Design and development of national geographic condition monitoring system based on WebGIS

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ABSTRACT

Our purpose was to systematically grasp the authoritative, objective, and accurate information of national geographical conditions, and improve the scientific level of management decision-making; this paper designs a national geographical monitoring system based on WebGIS. The system realizes the functions of storage, management, analysis, and visualization of the spatial data of the national geographical condition. It is applied to Xicheng District of Beijing to realize the monitoring of planning implementation assessment, ecological environment protection, historical and cultural city, and traffic travel. The system can use the Web browser to query and publish the information of national geographical conditions conveniently and quickly.

1. Introduction

National geographical conditions mainly include the spatial distribution, characteristics, and interrelations of the natural and human geography elements, which are an important part of the basic national conditions (Li, Sui, & Shan, 2012; Zhou et al., 2013). Mastering the authority, objective, and accurate national geographical information is conducive to the development and implementation of national development strategies and planning, optimize the pattern of land and space development, and various types of resource allocation (Ma & Du, 2011). Based on the data of national geographical conditions, it is very important to realize the integration of various economic and social information, and geographic information, which is of great significance to enhance the scientific level of management decision (Zhang, Lu, & Zhang, 2014).

China's national geographical conditions monitoring is still in its infancy, the content and form of its monitoring results are still widely explored. These results mainly include basic data, analysis data and thematic data, and other types of content, and tense type data are the common characteristics of these results. Therefore, the research and practice on the results of temporal data and the construction of the monitoring database of national geographical conditions in the future are the core contents of the construction of the national geographical conditions monitoring system (Liu, 2013).

In recent years, WebGIS technology with its powerful data management and space-time analysis functions to the rapid development of geographical conditions and monitoring in a wide range of applications. This paper combines the WebGIS technology with the national geography condition monitoring model to design and develop the national geographical condition monitoring system based on WebGIS (Li, 2011).

2. System design

2.1. System architecture design

This paper is based on the construction of XiCheng geospatial framework, which is divided into infrastructure layer, basic data layer, system management layer, service interface layer, and application service layer. The infrastructure layer provides the infrastructure needed for system operation, including wired and wireless networks and various hardware and software facilities. The basic data layer mainly includes the national conditions census surface coverage and national conditions elements layer, DEM, remote sensing images, industry special data, etc. are directly call the XiCheng geospatial framework results database. The system management layer defines the management work necessary for the normal operation of the whole system, including the information integration of various business spatial data, the update and verification of spatial data, and the management function of service system. After the system is completed, these management functions will ensure that the system can continue to provide normal daily services. The system management takes advantage of the
geospatial framework’s corresponding module functions directly. The system management takes advantage of the geospatial framework’s corresponding module functions directly. The service interface layer provides the basic management and integration services of basic data for all kinds of applications. It mainly includes: planning and monitoring service, ecological environment protection and monitoring service, historical and cultural city protection monitoring service, and traffic travel monitoring service as seen in Figure 1.

2.2. Database design

The geography and national conditions monitoring database should include six sub-reservoirs, including terrain and topography, remote sensing image, surface cover, geographical factors, special data, geographical and national statistical analysis results, among which terrain topography and remote sensing image are geospatial framework results database of XiCheng. Topographic data sub-library includes multi-scale DEM data and derived slope, aspect and elevation, and slope data. The remote sensing image data sub-library includes orthophoto data. The surface cover data sub-library is a complete cover data-set including 10 types of cultivated land, garden land, forest land, grassland, housing construction area (group), road, structure, artificial excavation, bare surface, and water body. National geographic condition data sub-library refers to the national geographic conditions statistical analysis of the collection of roads, waters, structures, geographical units, and other elements vector data-set. The thematic data sub-library contains various statistics, census data and relevant reference data collected and collated from professional and authoritative departments. The results of statistical analysis of national geographical conditions include the basic statistical analysis and comprehensive analysis of the data of the county level, natural, or economic geographical area.

Xicheng District Geographic condition spatial database in the relational database (ORACLE or SQL Server) based on the building, through SDE, ADO, ODBC, OCI, custom components, and other data interfaces to achieve database storage and access. The whole database system consists of database, data access interface, management system software, and so on. The database structure is shown in Figure 2.

2.3. The construction of monitoring and evaluation model

Planning and implementation of monitoring and monitoring of ecological environment protection, historical and cultural city protection monitoring, and traffic travel monitoring are the main research content of this article, each of which is determined by a number of factors. In order to describe the actual situation more scientifically and accurately, this paper uses the analytic hierarchy process to decompose each individual problem, reduce its connection with other individual items as much as possible, and establish a common monitoring and evaluation model.

According to the actual situation of Xicheng District and the information collected, and through expert consultation, literature review, respectively, to determine the planning implementation assessment, ecological and environmental protection and historical and cultural city protection, and traffic travel assessment indicators. A number of experts rated the monitoring and evaluation indicators built, and then took an average of each indicator.

The monitoring indicators selected in this paper are based on a statistical unit to calculate, such as the region and the streets.

3. System implementation

3.1. Research area profile

Xicheng District is located in the northwest of Beijing city center, latitude 39°53′45″ to latitude 39°58′14″; longitude 116°19′8″ to longitude 116°23′34″. The whole area of 7.1 km wide, 11.2 km long from north to south, with a total area of 50.70 square kilometers. Xicheng District, as one of the core functions of the capital, in Beijing, politics, economy, people’s livelihood, culture, and other fields are responsible for the task.
3.2. Related development technology

3.2.1. J2EE
Java Platform Enterprise Edition (J2EE) is Sun’s multi-tier, distributed and component-based enterprise application model, which can be divided by function and distributed to different computers and stay on the corresponding layer. It is provided by a series of services, APIs, and protocol development capabilities that support Web-based multi-tier applications for Java Platform Enterprise Edition for creating server applications and services. J2EE uses Java platform to simplify the deployment of enterprise solutions and management of some complex issues. J2EE key technologies include EJB, Servlet, JNDI, JDBC, JSP, RMI, JNDI, XML, JMS, JTA, JavaMail, and so on (Zhang, Li, & Lan, 2012).

3.2.2. WebGIS
WebGIS is a kind of computer information system which is compatible with Internet storage, processing, analysis, and application of geographic information in Internet or Intranet network environment. WebGIS has a lot of implementation technology; this paper uses a server-based approach and the server to complete the main work. The client is only responsible for sending the user’s request for spatial data and displaying the data returned by the server. This approach is a simple WebGIS, strong independence, high security, and portability, but this way the performance requires a high server and network transmission (Xia & Pan, 2014). WebGIS architecture is shown in Figure 3.

Compared with the traditional geographic information system, WebGIS has the following four characteristics: (1) Extensive customer access range: customers can simultaneously access the latest data on multiple servers located in different locations, and this unique advantage greatly expands the GIS data management capabilities and enhances the timeliness of spatial data management (Peng & Le, 2012; Tan, Li, Zeng, & Wu, 2015); (2) The independence of the client platform: regardless of the operating system of the client, users can access WebGIS data as long as they support a common Web browser; (3) Simpler operation: To make the GIS system for the majority of ordinary users to accept, it is necessary to reduce the difficulty of the operation of the system. Universal Web browser is undoubtedly the best choice to reduce the complexity of the operation; (4) Balanced and efficient computational load: most of the traditional GIS use the file server architecture, its processing power is completely depended on the client, the efficiency is low (Liu, 2013). Some of today’s advanced WebGIS can take full advantage of network resources, the server to deal with complex operations, and simple operation by the client directly to complete. This computing model
can be flexible in the server and the client between the reasonable allocations of processing tasks, improves the efficiency of network computing resources.

### 3.2.3. Service-oriented architecture

The system will adopt Service-Oriented Architecture (SOA). SOA is a component model that links different services in an application through the definition of a perfect interface and contract between application functional units (called services). Figure 4 shows the SOA model.

In the design and development process, as much as possible, the system provides external services, application functions, packaging, and publishing for the Web service (Web Service). They provide Web services to service consumers (applications of various components or departments). The functionality of the system can be integrated in a loosely coupled manner, which is scalable.

For spatial information services, OGC-based WMS, WFS, WCS, and CAT are used to encapsulate the standard spatial information Web Service, which encapsulates the spatial data sharing service as a Web component (Cui, Liu, & Armentani, 2016). The service is based on the Web Service approach to achieve the integration of the entire system.

### 3.2.4. Multi-source data integration

National geographic conditions monitoring data are often from different industries, departments, and it has many types, multi-scale, multi-resolution, multi-temporal, multi-reference system, and so on. The departmental thematic data in the collection, processing, and application process often be scalar, tense, semantic, and so on are inconsistent. How to integrate and integrating these inconsistent spatial data is the key problem in the process of national geographic conditions monitoring.

First, we study the difference in spatial representation and semantic description of multi-source, multi-scale, and multi-temporal spatial data. Then we establish the
spatial and temporal variation in spatial data and semantic converters of spatial data, the automatic correlation model of spatial entities, and the automatic correlation model of spatial data and statistical data. The basic geography data and the industry special data correlation analysis, the inconsistent spatial data in-depth integration and integration, in order to solve different scales, different semantic, different temporal spatial data compatible with the use of the problem.

3.3. System function design

The design of the system mainly includes the main interface, map operation, map query, planning and implementation assessment, ecological environment protection, historical and cultural city, and traffic travel these seven large modules. Detailed structure is shown in Figure 5.

3.4. Network system configuration

Computer network configuration is an important part of the system construction. According to the specific business situation, the entire network structure design is shown in Figure 6:

The network can be divided into three levels: (1) government private network: government private network by the backbone network, high-speed communications network, routing equipment, and other components. The backbone is used to connect the server and the local area network. The backbone network adopts FDDI double-ring fiber network, which can meet the needs of municipal administration information system. In the backbone of the remote router configuration, the use of telecommunications to part of the application of high-speed communications network (such as: DDN64 K remote digital line network) will be the unit of the LAN and the backbone of the connection; (2) Internal LAN: the LAN provides high-speed network interconnection for internal user workstations. LAN is divided into the core, the working group switches, and the city’s internal network switching center connected equipment and lines composed of three parts. In the local area network using the core switch, so that different network segments to form their own local area network. At the same time through a dedicated network segment, a firewall and the router was set up to achieve the party and government information network-government-specific network connection; (3) The external network connected to the public: the external network consists of a firewall, an access device, and a communication line connected to the Internet. The external network through the firewall and external network switches through the communication lines and the Urban Management Bureau of the internal network connection. External network for the provision of public services, information dissemination, such as WWW, FTP, and Internet users can access the network through the Internet.

3.5. National geographic condition monitoring based on WebGIS

On the one hand, the current fine spatial data collection is also mainly dependent on manual operations, while the various departments of the data collection need different, the overall update task is huge, and so many geographical information is inevitable with many time versions. On the other hand, multiple periods of continuous monitoring are more likely to find the laws of the change, digging out potential problems.

![Figure 5. System function module structure.](image-url)
National geographic conditions monitoring steps are summarized as follows: (1) To determine the statistical time range and spatial scope; (2) Using space-time retrieval technology, in the geographical conditions of space-time database query a certain type of target data-set; (3) The basic data of the target data-set, area, and other basic information summary; (4) Superimposing the population and other thematic information, using the monitoring model to calculate per capita green area and other monitoring indicators, for a variety of national conditions information, to carry out correlation analysis; (5) in all types of national conditions data statistics, using workflow technology, followed by the implementation of 1–4 steps to automatically complete the geographical conditions indicators statistics; (6) Using the time and space comparison, compare the results of multiple periods of national conditions, calculate the amount of change, relative rate of change, and speed of change. The system interface is shown in Figure 7.

4. Conclusion

The main task of this paper is to build a WebGIS-based national geographic conditions monitoring system, introduce the system architecture and database design, and system-related development technology, functional
design and network system configuration in-depth study. System test results show that it can easily use the Web browser to facilitate and quickly query and publish geographic information. It is important for the formulation and implementation of regional development strategy and planning, optimization of regional spatial development pattern, and various types of resource allocation.

**Disclosure statement**

No potential conflict of interest was reported by the authors.

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