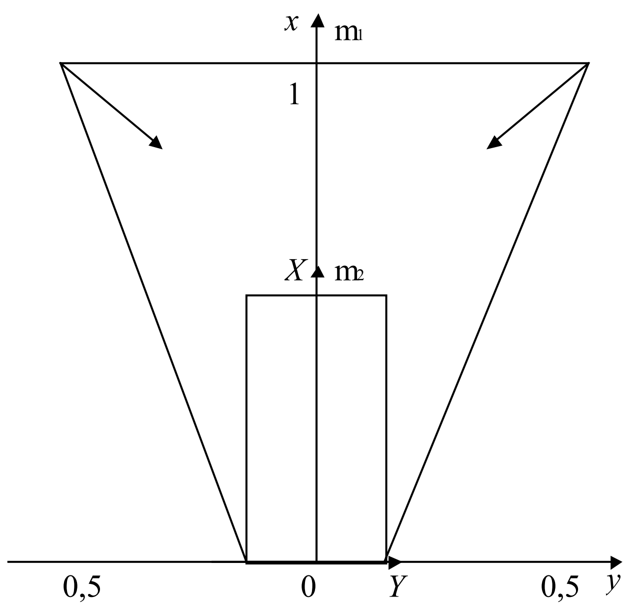

Fig. 1. Example of transformation of the cartographic image.

The equations for recalculation of coordinates from one scale in another in a general view can be presented as follows:

$$X = f(x)$$
$$Y = f(y) \quad , \qquad (1)$$

where x and y - rectangular coordinates of the image of some point on a plane in scale m1, X and Y - rectangular coordinates of the image of this point on a plane in scale m2.
For practical use it is possible expression (1) to present in the following kind:

$$\begin{aligned} X &= x - \frac{m_1}{m_2} x^2 \\ Y &= y - \frac{m_1}{m_2} xy \end{aligned} \quad . \qquad (2)$$

Let's consider display of a fragment of the plan of city with change of scale on two directions. The initial cartographic image in scale m1 with system of coordinates (x, y) will be transformed to derivative with system of coordinates (X, Y) with the help of special functions of smooth transition from one scale m1 to another m2 in a point given in coordinates (x1, y1). The equations for recalculation of coordinates from a projection with constant scale in a projection with variable scale in a general view can be presented as follows:

$$\begin{aligned} X &= x + \Delta x \cdot f_X(r) \\ Y &= y + \Delta y \cdot f_Y(r) \end{aligned} \quad , \qquad (3)$$

where x and y - rectangular coordinates of the image of some point in a projection with constant scale in m1, X and Y - rectangular coordinates of the image of this point of a projection with variable scale m1 < m < m2, $\Delta x = x - x1$, $\Delta y = y - y1$, r - distance from the allocated point up to current.

The essence of a method consists in increase of scale about one or several allocated centers [2, 5]. If there is only one such center, the transformation is carried out as follows. It is necessary to take polar system of coordinates (r, φ), which beginning is located in the allocated point, and to execute transformation, which will change coordinates of the current point (r_i, φ) on ($r_i \cdot (1+f)$, φ_i), щi), where $f = f(r, t, u, \ldots)$ function of distance from current up to the allocated point r and additional parameters t, u, …, influencing on a parity(ratio) scale / distance. For increase of scale about the allocated point in [2, 5] it is offered to use function of a kind:

$$f(r,t,u,\ldots) = \frac{A}{1 + Cr^{(d_0 + d_1 t + d_2 t^2 + \ldots + e_1 u + e_2 u^2 + \ldots)}} . \qquad (4)$$

But practically in works [2, 5] the case is investigated only $d_0=2$, $d_i=0$, $e_i=0$,… (i=1, 2, 3, …), that is the influence of additional parameters is not considered and function f - general for axes x and y, was used in the following kind:

$$f(r) = \frac{A}{1+Cr^2} . \quad (5)$$

The analysis of the equations (4) and (5) shows, what *A* is factor of increase / reduction " of an electronic lens " and there are no restrictions in a range -? < *A* < +? with an any step; *C* - factor the regulating diameter " of an electronic lens " and effectively works in a range 0,01 < *C* < 10,0 with a step of change 0,01; *d* is factor regulating character of change of scale between edge " of an electronic lens " and other part of the cartographic image and can be changed in a narrow enough range 2 < *d* < 8 with a step 1.

Having substituted (4) and (5) in (3) we shall receive the equations for recalculation of coordinates from a projection with constant scale in a projection with variable scale for practical use:

$$\begin{aligned} X_i &= x_i + \Delta x_i \frac{A}{1+C_X r_i^d} \\ Y_i &= y_i + \Delta y_i \frac{A}{1+C_Y r_i^d} \end{aligned} . \quad (6)$$

If there are some allocated centers with coordinates (x_j, y_j), where $1 \le j \le N$ that such the polyfocal variable-scale projection can be submitted in the following kind:

$$\begin{aligned} X_i &= x_i + \sum_1^N \Delta x_{ij} \frac{A_j}{1+C_{Xj} r_{ij}^d} \\ Y_i &= y_i + \sum_1^N \Delta y_{ij} \frac{A_j}{1+C_{Yj} r_{ij}^d} \end{aligned} \quad (7)$$

In a figure 2 the examples of change of function *f* for projections with one and two centers are submitted.

Using the considered above features, the electronic maps and plans for display on the screen can be developed with smooth change of scale both on one and on several directions. Thus the basic criterion should be display about equal quantities(amount) of the information on unit of the area of the cartographic image.

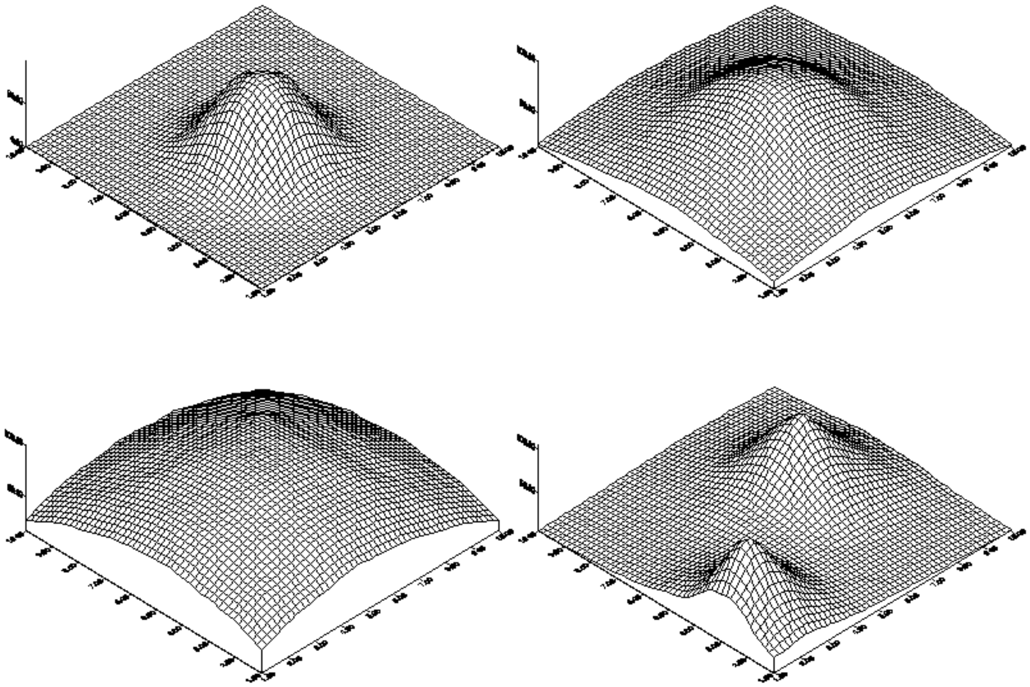

Fig. 2 Examples of change of function f for variable-scale projections.

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