The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, Volume XLVIII-1/W2-2023
ISPRS Geospatial Week 2023, 2–7 September 2023, Cairo, Egypt

A STUDY OF RAPID MAPPING TECHNOLOGY BASED ON ADOBE ILLUSTRATOR

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KEY WORDS: Rapid Mapping, Adobe Illustrator, Mapping Rule, Map Compilation, Database-driven

ABSTRACT:

At present, China's urban and rural construction, national security, emergency and disaster relief have put forward higher and faster requirements for high-quality and current maps. How to use the latest spatial database in the shortest possible time to produce and provide high-quality, highly presentable, content-rich maps is an urgent issue. In this paper, we study the rapid mapping technology based on GIS platform and map mapping software, study the automatic map mapping method under AI environment, design and develop the spatial basic geographic database-driven rapid mapping system, realize the automatic lossless conversion of GIS data to map mapping software according to the established mapping rule base, realize the automatic configuration of symbols and annotations, and realize the automation of processing of element relationship. The AI-based database-driven rapid mapping technology has been used in the practice of map compilation in prefecture-level cities, replacing most of the manual repetitive operations, greatly improving the efficiency of map compilation, and enhancing the capacity of emergency mapping services.

1. INTRODUCTION

At present, China's urban and rural construction, national security, emergency and disaster relief, etc. have put forward higher and faster requirements for high-quality and current maps, the first is the high efficiency of cartography, usually need to provide finished maps within a specified time, this limited time is generally a few hours or less, if the traditional mapping method, usually the mapping time is longer, and even far from meeting the time requirements of this, so the need to study more efficient cartography. Therefore, faster and more efficient cartographic methods need to be studied. Only accurate and reliable maps can be used by government departments as a good tool for overall planning, emergency response, and event planning. When managers use maps to assist in decision-making, they have higher requirements for map content, quality and topicality, and cannot afford to make any mistakes. Researchers can use accurate maps for comparative analysis and visualization of scientific results. Public readers get useful information and good knowledge guidance from accurate and reliable maps.

With the rapid development of observation technology, GIS, etc., an integrated collection, storage, analysis and application of geographic information has been gradually formed, and a multi-scale spatial database with integrated collection, organization and update mode of spatial and attribute information has been established, and this series of database has become the primary data source for map mapping, which can guarantee the reliability and present situation of map information, etc. Therefore, how to use the latest spatial database in the shortest possible time to produce and provide high-quality, highly current and content-rich maps is an urgent problem. (Wang *et al*., 2012; Wang *et al*., 2017)

At present, the mapping industry map preparation mainly uses GIS software and map publishing software, or a combination of two kinds of software. (Wang, 2011; Xiao, 2009; Yin *et al*., 2012) Rapid mapping based on GIS software can meet the demand for rapid mapping to a certain extent, but the mapping effect is general and cannot meet the requirements of high-quality map mapping. For example, based on MapGIS, SuperMap, GeoWay and other mapping software, special map symbols, note configuration, automatic processing of elements and other functions are developed to improve the efficiency of mapping, but the maps produced cannot meet the requirements of publication, and it is still necessary to transfer the mapping data into professional mapping software (such as Adobe Illustrator, etc.) for mapping. (Qiu, 2017; Yang *et al*., 2005) The authors of this paper have studied the MAPublisher software launched by Avenza, relying on the existing spatial database, and selected Chinese sub-county maps as the research object, and proposed an efficient mapping technology method based on MAPublisher software to generate sub-county map templates for mass production of sub-county maps, which greatly

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improved the mapping efficiency. (Qiu, 2017; Yang *et al*., 2016; Zhao *et al*., 2011; Zhao *et al*., 2018; Zhong, 2014) However, this mapping method has two drawbacks: first, it is difficult to be used directly for other types of map preparation, and other types of mapping templates need to be generated separately for rapid map preparation; second, because the MAPublisher software does not open the secondary development interface, some work that can be automated cannot be realized in the templates, and the mapping efficiency needs to be further improved.

To meet the demand for fast cartography of high-quality maps, this paper studies AI-based fast cartography technology, solves the key technology of automatic cartography, extends the automatic cartography function of cartography software through an embedded cartography plug-in system, and realizes the automation from spatially based geodatabase to fast cartography of high-quality maps.

2. RESEARCH ON RAPID MAPPING TECHNOLOGY

2.1 Basic Idea

Based on GIS platform (ArcGIS) and map mapping software (Adobe Illustrator), we study the rapid mapping technology, design and develop the rapid mapping system driven by the spatially based geographic database, and realize the automatic conversion of GIS data to map mapping software and rapid mapping functions.

2.2 Conversion Technology of GIS Data Model

The GIS data model focuses on the content and relationships of geographic elements under geographic semantics, with spatial relationships and analysis as the main focus, while the digital map mapping model focuses on the graphical configuration and visual relationships of map element geometries, with visual representation as the main focus. The two models are obviously different, and the scenarios of application are completely different. Due to the weak cartographic ability of GIS software, it is difficult to meet the requirements of refined cartographic maps, and the professional cartographic software is powerful in cartography, but requires a lot of processing work on GIS data, especially line delineation data, which will significantly reduce the production speed of maps, therefore, most of them use a combination of two kinds of software to produce completed refined maps.

At present, GIS spatially based geographic data are generally imported into mapping software through exchange data formats such as DXF, and exchange data formats generally focus only on the geometric information of data objects, while most of the semantic attribute information that occupies an important position in mapping is lost in the conversion process, and this conversion process is generally uncontrollable. (Wen *et al*., 2019; Zhao *et al*., 2011) In addition, mapping software such as Adobe Illustrator does not support the understanding of semantic attributes of geographic objects. Therefore, the GIS spatially based geographic data converted to mapping software is mainly geometric data, i.e., coordinate data, and a lot of semantic information of geographic elements is lost in the conversion process, and only a very small amount of semantic information is retained. Because of the incompatible symbols between GIS system and mapping software, the work of element classification and hierarchy, the relationship between elements, and the design of map symbols need to be reoperated in the mapping software, and the further operation and processing need to consume a lot of manual processing, which is difficult to meet the demand of emergency mapping.

In this paper, we study the conversion technology method of GIS data model, use the data conversion plug-in to obtain all geometric and semantic information of GIS data and realize the complete conversion of information, and realize the organization and management of geometric and semantic information by extending the mapping model, and establish the applicable data model for the next rapid automatic mapping. (Cao *et al*., 2021; Wen *et al*., 2019)

2.3 Data Pre-processing

To realize the spatially based geodatabase driven rapid mapping system, the first step is to realize data pre-processing and conversion through the data model conversion technology. (Wen *et al*., 2019) The original spatially based geodatabase contains rich data information, and the map is affected by map size, map scale, map type, print size, etc. The final map does not need all the data information in the database, but can select some layers and attributes of the data, and then streamline the data volume after data pre-processing to generate the mapping database, which improves the efficiency of data processing, and also improves the efficiency of map making.

Data pre-processing includes data format, projection conversion, data classification and grading, data filtering and data re-assignment, and other processing methods. At present, there are various data formats of GIS data depending on the software or operation platform, so the format can be converted with different conversion algorithms and conversion models, and then the appropriate projection method can be determined according to the map area range, map size and map scale to get the map data projected to the plane. The mapping software pays more attention to the visual display of graphics, and usually uses each individual layer to express a certain type of geographic objects. Therefore, the source data in the spatially based geographic database can be classified in the data processing, and each type of object is a separate layer. At the same time, for the final presentation of the map, the source data need to be graded, and the data after classification and gradation are more convenient for the selection and symbolization in the map mapping process, which again improves the efficiency of map mapping. Data processing requires data screening to select the data and attributes that need to be expressed and displayed, which not only reduces the redundancy of data, but also saves the time of data conversion, further enhancing the efficiency of map mapping. In order to facilitate the symbolization of elements in map mapping, it is necessary to add further assignments to some of the data. Take road data as an example, firstly, the road data are classified and graded into two categories: highways and non-highways, and non-highways are divided into national roads, provincial roads, county roads, etc. The intermediate code CLASID can be used, firstly, RTEG and GB are assigned to CLASID, and then CLASID is classified and assigned to RANK, that is, the complete mapping data of classification can be obtained.

2.4 Map Symbol Library

The symbols in the map are the most important way to convey information, and vivid symbols can efficiently and quickly convey and express the basic information of the map to the readers. Using concise map symbols instead of spatial data and visualizing the geographic location, quantity and distribution of elements through different symbols can clearly reflect the characteristics and distribution patterns of feature elements and provide a clearer and more intuitive understanding of feature elements. In this paper, symbols are managed by means of symbol library, which is conducive to automatic symbol matching, automatic symbolization of data and improvement of mapping efficiency. (Mei *et al*., 2007; Yang *et al*., 2004) According to the type of spatial basic geographic information data, it is divided into point symbols, line symbols and surface symbols. General mapping software has a point symbol library to facilitate the reuse of graphics for symbolization, and this method can be used in AI to pre-produce complex graphic symbols, stored in the point symbol library, in the graphics style, part of the line symbols and surface symbols can be pre-configured, and the symbols that cannot be pre-configured can be customized in a way to generate suitable symbols. In this paper, we use both AI symbols and custom symbols to build a map symbol library.

2.5 Map Annotation

Map annotations and map symbols occupy the same important position on the map, and they complement each other. (Yang, 2009) Based on the visual representation of map symbols, appropriate annotations add to the readability of the map and make it an effective tool for expressing the real world. Usually map annotations include font size, font shape, font orientation and inter-word spacing. The font size expresses the level, number and importance of the annotated elements, and decreases as the importance decreases. Take road data as an example, according to the level of the road represented on the map, the font size of highway, national road, provincial road, county road and other road annotations will be reduced in order. Font shape is the font used, usually based on the information load of the map surface, the aesthetics of the map surface and the reader's reading habits to choose the agreed mature font, often using the Founder's font, etc., will also use special deformation fonts such as shrug, left italic, etc., will be based on the specific direction of the elements of the annotation to mark. Font direction is the orientation of the Chinese head of the note, usually depending on the direction of the element to be marked. Font spacing is the size of the spacing between each font in the annotation group, which is related to the distribution of the marked elements and their shapes and sizes. The arrangement of the annotations has a great relevance to the map symbols on the basis of the overall coordination of the map surface. The configuration of the map annotations should be prepared to express the attribution of the annotations on the basis of spatial correlation, and each symbol annotation should be clearly distinguished from the other, so as not to cause the reader any trouble in reading the map. The map annotations are also divided into three ways: point annotations, line annotations and surface annotations. The point annotation is a map annotation that identifies the name, type, nature, and density of the dotted elements on the map surface, and is usually centered on the location of the elements on the map surface. (Qiao *et al*., 2016; Wang *et al*., 2020) Line annotation is a map annotation that identifies the name, type, nature and density of the line elements on the map surface, and usually arranges the annotation along the direction of the line symbols, some line elements extend longer on the map surface, a single annotation will affect the effect of reading the map, and usually use the repeated annotation way to repeat the annotation along the direction of the line elements at the same interval. The surface annotation is a map annotation that identifies the name, type, nature and density of the top-shaped elements on the map, which usually includes administrative divisions, rivers, lakes and settlements. (Wan *et al*., 2012)

2.6 Mapping Rule Base

To meet the demand for automated and rapid mapping of multi-level scale maps, based on many years of practical work experience, this paper summarizes the experience and knowledge of map preparation of multiple types, scales and modalities, researches and establishes a rule base applicable to map mapping at different scales, and builds a rule base with data conversion rules, layer display rules, symbol configuration rules, annotation configuration rules, element embossing rules, element conflict handling rules and other rules.

Data Conversion Rules			
Attribute-based element trade-off rule structure		All elements in the layer are rounded off when their attributes are value.	
No.	Name	Data type	Description
1	ID	Int	ID
2	LayerName	String	Layer Name
3	AttrName	String	Attribute Name
4	Value	String	Attribute Value
Distance-based element trade-off rule structure		The adjacent elements in the layer are rounded off if they are smaller than the given value.	
No.	Name	Data type	Description
1	ID	Int	ID
2	LayerName	String	Layer Name
3	MiniDistance	Double	Minimum Distance
Element attributes trade-off rule structure		Which properties are extracted from the layer.	
1	ID	Int	ID
2	LayerName	String	Layer Name
3	AttrName1	String	Attribute Name1
4	…	…	…
5	AttrNameN	String	Attribute NameN

Table 1. Data Conversion Rules.

Layer Display Rules			
Scale rule structure		The size of the scale affects how many map symbols are displayed in the mapping area.	
No.	Name	Data type	Description
1	ID	Int	ID
2	LayerName	String	Layer Name
3	Scale	Int	Scale
Display level rule structure		The weights and the minimum spacing of each location affect the map symbol loadings.	
No.	Name	Data type	Description

1	ID	Int	ID
2	LayerName	String	Layer Name
3	AttrName	String	Attribute Name
4	MiniDistance	Double	Minimum Distance
5	Weight	Int	Weight
Display order rule structure		The order of displaying the layers of points, lines and surfaces to which the features belong.	
1	ID	Int	ID
2	LayerName	String	Layer Name
3	AttrName	String	Feature Attribute
4	Value	Int	Display Order

Table 2. Layer Display Rules.

Symbol Configuration Rules			
Point symbol matching rule structure		Judgment point symbol level and attributes.	
No.	Name	Data type	Description
1	ID	Int	ID
2	LayerName	String	Layer Name
3	PointsymbolName	String	Symbol Name
4	（x，y）	Double	Plane Coordinates
Line symbol matching rule structure		Judgment line symbol level and attributes.	
No.	Name	Data type	Description
1	ID	Int	ID
2	LayerName	String	Layer Name
3	AttrName	String	Symbol Name
4	（x1，y1）	Double	Plane Coordinates
4	…	…	…
4	（xn，yn）	Double	Plane Coordinates
5	AIPathstyle Width	Width	Line Width
6	Fillpaint	AIBoolean	Whether to fill
7	Fillcolor	AIColor	Whether to fill the color
8	…	…	…

Table 3. Symbol Configuration Rules.

Annotation Configuration Rules			
Point annotation configuration rule structure		Location, font type, color and orientation of point annotation.	
No.	Name	Data type	Description
1	ID	Int	ID
2	LayerName	String	Layer Name
3	LabellName	String	Annotation Name
4	Font	String	Font
5	Color	String	Color
6	Offset	Int	Marking point location
7	Position	Int	8 directions
8	Angle	Double	Angle
Line annotation configuration rule structure		Location, font type, color and orientation of line annotation.	
1	ID	Int	ID
2	LayerName	String	Layer Name
3	LabellName	String	Annotation Name
4	Font	String	Font
5	Color	String	Color
6	Offset	Int	Distance from the center point
7	Position	Int	8 directions
8	Angle	Double	Angle
Surface annotation configuration rule structure		Location, font type, color and orientation of surface annotation.	
1	ID	Int	ID
2	LayerName	String	Layer Name
3	LabellName	String	Annotation Name
4	Font	String	Font
5	Color	String	Color
6	Offset	Int	Distance from the center point
7	Position	Int	8 directions
8	Angle	Double	Angle

Table 4. Annotation Configuration Rules.

Element Glanding Rules			
Weight-based gland rule structure		According to the weight of the size of the gland, the smaller the less gland.	
No.	Name	Data type	Description
1	ID	Int	ID
2	LayerName	String	Layer Name
3	Weight	Int	Weight
4	Rank	String	Classification number

Table 5. Element Glanding Rules.

Element Conflict Rules			
Element conflict avoidance rule structure		Avoidance and avoidance distance according to element type in case of conflict.	
No.	Name	Data type	Description
1	ID	Int	ID
2	FeatureID	String	Element ID
3	Type	String	Type
4	Offset	Int	Avoidance Distance
Element merging rules rule structure		Which attributes with the same value can be merged in case of conflict.	

No.	Name	Data type	Description
1	ID	Int	ID
2	FeatureID	String	Element ID
3	AttrName	String	Attribute Name

Table 6. Element Conflict Rules.

2.7 Map Decoration

The map decoration includes map name, latitude and longitude, location map, legend, lower left corner note and lower right corner note, etc. The map name includes the map name content, map name body, map name size, map name color, and map name distance from the outer map outline. Longitude and latitude can set the number of decimal points, font, note size, note color, longitude and latitude note position. The default position map is located in the upper left corner of the inner map outline, and we can set the position map name, font, size, distance of the map name from the position map, inner margin, font color, background fill and stroke, etc. The default legend position is located in the lower right corner of the inner map outline, we can set the legend font, legend size, vertical distance of the legend from the symbol, font color, background fill and stroke, inner margin of the legend, etc. Symbol and name configuration, we can set the symbol width, symbol name font, size, maximum number of characters, name distance from the symbol, distance between symbol columns. The default scale is located below the legend, we can set the note content, note font, size, note top margin, note color, etc. The lower left (right) corner of the note can set the note content, note font, size, distance of the note from the outer outline, note color, etc.

3. DATABASE DRIVEN AI RAPID MAPPING SYSTEM IMPLEMENTATION

The semantic attribute information of geographic elements describes the content, explicit or implicit relationships, etc. of geographic element attributes, which are essential for the geometry and visual relationship expression of corresponding map elements. And map mapping rules are map mapping experience and knowledge in map element configuration and relationship processing in map mapping and other engineering with objective and subjective characteristics. In this paper, we combine the characteristics of mapping software, carry out the accurate definition of geographic semantics and mapping rules, and establish the driving mechanism of geographic semantics and mapping rules for automatic mapping, and realize automatic mapping under the control of mapping requirements, data characteristics, semantic information and mapping rules through plug-in technology.

The database-driven AI rapid mapping system includes two parts: data pre-processing and conversion system, and rapid map mapping system. The data pre-processing and conversion sub-system is developed by ArcEngine platform, and the result is an independent desktop software sub-system, which realizes the pre-processing and conversion of data from spatially based geographic database to AI mapping software; the rapid map mapping sub-system is developed by C++ base layer and embedded into AI software in the form of plug-in, which realizes map mapping rules management, map symbol management, map annotation automatic configuration, map symbol automatic configuration, map element relationship processing, map decoration and other functions.

4. EXPERIMENTAL EFFECT

In this paper, we use the basic scale national basic geographic information database as the original data, and the data is stored in GDB database. Taking a prefecture-level city administrative map as an example, we choose the boundary, road, water and residential land layers, and after the data pre-processing and conversion system, we realize the lossless conversion from GIS data to mapping software, and on this basis, we automatically configure the symbol, annotations and element relationship processing.

Compared with the traditional mapping method, this system can improve the efficiency of map compilation by more than 70%, which can greatly save the time and cost of mapping. The system can automate the conversion of GIS data to cartography, configuration of symbols, configuration of annotations and processing of element relationships within 15 minutes, and complete 70% of the workload of map production.

5. CONCLUSION

In this paper, we study the rapid mapping technology based on GIS platform and map mapping software, study the automatic map mapping method under AI environment, design and develop the spatial basic geographic database-driven rapid mapping system, realize the automatic lossless conversion of GIS data to map mapping software according to the established mapping rule base, realize the automatic configuration of symbols, notes and automatic processing of element relationship and so on. The system maximizes data accuracy in AI, realizes automated cartography, replaces most of the manual repetitive operations, greatly improves the efficiency of map production, and enhances the capacity of emergency cartographic services.

The database-driven rapid mapping technology based on AI proposed in this paper has been used in the production practice of prefecture-level city maps, and further optimization of the mapping process and various functions is needed. It is necessary to study the knowledge reasoning technology in depth, reason out the new knowledge to deal with special notes according to the existing notes, and establish a more complex rule base on the existing note configuration rules, so as to improve the degree of automation and configuration efficiency of the notes. It is necessary to study the reverse conversion of cartographic data to GIS data, and synchronize the update of source GIS data based on the latest cartographic data. It is also necessary to study the collaborative mapping technology, so as to further improve the efficiency of map compilation.

ACKNOWLEDGEMENTS

The Project Supported by the Open Fund of Hubei Luojia Laboratory (No. 220100037).

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This contribution has been peer-reviewed.
https://doi.org/10.5194/isprs-archives-XLVIII-1-W2-2023-239-2023