Development of Underwater Water Quality Intelligent Monitoring System Based on Internet of Things Technology

Jie Wang
Sichuan Vocational and Technical College,Suining,629000,China

Abstract With the continuous development of Internet of Things (IoT) technology, underwater water quality intelligent monitoring systems have become one of the important means to ensure water quality safety and environmental protection. This paper aims to introduce the development of an underwater water quality intelligent monitoring system based on IoT technology. This system adopts a variety of sensors, including cameras, pH, water temperature, conductivity, turbidity, water pressure and other sensors, to achieve comprehensive monitoring of the underwater environment. The system realizes real-time collection, transmission and analysis of sensor data through IoT technology, and combines artificial intelligence algorithms to achieve intelligent analysis and prediction of water quality data. This system has the advantages of strong real-time performance, high data accuracy, and simple operation. It can be widely used in fields such as water environment monitoring and water resource management, providing effective technical support for ensuring water quality safety.

KEYWORDS: Internet of Things, Smart Hydrology, System Development

1. Preface

With the global water resources increasingly threatened by pollution and overexploitation, water quality monitoring and management have increasingly become key issues for environmental protection and sustainable development. Against this background, the rapid development of Internet of Things (IoT) technology provides a brand-new solution for underwater water quality monitoring. This paper aims to introduce the development of an underwater water quality intelligent monitoring system based on IoT technology, aiming to achieve real-time monitoring, data analysis and prediction of water quality conditions, and provide effective technical support for water environmental protection. Water is the source of life, and changes in water quality are directly related to human health, ecological balance and economic development. However, traditional water quality monitoring methods have problems such as low monitoring frequency and difficult data acquisition, which are difficult to meet the real-time and comprehensive requirements of water quality monitoring. Therefore, the development of an underwater water quality intelligent monitoring system based on IoT technology has important practical significance and application value.

Through Internet of Things technology, we can install various sensors in the hull. The hull dives underwater to realize multi-dimensional and real-time monitoring of water quality underwater. At the same time, with the help of cloud computing and big data analysis technology, rapid processing and analysis of massive monitoring data can be achieved, providing timely and reliable basis for decision-making. In addition, combined with artificial intelligence algorithms, intelligent analysis and prediction of water quality data can also be realized. Abnormal situations can be detected early and corresponding measures can be taken to effectively ensure water quality safety. This paper will introduce the design and implementation process of this underwater water quality intelligent monitoring system, including the overall design of the system, the design and implementation of the main modules of the system, the system operation and debugging, and the key technical solutions for data collection and transmission. We believe that this underwater water quality intelligent monitoring system based on Internet of Things technology will bring new development opportunities to the field of water quality monitoring and management and make positive contributions to the sustainable development of human society.

2. Overall System Design

The underwater water quality intelligent monitoring system is a water quality management tool based on Internet of Things technology, sensor technology and 4G communication technology, aiming to analyze water resources in areas such as reservoirs and rivers. The system uses cameras to collect water quality image information, preprocess the water quality image information, extract features and analyze the water quality. The microprocessor adopts ESP32 and has a built-in high-precision ADC to sample data from sensors such as turbidity, water temperature, conductivity and depth. When the hull dives underwater and the 4G signal is interrupted, the microprocessor locally stores the data of each sensor. When the hull floats to the surface and the 4G signal is stable, the sensor data is uploaded to the server through the 4G network. Through real-time monitoring and analysis of the data, users can understand important information such as the situation of water resources, water quality

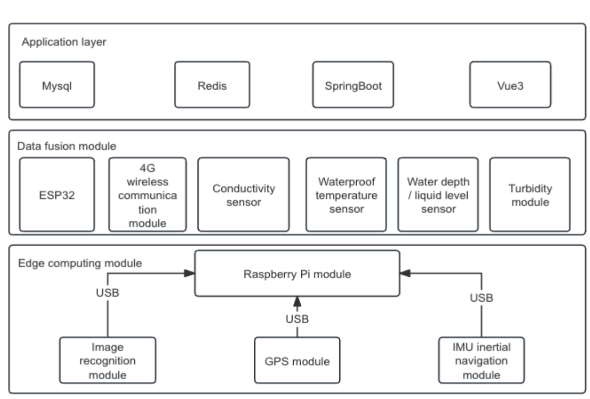

Figure 1: Overall structure diagram of the underwater water quality intelligent monitoring system

changes, water temperature and conductivity in real time.

The key technologies involved in the system development include sensor technology, image recognition technology, software development, application of wireless communication technology, etc. The overall structure of the system is shown in Figure 1.

3. Design and Implementation of the Main Modules of the System

3.1 The main modules of the system

The system needs to realize the functions of the underwater water quality intelligent monitoring system: water temperature change, conductivity change, water pressure change, water depth change, hull attitude monitoring, hull navigation speed in water, satellite information (altitude, number of satellites, orientation), camera turbidity recognition, etc. The data acquisition device in the hull is shown in Figure 2.

In the edge computing module, Raspberry Pi 4B is used as the data processing unit. The GPS Beidou dual-mode positioning module, image data acquisition camera and IMU inertial navigation module are connected to Raspberry Pi 4B through USB serial ports. Raspberry Pi 4B collects the data of each module in real time, filters, analyzes and verifies the data, and finally packs all the data and sends it to the data fusion module through the serial port. In the data fusion module, the data sent by the edge computing module is received in real time, and the received data is parsed and verified. In the data fusion module, data sampling is carried out on the liquid level sensor, turbidity module, water temperature module and conductivity sensor through the built-in high-precision ADC of the system. Finally, various types of data from the edge computing module and the sensor data collected by the ADC are fused and packaged, and the packaged data is sent to the server using the 4G module.

Since this system needs to collect the data of various sensors underwater, when the hull dives underwater and the 4G signal is interrupted, the data cannot be uploaded to the server in real time. The system adopts the following solution: When the hull dives underwater and the 4G network signal is interrupted, stop sending data to the server and save the currently collected data in the data fusion module. The data will be sent to the server again after the 4G signal is reconnected and stable when the hull floats up.

In the server, all uploaded data are stored, and a large-screen visualization application is developed to monitor the various data in the underwater water quality intelligent monitoring system in real time.

3.2 Database Design

The database is mainly used for the storage of various sensor data such as water temperature, conductivity, water pressure, water depth, attitude, position, satellite, navigation speed, camera turbidity recognition, hydrology, etc. in the monitoring system. The main data tables are as follows:

The `t_user` table: `id` (user ID), `user_name` (user name), `password` (password).

The `t_snesor_type` table: `id` (sensor type ID), `sensor_name` (sensor name). The `t_snesor_value` table: `id` (sensor data ID), `data` (sensor data), `date_time` (data update time).

3.3 Front-end design

The front-end development framework adopts Vue.js. Vue.js uses a reactive data binding mechanism, which keeps the view and data synchronized. When the data changes, the view will be updated automatically. It is a concise, flexible and easy-to-use front-end framework, suitable for building Web applications of various scales. In the underwater water quality monitoring system, various sensor data need to be displayed as shown in Figure 3. The page mainly shows location information, satellite information, navigation speed, camera, hydrological information, and the historical changes of various sensor data.

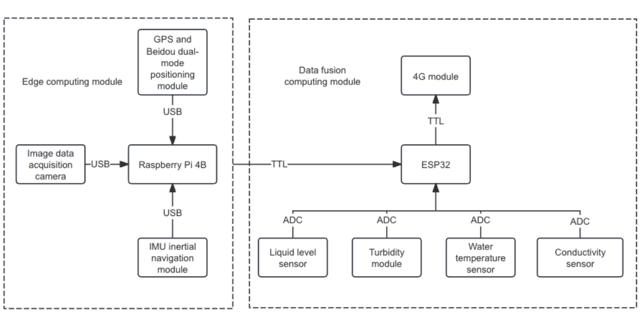

Figure 2 :Hardware design structure diagram of the underwater water quality intelligent monitoring system

Figure 3: Data large-screen display platform of the underwater water quality intelligent monitoring system

3.4 Communication Protocol of Underlying Devices

The communication between sensor devices and actuator devices and the server adopts the MQTT protocol. MQTT is a lightweight, flexible, open communication protocol based on the publish/subscribe model. It is a simple, flexible, reliable and efficient communication protocol, suitable for various different IoT and real-time communication scenarios. The reporting of sensor device data uses the sensor/up topic, and the control of actuator devices uses the actuator/down topic.

3.5 Back-end development design

The background management uses Java programs to implement MQTT service subscription, and perform message reception and sending control for the MQTT service. Corresponding interfaces for message reception and sending control of underlying devices are written to implement the front-end access to the back-end data interface of the visual large screen, so as to obtain the uplink data of each sensor for display, and the UI control can control the underlying terminal devices in the downlink. The Spring Boot technology framework is selected for the back-end Java program development framework, the MySQL database is selected for the storage of historical data of underlying devices, and the MQTT protocol is selected for the data communication protocol for receiving and sending data of underlying devices.

4. System operation and debugging

The system operation test aims to verify the stability, accuracy and reliability of the underwater water quality intelligent monitoring system based on Internet of Things technology in actual operation, to ensure that it can effectively monitor water quality and provide accurate data analysis and alarm functions.

The data fusion module has uploaded all the collected data to the Internet of Things cloud platform through the 4G module, as shown in Figure 3. In the data large-screen display platform of the water quality intelligent monitoring system, all the collected sensor data and sensor historical data can be viewed. Administrators can view and analyze the data through the platform. All data have fully met the expected standards as per the task requirements.

The test results confirm that the underwater water quality intelligent monitoring system based on Internet of Things technology has good stability, accuracy and reliability in actual operation, and can meet the needs of water quality monitoring. Through continuous optimization and improvement, the performance of the system will be further enhanced, providing a more reliable solution for applications in the field of water quality monitoring.

6. Conclusion

This article introduces the development process of the underwater water quality intelligent monitoring system based on Internet of Things technology and its application in environmental protection. Through real-time monitoring and data analysis of the underwater environment, this system can effectively monitor water quality indicators and provide timely warnings and feedback, which is helpful for early detection of abnormal water quality conditions and taking corresponding measures to protect water resources.

During the system design and development process, we have fully utilized the advantages of Internet of Things technology, including sensor networks and data transmission, to achieve remote monitoring and data management of the underwater environment. Through the testing and verification of the system, we have proved its stability and reliability, which has high practical value and application prospects.

However, although this system has achieved certain results in the field of water quality monitoring, there are still some problems and deficiencies. For example, the accuracy and stability of the sensors need to be further improved, the efficiency of data transmission and processing still needs to be optimized, and the cost of the system also needs to be further reduced. Future research directions include improving sensor technology, optimizing data processing algorithms, and enhancing the intelligent level of the system.

Figure 4: Underwater water quality intelligent monitoring system hull launching test

References

[1]Zhao Ruilin. Implementation of MQTT Protocol in Intelligent Power Gateway [J]. Electrical Appliances & Energy Efficiency Management Technology, 2021(07): 83-87.

[2]Guo Shoubing. Design and Implementation of Distributed General Internet of Things Data Management Platform [D]. Beijing University of Posts and Telecommunications, 2020.

[3]2019.[3] Lei Shifang. Design and Implementation of the Examination and Homework Management Subsystem of the Software Engineering Education Cloud Platform Based on Jenkins [D]. Nanjing University, 2019.

[4]Zeng Deshan. Design and Implementation of Communication Transmission in the Intelligent Water Conservancy Perception System [J]. Digital Communication World, 2022(11): 32-34 + 94.

[5]Yang Jianping, Liu Jiawei. Application of Internet of Things Platform in Quanmutang Reservoir Project [J]. Hunan Hydro & Power, 2023(05): 55-57.