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Optimization Method of River Water Pollution Prevention and Early Warning System Supporting Spectrum Classification and 3D Remote Sensing Technology

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Abstract: In recent years, people around the world are living in better and better conditions, and people are demanding more and more from their environment, and pollution of the water environment has become the most serious environmental hazard. In many areas, due to the strong development of agriculture and industry, their pollutants are discharged directly into nearby river basins, leading to eutrophication of water bodies. Failure to carry out river water pollution (WP) prevention and control not only poses a major threat to the health of the people in society, but also has a serious impact on the harmonious and stable development of society. Therefore, this paper uses 3D remote sensing technology (RST) to collect images of river basins, generate remote sensing maps of river basins, extract features of remote sensing images using spectrum classification, and establish river water quality monitoring stations to obtain water quality data of each basin section. The application of spectrum classification and 3D RST provides technical support for the construction of river WP prevention and early warning system (EWS), helps to monitor the water quality in river basins and early warning WP accidents, is conducive to promoting the development of WP prevention, and improves the current crisis of river WP prevention in China.

1. Introduction

Water is an essential resource for human survival, in a sense a non-renewable resource, but at the same time but also a source of human life. In recent years, with the increasing industrialisation, modernisation of agriculture and livestock and urbanisation in China, the problem of random discharge of pollutants into rivers has become more and more serious, putting increasing environmental pressure on rivers and intensifying the pollution of water bodies.

Research progress on WP prevention and early warning has been quite fruitful. For example, the prevention of WP and the different dimensions of WP control planning are key to solving the problem of WP. In order to solve this problem, it is necessary to implement joint management mechanisms for water security prevention and control, combining economic and technological concepts and the link between the state of the aquatic environment and WP, which is highly significant for WP control [1]. Some researchers have studied a watershed and used the hydrodynamic model MKE11 to modify water quality under different hydrological conditions. The fact that it can provide information on the extent and timing of pollution makes it an ideal method for designing model simulations [2]. In conclusion, when carrying out WP prevention and control, the market must respond to government guidelines and use market safety tools to prevent and control WP; only in this way can the effectiveness of WP prevention and control be further improved and the WP problem be solved more thoroughly.

This paper takes the problem of river WP prevention and control as the research object, and explores in detail how the 3D RST of SC optimizes the WP prevention and EWS, then uses the B/S mode to build the system structure, and designs the system function modules, finally tests the system performance, and puts forward countermeasures and suggestions for river WP prevention and control, so as to promote the innovative development of WP prevention and metallurgy.

2. River Image Acquisition Based on SC and 3D RST

2.1. Classification of Multi-Channel Spectrograms

The multi-channel spectrogram feature generation method is generally divided into 4 steps. In step 1, based on the LogMel features of the extracted image signal, it is assumed that the letters and data in the LogMel attribute [T, N, 1] at this point represent the time of the first operation, the frequency of the second operation, and the number of the third operation, respectively [3]. In step 2, we randomly select M (M<N) frequency components in the frequency dimension of the LogMel feature to create a new frequency component spectrum. If a frequency component is selected, the spectrum will be measured using either dimension [T, M, 1] or the selected frequency component and the spectrum will be measured using [T, M, 1]. In step 3, c random selections are made for the use of certain frequency components in step 2, which are used to create the spectrum [T, M, 1], thus generating a temporal spectrum map of c dimensions [T, M, 1]. Finally we stitch the c spectrogram features of dimension [T, M, 1] in the channel dimension [4-5]. With the above steps, the LogMel feature of dimension [T, N, 1] can be transformed into a multi-channel spectrogram feature of dimension [T, M, C]. Spectrogram features can also be obtained based on these principles for image feature extraction in river basins.

2.2. Optimization of River Image Data Classification Based on SC and 3D RST

Typically, spectral images are used to collect surface characteristics of certain rivers and remotely sensed hyperspectral images are used to capture these data. The data pre-processing of hyperspectral images with constant spectral and high resolution images generates a data cube in which three dimensions are contained. Of these, the two dimensions of image distance are denoted by X and Y, and spectral size is denoted by Z [6]. On the collected remote sensing images of rivers, we find any station on the other side of the river, e.g. TM1 has a spectral resolution of 0.45-0.52um, which is a band with strong penetration into water bodies and can be used for monitoring the pollution level of water bodies [7]. The river remote sensing image data is then spectrally classified to gather information for water quality monitoring. When reactivating the spectrogram using numerical analysis of unaltered data, the analysis should be repeated through all variables and not just based on individual variables; to determine the degree of dispersion between different categories, standard scaling vectors or covariance matrices can be used, with the position in the feature space expressed as a mean vector of some category [8-9].

3. Design of River WP Prevention and EWS

3.1. System Architecture Design

The system adopts B/S architecture and user interaction, as shown in Figure 1. The system consists of four layers. There is a direct connection between each layer and the next layer. The division of labor between each layer is clear, and the system is characterized by high cohesion and low coupling.

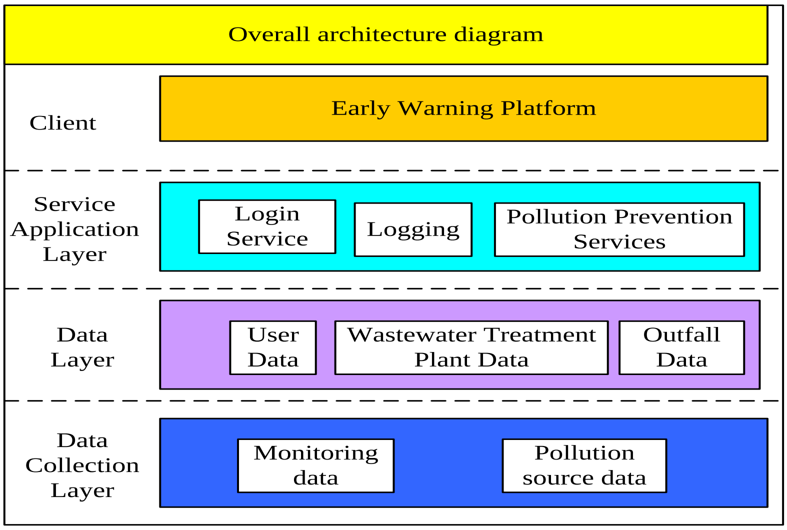

Figure 1. System structure

The data collection layer, as the implementation of an EWS for river WP prevention and control requires data from monitoring stations as support, the system is designed with automatic input from monitoring stations to automatically collect monitoring information and store it in the database; in addition, pollution source data is entered manually to meet the needs of different pollution control schemes [10].

The data layer is mainly used to isolate direct access to the business code and to redirect in the business code. Constraining direct reliance on external data through the data middle layer has the advantage of improving code reusability and code sustainability iterability [11].

The Service Application Layer is an aggregated data layer for business code processing and is a specific implementation of business requirements, providing a full range of functional services to the business layer.

The business layer provides a direct access interface to the front-end system using the functional, compositional and logical processing provided by the service application layer, and a service API (i.e. a server side for HTTP requests) using the Spring MVC framework [12].

The client side mainly provides an interactive interface for users and facilitates the use of platform resources via the web. The system uses an integrated classification development scheme. The front-end is only responsible for the display interface. All data-related requirements are implemented by calling the service APIs provided by the business layer [13].

3.2. System Function Module Design

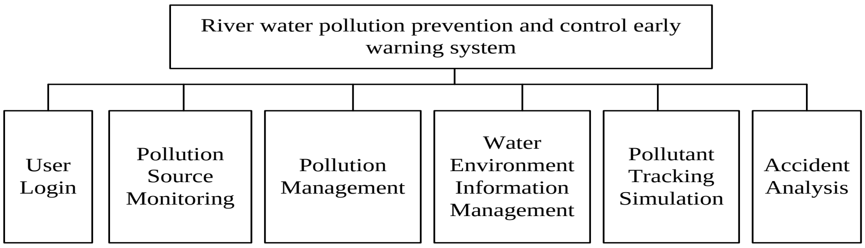

Figure 2. System function module structure

As shown in Figure 2, there are six modules of the River WP Prevention and Control EWS, with the following functional descriptions.

User Login Module: Users first register with the system to confirm the identity and password of the user who logged into the account, and then grant roles with different access rights. If entered correctly, they are transferred to the system home page, indicating successful login, and if entered incorrectly, they are prompted to enter the wrong secret and re-enter it [14].

Pollution source monitoring module: The locations of automatic monitoring stations, online pollution sources, sewage treatment plants and sewage discharge stations in river basins are mainly displayed on the remote sensing map, and detailed information of pollution source monitoring points is displayed by clicking on the markers on the map, and the historical monitoring data of the point can be viewed [15]. In addition, all monitoring statistics are displayed at the top of the page, which helps to give an overall picture of all stations and is one of the main features used by users on a daily basis, enabling them to view all monitoring points on the remote sensing map accurately and in real time, and to display the results visually [16]. The water quality evaluation of the monitoring points is calculated using the following formula:

$$Q_i = C_i / S_i \tag{1}$$

i denotes station, Q denotes pollutant standard index, C denotes pollutant concentration, and S denotes evaluation standard.

$$W_{pH,k} = \frac{7.0 - pH_i}{7.0 - pH_{sd}} \tag{2}$$

$$pH = -\lg[H+] \tag{3}$$

pH is the pH value of water quality, $W_{pH,k}$ is the pH evaluation value of water quality at the kth site, pH_{sd} is the threshold value of pH.

Pollution source monitoring management system module: Maintains basic information about the points displayed in the pollution source monitoring module, provides functions to input, modify and delete details of watershed points, and displays information about the points displayed in the map in the list of the pollution source monitoring module, and supports multi-conditional filtering of the displayed results.

Water Environment Information Management Module: The main function is to provide a tabular representation of the data collected at each monitoring point in the system basin, such as information on pollutants collected by automatic monitoring stations at different times. This module provides a number of alert monitoring functions and can display detailed information on alert events.

Pollutant tracking simulation module function: mainly relying on the sampling data from the basin monitoring stations to find the source of pollution and the reverse tracking simulation of the downward propagation of pollutants, this module is the main function of the system and can be used to visualise the simulation process and results by displaying them on a remote sensing map [17].

Incident analysis function mainly analyses the historical data of WP incidents. This function displays information on the pollutant concentrations monitored in the river involved in the incident, i.e. analyses the trend of pollutants over time, based on a statistical chart of the selected WP incident. In addition, it provides cross-sectional and peak analysis for incident dimensions and shows the specifics in a graphical legend [18].

4. Testing of the River WP Prevention and Control EWS and WP Prevention Recommendations

4.1. System Testing

Platform security testing. Test input by simulating illegal login to test the security performance of the platform, mainly including the test of login service, data operation test, access rights test, the results are shown in Table 1 and Figure 3.

Table 1. Security test results

	Number of tests	Number of successes	Success rate
Login Service	30	30	100%
Data Operations	60	58	96.67%
Data Operations	40	39	97.5%

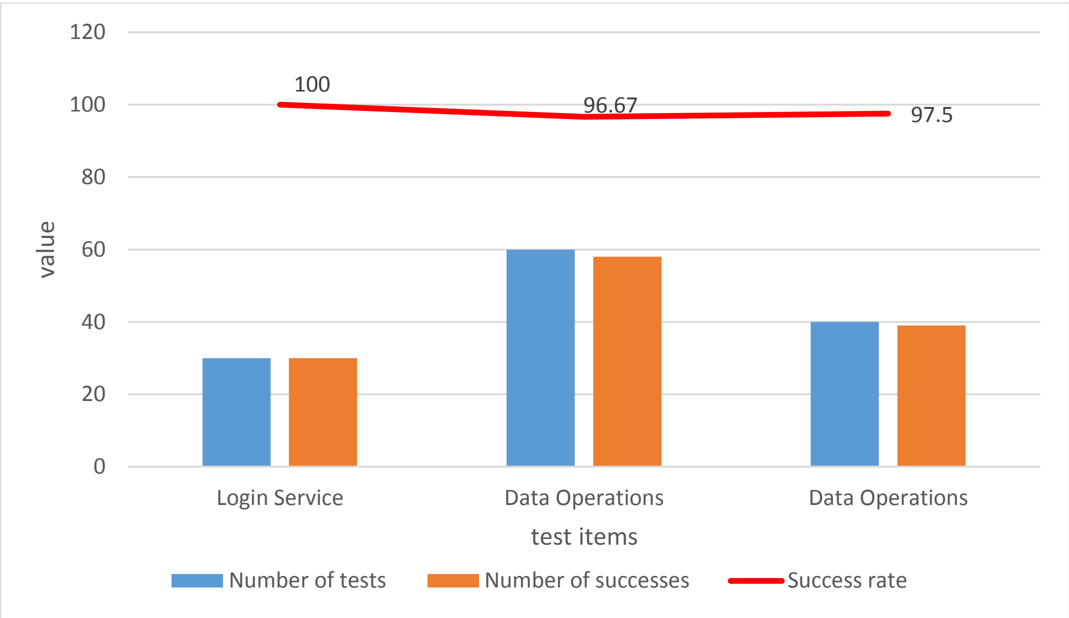

Figure 3. Number of tests and success rate

Platform stability test. Test whether the platform can provide various functions normally under extreme scenarios, including the sudden termination of a background service and the sudden stop of

MySQL, and the results are shown in Figure 4.

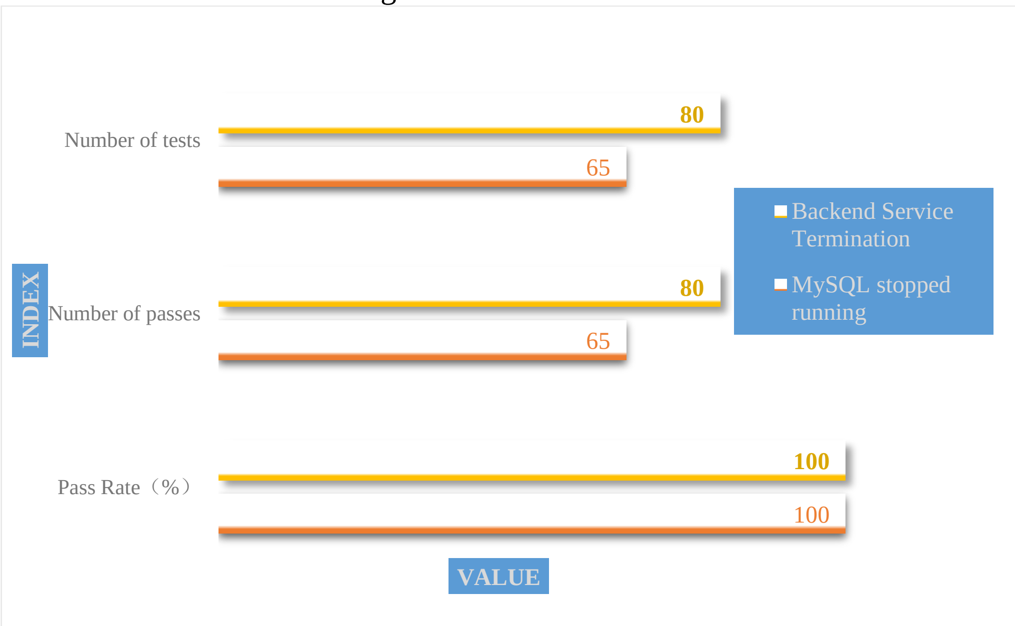

Figure 4. Stability test results

4.2. River WP Prevention and Control Measures

(1) Improving the coordination and linkage mechanism of water-related departments across river basins

Based on the construction of a long-term river system with more coordinated management of water resources protection and environmental protection services, a long-term mechanism for the seamless integration of basin functional areas and water environment functional areas has been established, and a data exchange platform for integrated water environment management in basins has been proposed. Integrated water environment planning and management covers a wide range of content-rich areas and disseminates a large amount of relevant data and information among different stakeholders. Data sharing and integration is fundamental to integrated basin planning and management. The shared content mainly includes monitoring data on hydrology, water quality, groundwater and pollution sources.

(2) Uniform water quality and discharge standards

River basins have different requirements for water quality according to the division of water functional areas such as fisheries, navigation and water supply, and distinguish between major pollution sources and potential pollution sources, and jointly establish a comprehensive control system of "pollution sources - river outfalls - water quality", i.e. determine wastewater indicators within the water environment capacity of the basin. The first is to pay attention to water quality standards for suspended substances, heavy metals, biological parameters, etc. The second is to control the total amount of basin entrances and exits, control WP discharge standards and gradually reduce point and non-point sources of pollution. In addition, unified water discharge standards for the basin should be developed based on the geographical characteristics of the basin sectors and the current status of development and use activities, and a list of pollutants and control requirements for the river sectors should be developed based on the following For enterprises that need to improve their wastewater treatment facilities, the basin coordinating bodies and governments should adopt a sustainable development and cooperation approach to help raise environmental awareness and replace pollution treatment equipment. Advanced pollutant treatment technologies should be actively used, such as the addition of activated carbon and ozonation filtration during the treatment process, biodegradation to remove pesticides from water, reduction of organic compound content and other programmes for exchange.

(3) Ongoing special investigation and inspection

A comprehensive survey of wastewater discharges from enterprises and institutions, the reporting process and the establishment of WP discharge files should include types of pollutants, discharge destinations and wastewater treatment capacity. Special funds are set up to ensure the smooth implementation of the independent approval process and to regulate the discharge of major rivers. A comprehensive census of the distribution of river effluent is carried out to determine the jurisdiction of each street and village (community) for sewage treatment and to determine water quality indicators for characteristic points such as sewage discharge and demarcation. High concentrations of pollutants, total sewage discharges, upstream water enterprises and residential areas should be strictly monitored, with major sewage units clearly defined and key monitoring implemented. Investigate and deal with sewage units that exceed the standard in accordance with the law, and strengthen the supervision of major pollutant discharge areas and enterprises. Enterprises that exceed the standard sewage should meet the standard discharge through pre-treatment facilities built independently to control the direct discharge of pollutants at source.

5. Conclusion

Nowadays, with the speed of economic development, the problem of WP in river basins has become a problem faced by many countries in the world. This paper is dedicated to solving the river WP problem and constructing a WP prevention and EWS. In designing the system, 3D RST is introduced to collect remote sensing images of rivers and then extract the image features through spectral classification. Through the testing of the system in this paper, it is found that the success rate of each item is above 95%, which verifies the usability of the system. Finally, this paper puts forward several suggestions for river WP management in order to establish the ecological balance of water environment.

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Data Availability

Data sharing is not applicable to this article as no new data were created or analysed in this study.

Conflict of Interest

The author states that this article has no conflict of interest.

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