

RESEARCH ON THE ATTENUATION RULE OF MAP INFORMATION IN MAP GENERALIZATION

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ABSTRACT:

With the development of the technique of multiple dimension GIS databases, the problem of the key-scale becomes an important technical problem. The paper presents a new method about how to determine the key-scale based on the theory of the information attenuation. From the large-scale to the small-scale, the self-similarity of map object descends gradually, and reflects as the change of the map information. Make use of the extend fractal model of inverse "S" can help to determine the key-scale between any two scales section. This method is better pertinent and self-adaptability and significantly to do further research.

1. INTRODUCTION

The scale is used to define the limit that people observe the earth originally. People cannot get the correct information from the map if the scale isn't given. The map scale determines not only the size of map but also the surveying precision and particular degree of map. For the general map, different scale corresponding to different purpose; for the digital map or GIS, the original meanings of scale are fading and map can zoom consecutively freely. In practice, the scale of map database describes the precision of the database (Ma YaoFeng 2004). With the developments of GIS theory and technology, the technology of multi-scale spatial database develops with the direction to stepless-scale spatial database. The discretionary scale database can be build based on a certain large-scale map database. As the display of graphics data is stepless in the multi-scale spatial database, not all zoom cause generalizes. The map graphics needn't to generalize but the scale's change comes to a certain grade, otherwise the simple affine transformation is enough. The scale that causes the generalization is called key-scale.

Key-scale comprises two significations in broad sense: one is generalizing scale the other is choosing scale. The generalizing scale means that the object existing in the map but the abstract grade is different. For example, the scale, which causes symbolizing, is a key-scale, the result is that the details disappeared and meaning information saved. The choosing scale decides whether the object should be expressed in the map or not.

2. ATTENUATION RULE OF SPATIAL INFORMATION

2.1 Self-similarity attenuation of spatial information

The Fractal is a new method to research the complex geography phenomenon. R Scott Snow had mentioned in a paper about the fractal camber of river that the shape of river stream is between the regular and fine random (C.H.Scholz 1991). That description posts the fractal character of the river. In fact, many

geography phenomenons can't be described by Euclidean geometry but can be described by fractal geometry.

The catastrophe theory that founded by mathematician R Thom not only makes geographer begin to research the non-continuum change in the geography seriously but also provide a new way in researching the induction and deduction logic problems (Pan YuJun 2001). For Map is an integrated media of geography phenomenon's induction and deduction, the research on its rule of shape change must take full consider about the catastrophe factor.

When we express the object as a plane graphics on map and ensure the geometry accuracy of figure's characteristic points that ensure the object's similarity at the same time. All the surveying maps have nicer similarity; the larger is the scale the nicer is the similarity. As the scale reducing, generative map can only describe the outline of the object. When the scale is too small to express the object with plane graphics (for example: display the resident area with circle mark), the map can just keep the objects' distributing similarity as a whole, namely correctness of interrelation (Wang JiaYao 1992). This is the attenuation process of map's self-similarity. The attenuation represents on not only the configuration but also the space relationship of the map objects. In principle, it changes from complexity to simpleness.

Topographic map are scaled-down models of Earth's three-dimensional surface, printed on flat (two-dimensional) pieces of paper [Richard M. Busch 2000]. The map cannot comprise all the objects on the ground or reproduce the surface precisely, but just express geography environments equation (composed of water system, physiognomy, soil, vegetations, resident area, road, and bourn and so on) evenly and relatively. The spatial information generalization represents at two sides mostly: one is classification and symbolization, namely meaning generalization; the other is selection and simplify of the spatial data, namely graphics generalization. The map symbol can resolve the oppose-unite between geometry accuracy and geography adaptability (Wang JiaYao 1992). In the process of map generalization, map object's self-similarity is attenuating with fractal geometry character (Li WenJing 2005). The map generalization process is an information attenuation process and

not ends with nothing; because any generalize results can't be a blank paper. The results from generalization always trends to the map marginal load. Spatial data expression doesn't change like the straight-line but the variation. The key-scale is the break point in the course of spatial date changing. For different geography element, its characters transform with scale at different degree.

2.2 Scale transformation rule of map symbols

With the scale reducing, the shrunken space can't express map objects' classification and multilevel detailed so we must select and combine some species to enhance the classify level and reduce the classification. The classification of map symbols affects the estimated precision of the map's numerical value and reflects the degree of generalization.

The qualitative generalization mostly behaves as taking the general classification instead of the detailed classification and taking general quality instead of accurate quality; the quantitative generalization mostly represents as reducing symbols and precision of the objects' quantity character. For examples: resident area always display as outline graphics in large-scale map; in the map that scale is 1:250000 a lot of resident areas displayed as circle symbol; in the map that scale is 1:1000000 only a few large city display as outline graphics. The map scale has important impact on the classification. Through the map symbol's classification on different scale map we can find the circs that the symbols classify changing followed with scale (see table1). For example in the map that scale is 1:500 to 1:2000 the factory and mine building's symbol is classified into three grades and 72 genuses; in the map that scale is 1:25000 the same object symbol is classified into one grade and 50 genuses. Thus it can be seen that with the scale diminishing the classification of map symbols reduce according to a certain rule.

Scale denominator	500	5000	25000	250000	500000	1000000
Surveying reference point	11	8	6			
Traffic and accessory	60	27	19	25	19	18
Pipe-line and accessory	26	6	6			
Water system and accessory	34	42	41	32	28	23
Bourn	8	7	6	7	7	6
Physiognomy and soil	32	27	26	22	18	14
Vegetation	27	24	18	9	6	6
Text note	9	6	5	28	32	29
Summation	299	222	184	151	123	115

Table1. Classification of map symbols

Most kinds of objects' symbol classification drop off follow the scale reducing, but a few special objects don't decrease, such as text note (see table.1). There are many reasons that cause the text note change in a reverse direction. In the large-scale map, limited by the expressing area, there are less objects drawing in a map, many text couldn't be written in, such as big rivers and mountains. For the objects such as surveying reference points and pipeline ant its accessory, they disappear in the map that scale is 1:250000. That means these two kinds of objects have a lower level and generalize at rapid speed. The disappearance

mentioned above may be replaced or combined by other symbols or really disappear in the map.

3. GENERALIZATION STEPS OF MAP SYMBOLS

The scale dependence of geography phenomena decide the relationship between the abstract of symbols and scale: geometry meaning and precision of map symbols are replaced gradually by geography configuration with reducing of map scale.

In the map that scale is 1:10000, almost all the houses and buildings will be selected and described comply with the scale; in the map that scale is 1:25000, generalization happens---generalizing the figures; in the map that scale is 1: 100000, almost all the residents will be selected however, but some of the text notes will be accepted or rejected. Generally buildings generalization begins at the scale 1:50000, but cave-houses and some solo buildings in country are not expressed comply with scale even in the map that scale is 1:25000; when the scale smaller than 1:50000, intensity of generalization strengthen evidently, the blocks appear in the city and details disappear from the buildings. If the scale keeps reducing, the map symbols can but reflect the distributing of geography objects without any configuration information. Except disappearing from the map, the final results of generalization are that express the location and meaning information by geometry symbols.

The pivotal steps of map generalization can be explained in Fig.1 (take generalization of resident area for instance). Every arrow in the Fig.1 represents a key-scale because the representation of every step is different qualitatively.

Different kinds of objects span different scale section and experience different generalization steps. The unimportant

objects may disappear from the larger scale map; some important objects even with small size may not be rejected with the scale reducing but it doesn't experience all the steps. The generalization speed has relationship with not only the size of object but also its significance level. As a rule, the lower is the object's significance level the more rapid is its generalization speed and it disappears soon; the higher is the object's significance level the slower is its generalization speed and it doesn't disappear in the end. Customarily the objects with

middle significance level generalize follow the four steps in Fig.1.

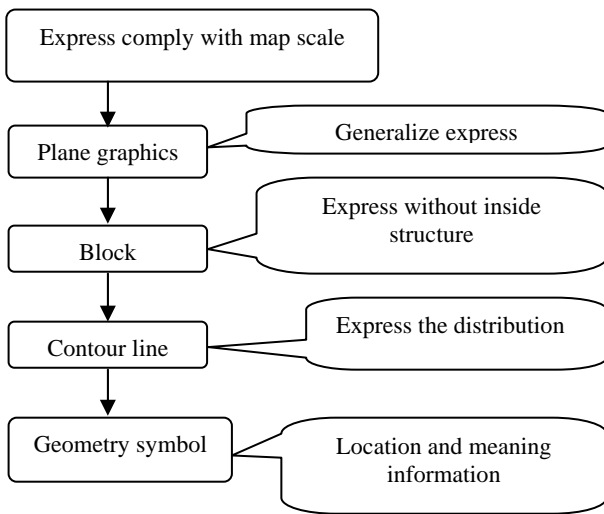


Figure.1 four steps in the generalization

Fig.2 shows the changing and converge situation of the map symbols with different significance level. The symbol information mentioned here is a collective trend includes symbol's quantity, size and complicacy and so on.

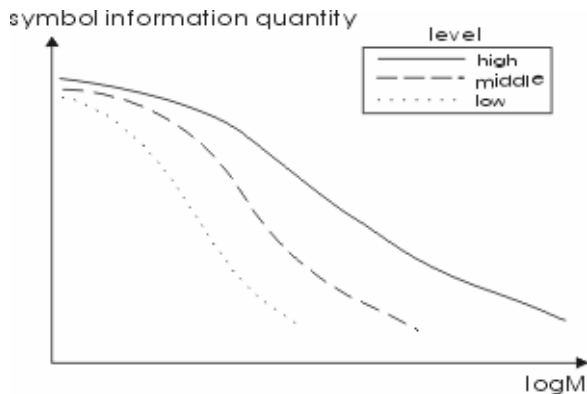


Figure.2 generalization different level symbols

4. KEY-SCALE IN THE MAP GENERALIZATION

With a certain scale, map always wants express the most information in the finite area. For the different geography objects with different characters should use different display and manage modes, we should classify and manage them according to their proper character and application purpose.

The routine map generalization arithmetic process from large-scale to small scale, the large-scale is known quantity. When the map scale spans a biggish section, the routine method seems uncontrollable in effect. The Morphing function arithmetic (AI TingHua 2004) has two known quantity: two boundary scales. In this method, the key-scale is help to control the graphic change. The key-scale lies on not only the auto-generalization technology but also the character of map object self. The key-scale must be appropriate. Redundant key-scale makes the auto-generalization lost signification but short key-scale increases the difficulty of map generalization.

National fundamental geographic information system has built the standard of terrain database. The resident area data classifies to two layers in the map that scale is 1:250000 and 1:1000000, but one layer in the map that scale is 1:4000000; railway and road data classified to one layer in the map that scale is 1:250000 and 1:4000000; geographic gridding data are classified as two layers in the map that scale is 1:250000, but one layer in the map that scale is 1:1000000 and 1:4000000. The data above indicates that we should measure the key-scale aim to different object and consider fully about every character of different object.

5. APPLICATION OF ATTENUATION RULE

For a certain kind of map object, we can build up a reverse 'S' curve about its scale and information quantity (see figure.3). There are three corresponding scales in the curve: max scale, min scale and key-scale. The min and max scale in the coordinates axes correspond to the max and min map scale in the map database. Axes Y express the information quantity under the scale. The inflexion of this curve corresponds to a key-scale between two scales. The inflexion is at the point that information quantity changing most between the max scale and min scale. Because the map information corresponds to the circumstances about change of map object's configuration, the scale correspond to the inflexion is the key-scale in the whole section. At the key-scale, object's configuration changes intensely. Different map object corresponds to different inverse 'S' curve in theory, so its key-scale must be different. Based on this method, we can separate the scale section father. The original key-scale separates one section into two; the two new sections will find new key-scale.

Take part of the data from Table.1 to simulate the thrice polynomial (see figure.3), axes x corresponds to map scale and axes y corresponds to map symbol's classifications.

As a whole the classification of these three different kinds of symbols show as attenuation trend when the scale change from large to small, but the speed and the intensity are different apiece (see figure.3). Sometimes the descending is not strict. The certain kind of symbol's classification doesn't decrease but increase with the scale reducing. There are many factors cause the result. For the different map scale corresponding to different map purpose and emphasize the different map content.

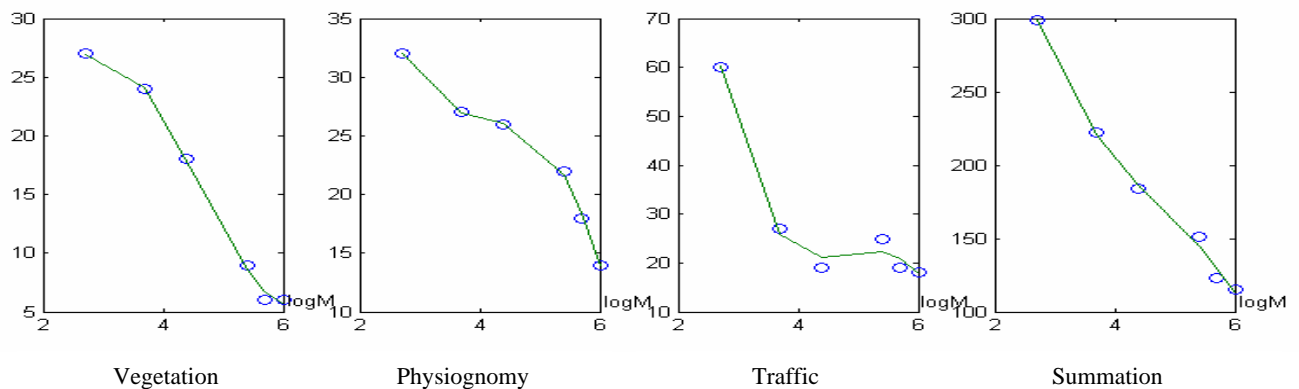


Figure.3 Transformations of map symbols' classification

6. CONCLUSION

The results above are concluded under the great scale span and the data is statistic and experiential, so it's can but represents the change rule of different objects simply. The method must be modified and perfected before using in the practice. The classification should be subdivided farther in order to guarantee the unique characteristic of the different objects evidently; the scale section should correspond to different application purpose and consider the restraining relationship between the map scale and map purpose fully. In order to guarantee the typical characteristic unaffected, we should add in some new restraining parameters according to the characteristic of different cartographic region.

Along with the improvement of application requirements, multi-scale spatial databases had build up in many departments already. Building every different scale database should cost a great deal money and bring many difficulties in updating. Many experts have put forward many database-building projects which considering the affiliation of scale. The problem about research on the information attenuation in the map generalization is a pilot study and its production can be used to measure the key-scale in the multi-scale database. In addition, using information quantity's transformation as the only restriction to decided key-scale is not enough. More parameters should be import to verify and revise in order to take this method into practice effectively.

References

- AI Tinghua, 2004. Key technologies and strategies in the development of multi-scale spatial database. *Science and Technology review*, (04),pp: 4—8
- C.H.Scholz, B.B.Mandelbrot, 1991. Special Issue: Fractals in Geophysics, *Pure and Applied Geophysics*, 13(1).
- Gao Wenxiu, Wu Hehai, Gong Jianya, et al. 2002. *Thematic data generalization in GIS. Geomatics and Information Science of Wuhan University*, (5), pp: 505-510
- Li Wenjing, Wu Hehai, 2005. Fractal attenuation analysis of cartographic object's self-similarity on cartographic generalization. *Geomatics and Information Science of Wuhan*

University, 30,(4), pp:309-312

Li Zhilin, Huang Peizhi, 2002. Quantitative measure for spatial information of map. *Int. J. geographical information science*, 16(7), pp: 699-709

MA Yaofeng, HU Wenliang, Zhang Dingan, 2004. *Theory of cartography.. Science Press.*

Pan Yujun, 2001. *Geography base. Science press.*

Richard M. Busch, 2000. *Laboratory manual in physical geology, Prentice-Hall, Inc.*

Shen Guoqiang, 2002. Fractal dimension and fractal growth of urbanized areas. *Int. J. geographical information science*, 16(5), pp: 419-437

Wang Jiayao, 1992. *Cartography generalization principle of general map. Surveying and mapping presser*

Wang Jiayao, 2001. *The theory of spatial information system. Science Press.*

Wang Qiao, Wu Hehai, 1998. *The research on fractal description and auto-generalization of map information. Wuhan Technical University of Surveying and Mapping Press.*

Wu Hehai, 1998. Numerical examination for fractal extension. *Journal of Wuhan Technical University of Surveying and Mapping*, 23 (4), pp:329-336

Wu Hehai, 2000. Research on fundamental theory and technical approaches of automated map generalization. *Journal of Wuhan Technical University of Surveying and Mapping*, (5), pp: 277-386

Wu Hehai, 2001. Map information's fractal description. *Bulletin of Surveying and Mapping*, (2), pp: 24

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