Design and Implementation of Soil Environmental Quality Visualization System Based on WebGIS

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Abstract. Multi-scale soil environmental quality survey and social production practice have accumulated a large number of soil data, which is the valuable essential data for practice and research. It is urgent to rely on information technology to strengthen the management and application of soil information. This paper designs a WebGIS system for visualizing soil environmental quality based on the B/S model of three-tier network structure. The system uses the map engine ArcGIS API for JavaScript and HTML5 canvas dynamic rendering technology as the core of the technology, and combines ArcGIS Server and spatial database technology to achieve a series of functions such as soil environmental quality data management, soil pollution visualization and statistical analysis. The system deployment is applied to the Yunnan Provincial Environmental Monitoring Center Station, which enables rapid and high-performance visual display of soil environmental quality information and enhances the rapid information sharing capability between the environmental monitoring departments of Yunnan Province.

1. Introduction

As one of the basic elements of the ecological environment, soil is the material basis for sustainable economic and social development. With the continuous expansion of industrialization, the increase of industrial waste emissions, and the irrigation of sewage, the excessive use of pesticides and fertilizers, the soil has been polluted to varying degrees. In the face of the increasingly serious situation of soil pollution, how to use the modern technology of computer, database, 3S to analyse and study the soil quality has become a hot spot in soil science research [1].

Soil information has obvious spatial characteristics, which are characterized by spatiality, time series and distribution [2]. The characteristics of the soil determine that the soil's attribute information is closely related to spatial information. Therefore, the soil information system must be extended based on the geographic information system (GIS). With the development of Internet technology, WebGIS, as a new branch of space technology, has potential value in data sharing and spatial data mining [3,4]. There are two main ways to implement WebGIS: client/server (C/S) model and browser/server (B/S) model. In the C/S model, the server deploys the application, and the client also needs to install the corresponding client software to implement network communication and service. Because the C/S model needs to rely on the PC operating system, the installation configuration is cumbersome. Although it has strong spatial data processing and visualization capabilities, the C/S model cannot be quickly deployed and shared [5]. The B/S model assigns all data storage, query, calculation, statistics, analysis and other functions to the server. The client can rely on the browser to communicate and interact with the server. Therefore, this paper will design a WebGIS system based on B/S mode to visualize soil environmental quality, and
realize the rapid information sharing between management departments and the application of cross-platform WebGIS.

2. System architecture design
The service of the soil environmental quality visualization system is mainly targeted at the environmental protection department, the agricultural department, and the land and resources department. The diversification of the service subject requires a simple system structure, user-friendly interface and easy access. Therefore, the system architecture is designed as a three-tier B/S structure web application system, and the system structure is shown in Figure 1.

![Figure 1. Structure of soil environmental quality visualization system](image)

The presentation layer uses the ArcGIS API for JavaScript based on the Dojo framework as the WebGIS map engine. The front end adopts the HTML5 canvas rendering technology, and cooperates with the ArcServer on the server side to realize the functions that most traditional desktop GIS can implement in the client browser without special plug-in support, such as: spatial data visualization, graphics drawing, symbol rendering, geoprocessing services, web analytics, online editing, etc. [6,7]

The application layer is the core content of the back end of the soil environment quality visualization system, which is mainly composed of two parts: GIS application server and Web server. After parsing the request sent by the client, the web server calls the corresponding GIS Server component interface function to process and analyze the data, and complete the functions of editing and updating, querying and spatial analysis.

The data layer mainly includes the spatial data engine ArcSDE and a relational database system that stores spatial data and attribute data. Spatial data is uniformly maintained and managed by ArcSDE [8]; attribute data is stored by relational database (Oracle); other data such as system configuration files, pictures, videos, etc., which are inconvenient for database storage management, are stored in the file as files. End, eventually called by the application layer.

3. System architecture design

3.1. Data organization and database design
The soil environmental quality visualization system uses a new generation of object-oriented spatial data model - GeoDatabase as a spatial data model. The model uses standard relational database technology to express the data model of geographic information, and integrates spatial data and attribute data into the standard relational database in the background to achieve seamless integration of spatial data and attribute data [9,10]. The soil environmental quality data covers a wide range of types and can be divided into four types: basic geographic data, basic background data, and soil quality survey data and metadata. Geodatabase spatial data model hierarchically designs, processes and manages data. The data layer is divided into three types: raster data layer, vector data layer and attribute data layer. The vector data mainly includes the soil environment survey point data of each department, the vector data in the basic
geographic data and the basic background data, and is organized and stored by the Feature Dataset. The raster data mainly contains remote sensing image data, and the image catalog is managed by Raster catalog. The tabular data is mainly soil environmental quality monitoring project data and metadata information, etc., which are mainly stored in Table and associated by the Relationships model in the GeoDatabase model. All spatial data layers should have a uniform coordinate system GCS2000 so that different data layers can be superimposed and visualized in the same space. The spatial database architecture of the soil environmental quality visualization system is shown in Figure 2.

![Geospatial database architecture](image)

**Figure 2.** The spatial database architecture of the soil environmental quality visualization system

3.2. **Design and implementation of system functions**

The main application targets of the system are the management personnel and scientific research personnel of the agricultural and environmental departments. Therefore, the principles of system design need to meet the simplification of the operation process, the visualization of the management process, and the humanization. According to the system's needs analysis and construction goals, its functional modules mainly include: system management module, map navigation and layer management module, data management module, soil contaminant visualization and statistical analysis module. Based on the relevant data provided by the Yunnan Provincial Environmental Monitoring Center Station, this paper takes Anning City, Yunnan Province as an example to introduce and display the system functions.

3.2.1. **Map navigation and layer management module.** System management includes two sub-functions: user management and role management. User management refers to the management of the user information of the system, including the user's user name, password, identity information of the department, and the role configuration information of the user. Role management is to control the operability of the system by using the role as the smallest unit. The roles include three types, system administrators, researchers, and general users. The assignment of different functional rights of the system is realized by establishing associations with user roles. The system's permission landing page is shown in Figure 3.
3.2.2. **Map navigation and layer management module.** The module is shown in Figure 4 and Figure 5. The functions mainly include basic map operations such as zooming in, zooming out, panning, refreshing, and basemap switching. The map navigation is designed with panoramic display and eagle eye function, which can realize one-click display full image and fast positioning local map. The layer management function realizes the management of multiple layers such as vector data and raster data in the spatial database, including the display and shadow of the layer, the unfolding function, and the transparency control function.

3.2.3. **Data management module.** The data management module is shown in Figure 6. The data management includes batch import, batch export and data addition, deletion and change operations of soil environmental quality data. The system supports batch import of Excel files conforming to a specific format and batch export of data in csv and txt format. The user can edit the data in the pop-up window by clicking the icon of the soil survey data point on the map. Data query includes two types of attribute query and spatial query, which can perform separate query of attribute and spatial information, and can also perform fuzzy query according to certain fields of data.
3.2.4. Soil pollution visualization and statistical analysis module. The module is shown in Figure 4 and Figure 5. The functions mainly include basic map operations such as zooming in, zooming out, panning, refreshing, and basemap switching. The map navigation is designed with panoramic display and eagle eye function, which can realize one-click display full image and fast positioning local map. The layer management function realizes the management of multiple layers such as vector data and raster data in the spatial database, including the display and shadow of the layer, the unfolding function, and the transparency control function.

Conclusions
In the era of mature 3S technology, traditional PC-based single-machine applications use reports to analyze data in a way that is not only inefficient, but also cannot visualize and analyze soil environmental quality data with numerous evaluation factors and complex data types. The system uses the B/S-based WebGIS architecture scheme to design and implement the soil environment visualization system, which realizes the rapid display, query and statistical analysis of soil environmental quality related data. The system is deployed in the Yunnan Provincial Environmental Monitoring Center Station, and the system operation results show that the human-computer interaction interface is friendly, easy to operate, responsive and stable. The system basically realized the rapid information sharing between the
environmental protection department, the agricultural department and the land and resources department, and improved the management efficiency and management level of the environmental monitoring and management department of Yunnan Province.

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