A NEW FORM OF OBJECT ORIENTED SPATIAL DATA MODEL IN GIS

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ABSTRACT:

On the basis of analysing the theories of object-oriented, topological relation model and non-topological relation model, this paper presents a new spatial data model. The thinking of new data model accords with the theory of spatial organization. It has its own characteristics compared with conventional data model. All of these ideas have been embodied in factual appliance of spatial analysis, such as overlap analysis, optimal spatial analysis and so on. The concrete analysis process and methods are set forth in the paper in detail, Moreover, this prototype can be applied to other fields, which involve spatial database building, etc.

1. INTRODUCTION

Geographical Information System (GIS) is a complex technology, starting with the digital representation of landscapes captured by cameras, digitizers, or scanners, in some cases transmitted by satellite, and then with the help of computer systems, stored, checked, manipulated, enhanced, analysed, and displayed as data referenced to the earth. It has a history of more than 30 years. It is a information system, so it has the properties of information systems. But the key difference is that the information being memorized and tackled is coded in geographic way, and the major part of it is geographic position and the attribute information connected with it. The core (most important) of GIS is how to describe, express and simulate geographic entities, phenomenon, mutual relations and distributed characteristics of the real world in a computer memory medium in a scientific and actual way, which is to build up spatial data model of geography.

2. SPATIAL DATA MODELLING

Spatial data model is a conception about the real entities and the relations of them. It provides a basal means for organizing and designing the models of spatial database. So, it is significant for understanding and studying spatial data models to design spatial data models of GIS and develop the new GIS systems.

Traditionally, spatial data models in GIS are composed by concept data model, logic data model and physic data model. Concept data model is an abstract conception aggregation about the real entities and the relations of them. Logic data model expresses the entities (or notes) and their mutual relations of concept data models. Physic data model describes the physic organization, memorized path and database structure of datum in computer. Concept data model considers about the commonness of the needs of users, and utilizes the uniform language to describe, synthesize and integrate various user views. The integral assignment is to confirm the interesting phenomenon and basic characteristics, and describe the mutual relation of the entities to make sure the information contents of spatial database. At the present time, the mostly used is point, line, and area data model based on planes and raster data model based on continuous (consecutive) tessellation.

3. OBJECT-ORIENTED DATA MODELLING

Object-oriented data model is a new data model that is brought forward according to the object-oriented techniques in 1990s. It builds up new models unitedly to the attribute datum (statement) of geographic objects and means (actions) of the attribute datum, and reserves them forever.

3.1 The Thinking of Object-Oriented

Object-oriented data model can build up hiberarchy of the objects, which accords with the hiberarchy of geographic elements. At present, there exists two directions on GIS software, one is build up the storage of object-orient, the other is build up the mechanism of reserving objects on the basis of correlation database, which is shown in the figure 1. Topological model and non-topological model are the two usual models utilizing the correlation database.

Object-oriented, means the structure of an entity can be denoted in only an object however complex the entity is, and can not be decomposed artificially on the grounds that technical limitation, such as the standardization of correlation models. The object-oriented technique provides 4 kinds of factual abstracting techniques (classifying, generalizing, combining, and assembling) and 2 kinds of tools to abstract datum (inheriting and spreading). The new types of data models utilizing the few techniques are more abundant and powerful than the traditional

data models, and especially an ideal way to expressing spatial datum.

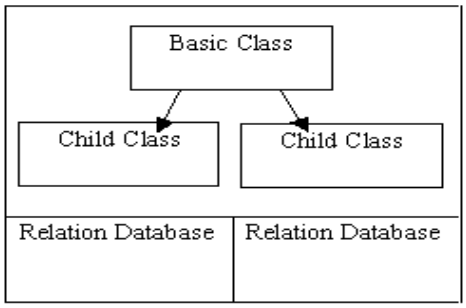

Figure 1. The theory of object-oriented thinking

An abstract data prototype is a data model that encapsulates one type with the correlative operation connected with the type. Considering about all of the entities of spatial datum, there are no more a few prototypes than these in geometric characteristics, 1) Point. It is expressed only in one place. 2) Line. It is made up of a few orderly coordinates, then lined up to express the shape. 3) Surface. It is also made up of a few orderly coordinates, but the difference is that the first coordinates are equal to the last coordinates, so it can make up a ring to express surfaces. 4) Complex. It is made up of the three above entities, maybe it can include its own boundary. All these four prototypes are considered as the superclass of any kind of entities in GIS (Gong, 1993). In object-oriented techniques, the most distinct characteristic is the single of sign, which means that each object of the same type has only one object sign, though the others of the two objects are completely same. If the sign is different from the other, they are considered as two different objects. The signs of objects are given automatically by the system. For a GIS system, the strongpoints of adopting object-oriented data model are, 1) All the entities are encapsulated as objects. 2) Complex objects can be made up of a series of simple objects, which is the basic requirement of GIS model, and also one of the key characteristics different from traditional data models. 3) There are strong inheritance and spread in the system structure of the types, and the correlations of spatial objects can be acquired easily in this way. 4) The expansion of object-oriented makes it possible for the advancing defined prototypes turns into user prototypes without obvious changes. 5) It has all the characteristics of traditional data models.

3.2 Topological Relation Model

Topological data model is set on the basis of arc. Some middle points make up arc, and the two ends of which are nodes. Topological data model does not store public borders of polygons, which will save up capacity. It is also convenient to have many operations such as adjacency, containment and adjoining, at the same time, the speed of spatial query and analysis is rapid. Therefore, the structure of topological data model is so complex that the topological relation will be broken after some points or arcs are added and deleted. The topological relation will be rebuilt through topological arithmetic, so that the coherence and integrity will be maintained. Besides these merits, there also exist some defects as follows.

1. The efficiency of manipulating single geographic entity is not so high. Since the topological data model faces up with the whole spatial area, and it emphasizes the joining correlations of the geometric elements. It does not pay enough attention to the complete and absolute geographic entity, so when any geographic entity is adding, deleting, and modifying, a series of files and relation datum will be broken, so it will make the management of programming more complicated and the executing efficiency will be reduced.

2. It is difficult to express complex geographic entities. A complete simple entity needs to be decomposed to a few geometric elements in topological data model because of the requirement of topological correlation organization. Complex geographic entities can be made up of many simple entities, and the nature is be decomposed usually. The integrity organization of topological data model determines that it is impossible to express efficiently the organic aggregation made up of many absolute entities.

3. It is difficult to realize quick query and complex spatial analysis. In topological data model, geographic entities are decomposed to geographic elements such as points, lines and surfaces. They are memorized at different files and different relation lists, so when we do operations about geographic entities, query and analyse, it will take up more CPU room, especially in complex spatial analysis to great areas.

4. Local renovation is difficult and the system is difficult to maintain. Since the data organization and storage of geographic fields regard basic geographic elements (points, lines and surfaces) as units, and the storages of complex topological relations in the systems are the basis of GIS, when part entities is changed, the topological relation of topological relation of whole layer has to be built up again. We have to spend more energy on maintaining and expanding the system, and it is easy for us to make mistakes.

3.3 Non-Topological Relation Model

The structure of non-topological data model is very simple, and the speed of graphic display is rapid. The coordinate data is corresponding to geometric objects (points, lines, surfaces, and so on), so it is convenient to edit datum, and other disposals are not needed, besides, the spatial relation of geometric objects can be worked out through mathematic methods such as 9-Intersection-Model). However, there are some defects in non-topological data model, for instance, the public borders are stored repeatedly, which will cause redundance. There are also some software that adopts data structure such as Mapinfor and Arcview.

4. THE SETUP OF NEW OBJECT-ORIENTED SPATIAL DATA MODEL

On the basis of object-oriented, we analysed the characteristics of topological data model and non-topological data model. On the grounds of them, we present a new type of spatial data model. It is set up on the basis of non-topological geometrical objects (points. lines, surfaces etc.), and transforms points and lines into nodes and arcs, which turn into two new geometrical object types, net and area. The net is made up of nodes, arcs and some relations of them; the area is made up of nodes, arcs, polygons and some topological relations of them. The basic thinking accords to the theory of spatial combination. Points of

geometric objects are regarded as nodes of vector structure, lines are regarded as arcs, and surfaces are regarded as the combination of arcs and nodes, which is managed by a geometric relation database. And topological relations of spatial relations are built up in another relation database.

When we only use geometric relations but not topological relations of graphics, such as the display of graphics, query and statistics, the files of geometric relation database are enough to build up graphics, and the query of point attributes can be finished under the help of geometric database. When spatial data organization and analysis are carried, the relevant points and lines are activated, so it can transfers geographic database to build topological relation to complete the mission. Every geometric database includes such fields as sings of classes, the coordinates of X and Y, basic geometric attributes of elements, geometric means included by elements and spatial relation of geometric objects. 9 topological relations are included in topological relation database. The basic topological relations are shown as figure 2.

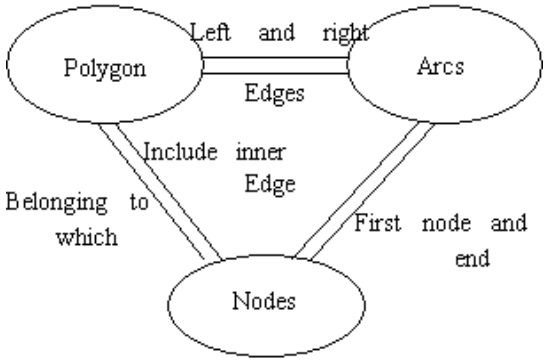

Figure 2. The basic relations of topological relation database

Though spatial analysis is carried, the new data model can do according topological relations in inner organization, but it is essentially different from topological data model. It can overcome the few defects of topological relation model, and has its own merits. (1) The room of storage is not big. The model is based on geometric objects, so it can only store geometric relations, but not topological relations, which will spare much room for storage. (2) It is easy to do such operations as query and spatial analysis. When geometric analysis is done, it can transfer geometric relation database directly. While spatial analysis is done, it can builds up topological database temporally. So it is easier to do these than traditional database. (3) It can be understood by users easily. The most important is that it make use of the thinking of object-oriented, so it accords to the thinking habits of humans, and more easier to be accepted.

The model has above merits, besides these, it also has some defects. (1) Topological relation needs to be built up temporally. (2) The common points and lines are stored repeatedly. The model regards geographic entities as primaries, so when an entity is stored, it does not depend on other objects, undoubtedly, it will cause the common points and lines to be stored again and again. (3) It is difficult to manage complex polygons and lines. To complex entities, it is difficult to build up topological relation. So it is difficult to manage them too.

5. SAMPLE ANALYSIS

Here, we give a sample to explain the applications of the new spatial object-oriented model as follows. The graphic is given as figure 3.

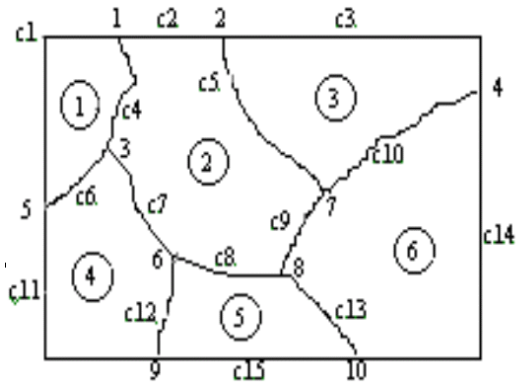

Figure 3. The graphic of sample

In the graphic 3, 1, 2, …10 represent points, c1, c2, …c15 represent lines, and ①, ②, … ⑥ represent polygons. The geometric relation is very clear. The topological relation is shown as table 1, 2, and 3. We can see the relations of nodes, arcs and polygons obviously, which is stored in the topological relation database.

Arc	The first node and end Node
C1	1, 5
C2	1, 2
…	…
C15	9, 10

Table 1. The relation of arc-nodes

Node	Arcs
1	c1, c2, c4
2	c2, c3, c5
…	…
10	c13, c14, c15

Table 2. The relation of node-arcs

Polygon	Arcs
①	c1, c4, c6, c1
②	c2, c5, c9, c8, c7, c4, c2
…	…
⑥	c14, c13, c9, c10, c14

Table 3. The relations of polygon and arcs

6. CONCLUSION

The new object-oriented spatial data model has many advantages that conventional models do not hold. Moreover, this prototype can be applied to other fields, which involve spatial database building. By altering the application models and by using other available datasets, this prototype can be applied to a wide range of disciplines, especially in all aspects of the GIS projects, and in the fields of object oriented applications. Moreover, this prototype can be applied to other fields, which involve spatial database building, etc.. Besides these, it also has some deficiencies that cannot be solved at present, and we will search for new methods in future work.

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