RESEARCH ON INFORMATION AUTOMATIC GENERALIZATION WITH VARYING MAP SCALE

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ABSTRACT
The change of spatial topological relation and how to recover these topological relations through studying the change of objects' geometrical relation are studied, twelve approaches have been given to resolve 12 kinds of geometrical deformation in map generalization.

1. INTRODUCTION

Along with the development of GIS in various application field, the existing GIS data processing technique can not meet with the requirements of space times and information society, the important problem is that GIS can not resolve the increase and decrease of information when data on vector space change with scale. Namely, the problem of extraction and recovery of space information with the varying map scale. The varying map scale GIS is a kind of information processing techniques for extraction and recovery of GIS space information in accordance with the scale, which the information of spatial objects increases or decreases automatically along with the change of the scale in a certain region, based on a big database. Varying map scale technique includes map automatic generalization and information automatic generalization. Many scientists had made a detail definition and analysis for map automatic generalization and gained mature results，But Information automatic generalization is emerging, which mainly studies the change of spatial objects' topological relation, geometrical relation and attribute relation in information extraction of GIS when map automatic generalization. This paper mainly research into the change of spatial topological relation and how to recover these topological relations through studying the change of objects' geometrical relation.

2. THE CHANGE OF INFORMATION IN MAP AUTOMATIC GENERALIZATION

As all known, the following means influence the geometrical relation of map in map automatic generalization:

1. Selection of diagnostic object sign
2. Displacement
3. Distortion
4. Merging

So, we can get 12 kinds of change in map generalization.:

1. Reshape polygon to counter self-coalescence
2. Reshape two polygons to counter coalescence
3. Displace polygon to counter coalescence
4. Select subset of points to counter congestion
5. Amalgamate polygons to counter coalescence and congestion
6. Partial area collapse to counter self-coalescence
7. Area conversion to counter congestion
8. Typification in sets of polygons to counter congestion
9. Dissolution in a subdivision to counter imperceptibility and congestion
10. Exaggeration amidst other features
11. Exaggeration in a subdivision
12. Typification of a polygon to counter self-coalescence

3. INFORMATION AUTOMATIC GENERALIZATION WITH VARYING MAP SCALE

Points are independent objects in topological data structure and they can be connected each other to form a line. Line is constituted by a series of connected points, starting with a start point and ended by a terminal point. String is a line of one or more polygons, also called arc or edge. Node is the intersectant point or the terminal point of line or string. A polygon is composed by a outer ring and zero to more inner rings, and a ring is composed by one or more strings. This shows that the essential geometrical structure in topological data is line, so we should generalize line, then smooth it and process consistency check. Now we discuss the change of topological data based on 12 kinds of deformation in map generalization.

1. Deformation of single polygon

We only need change the deformation of the line related to this polygon. A SHAPE polygon $C_i(s) = (u_i(s), v_i(s))$ is given, make a polygon S*(s, t) through these lines, t is the parameter of the SHAPE polygon, then $S^*(s,t) = (U(s,t), V(s,t))$ and

$U(s,t_i) = u_i(s), V(s,t_i) = v_i(s)$

$\forall t \in [0,1]$,make S(s,t)=(x(s,t),y(s,t),z(s,t)),so

$$S(s,t) = P(t) + a(s,t)\vec{x}(t) + b(s,t)\vec{y}(t)$$

a(s,t)and b(s,t)isdefined as follows:

Let

$$m_1 = \min_s U(s,t), m_2 = \max_s U(s,t)$$

$$m_3 = \min_t V(s,t), m_4 = \max_t V(s,t)$$

$$SC_x = \frac{m_2 - m_1}{|l_2(t) - l_1(t)|}, SC_y = \frac{m_4 - m_3}{|l_4(t) - l_3(t)|}$$

then

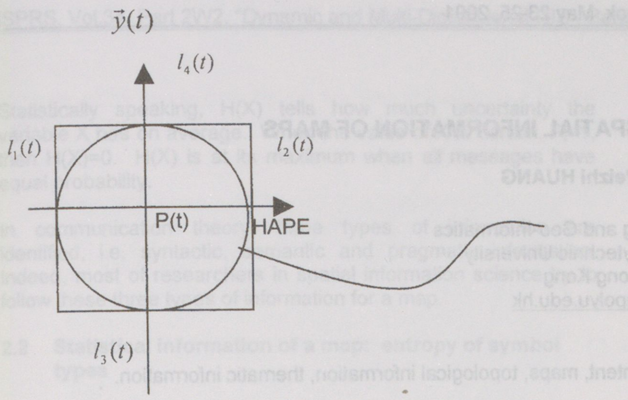

Figure1

$$a(s,t) = (U(s,t) - m_1)SC_x + < l_1(x) - P_1(t), \vec{x}(t) >$$

$$b(s,t) = (V(s,t) - m_3)SC_y + < l_3(x) - P_2(t), \vec{y}(t) >$$

2. Distortion of two polygons

We should distort the line included in the two polygons.

3. Displacement of polygon

Displace points in lines related to this polygon.

The special methods of 2 and 3 can be the same as 1.

4. Point selection

Filter the point information through the selection algorithm. For example, there are two classifications, consider the geometrical properties, first, computer the expectation $M_1 = \begin{pmatrix} m_{x1} \\ m_{y1} \end{pmatrix}$ of samples in ω_1 and the expectation $M_2 = \begin{pmatrix} m_{x2} \\ m_{y2} \end{pmatrix}$ of samples in ω_2. Then make the perpendicular bisector of the two points and use the perpendicular bisector as the criterion function g(X).

The linear equation is:

$$2x(m_{x1} - m_{x2}) + 2y(m_{y1} - m_{y2}) + m_{x2}^2 - m_{x1}^2 + m_{y2}^2 - m_{y1}^2 = 0$$

is just the criterion function of Bayes classification when we suppose $P(\omega_1) = P(\omega_2) = 0.5, p(X/\omega_i)$ is the planar probability density function which obeys $N(\bar{\mu}_i, \sum)$. That is:

$$p(X/\omega_i) = \frac{1}{2\pi |\sum|^{\frac{1}{2}}} \exp\{-\frac{(X-\bar{\mu}_i)^T \sum^{-1}(X-\bar{\mu}_i)}{2}\} (i = 1,2) \quad (2.1)$$

$$g(X) = W^T X$$

Here, $\bar{\mu}_i = M_i = \begin{pmatrix} m_{xi} \\ m_{yi} \end{pmatrix}$ is the expectation of ω_i, Σ is the 2x2 covariance matrix, $|\Sigma|$ is the determinant of Σ, $X = \begin{pmatrix} x \\ y \end{pmatrix}$ is the training sample ,and x,y with the same variance is statistical independence(correlation function $\rho = 0$).That is:

$$\sum = \sigma^2 I = \begin{pmatrix} \sigma^2 & 0 \\ 0 & \sigma^2 \end{pmatrix}$$

This geometrical classification is rational because the Bayes classification is the best classification.

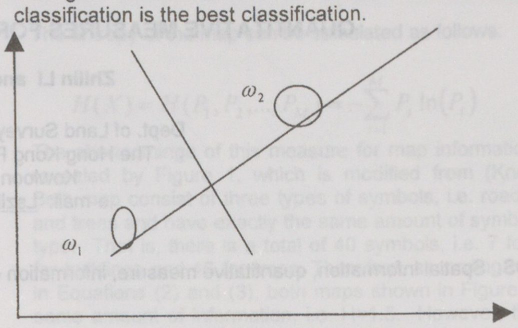

Figure 2

There are still other means, because of the length of the paper,we don't give unceccessary details, just narrate simply as follows:

5. Distort merging of two polygons

Distort lines included in these two polygons, and change the geographic object signs of related strikethroughs by topological table.

6. Combination of some regions
7. Substitue polygon for point set, and change the topology of the corresponding polygon.
8. Substitue one polygon for multi-polygon, and change the corresponding outer polygon.
9. Elimination of the same region
10. Scale-up the lines which composed the polygon, but don't add the number of the lines.
11. Enlarge the region needed to display, so that minish the corresponding polygon.
12. Simplify the complicated information of lines' shape.

4. CONCLUSION

Through these approaches above, we can resolve 12 kinds of geometrical deformation in map generalization. Because these approaches reserve the topological relations of geographic objects, it can resolve the varying map scale information automatic generalization in GIS preferably.

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