

Study on Geographic Information Generalization based on Digital Earth

LianwangYin¹ ChunPing Zhou² Jing Li³ Changyao.Wang⁴

¹*Institute of Remote Sensing Applications, Chinese Academy of Sciences*

P.O. Box. 9718, Datun Road, Beijing, China, 100101

Tel: 86-10-64889215, Fax: 86-10-64889876

Email: glob@irsa.irsas.ac.cn

²*Beijing Remote Sensing Institute, Beijing, China, 100011*

Tel: 86-10-66747976, Email: zcp1688@263.net

³*Institute of Remote Sensing & GIS, Peking University, Beijing, China, 100871*

Tel: 86-10-62757394, Fax: 86-10-62757394

Email: jingl@263.net

ABSTRACT The earth is so much complex and various that we must extract and generalize the infinite and continuous geographic information in three dimensions into definite and disperse format in a map. If we master the main essential features about the earth we can generalize something more important about the earth in a definite map area. This paper put forwards a new technique about geo-spatial data management on infinitely variable map scale. this means that geographic information about spatial objects in some region, by cartographic generalization, can be extracted automatically with a specific map scale based on one fundamental GIS databases .

KEY WORDS WebGIS, Cartographic Generalization

1. Introduction

The goal we shall realize based on Web GIS is that geographic information can be extracted and reduced automatically with the specific map scale under the conditions of theme in user's spatial applications and geographic region via Internet. Because the technique is concerned with many technologies as cartographic generalization(Liu,Y etc), databases management system, WebGIS etc., we must know first that which are the essential issues in solving these problems and how to find a set of mathematical and other methods in digital map generalization(Yin, L.W,1996).

Many conventional operations have been used in cartographic generalization, such as morphological operators, fractal computation and some rule-based map generalizations (Zhou, C.P, 1992) etc. Some of these kinds of methods, however, could just considered features based on a map rather than the real geo-spatial objects, thus it difficult to know which feature is more important than others just by some of its characteristics in map. There are two roads in a map, for example, some characteristics as the lengths and widths of the two roads are equal and either of which is as the same importance for the computer. But in fact

we assume that one of which is more important and should be represented form their feature attributes while the other one be omitted on smaller map scale. So we may draw a conclusion that the features' attributes are critical to map generalization. Hereby we need a database of geo-spatial attributes describing the importance of geographic features as a knowledge rule to the geographic information generalization.

2. Key Techniques and Solutions

The information processing technology with varying map scale means that the volume of the geographic information is compliantly increasing and decreasing with the given scale. The basic geographic database of large map scale is the foundation of this technology.

The concrete aims of the technology with varying map scale on Web GIS is to implement geo-spatial information extraction under the Internet environment. The technology is involving Digital Mapping, Database management system, GIS, computer network and geographic applications as listed below.

2.1. Database of Geographic Features Attributes

This database has much more information as attributes than that of those conventional geo-spatial databases, by which we can easily get the degree of importance of various geographic features. This is the basic knowledge for computer to select the most important spatial objects.

- Conceptual model (information model)
- Data model
- Data dictionary

2.2. Geographic Information Coding

It is to describe spatial distribution of geographic entity and the developing pattern by mathematical and logical language. In order to let the computer 'know' which spatial object is more important, the first task is to mark the levels of various geographic features by calculating their qualitative and quantitative attributes. And then we make the geographic codes according to the aforementioned levels, which is the rule knowledge to choose and omitted the spatial objects on varying map scale.

- object-oriented classification of geographic entities
- describe the entity attributes
- object-oriented coding of geographic entities

2.3. Modelling of Geographic Information Generalization

The essence of cartographic generalization is to represent geographic features of a region according to a certain map scale (Zhu, G.R. etc, 1980). At this scale level, some geographic entities would be more important and should be selected while others be omitted. Many rules and criteria can be used as the knowledge for geographic information generalization expert system by artificial intelligence.

- Knowledge database for cartographic generalization.
- The inference machine for cartographic generalization

2.4. Modelling of Geographic Features Semantics

With the map scale varying, the symbols' size and inner structures may cause to change. Take residence for example, its symbol would be polygon shape at larger map scale and will be changed very small just as point shape while at smaller map scale. And furthermore, different symbols would be more proper with different themes sometimes according to their requirement being described at different information detail levels.

2.5. WebGIS Components for Geographic Information Generalization

WebGIS is a basic technique supporting platform for geographic information generalization with varying map scale. Here are the plug-and-play components which are imbedded in client/server system of WebGIS environment.

- parallel computing models
- geographic information agent
- application-oriented models management
- geographic symbols bases integration models
- geographic information generalization models

3. The Flow of Geographic Information Processing

All the geographic entities will be ranked first from high level to low level of importance by calculating their importance degree form all their attributes recorded in the database. Then based on the quantities of the geographic features in the original geo-spatial database, the geographic entity is selected or omitted in accordance with a specific map scale, geographic region and symbols' sizes (including their annotations)(see the following figure).

3.1. Application Requirements Information Agent

Users send their particular application requirements at the client by the TCP/IP, including the theme and the region, such as the landuse classification in some region and these requirements would be carried to the server via geographic information agent of the Web GIS.

3.2. Locating the Information Source

Information source shall be located in the spatial database which is at large scale, for example, the 1:10,000, and composed of basic geographic elements (residence, roads, rivers, contours and boundaries) and the theme information. The database is usually large, maybe has thousands maps. These maps should be put logically together in a unified geodesic reference and managed by spatial database management system.

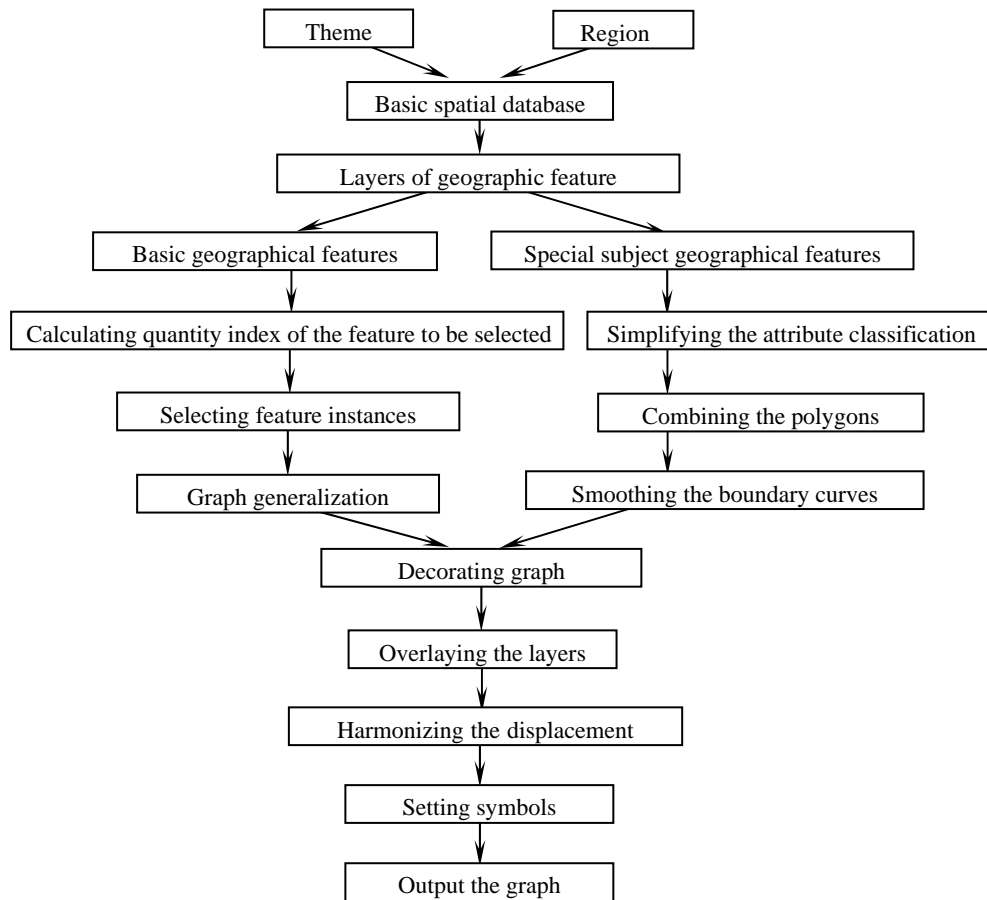
3.3. Calculating the New Map Scale

The new map scale can be derived from original region to its display area for output.

3.4. Structuring Feature Layers

The applications may be involving many different kind of features which have different information processing models. All features should be divided into layers according to the proper data processing models.

3.5. Information Generalization



Flow of information processing based on the varying map scale

For basic geographic information, such as residences, roads and rivers, the WebGIS shall determine the selecting quantity of features, the concrete feature instance and make the graph simple based on the knowledge database of the map generalization and the expert deduction models. As for theme information, the focus shall put on the polygon generalization of the landuse classes combination, and the method of boundary smoothing is similar to the graph generalization of the basic elements.

3.6. Graph Decoration

The information of the former map is decreased at great extent and suitable to the new map with smaller scale through the above processing. To represent the shape of line features and polygon features, it is need to decorate the graph by linear smoothing models. The strain spline function can be used for the graph smoothing.

3.7. Overlay Feature Layers

After information process of the varying scale finished, all layers should be overlaid in a unified geodesic reference. This processing maybe results in some errors of the feature relationship on the spatial distribution. The principles to harmonize relative location among geographic features are:

- Keep the natural element (like river), move the artificial element (as road beside the river)
- Keep the more important element (like road), move the relatively unimportant element (bridge of the road)
- Keep the more stable element (like contour line of a mountain), move the relatively unstable element (river around the mountain)

3.8. Setting Symbols

Map symbol is a language representing geographic information. The semantic model base is used for providing suitable symbol to each feature in particular application and specific map scale.

3.9. Outputting Graph

The final map processed by above flow will be transmitted to the client terminal via WebGIS, geographic information of which is suitable to the map scale, geographic region and symbols user defined.

4. Conclusions

This paper discussed the basic theory, methods and techniques of geographic information generalization on varying map scale based on WebGIS. I think, it will have a relatively long way to go in implementation of fully automatic cartographic generalization by computer, although we have proposed a set of geographic information models on varying map scale. Because there still remain many sophisticated problems to be solved among the mechanism of geographic information generalization at different level of map scale.

We believe that it is a potential way to cartographic generalization by features attributes from geo-spatial database, as many suitable

information models to some specific geographic features can be derived from it. The time for fully automatic geographic information generalization will come if many conventional practical models for various features are drawn out and integrated by artificial intelligence expert system.

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