Study and Practice on New Generation Digital-City Oriented 3D Digital Map

Xiaozhao He, Qi Li, Jicheng Cheng
Institute of RS & GIS, Peking University, Beijing, 100871, P.R.China

Abstract: Most current 3D digital maps are 2.5 dimension models based on DEM, which can only be recognized, browsed and operated by a special software, far from meeting the needs of a modern digital city (global) with the distributed, isomerous and multiple application on the real 3D representation and open sharing models. In this paper, a new generation digital city oriented 3D digital map is studied. Firstly, a real 3D digital map representation is presented. And then, some key techniques and methods for browser-based 3D digital map's representation, display and operation are introduced, which can realized the open sharing of 3D map in distributed, isomerous and multiple application environment. Furthermore, the scale driving technique of proposed 3D digital map is also studied. And currently, some developments based on some of the above methods are being carried to provide key and general platform for other application software's development.

Keywords: Octree, Digital Map, Digital City, DEM

1. Introduction

Nowadays, GIS systems should not be self-governed any more. As a basic and key part of the digital city, new kinds of open and general GIS systems are needed. In order to achieve this aim, the new generation 3D digital map model should be researched and realized firstly.

3D digital map has been widely researched and developed in GIS field in recent years. 3D digital map can help us to construct the real geographic object by computer models more exactly. Based on 3D digital map models we can do all kinds of spatial operation, analysis and 3D display more conveniently than based on traditional 2D map.

The representation of the 3D digital map model is one of the most key problems in this field. Nowadays, one kind of presentation can only meet the needs of some special applications. That means in most cases, in 3D GIS systems, if we want to do different operations or get different results from the computer based geographic objects' models, we should construct and use different models. So, the present 3D GIS systems have very strong pertinence. There is no general 3D GIS system in the market till now.

But above all, we can also divide the methods of the representation of 3D digital map models into two kinds, one is based on Vector-Model[1][2], and the other is based on Raster-Model. At present, most of the Vector-Model based 3D digital map models are based on DEM. Thus, we just get a 2.5D model, can't get a real 3D model. This is proved to be very limited in applications. For example, DEM models only contain the 3D surface information for terrain and have null internal. Furthermore, most 3D GIS software providers use a special representation that can only be recognized by themselves. When someone else wants to use the models their models produces, he must use their software. And it is very difficult for all of these soft wares to interchange data.

In this paper, we propose a new kind of representation for 3D digital map models, based on which we can meet the needs of more applications than current presented models. Real 3D is also realized in this model. And everyone can display and operate the model through Browser. Furthermore, We discuss some key problems for the scale-driving technique by using this model.

2. Base Model Representation——Real 3D Model

For the weakness of 2.5D DEM models in applications, there are many works have been done in the field of real 3D representation, mainly refer to 3D spatial data structure. And till now, some effective methods have been proposed, and some excellent 3D GIS software have also been developed and put into the market successfully. (Such as the LYNX of Canada, IVM, GOCAD, SGM etc.)

Among all the proposed 3D GIS models representations, Raster/Vector hybrid methods represent the mainstream and have been proved to be the most effective[3][4][5]. The main idea of Raster/Vector hybrid method use octree structure as the whole framework of the model. But here, instead of regular raster points as in traditional Raster models, the tree nodes of the new proposed octree are 3D solid element represented by vector structure.

In this paper, we also use the octree/solid based Raster/Vector hybrid method to realize the real 3D representation of the complex geographic objects. And we also do some amelioration on those proposed methods. The main ideas of proposed method are as follows:

(1) Octree structure is used to control the whole structure of the model.

(2) The tree nodes of the octree are vector & surface-based solid model. Here we use B-Rep (Boundary Representation) to describe the surface based solid. In the B-Rep, geometric elements (solid, face/surface, loop, edge/curve, vertex), topologic relations and non-geometric data (attributes) are contained[6].

(3) A templates lib for B-Rep based surface solid is also provided. By using the template lib, all the tree nodes of the octree can be created by giving some

parameters which one templates needed to the template.

- The templates in the templates lib are only B-Rep based topology of some kind surface based solid and it is parameter driving.
- When detailed parameters (some are dimensions) are given to the template, one instance (a detailed solid) of the template is created automatically. We call this procedure as instantiation.
- In the templates lib, there exist two kinds of solid template, some belong to regular shape (mainly includes some kinds of polyhedron), and the others belong to irregular shape (here the surface of a solid consists of polygons and exact spine surfaces). For example, among the templates of regular shape, there have cuboid, regular tetrahedron, regular octahedron etc.

(4) By the help of parametric templates lib, we can realize adaptive property when we construct the whole octree model. For example, in some simple area of the geographic object, we can create and use regular surface solids as tree nodes, in some complicate area, we create and use irregular surface solids as tree nodes, further, the dimension of surface solids can be big or small according to the property of the given area.

It should be noted that the above octree/solid hybrid representation would be used as the base model, which is the basis of the 3D electronic map representation proposed in this paper.

3. Dynamic Self-Adapting of the Models

In the above part we introduce the representation of the base model, which is a real 3D spatial data structure. As we know, in a special application, we usually only care about some special property of a spatial model[7]. This is the reason why the current 3D GIS systems often use a kind model that can only meet the needs of some special applications. For example, some GIS software pay attention to the display and visual realization of 3D geographic objects, and some pay attention to the spatial analysis, and some others pay attention to spatial operation to spatial objects.

In this paper, we attempt to propose a 3D GIS model representation mechanism that can meet the needs of more applications (all applications theoretically). The main points of the proposed mechanism are as follows:

- A whole 3D GIS model consist of many view-models, each view-model (except for the base model) can fit the needs of a special application.
- A view-model in the whole model is generated dynamically when a special application applies for the system.
- Each view-model is generated by a corresponding Application Engine based on the base model. The Application Engines are also a part of the proposed 3D GIS model.

For example, when we want to display a 3D GIS model, an Application Engine will transfer the base model into a pure DEM model that only have the 3D surface data of the geographic object. And when we want to get some continuous properties of given area, a Application Engine will transfer the base model (Raster/Vector Hybrid Model) into a pure Raster model, here some division to should be done to all the octree tree nodes of the base model.

We call the procedure of using Application Engine to generate application oriented view-model as dynamic self-adaptive mechanism, which can be shown by the figure as below:

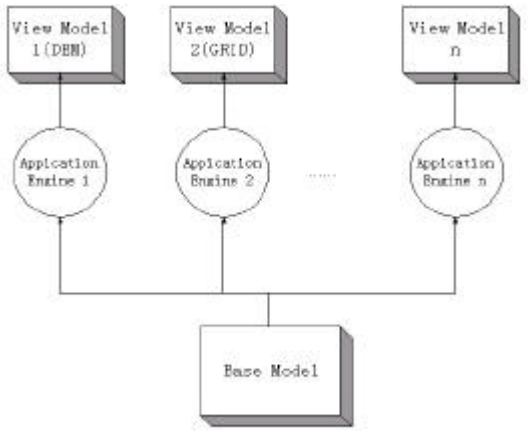

Figure 1 The Representation of the proposed 3D GIS model

Here we only present a mechanism which attempt to solve the problem of developing general GIS system which can meet the needs of all kinds of application. In practice, the situation is not so simple. Till now, based on proposed base-model of the paper, we can only design very limited kinds of Application Engines. So, the proposed mechanism is still immature and need to be improved greatly.

4. Browser-Based Representation and Operation

As introduced above, one important drawback of the current 3D digital map is that it can't be recognized and operated by others except for the system developer themselves. In this paper, we represent the proposed model as browser model, so every one can share the model in some degree through browser on World Wide Web.

Here, the VRML is used realize the display of 3D GIS model on Web. So, a VRML Generation Engine is designed and also embedded in the proposed 3D Model, it can transfer one View-Model (Such as a DEM sub-model) into a VRML file (.wrl file). all the clients on Internet can browse our model through a general browser with the VRML component.

As well as displaying, we also need to revise the model on Internet through browser. In order to achieve

this aim, a web-based model operation module should be designed and developed. Here, the JSP+Servlet mechanism of the J2EE architecture is adopted. By this module, the structure and the nodes of the octree of the base-model can be revised by browser on Internet.

The browser-based schema of the proposed 3D GIS model can be shown by the figure 2.

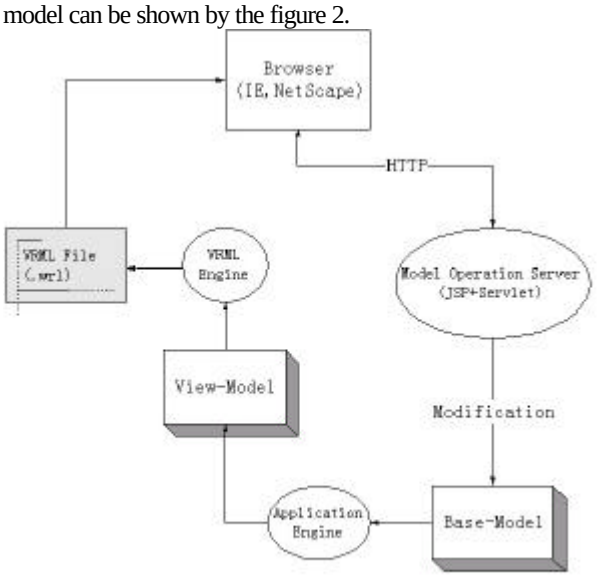

Figure 2 Browser-based Display and Operation Schema

5. Scale-Driving of 3D Models

The advanced spatial data model should meet the needs of different scales of a map. Traditional, we think it is possible to get a larger scale map from a smaller scale map, because the larger scale map must contains the information of a smaller scale required. But what can we do from smaller scale to larger scale? That means, we need to build a kind of model which can realize self-adaptive adjustment to scales. We call this kind of model as flexible model.

To build a flexible model, a spatial data model should be embedded with scale driving mechanism and algorithm, as well as contains all kinds of spatial data and topologic structure.

Some current 2D image zooming oriented algorithms, such as wavelet transformation, can only realize the scale driving of image data. But the proposed 3D GIS model contains not only 3D location and topologic information, but also all kinds of attached attributes and knowledge resources. So, the current algorithms can't meet the needs of scale driving of the proposed model in this paper.

New method should be researched and presented to make the proposed model into a flexible model which is self-adaptive to scales. In this paper, only some basic properties of the scale driving technique are proposed as above. The detailed implementation method also need further study.

6. Results

In order to meet the needs of digital city, a kind new 3D digital map model is researched and proposed in this paper. Firstly, octree/Solid hybrid representation is designed in the proposed model to realize real 3D representation, instead of 2.5D in most of the current 3D GIS systems. Secondly, with embedded application oriented engines, the proposed model becomes general model, that is to say, it is a dynamic self-adaptive model when used to different applications. Thirdly, a browser-based display and operation schema is designed to make the proposed model as a really open model which can be shared by all the clients through browser on Internet. Furthermore, the proposed model can also be developed into a scale adaptive flexible model. Finally, we get a real 3D, general (to applications), open and flexible (to scale) new generation 3D digital map model which can meet the needs of digital city. At present, developments based on some of the above methods and ideas are being carried to provide a key and general platform. The platform is planed to be made into some general development supporting package (such as .dll files). So in an application software' development, they can be used directly and conveniently.

References

[1] Molenaar M .A Topology for 3D Vector Data Maps .ITC Journal, 1993(1):25～33

[2] Chen Yunhao, Guo Dazhi. The study on 3D-GIS vector data structure. ACTA GEODAETICA et ACRTOGRAPHICA SINICA, Vol.28 No.1 1999

[3] Li Qingquan. 3D vector structure GIS topologic relation and dynamic construction. ACTA GEODAETICA et ACRTOGRAPHICA SINICA, Vol.26 No.3 1997:235～240

[4] Gong Jianya, Xia Zongguo. The 3D data structure integrating vector and raster features. Journal of Wuhan Sci & Tech University, Vol.22 No.1 1997:7～15

[5] L. Xiao, Y. Zhang J. Luo, C. Xie, D. Guo. A 3D GIS Four-level Vectorized Octree Structure Integrating Vector and Raster Features. http://www.gisforum.com/maindoc/simchin/gisforum/thesis

[6] Navazo, Ayala, and Brunet. A Geometric Modeller Based on the Exact Octree Representation of Polyhedra, Computer Graphics Forum, 5.1986: 91~104

[7] Li, Q., Li, D. Research on the Conceptual Frame of the Integration of 3D Spatial Data Model, ACTA GEODAETICA et CARTOGRAPHICA SINICA, Vol.27 No.4 1998: 325~330