An Intelligent Cartographic Generalization Algorithm Selecting Mode Used in Multi-Scale Spatial Data Updating Process

Junkui Xu, Dong Li, and Longfei Cui*

***Abstract*—**In multi-scale spatial data updating process, cartographic features vary dramatically with the scales evolution. So, it is the critical step to select suitable cartographic generalization algorithm which can perfectly fulfill the scale-transformation task. This problem is also a main obstacle in the way of automatic spatial data updating. Through deeply studying the flows of multi-scale spatial data updating process, an intelligent cartographic generalization algorithm selecting mode is proposed. Firstly cartographic generalization algorithm base, knowledge base and case base is built in this mode. Secondly, based on the step of resolving the cartographic generalization process into segments, a self-adaption cartographic generalization algorithm selecting architecture is constructed. Thirdly, an intelligent cartographic generalization algorithm selecting and using flow is established and put into effect. Overall, this mode provides a new idea to solve the automatic problem of multi-scale spatial data updating.

***Keywords*—**spatial data, updating, cartographic generalization, intelligent selecting, multi-scale map.

I. Introduction

MULTI-SCALE spatial data updating process involves scale-transformation of spatial objects in every scale. Due to the variety of settlement shape and updating scenes, the scale-transformation algorithms will change according with the updating area and map usage. The same algorithm, such as settlement simplification, will change its contents coping with buildings and blocks. So, it is the kernel steps to develop generalization algorithms for certain scale in spatial data updating. To multi-scale spatial data incremental propagating updating method, how to design scale-transformation algorithm selecting mode is the vital problem.

To realization self-selecting of generalization algorithms, firstly, the basic information of generalization algorithm, such as function, objects, strong and weak points, parameters, etc., should be clarified. And these information should be expressed in language which can be understand by computer. This process will involve the construction of algorithms base. Secondly, computer should be taught something about how to select right algorithm according to generalization scene, which need the ability of induction on the basis of generalization knowledge. Thus, generalization knowledge lab should be built to support algorithm selection. Meanwhile, successful generalization process could be store in database as a generalization case, which can be used when updating scene is fitting. On the whole, the self-adapting generalization algorithm selection mode is built on the basis of algorithm base and knowledge lab, and fulfilling algorithm selection with the help of case base.

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II. THE CONSTRUCTION OF AUXILIARY LABS OF SPATIAL DATA UPDATING

A. The construction of generalization algorithm base

Through hard work of domestic and abroad researchers, a lot of generalization algorithms are developed. Let's take the point cluster selection algorithms for an example. Deng Hongyan put forward a model of point cluster selection based on genetic algorithms[1]; Qian Haizhong put forward a point cluster selection algorithm based on CIRCLE character transformation techniques[2]; Cai Yongxiang put forward points group generalization algorithm based on konhonen net[3]; Ai Tinghua put forward a method of point cluster simplification with spatial distribution properties preserved[4]; Yan Haowen put forward a generic algorithm for point cluster generalization based on voronoi diagrams[5].These algorithms mostly aim to special data type and generalization environment. So, the metadata of these algorithms, such as working environment, function and parameter, should be abstracted and listed [6].

Table 1 Main algorithm metadata and its description

Algorithm metadata	Description
Adapting range of algorithm	Map type, scale, district character, etc.
Function of algorithm	The function type of algorithm, such as selecting, simplify, merge, move, etc. operating object of algorithm like point, line and area.
Parameter of algorithm	Data should be set and used in generalization algorithm.
Basic information of algorithm	Information like development department, member, time, object, contact details.

2) The construction of generalization algorithm base

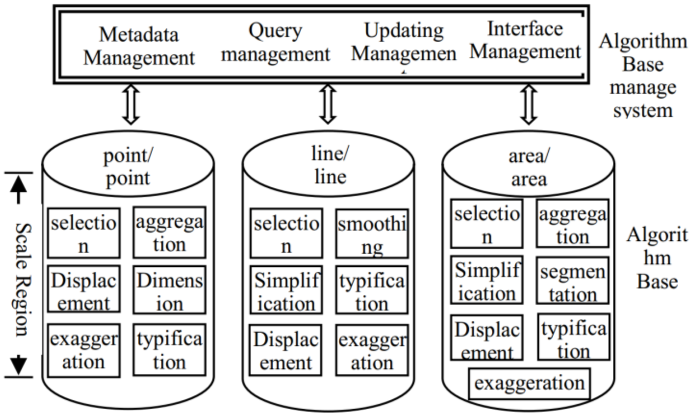

Fig. 1 Structure of generalization algorithm base

Generalization algorithm base is based on the relational database. According with map scale, map type and map character, the generalization algorithm metadata stored in data tables, and the algorithm itself is stored as binary code in the form of dynamic linking base. The structure of algorithms base is shown in figure 1.

B. The construction of knowledge base

1) The concept of generalization knowledge

If algorithms base is compared to tool-box of generalization operation, knowledge base can be taken as the brain of using these tools. The algorithm base depends on the direction of knowledge lab. Knowledge of generalization mainly comes from the specifications in mapping.

2) The abstraction of generalization knowledge metadata

It is a difficult work to build generalization knowledge lab. Through abstraction of generalization knowledge metadata, we can fulfill the management of generalization knowledge. The knowledge metadata is data which describing how to use and manage generalization knowledge. It can associate actual algorithm with tools to solve complicate problems. With the analyses of generalization knowledge, the generalization

- Knowledge ID
- Scale of knowledge
- Map type of knowledge
- Regional characteristics
- Feature type of knowledge
- Algorithm type of knowledge

} Description information

- Founder department
- Validity period
- Founder name
- Knowledge source
- Contact information
- Founder time
- Updating time
- Working language
- Added message

} Basic information

Fig. 2 Metadata types of generalization knowledge

knowledge metadata structure is designed as figure 2.

Following the expression of metadata in figure 2, the generalization rules like street blocks whose area less than $12mm^2$ should be deleted in 1:250000 maps, and settlement block which doesn't located far from 0.3mm, can be margined with nearest street block, could be extracted the metadata as table 2.

Table 2 the example of knowledge extraction

SCALE	1:25000	1:250000
MAPTYPE	Topographic map	Topographic map
AREA CHARACTER	Alll	All
FEATURE TYPE	130204	130204
ALGORITHM TYPE	Select	Merge
FACTOR TYPE	Area	Distance
FACTOR THRESHOLD	$12mm^2$	0.3mm
QUANTIZATION DEMAND	<	<
GENERALIZATION ACTION	Delete	Merge

3）The construction of generalization knowledge lab

The generalization knowledge labs are composed with many kinds of knowledge which contain every aspects and factors in generalization process. Meanwhile, there are much information such as threshold, using scope, operator of generation algorithm. The structure of knowledge labs will affect the operation efficiency of all the system. So, on the angle of performance and compatibility, it is suitable to use algorithm base structure to organize the generalization knowledge. Its main structure is

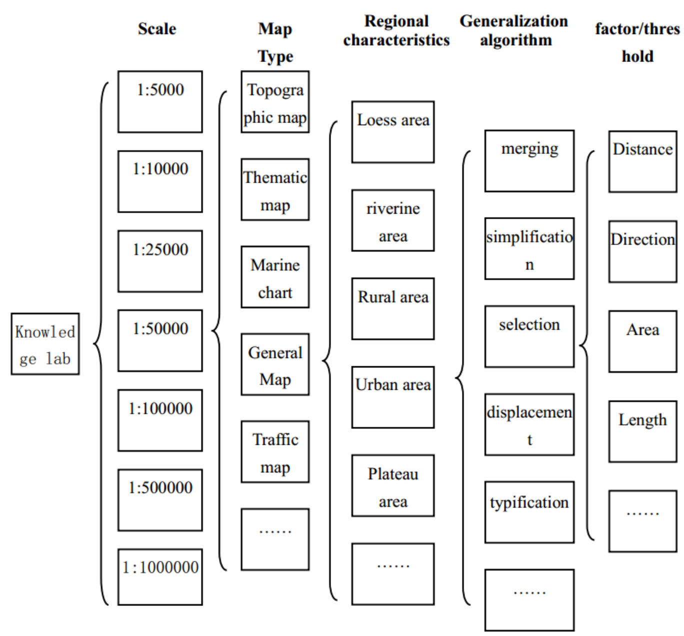

Fig. 3 the structure of generalization knowledge lab

shown as fig 6.4. Firstly, knowledge is classed by scale, map type, regional characteristic. Secondly, it is divided by generalization algorithm. And finally, the factor and threshold is decided by actual generalization scenes and algorithm characteristic.

C. The construction of case base

1）The concept of case-based reasoning

CBR (case-based reasoning) is one of the most important ability of human beings' intelligent, which solves problems by the way of similar successful cases. These cases can probably come from knowledge acquisition project from professional people, or comes from searching existing cases. For example, medical training not only depends on the theory model of anatomy and psychology, but also depends on the experience on similar cases [7]. So, CBR can also be used in improving the level of intelligent and automation in generalization field. If we record how the specialist solving generalization problem, the knowledge acquisition process will be probably shorten.

2) Organization and construction of case base

Generalization scenes and spatial data structures which used in case reasoning vary dramatically. So, the framework skeleton of cases has much relation with the searching and appliance efficiency. In common place, a case is recorded as a relation-group, that is, some of the data list the characteristic of

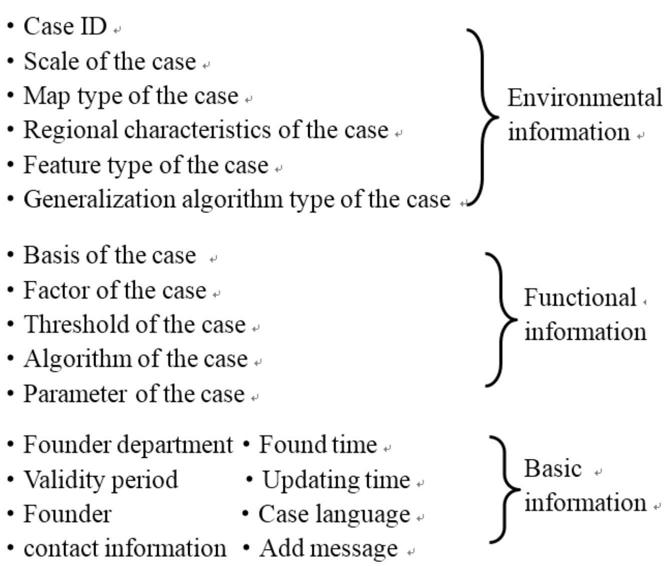

Fig. 4 Metadata of the case

case, and others described steps of problem solving. Otherwise, cases can be expressed in more complicated mode, like proof-tree. In this paper, cases will be organized in relation-group, which is shown in figure 4. And case information is divided into three parts, which is Environmental information, functional information and basic information.

III. GENERALIZATION ALGORITHM SELF-ADOPTING SELECTING METHOD

In upwards text, the concept and structure of generalization algorithm base, knowledge lab and case base have been presented. On the basis of these supporting labs, we will propose an intelligent self-adopting generalization algorithm selecting method. In the process of generalization, algorithm base provide tools, and how to use these tool depend on the direction of knowledge labs. Algorithm selecting system based on rules has many merits. Firstly, it can provide experience directly from cartographic experts. Secondly, the knowledge and control separating skeleton will help in circulate knowledge gaining and using.

If only using knowledge-based algorithm selecting method, there are many limitation. Firstly, it is difficult for knowledge-based algorithm selecting method to properly deal with incomplete information and unexpected data. Secondly, in the edge of knowledge, the efficiency of system will decay badly. While case-based algorithm selecting method can easily gain successful case from case base and it will relax the problem of knowledge getting. But case-based algorithm selecting method also has its shortages. First of all, the case can't contain more knowledge. And secondly, it is a hard work to index and choose proper case form hundred and thousands of cases.

Based on these analyses, a new compounding algorithm selecting method, which combines the merits of above tow method, is proposed. In this method, you can firstly search case base, if can't find related cases, knowledge-based algorithm will

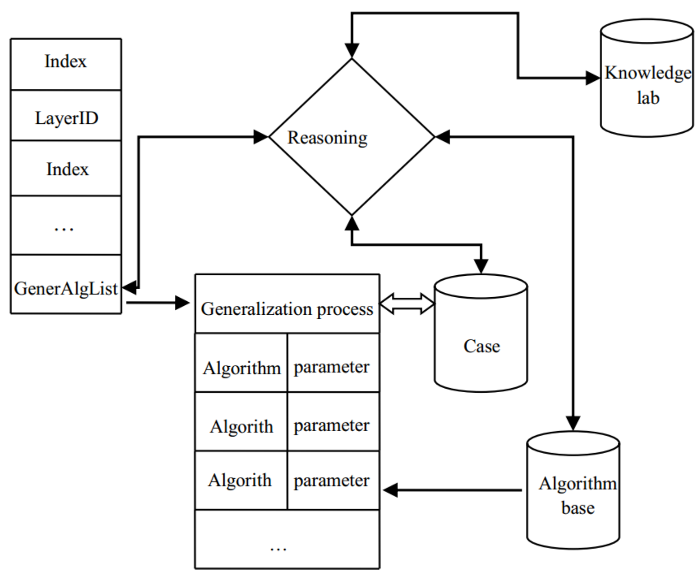

Fig. 5 the Skelton Figure of intelligent self-adopting algorithm selecting method

be used to reason and analysis. Meanwhile, the correctness of system-prompted case can be verified by content in knowledge lab. Moreover, the case which comes from knowledge lab reasoning could be put in the case base too. By this way, the intelligence of the system will improve gradually.

Figure 5 shows the main idea of intelligent self-adopting generalization selecting method. Firstly, the 'GenerAlgList' item is inserted in the multi-scale spatial data link structure to record how the object data produced from large scale data. Secondly, the algorithm which used in the generalization and parameters of the algorithm are put in the case base. And finally, the intelligent self-adopting algorithm selecting method is constructed with the help of the case base and knowledge lab.

In actual generalization process, the algorithm and parameter selecting steps is shown in figure 6. Firstly, generalization tasks are decomposed by work control produce. The long line of work is decomposed into segments. Secondly, the characteristic of generalization step is abstracted from the generalization scene of every part, which will be used in case base searching. Thirdly, if proper case can be found in case base, the generalization segment will be finished with the step of found case and parameters. Fourthly, if generalization succeeded, the priority and experience of the case will be increased, and if fail or proper

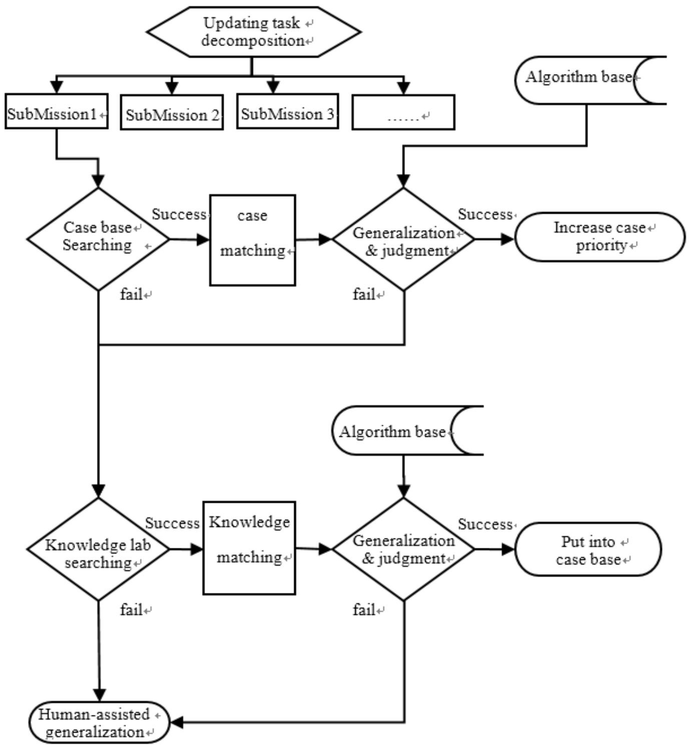

Fig. 6 the flow diagram of intelligent self-adopting algorithm selecting method

case can't be found in the case base, then the rules will be searched from knowledge lab through generalization scene and updating surroundings. If usable rules is found, then use it to fulfill the last generalization steps, if generalization succeeded, put the generalization scene and algorithm into case lab, if fail or nothing be found in knowledge lab, it is the last way to deal with the work by helping of experts.

IV. CONCLUSIONS

Multi-scale spatial data updating process involves scale-transformation of spatial objects. Due to the variety of settlement shape, the scale-transformation algorithms will vary with the updating area and map usage. Through deeply studying the flows of multi-scale spatial data updating process, an intelligent cartographic generalization algorithm selecting mode is proposed. Firstly cartographic generalization algorithm base, knowledge base and case base is built in this mode. Secondly, based on the step of resolving the cartographic generalization process into segments, a self-adaption cartographic generalization algorithm selecting architecture is constructed. Thirdly, an intelligent cartographic generalization algorithm selecting and using flow is established and put into effect. Overall, this mode provides a new idea to solve the automatic problem of multi-scale spatial data updating.

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