ON THE GTP-BASED 3D MODELING METHOD FOR COMPLEX GEOLOGICAL BODY

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1. INTRODUCTION

In recent years, three-dimensional (3D) modelling of geological body is an important issue of 3D GIS and 3D geosciences modelling (3DGM), and one of the key technologies of digital mine. 3D geological modeling not only can precisely describe the 3D spatial information underground, but also provide a decision background for resource analysis, underground engineering planning, disaster prevention and mitigation. There are more than twenty models presented for 3D geosciences modeling during the past decade (Breunig et al., 1999; Wu et al. 2003, 2005), such as triangular irregular network (TIN), multi-DEM, TEN (Pilouk et al., 1994; Chen, 1995), 3D Voronoi (Courrioux, et al., 2001) tri-prism (Houlding, 1994; Dai and Zou, 2001; Gong and Cheng, 2004), generalized tri-prism (GTP) (Wu., 2004; Che et al 2006) and so on (Bian et al., 2000; Sun and Chen, 2000). We can find many deficiencies in some of above these models after comprehensive analysis them: 1) There are so many interactive operations in the modeling process, they are very fussy. 2) It is very difficult to add the geological knowledge inference rules in the course of constructing the geological models. These models have few necessary “knowledge inference rules”. 3) The faults’ influence isn’t considered in these models, it is a limit for these models to be applied widely. In this paper, based on the analysis of previous researches on 3DGM, we propose a new approach for 3D modeling and visualization of complex geological body based on generalized tri-prism (GTP) volume.

2. CHARACTERISTICS OF GTP MODEL

Data model is the bridge linking real world and computer world; it should reflect the real world naturally and be propitious to the comprehension of real world. Based on previous research achievements on GTP, the components of GTP are modified, and five primary components of GTP, which are respectively Node, Edge (up-edge, down-edge, side-edge, side-diagonal-edge), Up_Down_Triangle, Side_Triangle and GTP, are put forward to meet the demands of multi-scale modeling of complex geological body. The concept model, logical model and topology description of the amended model are given. According to the need of creating the complex geological body model, two important concepts such as rock pole body (RPB) and limiting triangle are defined. The GTP model was presented by Wu et al. (Wu, 2004) to solve the modeling problem of divergent of boreholes as well as the complexity of geological structures. GTP has six basic geometrical primitives: vertex, edge (TIN-edge, side-edge), triangle, spatial quadrangle and GTP. (a). According to the borehole data, GTP model can be degenerated into Pyramid or tetrahedron, as shown in Fig.1. (b), (c), which can be used to model the pinch-out, bifurcation, fault and other complex geological structures. According to analysing the relation between chronolith and rock attribute comprehensively, the concepts of 3D modelling logic scale, which is “the whole geological body, system, series, group and rock characteristics”, is put forward. Multi-scale 3D modelling of geological body based on GTP model is realized. It is the key of 3D modelling of geological body to creating the limiting triangles of the RPB. The limiting triangles act the part of “limiting” during multi-scale 3D modelling of geological body. For example, the GTP models, creating them based on the scale of series, cannot exceed the limiting of the previous scale of system. In order to add the knowledge of geologist and experts to the result of 3DGM, 3D spatial interactive technology (3DSIT) developed in this paper can be made full use of during the process of 3DGM.

3. CONSTRUCTION PROCESS OF 3D FAULTS MODEL BASED ON GTP VOLUME

Data of fault for modelling is difficult to be obtained, and the fault’s spatial geometrics are very complicated. The research on fault’s 3D simulation is in primary state. In consideration of the deficiency of the method of creating faults model and the feature of faults, the idea for creating 3D faults model is proposed, which is based on adding fault-scale to multi-scale of 3DGM. The faults are classified to simple faults and complicated according to the faults amount and their relations. The idea
of subdividing complicated fault into simple faults according to some rules is presented to create the entire simple faults model in the geological body. Process of simple faults modelling is put forward according to the features of simple faults, including pre-processing data of fault, taking simple faults as the scale to build limiting triangles of RPB, checking fault model and interactive edit. For creating the model of complicated faults, priority of 3D modelling of faults is established according to the precedence relationship of faults’ construction, and its dissected topography and limiting triangles of faults in RPB are built according to the priority. Complicated fault is subdivided into many simple faults according to previous limiting triangles, and all the faults could be modelled according to the method of simple faults modelling.

4. CONSTRUCTION PROCESS OF 3D FOLDS MODEL BASED ON GTP VOLUME

The fold has complex structures, diverse types and many kinds of combination patterns. So, it is one of the hot and difficult issues in the domain of 3DGM. In this paper, a new method of 3DGM for folds is proposed. The key of the modelling of geological body with fold is the construction of the limiting-triangle, which includes automatic and interactive construction of limiting-triangle. This method puts the detection of fold through the entire process of creating multi-scale geological modelling of geological body. Meanwhile, with the flexible 3D interactive technology developed in this paper, it is easy to construct and to edit GTP model interactively. Hence, the geological body with complicated fold can be accurately generated.

5. EXPERIMENTS

With all the researches above and based on PC-Windows development environment, object-oriented programming language Visual C++ 6.0 development, 3D graphics adapter OpenGL and SQL Server, the functions of multi-scale spatial modelling for complicated geological body are realized in GeoMo3D. The main modules of GeoMo3D system include: engineering document management, spatial data management, 3D spatial modelling, 3D visualization, and 3D spatial analysis, engineering design, professional application module adapter, and so on. With actual geological and relative engineering raw data from an iron mine, a 3D geological model is generated and the spatial operations including visualization, spatial analysis and engineering design are verified.

6. CONCLUSIONS

The GTP model is a powerful spatial data model for real-3D geosciences modeling and visualization. The 3D modeling method of faults and folds 3DMF, based on GTP volume can convert the complex faults and fold into simple form by constructing limit triangles. The difficulties of 3D modeling faults are some what overcome, and the description and modeling of 3D complicated faults and folds could be solved.

7. ACKNOWLEDGEMENT

This research is jointly supported by the National 863 High-Tech Program of China (ratified No. 2007AA06Z108, 2006AA122216), the Natural Science Fund of China for Distinguished Young Scholars (No. 50525414), the National Natural Science Foundation (No. 40571137).

8. REFERENCES