Approach to General Data Model of GIS Symbol Library and Symbol Library Data Exchange XML Schema

LI Qingyuan  SU Deguo  LI Hongsheng  LIU Haochen  SUN Lijian

Abstract  Symbol portrayal is an important function of GIS. Sharing symbolic information in different GIS platforms is necessary for GIS applications and users. This paper discusses the necessity, possibility and solution technique of sharing a symbol library in different GIS platforms. The route map is designed as follows: first, to set up a general data model for the symbol library, then to design a standard exchange format, and finally to call on the GIS manufacturer to provide the interchange tools for their symbol library for the standard exchange format. This paper analyzes the general characteristics of GIS symbolic library, gives a symbol library model and a draft of XML schema of the symbol library exchange format.

Keywords  GIS; symbol library; general data model; exchange format; XML schema

Introduction

The importance of the visual portrayal of geographic data cannot be overemphasized (OGC [1]). Symbol presentation is the most important portrayal method for geographic data. “Essence and prototype of GIS is a symbol portrayal system” [2]. Exchanging and sharing of spatial data have brought great social and economic benefits to society and the GIS industry. Nowadays, people are not satisfied with only sharing spatial position and topology relationship of spatial data, but also hope to share portrayal presentation, including symbol expression. Sharing of geographic information should include not only position and topology of spatial data, but also portrayal presentation, including symbol drawing style. Sharing of symbol library should be studied [3,4].

There are many research works on data model and implementation of a symbol library. In this paper, first, the authors discuss the necessity of sharing symbolic lib in different GIS platforms. Then, the authors analyze symbolization method in GIS. By the fact that the implementation method of map symbol has developed from early “function” to current “symbol library”, the authors drew a conclusion that it is possible to exchange and share symbol information in different GIS platforms. After analysis of the commonness of the GIS symbol library, the authors gave a general data model of symbol library and an XML schema of the symbol library interchange format. It has been suggested that the general data model...
of symbol and exchange format should become a part of OGC and ISO TC211.

1 Research background

1.1 Necessity of research work about GIS symbol library data exchange

Exchange is a basic method of data sharing. Even after attaining inter-operation in different GIS platforms, it is still needed for exchanging spatial data. Current main GIS platforms have provided an exchange format for spatial data. Many nations have enacted national standards for spatial data exchange format to ensure translation and exchange of spatial data in different GIS platforms. These measures have promoted the progress of the GIS industry. However, portrayal presentation, especially map symbol information, cannot be shared in different GIS platforms at present. The users need to invest a lot of repeated work when they integrate information from different data sources. It wastes a large number of social resources.

SuperMap Inc has published ‘SuperMap Vector Map Symbol Library Exchange File Format 2.0’ in 1999[3]. They hoped to share the symbol library data by exchange file. Tao has proposed a symbol sharing model based on a common integrated symbol editor[2, 4]. Fulan has provided a design and attained a symbol database based on multi-interface symbol display technology.[5]. The author has given a symbol library exchange format based on XML.[6].

ISO TC/211 and OGC have done much work in sharing portrayal presentation, but dealt little with the symbol library problem. ISO 19117[7] (Geographic Information Portrayal) described the portrayal presentation mechanism of geospatial data, only mentioning that portrayal presentation includes symbol presentation, without further explanation. OGC 02-027[1] (Styled Layer Descriptor Implementation Specification) prescribed the portrayal presentation rule of point, line, area, annotation and image in web map service. It prescribed a method for calling a symbol library of platforms, but did not discuss how to construct the symbol library. The OGC 02-027 specification has been divided into two, 05-077r4 (Symbology Encoding Implementation Specification)[8] and 05-078 (Styled Layer Descriptor Application Profile of the Web Map Service Implementation Specification)[9], describing more about the symbol portrayal, but still not giving a criterion for the symbol library.

1.2 Function method and library method for symbol portrayal

In the early days of GIS, function method was the only way to portray symbols. In the function method, symbol style is fixed in function. When users hope to modify a symbol style or add a new symbol they need to modify the function, so it impossibly becomes a general method. Recently, most GIS platforms have evolved into the symbol library method. Symbol library method takes portray style information as parameters storing them into a symbol library (file or database), and uses a general program to make and modify the symbol library, to portray a symbol according to style information in the symbol library. That is to say, the processes of making, modifying and displaying a symbol have been separate from the symbol style information. Symbol library method has become prevalent in GIS symbol portrayal.

For a symbol system, symbol portrayal effect relies on symbol style parameters which are stored in the symbol library. It provides a possibility of sharing the symbol library in different GIS platforms. The characteristics of a symbol library are as follows: (1) structure is uniform for every symbol in a given symbol library, (2) symbols are parallel to each other, and (3) the difference is that only parameters are stored in the symbol library. It is convenient for dynamic expansion and modification of the symbol library. However, there are big differences in implementation method and storing structure among different GIS symbol library systems. If it is possible to express a symbol style parameter by a general model, the implementation of symbol library data exchange among different GIS platforms is a problem which should be studied in GIS science.

2 General data model for symbol library

In the spatial distribution morphology of geographic feature represented by map symbol, cartog-
raphers classify symbols as point symbol, line symbol and area symbol\textsuperscript{[10]}. A point symbol presents a small thing or point feature which does not rely on map scale. A line symbol presents linear or strip distribution features, whose length depends on scale, but the width of portrayal does not rely on scale. An area symbol presents an area distributive feature relative to scale. A GIS symbol library also classifies symbols as these three classes of point, line and area. Every class can be subdivided into many symbols. A symbol is composed of many layers. A layer can be assembled by many basic elements. A symbol is combined by layered element on a local coordinate, so it can be taken as a “micro vector map” with a local spatial reference system. A symbol library stores point, line and area elements and local spatial position and laying sequence of every symbol. Referencing the spatial data exchange research result, theoretically speaking, the symbol library can be exchanged and shared in different GIS platforms. Therefore, the common characteristics of main GIS platforms need to be studied, to discard concrete detail of implementation and to setup an abstract general symbol library data model as a foundation of symbol library exchange. This paper proposes a general symbol library data model.

2.1 General structure of map symbol library

Map symbol library can be divided into three classes: point, line and area. Every class consists of many symbols. Every symbol consists of name, Id, unit and vector layers. Point, line and area symbols are not isolated. There are some combination relationships: line symbols often include point symbols, area symbols often include point symbols and line symbols. Symbol portrayal is computationally intensive, so most symbol libraries construct a multi-tier index. The graphic element is composed of basic graphic elements and symbol references. A point element includes basic point elements and point symbol references. A line element includes basic line elements and line symbol references. A point element can be a component of line symbols. A point element or a line element can be components of area symbols.

2.2 Characters and structure of point symbol

Point symbol figure does not change with its position. The symbol has a location point and a direction. It can be zoomed in or out. It is made up of layered point elements. From the view, “A map symbol is a micro-vector map”, point symbol is a typical example. A symbol library stores layered description parameters of every point symbol, including type of element, local coordinates, color, rotary angle and extension scale. The elements of point symbol include curve string (segment string and spline string), polygon, rectangle, round-rectangle, ellipse, arch, TrueType character and bitmap. The TrueType character is an excellent point element, which records boundary coordinates and curve smooth parameters of different patterns with character shape. It is a general character format and provides great flexibility for point symbol making. Now, almost all professional GIS symbol library systems support TrueType characters. Fig.1 shows some examples of point symbols.

![Fig.1 Some point symbols](image)

2.3 Characters and structure of line symbol

Line symbols are principal and the most complicated components of a map. A line symbol extends like a strip along a located baseline. It is made up of layered line elements and point elements. There are two types of line graphic distribution along the baseline. One is simple (non-segment), and the other is segment (recycle).

1. The simple type only has line elements, as shown in Fig.2, a freeway and two railway symbols. The freeway symbol is made up of a narrow solid yellow line overlaying a wider solid red line. The two railway symbols are made up of a white dashed or dotted line overlaying a wider black solid line.

2. The segment type is built by a recycled placed segment consisting of line elements and point elements. The segment has a length. The elements need to be recorded lateral offset from the baseline and longitudinal offset from segment start. The examples are shown in Fig.3.

Of course, the symbols in Fig.2 can also be built by segment placement. In fact, many line symbols (such as railway or highway) can be made up of simple type
or segment type. Generally speaking, “simple type” is more effective than “segment type”, because the former calls basic line pattern provided by the system, while the latter is more agile in style. Point elements exist not only in cycled segment, but also in peculiar position of line, such as start point, end point, middle point or any position, as shown in Fig.4. Some line symbols have directions, such as river bank or cliff, as shown in Fig.5.

Fig.2 Line symbols built by simple type

Fig.3 Line symbols built by segment type

Fig.4 Arrow exists at start, middle and end of a line

Fig.5 Bank with a direction

2.4 Character and structure of area symbol

An area symbol is made up of layered area graphic elements. All layers in an area symbol share a closed visible or invisible boundary line (also called outline). A boundary line may be a line element or null (when invisible). Filling element may be color, point symbol and line symbol. When filling, it may be a simple color or gradually changing color. When filling with a point symbol, we need to offset a distance in x and y, and the point symbol is arranged in three different types. The first type is triangle, as shown in Fig.6. The second type is square, as shown in Fig.7. The third type is random-scatter, as shown in Fig.8. When filling with a line symbol, we can set different line width, color, rotary angle, and a space distance. As shown in Fig.9, an area rock symbol in a geological profile can be made up of some line symbols rotated a certain angle.

Fig.6 An area symbol filled point symbols arranging in triangle type

Fig.7 An area symbol filled point symbols arranging in square type

Fig.8 An area symbol filled point symbols arranging in scatter type

Fig.9 An area symbol in geology profile, filled line symbols rotated an angle

3 XML schema of symbol library data exchange format

The symbol library exchange format should be readable and traceable. The authors designed an XML schema for symbol library exchange format.

3.1 Prescriptions for the XML schema

In these structure schema diagrams, sign presents that the left element consists of right elements in sequence, presents that the left element consists of one of the right elements. Sign presents that there are 0-multi elements. Sign presents that there are 1-multi elements. Dashed line
frame presents that the element is optional. Sign \( \infty \) presents that this element is extendable.

### 3.2 Total frame of XML schema for general symbol library exchange format

Fig.10 is the outline of the XML schema for the symbol library exchange format. A symbol library consists of point symbol set, line symbol set and area symbol set. The point symbol set consists of some point symbols. The line symbol set consists of some line symbols. The area symbol set consists of some area symbols. Every symbol consists of Id, index, name, unit and relevant layered symbol data. The unit may be pixel, inch, millimeter and centimeter.

### 3.3 XML schema of point symbol layer

Fig.11 is the extension of the point symbol layer in Fig.10. It consists of type and data. The type is one of the eight types, which are line string, polygon, rectangle, round rectangle, ellipse, TrueType character and picture.

The data of every type are different, as shown in Fig.12. Many items are optional. Most of the optional items have default value.

![Fig.10  Schema view of symbol library](image)

![Fig.11  Point symbol layer schema view in Fig.10](image)

In Fig.12, “SplineType” in curveString is linear, tension spline and Bezier spline, the default value is linear string (line segment connection); for tension spline, there is tension coefficient, the default value is 0.5. The default value of line width is 1. The default values of color and boundary color are black. The default value of fill is null, i.e., not fill. In rectangle, round-rectangle, ellipse and arch, if there are no
“XLeft” and “YTop”, the center of point symbol is center. Default of height is width. The default values of rotary angle, x-offset and y-offset are 0. The default values of background color and transport color are null, i.e., without background color and transport color.

3.4 XML schema of line symbol layer

Fig.13 shows the detail of line symbol layer in Fig.10. Here, the baseline offset is the distance from the baseline. The segment offset is the distance from segment start. The default values of baseline and offset segment offset are 0. A special point is used to express point symbol which exists in a special position of line symbol (Fig.4), and the position is expressed by a percentage of the point element in the line symbol. It may be any value between 0 and 100, 0 being the beginning point, 100 being the end point.

Fig.12  Schema view of point graphic elements

Fig.13  Line symbol schema view in Fig.10

Fig.14 shows the details of the line element, which is basic line element in Fig.13 and Fig.16. It consists of basic line element and line symbol reference. The basic line element consists of element pattern, width, color and close cap. Here, the value of pattern is one of solid line, dashed line, dotted line and dash-dot line, the default line type is solid line. The default width is 1. The default color is black. The value of close cap is one of butt, round and triangle, and the default value is butt. The reference of the line symbol may include line width and color, and the default values are line width and color of original line symbol.
Fig. 14  Line Element schema view in Fig. 13

Fig. 15 shows the details of Fig. 13 and Fig. 16, consisting of the basic point element and point symbol reference. The basic point elements are the same as in Fig. 12. The point symbol reference may include size, color and angle. The default values of the first two are the values of the original point symbol. The default value of rotary is 0.

Fig. 15  Especial point schema view in Fig. 13

3.5 XML schema of area symbol layer

Fig. 16 is the schema view of area symbol layer. Every area symbol layer consists of boundary and fill. The boundary is an optional line element (see Fig. 14), and the default value is null, i.e. no boundary. The fill is one of five patterns: simple color, gradient color, picture fill, point fill and line fill. The simple color fill pattern is a simple color.

The details of gradient color fill schema view, picture fill schema view, point fill schema view and line fill schema view in Fig. 16 are shown in Fig. 17. The

Fig. 16  Area symbol schema view in Fig. 10

Fig. 17  Detail of gradient color schema view, picture fill schema view, point fill schema view and line fill schema view in Fig. 16
gradient color consists of begin color, end color, begin scale, end scale, interval, style and angle. Style is one of four: linear change, rectangle change, ellipse change and buffer change. The point element is the same as in Fig.12. The arrangement type could be a triangle, square and scatter (Figs.6, 7 and 8). The first two types need to have $x$ and $y$ distance, the third type needs to give minimal radius of random placement (in XOffset). The line element is the same as in Fig.14.

4 Conclusion

After studying the symbol system of different GIS platforms, the paper proposes a general data model for a symbol library and an XML schema for symbol library exchange. It is basic work for symbol library exchange in different GIS platforms. However, the difficulty in symbol library exchange is much more than exchange in general spatial data. To recognize the symbol library in different GIS platforms, we need to consider implementation and symbol library system storage structure of different GIS platforms. The cooperation between user, GIS manufacturer and GIS standard organizations is needed. In summary, there is a long way to go for symbol library exchange in different GIS platforms, but it should be a target for the GIS community. The authors hope that the general data model symbol library and exchange format schema could develop to becoming a part of OGC and ISO /TC211.

References

[1] OGC (2002) OGC 02-027 Styled layer descriptor implementation specification[OL]. http://www.opengeospatial.org/standards/sld
[2] Tao Tao, Zhang Shuliang, Li Xiumei (2005) The design and realization of common line editor for geographic sharing[J]. Computer Applications and Software, 22(12): 52-54, 141
[3] Beijing Super Map GIS Lit. (1999) SuperMap vector map symbol library exchange format 2.0[OL]. http://www.gis-china.com/maindoc/simchin/gisforum/format/vector006.htm
[4] Tao Tao, Lv Guonian, Li Yanna (2005) Study on symbol sharing based on common integrated symbol editor [J]. Geography and Geo-Information Science, 21 (4): 28-31
[5] Shi Fulan, Zhang Shuliang, Tao Tao (2004) Design and realization of symbol database based on multi-interface symbol display technology [J]. Computer Engineering, 30 (17): 195-197
[6] Li Qingyuan, Su Deguo (2005) Research on GIS map symbol library exchange format [J]. International Journal of GeoInformatics, 1(4): 59-66
[7] ISO TC 211/WG4 (2002) ISO DIS 19117 Geographic information–Portrayal[M]. Beijing: Standards Press of China
[8] OGC (2006) OGC 05-077r4. Symbology Encoding Implementation Specification[OL]. http://www.opengeospatial.org/standards/symbol
[9] OGC (2006) OGC 05-078 Styled Layer Descriptor Application Profile of the Web Map Service[OL]. http://www.opengeospatial.org/standards/sld
[10] Ma Yaofeng, Hu Wenliang (2004) Theory of mapping [M]. Beijing: Science Publishing