Automated Interference Detection in Cartographic Generalization

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Abstract:

Displacement is a vexing problem in automated generalization. We must detect the positions of feature interference on maps before displacement. In this paper, the methods of detecting the interferences based on map database are discussed and the example is given.

1 Introduction

The automated cartographic generalization is a important problem awaiting solution in geographic information system or in automated map compilation system based on map database. But there are still many difficulties to completely solve these problems at present.

Displacement is one of most difficult tasks for cartographic generalization. Obviously displacement is easy in manual generalization because a cartographer can see at a glance when features in the map will interfere with another, and can adjust the feature positions on the pull—up to resolve this interference. However the same problem is difficult in automated cartographic generalization because the same result must be accomplished by means of the application of a variety of computational geometry techniques. In automated generalization, three steps to be best solved are as follows:

(1)Detecting where the overlapping positions on maps exist,

(2)Determining preference of the overlapping features in overlapping areas and displacing or breaking the feature which has the lower rank and,

(3)Ensuring new overlapping never appear after the feature is displaced.

Because in step (1) and (3) the overlapping positions automatically need to be detected by computer, the automated interference detection is a vital task that will be done from begin to end in displacement. A convenient and effective method of the automated detection for interference is presented in this paper.

2 Automated detection of interfering features

2.1 The kinds of interference and the determination of the ranking of features

Point feature, linear feature and areal feature are three kinds of features on maps. And there are five kinds of interfering features in interference detection corresponding to the three kinds of features. They are point overlapping with point, point overlapping with line, point overlapping with area, line overlapping with line and line overlapping with area. Because the area can be regard as a closed line the beginning of which touches its end, the five kinds can be generalized three. They are point overlapping with point, point overlapping with line and line overlapping with line.

To resolve the interference one feature must be displaced and the other mustn't, or the two features are all displaced. Ranking of interfering features is to determine in two overlapping features which is to be displaced and which is to remain fixed in its original location. It is necessary to rank these interfering features in some way to indicate the severity of the interference. Ranking of interfering features based on the following two factors:

(1)The importance of a feature and,

(2)The direction change of the linear feature.

The above two factors are considered between overlapping features. All features on topographic map are ranked as follows:

sea line, large river, control survey point,

other hydrography feature, railroad, highway,

large residential area, prominent feature,

small residential area, other road, boundary,

contour line, isobath, pipeline,

land boundary.

Once the interfering features are ranked, the feature with lower rank is chosen as the feature to be displaced with respect to the higher one. If the ranking of two features are the same, the feature which has the greatest amount of direction change is chosen as the feature to be displaced.

2. 2 Automated detection of interfering features

According to the mode of interference of features listing in section 2. 1 the detection of interfering features on maps is divided into three kinds. The detection of three kinds of point overlapping with point, point overlapping with line and line overlapping with line will be done by different algorithms.

2. 2. 1 Detection of point overlapping with point

The ordinary method of detecting point overlapping with point is to calculate the distance d between the centers of the two point symbols. Defining d1 is the smallest distance between the two points on generalized map. If $d < d1$, the two points are overlapping. And the two points will no overlapping if $d > d1$.

Because the time to calculate the distance is very long, the distances of one point to all the others don't all need to be calculated. To detect the interference the correct algorithms is to open a window and detect the objects that falling into the window. The window is a square and the center of which is the center of the point symbol and the length of its one side is 2d1. Calculating the distances between the center point and all the others falling into the window will save much time. The others overlapping with the center point is always near the center point and falling into the window. The distance between the center point and the others out of the window can't be calculated because it is always larger than d1. When the distance d is calculated we can compare d with d1 to determine whether the center point is overlapping with the other points.

2.2.2 Detection of point overlapping with line

The algorithm that detected the overlapping between the point and the line is similar to the detection of point overlapping with point. The difference is the distance d is not between the point and point but between the center of the point feature and the centerline of linear feature, and the window is a rectangle whose size is corresponding to the maximum and minimum values of the centerline's coordinates. We only calculate the distances between the centerline and the point which fall into the window. Suppose d1 is the vertical distance between the point center and centerline in the generalized map. Comparing the d with d1 we can determine whether the point overlap with line.

The window can be set into a polygonal one in order to save the calculating time. When linear features are plotted on a map, they take on a finite width. To detect the possible interference in the generalized map, the linear feature is first expanded into a simple polygon and this polygon forms a band of half—width d1 centered on the polyline. So the left polygonal polyline and the right polygonal polyline must be formed by using the center polyline in order to form this simple polygon. Then detect the points falling into the polygon and calculate the distances d between points and centerline. Finally the interference among points and lines can be found.

According to the relationship between point and line the three different kinds of detection of point overlapping with line should be distinguished.

(1)The point is located on the line

In this type the distance between point and centerline is smaller than the error of digitizing linear features. If the distance between the point and the start or end node of line is smaller than half—size of the symbol, the point feature locates on the start or end node of the line. Otherwise the point feature locates on any point of the line except its start node or end node.

(2)The point is tangential to the line

Under these circumstances the point feature would overlap with linear feature in generalized map when the scale decreased.

(3)The point is apart from the line

The point feature may interfere with linear feature when plotted in the generalized map.

When (2) or (3) occurs, it can be detected by using the algorithm given above.

2.2.3 Detection of line overlapping with line

The detection of interfering lines is more complex. It can be realized by means of using the center polyline of the two lines generate the left offset polyline and right offset polyline to form a simple polygon, and check whether the two lines interfere with each other. But using this method the calculating is too large and it will spend much time. A good method is as follows: first open a window and then make a rough estimate to see whether the two lines are close to each other. The near lines in window are checked exactly using the raster mode for interference detection.

Detecting line interference by raster mode is easy to be realised. First the grid size should be chosen and a vector—to—raster conversion of the near lines is made, then the degree of the interference can be estimated by adding up the number of yes—cells, and the complexity of interference might be inferred from the number of contiguous groups of these yes— cells. The important thing in raster mode is to choose the grid size. Grid size clearly should not be so large as to suggest a need for displacement where linear symbol are merely close but not touching. Equally inappropriate is the crude approximation of the symbol by its center line alone, the feature path of overlapping parallel line symbols need not share the same grid cells. A reasonable compromise, however crudely it might portray a feature's curvature, is a grid with cell height and width equal to half the thickness of the two linear symbol and add the minimum space between two lines on generalized map.

There are many algorithms for vector — to — raster conversion. The algorithm used here is according to reference [1]. By adding up the number of yes — cells the degree of interference can be inferred. If the number of contiguous groups of yes — cells are elongated clusters, and for which the feature azimuths differ by not more than 25°, the displacement clearly is needed to resolve graphic interference. Very small and very large clusters are particularly characteristic of graphic interference that might be removed by displacement. In contrast , if trend azimuths are 75° apart and the yes — cells in the case of a single compact area, the two lines merely cross so displacement would be both unwarranted and futile.

3 Example analysis

A system of programs was written by C program language to implement the methods developed in the previous sections. It is run on a PC 486DX/40 computer. The data of the example is from a map database. Two sheets of map are used to test. The results of running system demonstrated convincingly the effectiveness of the approach developed in the previous section.

The correct rate of automated interference detection is very high and the running time is short. The size of the window and the space between two lines on generalized map are the important value that must be chosen correctly for interference detection. The grid size of raster mode is choose carefully too. The rnuning time is longer if there is a high density of map features. In contrast, the time was short.

REFERENCE

[1]Hu Youyuan, Huang Xingyuag, 1987. Computer — assisted cartography. The print of surreying and mapping.

[2]Mark Monmonier, 1987. Displacement in vector — and raster — mode graphics. Cartographica, Vol. 24, No. 4.

[3]Bradford G. Nickerson, 1988. Automated cartographic generalization for linear features. Cartographica, Vol. 25, No. 3.