AN OBJECT-ORIENTED DATA MODEL FOR DIGITAL CARTOGRAPHIC OBJECT

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ABSTRACT

This paper presents an object-oriented data model of digital cartographic object developed to serve as general base for meta data and cartographic data organization, spatial data transfer, cartographic generalization, and data quality control. The model handles the geometry and attribute of features stored in feature classes or other graphical elements. Other considerations include the design for the map symbol base. The map symbol specifies symbol attributes such as color, style, and orientation. A symbol object by itself is not sufficient to display the shape it describes. It needs to be combined within a graphic element object in order to be displayable. The same symbol object may be used to set the attributes for more than one symbol instance. The best thing to do is the symbols' polymorphism, inheritance and encapsulation ability. With the relation database, we can manage multitudinous data, and with Object Oriented Programming (OOP), we can create the gigantic and complex software system. So we find the relations between the spatial relations modal and the spatial object modal, expose data from a variety of sources, and map the spatial object class to the relation table. Based on the model and the characters of the large-scale map symbol, the hierarchical large-scale map symbol base have been achieved following Programmer's Hierarchical Interactive Graphics Standard (PHIGS), specifications for computer-aided mapping of large-scale topographic maps, topographic map symbols. In addition, utilizing the object-oriented data model we actualize the seamless spatial data organization, data retrieval, and management of the multitudinous data. Using the object-oriented map symbol base, the logical consistency and integrity of the spatial data can be assured in the procedure of digital map design and production, and the efficiency of map browsing, inquiring and editing are improved. We also actualize the map transfer of the different scale and the automatic generalization based on the transform rule database. The presented examples in this paper should mainly prove the high functionality of the object-oriented data model for digital cartographic object and the user-friendliness of the software system followed the model.

1. INTRUDUCTION

There have been many years in the history of the map. But its connotations and extensions are not same at the special times. Historically, map production has been seen as an isolated task, compiling information together from various sources to produce a particular cartographic product. This traditional view is now challenged by the availability of new environments which bring together database, object data modeling, image analysis (LI De-ren and ZHOU Yue-qin, 2000), active agent behavior (John A., 1996), automated cartography to produce a unified flowline for production of multiple maps, charts, geospatial data (Zhao Hongrui and Chen Yijin, 2000), on-demand spatial visualizations such as Internet web mapping (Wang Weian, 1997. YUAN Xiangru, CHEN Nengcheng, GONG Jianya, 2000), multitudinous data management, spatial data transfer, cartographic generalization, data quality control and so on. This paper presents an object-oriented data model of digital cartographic object developed to serve as general base for meta data and cartographic data organization, spatial data transfer, cartographic generalization, and data quality control. The model handles the geometry and attribute of features stored in feature classes or other graphical elements. Other considerations include the design for the map symbol base. The map symbol specifies symbol attributes such as color, style, and orientation. A symbol object by itself is not sufficient to display the shape it describes. It needs to be combined within a graphic element object in order to be displayable. The same symbol object may be used to set the attributes for more than one symbol instance. The best thing to do is the symbols' polymorphism, inheritance and encapsulation ability. With the relation database, we can manage multitudinous data, by the hierarchical model and OOP, we can create the gigantic and complex software system. So we find the relations between the spatial relations modal and the spatial object modal, expose data from a variety of sources, and map the spatial object class to the relation table. Based on the model and the characters of the large-scale map symbol, the hierarchical large-scale map symbol base have been achieved following PHIGS, specifications for computer-aided mapping of large-scale topographic maps, topographic map symbols. In addition, utilizing the object-oriented data model we actualize the seamless spatial data organization, data retrieval, and management of the multitudinous data. Using the object-oriented map symbols base, the logical consistency and integrity of the spatial data can be assured in the procedure of digital map design and production, and the efficiency of map browsing, inquiring and editing are improved. We also actualize the map transfer of the different scale and the automatic generation based on the transform rule database. We validate the principium and method of above with the actual system.

This introduction will be followed by a more detailed analysis of object-oriented symbol modeling (Section 2). After that, a discussion of the a framework for automatic of the geographic and the data operation by the Object-Oriented program designed method and OLE DB geospatial databases principles behind the algorithm development will be outlined. The practical solutions for generalizing cartographic data have also been discussed by the combinations of automated processes and interactive editing under the data structure and software framework (Section 3). Experimental tests have also been conducted to evaluate the performance of this papers' analysis (Section 4).

2. OBJECT-ORIENTED SYMBOLS MODELING

The traditional map is a model of part of the surface of the earth presented conventionally as a graphical illustration. But the modern digital cartographic maps are produced for different purposes and will tend to exaggerate relevant features. Now the term 'map' has been extended to cover the range of mapping products such as electric maps, topographic maps, thematic maps, charts, plans, atlases and geodata. Producing such mapping products used to be a manual draughting task, but increasingly relies on computer cartography. The simplicity in existing map symbol data structure and programming method have been slow to incorporate the concept of an integrated, multi-leveled Spatial Data Infrastructure (SDI) concept at various political and/or administrative levels as well as the Geographic Information System (GIS). Failure to incorporate this multi-dimensionality, and the dynamic mechanistic and functional roles of the SDI, have rendered many descriptions of SDI inadequate to describe the complexity and the dynamics of SDI as it develops, and thus ultimately constrain GIS and SDI achieving developmental potential in the future. As a result, the objective of this section is to describe the fitness and applicability of object-oriented symbols modeling. It is also argued that by better understanding and demonstrating the nature of symbols and signs of maps.

The object-oriented analysis and design methodology classification emerged in the mid- to late 1980s as businesses began to seriously consider object-oriented programming languages for developing systems. At least eight characteristics or principles for managing complexity are considered foundation and generally accepted characteristics of object-oriented analysis, design, and programming. They are (Ronald J. Norman, 1996): (i)common methods of organization, (ii)abstraction, (iii)encapsulation or information hiding, (iv)inheritance, (v)polymorphism, (vi)message communication, (vii)associations, and (viii)reuse. Many models can be organized as a hierarchy of symbols. The basic “cartographic map symbols” for the objected-oriented symbols model are defined as simple geometric shapes, such as POINT, LINE and AREA, appropriate to the type of model under our consideration. These basic symbols can be used to form composite spatial objects, called base class, which can be inherited to form lower-level class, and so on, for the various components of the model. Figure 1 simply gives us the model’s hierarchy structure.

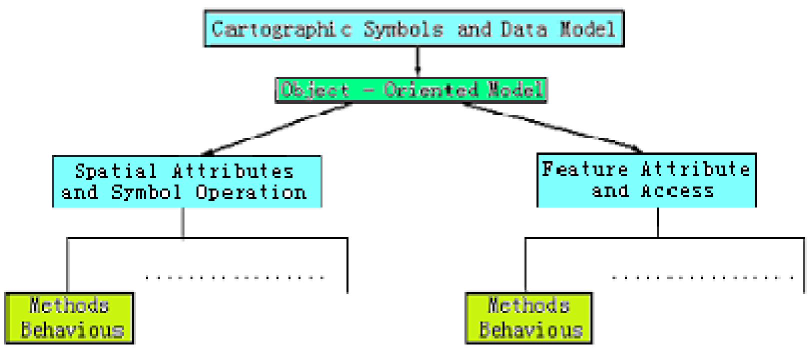

Figure 1. Object-oriented Cartographic Symbols and Data Model Hierarchy Structure

The model methods are grouped into six general classifications. The methods are responsible for:

1. Data capture, draw symbol and interactive editing.
2. Spatial data quality management.
3. Object versioning and long transactions.
4. To manage the metadata about the digital cartographic map.
5. The geographic data transformable among the different GIS software systems.
6. Topology structure creating and maintenance.

A main challenge for the digital cartographic object is the interactive characters for the map symbols. Requirements interactive editing is the general symbol-gathering activity done during map design and production. The model classes have fours behaviors (the detail information look at section 3). Figure 2 shows the system modules composing (Gubin and Chen Yijin, 2000).

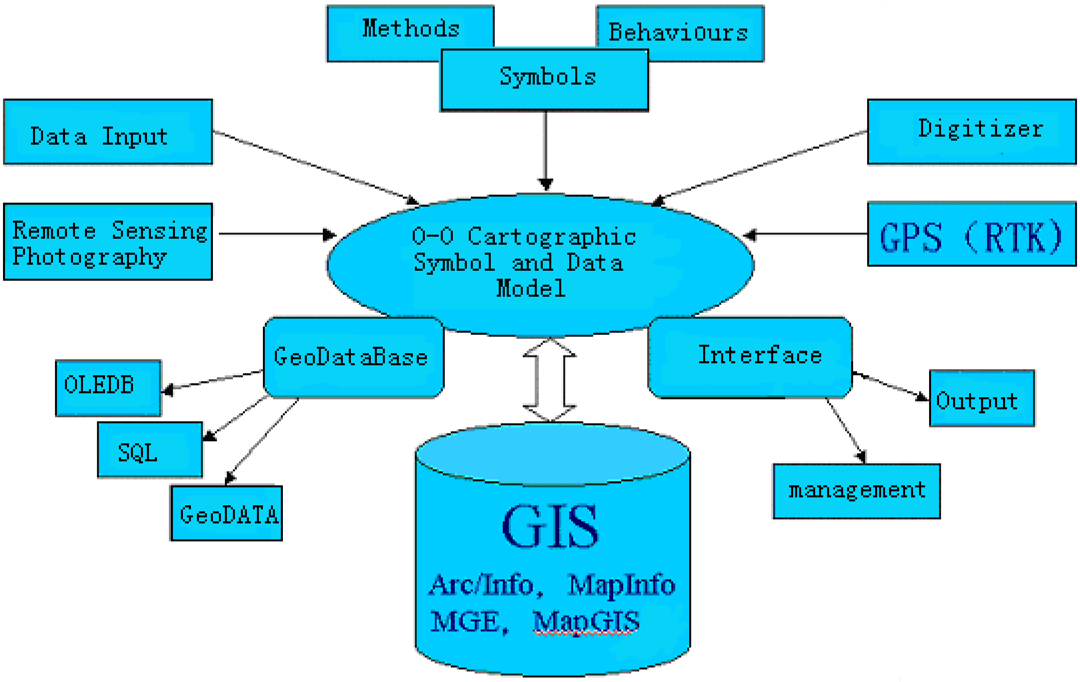

Figure 2. System Modules Composing

3. A OBJECT-ORIENTED FRAMEWORK FOR AUTOMATICITY OF THE CARTOGRAPHY AND DATA OPERATION

Some general-purpose graphics systems, Graphical Kernel System, for example, are not designed to accommodate digital cartographic object modeling applications.

Traditionally, routines necessary to handle modeling procedures and data structures are often set up as separate modeling packages, and graphics packages then can be adapted to interface with the modeling package. The purpose of graphics routines is to provide methods for generating and manipulating final output displays. Modeling routines, by contrast, provide a means for defining and rearranging model representations in terms of symbol hierarchies, which are then processed by the graphics routines for display.

Although the PHIGS (Sheng Huanhua and Cheng Yang, 1992) is not an object-oriented system, but it is a world standard for portable, device-independent interactive graphics software development. PHIGS is also an ANSI and ISO standard developed over a period of about ten years. The standard specifies basic drawing primitives along with a set of attributes for each. Primitives are invoked in a conceptual graphics workstation operating in the context of control functions that determine its state. PHIGS is notable for its sophistication in definition, modification and display of hierarchical graphics data. It is suitable to draw and interactive edit cartographic symbols. So, in our system, we mainly follow the standard for the symbols by the OOP technology. Besides that, we have designed the following cartographic symbol behaviors:

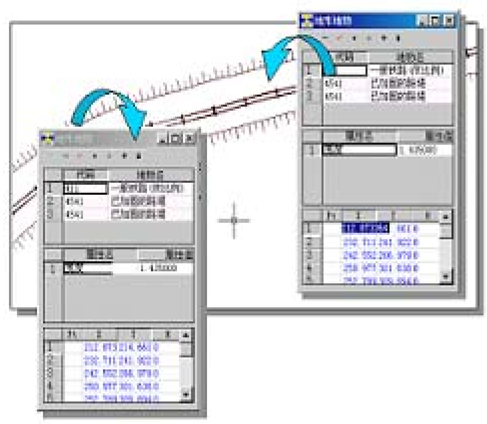

Figure 3. Attributes feature and spatial data operation

1. **The Attributes feature automatic display.** If user hopes operation for the attributes feature in time during map design and production, they might open the function. By the function the user can input and retrieve graphics or attributes information, such as shown in Figure 3.

2. **Snap modes implementation.** The snap mode is also a kind of behavior and is set for grip points.

3. **Grip points implementation.** The grip points appear when the user selects an entity with the pointing device. If the digital cartographic entities have grip points, the user might expediently edit the entity in interactive. So the behavior has been defined for an entity.

4. **Notification.** When an event occurs in the system, certain objects, called notifiers, automatically relay the event to other objects. For example, when a user copies, erases, or modifies an symbol object or when a user issues an UNDO or REDO command, a corresponding notification for each event is automatically triggered.

The major database vendors now make it possible to store, index, and query spatial data using object/relational technology. Spatial functionality is being pushed into the server to improve performance, interoperability, scalability and security. This is part of a growing emphasis by vendors to manage abstract data types (spatial, imagery, video, audio, time series, text) using commercial database technology. Here, for the spatial data management, OLE DB is introduced to our system. The OLE DB is composed of a general-purpose set of interfaces designed to let developers build data access tools as components using the Component Object Model (COM). OLE DB enables applications to have uniform access to data stored in DBMS and non-DBMS information containers, while continuing to take advantage of the benefits of database technology without having to transfer data from its place of origin to a DBMS.

Categorical map generalization has long been the key problem in cartography (Qi Qingwen and Liu Yue, 1998). Cartographic generalization is the science (and art) of exaggerating those aspects that are important for this particular map purpose and scale, and removing irrelevant detail that would clutter the map and confuse the user. In our system, we also design a generalization rule database (Figure 4). By a three-stage iterative process: ***analysis*** of spatial data, ***transformation*** and ***control*** (Figure 5), the map generalization has been realized. The Figure 6 shows the same area at two different scales, showing different levels of detail, and different objects for the same entity (e.g. area at detailed scale goes to symbol at small scale).

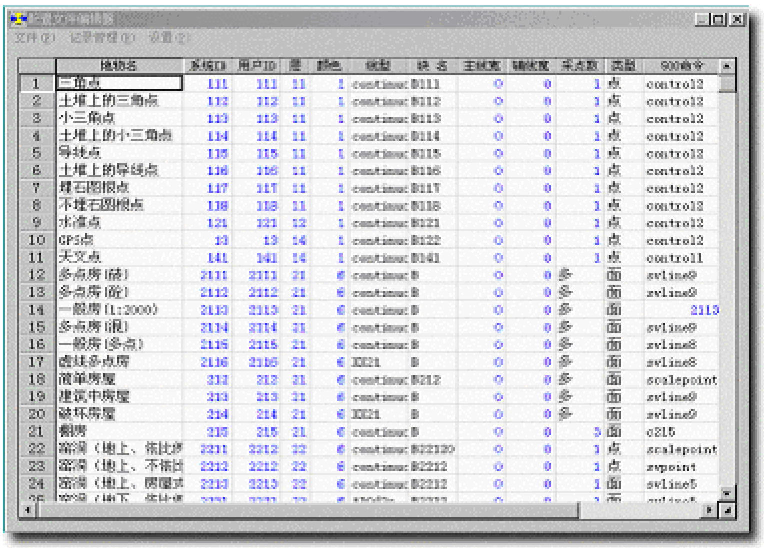

Figure 4. Generation Rule Database

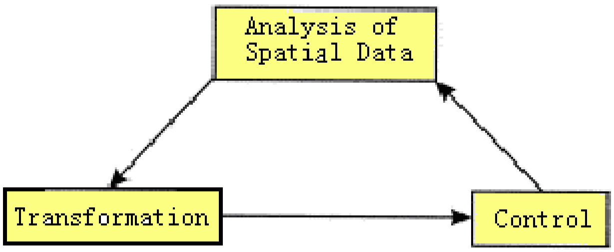

Figure 5. Generalizaiotn of iterative Process

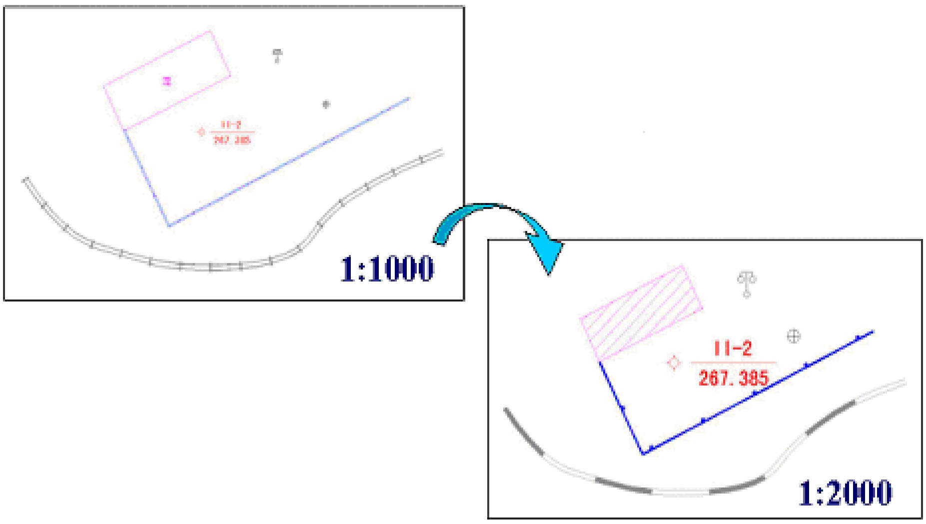

Figure 6. Generalization Contents

4. CONCLUSSIONS

The intention of this paper was to present shortly the possibilities and applicability of the object-oriented data model for digital cartographic object and the graphic software packages in map design and production. The presented examples as above and Figure 7 should mainly prove the high functionality of the software and the user-friendliness of the system. The package is especially suitable for the data capture as well as map design and production.

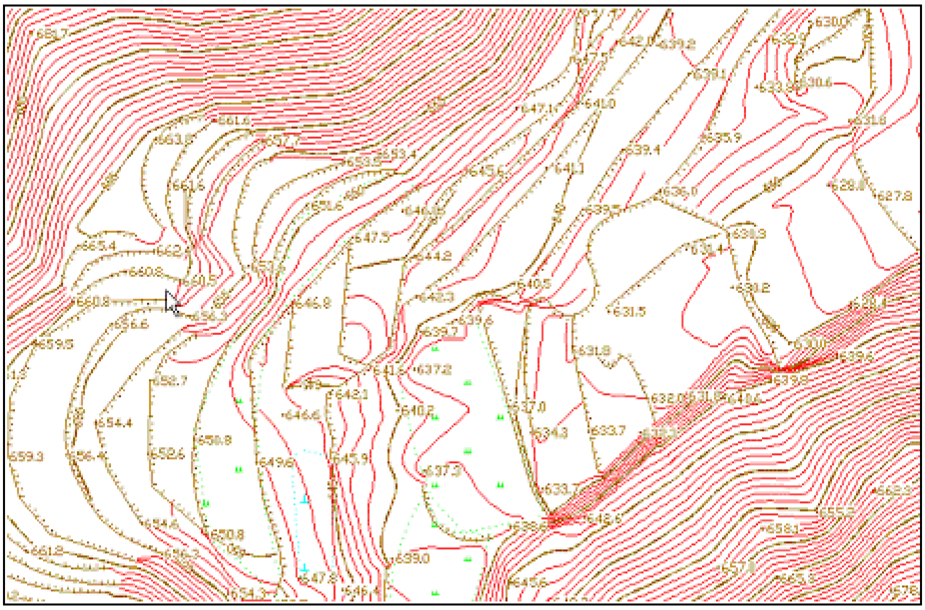

Figure 7. Map Design and Production Example

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