

Investigation on spatial relations between complex objects based on NIV

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Abstract: In this paper, the NIV model for describing spatial relations was introduced, and then based on it, the methods of describing the relations between complex objects were proposed. At last, one example was given to explain the formula.

1. Background

Spatial relations play a key role in GIS analysis, it is the basis of spatial analysis, spatial reasoning, spatial query and some spatial operations. So, the research on spatial relations is a hot point from 1984 until now. In the field of spatial relation research, the formal description of spatial relation is the core. Many scientists cost much energy on it. Before 1989, the point set theory is used in spatial relation description formally. Under this theory, object A and object B were considered as the set of point, the intersection of set A and Set B has two cases, empty and not empty, the relation between A and B also has two possible cases, disjoint and overlap. However, there exist many cases not to be distinguished, A include B, B include A, A touch B etc. In 1989, Egenhofer(1989) proposed the 4-intersection model on the basis of point set topology theory. The basic idea is that each object was divided into two components, one is boundary, another is interior. The intersections of object A's boundary, interior and object B's boundary, interior consists the 4-intersection model, each intersection has two possible cases, empty and not empty, the total are sixteen possible cases.

2. Shortage of 4-intersection and 9-intersection

4-intersection model can distinguish more spatial relations than ever, but some cases also can't be distinguished. In 1991 Egenhofer(1991) proposed the 9-intersection model, the basic idea is that it divides the object into three components, one is boundary, the second is interior and the third is complement. The intersection of object A's three components and object B's three components consist 9-intersection model. However, the sum of interior, boundary and complement equal to the whole space, so they have linearly correlation relation. In the view of theory, 9-intersection model can't distinguish more relations than 4-intersection.

For avoiding the above disadvantage, Li Chengming (1997) proposed the NIV model such as Formula 1, in this model the voronoi region of object replaces the complement of object. Each object can be divided into three components, boundary, interior and voronoi region. The intersection of object A's three components and object B's three components consist 9-intersection based on voronoi region model (NIV).

$$r(A, B) = \begin{bmatrix} \partial A \cap \partial B & \partial A \cap B^o & \partial A \cap B^v \\ A^o \cap \partial B & A^o \cap B^o & A^o \cap B^v \\ A^v \cap \partial B & A^v \cap B^o & A^v \cap B^v \end{bmatrix} \quad \text{formula 1}$$

3. The line of describing the spatial relations between complex object based on NIV

LI (1998) proposed the methods how to describe the spatial relation between simple objects, and the results are also given. But he didn't consider the complex object. In this paper the definition of complex objects were given at first, and then the complex object was divided into several simple object. For example, complex object A can be divided into simple object A1, A2, A3, complex object B can be divided into simple object B1, B2, B3, the relation between complex A and complex B can be given expression to formula 2.

$$r(A, B) = \begin{bmatrix} r(A1, B1) & r(A1, B2) & r(A1, B3) \\ r(A2, B1) & r(A2, B2) & r(A2, B3) \\ r(A3, B1) & r(A3, B2) & r(A3, B3) \end{bmatrix} \quad \text{formula 2}$$

In formula 1 the spatial relation of simple object A1 and simple object B1 can be got by using NIV in Li(1998).

For example, A is a complex object, including A1 and A2, B is also a complex object, including B1 and B2. The spatial relations between A and B were shown in figure 1.

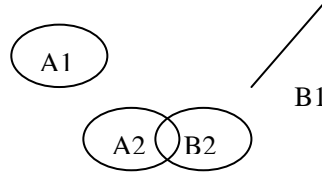


Figure 1 Complex object A and Complex Object B

And then the spatial relations can be expressed as follows:

$$r(A, B) = \begin{bmatrix} r(A1, B1) & r(A1, B2) \\ r(A2, B1) & r(A2, B2) \end{bmatrix} \quad \text{formula 3}$$

In formula 3,

$$r(A1, B1) = \begin{bmatrix} \emptyset & -\emptyset & -\emptyset \\ \emptyset & \emptyset & \emptyset \\ -\emptyset & \emptyset & -\emptyset \end{bmatrix} \quad r(A1, B2) = \begin{bmatrix} \emptyset & \emptyset & \emptyset \\ \emptyset & \emptyset & \emptyset \\ \emptyset & \emptyset & -\emptyset \end{bmatrix}$$

$$r(A2, B1) = \begin{bmatrix} \emptyset & -\emptyset & -\emptyset \\ \emptyset & \emptyset & \emptyset \\ -\emptyset & \emptyset & -\emptyset \end{bmatrix} \quad r(A2, B2) = \begin{bmatrix} -\emptyset & -\emptyset & -\emptyset \\ -\emptyset & -\emptyset & -\emptyset \\ -\emptyset & -\emptyset & -\emptyset \end{bmatrix}$$

4. Conclusion remarks

In this paper, three conclusions can be drawn, they are:

- (1) the precise definition of complex object was given, and the idea of dividing the complex object into simple object was also feasible;

- (2) using the spatial relations of several simple objects, which consist the complex object, to represent the complex object's spatial relations model, it can describe the spatial relations of complex objects wonderfully.
- (3) The example narrates the correctness of this method.