3D DIGITAL TOPOLOGICAL RELATIONSHIP ANALYSIS FOR SPATIAL ENTITY WITH FUZZY BOUDARY

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ABSTRACT

With continuous development of human cognition and behaviors, the human has gradually changed their attention on geo-objects from two-dimensional plane to three-dimensional space and from earth surface to underground space. As a result of human activities, entities on earth surface are usually artificial entities with regular structure, accurate position and unambiguous boundary, which can be properly represented with vector data structure. While the underground space is usually invisible and continuous; many kinds of entities that embodied in underground space are usually with fuzzy boundary and invade into each other. In this situation, the boundaries of underground Geo-entities can not be properly represented with geometric elements; especially the sequential relation between inner parts of an entity and relation between adjacent Geo-entities can not be indicated. The digital space based on raster tessellation is more suitable for the representation of the continuity and structured variability of underground space.

Topological spatial relationship, which denote the unchanged characteristics under the topological transform such as translation, rotation and scale, is one of the most foundational and important spatial relationships. Currently, the 9-Intersection Model (9-I Model) presented by Egenhofer is widely used in two dimensional space for both theoretical researches and practical applications in GIS. However, there are some imperfections in 9-I Model, such as the linear dependency between the three sets of an entity (interior, boundary and exterior), difficult definition for the exterior of an entity especially worse computability. The fast development of digital city, digital mine and digital geo-engineering in 3D spatial information organization, inquiry and visualization have facilitated the current development of 3D GIS. Anyway, a computable framework for the topological relations of 3D spatial entities is lacked, and it is impossible to quantitatively compute and analyze the topological spatial relations of complex entities in 3D digital space.

A new topological relationship representation model improved from 9-Intersection Model is presented and named as *k*-order six neighborhoods 9-Intersection model (*K*6N9-I Model). In this model, the original interior, boundary and exterior of 9-I Model are respectively replaced with I_6, B_6 and E_6^k. A computation method for topological relations query and analysis based on relation database query language SQL is presented, by which the count and the content of each element of the new model are computable. An experiment system based on *K*6N9-I model and the computation method was finished with VB. Six basic topological relations (disjoint, meet, intersect, overlay, contain, equal) could be computed in this system.

The experimental cases show that the *K*6N9-I Model is computable and with well utility. Further analysis on the experimental results indicated that: 1) the count of model element is not only the factor that can represent topological relations, while the content such as hexahedron distribution and its statistical characteristics of the model element can also do much favor for topological relationship analysis; 2) this model is not only effective for the query and analysis of topological relationship, but also promising for other spatial relationships of complex entities such as metric relation and

direction relation in 3D digital space.

Keywords: topological relationship; 3D spatial entity; fuzzy boundary, 9-Intersection model; k-order six neighborhoods

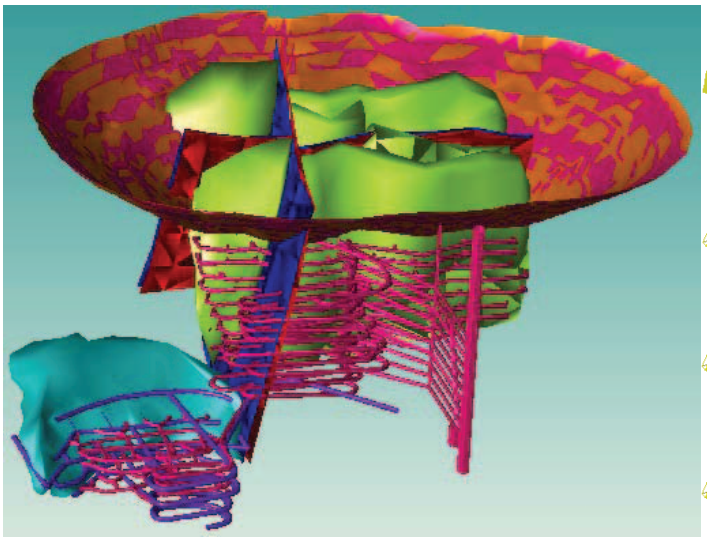

Fig.1 Underground spatial entities of a typical mine

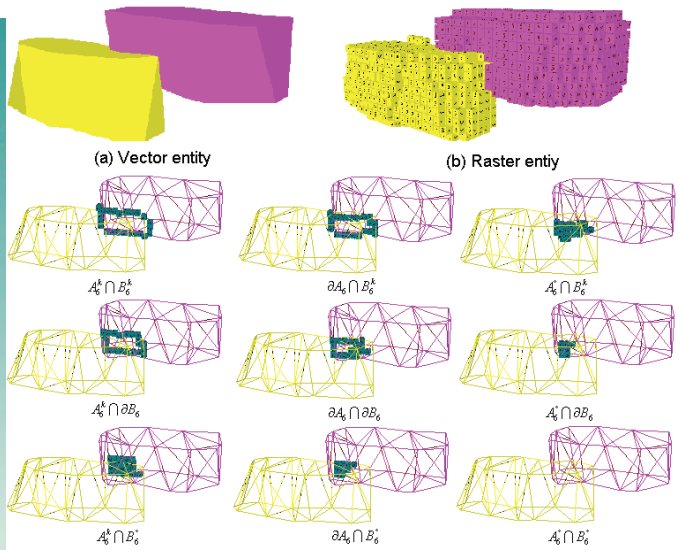

Fig.2 3D raster topology analysis based on *K*6N9-I model