Rule-based Data-Driven Thematic Mapping Technique

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***Abstract*—Mapping automation is not only a key objective of cartology, but also a study hotspot of geo-spatial information science at present. Here, we take thematic mapping of river channels (pipelines) passing through Yunnan in Kunming City for example to study and discuss, with regard to the effect required by complicated mapping encountering in the process of project implementation and the requirements on high quality of mapping data, the representation of rule-based data-driven computer mapping by the Representation technique of Arcgis9.3 to partly accomplish such mapping task that needs a lot of manual editing in traditional mapping mode, especially achieve the some kinds of mapping effect that cannot be achieved by traditional mapping without destructing GIS spatial information. The findings indicate that, the representation technique of rule-based driven computer mapping can reflect the advantages of both GIS spatial database establishment and mapping. This technique can make map rapidly according to different data requirements, and achieve the effect of traditional mapping. Due to less demand on manpower and financial capacity, such technique has a broad prospect of promotion and engineering application.**

Keywords-Map database, rule-based driven, representation of mapping

I. INTRODUCTION

GIS originates from initial computer-aided cartographic system. In early stage, main aim of GIS was mapping, weaker in spatial analysis. With further application of GIS in various fields, establishment of spatial relationship, spatial analysis and spatial information share became popular, and GIS was gradually separated from mapping, where the former emphasized geographic information spatial analysis and spatial semantic share, the latter paid more attention to map face expression and mapping specification. Direct consequences of such difference are the inconsistency of map-spatial information generated, as well as data redundancy and resource waste arising from independent establishment of database.

However, mapping is still one of important tasks in geomatic field. In many countries, the concern to mapping is not weakened but intensified. Many specifications and basic principles of traditional mapping still have incomparable advantages in representation, summarization and application of geo-spatial characteristic information. These advantages shall be absorbed and developed by GIS representation[1].

As geographic information data plays an increasingly important role in current mapping, combination of map with geographic information system has already been current development trend and technical mainstream. When geographic information data are output as thematic map, how to quickly output a thematic map as is required by map making specification and aesthetic effect while keeping spatial data integrate, namely mapping automation, as well as how to save the work load of repeated manual editing while meeting the requirements on traditional map editing, have been the hotspots that should be solved urgently and key objectives of cartology.

II. PROPOSAL AND ANALYSIS OF PROBLEMS

The elements of traditional thematic map are mainly edited and processed by mapping software for professional publication use. The common method is to read basic vectors or grid data by data import, as map design required, manually edit the imported point, line and plane data according to mapping principle, such as size of character, width of line style, type of line segment, element of filling, etc. Non-GIS publication software, like CORDRAW and ILLUSTRATOR, is usually used for mapping. The following data and efficiency problems lie in these mapping methods.

A. Data structure lopping

Since most of non-GIS publication software lack spatial coordinate system, some data generated based on spatial positions (like DWG data generated by AUTOCAD software) lose position information after importing publication software, and change to map data that contain no position information and are only suitable for printing and publication. Therefore, geo-spatial information of data is lost. For this reason, some CAD charting software like Microstation prepare two sets of data to solve this problem, one set to satisfy GIS data demand and the other set to meet mapping and publication requirements. The disadvantages in this mode are visible, that is to say, spatial information and map

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representation are manually lopped, resulting in information isolated island and manpower waste.

B. Data update issues

Another problem of mapping by non-GIS publication software is impossible to input attribute data, as a result of which map update, especially attribute data update, fails. In long history of mapping, as social economy gradually develops, map data (including spatial and attribute data) keep changing with social development and construction. Non-GIS publication software cannot make use of dynamic spatial attribute elements, which are unique to GIS data, to update the map, so data update has to be realized by professional GIS. In this way, data update is inefficient, especially for the update data without real spatial coordinate record, and attribute information of GIS data cannot be recorded.

III. THOUGHTS ABOUT THE SOLUTION TO THE REPRESENTATION OF RULE-BASED DATA-DRIVEN MAPPING

Generally speaking, to solve the problems of current mapping, the conflict between mapping automation and autonomy must be eliminated. A great deal of repeated work manually processed is handed over to computer for automatic processing, so as to greatly improve the map production efficiency. Our thought to achieve this goal is that: firstly, establish a spatial database for mapping data, and create rule fields in the database for storing the mapping representation rule; secondly, utilize the Representation technique of ArcGIS93 and the override function of mapping performance and GIS elements to unify the automation and autonomy of mapping. See Fig. 1:

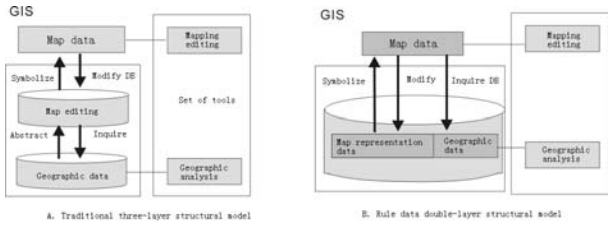


Fig. 1 Map of the expression of the traditional rules of the data model and the map after the expression of model comparison

This technique solves two problems mentioned above to guarantee the continuity of GIS elements and satisfy the representation of mapping. Work load of manual editing is reduced by the law of data storage to facilitate the realization of mapping automation and improve working efficiency[2]. Using this technique, which is the result of deeper development of information technology, compared to traditional paper map, map symbols (including points, lines, planes) are capable of dynamic zooming in electronic map and direct representation of mapping according to mapping output rule in non-manual intervention mode[3]. In nature, this technique is to store symbolic information and element's geometry in the element category to allow user define the appearance of the element by himself. With this additional control, user can meet the requirements of demanding mapping specification or only improve the display effect of elements. Furthermore, element category can possess several ways of representation associated with it. In this way, among different map products, the same data is capable of displaying in different mapping modes.

IV. RESEARCH INTO RULE-BASED DRIVEN MAPPING REPRESENTATION

A. Working mechanism of representation

At present, spatial database based on knowledge and regular-driving is mostly realized by trigger, constraint, function, process and snapshot in comprehensive application database management system (DBMS). Database-based map rapid-making and representation can be considered as a performance behaviour of spatial data element or a data behaviour oriented to object database. To establish knowledge-based rule-based driven spatial database, the key is to assign the rule of conduct to every geographic element and express the data by this rule.

Representation tool provided by Arcgis is stored as an attribute in spatial database, that is to say, store the data rule information as an attribute field information in the database. The scheme of mapping can be shared and reused in the process of multiple-user environment and spatial data transition, namely, realize the universality of data expression. The key is to symbolize a graphic layer by several kinds of Representation Rulers which are composed of symbol layer and geometric effects. Among them, symbol layer can be either point, line or plane graphic layer, and geometric effects are the options of Representation Rulers. They can change the position where the symbol is placed, but not affect data source. The shape of symbol, even geometric type, can also be modified. This is the core of regular data.

B. Research into representation-based rule-based thematic mapping

Representation is a functional block of Arcgis 9.3 software. It can use rule-based structure to symbolize the data. These structures, together with the data, are stored in geographical data base. Element category can support several kinds of element category mapping representation. Therefore, several map products can be acquired from a single data base, without storing the copies of data. The mapping representation of a single element can be modified when necessary to permanently overwrite the mapping representation rule. This rule is also stored and maintained in geographic data base. Mapping representation provides the organizational structure of rule-based symbol system, while keeping it flexible and can customize the drawing methods of all elements.

Representation-based mapping representation rule includes symbol layer and geometric effects. By this rule, the drawing method of a group of related elements used in mapping representation can be customized, while mapping representation rule is stored inside for share and repeated use in other mapping representations.

Symbol layer is basic structural unit used in mapping representation rule. It can be defined as either of three types, including flag, line or fill. A mapping representation rule

needs at least one symbol layer, but can use several symbol layers to support complicated drawing. Geometric effects are optional component part of mapping representation rule. While drawing the element's geometrics, geometric effects are subject to dynamic modification to present the required appearance, but such change won't affect the shapes of elements themselves. This means a possibility of achieving complicated data view without affecting current spatial relationship. In mapping representation rule, geometric effects can either be applied in only one symbol layer, or be applied all symbol layers in global mode. Geometric effects are sequentially achieved, so dynamic results of geometric effects will become the input of geometric effects.

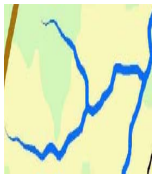
Designation of Mapping Representation	Scope of Representation	Settlement of Problems Encountered in Traditional Mapping	Effect of Realization
tapered polygon	Gradient river channel	Gradually changing segment between river channel sections shall be interrupted.	
donut	Gradient segment	Use of redundant surface of repetitive padding during the stratigraphic classification	
buffer	Gradient filling	The color of map transits uniformly.	

Table 1: some of the rules and to achieve results

Where symbol layer is drawn by mapping Representation technique, the elements will be drawn to express the attributes according to mapping representation rule assigned to an element. In some cases, the appearances of some elements might be customized to distinguish with the drawing method corresponding to the rule assigned. In such case, special setting is available to mapping representation rule attribute of a single element. Such change will be stored and maintained in geographic data base as attribute overwrite, can be displayed any map where this mapping representation is introduced. Through modifying or removing the overwrite, mapping representation of elements can be returned to default drawing method of drawing representation rule. Or, mapping representation can be used to overwrite the geometrics. The appearance of element's geometrics in the map can be geometrically overwritten, without affecting the elements of geometric source possibly used for analysis or processing. Different from dynamic geometric changes made using geometric effects when drawing, these edits are permanent.

In part of mapping representation involving in traditional mapping process, the following means are used for solution in this research. For the process of implementation, see Table 1.

V. Application Cases of Rule-based Data-Driven Mapping of River Network

Electronic map project of river channels (pipelines) passing through Yunnan in Kunming City is to build 36 river channels (aboveground rivers) and underground rivers (underground drainage pipelines) flowing from Dianchi Lake basin to lake. During implementation of project, with application of rule-based data-driven mapping representation, mapping representation of above data can be realized by Representation tool of Arcgis, so that GIS data can be directly produced into electronic map data and map publication data. Moreover, provision of electronic and paper map products greatly saves work load. Rule-based data processing functions that can be realized in the process of project implementation are listed as follow:

A. Overwrite processing of primary and secondary ground objects

Traditional map often represents the road connection by a bridge crossing over a river in two processing ways. One way is to interrupt the river and delete the data of the part of river interrupted. The biggest problem of this way is the harm to continuity of river channel data. This method is adopted by earlier versions of Microstation developed by Benteley, but the data specially customized for mapping function is available only once. The other way is to place colour blocks with same background colour above river channel to overwrite the data of river channel. However, many "plane" files generate without reason and consequently stuffs the geographic data base, resulting in unnecessary expansion of capacity.

Mapping representation field provided by Representation tool can realize the overwriting between elements. The flow of overwriting is that: enter the rule in the RuleID of database, when showing the map, automatically cover the river channel to satisfy mapping specification without modifying the database (for details, see Fig. 2).

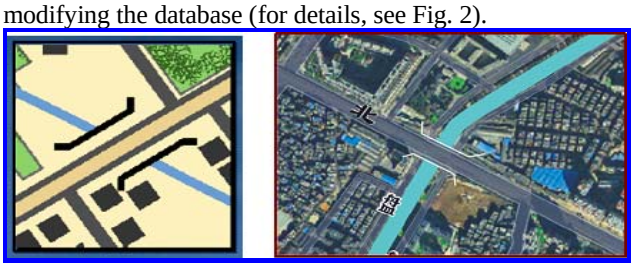


Figure 2 Road, bridge, river cover the rules of mutual

B. Incorporation of streets of different grades

When making a map, the way to interconnect double-line street in a city is to copy the line document of every road by two layers, upper layer white and lower layer gray, and

overlap the wide gray layer with narrow white layer. In this way, the roads are represented in a map, but the problem lies in that every road is made up of two lines, unconformable to the standard which requires uniqueness of geographic elements contained in GIS data, as a result of which a lot of data are redundant.

In this research, the regularity expressed by double-line roads is interpolated to RuleID field of database with JOIN tool in mapping rule, so that the interconnection between roads of different grades or line styles can be realized in mapping representation.

Effective integration of road sidelines, regularity of mapping, and uniqueness of GIS data are realized. For results of realization, see Fig. 3.

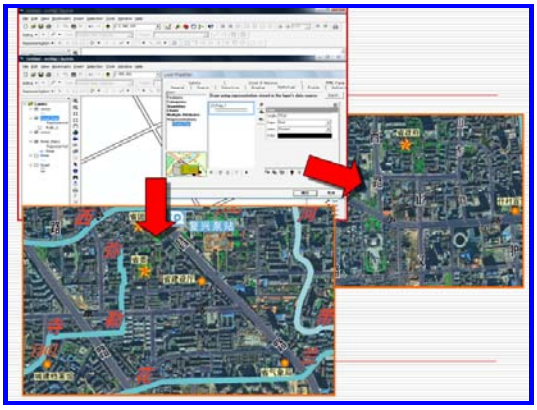


Figure 3 Roads, bridges, river rules of each covered

C.Processing of boundary line crossover

In traditional mapping mode, due to inherent limitation of cartographic line symbols, the boundary lines hardly cross over by solid lines according to traditional mapping specification. The traditional method is to extend these line segments with monocline to realize crossover between segments. The weakness of such method is reflected in increasing line data in database. Therefore, it can only meet the requirements for “one-off” mapping (Fig. 4).

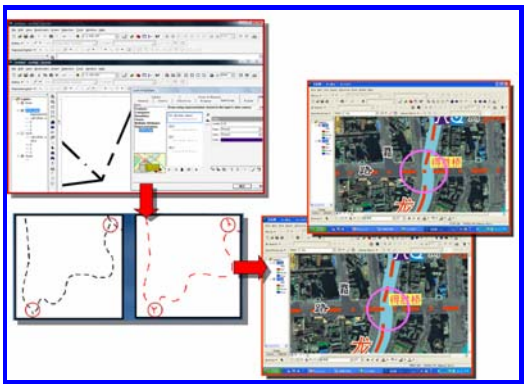


Figure 4 Edge boundary line

VI. Conclusion

The Series Map of River Channels Flowing from Dianchi Lake Basin to Lake makes use of Representation regular data representation technique provided by Arcgis and undertakes secondary development processing, so mount of labor is somewhat saved. With engineering applications, fussy manual editing work is replaced by set of rules in mapping representation, contributing to higher working efficiency. The research indicates key objective of Representation is to realize the autonomy and support the automation of mapping. The tool provided can solve part of manual editing work, so that map maker can pay more attention to map design and processing. Rule based data driven mapping representation will greatly improve the representation process of data map, especially in the representation process of dynamic data where such representation plays a key role, and will become an important development direction of mapping in the future.

Judging from engineering practice, we think several places need to be improved.

(1)There shall be more rich mapping representation rules. Some places in Representation are still not humanistic (still needing human intervention), such as incapability of clicking, picking and moving MAKER in the plane. This brings a certain difficulty to freedom of map editing, so research and development shall be detailed to satisfy varieties of needs in mapping representation.

(2)Representation editing tool is not convenient and perfect enough, and needs to add more flexible editing functions in future applications through version update or secondary development of ARCGIS, so as to meet increasingly changing needs of mapping.

(3)Graphic display efficiency decreases sharply after setting to Representation. Redrawing speed slows down. This is a matter that the user of low-performance computer shall consider, therefore better computer hardware shall be taken into account.

Rule-based data-driven mapping representation is a development trend for thematic map publicly published. So, this paper takes the Series Map of River Channels Flowing from Dianchi Lake Basin to Lake for example to realize the process of generating thematic map with geographic data rules and further improve the production efficiency. With increasingly development of computer software and hardware, especially further development of GIS and database technique and part of theoretical investigation, the effects achieved by this method will be further improved.

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