3D SPATIAL MODELING FOR URBAN SURFACE AND SUBSURFACE SEAMLESS INTEGRATION

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Abstract: GeoSpace is a continuous 3D space. It is one of the important issues in GIS to represent geospace in 3D space. Current 3D GIS mainly researched on the spatial objects on and above surface in geospace. With the rapid development of computer science and spatial information technology, the spatial data that GIS managed are not only include the nature geographical data with reference of ground surface, but also its theory and application extend to above surface and subsurface. It is an important category in GIS to research on the expression and analysis of surface and subsurface integrated spatial data.

There are two problems in city spatial objects integration, first is the interface management between geographical spatial objects and terrain, second is the integration of geological objects and terrain. The first problem can be resolved by employing a constrained Delaunay triangulation, where the edges of the geographical objects, such as buildings, touch the terrain as constrained lines insert the terrain TIN. Both of the two objects can be integrated seamlessly and unified in topology. On the other hand, Integrated Ear Elimination (IEE) algorithm and Influence Domain Retriangulation for Virtual Point (IDRVP) algorithm are presented to resolve two key issues of point deletion and constrained line deletion in constrained Delaunay TIN. Compared to the point deletion in D-TIN, the deletion in CD-TIN is not only considering the visibility of constrained edge, but also resolving the intersection of constrained edges. The main idea of IEE algorithm is that the star-shaped polygon H neighbouring to the deleted point p is examined and retriangulated. IDRVP is able to resolve the problem of intersection of constrained edges. Firstly, delete the endpoint of edges by IEE, then the influence domain of virtual point is examined and retriangulated according to the constrained empty circle property, finally delete the virtual point. IEE and IDRVP were used for the integration of geographical objects and terrain that insert or delete geographical objects dynamically. Hierarchical Triangulated Irregular Networks (HTIN) can achieve the second problem on the integration geological objects and terrain. Firstly, GTP models the geological body according to the drill hole data. Using collar data, the dissertation constructed the original TIN, Collar TIN, on the top of geological body. On the basis of original TIN, the Terrain TIN is interpolated by the terrain sampling data. Directed Acyclic Graphs are used for representing the relation of Terrain TIN and Collar TIN, so as to spatial querying and analysis between geographical objects and geological objects is able to be realized. Collar TIN is replaced by Terrain TIN for 3D visualization and spatial calculation. Finally, geographical objects and geological objects are integrated with terrain.

The Generalized Tri-Prism (GTP) model, which is an universal form of Tri-Prism (TP), Pyramid and TEN, is used to construct 3D subsurface model. The constructing process includes two steps, the first is to generate the Delaunay TIN (D-TIN) of terrain according to borehole’s collar data, which is the foundation of constructing a 3D geological model; the second is to extend each triangle of the TINs along the borehole line. Two kinds of constructing algorithm for D-TIN, respectively be constraint D-TIN (CD-TIN) and no constraint D-TIN, are discussed. The Dynamic Including Triangle (DIT) method is introduced to solve the expansion of borehole collar point sets, and an improved repeating diagonal exchange algorithm for the compulsively inserting of constraint edge is applied to solve the characteristic line constraint of terrain. A 3D modeling inference rule is proposed to solve the automatic constructing problems of 3D geological model. In consideration of the strata code of borehole, this rule decides the mode of the extension of a triangle into a GTP by judging the number of triangle's vertex, which can solve the constructing problems of complex geological structure, such as bifurcation, pinch-out and fault.

At the end of the dissertation, using Visual C++ and OpenGL, an experiment system of 3D modeling is designed for city spatial objects integration based on the 3D Spatial data model of city surface and subsurface integration. In the system, the author makes use of some experiment data, such as drill hole data, building data, road data and terrain data, to integrate the surface and subsurface objects, and to test the model and algorithms correctness.

KEY WORDS: 3D spatial modeling; digital city; generalized tri-prism (GTP) model; city surface and subsurface space, seamless integration