A WebGIS-Based Platform for Sewage Treatment Facilities in Villages and Small Towns Near the Lake Dian

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Abstract. Lake Dian is one of “Three-river and Three-lake Project” that focus on water pollution prevention and control in China. Rural non-point source pollution is increasing year by year. In order to effectively control the amount of sewage from villages and small towns entering the lake, a full coverage of treatment facilities has been built near the Lake Dian. Among them, the facilities are scattered in the eight districts and two counties of Kunming City, Yunnan Province. It is so difficult to manage that we have to rely on WebGIS technology for management and analysis. This paper designs a visualization platform for sewage treatment facilities in villages and small towns, which is a three-tier system architecture of B/S model. The system takes the map engine of ArcGIS API for JavaScript and the component development of Vue.js as the technical core, combined with ArcGIS Online service portal and spatial database technology. It finishes function implementation such as the visualization of the treatment situation and data management. The platform can scientifically analyse the problems in the construction, management, and operation of sewage treatment facilities in villages and small towns. It improves the ability to share information, and provide decision-making support to the sewage treatment department of the Lake Dian.

1. Introduction
Water pollution prevention and control is a global problem faced by various countries in the process of modern urban construction. With the emphasis on this problem, urban point source water pollution such as industrial sewage and residential sewage has been effectively controlled, and rural non-point source water pollution become an important part of water pollution. The central government and the governments at all levels in Yunnan Province attach great importance to the treatment of water pollution in the Lake Dian. Due to the lack of concentration of domestic sewage in rural areas, most of the sewage treatment facilities are located in geographically dispersed villages and market towns, and the treatment function is not perfect[1]. In order to accurately implement the various measures for sewage treatment in the Lake Dian, this paper comprehensively applies Geographic Information System (GIS) and WebGIS technologies, takes the map engine of ArcGIS API for JavaScript and the component development of Vue.js as the technical core, and combines the ArcGIS Online service portal and spatial database technology to design and develop the WebGIS platform for sewage treatment facilities in villages and small towns near the Lake Dian. It realizes the informatization and visualization management of sewage treatment facilities, and improves the work efficiency of relevant management departments.

The information of sewage treatment facilities has obvious spatial characteristics. GIS, with its special functions of spatial data processing, is widely used in urban water environment improvement and lake pollution prevention and control[2]. With the development of Internet technology, WebGIS
integrates network and GIS technology as a new branch of spatial technology. It has become the mainstream of GIS applications, realizing spatial data management, remote collaborative work and online processing of geographic information data. The system framework of WebGIS gradually developed from the C/S (client/server) model inside the LAN to the B/S (browser/server) model in the Internet environment. As the C/S model, the system is oriented to a fixed user group, who needs to install the software to access the GIS service, it depends on the operating performance of the hardware and it is not easy to update and maintain. The WebGIS system of B/S model is a three-tier architecture composed of a database, an application server, and a browser. Users can access and obtain services directly through the browser, which can realize the distributed deployment of the system, cross-platform support, and low network bandwidth requirements[3,4]. This paper will design a WebGIS platform based on the B/S model to visualize the distribution and related attributes of sewage treatment facilities, and realize the rapid information sharing of WebGIS application.

2. Platform architecture
The services of the visualization platform of sewage treatment facilities in villages and small towns near the Lake Dian are mainly for environmental protection departments, sewage treatment and operation departments of Lake Dian. According to the system requirements analysis, it is necessary to design a stable system architecture, which has concise user interface and easy operation methods. Compared with the traditional development framework, the single-page program avoids the continuous reload and refresh of the page, and makes the interactive experience smoother[5]. Therefore, the system architecture adopts a layered approach and is designed in accordance with the principle of separation of front and back ends, and it is functionally divided into a view layer, a service layer and a data layer. It is a web application based on B/S model with a three-tier architecture, as shown in Figure 1.

![Figure 1. The three-tier platform architecture](image)

The view layer is mainly based on the Vue.js single-page component development technology of front-end, and uses the ArcGIS API for JavaScript of the Dojo framework as the WebGIS map engine. According to the HTTP protocol, the browser requests the ArcGIS Online portal on the server to load the map service through the ArcGIS API for JavaScript. Most of the functions on the traditional GIS platform can be realized through the browser, so that the popularization of GIS and the high sharing of information are truly realized. During spatial data visualization and layer services, no additional plug-in support is required.

The service layer mainly includes the ArcGIS Online portal and web server, and the ArcGIS Online portal contains ArcGIS Server and ArcGIS Pro application, which is the significant content of the back end of the visualization platform. It After the client sends the request to the server, the web server returns HTML documents and various scripts for analysis, and then calls the corresponding ArcGIS
Server component interface functions through ArcGIS API for JavaScript to access online content and services, which supports to edit and update data, query and spatial analysis, process and analyze[6,7].

The data layer is mainly composed of the ArcGIS Pro as spatial data engine and the Geodatabase as relational database system that stores spatial data and attribute data. In addition to implement the unified maintenance and management of spatial data, ArcGIS Pro also has the capabilities of mapping and spatial analysis, two-dimensional and three-dimensional integration, and vector slice production and publishing[8,9]. The relational database management system uses MySQL, which mainly stores attribute data. Other types of data such as system configuration files and supporting documents are stored locally in the form of files.

3. System function implementation

3.1. Database architecture

The visualization platform of sewage treatment facilities in villages and small towns near the Lake Dian uses the geographic element data collected by the research team of Yunnan University, including spatial data and attribute data of sewage treatment facilities in villages and small towns, sewage treatment plants in the main urban area, river courses, administrative areas. The sewage treatment scope covers a geographic area of 2,920 square kilometers in eight districts and two counties of Kunming. Spatial data are obtained through surveying and mapping and manual sorting of drawings, and attribute data are obtained through the collation of forms and field collection by industry insiders. The system takes the data model Geodatabase representing geographic information and relationships of data, and it processes and manages data in a hierarchical manner. The main function involves storage, editing, update, and output of data, and a authority management module[10]. The data layer’s structure is as described above, which is divided into three types: raster data layer, vector data layer and attribute data layer. Feature Dataset mainly stores basic geographic data and other background data. Attribute data is mainly sewage treatment facility data and metadata information. The geospatial database architecture is shown in Figure 2.

![Figure 2. Database architecture](image)

3.2. System function composition

The user groups targeted by the system are managers and scientific researchers in environmental departments. Therefore, the functions implemented by the system need to meet concise operating procedures, visual information display and other specific requirements. According to the related principles of system design and needs analysis, its functional implementation mainly include: system management module, map navigation module, data management module, visualization and statistical analysis module. The system function composition takes 912 sewage treatment facilities within the
sewage treatment area of villages and small towns near the Lake Dian as an example to introduce and demonstrate the effectiveness of the system.

3.2.1. System management module. System management module is mainly responsible for recording and managing user information, including user name, password, institution identity information, and user role configuration information. Role configuration information is to adjust the operability of the system by judging the current role of the user. There are three types of roles: system administrator, researcher and general user. The system conducts identity verification and daily management of users through user management, and establishes associations with users through role management to realize the distribution of different functions and permissions of the system. For example, general users do not have permissions to edit attribute data online.

3.2.2. Map navigation module. The functions mainly include the basic operations of the map, such as zooming in, zooming out, panning, returning to the initial position and switching base maps. The map navigation has a panoramic display and an eagle eye function, which can drag to display the overview map and fast positioning of the local map. The map layer mainly adopts the scene view, which can be freely converted and adjusted for angle of view through the right-click operation of the mouse. It realizes the multi-layer management of the point layer, the polyline layer and the surface layer in the spatial database. The legend function is convenient for users to view the content of the map according to the label information of various elements. For the attribute data of a specific layer, users can directly click on the element points on the map to obtain basic attribute information. Sketch widget provides a simple UI for creating and updating graphics on the scene view, as shown in Figure 3.

3.2.3. Data management module. The data management module adopts the attribute data of sewage treatment facilities in villages and small towns near the Lake Dian, including id, site name, administrative area, sewage treatment technology, treatment scale, service population, etc. This module provides an interactive tabular view of each feature's attributes in a feature layer. Users can edit and change data online by double-clicking specific cells in the table. Data query includes attribute query and spatial query, attributes enable rapid positioning of map element points through the selected in the table, and accurate and fuzzy queries can also be made based on id or site name. The related operations on attribute data are shown in Figure 4.
3.2.4. Visualization and statistical analysis module. The visualization module uses a plugin for ArcGIS JS API to load Apache eCharts 3 map. Based on the treatment scale of the sewage treatment facilities in villages and small towns near the Lake Dian, a scatter diagram of the station distribution is drawn. Change the size of the scattered points according to the value of the sewage treatment volume to realize the visualization of the sewage treatment situation. The statistical analysis module takes pie and bar charts to visually display the analysis of specific attributes. For example, based on the attributes of rural sewage treatment facilities, the statistics of the number of facilities about four treatment processes are drawn, which are shown in Figure 5. According to the chart, the incompleteness of the survey data is the work that needs to be improved in the future.
4. Conclusions
With the rapid development of 3S and network technology, distributed computing and computational graphics, a new era has been opened for GIS. The demand for WebGIS applications in various fields is constantly deepening and broadening, and the concept of geographic information service is the inevitable trend of GIS. The platform adopts a three-tier WebGIS system structure to design and develop a visualization system for information on sewage treatment facilities in villages and small towns near the Lake Dian. It implements the rapid display, query and modification of basic data, visualization and statistical analysis of multiple attributes. The function modules implemented by the system show the clarity and simplicity of the platform. The platform has been practically applied to Kunming municipal construction and management departments, and has basically realized the visualization and remote management of the operation status of rural sewage treatment facilities. It effectively reduces the costs in the management and operation of rural sewage treatment facilities, accelerates the communication between various departments, and improves the management efficiency and level of the department. This research has certain reference value for the sewage treatment planning of the Lake Dian in the future.

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