Construction of Grid Management System for Ecological Data of Rivers and Lakes Based on Data Fusion Technology

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Abstract

At present, with the rapid development of China's economy and society, environmental problems such as eutrophication of urban lakes, water pollution and destruction of water environment ecosystem are constantly appearing and occurring, which seriously affect the production and life of local people. In order to achieve the purpose of long-term lake management and protection, grid management is introduced into lake management and protection, and the mechanism and means of lake management are improved. A grid management system of ecological data of rivers and lakes based on data fusion technology is proposed. By using GIS spatial data processing method, the objects of hierarchical river reach are spatially gridded according to administrative divisions, and the GIS spatial gridded spatial data objects of rivers and lakes resources based on river and lake model are formed. The platform realizes data collection, collaborative processing and resource sharing of river and lake management information, which can meet the requirements of gridded management and provide reference for gridded management and informatization construction of ecological data of rivers and lakes.

Keywords*: Data fusion, River and lake water body ecology, Grid management*

Ⅰ. Introduction

In recent years, with the increasingly serious pollution of water resources, speeding up the construction and management of environmental information systems, ensuring the real-time and smooth flow of information, improving the effectiveness and security of information and ensuring work efficiency have become urgent problems to be solved all over the world. Over the years, China has attached great importance to the management and protection of lakes. Comprehensive management has been continuously carried out, the management system and mechanism have been continuously improved, and the public welfare functions of lakes have been restored and upgraded. However, the problems such as illegal enclosure, illegal sand mining, illegal construction, water ecological degradation, water quality deterioration and disordered development have not been fundamentally solved [1-3]. Dynamic management and protection of lakes is a management mode in which the key problems of lake water ecological environment are analyzed and predicted in the process of lake management and protection, and the means and ability of lake management and protection are adjusted in time.

Grid management, as a new mode to adapt to modern social management, relies on a unified management platform, establishes maintenance management system, operation supervision system and performance guarantee system, forms a dynamic management mechanism, refines management, supervision, inspection and assessment systems, and has an efficient disposal scheme. Macroscopically, relying on high-tech means can strengthen the initiative and foresight of management, while microscopically, relying on scientific management system can improve the comprehensive management ability and processing speed, effectively reduce the probability of events or minimize the harmfulness of events [4]. It is of great significance to build a grid management system of ecological data of rivers and lakes based on data fusion technology to realize information sharing and business collaboration.

Ⅱ. Dynamic Management and Protection Based on Grid Management

With the continuous development of economy and society, the illegal occupation of rivers and lakes, water pollution, water ecological degradation, unreasonable development and utilization and other issues are in the process

of development, change and dynamic evolution. This puts forward new requirements for the management and protection of rivers and lakes, and the management department needs to dynamically adjust the content and ability of river and lake water management and protection. The main reason is that the ecological management system and mechanism of rivers and lakes are not perfect at present, and the responsibilities of rivers and lakes management in cities and counties have not been well implemented. There are many dead ends in inspections and law enforcement, and the effectiveness of long-term management is not ideal [5]. Under the realistic problems of man-made encroachment on rivers and lakes and destruction of water ecological environment, it is urgent to timely adjust and improve the management means of rivers and lakes.

In this paper, a dynamic management and protection mode based on grid management is proposed, that is, a dynamic management and protection system of rivers and lakes is established by subdividing the geographical information of water body management and protection areas, perfecting the system and strengthening the management and protection ability. Geographically, grids are divided according to administrative divisions, topography, area, etc. within the management scope, and the management system and mechanism of each grid are improved, so as to achieve fixed frame, fixed person and fixed responsibility. Then, according to the characteristics of each grid, the management and protection capacity building is carried out, and the main body of management and protection responsibility, specific geographic information, management and protection requirements, management and protection objects and capacity building in the grid are dynamically adjusted.

Ⅲ. System Architecture Design

Grid management system of river and lake water ecological data is mainly divided into four parts: mobile WEB APP grid management system of river and lake water ecological data, PC terminal supervision and release system of river and lake water quality, MySQL database and Tomcat server. The physical structure diagram of the system is shown in Figure 1:

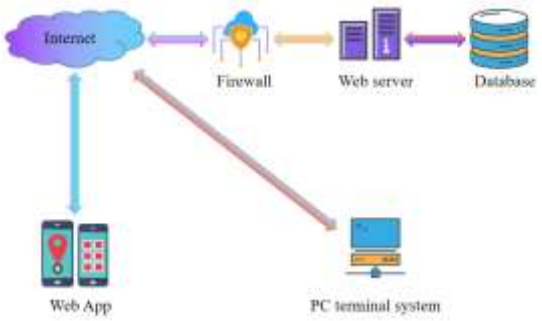

Fig.1 System Physical Structure Diagram

The web app needs to be installed on mobile devices, which can view mobile services such as water quality categories of rivers and lakes, grid management, river information, water quality in lakes, comprehensive inquiry, and contacting responsible persons for processing. The PC terminal water quality supervision and release system is accessed through a browser, which can edit monitoring data, generate Excel reports and conduct grid management. MySQL database is used to save a large amount of data such as historical data, river channel information, monthly water quality report data, grid management, user login data, etc. Tomcat server mainly provides related services for water quality supervision system. For example: water quality category display, grid management, comprehensive inquiry, etc.

The grid management system of ecological data of rivers and lakes mainly includes the following business processes: users log in to the water quality supervision system Web APP through mobile devices, and ordinary users can check the water quality categories of rivers and lakes, the water quality categories of rivers entering lakes, grid management, real-time information and monitoring data of rivers, water quality conditions and detailed data in lakes, monthly and historical data of water quality, comparison of test points and test indicators, and timely contact

the responsible person for handling problems found; After logging in, administrators and senior administrators have the functions of editing grid management, river channel information, uploading the data of rivers entering the lake and water quality in the lake to the server and saving them to the database.

On the PC terminal, after logging in to the water quality supervision and release system through a browser, the senior administrator can upload, modify, delete and generate reports, import Excel tables of monthly water quality reports of rivers and lakes, upload, modify and delete monthly water quality reports, perform grid management, edit river information, modify passwords, and check user registration and login information.

Ⅳ. Main Functional Design

A. Mobile Terminal for Inspecting Rivers and Lakes

The mobile terminal for river and lake patrol is mainly used for river and lake field patrol operation, which can load image base map and water conservancy thematic data, and carry out relevant inquiry, management and analysis. It can collect the real-time geographic location information of patrol personnel, vehicles and ships, as well as the problem information found during patrol, including the geographic location coordinates of the problem (such as the location of an illegal construction, the coordinates of four corners of a circle and a polder, etc.), calculate the length and area, take photos on the spot, and explain relevant texts. All information is sent to the background server through 4G /5G mobile network or wireless network. See fig. 2 for functional modules of mobile terminal.

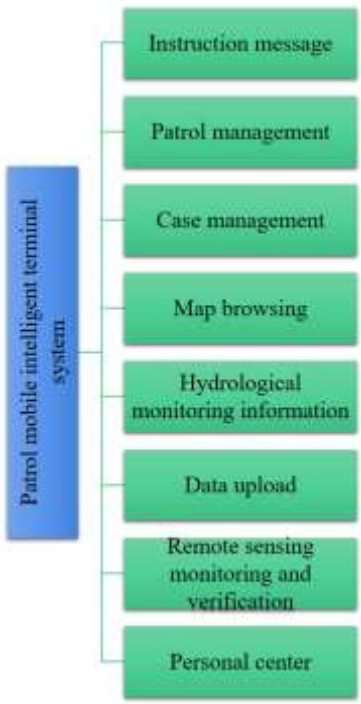

Fig.2 Mobile Terminal Function Module

The mobile intelligent terminal system for river and lake patrol is developed based on Android platform [6], which realizes the real-time sending of patrol position. When problems are found during patrol, you can fill in relevant information, take photos, and send all the data to the background server, or send other information such as starting patrol and ending patrol. At the same time, the software can be upgraded through the network, constantly adapting to the business requirements, the development of science and technology, and the demand changes of geographic information collection tasks.

B. Business Information Sharing

According to the responsibilities of the Ministry of Water Resources, watershed management agencies and water conservancy administrative departments at or below the provincial level, their management categories are summarized into three aspects: social services, industry services and agency services [7], corresponding to the six functional modules of the integrated business platform. However, due to the different authorities of different administrative departments, the sharing authority of different business systems is also different. The initiator of the sharing process of water conservancy work at the same level or across levels is the processor of water conservancy affairs, and the processor of water conservancy business or the processor of subordinate affairs is usually the collaborator of the sharing process. In order to better realize this business sharing process, two collaborative sharing modes, top-down and bottom-up, are proposed:

Top-down mode is based on unified authority management directory and authorization management support module, and higher administrative departments give lower departments certain system and function authority according to actual needs; Bottom-up mode is a distributed database system based on data fusion platform, in which lower administrative departments actively choose to share the resource directory and function modules of the subsystem in the whole platform.

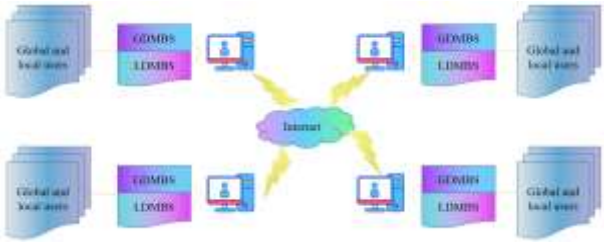

Fig.3 Network Topology Diagram of Data Fusion Platform

The construction of data fusion platform is based on distributed database storage (see Figure 3), which integrates metadata technology, data warehouse, data dictionary and other technologies into a unified data fusion platform through computer network. The data fusion platform is functionally divided into two parts: distributed database system and distributed database management system. The distributed database is a logical collection of databases on each site or node in each water conservancy information system, and the distributed management system is a set of middleware in the distributed data system, which is responsible for managing data access, security, consistency and integrity in distributed environment.

C. Database Operation Function Module

The main function is to operate the system attribute data such as historical monitoring data, field sampling analysis data and the spatial data of geographical entities, and realize the functions of information data entry, update, deletion and query.

D. Gis Visualization Function Module

Using VB.NET language to carry out secondary development based on ArGISEngine9.2 component, the geographical entities and their spatial features are stored in the form of graphic elements and displayed in the map in the form of layers [8]. This module of the system contains the basic functions of map display and map operation. In addition, the attribute data of the database can be displayed in the form of map elements through the secondary development component interface, thus realizing the visualization function of attribute data.

E. Operation Function Module of Water Environment Evaluation

The main function of this module is to run the mathematical model of water environment evaluation embedded in the system through the system interface, calculate, analyze and predict the original monitoring data, and provide users with timely, correct and scientific evaluation results. According to the different requirements of water quality

analysis, this module selects the evaluation model widely used in water environment evaluation of rivers and lakes, and embeds it into the system, so as to realize the rapid evaluation of pollution degree and lake eutrophication degree of one-way indicators of water quality of rivers and lakes

Ⅴ. Implementation of Key Technologies in System Construction

A. Service-Oriented Spatial Information Analysis Technology

Grid management system of ecological data of rivers and lakes uses ArcGIS Server platform and Silverlight development environment to develop spatial information analysis function. The ArcGIS API for Silverlight introduced by ESRI supports REST service in ArcGIS Server, which can be dynamic or static, and the map can be any coordinate system. Graphic objects of ArcGIS API for Silverlight are rich in symbolic expressions and special effects, which can show ideal pictures and interactive effects.

The current version of ArcGIS API for Silverlight is basically not extensible, so it needs to rely on the module processing function to realize the spatial information analysis service in client/browser (B/S) mode. Most ArcGIS functions can be realized through modular processing. The spatial analysis function of the platform is realized by means of module processing.

B. Database

Nowadays, most small and medium-sized websites use MySQL as their database. MySQL has become the first choice for small and medium-sized websites because of its low development cost, fast running speed, small memory occupation and convenient use, which can reduce the development cost of websites, improve the company's revenue and meet the needs of customers. Because MySQL is a lightweight process, it can run quickly with only a small amount of memory. In order to ensure the safety of users, MySQL will check the user name and password when users log in. MySQL has very powerful single-table or multi-table joint queries, and also supports advanced queries such as filtering queries.

In the design and implementation of this system, MySQL is selected as the database to store all the data of mobile water quality supervision web app and PC terminal water quality supervision publishing system. The MySQL visual management tool navicatformysql is installed to operate the database. The basic operations of MySQL database include establishing database, adding, modifying and deleting tables, inserting, modifying and deleting table records, etc.

C. River and Lake Model

The relationship between the river and lake resource model and the management hierarchy model can be established by bridging or many-to-many mapping, but this is a weak relationship. Its purpose is to establish the relationship between the river and lake resources and the corresponding hierarchy of river chiefs and their offices, which does not involve the association operation between entities. In the follow-up, the river and lake resources are further gridded, and the rivers are divided into jurisdictional river sections, thus providing river and lake model services for the subsequent application and development of the river length system information system [9-10].

River section gridding is based on river GIS model, which transforms the river resource model into GIS object model with topological spatial relationship. According to the different precision division of river objects, the river and its tributaries are modeled by GIS with line and area objects of GIS spatial object type as basic units, and the mapping relationship with the objects in river and lake model is established, thus realizing the unified management of river hydrological information and spatial information. Thereby forming a GIS model library of rivers and lakes. On the basis of establishing GIS model of river system, the grid work of rivers and lakes is carried out. Fig. 4 shows the basic hydrological data model structure.

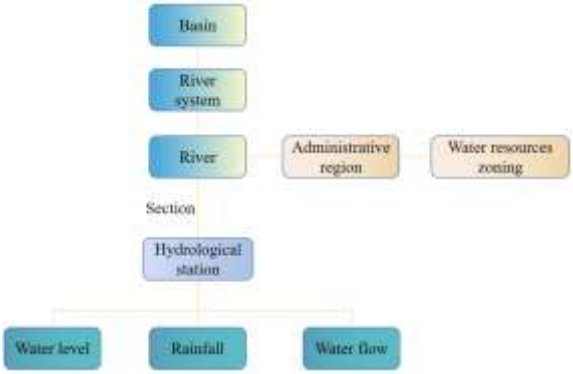

Fig.4 Basic Hydrological Data Model Structure

The top-level design starts from the basin, and the lower water system and river are layered step by step. The same river is subdivided into fault surface types. There are few types of monitoring parameters in hydrological stations, which are generally water level, rainfall, instantaneous discharge and cumulative discharge. Environmental monitoring data and basic hydrological monitoring data are independent of each other, and the data catalogue, modeling level and measurement value type have distinct industry characteristics.

D. Realization of Water Environment Quality Evaluation Model

According to the evaluation characteristics of single factor water quality evaluation model and comprehensive nutritional status index evaluation model, combined with the water quality characteristics of rivers and lakes and the field monitoring indicators of the project, the system has designed different user interfaces to realize the functions of the water quality evaluation model to meet the needs of users.

After the single factor evaluation model program is called, a user interface appears. Users can query the monitoring data of a certain station at a certain time according to their needs, and select the corresponding functional categories of water areas to be referred to. The system will automatically give the evaluation standard value of each major pollutant index in this category. Click the “Single Factor Index” button, and the system will input the user's query data and the standard data of the corresponding water quality functional categories into the single factor model. After the model function and circulation algorithm, the single factor index of each index is obtained.

Chlorophyll, total phosphorus, total nitrogen and potassium permanganate index were selected as the main indexes, and the eutrophication status of water body was evaluated by calculating the comprehensive nutritional status index. After the comprehensive nutrition status index evaluation model program is called, the user queries the monitoring data by time and station, and the system database retrieves the data by SQL language, and feeds the query information back to the user interface. Carry out conditional operation in the system and return the final evaluation result to the user interface.

Ⅵ. Conclusion

The grid management system of ecological data of rivers and lakes based on data fusion technology provides a structural design method of data resources for the development of grid management system of ecological data of rivers and lakes. The grid management system of river and lake water ecological data makes use of the basic water conservancy geographic information data related to the existing river and lake water ecological data, takes the intelligent mobile terminal as the carrier, uses the global satellite positioning system, remote sensing technology and GIS, etc., and comprehensively realizes the systematization, standardization and automation of data collection, analysis, processing and management required by grid management of river and lake water under the Web environment, which provides strong support for the scientific decision-making and collaborative processing and resource sharing of management. This research on grid management system of ecological data of rivers and lakes based on data fusion technology has important practical significance.

Ⅶ. Acknowledgment

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