

Interactive system for input digital geographic and bathymetric information*

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Geographic information systems (GIS) of different kinds are now widely used for numerical modeling of geophysical processes. The main idea of GIS is visualization of some kind of objects and results of mathematical modeling on a geographic map which if drawn on the screen of computer. In majority GIS during work deep zooming of geographical map is required, that involves necessity of use vector principle of computer maps drawing (the most widely used principle of electronic mapping). However, in this case geographical data in digital vector form is needed. If the user has access to sufficient (for him) digital cartographic information, the problem can be resolved by convert of that data in format used by him. If the access to such data is not available, the Interactive System for input geographic information proposed here can be used for creation digital geographical and bathymetric data.

This system represents graphic shell with pull-down menu, which permits to input interactively any kind of cartographic information (lines and points) from PCX image of chosen fragment of geographic map. Some features and steps of this technology are briefly described in [1]. PCX image can be initially obtained by scanner and then edited by graphic editor (if necessary).

For the choice of an initial picture it is necessary to enter in submenu (File) where the list of all PCX-files in given directory will appear. After choice of a file a picture will be displayed on the screen of PC (Figure 1). If the size of a graphic image exceeds the size of the screen, the picture is accordingly scaled (it size decreases in 2, 3, ... times). However it does not mean, that the process of the cartographic information input would be carried on from reduced map. Using option (Zoom in), in submenu (Digitize), the user with the help of an appearing frame (Figure 2) can choose any rectangular fragment of initial map and to display it on screen with smaller reduction or without any zooming (Figure 3).

At the command of user there are two opportunities of realization of vectorization of the available raster image of geographical map: manual and automatic. For entrance in manual digitizing mode it is necessary to push (Digitize) button in (Digitize) submenu and then the user with the help of

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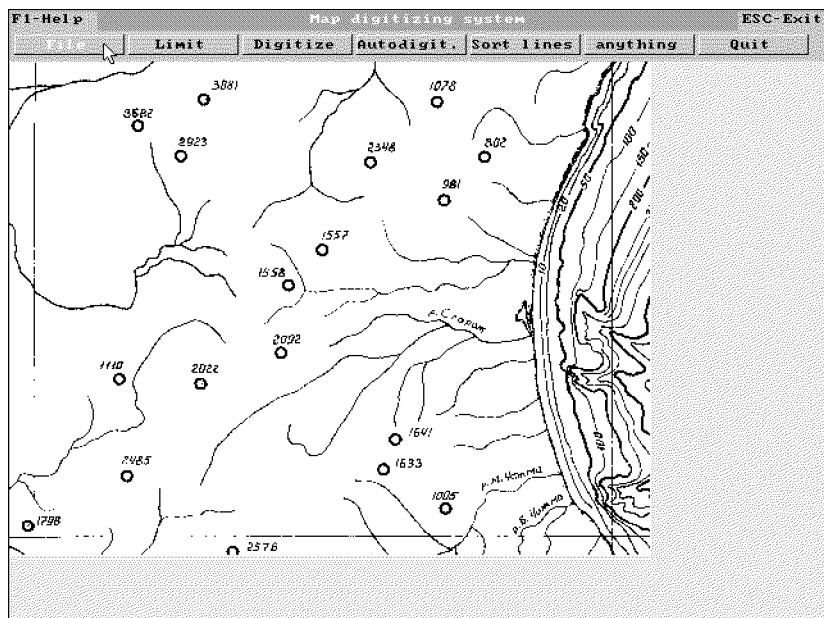


Figure 1. Main menu with initial map on the screen

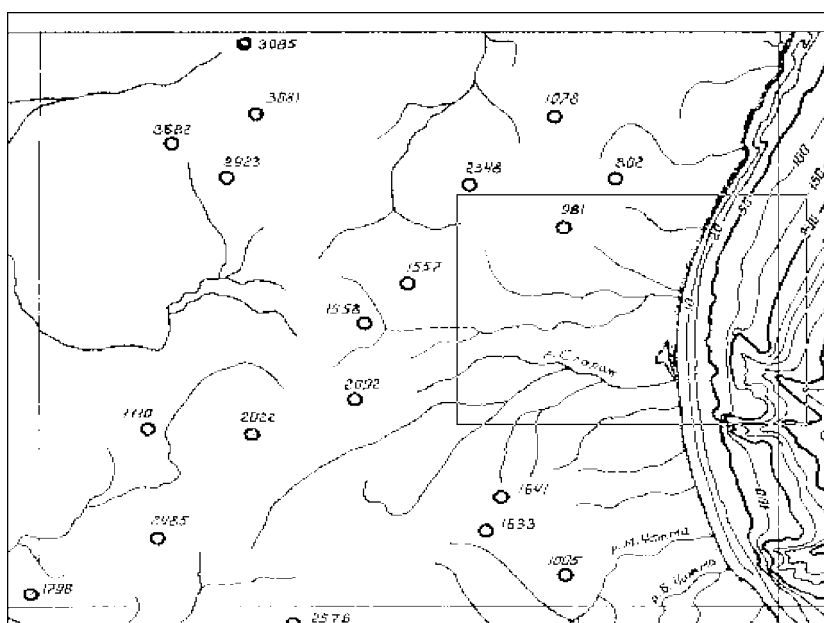


Figure 2. Selection of the fragment for manual digitizing

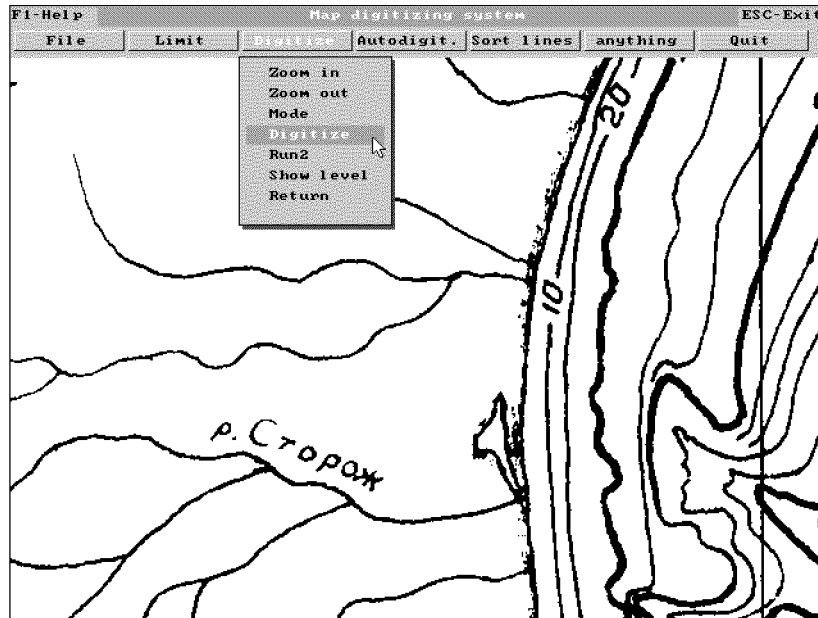


Figure 3. Selected area and submenu for digitizing in manual mode



Figure 4. Process of digitizing in manual mode. User moves cursor along lines and inputs its coordinates by clicking mouse button. Inputted segment is drawn with black color

“mouse” moves the cursor along selected curves and inputs into computer screen (sheet) coordinates of the cursor by clicking mouse button (Figure 4).

During digitizing process inputted lines are drawn with specified color. On transition from one segment (element) to another pressing of a key ⟨Insert⟩ will label segment with the number, which can mean category of inputted geographical object, or level of isoline. When all required lines are inputted user comes back in the main menu. By the way, it is possible to interrupt process of manual digitizing in any moment. By repeated call of this program, the elements inputted earlier will be drawn with other color, and thus the process can be continued, being not afraid of repetitions. We shall notice, that at restart of the program of hand-operated digitizing the fragment of the initial map or zooming value can be another. At input of lines from black-and-white picture for best observation of the cursor the color of a background can be changed on opposite (for example, before the start of digitizing user changes a white background on black). Mode switching can be made by choosing the ⟨Inverse⟩ or ⟨Normal⟩ mode in the window that appears after pressing ⟨Mode⟩ button. The color of lines thus will be also changed on opposite.

In the case of automatic vectorization it is previously necessary to enter some parameters. There are: color of lines, being a subject of vectorization process, maximum and minimum radiuses of search of the subsequent point. The program of automatic vectorization enters coordinates of points along lines of specified color and with given step along lines without manipulations by the Mouse or the keyboard.

Let us briefly describe algorithm of automatic vectorization. First of all the program looks through the picture bitmap and searching pixel of specified color. Then program looks for the same color points on the distance equals minimum radius. If such a point exists, we regard this point as continuation of line and then program looks for next point of the segment. If there are no points of specified color on this distance the radius of searching increases on one unit (unit is the distance between neighboring pixels). If the program will not find any point of specified color the radius of search (for this point) will step by step increase until maximum radius, which was inputted before start of automatic vectorization. If program still not found any point of specified color in the neighborhood of regarded point then we suppose that here is the end of segment and program begins to look through all bitmap for new point. The process stops when we check all bitmap points. After the program of automatic vectorization stops working user can make control output of inputted elements on the same screen or the other fragment of raster image or on the black background (Figure 5).

If initial raster picture contained a lot of “garbage” or “noise” (various auxiliary marks and lines, which have the same color), automatically vectorized image, representing a sequence of pairs of screen (sheet) coordinates

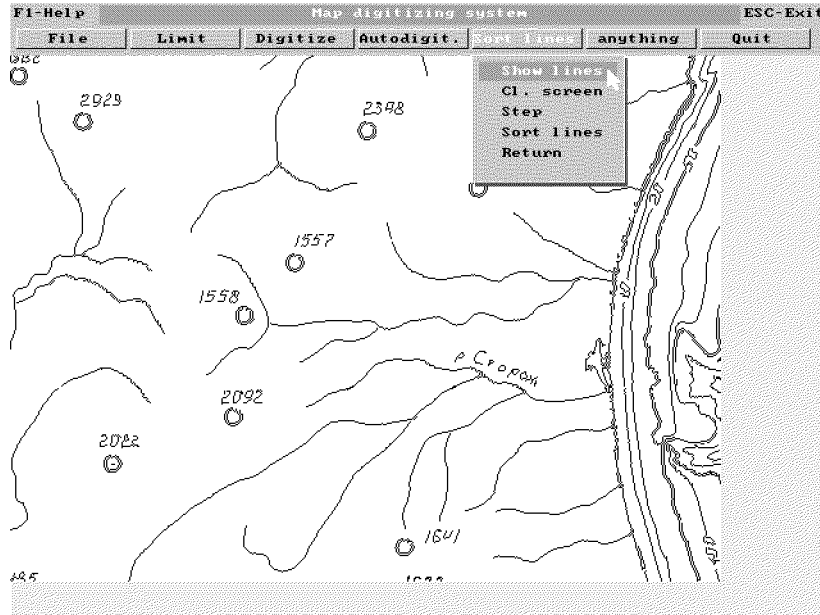


Figure 5. Vector data obtained during process of automatic vectorization

of points along lines with index of pen position (to draw, or move without drawing) also will contain a lot of “noise”.

The dot elements of map can be automatically ignored during automatic vectorization (if necessary). The other noise must be removed later. For this purpose the interactive system have the program of cleaning of a vector data file. This program will remove in semi-automatic mode all the “garbage” from received vector data. Sorting of segments and labeling each of them can be done during process of cleaning. The moment of cleaning and sorting vector data is shown in Figure 6.

The program runs through all entered vector data, and the user in interactive mode removes all “garbage” and saves only necessary data (in Figure 6 only rivers data is saved and the other data removed). After the end of this stage the cleared data can be drawn on the screen where the raster map can be used as a background (Figure 7).

For conversion of received sheet coordinates into real geographical it is necessary to run item ⟨Corners⟩ in submenu ⟨Limit⟩ and with the help of the mouse to input by clicking mouse button (moving clockwise) screen position of the four corners of an entered fragment of map, the geographical coordinates of which are known for the user. Usually the role of such points play crossings of a geographic coordinate grid. We require to consider all four angular points because in some projections a cell of a geographical grid has the form of trapezes, and knowledge of all four corners is necessary for



Figure 6. The procedure of the vector data cleaning. Saved data is drawn with black color. All the vector data after automatic vectorization is drawn as gray lines

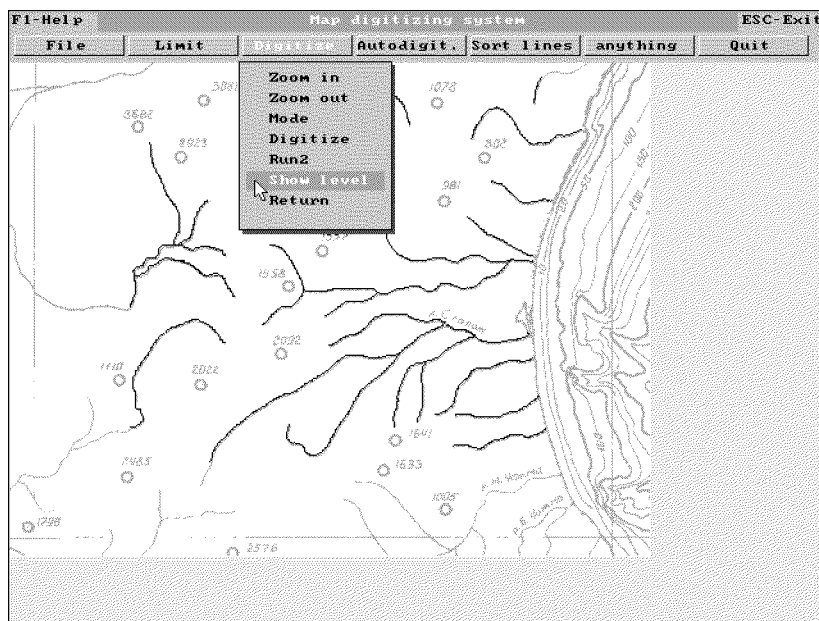


Figure 7. Inputted lines (black) drawn above the initial raster picture (gray)

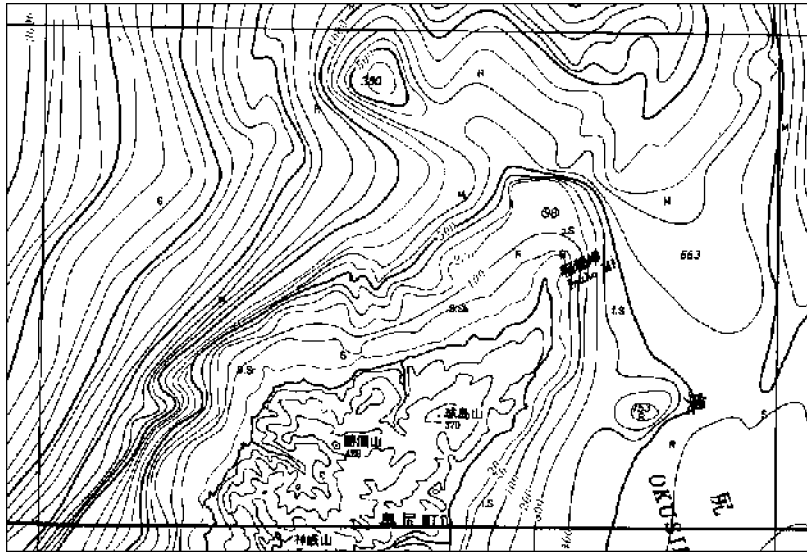


Figure 8. Initial raster map of the northern part of the Okusiri area

correct calculation of geographical coordinates of all other points on this map.

For recalculation of screen coordinates obtained with the help of this system it is required to enter latitudes of southern and northern borders, and longitudes of western and eastern borders and to start the program of conversion. Thus it is possible to convert into geographical the sheet coordinates of all lines and points, received at automatic vectorization, or levels, received at manual input or during sorting and clearing. Finally on the output the user will have a sequence of pairs of geographical coordinates with index of a beginnings or continuation of a line segment. These digital data then can be updated to geographical database and be used in geoinformation systems.

If with the help of proposed system user will enter isolines of depth from marine bathymetric charts, special program permits him to create a file of depth values on regular grid with any spatial step, covering any rectangular part of initial bathymetry chart. This method was used for creation of very detailed digital bathymetry around Okusiri island (Japan) for numerical modeling the catastrophic tsunami which occurs there in 1992. In Figure 8 the fragment of bathymetric chart is shown. Labeled isolines of depth are drawn in Figure 9. It is very important to input location of all local extreme points of the depth, because the program of digital bathymetry creation is based on interpolation method. Figure 10 shows the depth isolines of obtained 200×100 digital array of depth values. And finally in Figure 11 digital bottom relief is shown (view from the north-west of Okusiri island).

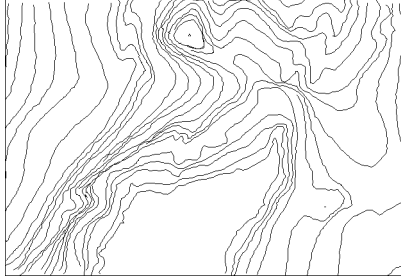


Figure 9. Manually inputted isolines of depth

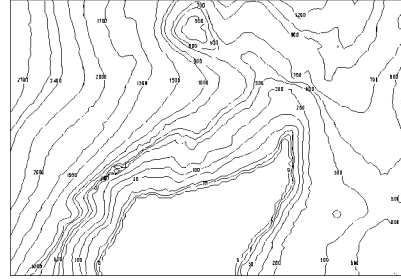


Figure 10. Depth isolines of digital bathymetry

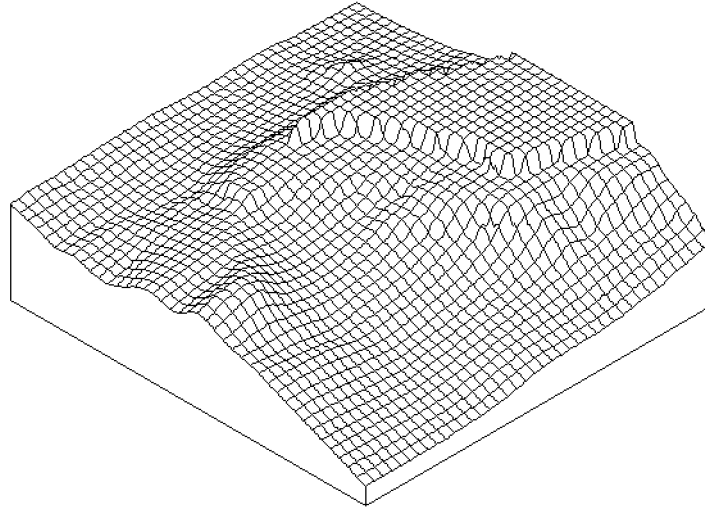


Figure 11. Bottom relief near Okusiri island which was obtained using proposed digitizing technology

References

- [1] An.G. Marchuk, *Technique for digitizing bathymetry information using personal computer*, Bull. Nov. Comp. Center, ser. Math. Model. in Geoph., No. 1, 1994, 79–86.