
GeoStar—a China Made GIS Software for Digital Earth

Deren Li Jianya Gong Qing Zhu Xinyan Zhu

*Wuhan Technical University of Surveying and Mapping
Luoyu Road 129, Wuhan, P.R. China, 430079*

Abstract After giving the definition of digital earth (DE), the requirement of DE to GIS software is discussed. As an initial solution for this purpose, GeoStar software made in China is presented. By means of GeoStar, multi-scale images, graphics and DEMs integrated very large seamless database can be created, and the 3D visualization with multi-resolution is also available. At last, the applications of GeoStar for a few pilot projects of SDI in China are illustrated and several concluding remarks are stressed.

Key Words Digital Earth, SDI, GIS Software, GeoStar

1. What is Digital Earth

Despite the global nature of the information revolution, most policies for information infrastructure as well as telecommunications infrastructure are developed at the national level. These national policies reflect local economic, social, historical, and political circumstances. By 1993, US Vice President Al Gore was promoting concept of an "information superhighway" and advancing the idea that an advanced communications and information infrastructure should be a national priority. National Information Infrastructure (NII) Initiatives includes a dozen case studies analyzing how national-level policy initiatives address the challenge of information technology, interactive content, and new applications, as well as the "information superhighway."

The world's economic, social and environmental wellbeing is heavily dependent upon the use of land and water resources, for example, mining, farming, forestry, transport, tourism, coastal zone management and the planning of services for the community. On the other words, more than 80 percent of the affairs we concerned in the world are related to the spatial distribution. Spatial data is defined as those data describing phenomena directly or indirectly associated with a location and time relative to the surface of the Earth. The Spatial Data Infrastructure (SDI) is critical to the attainment of sustainable development in both the developed and developing countries of the world. SDI encompasses the policies, technologies, standards and human resources necessary for the effective collection, management, access, delivery and utilization of spatial data. National and regional and protecting, land use planning, education and sustainable development, and so on. By means of DE, it is easy to get in control of basic necessities of life, and it is also possible to understand the complicated problems like the global change

SDIs and the global SDI will provide improved access to geographic information at local and national levels through the development of an online directory and distributed clearinghouse, consist standards and policies for sharing and using data.

The Digital Earth is a virtual representation of our planet that enables a person to explore and interact with the vast amounts of natural and cultural information gathered about the Earth (Gore 1998). The Digital Earth is seen as a multi-resolution, three-dimensional representation of the planet, in which we can embed vast quantities of geo-referenced data. There is understandably no clear agreement on what is DE, the authors suggest the following definitions:

"The Digital Earth is based on the computer technology, multimedia technology, mass storage technology, and broadband network, making use of great capacity of digital global information to describe the Earth with multi-resolution, multi-scale, multi-temporal-spatio and multi-dimension, which can be used as the tool for supporting and improving human being's activities and life."

It's obvious, the SDI is the mathematic base and spatial information framework of DE. In recent years, the proposed development of national and provincial SDI has received considerable attention in many countries including China.

Since the US Vice president Gore promoted the concept of DE in 1998, it is considered as the footstone of knowledge economy, more and more developed or developing countries are increasingly being urged to realize national or regional projects. Undoubtedly DE will play significant roles in very broad fields, such as agriculture, resource exploring comprehensively. The Digital Earth project could allow us to respond to manmade or natural disasters -or to collaborate on the long-term environmental challenges we face. The potential applications of DE that will be possible with broad,

easy to use access to global geospatial information will be, in the words of Vice-President Gore, limited only by the imagination

2 The GIS Software Technologies Needed for Digital Earth

Anne Branscombe introduced the term "information infrastructure" to refer collectively to the various media, carriers and even physical infrastructure used for information delivery. Neil Anderson extended the definition by suggesting that information infrastructure should possess the following three important characteristics:

- (1) the contents (data), conduit (telecommunications network) and flow-control procedures should be standardized;
- (2) the major sources and users must be networked together; and
- (3) the network must be customised for easy third-party access.

For SDI, at least five important aspects have to be concerned:

1. Increasing prominence of spatial data handling (collection, management, analysis and representation)

2. Robust, easy-to-use and relatively inexpensive tools, like GIS software
Ubiquitous data (spatial data, databases and metadata)

3. Ubiquitous communications (data networks)
Greater availability of experienced people
Clearly, a GIS software suitably used for SDI or DE has to satisfy at least the following requirements:

2.1. Image, graphics and DEM integrated very large database

As US vice president Gore mentioned, in the first stage, we should focus on integrating the data from multiple sources that we already have, such as satellite imagery. Moreover, the Digital Earth will require storing quadrillions of bytes of information, NASA's Mission to Planet Earth program will generate a terrabyte of information each day. Various images at multi-scale are the fundamental parts of SDI, and from image most of the GIS objects with good currentness we need can be extracted very quickly and accurately. DEM is the most existent information carrier of geospatial data, and based upon it the virtual-reality landscape of the Earth can be reconstructed. Many classes of graphics data as GIS objects (like borders, police resources) in vector form are also the significant contents of DE, by means of this kind of data we can do multifarious spatial analysis supporting decision-making. As the basic tool of DE, GIS softwares then have to possess the abilities of

managing such kind of integrated huge seamless databases.

2.2. Object Oriented

The DE can be understood as a dataset of Earth based objects and their relations in digital form, a object oriented GIS will be easy to follow this nature and helpful in data enquiry, data mining, spatial analysis for DE users.

2.3. Dynamic, multidimensional and real 3D visualization

The Digital Earth would be composed of both the "user interface" - a browsable, 3D version of the planet available at various levels of resolution, a rapidly growing universe of networked geospatial information, and the mechanisms for integrating and displaying information from multiple sources. For example, the future warfare will be "multi-dimensional", requiring the integration of information to support land, air, sea and even space-based operations in the process.

2.4. Multiscale representation

For military purpose, the collection and/or integration of spatial data at a wide variety of scales are very fundamental. Today, the application of information technology to weapons has involved "gathering huge amounts of data; processing them so that relevant information is displayed on a screen; and then destroying targets, at much greater distance and with much greater accuracy than was previously possible."

2.5. Data fusion and information fusion

High level of data fusion technology has played very important roles in utilization and development of increasingly complicated data like multi-source image. For instance, this revolution in military affairs revolves around advances in three types of systems: intelligence gathering – through sensors in satellites, aircraft, unmanned aircraft; intelligence processing – advanced C4 systems (for command, control, communication and computing) make sense of the data, display it on screen and assign weapons to **particular targets**; response – acting on all this intelligence (e.g. by using long-range precision strikes to destroy **targets**) .

2.6. Data mining and knowledge discovering from spatial DB

A Digital Earth could provide a mechanism for users to navigate and search for geospatial information. Especially, the automatic interpretation of image and the extraction of semantic and non-semantic information from images need the intelligent decision-making support of GIS. Fortunately most

of the knowledge needed for expert system (ES) just exists in GIS database implicitly, and which provide a mutual facilitative and interactional integrated environment for ES's development and applications.

3 GeoStar : a GIS Software for DE

GeoStar is a GIS software which is developed by Wuhan Technical University of Surveying and Mapping (WTUSM) in China since 1992. The object-oriented technology has been used in the design and development of the software. The major characteristic of GeoStar is that various kinds of tasks can be performed and various kinds of spatial data including image, DEM, graph and attribute data can be managed under an integrated network environment.

3.1. Architecture of GeoStar

GeoStar is designed as an enterprise GIS software, which contains almost all of GIS functions. It is an integrated software architecture (Figure 1). Its modules include Spatial data management, Spatial data exchange, Map scanning vectorizing, Digital photogrammetry, Remote sensing image processing, DEM and application, Mapping, Spatial query, Spatial analysis and Internet GIS. The core module of GeoStar is the platform of spatial data management, which is responsible for receiving, processing, querying, indexing, and transferring spatial data. A set of API functions have been extracted. This set of common functions has been used by high level system for data collection, spatial query, spatial analysis and other applications. A common spatial database can be shared by all modules.

3.2. Characteristics

The major characteristic of GeoStar is that it can

integrate vector data, attribute data, image data and DEM. The integration is used mainly for professional large spatial database. Vector data, attribute data, image data and DEM can be stored into different database respectively and can be managed in distribution. Through the integrated interfaces, the four kinds of data can be manipulated in cooperation, such as zooming in and out in any size, seamless roaming, and performing spatial queries. Geostar is certainly a vigorous pioneer of large domestic GIS software, and it has shown that China own large domestic GIS software in China to manage spatial data based on from national to city levels.

An object-oriented integrated spatial data model is used in GeoStar. The data model and architecture of GeoStar are illustrated in Figure 2 and Figure 3. There are four geometric classes in figure 2, which are of the types POINT, LINE, SURFACE and ANNOTATION. The POINT includes single point and group points, the LINE includes ARC and routine and the SURFACE includes single polygon and region. The feature class is defined according its attribute characteristics. An object belongs a feature class and each feature class is declared as belonging to a superclass of four geometry classes, which are distinguished according to representation but not phenomenon. A theme layer consists of feature classes and all features in a workspace range compose a partition. The image data set and DEM data set are as layers. A project is an integrated spatial database, which can include many partitions, several graph layers, image layer and DEM layer. Based on the object-oriented integrated spatial data model, an integrated spatial database management system has been designed and implemented in GeoStar.

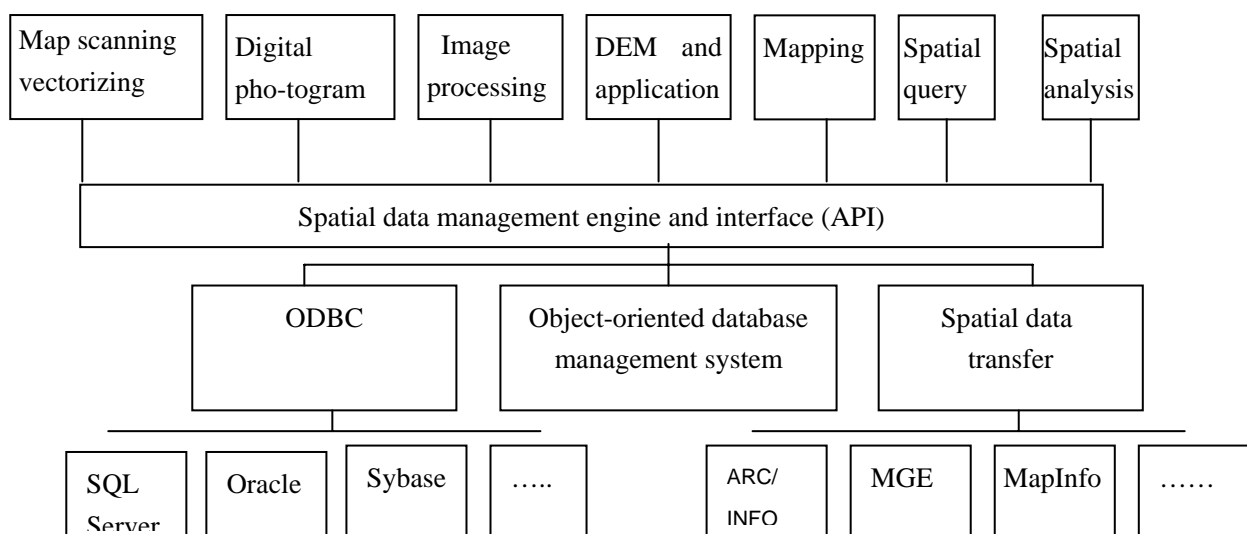


Figure 1 The Architecture of GeoStar

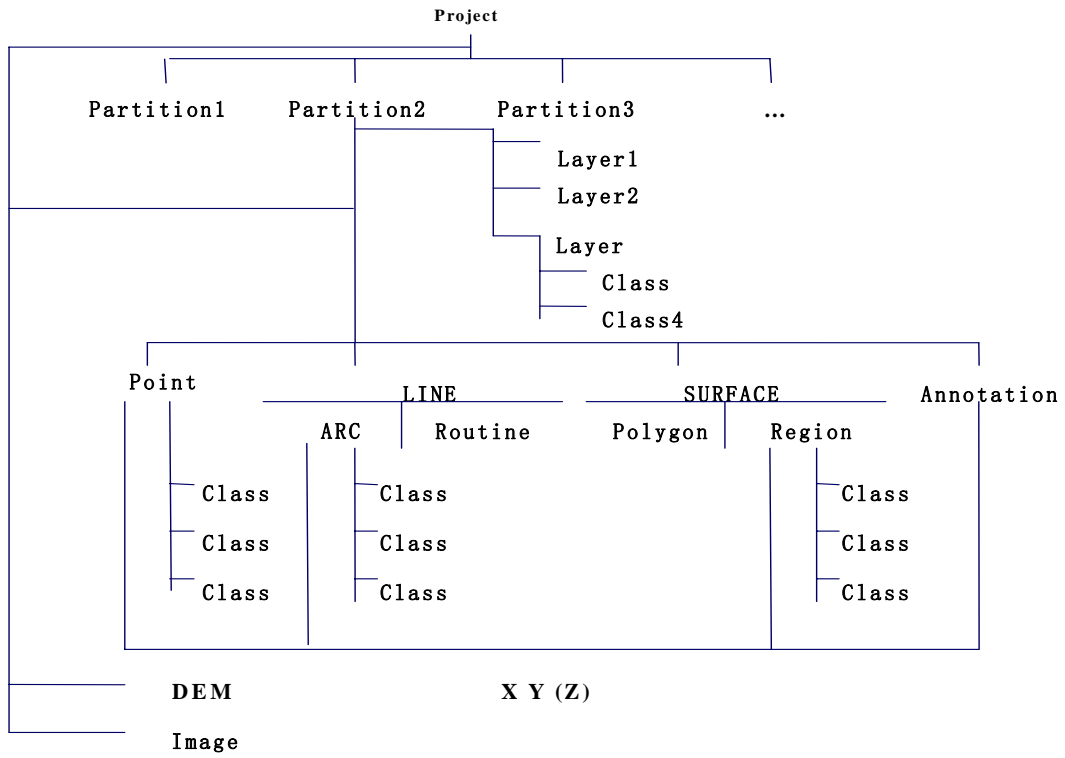


Figure 2 The spatial data model of GeoStar

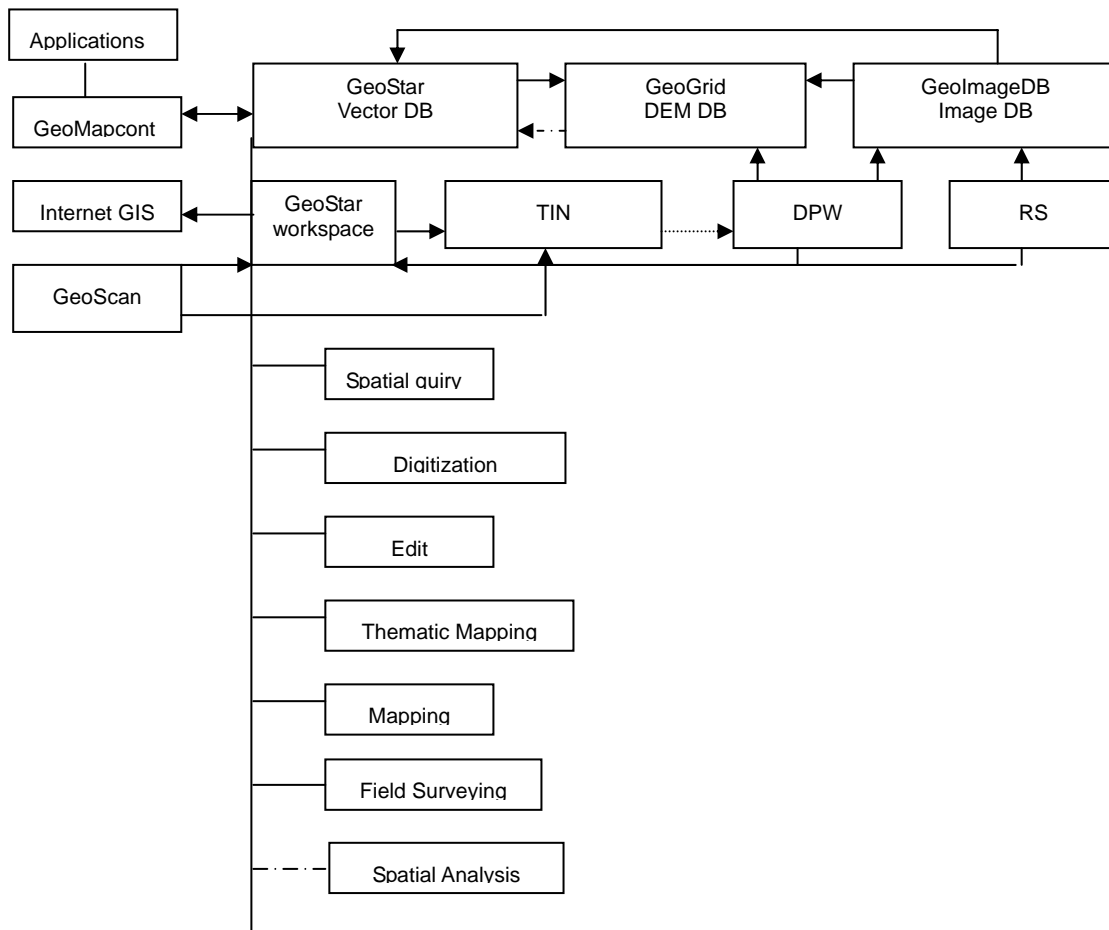


Figure 3 The relationships of each module in GeoStar

The concept of SDI development was being proposed in support of accelerating geographic information exchange standards efforts, selected national mapping programs and the establishment of nation-wide spatial information networks. For instance, GeoStar has been successfully employed to establish the provincial SDI of Guangdong province of South China. This pilot project consists of more than 80 gigabytes image data, graphic data and DEMs at scales from 1:10,000 through 1:250,000. The integrated hybrid databases can be browsed seamlessly, and by means of which the land use dynamic monitoring and precision agriculture can be supported. GeoStar is also used to create the Cybercity of Shanghai in East China and Shenzhen of South China, the Cybercities have played important roles in municipal facility management and urban planning. The Figure 4 and Figure 5 illustrate the applications of GeoStar in these projects.

4 Conclusion

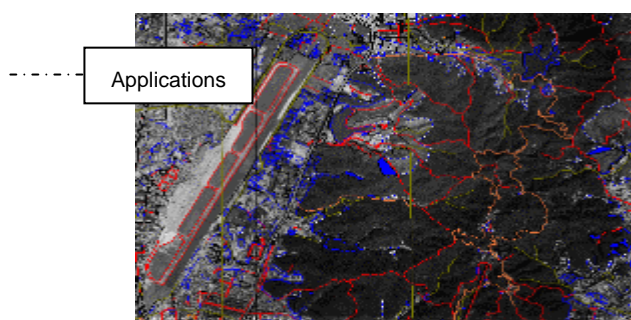
From above discussion, the following concluding

remarks can be obtained:

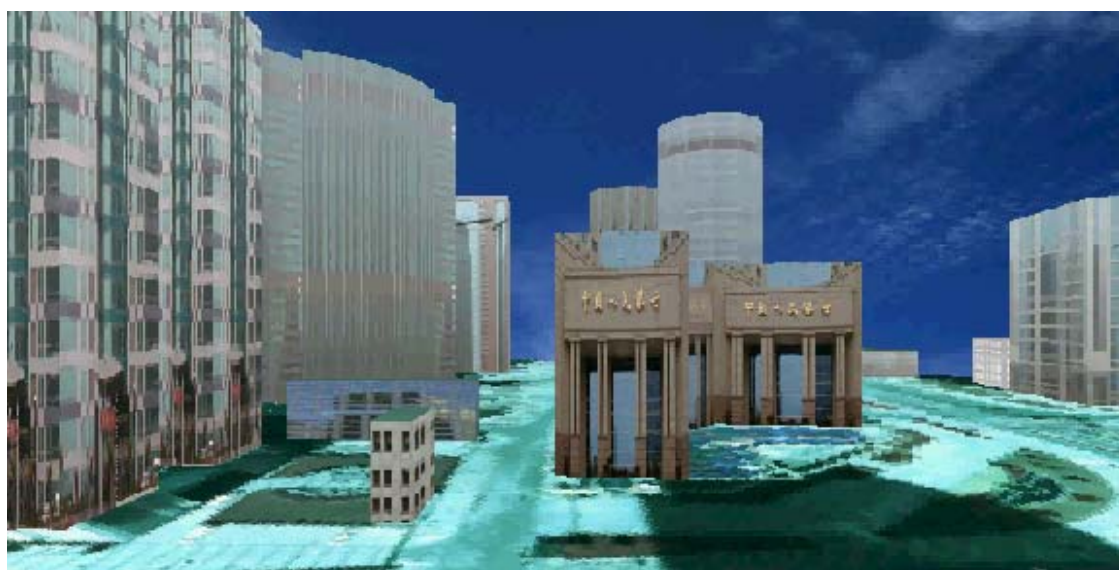
For creating digital earth and NSDI, the integration of multiple different huge databases and its visualization are very important. In this paper, an initial solution for image, DEM and GIS integration is presented and implemented in GeoStar, which has been adopted in the pilot project of building provincial spatial data framework and also has been used to build a few cybercity systems like Guangzhou, Shanghai and Shenzheng.

It's obvious that the direction of GIS software research, development and applications is just to meet the requirements of DE, on the other words, GIS would become multi-scale, multi-resolution, multi-resource, multi-temporal, multi-media, and multi-dimensional dynamic, which should be created, maintained and used by all kind of users in a powerful network.

Based on the concept of DE, the R&D of GIS software has been undoubtedly improved to a new higher stage, and facing a new chance and challenge.



Figuer4 Integrated database of image, DEM and graphics



Figuer 5 a snapshot of walk-through Cybercity**References**

- David J. Coleman and Dr. John McLaughlin 1997, Defining Global Geospatial Data Infrastructure (Ggdi): Components, Stakeholders And Interfaces.
- Deren li, et al, 1999, 3D City Landscape Visualization Based on Integrated Databases
- Deren Li and Qingquan Li, 1999, Geomatics And Digital Earth
- Gore A. 1998, The Digital Earth: Understanding Our Planet in the 21st Century available at <http://www.digitalearth.gov/speech.html>