A NEW APPROACH FOR CHECKING CONTRADICTIONS OF CONTOUR ELEVATION

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ABSTRACT:

The elevation contradiction of contours is an important question in the quality checking for spatial data in geographical information system. This paper presents a new approach to check the elevation contradiction among contour lines based on the problems and shortages of the conventional approaches. This approach checked the elevation contradiction between every contour and its adjacent contour on the given side so that it can check the elevation contradictions in the whole data layer. The research makes clear that this approach runs fast, has unique checking-result, and is quicker and more convenient to find the contours. This approach has been applied in the Quality Checking system for National 1:50 000 DLG which developed by the National Quality Supervising and Testing Center for mapping products, and has achieved good results.

1. INTRODUCTION

The elevation contradiction of contours is an important question in the quality checking for spatial data in geographical information system. It is one kind of attribution errors of contour elevation, and is a main error type of contour lines. It mainly belongs to mistake, and is the key point in the quality checking of contour, and has biggest difficulty in technical. In the recent years, technologist have done some work on the question, and the author has done special research on the question during the developing of the Quality Checking system for National 1：50 000 DLG, and has presented a new approach which named directional scanning to check the contradictions of contour elevation.

2. QUESTION DEFINITION

2.1 Fundamental Concepts

If the contours are complete and their elevations are correct, the lack between the elevations of two adjacent contour lines has five circumstances, supposing that the contour interval is 10 meters.

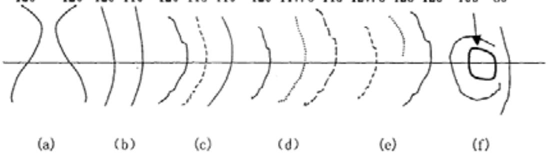

Figure.1 The Sketch Map of elevation lack between two adjacent contour lines

- Equal zero, like Fig.1(a)
- Equal to the contour interval, like Fig.1(b)
- Equal to a half of contour interval, like Fig.1(c)
- Equal to a quarter of contour interval, like Fig.1(d)
- Equal to three quarters of contour interval, like Fig.1(e)
- Uncertain value, like Fig.1 (f). If the contour lines are very thick, some contour lines may not complete, and then the lack between the elevations of two adjacent contour lines may be uncertain.

If the lack between the elevations of two adjacent contour lines don’t satisfy the six circumstances above, and then it may have elevation contradiction between the two lines.
The automatic checking system can only check the front four circumstances, but for the (e) and the (f) circumstance we can only record it as errors, and then check it by human.

2.2 Question Proposing

We can know from the definition of elevation contradiction that if we fully use the graphic relativity between two adjacent contour lines, describe the adjacency relationship of the contour lines by some means, get the spatial and attribute information of every two adjacent contour lines, and then we can check the elevation contradictions of the contours simply and effectively.

3. CONVENTIONAL APPROACHES

There are four approaches to check the elevation contradictions of the contours under present technology.

- The Voronoi graph approach

Firstly, create voronoi graph from vector contours under the basic GIS software; secondly, extract the contour lines which has common voronoi edge, computer the adjacency coefficient, and built the adjacency relationship table; last, check the elevation contradiction of the contour lines which are adjacent according to the adjacency table, and exclude the abnormal abuttal.

This approach has unique, correct and dependable checking results. But it is hard to built voronio graph and extract the adjacency relationships in the approach, and the time consume of this approach is very large.

- The grid approach

Firstly, convert the contours to grid as the following regular that the values of the pixels which have contours cross are the elevation of the contours when the pixels which have no contour cross are null; secondly filled the pixels whose values are null with the elevation of the contour line which most adjacent to them; last of all, check the grid image with the 3*3 float template.

This approach has high accuracy, and the system resource requisition is low, but is difficult to decide the size of the pixel. If the pixel size is too small, and then the computation amount will enlarge in multiples, so it may influence the efficiency of the approach. If the pixel size is two large, it will bring down the precision of the contour grid and then influence the accuracy of the check results. And the check result of this approach is influenced by the pixel size, so the check results are not unique. The error contour lines can only located by x and y coordinates in the approach, and can not identify by attribution.

- The bi-direction scanning approach

Firstly, intersect the contours with horizon lines with a certain interval from left to right, sort the intersections of each horizon line by x coordinate, and then check the elevation lack of the adjacent contour lines according to the intersections; secondly, intersect the contour lines with perpendicular lines with the same interval from down to up, sort the intersections of each horizon line by y coordinate, and then check the elevation lack of the adjacent contour lines according to the intersections.

This approach is similar to the grid approach, has high accuracy, and the system resource requisition is low, but the computation amount is large, and it enlarges exponentially as the contour density enlarges.

- Layering approach

Display the contours by layering means that colors each contour line according to its elevation, and the colors of the contours gradually change according to the stepwise changes of elevations.

This approach is very simple and easy to execute, but the distinctions of colors are unapparent that we can't distinguish them while the number of the contour lines is large, so generally we don't use the approach.

Altogether, the approaches above have is either complicated and low efficient, or has no unique solution and difficult to identify the error contours. This paper presents a high efficient, unique solution and easy-identifying new approach which named directional scanning to check the contradictions of contour elevations based on the problems and shortages of the conventional approaches, and it is described as follows.

4. DIRECTIONAL SCANNING APPROACH

4.1 Algorithms thought

For the lack between the elevations of two adjacent contour lines in any indiscriminate direction must conform to the elevation change law, thus if we check and only check the elevation contradiction of one contour and its adjacent contour on a certain direction, and then we can find all the contradictions in the whole contour layer. This above is exactly the central thought of the directional scanning approach. This article had chosen the north direction to verify this thought, it checked the elevation contractions in the whole layer by checking the elevation contradiction between every contour and its northern adjacent line (if the north adjacent line is not exist, use the eastern adjacent contour line instead).

4.2 The steps of the algorithm

Firstly, figure out the biggest x coordinate Xmax and the biggest y coordinate Ymax of the contour layer according to the coordinates of the starting points and end points of contours.

Secondly, decide the scanning interval △d according to the density of the contour lines. The thicker the contour lines are, the smaller △d is; the lanker the contour lines are, the bigger △d is.

Thirdly, get the first one contour line in the contour line layer.
The fourth, search the north adjacent contour line of the contour line according to Ymax and △d. If find, execute the sixth, else execute the fifth.

The fifth, search the eastern adjacent contour line of the contour line according to Ymax and △d. If find, execute the sixth, else execute the seventh.

The sixth, calculate the elevation lack of the two adjacent contours, if it satisfies the frontal four conditions of figure 1, mark correct, else write error information.

The seventh, move to the next contour line, execute the forth to the sixth repetitively.

The eighth, return the error information, and complete the algorithm.

4.3 The key point of the algorithm

The algorithm for searching the northern/eastern contour line is described as follows. First, get the minimum-circumscribed-rectangle of the contour, draw the minimum-circumscribed-rectangle's middle-perpendicular line on the Y/X direction, and find the point whose Y/X coordinate is the biggest in the intersection set of the contour and the middle-perpendicular line. Extend the point to be a segment of line in a parallel with the Y/X axis, and intersect the segment of line with other contours, the first contour line which intersects with it is the wanted.

The algorithm for searching the north adjacent contour line is described as follows, and figure 2 is the flow sheet of it.
The first, find the minimum-circumscribed rectangle of the contour line L1.

The second, draw the minimum-circumscribed rectangle's middle-perpendicular-line on the Y direction, and find the point ppoint(x, y) whose Y coordinate is the biggest one in the intersection set of the contour line and the middle-perpendicular line.

Thirdly, judge if y plus 0.01 is greater than Ymax. If greater, then execute the ninth, else, execute the fourth.

The fourth , let n equals to 0. Draw segment of line parallel with Y axis from ppoint1(x,y+0.01) to ppoint2(x, y+（2n+1）*△d), and search the intersection set of the segment of line and the contour line. If the intersection set is empty, then execute the fifth, else execute the seventh.

Comment, the Y coordinates of the beginning point plus 0.01 so that the segment of line won't intersect with the original contour line, and it will speed up the calculation by using the crescive scanning interval （2n+1）*△d .

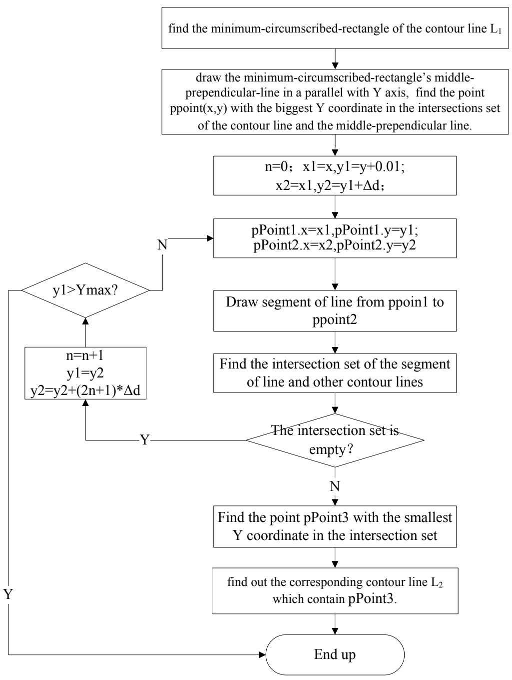

Figure.2 The algorithm flow sheet to get the closest contour line in the northern side

The fifth, judge if the Y coordinate of the segment of line is greater than Ymax, if greater, then execute the ninth, else, execute the sixth.

The sixth, n plus 1. Draw new segment of line with the length of（2n+1）*△d from the end point of the original segment in a parallel with the Y axis, and search the intersection set of the new segment and other contour lines. If the intersection set is empty, then execute the fifth, else, execute the seventh.

The seventh, find the point with the smallest Y coordinate in the intersection set, and find out the corresponding contour line L2 which contain the point. L2 is exactly the wanted.
Experiments

The author has chosen 4 pieces of 1:50 000 contour line data of different geography as experiment data, and has done experiments on the AMD Sempron Processor 3000+ computer, the result was showed in table1.

Geography	**The number of contour lines (pieces)**	**Elevation contradictions**	**Time waste (minutes)**	**Checked out Elevation contradictions**
Plain	1104	3	1.4	3
Down land	1314	3	1.5	3
Up land	4398	3	17.18	3
Mountainous region	5306	4	34.12	4

Table.1 The experimentation result of directional scanning

We can see from the experiments above that, it is commendably to use the directional scanning approach to check the contradictions of contour elevation.

5. CONCLUSION

The contradiction of contour elevation is one of the inevitable and most difficult questions in the quality checking for spatial data; many spatial data quality checking software evades this question. The text introduced a simple and efficient algorithm to check the elevation contradictions, and had applied it in the Quality Checking system for National 1：50 000 DLG which developed by the National Quality Supervising and Testing Center for mapping products. The results show that the algorithm runs fast, has correct and dependable results, and has good stability.

REFERENCE

Liu Jianjun, Wang Donghua, Qiao Chaofei, Shang Yaoling, 2004. The Study of Description and Application of Contour Adjacency Relationship. Journal of Surveying and Mapping.33 (2), pp.174-178.

Liu Jianjun, Wang Donghua，Shang Yaoling, 2001. The Software Automatic Checking Methods for the Quality of Contour Digitizing [J]．Science of Surveying and Mapping，26(4), pp.36-38

Qiao Chaofei, Chen Jun, Li Zhilin, Liu Jianjun, Zhao Renliang, 2005. Representation of Spatial Relationships of Contours Based on Graph Theory. Journal of Mining Industry University of China. 32(3),pp.279-283

Xu Jian-da, 2004. The quality control of aerial surveying geomorphological data, thesis for master's degree: Photogrammetry and Remote Sensin. Zheng zhou,China.