Cyanobacteria bloom prevention and control and salvage disposal integrated management system

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Abstract. Cyanobacteria are large single-cell prokaryotes that can undergo oxygen-producing photosynthesis. However, if the cyanobacteria are contaminated by nitrogen, phosphorus and other elements, cyanobacteria will cause the phenomenon of “water bloom” in the lake, which will seriously endanger the safety of humans, animals, fish and shrimps. To help lake management units to prevent and control the outbreak of cyanobacteria, this paper designed and developed a comprehensive management system for the prevention and control of cyanobacteria blooms and salvage treatment. The system consists of four subsystems: the operational reporting subsystem, the monitoring data management system, the algae environmental protection disposal process management system, and the real-time cyanobacteria monitoring system. The three-dimensional interaction between the WEB end and the mobile patrol handheld terminal makes the system more efficient and convenient. The neighborhood image is denoised by the neighborhood averaging method, and the K-means algorithm is used for clustering training, which makes the classification of the algae pictures taken. The realization of the system effectively prevented the large-scale outbreak of cyanobacteria, providing a new idea for monitoring and processing cyanobacteria blooms.

1 Introduction

With the rapid development of modern industry and agricultural technology, coupled with the long-term lack of environmental protection concepts, it is not uncommon for domestic sewage and industrial wastewater to be directly discharged into lakes without treatment, and these waters are rich in high amounts of nitrogen. Nutrients such as phosphorus provide rich nutrients for the growth of algae such as cyanobacteria, algae can be madly propagated, and water blooms. When the nitrogen content in the water exceeds 0.2-0.3ppm, the biochemical oxygen demand is greater than 10ppm, the phosphorus content is greater than 0.01-0.02ppm, and the total number of bacteria in the fresh water with pH 7-9 exceeds 100,000 per ml. The chlorophyll-a characterizing the number of algae When the content is more than 10 µg/L, it is characterized as a cyanobacteria burst. The current market for cyanobacteria treatment monitoring products are mainly divided into two major categories, one is the cyanobacteria bloom monitoring system, which is equipped with cameras around the lake, and hires special personnel to observe the cyanobacteria outbreaks in each water area in the terminal room; The large category is the cyanobacteria salvage processing business sold by third-party companies. However, there are currently no products on the market that can integrate the two aspects of cyanobacteria monitoring and salvage. In view of this situation, this paper studied the outbreak of cyanobacteria blooms and established a comprehensive management

system for prevention and control of cyanobacteria blooms and salvage disposal. There are two innovations in the system. One innovation point is to combine the prevention and control of cyanobacteria blooms with the salvage to form a system. Innovation point 2: In this paper, K-means algorithm is applied to machine learning to classify images, and AI is used instead of manual for unattended operation, which greatly improves efficiency and reduces error rate.

2 Introduction of relevant methods

The k-means algorithm is an unsupervised learning algorithm, which can realize the classification of cyanobacterial outbreak degree class clusters through repeated and efficient iteration. The following basic concepts are defined:

Definition 1 The formula for the distance between sample $A(\alpha_1, \alpha_2, \dots, \alpha_n)$ and the sample $B(b_1, b_2, \dots, b_n)$ is:

$$\text{dist}(A, B) = \sqrt{\sum_{i=1}^n (a_i - b_i)^2} \quad (1)$$

Definition 2 The formula for the distance between sample s and region D (blue algae cluster) is:

$$\text{dist}(s, D) = \text{dist}(s, \text{center}) - \text{dist}(\text{center}, \text{bound}) \quad (2)$$

In the formula, the centroid position vector represented by center, and bound represents the intersection of the center and s lines and the area boundary.

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Definition 3 Let there be several pictures of cyanobacteria in a certain area, all cyanobacteria pictures have m attributes, $d_{(i,max)}$ represents the maximum value of attribute i , and $d_{(i,min)}$ is the minimum value of attribute i , then the formula for calculating the centroid position vector of the area is as follows :

$$center(d_1, \dots, d_m) = \left(\frac{d_{(1,max)} - d_{(1,min)}}{2}, \dots, \frac{d_{(m,max)} - d_{(m,min)}}{2} \right) \quad (3)$$

Definition 4 The sum of squared errors of all cyanobacterial image data is defined as follows:

$$E = \sum_{i=1}^K \sum_{s \in C_i} dist(s, C_i)^2 \quad (4)$$

In the formula, E is the sum of the squares of the error of all the cyanobacteria picture data, s is a training sample belonging to the cyanobacteria image training set belonging to the area C_i of the cyanobacteria, and C_i is the centroid of the area C_i of the cyanobacteria. According to the calculation of formula (4), when the sum of the squares of all the cyanobacteria picture data errors takes the minimum value, the sample data in the cyanobacteria burst degree area are most similar to each other. The detailed workflow of the K-means algorithm is as follows:

First, the entire cyanobacteria image data set S will be divided into k cyanobacteria burst degree regions ($C_1, \dots, C_i, \dots, C_k; 1 \leq i \leq k$), k is manually set, then k cyanobacteria image data can be randomly selected from the cyanobacteria image data set as the central point.

And then, calculate the training focus except k cyanobacteria graphics data with the Euclidean distance of algae bloom degree of each cluster center, and move the adjacent algae images to distance the recent within clusters, as new blue-green algae bloom images at the same time we have added need to recalculate all the data in the algae bloom degree of each cluster mean vector, according to the new vector is obtained to define each algae outbreak degree of cluster center.

Finally, the above process was repeated repeatedly, and the algorithm was stopped under the condition that the error sum of squares of all trained cyanobacteria images was stable and unchanged.

Fig.1 shows the blue algae classification data set:

Fig. 1. Cyanobacteria data set

As shown in Fig.2, when $k=5$, 4 out of 5 similar samples are classified as severe pollution, and the sample data belongs to heavily polluted picture data.

Fig.2. Classification when $k=5$

3 System design

3.1 System architecture

Relying on the computer software and hardware links and the network communication platform, the integrated management system for the prevention and control of cyanobacteria bloom and the salvage and disposal of cyanobacteria bloom is developed with the information standard and security system as the guarantee. As shown in Fig.3, the system adopts multi-layer architecture design and development of data acquisition layer, infrastructure layer, data layer, support layer and application layer. It mainly provides functions such as real-time lake cyanobacteria monitoring, cyanobacteria bloom early warning and judgment, historical spatio-temporal big data query and summary, report generation and export.

Fig.3. System architecture

3.2 System functional structure design

As shown in Fig.4, the comprehensive management platform for cyanobacteria bloom control and salvage disposal is divided into four subsystems: operation report subsystem, monitoring data management system, algae mud environmental protection whole process

Fig. 4. Functional structure of the integrated management platform for prevention, control, salvage and disposal of cyanobacteria bloom

(1) Operation report subsystem: complete the statistical archiving of various reports. At the same time, it also receives the judgment result from the terminal to take the picture and delivers the task.

(2) Monitoring data management system: summary monitoring data and pollution data reduction amount files, archive processing.

(3) Algae mud environmental protection disposal process management system: real-time location of algae transport vehicles. Match the disposal of algae mud with the responsible person.

(4) Real-time cyanobacteria monitoring system: real-time monitoring of water surface conditions. Intelligently judge the outbreak of cyanobacteria and issue warning information to the lake management company.

4 System implementation and application

4.1 system implementation

Uniapp was used for cross-platform coding of mobile terminal, and django in python was used as the development framework of web terminal. Adopt MVC software design pattern and design website. The database and application system are deployed in Windows 10 64-bit operating system, and Oracle, the mainstream relational database, is used to build the storage space. Using the popular Browser/Server structure mode, simplify the maintenance and use of the web side, centralize the core parts of the system functions to the Server. Through the browser access to achieve a variety of functions.

4.2 Display of system application effect

The mobile patrol handheld terminal and the WEB end part of the user interface are shown in Fig.5:

Cyanobacteria prevention and control and salvage management system

User Routine Equipment Operations admin [log out]

[Map](#)
[Trucks](#)
[Create removal equipment](#)
[List of users](#)

[User management](#)
[User center](#)

[List of users](#)
[Supervision management](#)
[Create user](#)

No.	User name	Real name	Tel	User type	Login status	Operation
4	4	001	3	Patrol user	Online	View Edit Delete
12	12	001	11	Patrol user	Online	View Edit Delete
13	13	001	12	Patrol user	Online	View Edit Delete
14	14	001	13	Patrol user	Online	View Edit Delete
15	15	001	14	Patrol user	Online	View Edit Delete
16	16	001	15	Patrol user	Online	View Edit Delete
17	admin	admin	16	Patrol user	Online	View Edit Delete
18	0001	22	17	Patrol user	Online	View Edit Delete
20	1587704670	1511111111	1311111113	Patrol user	Online	View Edit Delete
22	1587704702	22	1311122111	Patrol user	Online	View Edit Delete

Displays records 1 through 13, for a total of 13 records

Fig.5.Mobile patrol handheld terminal and WEB end part of the user interface display

5 Conclusion

The temporal and spatial variation characteristics of cyanobacteria blooms rely on manual monitoring methods to achieve dynamic monitoring and timely prevention and control of cyanobacteria blooms. In this paper, according to the problem of cyanobacteria bloom pollution, according to the work requirements of lake management for cyanobacteria bloom management, relying on computer software and hardware environment and network communication platform, research and development of cyanobacteria bloom prevention and control and salvage disposal integrated management system, preliminary construction Lake ecological environment monitoring network, which integrates land and water information sharing, integrates various historical data to realize the archiving and display of various data. Through the system real-time monitoring,

summary reporting and other application functions provide a convenient tool for cyanobacteria bloom dynamic monitoring management. Based on real-time acquisition of cyanobacteria growth picture data, the network and process application of cyanobacteria bloom monitoring, outbreak disposal and information release

were realized, and the cyanobacteria bloom monitoring and processing mechanism was further improved, the ideas of monitoring and management were broadened, and labor was promoted. The application of intelligent technology in the environmental monitoring department

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