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Transformation of Cartographic Image into a Digital Model

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ABSTRACT The considered system in based on principles outlined in the book (1). The chief requirement to them is the optimum distribution of functions between man and computer in terms of reliable identification of signs, efficient and accurate construction of a digital model (DM) in the automatic image selection mode. The above requirement is achieved through normalization of the original cartographic material obtained during field work (eg. geologic survey) and application of the appropriate software. The normalized signs placed on the original should contain only those information-bearing elements that are easily reproduced graphically and reliably controlled visually (simple metric parameters, topological invariant and context). Individual types of normalized signs should answer the following requirements.

Editing signs. The primary images neither covered nor marked as noise by editing signs and located outside the sign of the planned interrogation are represented by a set of lines. This set is further used as the area for machine tracing and construction of axial lines. The structure of signs proper should permit the reconstruction of the image lost under them (isolines, contour lines, etc).

Signs of naming. Two types are recognized within this group of signs. The first type includes the signs whose structure, distribution and parameters permit the automatic search of the data they denote (eg. additional berglines, used for normalization of horizontal lines). The second type comprises the signs applied by the user to bind the information on the subsequent DM operation stages (eg. the areas naming). There should exist two ways of representation of the second group of signs, namely: graphically (performed by the user) and by a digital code comparable with additional information. Hence, there in need for another procedure of transforming the sign image into a code.

Signs of the planned interrogation. If a standard printer is used to reproduce the image graphically, there emerges a restriction as to the horizontal length of the modification area.

The frame of reference signs. The sign's shape should reproduce the angle points of image with the maximum accuracy possible for the applied scanning technology.

The type of a digital mode (DM) is determined by the type of the initial map. The software therefore should be universal and uniform to meet the following requirements. The first standard step in the DM construction (after scanning the map) is to create an intermediate DM being the direct result of machine tracing of the original map and, separately, of signs. The second step depends on the specific properties of the model proper. There are reflected by the software tools organized in the form of library of graphic procedures. The library's units should be universal to construct the higher-level programs, to process (identify) the normalized and traditional signs, construct DMS, etc. The software components at all stages are linked into a system by applying a single data pattern to reproduce geometrical objects.

To illustrate the system's operation, we shall consider the process of machine transformation and analysis of cartographic data starting from its input into the computer (by scanning of the original topographic map in horizontal lines) and finishing by getting the results on the printer or graph plotter in the form of digital data or the resulting cartographic image, the above example treats the problem of extension of a deformed trend surface relief resulting from the motion of plates (blocks) of the earth's crust. The problem aims at defining their pre-deformation boundaries i.e. at reconstructing their initial position this task which is of great interest to geologists and geophysicists has not yet been adequately solved. An effective solution could be achieved by the method of analytical-geometrical simulating directly on a map of horizontal lines provided that the entire processing involving the

The entire succession of the processing operating applied to solve the problem includes.

1.Normalization of the original topogra- phic map. This is done if the original map has not been intended for machine processing. It is desirable that the topographic map should contain only the image of contour lines with berglines. Other images present on the map makes the identification of contour lines less reliable and reduced the speed of data processing.

2.The input of the relief map into a computer (by scanning).

3.Construction of a semi regular digital matrix including the following program procedures: tracing

of contour lines, i.e. introduction of a frame of reference (x, y) for a succession of discrete points on the horizontal line by a given vector, identification of berglines and contour lines (specifying the h coordinate). Recognition of digital values (altitudes) is provided for a complicated (rugged) relief.

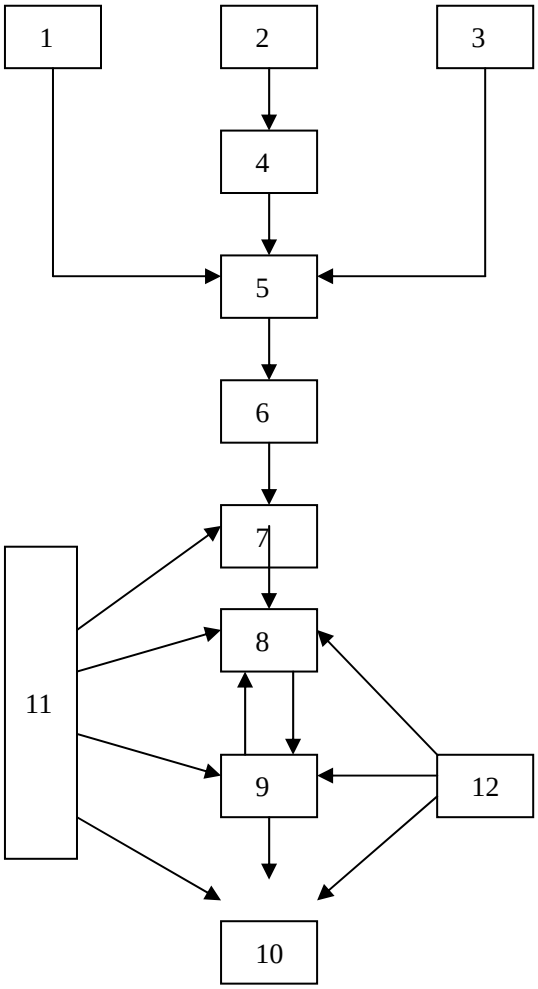

Fig. shows the block-diagram of geographic informational system.

1-primary survey data(maps, schemes, interpreted aerospace images) in the normalized form;2-published maps (geographical, geophysical, etc.); 3-copies of manuscript maps by predecessors reduced to the normalized form; 4-reduction to the machine oriented (normalized) form; 5-input into a computer by scanning; 6-preliminary processing; 7-construction of intermediate digital model (IDM); 8-processing (identification) of normalized and traditional signs; 9-transformation of an IDM into a DM (digital model); 10-application of DM (the access methods), 11-data structures for representation of geometrical objects; 12- library of graphic procedure.

above geographic information system is completely automated.

4. Construction of a map of gradient fields using the technique described in the book [1] and definition of the resultant pressure force vector in accordance with the postuldlse provided in [2] .

5. Determination of the length value of displacement vector in discrete points located along the plates' contact directed by the vector which characterized the minimum value of angle between the deformed and level surfaces in a given point (in compliance with the resultant pressure force vector) when $\partial h/\partial L_i = Pr_L \operatorname{grad} h$. The length is obtained from formula:

$$\left| \bar{d}_i \right| = \sqrt{\Delta h^2 + L_i^{\,2} - L_i} \qquad (1)$$

This is achieved under the following conditions: the displacement vector di coincides with the projection of line Li; grad is perpendicular to line h = const, the relief section h = const.; Li lies in the projection between points i, i+1 on the lines of constant levels hi and hi+1, respectively; i=1,2,3,⋯ n.

6.Determination of a sum of free vectors Dj each discretely chosen point j on the plate contact line.

$$\overline{D_j} = \bar{d}_{j,1} + \bar{d}_{j,2} + \bar{d}_{j,3} + \cdots + \bar{d}_{j,n} \cdots \qquad (2)$$

To ensure reliability of results, the following conditions must be considered:

$$\overline{D_j} = \lim(\bar{d}_{j,1} + \bar{d}_{j,2} + \bar{d}_{j,3} + \cdots + \bar{d}_{j,n}) \qquad (3)$$

$$\Delta h \to 0$$

$$n \to \infty$$

$$H = \lim H^m \quad when \quad m \to \infty \qquad (4)$$

where H- is the plate contact line;

m- is the point of observation on the plate contact line;

j=1,2,3,⋯m.

7.Construction of a restored line of the plates' contact by transferring the obtained summary values of vectors Dj by changing them to a reverse sign. This is followed by the point-by-point approximation of vector tips and drawing the initial (pre-deformation) line of the plates' contact.

Reliability of the assessment results (and of the method proper) may be checked up by correlating the size of the areas: those denoting a physical surface of the relief model constructed by points of a rectangular matrix and a flat surface obtained from extension using the techniques outlined in the book 1. Comparison of these areas has shown the value of their divergence to be within the map's accuracy.

Thus, the considered example illustrates that all operations of the normalized map processing can be performed entirely in the automatic mode.

References

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