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Design of Fish Pond Water Quality Detection System based on STM32

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Abstract: The traditional method of manually sampling water quality is time-consuming, labor-intensive, inefficient, and susceptible to external environmental influences. In order to improve the stability and ease of control of fish pond water quality detection, an online water quality monitoring system based on STM32 is designed in this article. The STM32-based fish pond water quality detection system uses the STM32 microcontroller as the core controller and consists of six parts: power supply module, liquid crystal display module, water turbidity sensing module, PH value sensing module, and wireless WiFi module. The test results show that the detection system can realize online detection of target water quality by viewing it on the web page, and can detect the PH value and turbidity of fish pond water in real time. It has the characteristics of low cost, high availability and strong practicability. It is for the realization of fish pond water quality. Pond water quality monitoring and intelligent management provide a better solution and are of great significance to promoting aquaculture.
Keywords: Water quality monitoring; Sensor; STM32; pH; System design

1. INTRODUCTION

At present, China's rapid economic development, people's quality of life gradually improved, but environmental pollution, especially water pollution is increasingly serious, affecting people's daily life. The protection of water resources has gradually become the focus of social attention. According to statistics, the water quality of nearly half of the drinking water sources in cities and towns across the country is not up to standard, highlighting the importance and urgency of water resource protection. [1]Water quality testing is an important indicator of water quality protection, but due to the backwardness of the testing equipment and the lack of intelligence, the testing efficiency and accuracy are limited. For this reason, the introduction of an intelligent water quality testing system to achieve real-time and accurate monitoring[2]is of great significance for the protection of water resources and the promotion of aquaculture. Water is the foundation of aquaculture, each aquatic animal has specific needs for water quality, and a suitable water quality environment is the key to its growth.The development of fishery cannot be separated from the water quality, and the core of intelligent fishery lies in the use of modern information technology, real-time, accurate monitoring and analysis and evaluation of water quality parameters of fish ponds, and then realize the intelligent early warning, promote the development of fishery to the direction of intelligent and efficient [3].Intelligent fishery relies on modern information technology to monitor and analyze water quality parameters in fish ponds in real time, so as to realize intelligent early warning and promote the efficient development of fishery. In addition, the research team has developed a new water quality monitoring technology that combines glass fiber reinforced plastic (FRP) cement material with a circulation system, which can accurately monitor the water temperature, acidity and alkalinity, oxygen content and other indicators. However, it relies on an artificially constructed system, which makes it difficult to adapt to different regions and water quality conditions, especially for rural fisheries with limited resources.

Based on the research of Closed Cycle Aquaculture-Plant Hydroponics Integrated Production System, Zhang Minghua's team at China's Academy of Aquatic Sciences developed a new water quality monitoring technology. The technology incorporates fiberglass cement materials and a recirculation system to comprehensively monitor core indicators such as water temperature, pH, oxygen content and turbidity. However, its limitations lie in its dependence on artificial materials and circulation systems, making it difficult to adapt to different regions and water quality conditions. Especially in rural fish farming, due to limited resources and reliance on natural water sources, it is challenging to popularize the construction of a comprehensive system. In reality, there are too many uncontrollable factors due to different regions and water quality, and most of the rural fisheries are located near the mountains and the water, so it is rare to have such a comprehensive system construction. [4][5]

2. SYSTEM OVERALL PROGRAM DESIGN

This water quality monitoring system for fish ponds consists of two modules: a water turbidity sensor and a pH sensor. The working principle of the water turbidity sensor TS300B is based on the transmission and scattering of light in water. The sensor uses an infrared tube, when the light passes through the water, the turbidity of the water will affect the intensity of the transmitted light, turbid water transmits less light, the intensity of the transmitted light is converted into a current value. By measuring the current, the turbidity of the water can be obtained, and then use ADC analog-to-digital conversion to achieve turbidity detection. The pH sensor is equilibrated with the solution by inserting the probe into the solution and waiting for a few minutes to equilibrate the sensor with the solution. The sensor collects the voltage output from the pH glass electrode, amplifies it and transmits it to the microcontroller for processing, and finally obtains the pH value. Glass electrode internal resistance is extremely high, up to 1012 Ω, it is necessary to choose a high input impedance operational amplifier, the reference electrode selected by the system is a neutral solution, used to control and determine the pH sensor output electrode signal and the relative voltage between the reference electrode. This setup allows the pH sensor to more accurately reflect the acidity and alkalinity of the water body, which in turn provides reliable data support for water quality monitoring and regulation [6].

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The sensor transmits the data to the microcontroller, converts it into physical values and then displays the water quality data through the LCD1602 display. When the set threshold is exceeded, the buzzer alarms. Through the WIFI module, the microcontroller uploads the water quality data to the mobile application in real time to realize remote monitoring.

2.1 System Planning and Modularization

For the water quality monitoring system designed in this paper, after determining the overall planning and distinguishing modules of the system, the STM32 is determined as the core chip after in-depth research and planning. The design system has several key hardware components, including the microcontroller part for core control, the power supply module to ensure the stable operation of the system, the LCD liquid crystal display module for displaying information, the sensor module for measuring the turbidity of the water, the sensor module for detecting the PH value, and the wireless WiFi module for realizing remote communication. Together, these six modules form the core of the designed system, providing the basis for realizing the intelligence of water quality monitoring and management.

2.2 Total Solution Design

The pH value is a measure of the concentration of hydrogen ions in water, and this detection technology is also widely used in industry. Although the commercially available pH detection devices cannot be directly developed for secondary use, there are mature pH detection devices that can be used in conjunction with pH measurement electrodes. These devices are not only low-priced, but also simple and convenient to operate, so they are used. Comprehensive analysis of the above four points concluded that the use of ph value measurement is relatively convenient, intuitive, so the water quality monitoring system indicators using PH value as a measure of detection standards.

GE designed specifically for household appliances TS turbidity sensor, low cost, simple operation, in washing machines, dishwashers and other household appliances, you can effectively detect the turbidity of water, can also be used for industrial control systems, environmental wastewater recycling and other turbidity detection and control applications. The low price of this sensor makes it suitable for development purposes, hence the use of the TS300B.

3. SYSTEM HARDWARE CIRCUIT DESIGN

3.1 Microcontroller Minimum System Module

The STM32F103C8T6 forms the core system of the microcontroller, which is a 32-bit microcontroller based on the ARM Cortex-M core and belongs to the STM32 family. This microcontroller offers excellent performance with a program memory capacity of up to 64KB, capable of storing large amounts of programs and data. It has a wide range of operating voltages from 2V to 3.6V to accommodate different application requirements.The STM32F103C8T6 has excellent temperature stability and operates in extreme temperature conditions from -40°C to 85°C.

3.2 Liquid Crystal Display Module

Character LCD module is a kind of dot-matrix LCD, when choosing this kind of module, usually consider a variety of different specifications, such as the common 16 × 1, 16 × 2, 20 × 2 and 40 × 2, etc.LCD1602 this kind of liquid crystal display, its internal controller is mostly used HD44780 model, this controller is powerful, not only can clearly display the English alphabet, Arabic numerals, but also supports Japanese katakana and commonly used symbols.

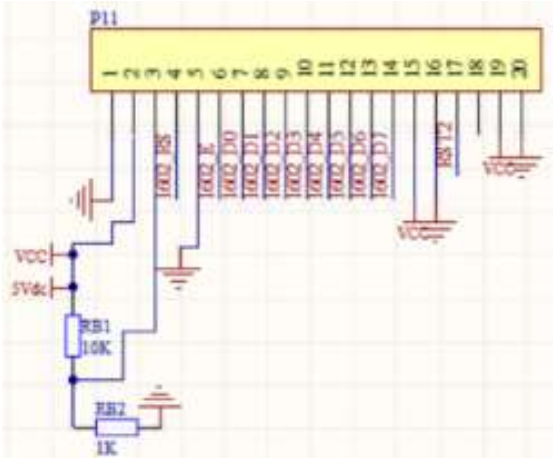

Figure.1 LCD1602 Circuit Diagram

3.3 Water Turbidity Sensor Module

Turbidity is a key indicator of water quality testing, reflecting the number of impurity particles in the water and affecting the clarity of the water. The more particulate matter in the water, the lower the transparency, the more turbid the water. The degree of turbidity is related to the refraction coefficient of light in water, the worse the water quality, the less light passing through. The role of the photosensitive sensor is to convert the received light intensity into a quantitative signal, through a specific formula conversion, the electrical signal is converted into the corresponding turbidity information, which provides us with a quantitative basis for assessing the water quality condition [7].

The module integrates analog and digital output interfaces to facilitate water quality monitoring. The analog output interface reflects the turbidity of the water in real time and provides accurate turbidity data by connecting to the A/D converter of the microcontroller for analog-to-digital conversion. The digital signal output interface is used to trigger the response action, by adjusting the potentiometer to set the turbidity threshold.The water turbidity sensor is based on the principle of light scattering and absorption. When light passes through a liquid, the scattering and absorption phenomena change the intensity of the light, the higher the turbidity of the liquid, the greater the degree of light scattering. The sensor calculates the turbidity by measuring the intensity of unabsorbed light. When the turbidity reaches the set threshold, the module will trigger a buzzer alarm or record data to realize real-time monitoring and control of water quality.

3.4 PH Sensor Module

The working principle of the pH sensor is mainly based on the chemical properties of the glass electrode, which consists of three core components: the glass membrane, the internal reference solution and the Ag/AgCl reference electrode. When the glass electrode is immersed in a body of water, its special glass membrane allows selective transmission of hydrogen ions from the water to the inner side of the electrode. Due to the selective permeability of the glass membrane to hydrogen ions, the difference in the concentration of hydrogen ions between the inner and outer sides results in a change in the potential of the glass electrode. This change in potential can be processed and converted to generate a standard electrical signal.

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The reference electrode also plays a role in the measurement process of the pH sensor. Its potential remains stable throughout the measurement process, providing a potential reference for the measuring electrode and thus ensuring the accuracy of the measurement. By comparing the potentials of the measuring electrode and the reference electrode, the pH value of the water body can be obtained.

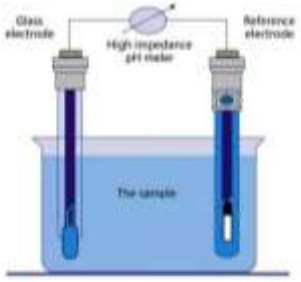

Figure. 2 PH Sensor Schematic

The core function of the pH measurement module is to capture the electrical signal generated by the pH glass electrode. This electrical signal is first enhanced by a signal amplifier and then transmitted to the microcontroller for detailed data processing. The microcontroller uses its built-in algorithms and programs to finely parse and accurately calculate these voltage signals to produce an accurate pH value.

4. Software Programming

4.1 Overall system programming

An integrated system is constructed based on STM32F103C8T6 microcontroller. The system mainly includes the main program, pH measurement, water turbidity measurement, liquid crystal display and wireless data transmission and other modules. pH measurement module and water turbidity measurement module in the acquisition of sensor signals, need to go through the analog-to-digital conversion (AD conversion) link, for subsequent data processing. In order to realize the remote transmission of data, the wireless WIFI data transmission module adopts serial communication to ensure accurate and efficient data transmission. Overall, the modules work together to form a water quality monitoring system.After connecting the power supply, the system and the modules begin to initialize, the corresponding module begins to collect data and then converted by the analog-to-digital converter, respectively, the data will be transmitted to the microcontroller, shown through the display, and then through the wifi module will be transmitted to the cell phone or web page side of the numerical value, in which if it exceeds the threshold value, the buzzer will start the alarm, and if it does not exceed the threshold, it will be transmitted by the normal collection, and the final process is finished. According to the analysis, the flow chart of the program is as follows.

Figure. 3 master flow chart

4.2 Water Turbidity Sensor Programming

First of all, after power on, the system, IO ports, etc. initialization, the sensor probe began to collect information, detect whether the threshold is exceeded, more than then the system responds accordingly, and finally the data is transmitted to the microcontroller, through the display show up.

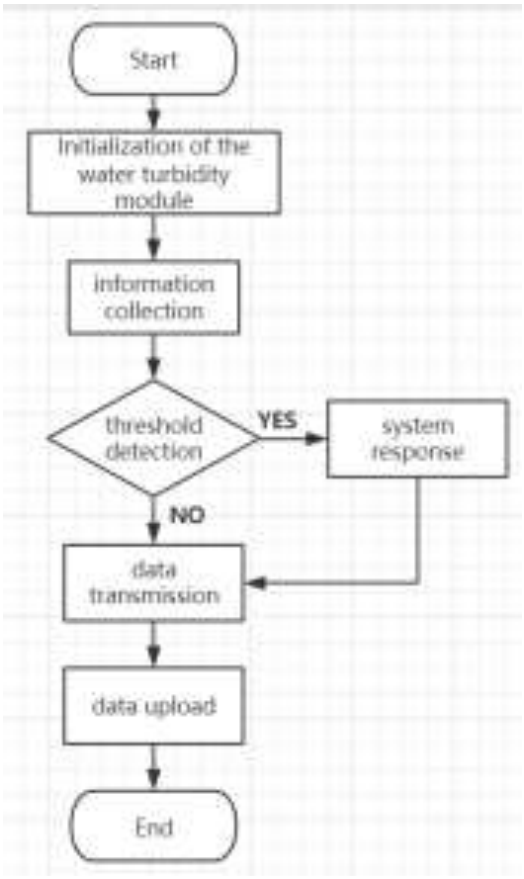

Figure. 4 Water Turbidity Program Flowchart

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```
shuizhi = 3291.3 - 865.68 * (GetADCResult(hzdao, 0) / 4096.0 * 3.3
if (shuizhi < 600)
  shuizhi = 0;
else
  shuizhi -= 600;
```

Figure. 5 Water Turbidity Information

4.3 Programming of PH value module

The main function of the PH value detection module is responsible for collecting the PH value of water quality. It consists of two key components, the electrode and the transmitter, which work together to accomplish the detection task. In the detection process, the module measures the hydrogen ion concentration in the water with the help of a glass tube, and then converts this concentration data into an outputable digital signal through the internal circuit system for subsequent data processing and analysis [8]. The signal is then transmitted from the output to the microcontroller, thus completing the entire detection process.

```
shuizhi = 3291.3 - 865.68 * (GetADCResult(hzdao, 0) / 4096.0 * 3.3
if (shuizhi < 600)
  shuizhi = 0;
else
  shuizhi -= 600;
```

Figure. 6 Getting the PH value

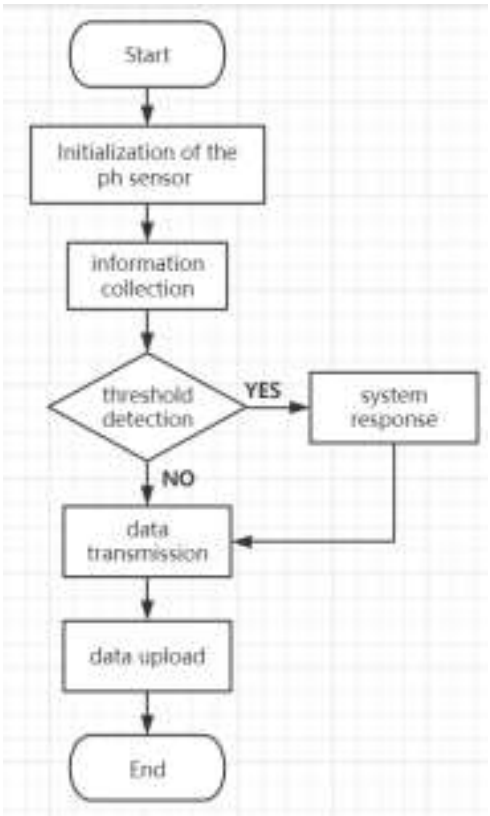

Figure. 7 PH module program flow chart

4.4 WIFI transmission module

The original serial port can only send a single character, in order to send a string, a program needs to be written to extend its function. First of all, the WiFi module starts initialization after powering on, detects whether the network is connected successfully or not, and if it is successful, it acquires real-time data through MQTT protocol and transmits it to the microcontroller. The data is transmitted to the web page through the ESP8266 module, the two sensors at the front end collect the data and store them, and the ESP8266 then uploads these data to the web page. At the same time, the user can view the data in real time through the cell phone APP. The technology encapsulates the HTML webpage into an APP, and users can directly access the webpage content through the APP without a browser. This APP is actually an application based on WebView, which is a key component in the Android system for displaying web content inside the application. During data transmission, the collected data and its meaning are filled into the character array one by one. Then through the MQTT protocol [9], the character arrays will be encapsulated into packets. Finally, these packets will be sent to the web page through the ESP8266 module.

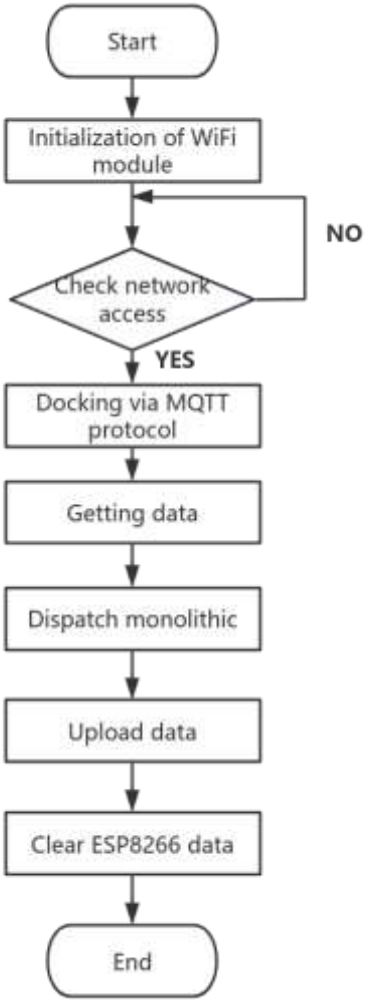

Figure. 8 WiFi transmission module program flow chart

5. CIRCUIT HARDWARE ASSEMBLY AND SYSTEM DEBUGGING

This smooth should be followed as much as possible during the soldering process in the programming and program debugging stage, Keil uVision5 software was used as the development tool. After the debugging process, once the program runs without any misunderstanding to generate hex file. The compiled code is downloaded to the actual hardware for functional testing. After testing and verification, the results show that the system functions well, the screen is able to present the required prompts and status updates, and the sensors work properly to perform their intended functions. The turbidity and pH values exceeded the threshold values accurately, the alarm light came on after exceeding the threshold values, and the monitored data information was sent to the cell phone. The function of the water turbidity sensor is also equally normal, and can effectively detect changes in the total amount of suspended solids in the water. At the light receiving end, the intensity of the light is converted into the magnitude of the current. If the light is very strong, the current becomes larger; if the light becomes weak, the current becomes smaller. This conversion allows the light signal to be turned into an electrical signal.

6. CONCLUSION

In practical application, water quality monitoring system is undoubtedly an indispensable part of aquaculture. Therefore, it is very important to develop a set of water quality monitoring system with intelligent management, low cost, high performance and high reliability. Such a system not only helps to improve the efficiency of aquaculture, but also ensures the safety of water quality in fishponds, which is of far-reaching significance to the sustainable development of the whole aquaculture industry, but there are still shortcomings. In particular, when the area of the monitored waters is more complex, it may be difficult to grasp the water quality condition of the whole waters comprehensively and objectively. Moreover, water quality conditions may vary at different depths. Therefore, when carrying out water quality monitoring, the size of the water area and changes in the depth of the water body must be fully taken into account, so as to be able to obtain more accurate and comprehensive water quality data in order to better understand the overall situation of the water.

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