THE INTEGRATED SPATIAL DATABASES OF GEOSTAR

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ABSTRACT
GeoStar is the registered trademark of GIS software made by WTUSM in China. By means of GeoStar, multi-scale images, DEMs, graphics and attributes integrated very large seamless databases can be created, and the multi-dimensional dynamic visualization and information extraction are also available. This paper introduces the fundamental characteristics of such huge integrated databases, for instance the data models, database structures and the spatial index strategies. At last, the typical applications of GeoStar for a few pilot projects like the Shanghai CyberCity and the Guangdong provincial spatial data infrastructure (SDI) are illustrated and several concluding remarks are stressed.

1 INTRODUCTION

At present, so many new concepts such as information super highway, GIS, virtual reality are mentioned and used very often in various cases. The occurrence of digital earth (DE) and CyberCity are just the necessity of the continuance development of modern information technology. From the meanings of the name digital earth, all the information related to the earth including natural phenomena and human beings society will be digital and can be spread and employed through information highway. Without doubt, the digital earth will deeply impact and even change the style of our work, learning, amusement, daily life, and so on. As the fundamental information carrier and geographic reference of digital earth, the geo-spatial data has received more and more attentions. The spatial data framework includes the most fundamental spatial data set, such as digital orthoimage, digital elevation model (DEM), and GIS framework vector data like water system, boundary, and placename, etc. This framework can provide not only the most significant and public data set for observing and researching the earth and geographic analysis, but also the basic geographic location reference for adding various information related to the spatial position. On the other hand, this framework data even possesses very wide potential applications, such as land usage dynamic monitoring, precision agriculture, disaster prevention and after disaster reconstruction, and so on.

The construction of spatial data framework at large scale like 1:10000 even for a province in China is also a very large project, which will take a long time and need great financial support. Of course, there also must be a very strong technical support for collecting and updating, management, analysis and visualization of various information with multiple resolutions from multiple sources. For building the national spatial data infrastructure (NSDI) at large scale, there are many critical problems have to be dealt with to promote the application of innovated GIS technology in DE, such as how to manage great capacity of image data, how to integrate multiscale and multitype databases and how to extract GIS objects from image based on databases driven, etc.

An initial solution for image, DEM and GIS integration is presented and implemented in GeoStar, a general purpose GIS software developed by WTUSM in mid China, which has been adopted widely in building national and provincial spatial data framework. After briefly introducing the organization of multitype data set, the integration method of databases, the databases driven GIS objects extracting, and 3D dynamic visualization will be discussed respectively.

2 THE INTEGRATED RASTER AND VECTOR DATABASES

Ortho-images will fully integrated in GIS. No Flexible, general purpose GIS can exist without the integration of ortho-images and other raster data. For small GIS projects it may be sufficient to store information as simple files, however when data volume becomes large and the number of data users becomes more than a few, the database management system becomes the most important component. For instance, the basic design of GeoStar is based on the Client/Server architecture and using large RDBS and OODBS to manage the raster and vector data such as graphic data, attribute data, image data and DEM at the same framework, which is a through and seamless integrated solution for GIS applications. The brief structure of database, which is really hybrid and integrated, as shown in Figure 1.

In order to provide more efficient data access or browse for a large area, the vector data is organized according to the classified spatial index based on an extended quadtree code stored as cluster related to the feature size. The raster data like image and DEM are organized in pyramid gridded manner. Specially we are also facing with the problem of multiscale databases within different coordinate systems and different map projections in China, the more sophisticated

databases integration method therefore has to be developed to deal with the so called "crossing the projection zone" problem.
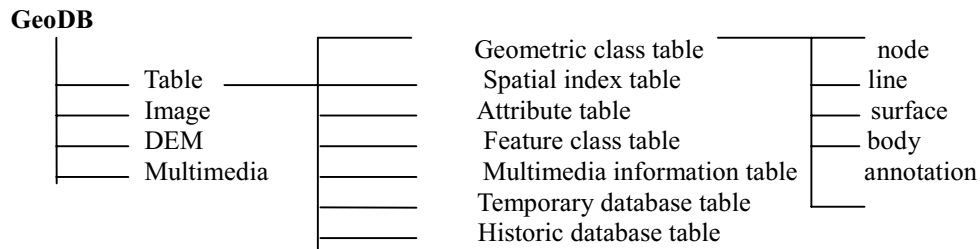
GeoDB

Table — Geometric class table — node
Image — Spatial index table — line
DEM — Attribute table — surface
Multimedia — Feature class table — body
Multimedia information table — annotation
Temporary database table
Historic database table

Figure 1.   The brief structure of Geostar databases

Level 3

Level 2

Level 1

Organize

Level 0
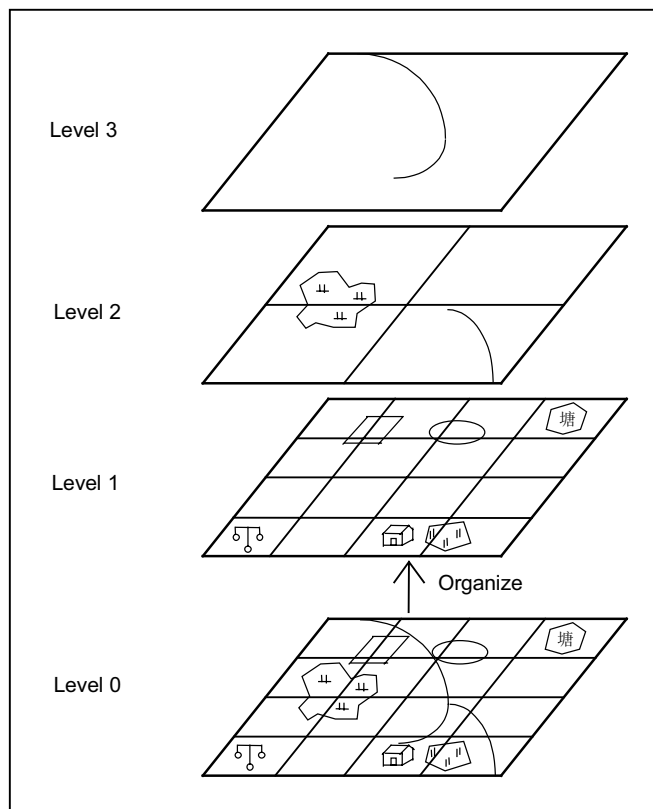
Figure 2. The hierarchy structure of vector data

coarse

fine

The highest layer: satellite image or automatically extracted from the lower layer

The mid layers

The lowest layer: aerial or satellite image
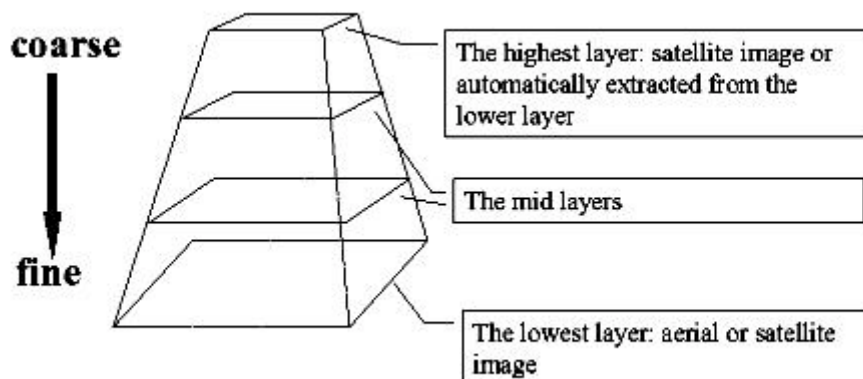
Figure 3. The pyramid structure of raster data

3 DATABASES DRIVEN GIS OBJECTS EXTRACTING

As general purpose GIS, there are five processes or tasks to be performed essentially. That is input, manipulation, management, query and analysis, and visualization. Once the spatial data framework is created, the new GIS object we need can be extracted from the image, and based on the integrated databases, image processing such as automatic change detection can also be promoted. For this purpose GeoStar provides an optional components offering the necessary functionality for the display and processing of integrated ortho-images, like enhancing, filtering, fusion, classification, and raster-to-vector conversion. Especially, for assisting the image understanding various useful knowledge, for example, the terrain relief factors, geographic spatial relationship, and trend analysis results, can be mined from the integrated databases.

4 3D DYNAMIC VISUALIZATION

As the DE has revealed, it will face various kinds of users, including small kids or handicapped persons, how to provide the flexible and convenient user interaction capability and realistic visualization becomes one of most challenging tasks of GIS. Three dimensional visualization even virtual reality of digital earth will no longer be looked upon as simple act of information presentation but rather as a bi-directional process that takes into account interaction with users. The GeoStar's visualization system can deal with data in the most general sense as any digital encoding of representations of things, measurements, concepts, and relations, that may be real or imagined. In the past, spatial analysis was performed using visualizations of spatial relationships on paper, from this sense, 3D visualization must be an integral part of spatial analysis. For this purpose, GeoStar provides an appropriate form of information visualization and suitable interactive mechanism, it's designed to be a real-time application, the technique named multi-grid method for accessing the data involved in a certain interesting area from integrated databases is developed. For a large area, the image and DEM data will be automatically generalized to a lower resolution or directly extracted from the corresponding pyramid layers. All the queried features can be displayed in a perspective view along with the image, and during a fly-through, users can point at a feature and obtain its attributes. Specially a model creator is also available to reconstruct the 3D model of buildings just based on the 2D GIS or 3D photogrammetric observations, DEM and image data, which can be collected from DPW like JX-4A made in China, this has been employed successfully in several Cybercity pilot projects for Shanghai, Shenzhen, and Guangzhou, as illustrated in Figure 4. Of course, it's difficult to avoid the edit and correction of geometric and texture data, so GeoStar also provides a flexible modeling and edit platform, including various operations such as remove, add, modification, and so on.
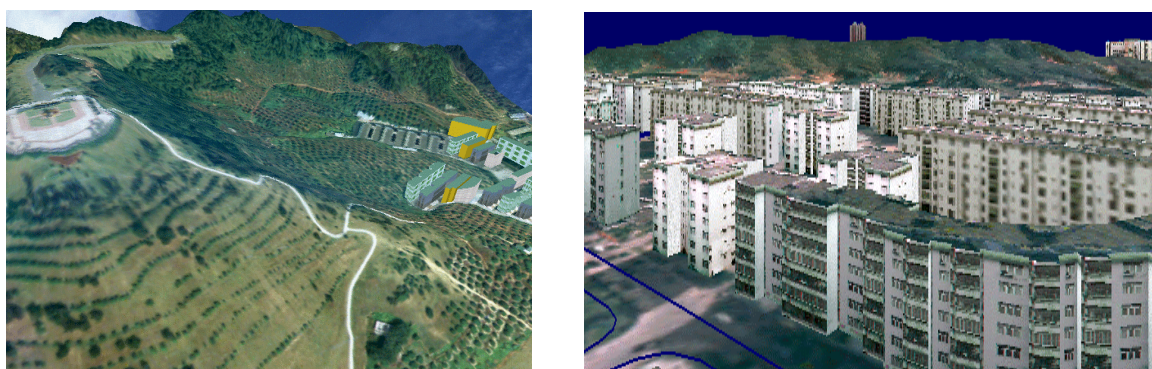

Figure 4. Virtual landscape and cityscape based on the integrated databases

However, in order to create a realistic CyberCity, both the geometric shape of buildings' surface in detail and the real texture characteristics have to be described, this results in the complexities and difficulties of data collection and the data processing. For instance, there are usually more than 50 small surfaces for a very general building , as shown in Figure 5. The workload and the data volume just depend on the strategies of detail accept or reject and the data organization. If the texture images have been pre-processed according to its sizes and types, the efficiency of visualization would be improved.
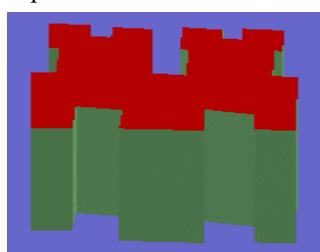
(a) 3D geometric model   (b) 3D building model after texture mapping
Figure 5. There are dozens of small surfaces with different textures used to describe a building

For a large area, it is required to browse the general landscape and to look at the local part in detail, especially during the walk-through or fly-through, the view field is frequently changed, the difficulty is how to clip or to select properly the objects in or out the field in order to make the scenery to be more real. Because even some high and large buildings are located at out the field, but they still can be seen. Such kind of clipping and selection also depend on the method of data organization and spatial index.

5 CONCLUSIONS

CyberCity and Digital Earth require more powerful integration of quite different spatial databases, such kind of integration not only includes the flexible and effective data organization , but also includes the easy interoperabilities between different databases. Especially, since the three dimensional spatial data volume is still very huge even for a small city, the LOD control for data retrieving becomes more significant, or else it is too hard to ensure the real time application of 3D fly-through or walk-through animation satisfy our requirements. For this purpose, GeoStar just provides an initial solution.

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