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Dedicated to Professor Iulian Coroian on his 60th anniversary

A CONTOUR TRACE ALGORITHM

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Abstract.

Contour maps represent a typical mode of display spatial relationships not only in geology, but in many other fields when the distribution of a property over space is investigated. Computer contouring has many advantages. All the main aspects of contouring are discussed. A contour following algorithm is given. It was implemented in ZAZA, o general-purpose surface modeling software.

Keywords: contouring, grid, algorithm, grid scan techniques, contour following techniques, continuos tracing, software implementation.

Contouring

Spatial data are three dimensional data where a dependent variable z is a function of two independent variables x and y, z=z(x,y). Although data are three dimensional, they can be represented in a two dimensional form by projecting the contours in three-dimensional space into the two dimensional (independent variable) plane. Contour maps represent a typical mode of display spatial relationships not only in geology, but in many other fields when the distribution of a property over space is investigated: hydrology, environmental, meteorology, agriculture, biology, mathematics, statistics, engineering. Such maps have both quantitative and pictorial values.

Contouring is a laborious task even for experienced specialists. Computer mapping has many advantages:

- large data sets can be manipulated;
- high speed in contouring;
- data can be easily updated;
- multiple hypotheses can be tested;
- mapping results can be further analyzed using other programs.

The object of contouring is graphical drawing of isolines. Isolines are lines joining points having equal values of some property. They are lines of constant value of dependent variable z, projected into the plane of independent variables x, y. Data may consist either of a finite number of values of the dependent variable (z_i) at a set of locations (x_i, y_i), or a mathematical expression relating z to x and y. The discrete case is the most common one. Usually data points are irregularly spaced. That is why contouring methods generally contain two distinct stages:

- interpolation of irregularly spaced data to a systematic grid points (gridding);
- drawing of isolines (contouring).

The principle of isolines construction is to avoid calculating unnecessary points values, but instead to find only a selection of points at specified z values. No value is calculated for points that fall between isolines.

Contouring problem has two main aspects:

- calculation of contour line segments;
- drawing of contour line.

Calculation of contour line segments

A contour is formed either by straight-line segments or by curved line segments. Even if the use of straight line segments across each grid cell may produce contour lines of objectionable appearance, they are widely used, mainly because the problem can be eliminated by reducing the grid size.

If z_1 and z_2 are z-values in two adjacent points of a grid cell and z_c is the contour level, then the contour level will intersect the grid side if:

$$(z_c - z_1)(z_c - z_2) < 0 \tag{1}$$

The end points of the line on a grid are found by linear interpolation between grid points along the edges of the grid element. If other nearby grid nodes are used, a curved function can be calculated with nodes surrounding the cell.

Usually only one (or none) contour lines of a given level will pass through a grid cell. Whenever two opposite corners of a grid cell are greater than a given contour level and the other two corners are less, that grid cell can have two contour lines passing through it. When two contour lines pass through the same grid cell, determining their positioning from the cell boundary coordinates is ambiguous. The lines must connect adjacent sides, otherwise the contours will cross. A new z value can be determined at the diagonals' intersection, in order to eliminate the ambiguity. The new z_M value will be equal to the average of z values in the corners of grid cell, z_A, z_B, z_C and z_D.

$$Z_M = (Z_A + Z_B + Z_C + Z_D)/4 \tag{2}$$

Drawing of contour lines

There are two classes of contour drawing algorithms:

- grid scan techniques;
- contour following techniques.

Grid scan techniques examine each grid cell in turn. When a grid element is examined, the identified line segments are drawn. The method is very simple and minimizes the computer time. Major disadvantages are the difficulty in assigning contour level and the inefficiencies of pen movement, when a plotter is used as graphic output device.

The method can be improved in order to continuously draw a given contour level. All line segments belonging to that contour must be first stored and ordered, then drawn. This implies additional memory to store the line segments and increased computation time.

Contour following techniques consists in a continuous generation of segments of a single line contour. The procedure terminates either upon closure of the line or intersection with the grid boundaries. The logic of such a method is more complex than the grid scan techniques and requires increased computation time. The logic must also include a method of preventing redrawing of a contour when another portion of it is encountered.

Isolines are often smoothed, generally using splines. Splined isolines are primarily cosmetic. They do not add information or improve the surface estimate. Bad spline algorithms can even produce spurious sinuosity or contour crossing.

A continuos contour tracing algorithm

A continuos contour tracing algorithm was implemented in ZAZA, a general-purpose surface modeling software. Every contour level is drawn in at most two steps. Assigning contour level is possible. Undefined z-values in grid are allowed.

The algorithm is a combination of grid scan and contour following techniques. For every contour level that must be drawn, grid is scanned. When a line is found in current cell, the procedure shown in fig. 1 is followed. The procedure implements a contour following method. Assigning contour level is optional.

Every encountered cell when a contour line is traced will be marked. Cells are reset every time a new contour level is started. Interior isolines are drawn in one step. Boundaries' isolines are drawn in one or two steps. Double track isolines in a cell are always detected.

The algorithm was implemented in Borland Pascal 7.0, using object-oriented methods.

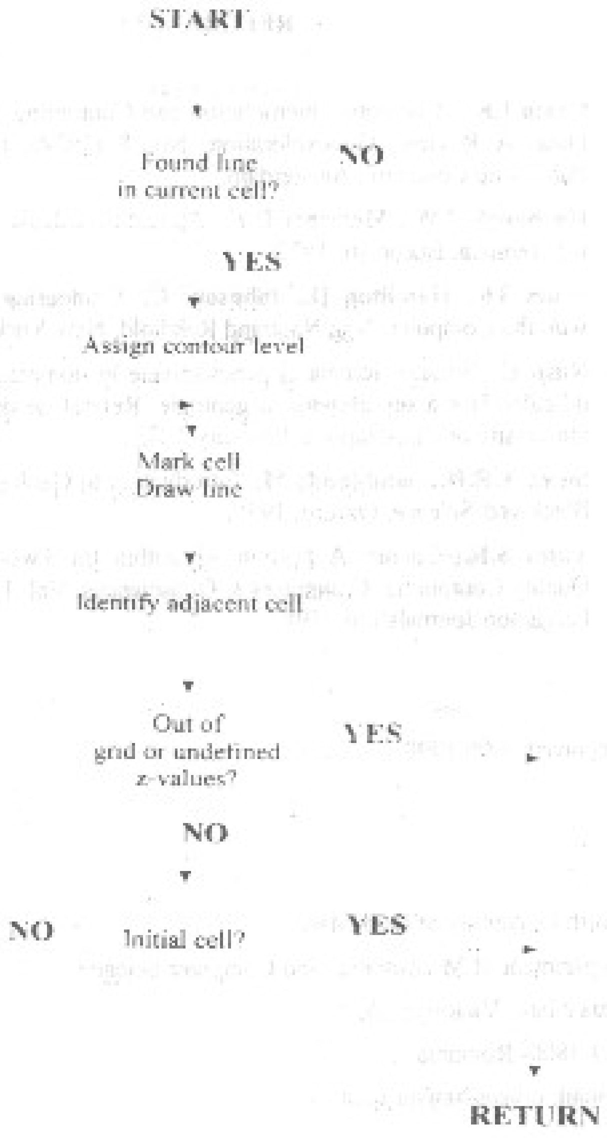

Fig. 1 Contouring algorithm

REFERENCES

1. **Crain I.K.**: Computer Interpolation and Contouring of Two-dimensional Data: A Review, Geoexploration, No. 8 (1970), pp. 71-86, Elsevier Publishing Company, Amsterdam.
2. **Harbaugh J.W., Merriam D.F.**: Aplicaţiile calculatoarelor în geologie. Ed. Tehnică, Bucureşti, 1972.
3. **Jones Th., Hamilton D., Johnson, C.**: Contouring Geologic Surfaces with the Computer, Van Nostrand Reinhold, New York, 1986.
4. **Rusu C.**: Situaţia actuală şi perspectivele în domeniul modelării asistate de calculator a suprafeţelor în geologie, Referat de doctorat I, Technical University of Cluj-Napoca, February 1998.
5. **Swan A.R.H., Sandilands M.**: Introduction to Geological Data Analysis, Blackwell Science, Oxford, 1995.
6. **Yates S.R.**: Contur: A Fortran Algorithm for Two-Dimensional High-Quality Contouring, Computers & Geosciences, Vol. 13, No. 1, pp. 61-76, Pergamon Journals Ltd., 1987.

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