

# Design of an Automatic Watering System for Household Potted Plants Based on the Internet of Things

Deng Yun<sup>1,a,\*</sup>, Tao Ye<sup>1,b</sup>, Luo Shunan<sup>1,c</sup>

<sup>1</sup>University of Science and Technology Liaoning, Anshan, China  
<sup>a</sup>3091576143@qq.com, <sup>b</sup>38045746@qq.com, <sup>c</sup>1026485105@qq.com  
\*Corresponding author

**Abstract:** This paper designs and implements an automatic watering system for home potted plants based on the Internet of Things. The system can monitor the relevant parameters of the potted plant growth environment in real time, support local and remote control, and automatically complete operations such as irrigation, light supplementation, and cooling according to preset thresholds. It is equipped with functions such as abnormal alarm and parameter customization to meet the maintenance needs of different potted plants. The system realizes the automation and intelligence of home potted plant maintenance, reduces manual intervention, saves water resources, and is suitable for scenarios such as homes and offices. It provides a practical solution for intelligent potted plant maintenance and also offers practical reference for the application of smart home scenarios.

**Keywords:** Smart Home; Automatic Watering; Potted Plant Maintenance

## 1. Introduction

With the upgrading of living standards and the rapid development of smart home technologies, the demand for intelligent maintenance of potted plants has grown increasingly urgent<sup>[1]</sup>. Conventional manual watering methods are not only time-consuming and labor-intensive with poor precision, but also liable to cause water waste, thus failing to meet the current requirements for potted plant maintenance. To address this issue, this paper designs and implements an IoT-based automatic watering system for household potted plants. The system is capable of real-time monitoring of the environmental parameters of potted plant growth and automatically executing operations such as irrigation, light compensation and temperature reduction<sup>[2]</sup>. It also supports both local and remote control, and can be adapted to the maintenance needs of different types of potted plants, effectively overcoming the various shortcomings of manual maintenance<sup>[3]</sup>. Featuring high practicability and wide adaptability, the system boasts considerable value in production, popularization and application within the field of intelligent potted plant maintenance.

## 2. Overall Design of the Automatic Watering System for Household Potted Plants

The designed system consists of an STM32F103C8T6 microcontroller, a soil humidity sensor, a temperature sensor, a light sensor, an LCD display module, a micro water pump, a cooling fan, an LED light compensation lamp, an audible and visual alarm module, a WIFI communication module and a key control module. Among them, the temperature detection module, light detection module, buzzer module, humidity detection module, key module and display module jointly form the perception layer of the system; the WIFI communication module constitutes the transmission layer; and the mobile phone APP serves as the application layer. The corresponding system architecture diagram is shown in Figure 1.

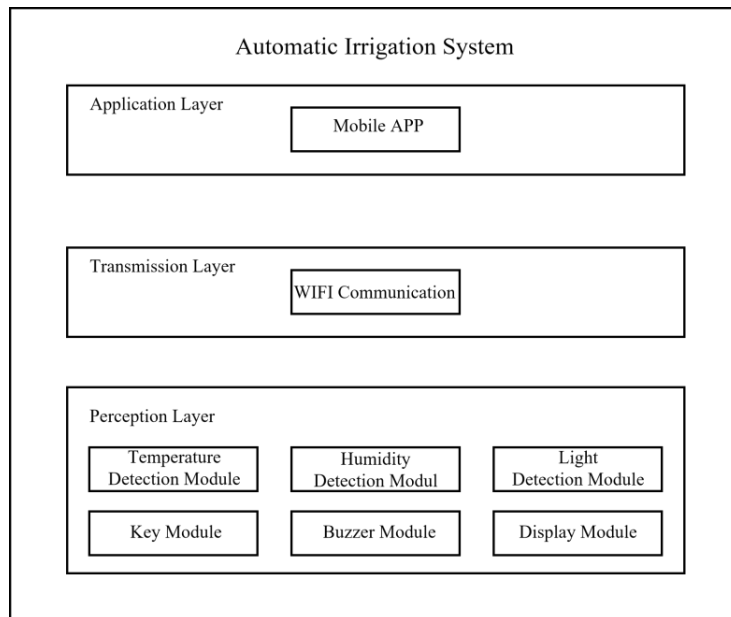


Figure 1: System Architecture Diagram

### 2.1. System Hardware Design

With the STM32F103C8T6 microcontroller as the core, the hardware of this system is divided into core control, execution drive, wireless communication and other modules by function<sup>[4]</sup>. The selection of each module takes both practicability and cost performance into account; the circuit design follows standard specifications and the architecture adopts a modular design<sup>[5]</sup>. The hardware fully supports environmental monitoring for potted plant maintenance, automated execution, local interaction and remote communication, featuring stable overall connection and good coordination, and is adaptable to the deployment requirements of intelligent potted plant maintenance in multiple scenarios<sup>[6]</sup>. The physical map of the corresponding system hardware is shown in Figure 2.

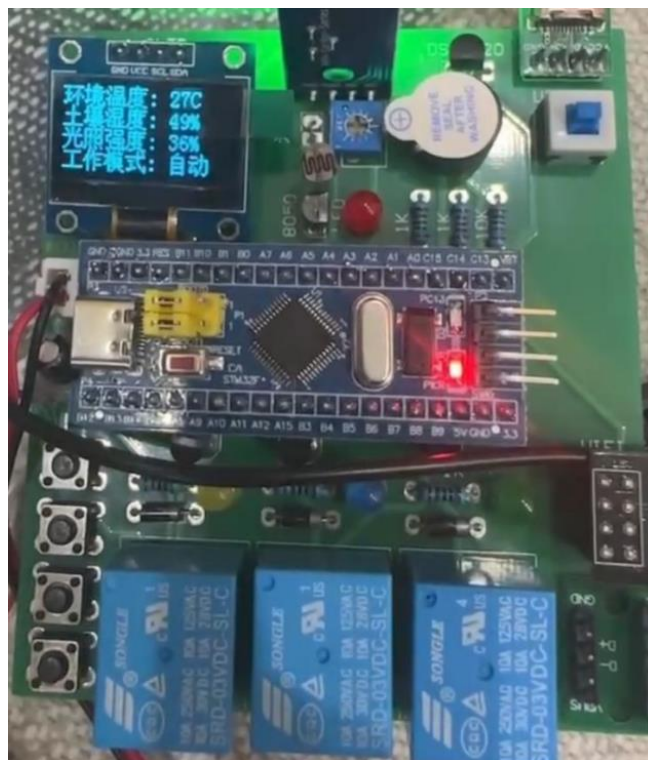


Figure 2: Physical Prototype of the System Hardware

### **2.1.1. Core Control Unit**

The STM32F103C8T6 single-chip microcomputer is selected as the core control unit of the system in this project, and the DS18B20 temperature sensor, YL-69 soil humidity sensor, 5528 photoresistor and water level sensor are adopted for the sensing and detection module. The core control chip features a high operation speed and abundant peripheral interface resources, and all types of sensors boast high detection accuracy, fast response speed and strong adaptability<sup>[7]</sup>. Relying on the excellent performance of the hardware, the system can achieve accurate and real-time collection of environmental temperature, soil moisture content, light intensity and water volume in the water storage container, and simultaneously complete core tasks such as data logical operation and control instruction issuance. This provides a stable and reliable main control support and accurate environmental data basis for the coordinated and linked operation of all system modules<sup>[8]</sup>. In addition, a crystal oscillator circuit and a reset circuit are specially designed for the core chip, which further ensures the stable startup and continuous high-efficiency operation of the hardware system.

### **2.1.2. Execution and Drive Module**

For the execution and drive module of the system in this project, a micro water pump, a cooling fan and an LED light compensation lamp are selected; for the human-computer interaction module, an LCD1602 display module, physical keys and an audible and visual alarm module are adopted<sup>[9]</sup>. All types of execution devices have the characteristics of sensitive response, accurate action and low energy consumption, while the human-computer interaction components feature clear display, convenient operation and intuitive alarm prompts. The use of relays enables the control of high voltage with low voltage, which effectively improves the operational safety of the hardware. Relying on the excellent performance of such hardware, the system can automatically complete potted plant maintenance actions such as irrigation, temperature reduction and light compensation according to the instructions from the core control unit. At the same time, it realizes the real-time local display of monitoring data, the custom adjustment of system modes and maintenance parameters, as well as timely local reminders in case of abnormal environmental parameters and insufficient water volume, which comprehensively guarantees the automation and convenience of potted plant maintenance.

### **2.1.3. Wireless Communication Module**

The WIFI communication module is selected as the wireless communication module of the system in this project. This module features a high transmission rate, strong communication stability and high civil applicability, and can interface with the STM32F103C8T6 microcontroller efficiently and accurately. Relying on its excellent communication performance, it can build a wireless data link between the system and the mobile APP, realizing the remote upload of monitoring data and the remote issuance of control instructions, and providing convenient hardware communication support for users' remote monitoring and remote control. Meanwhile, all hardware modules adopt standardized circuit design and accurately interface with the GPIO ports of the core control unit. The overall hardware architecture has a high degree of modularization, facilitating assembly, debugging and later maintenance, and can be directly adapted to the hardware deployment requirements of potted plant maintenance in various scenarios such as homes and offices.

## **2.2. System Software Design**

The software design of this system adopts a modular development concept, and builds a complete software architecture divided into two major parts: the main control terminal and the mobile terminal. A number of dedicated subroutines are developed around the core functions of data acquisition, logic control, wireless communication and human-computer interaction, taking into account the requirements of the system's automatic operation and dual local and remote control. The program logic is clear and the module coordination is strong, which can realize intelligent software support for the entire process of potted plant maintenance. The functions of the corresponding software system are shown in Figure 3.

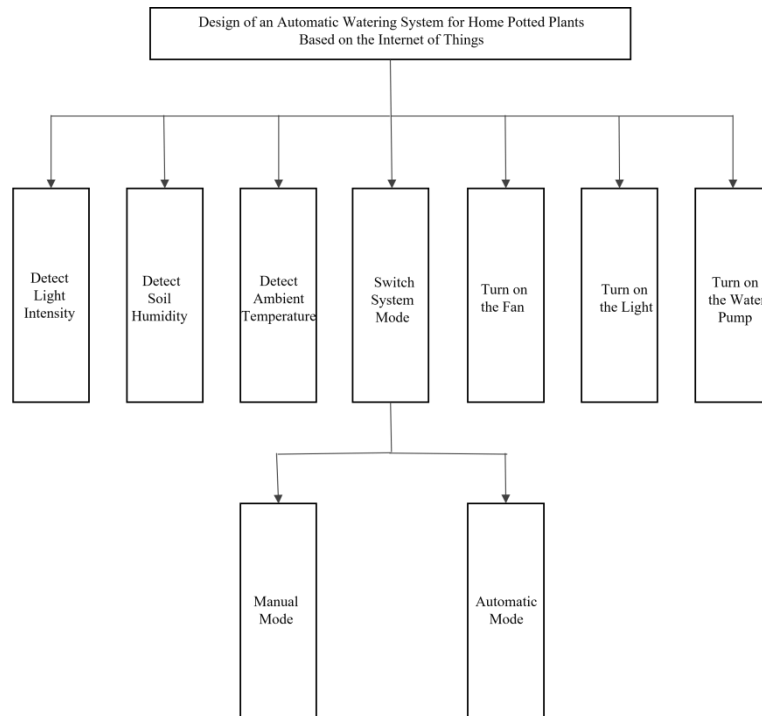


Figure 3: System Function Diagram

### 2.2.1. Main Control Terminal Software

The main control terminal software serves as the core of the system operation. The main program adopts an operating mechanism combining cyclic scanning and interruption. After completing system initialization, it sequentially implements the driver configuration of each hardware module, including the initialization of sensor acquisition interfaces, actuator control interfaces, LCD display interfaces, WIFI communication interfaces, and key interrupt interfaces, laying a foundation for subsequent data acquisition and instruction execution. For the sensing and detection module, a dedicated data acquisition subroutine is designed: analog signals such as soil humidity and light intensity are collected and digitally processed through ADC analog-to-digital conversion, and digital signals from the DS18B20 temperature sensor are read using the 1-Wire protocol. Meanwhile, a data filtering algorithm is incorporated to effectively reduce environmental interference and improve the accuracy of monitoring data.

### 2.2.2. Automatic/Manual Dual-Mode Control Subroutine

In accordance with the system control requirements, an automatic/manual dual-mode control subroutine is designed: (1) In automatic mode, the subroutine compares real-time collected environmental parameters with user-preset thresholds. When parameters exceed the threshold range, control instructions are automatically issued to drive the relay module to conduct, enabling actions such as micro water pump irrigation, fan cooling, and LED light compensation. The actuators stop automatically once parameters return to normal. (2) In manual mode, it responds to control instructions from physical keys or the mobile APP to directly start/stop actuators and switch modes. An LCD display subroutine is designed to refresh and display processed environmental parameters and system operation modes on the LCD1602 screen in real time. Additionally, a key scanning and debouncing subroutine is developed to support users in locally customizing threshold values for temperature, humidity, light and other parameters, and completing mode switching and manual control operations.

### 2.2.3. Wireless Communication Subroutine

The wireless communication subroutine is implemented based on the WIFI module, and a wireless data link between the main control terminal and the mobile terminal is established using the TCP/IP communication protocol. On one hand, it encapsulates real-time monitoring data and system operation status in a fixed format and uploads them to the APP; on the other hand, it receives remote control instructions and parameter setting instructions issued by the APP, parses them, and transmits them to the main control program for execution, achieving two-way data interaction. For abnormal states, an alarm trigger subroutine is designed: when environmental parameters are abnormal or the water level is

too low, it automatically drives the audible and visual alarm module to work, and simultaneously uploads abnormal information to the mobile terminal, realizing dual local and remote alarm reminders.

#### 2.2.4. Mobile APP Software

The mobile APP software features a concise interface design and is divided into three functional modules: data monitoring, device control, and parameter setting. The data monitoring module receives and displays the environmental parameters and system status uploaded by the main control terminal in real time, enabling remote visual monitoring. The device control module is equipped with buttons for the remote start/stop and mode switching of the light, fan and water pump, with operation instructions sent to the main control terminal in real time. The parameter setting module supports the remote modification of maintenance parameter thresholds and is linked with the local key setting function to ensure parameter consistency. A data caching function is also integrated into the APP, which temporarily stores historical monitoring data, facilitates users to view the change trends of environmental parameters and enhances the operating experience. The core functions of the APP are shown in Table 1.

*Table 1: Core Functions of the APP*

Functional Module	Core Functions
Data Monitoring	Real-time reception and display of monitoring data such as soil humidity, ambient temperature, and light intensity uploaded by the main control terminal, along with the system operation mode. Caching of historical data from the most recent month to support viewing of parameter change trends.
Device Control	Provision of remote start/stop buttons for lights, fans, and water pumps, as well as support for automatic/manual mode switching. Operation instructions are issued to the main control terminal in real time, with a response delay of less than 30ms.
Parameter Setting	Support for remote modification of maintenance parameter thresholds including temperature, humidity, and light intensity, in conjunction with local key setting functions to ensure consistency between local and remote parameters.

### 3. Conclusion

Based on the Internet of Things, embedded control and sensor detection technologies, the automatic watering system for household potted plants can collect the environmental parameters of potted plant growth in real time, realize automatic irrigation, light compensation and temperature reduction, and support dual local and remote control as well as abnormal alarm functions. It effectively addresses the drawbacks of traditional manual maintenance and achieves automated and precise maintenance of potted plants. With strong practicability, high cost performance and adaptability to a variety of indoor scenarios, the system provides an efficient solution for potted plant maintenance and boasts practical application value. Meanwhile, it offers a practical reference for the civil popularization of IoT-based intelligent maintenance technologies<sup>[10]</sup>.

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