Circular Economy: Integrated Design of Fish Tank- Flower Nursery

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Abstract. The internet of Everything has come into reality. Smart home has entered our life and changed our life style. Using traditional methods, consumption of time and labour needs to be considered for family breeding and conservation. Based on analysis and research on the application status of household flower nursery and aquarium equipment, an integration fish tank-flower nursery ecosystem was designed. An interaction between aquarium automatic water exchange maintenance and automatic watering system of flowers and plants can be designed via several techniques, where contains single-chip computer technology, open source Arduino technology and multi-sensor fusion technology. Furthermore, the goal of recycling of water can be fulfilled by using the rich water of fish culture to water flowers. Experiments show that the integrated ecosystem can replace the traditional manual maintenance, save resources and bring people a better home experience.

1. Introduction
With the progress of science and technology and the continuous improvement of living standards, people continue to pursue a better home environment. The cultivation of ornamental fish and various flowers and plants can not only beautify the environment, but also cultivate one's own temperament so that people can release their pressure and feel comfortable at home after a whole day of intense work. In developed countries such as Europe and America, the popularity rate of family aquarium has reached 20-33%. In China, the annual consumption growth rate of aquarium industry has exceeded 40% [1], and the annual consumption growth rate of flowers and plants has exceeded 50%.

The improvement of people's living environment is often accompanied by the consumption of more social resources. Under a situation that global resources are increasingly exhausted and environmental pollution is more and more serious, the more green and low-energy work and life style is the inevitable requirement of this era for us. However, the traditional maintenance of family plants and fish is time-consuming and laborious. Due to the lack of maintenance knowledge and improper management of most ordinary families (i.e., family travel or business trip), it cannot be guaranteed to provide a suitable living environment for the plants and fish in the flower garden, resulting in the withering or drowning of the plants and the death of the fish due to the deterioration of the water quality environment [2].

At present, researches on fish farming in family aquarium and automatic watering and maintenance of flowers and plants has been quite mature, but both of them are based on the design and research of two independent systems, which are FishBit intelligent aquarium ecological monitoring system, various intelligent flowers and plants watering system, etc. Therefore, it is of great significance to design a system that integrates and interacts the intelligent water quality management of fish tank and
the intelligent maintenance system of flower garden to realize the recycling of water. Inspired by the idea of product system design, Smart phones, water quality monitoring, soil temperature, humidity monitoring and other sensors are regarded as carriers. This paper constructs a fish tank- flower garden integrated ecosystem with easily operations and designs corresponding applications and supporting hardware products to help users to solve the problems of water quality management and soil humidity management in family fish farming and improve the user experience.

2. Overall function and structure of the system

Fish tank- flower garden integrated ecosystem consists of three sections, where the first one is fish tank intelligent water quality monitoring and management subsystem, the second one is flower garden soil automatic monitoring and watering subsystem, the last one is mobile application. The relationship between them is shown in Figure 1.

![Figure 1. Diagram of aquarium-nursery ecosystem](image)

Through monitoring, the fish tank subsystem will make the water which is not meet the requirements of fish growth flow into the water storage, meanwhile, it injects the ecological water that meets the requirements. In the flower garden subsystem, the spraying device starts as long as the soil humidity below the standard. The spraying device starts as long as the soil humidity below the standard. Fish rich water is used to irrigate the flowers and plants under appropriate conditions so as to realize the recycling of water resources.

The intelligent detection hardware of the fish tank and flower garden subsystem can be connected to the mobile app through Bluetooth. Hence, the user can set the parameter limits of each subsystem through the mobile phone, meanwhile, the water quality and soil related data can be obtained. The information of water quality of fish tank and soil state of flower bed can be presented to the user in the form of on-site display and app so that the user can know the water quality and soil state in time, and take corresponding measures to ensure the safety of fish, flowers and plants.

3. System hardware design

3.1. Garden subsystem

The flower garden subsystem is a system constructed by 8-bit single-chip microcomputer STC89C52, where its architecture is shown in Figure 2. The whole function is composed of environment parameter acquisition module and control module. The environmental parameter acquisition module detects the
soil humidity, soil temperature and other parameters in the flower bed through various terminal sensors [3]. The controller analyzes and processes the collected data [4], which is displayed in real time on site and transmitted to the mobile app through the Bluetooth module. According to the data analysis and processing results, the controller intelligently decides whether to water under appropriate conditions.

Y1-69 is used to detect soil moisture in the flower garden subsystem. The principle of the sensor is humidity sensitive capacitance. The capacitance is proportional to the soil moisture. It has the characteristics of high sensitivity and fast response. As a soil temperature sensor, the resistance of the thermistor is inversely proportional to the soil temperature. The nixie tube is displayed as a parameter, the limit value of professional plant soil temperature and humidity is preset by pressing the key, and the collected soil humidity value is compared with the preset limit value of soil humidity [5]. When the soil humidity value is lower than the preset lower limit value, the system controls the water storage part to water through the control relay, and the buzzer will send out a synchronous alarm tone. When the system detects that the soil moisture value reaches the set upper limit through the soil moisture detection device, the system controls the relay again to control the watering system to stop watering. According to the parameters of soil temperature and humidity, the system water under suitable conditions to avoid the transpiration of plants [6], which is conducive to plant growth.

The analog quantity information measured by y1-6 soil humidity sensor and soil temperature sensor is converted into digital quantity by ADC0832 which has two analog quantity inputs after conditioning circuit.

3.2. Fish tank subsystem

The aquarium subsystem is a system based on Arduino single chip microcomputer with open source code. The system architecture is shown in Figure 3, which is composed of environment parameter collection module, control module and Bluetooth communication module. Arduino single chip microcomputer has digital interface and analog interface, and it supports SPI, IIC, UART and other communication modes. It can connect various types of sensors, which has rich library functions, as well as convenient programming characteristics.
The analog port A1 of Arduino is connected with the PH value sensor produced by the DFROBOT to detect the PH value of water. When the PH value exceeds the set limit, the water change operation is started: turn on the relay 1, and the water pump will pump the rich water in the fish tank into the water storage equipment through the preset pipeline. At the same time, the water level sensor connected with the analog port A0 of Arduino monitors the current water level. When the water level of the fish tank reaches the set point, the system stops injecting water, and relay 2 opens. The water solenoid valve starts to inject the prepared ecological water for fish farming. When the water level of the fish tank reaches the set upper limit, the water stops. At this time, if the pH value test result is still not up to the standard, the system will automatically repeat the above water change operation again until the pH value is up to the standard. The analog parameters collected by the system sensors are processed by the internal integrated A/D conversion module of Arduino, without the need to expand the A/D conversion chip.

![Diagram of fish tank hardware](image)

**Figure 3. Hardware block diagram of fish tank**

### 3.3. Bluetooth module

Bluetooth technology [7] establishes a relatively close wireless connection for mobile and fixed device communication environment, which can easily establish network connection. It can also carry out data communication or access the Internet through mobile terminals [8]. The system uses the British CSR company hc-05 Bluetooth module which relies on Bluetooth specification v2.0 with EDR Bluetooth protocol data transmission module. The working frequency band is 2.4ghzism, and the maximum transmitting power is 4dbm. The PCB antenna on board can realize 10 meter distance communication. The module supports UART, SPI, USB and other interfaces. Moreover, it supports spp Bluetooth serial port protocol and contains the function of integrating master and slave. It can connect 7 devices [9]. Since the system can set the mode to wireless transmission mode when initializing through UART transmission layer interface, Bluetooth can be realized The raw data received by the module is directly output through UART [10].

The hc-05 module is connected with the serial port of single chip microcomputer and arduino respectively. The connection mode of system Bluetooth module is shown in Figure 4.
4. System software design

4.1. System software structure
Two subsystems of fish tank and flower garden are programmed independently. The aquarium subsystem uses IDE, which is a professional Arduino development tool, to write and develop the system program besides ISP online programming. Arduino has rich library functions, which is very convenient for the realization of system functions. The system uses C++ programming language to obtain pH value and water level sensor value respectively by calling analog quantity collection library function. The pH value sensor is collected every 1 second, and the program is as follows:

```c
void loop()
{
  static unsigned long timepoint = millis();
  if(millis()-timepoint>1000U){
    timepoint = millis(); // time interval: 1s
    voltage = analogRead(PH_PIN)/1024.0*5000; // read the voltage
    phValue = ph.readPH(voltage); // convert voltage to pH
    Serial.print("^C pH:");
    Serial.println(phValue, 2);
  }
  ph.calibration(voltage, temperature); // calibration process by Serial CMD
}
```

The flower garden subsystem is programmed by C language and debugged by keil uvisin4. The main flow diagram of fish tank and flower bed subsystem is shown in Figure 5.
4.2. Mobile app

Users can realize the real-time monitoring and artificial control of the aquarium garden system through the mobile app.

Before Bluetooth 4.0, communication was realized through socket socket. When one-to-many master-slave communication was realized, polling mode was adopted, which greatly increased the power consumption of both sides of communication, and increased the interference factors, making the communication unreliable. The system uses the form of broadcast packet to inform the host [11]. There are two subsystems that collect the soil parameters of field flower garden and any other parameters which can be written into the broadcast packet bytes, respectively. Then, information of mobile APP can be uploaded in terms of broadcast packets within a specified time. It can also greatly reduce the consumption of the system energy since other time is at a sleep state.

The mobile app interface is shown in Figure 6. When the user connects the circuit as shown in Figure 4, turn on the Bluetooth of the mobile phone, the pairing code is the same (the default is 1234), that is, the baud rate is the same, and the connection can be automatically made after power on. After the user connects successfully, the current pH value can be obtained in the mobile phone interface, and the water can be changed manually, and the current liquid level can be obtained during the water change.

5. Conclusion

Through the interaction of human, flower and fish tank information, the fish tank-flower garden system realizes the seamless connection between the scientific maintenance of plants and the efficient utilization of water resources. A fish tank flower garden ecosystem can also be well designed. After a period of operation, the measurement data error is small, the operation is stable, and the system has a very reliable utilization effect. Our system, instead of manual system, can be automatic operated, which integrates flower garden watering and fish tank water exchanger. It can also make fish and flower garden plants complementary symbiosis [12] and achieve the goal of saving green energy. The design of the system is based on the small family life scene, which reduces the difficulty of breeding and maintenance and improving the fun [13]. At the same time, the design has been improved to some extent, such as changing Bluetooth communication to WiFi, which brings people greater convenience. It can also be used in agricultural production to make agricultural production intelligent and realize the modern "Sangji fish pond" [14] agricultural mode.
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