

AUTOMATIC DETERMINATION OF TOPOGRAPHIC DEPRESSIONS FROM VECTOR DATA

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Abstract

Although several methods have been proposed to reveal topographic depressions from raster datasets based on cell height data operations, there is no certain method of detecting them from vector elevation data (contour lines). Only rule-based approaches can be utilized to automate the detection of such features from vector data. Here we introduce a method to find topographic depressions in vector datasets. Using this method we develop an ArcGIS tool by the help of ArcObjects utilities and make some applications with 1/50.000 and 1/100.000 scaled vector dataset. Preliminary results show that it takes few minutes to detect all depressions throughout the map. More applications should be performed and the results be compared with raster outputs.

Introduction

Depressions are the natural troughs and one of the most critical features that should be indicated with a cartographic symbol in the topographic maps especially for GIS applications. They can be defined as closed contours delimiting an area of lower elevation than the surrounding terrain out of which there is no surface drainage. They are represented by a series of concentric closed lines with a mark pointed towards the lowest depression contour in our cartographic data model (Figure 1). They are approximately the same shape as the hills, located on the concave side, whereas the hills have an asymmetric cross profile with highest point and steeper slopes on the convex side. That's why; a clear distinction should be created between closed contour lines indicative of hills and depressions. However the problem frequently encountered is how to determine topographic depressions or hills exist in topographic map with or without adequate spatial information of terrain.

With the fast growing computer technologies and raster data manipulations, topographic surface can be automatically detected in raster data by pointing a cell where the elevation is lower or higher than all of its neighboring cells. Some ArcGIS spatial analyst or spatial statistic tools (like SLOPE, ASPECT, SINK, FILTER, etc.) can be utilized for the detection of depressions. These tools use some methods for derivation of surface network: east-manual (Wolf, 1984), triangulation (Takahashi, 1995), or complex surface fit (Pfaltz, 1976), (Wood, 1998) and calculate values with stochastic or deterministic models (Sengün et al, 2006).

Depressions can be determined not only with raster data but also vector data by spatial query. Since the map production process in General Command of Mapping (GCM) is performed by using vector data, it encourages us to detect depressions from vector data instead of raster one. Although we get line depression features from 1/25.000 scaled master dataset, we cannot correctly locate them in derived maps on account of the structure of data model, cartographer errors and generalized contour lines.



Figure 1. Symbolology of topographic depression features
(a) Line symbol, (b) Point symbol

Objectives

Understanding the shape of the topographic surface is useful for many fields, such as regional planning, agriculture and forestry. Due to the undesirable effects resulting from the occurrence of topographic depressions, most environmental modeling (particularly hydrological modeling) has its first step as the identification of topographic depressions (Cooper and Bottcher, 1993). This identification focused on analysis of closed depressions throughout the area to determine the origin and assess potential recharge rates which is important for creating a trench through a dam or obstacle in front of a depression. It is also important for potential flood tendency determination based on geographical analyses of land use, soils and topography to find potential depressional areas and estimate the quantity of runoff. Moreover, depressed areas are essential for meteorology to forecast accumulation of warmer air due to its negative relationship with elevation.

Because of these reasons, it is necessary to determine depressions and visualize them on maps. In addition; keeping depressions in vector format in the databases provides more flexibility for GIS applications.

Methodology

In our data model, depart from other important characteristic of topography such as hills, ridges and mountains, depressions are related with a feature (line or point) and denoted in maps with specific symbols. In this study, we introduce a new method to find topographic depressions in vector datasets whose flow chart is shown in Figure 2. The

method is based on intersections of exterior rings of 0.2 meters buffer zones constructed around closed contours and Triangulated Irregular Network (TIN) data created from 1/25.000 scaled elevation, hydrology and utility feature classes.

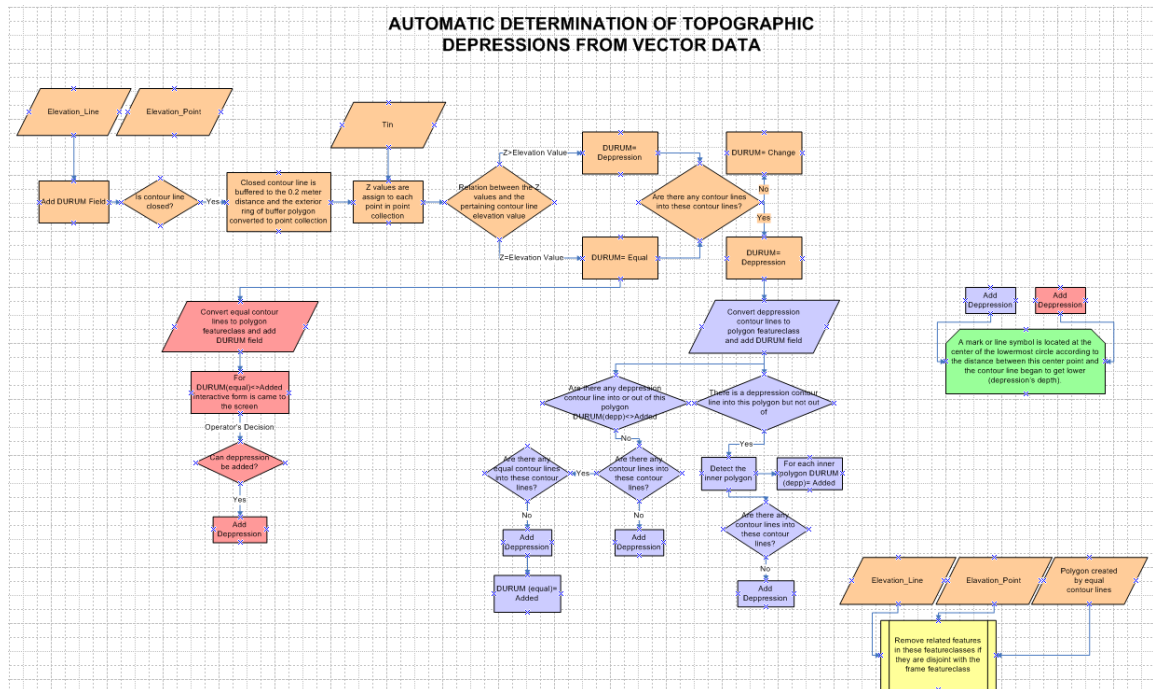


Figure 2. A flow chart describing the automatic detection of topographic depressions from vector data

The method comprises of two main steps namely automated and interactive parts. In the automated part, depressed contour lines are determined via the Z values assigned to the vertexes of exterior rings of buffered contour lines from TIN data. In order to determine whether the topography is getting lower or not, the elevation value of each vertex is compared with the value of corresponding contour line. If it catches a higher Z value than contour elevation, it adds a depression mark to this contour.

After automated process completed, an interactive form for the cartographer's decision is displayed (Figure 3) on the computer screen when it catches equal Z values with the value of corresponding contour lines. In this case cartographer checks the nearby auxiliary contour lines around the principal contours and decides to add a depression mark.

Eventually, if a depression is found in both steps, a mark or line symbol is located at the center of the lowermost circle according to the distance between this center point and the contour line began to get lower (depression's depth).

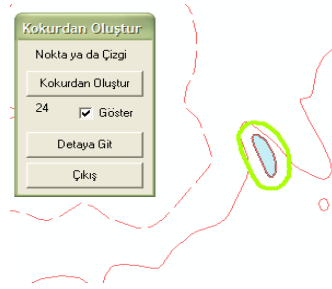


Figure 3. Interactive form for the cartographer's decision

The method takes into account the special cases e.g., at the edge of maps where the contour lines cannot constitute a closed line and pass to neighbor maps or depression symbols aesthetically wrong located (Figure 4).



Figure 4. Depression symbols aesthetically wrong located.

We develop an ArcGIS tool by the help of ArcObjects utilities and make some applications with 1/50.000 and 1/100.000 scaled vector dataset using this method. We also compare our results with those obtained from raster operation for the same area Figure 5.

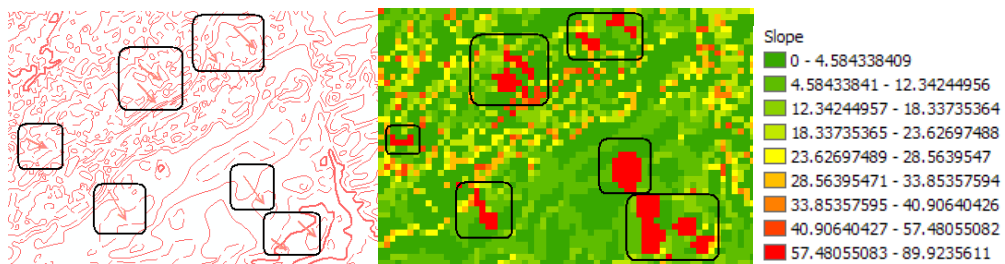


Figure 5. Topographic depressions shown with grid data

Results and conclusions

Contours are indeed 3D geometry shapes. Their third dimension is concealed on their geometric shapes. Nevertheless it is rather difficult to discern topographic changes with them, because they designate the third dimension only with spatial query (Cetinkaya et al, 2006). Being part of this phenomenon, topographic surface can be categorized into

different morphological structures such as hills and depressions for the aim of analysis and visualization. Depressions are the natural troughs and one of the most critical features that must be indicated in the topographic maps especially for GIS applications. They can be detected both with raster and vector data. During our map production process in GCM depressions are detected from vector data instead of raster one. In this study, we introduce a method based on polygon's exterior and interior rings intersection with contour lines to find topographic depressions in vector datasets and develop an ArcGIS tool using ArcObjects utilities. Preliminary results show that it takes few minutes to detect all depressions throughout the map. Compared with the raster outputs, this method takes approximately same time to detect and represent depressions cartographically. By this way, interactive editing time is shortened, errors made by cartographers are reduced and more accurate maps can be produced.

References

Cetinkaya,B., Aslan,S., Sengün,Y.S., Cobankaya,O.N., Ilgin,D.. 2006. Contour Simplification with Defined Spatial Accuracy, *ICA/ Workshop on Map Generalisation and Multiple Representation*

Cooper, A.B. and Bottcher A.B.. 1993. Basin Scale Modeling as a Tool for Water Resource Planning. *J. Water Resource. Plan. & Mgmt.*, Vol. 119. No. 3. pp 306-323.

Pfaltz, J.L., 1976. Surface Networks. *Geographical Analysis* 8 (2), 77-93

Sengün,Y.S., Aslan,S., Cetinkaya,B., Cobankaya,O.N.. 2006. Determination of Field Characteristic by the Help of Defined Features, *ICA/ Workshop on Map Generalisation and Multiple Representation*

Takahashi, S., Ikeda, T., Shinagawa, Y., Kunii, T.L., and Ueda, M., 1995, Algorithms for Extracting Correct Critical Points and Constructing Topological Graphs from Discrete Geographical Elevation Data. *The International Journal of the Eurographics Association*, 14 (3),C-181- C-192.

Wood, J.D., 1998. Modeling the continuity of Surface form using Digital Elevation Models. In: *Proceedings 8th International Symposium on Spatial Data Handling*, Vancouver, Canada, 725-736.

Wolf, G.W., 1984. A Mathematical Model of Cartographic Generalization, *Geo-Processing*, 2 (3), 271-286.