Geoscience Information Integration and Visualization Research of Shandong Province, China Based on ArcGIS Engine

Mingzhu Xu[*a], Zhiqiang Gao[b,c], Jicai Ning[b]

[a]Institute of Geographical Sciences and Natural Resources Research, Chinese Academy of Sciences, Beijing, 100101, China

[b]Yantai Institute of Coastal Zone Research,Chinese Academy of Sciences, Yantai, 264003, China

[c]USDA UV-B Monitoring and Research Program and Center of Remote Sensing and Modeling for Agricultural Sustainability, Natural Resource Ecology Laboratory, Colorado State University, Fort Collins, CO, USA

ABSTRACT

To improve the access efficiency of geoscience data, efficient data model and storage solutions should be used. Geoscience data is usually classified by format or coordinate system in existing storage solutions. When data is large, it is not conducive to search the geographic features. In this study, a geographical information integration system of Shandong province, China was developed based on the technology of ArcGIS Engine, .NET, and SQL Server. It uses Geodatabase spatial data model and ArcSDE to organize and store spatial and attribute data and establishes geoscience database of Shangdong. Seven function modules were designed: map browse, database and subject management, layer control, map query, spatial analysis and map symbolization. The system's characteristics of can be browsed and managed by geoscience subjects make the system convenient for geographic researchers and decision-making departments to use the data.

Keywords: GIS, geoscience data, geodatabase, ArcGIS Engine, data management system.

1. INTRODUCTION

Digitization of map information and satellite technology bring large volumes of geoscience data, including current and historical data of geographic base maps, land use maps, meteorology, hydrology, vegetation and soil maps. The data is essential for geoscience research and other related discipline research (Lin 2008). To get integrated and overall information of an area, there should be a data management system to integrate all the geoscience data and manage them efficiently.

As geoscience data has the characteristics of broad spatial distribution, long time series, rich data quantity, and data content and data format diversity, there are difficulties to manage, query and use geoscience data (Dong 2000). Geographic Information System (GIS), a computer system designed to capture, store, manipulate, analyze, manage, and present all types of geographical data (Wang 1997), is the right way to achieve efficient spatial data management and analysis. GIS has been used in various industries, including natural disaster reduction, hydrology management, transportation, land resource management and estate management (He et al. 2003; Huo and Hu 2002; LI 2009; Teng et al. 2007; Wei and Yu 1997; Zhen and Meng 2009). To manage spatial data, Geographic Information System (GIS) created many kind of spatial data models (Hu et al. 2002), among which the object-oriented data model geodatabase created by ESRI (Zeiler 1999) is one of the most frequently-used model. Geodatabase store spatial data and its attributive data in a relational database management system (RDBMS) to implement integration management. And multiuser geodatabases leverage ArcSDE technology to get quick access to the data stored in RDBMS and to provide data support for front-end GIS applications (West 2001; Xiong and Yang 2004). But geodatabase classifies spatial data into vector, raster, TIN

[*] Corresponding author. Email: xumzhu@gmail.com

Remote Sensing and Modeling of Ecosystems for Sustainability XI, edited by Wei Gao, Ni-Bin Chang, Jinnian Wang, Proc. of SPIE Vol. 9221, 92210P
© 2014 SPIE · CCC code: 0277-786X/14/$18 · doi: 10.1117/12.2058426

which is unsuitable for data browsing. Because data types are not what users concerned. In data management system it is better to classify geoscience data according to its subjects.

In this study an integrated geoscience information management system (IGIMS) based on Shangdong province, China is introduced. The system is implemented by ArcGIS Engine, the collection of GIS components and developer resources. IGIMS manages different kinds of geographic features in history and the current years according to features' subjects. And functions like map query, spatial analysis, map symbolization have been implemented. It will be a strong support for local geographical research.

2. DATA AND DATABASE DESIGN

2.1 Geoscience data

Geoscience subjects in IGIMS include administrative division, transportation, settlements, topography, physiognomy, soil, vegetation, land use, climate, environment assessment and satellite images. In time dimension they include historical data and current data. In spatial dimension they cover not only Shandong province, but also some detailed spatial information in focus area of Shandong province. Original data should be preprocessed in advance, including data inspection, image registration and projected coordinate systems unification.

2.2 Database design

Table 1: Concept design of database

Feature subjects	Entity objects name	Essential attributes	Data expression
Administrative division	Prefecture-level city boundary	name	region
	County boundary	name	region
Roads	Highway	name, code	line
	Subway	name, code	line
Settlements	Prefecture-level cities	name	point
	Counties	name, city	point
Hydrology	Lakes	name	region
	First-level river	name	line
	Second-level river	name	line
	Third-level river	name	line
Topography	Elevation	elevation	contour line, raster
Physiognomy	Physiognomy classification	code	region
Climate	Average temperature	temperature	raster
	Moist index	index	raster
	Drought index	index	raster
	Accumulative temperature(10 degree)	temperature	raster
	Accumulative temperature(0 degree)	temperature	raster
Soil	Soil classification	code	region
Vegetation	Vegetation classification	code	region
Environment	Environmental assessment	class	raster
	Soil erosion	class	raster
Land use	Land use structure	code	region, raster

A good database should store geographical data efficiently, and ensure data sharing as well as data safety. Database design includes concept design, logical design and physical design(Sanjay 2004). In concept design, as described in table 1, geoscience features are entities (column 2) and there are no relations between these entities. In this study, geoscience features are further classified by geoscience subjects (column 1). And every entity is expressed as point, line, region or raster (column 4). Database logical design is to convert entities' concept model into geodatabase data model. Geodatabase model stores vector data structure in a feature class or a feature dataset and stores raster data structure in a raster dataset or a raster category(Zhang and Shang 2005). Then we use ArcCatelog software to store the data as designed, and physical design has already implemented by the software.

3. SYSTEM DESIGN AND DEVELOPMENT

3.1 Identified System Requirements

IGIMS is oriented to make services for professional geoscience researchers and government policy-makers. They need to analyze an area from different environmental and resource sides like soil, meteorology, vegetation and land use, integrate multi-disciplines, and make temporal and spatial comparison. Thus IGIMS should: (1) have comprehensive geoscience information; (2) the information is classified by feature subjects; (3) have functions of managing database and subjects, browsing maps and attributes, spatial querying, spatial analyzing and map symbolization.

3.2 System Architecture

IGIMS is based on a C/S structure and adopts a three-tier deployment architecture: data layer, middle layer and application layer, as described in figure 1. Data layer is based on relational database management system (RDBMS). Spatial data is stored in the form of Geodatabase data table. And SQL server stores the data entities and manages them. Middle layer refers to the spatial data engine ArcSDE. ArcSDE connects application layer and data layer. It facilitates storing and managing spatial data in a DBMS and makes the data available to applications. Application layer refers to the clients.

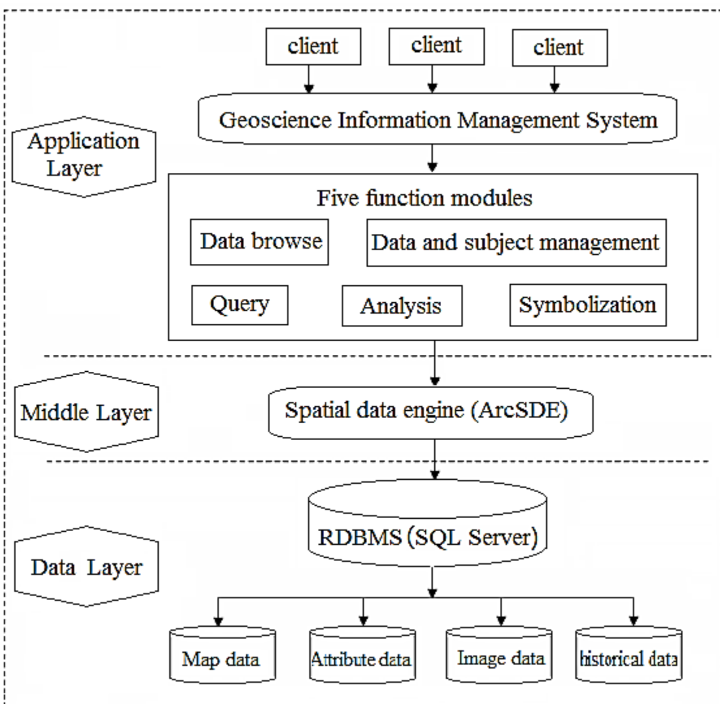

Figure 1. The framework architecture of the system

3.3 Functional Design and Development

Based on the results of requirement analysis, seven system functions has been designed:

(1) Database management module: The main functions include connect and refresh spatial database, and read maps in geodatabase. This module provides source data to subject management module.

(2) Subject management module: it has functions of add subject, delete subject, add subject map item, delete subject map item, update subject and open subject map in a new map document or in current map document.

(3) Layer control module: The main functions include add map layer, remove map layer, change layer order, control layer display and open layer attribute table.

(4) Map browse module: This includes map display and map navigation.

(5) Map query module: The main functions include query geographic information based on attribute and space, geometric select query.

(6) Spatial analysis module: This module has functions of zonal statistics, zonal statistics as table, raster algebra computation and vector and raster data conversion.

(7) Map symbolization module: It is used to render points, lines, regions and raster layers.

IGIMS development is based on ArcGIS Engine, which is a developer product for creating custom GIS desktop applications. ArcGIS Engine is a collection of GIS components and developer resources that can be embedded, developers can use ArcGIS Engine to add dynamic mapping and GIS capabilities easily and conveniently into stand-alone applications. It provides application programming interfaces (APIs) for COM, .NET, Java, and C++ for the Windows, Linux, and Solaris platforms. Here IGIMS is developed based on C# .NET on Windows platform. Most of the system functions like database management, layer control, map display and navigation, spatial analyze and map symbolization is implemented on the basis of ArcGIS Engine components. Subject management is based on TreeView ActiveX. TreeView ActiveX is a graphical user interface element that presents a hierarchical view of information. Here we use nodes present subjects and use subitems of each node present maps in that subject. The information of subjects and maps is stored in a text file. Through operating TreeView we can implement subject update. Map query module is based on the component of QueryFilter. QueryFilter's attribute WhereClause specifies the query conditions which is a SQL statement.

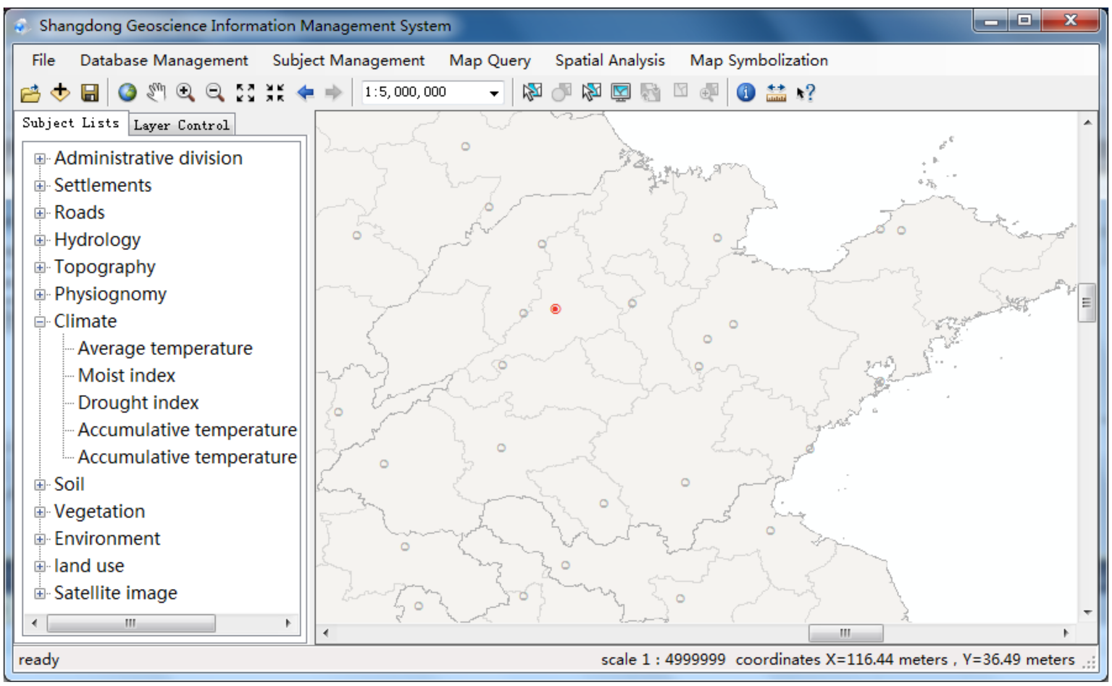

Figure 2. Main interface of IGIMS

4. DISCUSSION

IGIMS aims to provide support to browse and analysis geographical data. To develop the system, integrate and all-sided geographical data is needed. Data collected from different source is in different data format. To achieve visualization these data should be converted into GIS maps which can organize spatial and attributive information efficiently. In IGIMS all kinds of data are processed as shapefile and stored in geodatabase. But there still are problems in data resource. To serve geoscience research, all kinds of geographical data should be collected. Geoscience subjects in IGIMS have included administrative division, transportation, settlements, topography, physiognomy, soil, vegetation, climate, land use, environment assessment and satellite images. But the subitems of each subjects are incomplete. For example, only land use and satellite images have historical data. Historical data of other subjects like topography, physiognomy, soil, vegetation, climate and environment assessment should be collected. Second, IGIMS has obtained basic functions of GIS like map browse, query and analysis. Some advanced functions like making and running models, user account management, and geostatistical analysis can be achieved to make better research. Finally, the system doesn't have a robust security mechanism, which is essential before the system put into use.

5. CONCLUSIONS

The study take Shangdong Province, China for example, provides a strategy for managing and visualizing geoscience data, including choose a suitable spatial data model, a data storage solution, a GIS development platform. Integrated geoscience information management system (IGIMS) bases on a C/S structure and a three-tier deployment architecture. It uses Geodatabase spatial data model and ArcSDE to organize and store spatial and attribute data and establishes geoscience database of Shangdong. The database provides efficient access, supports storage of huge quantities of data and is convenient for further extending. IGIMS is developed based on ArcGIS Engine on .Net platform. It has implemented functions of data access, subject management, map browse, map query, spatial analysis, map symbolization. The characteristic of managing and browsing geographical maps by subjects provides convenience for geographic researchers and decision-making departments.

The novelty of this study is: (1) It integrates all-sided map information of geography, including data and maps of administrative division, transportation, settlements, topography, physiognomy, hydrology, soil, vegetation, land use, environment assessment and satellite images. And it develops a stand-alone application to visualize the geographical information. (2) Geographical data are classified by its subject in IGIMS which is implemented with a TreeView ActiveX. This characteristic makes it convenient to search and browse data.

ACKNOWLEDGEMENTS

The author are grateful for the support from Key Research Program of the Chinese Academy of Sciences(KZZD-EW-14), the National Science and Technology Support Program (2014FY210600), the National Natural Science Foundation of China (41171334)，the Talent Fund of Yantai Institute of Coastal Zone Research, the Ecological Innovation & Breeding Project (Y254021031, Y355031061) and the USDA NIFA Project (2010-34263-21075).

REFERENCES

[1] Dong, M., "A Preliminary Study about the Digitalcity Construction", *Natural Sciences Journal of Harbin Normal University,* 16: 101-105 (2000).

[2] He, Y., Xu, J., and Shi, J., "Current situation and development of application of GIS in environmental protection", *Environmental Pollution and Control,* 25(06): 359-361 (2003).

[3] Hu, P., Huang, X., and Hua, Y., [Geographic Information Systems], Wuhan University Press, Wuhan, 5-6 (2002).

[4] Huo, H., and Hu, F., "Application of GIS in Transportation Information Management System", *Computer Engineering,* 28(05): 215-216 (2002).

[5] LI, J., "Design and Realization of the Digital Real Estate Information Management System of Shijiazhuang", *Geospatial Information*, 7(06): 67-69 (2009).

[6] Lin, A., [Physical Geography], Wuhan University Press, Wuhan, 2-3 (2008).

[7] Sanjay, S.S.C., [Spatial Database], Beijing Machinery Industry Press, Beijing, 23-25 (2004).

[8] Teng, J., Wu, W., Sun, M., Li, D., and Yu, F., "Aided decision-making information system besed on GIS for disasterm itigation of storm surge", *Journal of Natural Disasters,* 16(02): 16-21 (2007).

[9] Wang, R., "The Application of GIS In Physical Geography Study", *Journal of Xinjiang institute of technology,* 18(03): 218-221 (1997).
[10] Wei, W., and Yu, J., "Application of GIS to Hydrology and Water Resources Management", *Advances in water science,* 8(03): 206-300 (1997).
[11] West, R., [Understanding ArcSDE: GIS by ESRI], Esri Press, California, 23-30 (2001).
[12] Xiong, L., Yang, F., "Application Study of Spatial Database Technology Based on ArcSDE", *Computer Applications,* 24(03): 90-91 (2004).
[13] Zeiler, M., [Modeling our world: the ESRI guide to geodatabase design], Esri Press, California, 12 (1999).
[14] Zhang, Z., and Shang, Y., "Design of Object-oriented Spatial Database Basd on Geodatabase", *Geospatial Information,* 3(2): 33-35 (2005).
[15] Zhen, J., and Meng, B., "Construction of GIS-Based Land Resource Management System", *Gudong Land Science,* 8(06): 46-48 (2009).