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Intelligent Water Quality Testing Device based on Internet of Things Technology

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Abstract: Water quality testing is an important environmental testing standard. However, at present, Internet of Things water quality testing products generally have problems such as single function, complex interface, and short sensor life. The design of this paper is a device with intelligent water quality detection technology, including the independent design of the sensor interface standard, the sensor automatic recognition, plug and play; The sensor is equipped with a lifting mechanical structure to avoid long-term soaking of the sensor and increase the service life of the sensor by 35%. At the same time, combined with intelligent Internet of Things, big data analysis and other technologies, help relevant departments to grasp water quality information in a timely and accurate manner, early warning and forecasting of major regional water pollution accidents, supervision of pollutant discharge, and implementation of control systems to provide help. It is mainly used to monitor the water quality data of small and medium-sized reservoirs, rivers and lakes to achieve intelligent management within the jurisdiction.

Keywords: Water Quality Detection Technology; Sensor Interface Automatic Recognition; Increase Service Life; Intelligent Management.

1. Introduction

With the development of society, the importance of water quality safety is self-evident. In recent years, with the development of Internet of Things technology, water quality testing technology is constantly updated, in China, large, small and medium-sized cities have generally carried out water quality testing work, but the domestic water quality testing industry still has low technical level, weak innovation ability, mainly manifested as the sensor has no unified interface, poor compatibility, single detection function, limited application scenarios, high cost of use. The backward detection scheme and low technical efficiency lead to the single detection data of the water quality detection device, the high cost of use and the complex operation. Therefore, this paper proposes a device with a new intelligent water quality detection technology, including the self-designed sensor interface standard and the technology of lifting mechanical structure. This paper uses the existing Internet of Things communication technology, artificial intelligence algorithm, sensor technology, mechanical design, 3D printing technology and laser processing technology to design and produce this all-round, intelligent and compatible Internet of Things water quality detection device.

2. Research Purpose

2.1. Essentials of Water Environment to Social Development

With the development of economy and society, the problem of water pollution is becoming more and more prominent in our country, and the importance of water quality safety is self-evident. For the country, water quality testing data directly affects the government's macro decision-making; For individuals, water quality testing has great significance for daily life, aquaculture, and crop cultivation; For industrial water, due to different industrial production uses, there are different requirements on water quality and discharge permit standards, so it is particularly important to test various data of industrial water [1-2]. In addition, water quality testing can also provide data and information for environmental management and environmental scientific research, determine the distribution of pollutants in water bodies, trace the source of pollutants, pollution routes, migration and transformation, and the law of growth and decline, predict the changing trend of water pollution, judge the impact of water pollution on environmental organisms and human health, and evaluate the actual effect of pollution prevention and control measures. It is of great significance for further theoretical research on water environment and pollution to provide data representing the status quo of water quality, evaluate the use of water environment quality and find out the causes, mechanisms and various pollutants [3].

2.2. Development History and Trend of Water Quality Testing Technology

In the 1970s, developed countries such as Europe and the United States carried out automatic online detection of surface water such as rivers and lakes, and automatic online detection of sewage treatment plant drainage in cities and enterprises was also implemented. There are two kinds of methods: real-time on-line detection and intermittent on-line detection. The measured items include water temperature, REDOX potential, dissolved oxygen (DO), turbidity, conductivity, ammonia nitrogen, oxide, cyanide and so on. With the increasingly serious surface water eutrophication, strict law enforcement and the implementation of the total amount control system, Chemical Oxygen Demand (COD), mercury (Hg) and TN (total nitrogen, TN) have gradually increased. The total amount of various forms of inorganic and organic nitrogen in water) and other automatic online detection projects, through the remote transmission system, the detection data is automatically transmitted to the environmental protection administrative departments at all levels and environmental detection law enforcement departments. In recent years, with the increase of sewage treatment and the improvement of surface water environmental quality, many developed countries have

included integrated municipal sewage outfall into the key detection scope of automatic online detection. In recent years, with the development of Internet of Things technology, water quality detection technologies based on the Internet of Things continue to emerge. The research and development of water quality sensors in developed countries is at the international leading level, and well-known brands have independently developed intelligent water quality detection schemes and technologies [4].

As far as the domestic, in recent years, benefiting from the impact of environmental protection related policies, testing technology has developed rapidly, especially water quality testing technology. At present, China has formed a basic framework for environmental testing, which mainly includes pollution source testing, air environment testing and water quality testing [5]. However, China's water quality testing equipment industry still has problems of low technical level and weak development ability, which are mainly reflected in the weak scientific and technological foundation of the industry, poor independent development and innovation, and the design scheme of the existing testing system generally has problems such as low data collection accuracy, high use cost and unreasonable mechanical design [6].

3. Research Content

3.1. System Functions

In this paper, the automatic recognition technology of sensor interface is designed to realize the unity of sensor interface, plug and play. All water quality sensor modules include the sensor, front-end amplifier circuit and a small data processing chip, which is responsible for converting the original voltage data of the sensor, storing the sensor information, and storing the sensor information. And listens for the command packets sent from the Serial Peripheral Interface (SPI) bus. Each socket has an independent SPI bus. When the main control part detects the sensor information at the corresponding port, it will match the corresponding data conversion method to the corresponding channel of the socket and convert the corresponding data. The mechanical connection between the sensor module and the host interface adopts the structure of rotating quick joint, and the user only needs to rotate the sensor 120 degrees to fix the sensor, and the interface is sealed by O-ring.

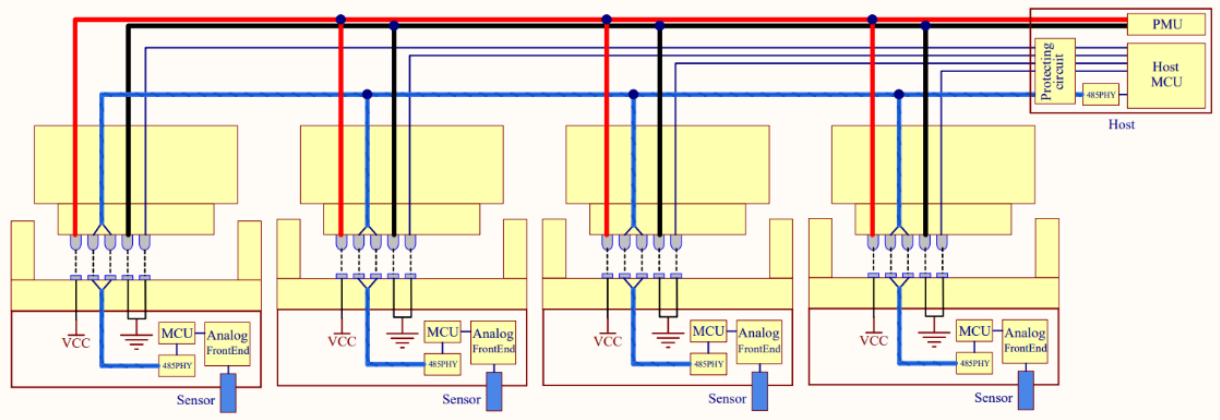

Figure 1. Interface network topology diagram

Each sensor module interface is independently connected to the main control unit, and different sensor modules can be connected to any interface when used, which is convenient for later maintenance and upgrade of sensors. It solves the shortcomings of traditional detection devices such as fixed sensor type, single detection data, high cost, poor mobility, etc., and realizes on-demand adaptation and multi-scenario application. Each sensor module interface is independently connected to the main control unit, and different sensor modules can be connected to any interface when used, which is convenient for later maintenance and upgrade of sensors. It solves the shortcomings of traditional detection devices such as fixed sensor type, single detection data, high cost, poor mobility, etc., and realizes on-demand adaptation and multi-scenario application.

Table 1. This design standard table

Structure	specific standard
Water quality sensor interface	1. self-designed waterproof interface 2. Independently developed communication protocols 3. custom electrical connection standards
Water quality sensor Compatibility	Compatible with any device with this interface
Water quality sensor installation position identification	support
Maximum data length	256B
Water quality sensor Installation Method	Insert the water quality sensor and rotate it 120°
Water quality sensor hot swap	support
Automatic address assignment	support

During the sampling process, the automatic lifting mechanical structure at the sensor module is designed and

made, so that the water quality sensor can be freely telescoped, lifted out or inserted into the water surface, with better flexibility. This design is used with the test, to ensure that the water intake works normally, while avoiding the long time soaking of the sensor, extending the life of the sensor by 35%. The self-locking performance of the steering gear can make the lifting platform stay at a height without falling. If this scheme is applied to the dynamic cruise detection platform, when the water quality sensor is completely exposed to the water surface, it can reduce the resistance brought by the water quality sensor during navigation, reduce the overall energy consumption, and improve the endurance and flexibility of the system.

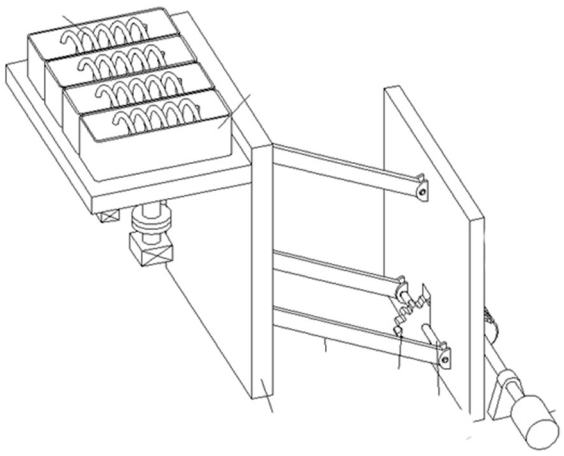

Figure 2. Mechanical design drawing of automatic lifting sensor

Relying on the Internet of Things cloud platform, the detected data is analyzed and uploaded to the cloud, and the detection data can be viewed at any time through the monitoring platform, so as to realize the intelligent management of all small and medium-sized reservoirs, rivers and lakes in the area, and accelerate the modernization of water management.

3.2. Overall Structure and Principle of the System

The design part of the intelligent water quality detection device based on the Internet of Things technology mainly includes water quality sensor unit, climate sensor unit, power management unit, main control unit and wireless transmission unit. Each functional unit is independent of each other into modules, which is convenient for product design and assembly, as well as for later product maintenance and repair.

After research, we determined the following basic process. That is, the TP-RY-1 dissolved oxygen sensor, TetraCon conductivity sensor, and DHT22 temperature and humidity sensor are used to obtain hydrological information and surrounding environment data. The interface of the sensor module is set on the surface of the detection platform device. The water quality sensor is connected with the front-end amplifier plate of the sensor, and the front-end amplifier plate of the sensor is also connected with the analog signal output line, and the SPI bus, the chip selection signal input line and the analog signal output line are respectively connected to the identification chip. The input end of the master control unit can be respectively connected with the climate integrated analysis unit and the wireless data communication unit through electrical signals, and the wireless data communication unit is connected with the user's handheld operator through wireless communication. A bidirectional electrical signal is connected between the main control unit and the automatic lifting sensor unit.

The whole transmission system adopts 4G LTE module access mode, the downstream rate can reach 60Mbps, the upstream rate can reach 30Mbps, and the actual test delay is less than 50ms [7]. Depending on this network speed, the video data collected by the Open CV (Open Source Computer Vision Library) can be transmitted to the web page in real time, and the hydrological data collected by the device can be transmitted to the cloud platform. The detection platform can issue control commands through the cloud platform and use the dual Positioning System based on GPS(Global Positioning System)+ Beidou to achieve accurate positioning [8]. To realize the normal detection of reservoir river and lake hydrological information, real-time data display, data query, data statistics, report generation, background management and sampling and testing functions. Through the background big data statistics, the water quality data and historical data of continuous detection points are summarized and analyzed, which can realize the rapid location of pollution sources and real-time alarm.

3.2.1. Water Quality Sensing Unit

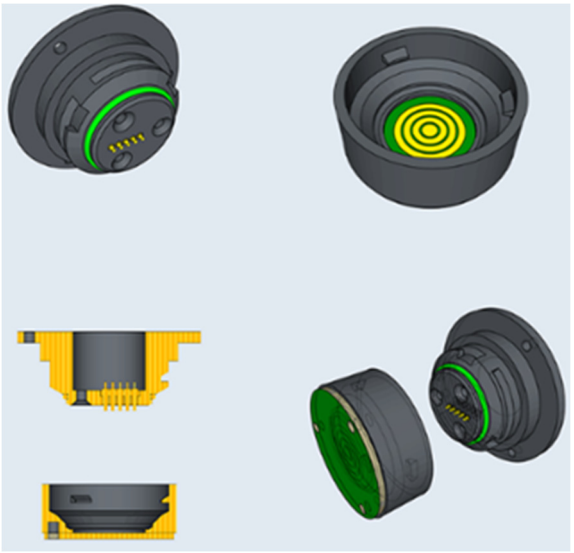

Figure 3. Schematic diagram of sensor mechanical interface design

It realizes the fixing of sensor module, electrical connection, data conversion and recognition of sensor module. The sensor electrical connection adopts the structure of spring contact pin and contact ring, in which the contact pin is 5 feet, the contact ring is four rings, and the two rings located on the inside are the negative electrode of the power supply and the detection electrode, which contact with the innermost ring of the contact ring to realize the detection of whether the interface is connected to the sensor. The other three contact pins are connected to the remaining three contact rings respectively, and are responsible for connecting the SPI bus and the sensor power supply. The mechanical connection between the sensor module and the host interface adopts the structure of rotating quick joint, the user only needs to rotate the sensor 120 degrees to fix the sensor, and the interface is sealed by O-ring. The sensor module transmits the collected information to the main control unit through analog signals. In order to enable the main control unit to accurately identify the access sensor module and its access socket, an eeprom chip with SPI bus is added to the sensor module to store the

information of the sensor in it. Each socket has an independent SPI bus. When the main control part detects the sensor information at the corresponding port, it will match the corresponding data conversion method to the corresponding channel of the socket and convert the corresponding data.

3.2.2. Climate Sensor Module

It is an auxiliary sensor unit of the water quality buoy, responsible for collecting indicators such as air pressure, air humidity and air temperature, which is convenient to assist users to measure hydrological data such as evaporation. A three-in-one sensor of air pressure, temperature and humidity is added to the interior, which is connected to the outside air through the pipeline and the porous protective cover, ensuring sufficient air flow while ensuring the overall waterproof characteristics.

Through the three kinds of climate data, such as air pressure, humidity and temperature, the weather conditions of the monitored areas can be roughly estimated, and simple hydrological information such as evaporation of the monitored waters can also be estimated, which is convenient for users to carry out more comprehensive analysis and evaluation of the monitored waters.

3.2.3. Power Management Unit

Mainly responsible for the overall power supply, but also responsible for the management of solar charging process and battery discharge process management; The main control unit is mainly responsible for the management of various control processes inside the water quality buoy and the conversion of analog signal data and digital signal data. The power management unit provides an independent DC-DC (DC-DC converter) power supply circuit for each of the remaining parts to ensure the stability of each part of the power supply, and each DC-DC can separately control it enable state to facilitate the realization of the overall low-power function [9].

3.2.4. Wireless Transmission Unit

The interior is divided into two modules, one is a data transmission module, responsible for data transmission and equipment networking, and the other is a GPS module, responsible for obtaining satellite timing and buoy position information. As a module sensitive to interference signals, the wireless transmission module also needs electromagnetic shielding measures, so we also carry out modular design to ensure its best anti-interference performance.

4. Analysis of Research Results

The device has self-designed sensor automatic recognition, automatic lifting mechanical structure, is a heavyweight innovation technology to improve the current industry pain points. Independent research and development of industrial quick connector design, the use of independent intellectual property rights of the mechanical structure and electrical connection standards, the existing sensor data into the interface database and interface adaptation can achieve the support of all sensors on the market, according to the monitoring of water quality index needs to select different sensors, so as to achieve plug and play effect. The use of 3D printing technology and laser processing technology to design this mechanical structure, to achieve the free rise or fall of the lifting platform, so that the water quality sensor can also be freely telescoped and lifted out and inserted into the water surface, with better flexibility, can be more efficient and accurate analysis of the water environment in a shorter time, this design is used with the test, greatly improving the service life of the water quality sensor.

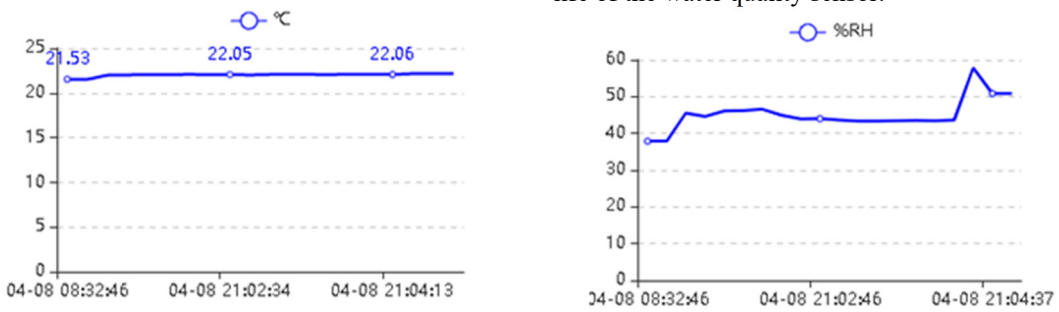

Figure 4. Sorting of test data

The device can realize the monitoring of highly polluted waters, real-time monitoring and analysis of water quality, hydrological conditions and weather information, and upload the obtained analysis data and hull image content to the cloud through the Internet of Things technology. Modular design, with low power consumption, high-performance solar independent power supply, unified sensor interface and other advantages, its small size, suitable for large area distribution, mainly arranged in streams similar to Caishi Creek, to achieve the normal monitoring of river and lake hydrological information, real-time data display, abnormal alarm, data query, data statistics, report generation, etc. Background management and sampling detection and other functions. To achieve automatic video information collection, transmission network, intelligent analysis, to achieve the water quality management of streams, reservoirs, rivers and lakes.

5. Summary and Prospect

Compared with the traditional water environment analysis technology based on the Internet of Things, the detection scheme proposed in this paper achieves multi-scenario adaptation, reduces the cost, improves the efficiency of water quality detection, and solves the common drawbacks of existing water quality detection products such as single function, complex interface and short sensor life. This paper independently designed the sensor interface standard, lifting mechanical structure and other technologies to realize the plug and play of the sensor, increase the service life of the sensor 35%, accelerate the modernization of water management.

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