10.18686/aitr.v2i2.4009

The Design of an Intelligent Aquarium Management System

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Abstract: The comprehensive intelligent aquarium management system designed and implemented in this paper meets the diverse needs of aquarium management. The system includes functions such as automatic water change, temperature control, automatic water replenishment, light adjustment, timed feeding, oxygen supply, manual control, data display, and remote monitoring, providing users with comprehensive and convenient management capabilities. Through intelligent control strategies and a WIFI module, the system achieves comprehensive monitoring and precise control of the aquarium environment, allowing users to remotely monitor and control via a smartphone application at any time. Strict experimental verification ensures the stability and reliability of the system, meeting the practical needs and application scenarios of aquarium farming.

Keywords: Aquarium; STM32; Sensor

Introduction

In today's rapidly advancing era of Internet and IoT technologies, smart homes have become an integral part of people's lives. As a component of the smart home ecosystem, aquariums have also garnered increasing attention. Given the existing issues in traditional aquarium maintenance, the development of intelligent aquarium control systems holds significant importance[1]. While there are already smart aquarium monitoring products on the market, inconsistencies in technical standards and product performance persist. Consequently, the development of a stable, feature-rich, and user-friendly aquarium control system has become a focal point in the field of smart homes.

1. Related Work

This design employs a microcontroller as the core controller, along with other modules, to constitute the entire system[2]. This includes the central control part, input part, and output part. The central control part utilizes a microcontroller as its controller, primarily responsible for acquiring data from the input part, processing it internally, making logical judgments, and ultimately controlling the output part[3]. The input part consists of seven components: the first part is the water quality and temperature detection module, which detects water quality; the second part is the waterproof temperature detection module, which detects water temperature; the third part is the water level detection module, which detects water level; the fourth part is the light intensity collection module, which detects illumination values using a photosensitive resistor; the fifth part is the voice recognition detection module, which controls water replacement, heating, cooling, water addition, feeding, oxygenation, supplementary lighting, and mode switching through voice recognition; the sixth part is the button module, which enables interface switching, threshold setting, mode switching, etc.[4]; the seventh part is the power supply module, which provides power to the entire system. The output part consists of three components: the first part is the lighting module, which provides supplementary lighting; the second part is the display module, which displays monitored data and set thresholds; the third part is the relay module, which controls water replacement, heating, cooling, water addition, feeding, oxygenation, and mode switching via six relays. Additionally, the WIFI module serves as both input and output. It connects with a smartphone to transmit monitored data to the user's phone, allowing users to control the operation of the relays and switch modes through the smartphone[5]. The specific system diagram is shown in Figure 1.

The design of the aquarium management system mainly includes the following parts:

(1) System hardware design: Selecting a suitable hardware platform for the intelligent aquarium control system, including the main control chip, sensors, actuators, etc. Designing the circuits required for the system, including power supply circuits, sensor interface circuits, actuator control circuits, etc. Conducting PCB board wiring and design to ensure the stability and reliability of the hardware circuits.

(2) System software design: Designing the software architecture of the system, including the main control program, sensor data acquisition program, user interface program, etc. Writing program code for each module of the system to implement various functions of the intel-

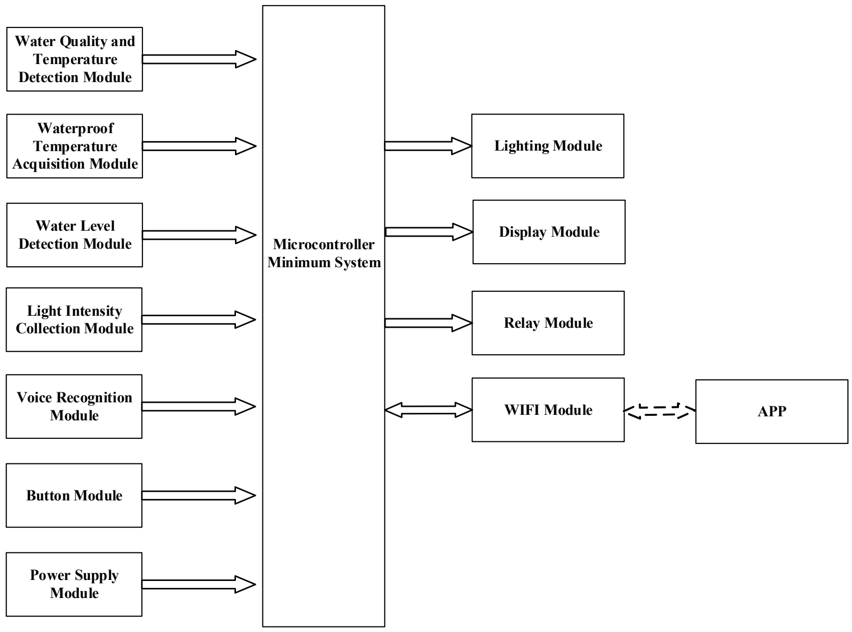

Figure 1: System Diagram

ligent aquarium control system.

2. Hardware System Design

2.1 The main control chip

The STM32F103C8T6 microcontroller manages the primary control logic processing of the system. Through programming, it enables functions such as temperature monitoring, water level detection, and water quality control to maintain optimal conditions within the aquarium. It intelligently controls the system based on preset conditions and user requirements to ensure stable operation. Additionally, it handles data acquisition and processing by connecting various sensor modules, such as temperature and water level sensors, to collect real-time data. This facilitates real-time monitoring, data recording, and analysis of the aquarium's status, supporting subsequent control decisions. The microcontroller also governs external devices. The STM32F103C8T6 Microcontroller Circuit Diagram as shown in Figure 2.

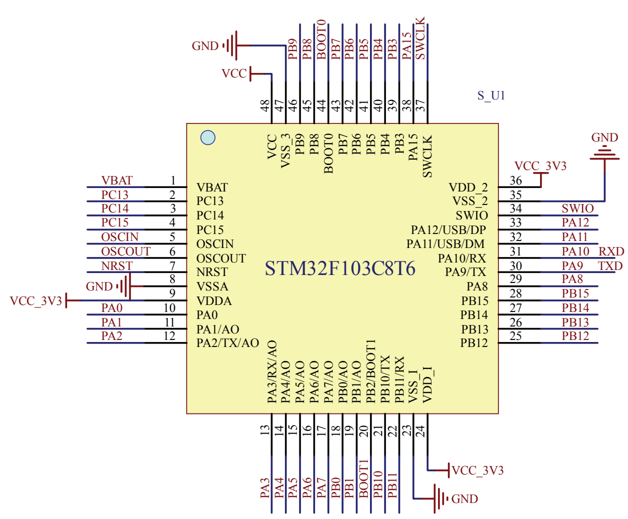

Figure 2: STM32F103C8T6 Microcontroller Circuit Diagram

2.2 Sensor Design

The aquarium management system includes a TDS sensor, measuring the total amount of dissolved mineral salts in water, indicating its impurity content. A DS18B20 temperature detection chip monitors temperatures ranging from -55℃ to 125℃ , with an accuracy of ±0-4℃ . The YW_01 liquid level sensor detects water levels using exposed parallel conductor traces, converting them to analog signals readable by the MCU's AD function module.

2.3 Communication Module Circuit Design

ESP8266-12F is a powerful Wi-Fi chip module suitable for various IoT and embedded system applications. It features a built-in Tensilica L106 32-bit microcontroller core, operating at up to 80MHz, with 4MB of flash memory and 64KB of RAM, capable of supporting complex applications and data processing. Additionally, ESP8266-12F integrates various communication interfaces, including UART, SPI, I2C, etc., facilitating data exchange and communication with external devices. This provides it with good flexibility and scalability when connecting sensors, actuators, and other devices.

2.4 Communication Module Circuit Design

SU-03T Offline Voice Module is a hardware device based on digital signal processing technology, featuring functions such as natural language voice recognition and text-to-speech synthesis. It does not rely on cloud services but performs voice recognition and synthesis directly on the device, providing advantages in response speed, stability, and security.

3. Software System Design

The software system consists of three parts: central control, input, and output. The central control part utilizes a microcontroller as the controller, mainly responsible for acquiring input data, performing internal processing, logical judgment, and ultimately controlling the output. The input part is divided into seven modules: water quality and temperature detection, waterproof temperature detection, water level detection, light intensity collection, voice recognition, button control, and power supply. The output part includes the lighting module, display module, and relay module. Additionally, the WIFI module serves as both input and output, connecting to a smartphone to transmit monitoring data to the user's mobile app. Users can also control the operation of the relays and switch modes through the smartphone app. The overall design key code as depicted in Figure 3.

```
  Oled_ShowString(1,6,"WIFI ");
  Oled_ShowCHinese(2, 2, "初始化中");
  ESP8266_Init();
  while(Aliyun_DevLink())
  Delay_ms(500);
  Aliyun_Subscribe(topics_set, 1);        /.
  Aliyun_Send_Data();
Oled_Clear_All();
  while(1)
  {
      Key_function();
      Monitor_function();
      Display_function();
      Manage_function();

      time_num++;
      Delay_ms(10);
      if(time_num %10 == 0)
          LED_SYS = ~LED_SYS;
      if(time_num >= 5000)
      {
          time_num = 0;
      }
  }
```

Figure 3: Overall Design Key Code

3.1 Sensor Software Design

First, initialize the pins and DS18B20. Send commands to start temperature conversion. After a delay, reinitialize DS18B20 and issue a read scratchpad command to retrieve temperature data. Integrate the data and calculate temperature using a formula. The YW_01 liquid level sensor operates using either pressure sensing or capacitance principle. In pressure sensing, rising liquid level increases pressure on the sensor, converting it into an electrical signal. In capacitance principle, the change in capacitance between liquid and sensor is measured and converted into an electrical signal to determine liquid level height. The Sensor Key Code as shown in Figure 4.

4. System testing

Connect DS18B20 temperature sensor, water level sensor, fan, servo motor, heating rod, water pump to the STM32F103C8T6 control board to collect relevant data information. Display the current data in real time through the LCD display screen, and also enable monitoring through a mobile app. After the system is powered on, the display screen shows four lines of data: the first line displays real-time temperature and light intensity values, the second line displays real-time water level, the third line displays real-time turbidity, and the fourth line displays the system mode and which relay is being controlled. The mobile app also displays real-time data. The System Test Diagram as shown in Figure 5.

```
    DS18B20_Start();
    DS18B20_RST();
    DS18B20_Check();
    DS18B20_Write_Byte(0xCC);
    DS18B20_Write_Byte(0xBE);
    TL = DS18B20_Read_Byte();
    TH = DS18B20_Read_Byte();

    if(TH>7)
    {
            TH=~TH;
            TL=~TL;
            temp=0;
    }else temp=1;
    tem=TH;
    tem<<=8;
    tem+=TL;
    tem=(float)tem*0.625;
    if(temp)return tem;
    else return -tem;
}
```

Figure 4: Sensor Key Code

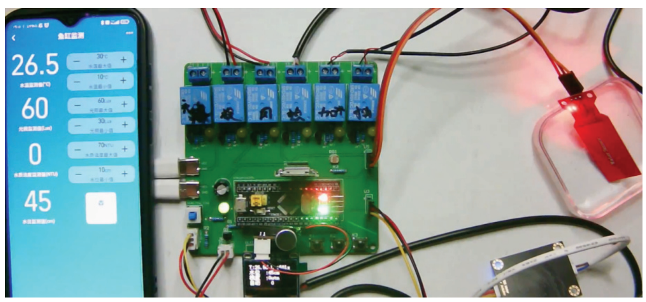

Figure 5: System test diagram

5. Conclusion

The comprehensive intelligent aquarium management system outlined in this paper effectively caters to the diverse requirements of aquarium upkeep. Offering features such as automated water replacement, temperature regulation, light adjustment, scheduled feeding, oxygen provision, and remote monitoring, the system empowers users with comprehensive and user-friendly management functionalities. Leveraging intelligent control strategies and a WIFI module, it ensures thorough monitoring and precise control over the aquarium environment, enabling users to oversee and manage their aquarium remotely via a smartphone application. Rigorous experimental validation guarantees the stability and reliability of the system, perfectly aligning with the practical demands and operational contexts of aquarium maintenance.

References

[1] Zhao ZJ. Design and Implementation of Remote Controllable and Communicable Aquarium Based on Internet of Things [D]. Hebei North College, 2017: 1-6.

[2] Zhao FQ, Zhang CX, Liu Q (Eds). New Technologies in Ornamental Fish Farming. Beijing: China Social Sciences Press, 2005: 3-7.

[3] Zhang FP. Design of Intelligent Aquarium Remote Monitoring System [D]. Southwest Jiaotong University, 2018: 1-5.

[4] Ding JY. Interaction Design Research of Smart Home Aquarium System Based on CUBI User Experience Model [D]. Shandong University, 2018.

[5] Yang TT. Design on Educational Administration Management System based on SSH Framework [J]. Volga Archaeology, 2019, 30(4).