PRINCIPLES OF MAPPING SUPPORT IN GEOGRAPHIC INFORMATION SYSTEMS

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KEYWORDS: geographic information systems, mapping.

ABSTRACT

The use of different ways of presenting geographic maps on PCs depends on the GIS objective. In this paper some techniques for preparing map data are described and illustrated.

INTRODUCTION

The main idea of a Geographic Information System (GIS) is visualization of some kind of objects on a geographic map which is drawn on the screen of a computer display. So the first task for every GIS is to draw the map of the chosen geographic area on the screen. There are several principles of drawing geographic maps on a PC screen. Their use depends on the goals of the GIS.

RASTER MAPS

If the user of a GIS needs the map of only one region without any zooming during his work, then one raster image (obtained via scanner) will be enough. In this case we can slightly zoom this map (with 2,4 or 8 magnification) and the picture will be good enough for work. For example, the point on the initial image (on the screen) which was drawn as one pixel after double zooming becomes a small rectangle with size 2x2 pixels. Lines will be twice as thick and so on. So after very deep zooming the picture on the screen will consist of very large rectangles of different colors (every pixel becomes a rectangle) and will be very unpleasant for viewing. This means of map presentation can be used if the degree of zooming is not very big. As an illustration of this way of map presentation we can show the elements of mapping support of the Tsunami Modeling System (TMS) which was developed at Novosibirsk Computing Center for tsunami warning and research purposes (Gusiakov *et al.* 1992). On figure 1 the map of the Pacific is shown. From this raster picture we can choose a sub-region using a moving frame. The map of this sub-region then can be magnified up to almost the whole screen (fig.2). After this it is necessary to pick up a small region for tsunami modeling. The size of the chosen geographic area will be stretched to the size of the drawing field. So, if the area is rather smaller than our sub-region the picture of the chosen area will be unpleasant (Fig.3).

VECTOR MAPS

If the user of a GIS is going to use very deep zooming, the map must be used in vector form. This means that all the elements of the map during visualization on the screen will be drawn as points or pen movements. The advantage of this approach is independence of the point object size (or the thickness of lines) from the zooming degree. In a global GIS, coordinates of map elements are usually stored as absolute geographic coordinates (latitude and longitude); but in regional or local GIS's it is possible to use relative coordinates (relatively to boundaries of the initial region). An example of a very compact global GIS is one for visualizing different kind of point objects (for example, earthquake epicenters) on a PC screen. Mapping support of this kind was developed at Novosibirsk Computing Center. Absolute geographic coordinates of points along the coastlines, rivers, shores of lakes, and state boundaries are stored in the computer memory and can be drawn on the screen after selection of a geographic area. Locations of cities and their names also can be drawn. Map output on the screen is realized in two projections: 1) Rectangular projection (each cell of the geographic grid has the form of rectangle), 2) Orthographic projection (the point of view is located on a line normal to the Earth surface). The initial selection of a geographic region is made from a map of the globe (Fig.4). The rotation of the globe is made by pressing the space button on the keyboard. After the selection, elements of the map can be drawn on the active field of the screen. Menu buttons execute the drawing of corresponding geographic elements (rivers, lakes, boundaries, relief, cities, etc.) and other objects (Fig.5). On the displayed map it is possible to make the next choice of geographic area. Vector presentation of the map permits us to make a very deep zooming of the map. The limit of zooming depends on data format. The GIS which is described here has an 0.2 minute spatial resolution for global data.

UPDATING OF GEOGRAPHIC DATA.

For systems which use vector drawing of geographic maps the problem of vectorization of maps arises. There are some institutions and corporations (ArcInfo, MapInfo, EIS and some others) where you can order digital data for your GIS in a specific format. But if the user needs a very detailed electronic map of some region it is not difficult to input geographic elements into the computer from an original map. Some technologies for updating geographic information are briefly described here. This work can be done in two ways: manually or semi- automatically. First we'll describe the so called "mouse" technology. Here it is necessary to obtain a fit-to-screen graphic image of our region (or its part). This step can be done using a scanner and graphic editor. Then we run the digitizing program and tracing along isolines with the help of a mouse we input screen coordinates of the cursor position into the computer by clicking the mouse button. During this procedure all the points we want to input will be plotted and connected by a specified color on the screen. For linking screen coordinates to the geographic grid it is necessary to input screen coordinates of the upper left and lower right corners of the digitizing area (where the geographic coordinates are known).

Some years ago the author used a table digitizer for inputting coordinates of map elements. Resolution was good enough (0.1 mm) for our goals. The advantage of this kind of equipment is the possibility to work with large sheets of paper (up to 1x1 m). But, disadvantages are difficulties with fixing of the chart during the whole process of digitizing and the impossibility of determining line segments which are already digitized. In some cases the use of large table digitizers is more effective than the "mouse" technology described here.

There is another way to get screen coordinates of line points without using a mouse. This technique is more automated but also needs some handling. In this technology the black-and-white (b/w) raster image of a chosen part of an original bathymetry chart is transformed into a bitmap, using the structure of a graphical format (usually we use the TIFF format). Then a program transfers the raster graphic image into vector form. It means that all elements of the picture will be recorded as pen movements with indicators of pen rising, during its tracing from element to element. The result of this procedure will be a sequence of pairs of integer screen coordinates of points along all lines on the initial picture. Usually the size of a scanned image (with resolution 150 dpi) is up to 1200x1200 pixels. A personal computer is powerful enough to vectorize such a bitmap. As an illustration of the vectorization process let's look at figure 6, where the raster image (after scanning of part of a bathymetry chart) is shown in the upper part and the vector image is in the bottom. In the vector image we have got, it is necessary to remove some map "noise" (titles and other useless lines). A special program easily sorts all line segments, saving some of them as coastlines, as rivers, as boundaries, as isobats etc. Only in this step some handling with the help of a keyboard is needed. A few words about color scanning: If on the original map different geographic elements are drawn with different colors, we can use this circumstance to avoid the procedure of sorting line segments. But here some new problems arise. During color scanning map elements of the same type can be recorded with different colors, so we have to prepare our graphic image for further work with the help of a graphic editor or some other technique. As the result of updated technology one can view the map of Shikotan island (South Kurils)(Fig.7). The geographic data (coastline) in the GIS was improved after the major earthquake and tsunami on 4.10.1994. This was caused by the necessity of pointing out different harbors around this small island.

CONCLUSION

There are different ways of presenting geographic maps on PCs. Use of them depends on the GIS objective. In this paper some techniques for preparing map data are proposed. As examples, a few GIS's for earthquake and tsunami research are shown. They were developed at Novosibirsk Computing Center with different mapping support.

This work was supported by the Russian Fund of Fundamental Research under Grant 93-05-14499.

REFERENCES

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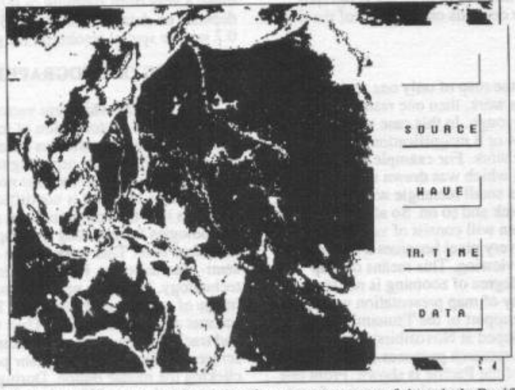

Fig.1 Selection of a geographic region from a raster map of the whole Pacific.

Fig.2 Selection of a small geographic area from a map of the Southwest Pacific. Using a moving frame one can choose an area in the Solomon Sea for tsunami simulation.

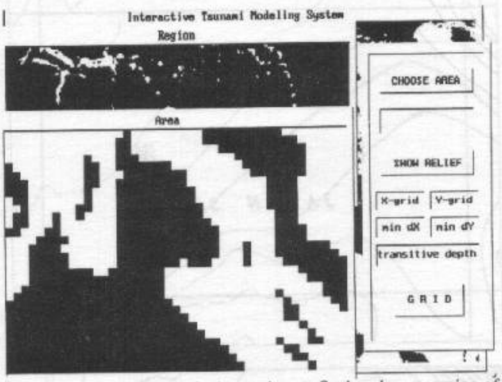

Fig.3 The area in the Solomon Sea selected for the numerical experiment. Such a deep zooming of the geographic map makes the picture unpleasant.

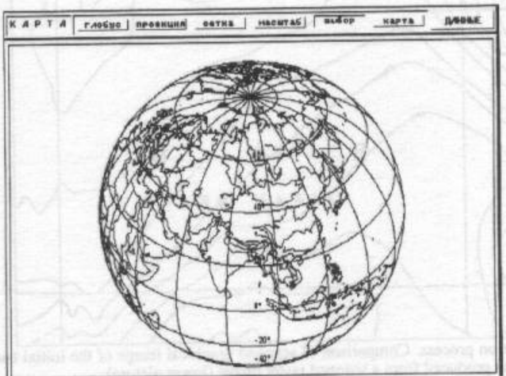

Fig.4 Map of the globe for initial selection of a geographic region in the GIS with vector presentation of map elements.

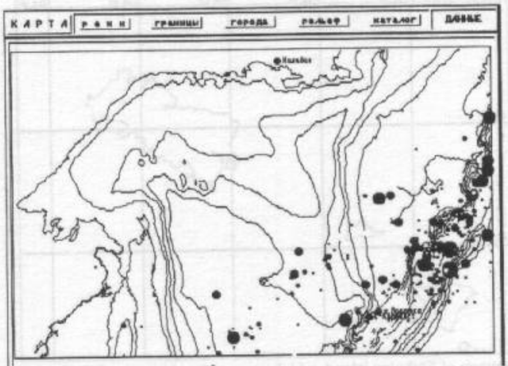

Fig.5 Example of geographic support with vector presentation of the map.

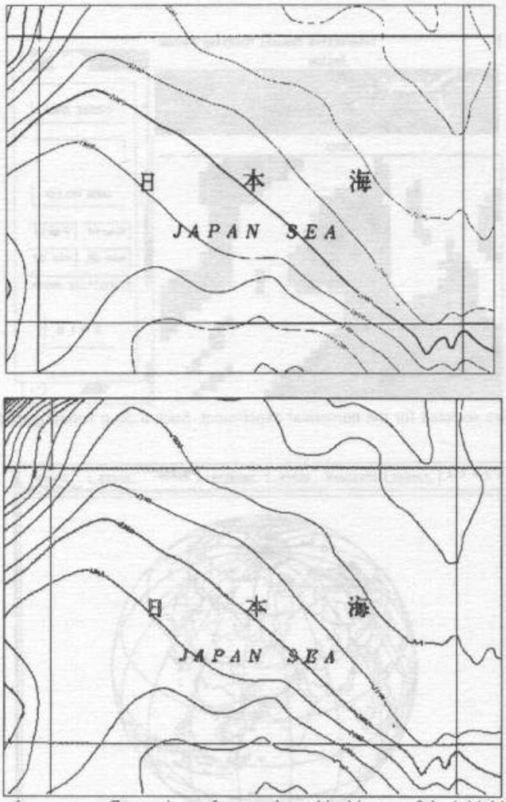

Fig.6 Illustration of the vectorization process. Comparison of scanned graphical image of the initial bathymetry chart (upper picture) with the vectorized one, which was produced from a scanned raster image (lower picture).

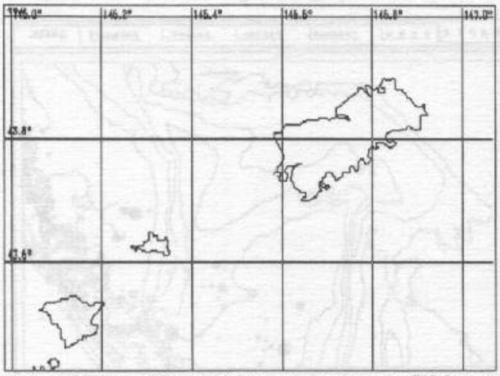

Fig.7 The contours of Shikotan island, which were updated into the GIS from a paper chart.