Design of horticultural wireless intelligent maintenance system based on STM32 and Android

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Abstract. According to the need of indoor potted plant maintenance, the control system is designed with STM32 single chip microcomputer and Android technology. To solve the problem of wiring difficulty in traditional wired control system, wireless monitoring is realized by using Internet of things and wireless sensor technology. The system detects soil moisture, pH value, environmental temperature-humidity and illuminance of potted plants by sensor module, and the detection value is displayed after being processed by STM32 single chip microcomputer. Set the range of humidity value, temperature value, pH value and the minimum threshold of light intensity by pressing the key, and compare the set value with the monitored parameter value. If the humidity value is not within the set value range, the SCM outputs the control signal to start or close the solenoid valve for watering; if the temperature value is not within the range, the heater can be started for heating or the fan ventilation can be started for cooling; if the pH value is not within the range, an alarm will be given automatically to remind the user to fertilize and allocate the soil; when the photosensitive sensor module detects that the light intensity is insufficient, it turns on the LED light to supplement the light. At the same time, Android application is developed to realize remote control of watering, lighting and ventilation through mobile terminals. The simulation results show that the system has a high degree of automation, which can realize the intelligent maintenance of horticulture. It is of great significance to further improve the development of planting and maintenance towards intelligent direction in China.

1. Introduction
Potted plants can beautify the environment and purify the indoor air through photosynthesis [1]. Therefore, they are favored by more and more people. In order to improve the output of potted plants, most of the growers adopt the closed planting mode, which has many advantages, but there is a risk of flower death due to poor control of the planting environment. At present, there are five different types of horticultural maintenance products [2,3] in the market, including timed horticultural soil detector, timed irrigator, soil moisture automatic detection and irrigating system, soilless cultivation automatic control system and mobile intelligent plant wall. Horticultural soil detector can only monitor four parameters of soil, and can not carry out automatic control; timed irrigator has low intelligent degree and rough design, which can not meet the higher requirements of growers; soil moisture automatic detection and irrigating system only controls humidity, and can not integrate temperature and light control; soilless cultivation automatic control system has large barrel size and the connection of barrel; the mobile intelligent plant wall has no nutrient control function and high cost.

The ideal horticultural maintenance system should be able to achieve higher intelligence at a lower cost and be convenient to use[4]. Therefore, this paper designs a set of potted flower soil humidity, PH
value, environmental temperature and illumination detection through STM32 single-chip microcomputer and Android technology, and realize the potted flower automatic maintenance, and realize the remote intelligent maintenance through the mobile terminal.

2. Influencing factors of potted plants
There is an inseparable relationship between the growth of plants and the surrounding environment. There are many environmental factors that affect the growth of plants, and the environmental factors are related and interact with each other. The environmental requirements of several flowers are listed in Table 1.

| plant type          | temperature (°C) | moisture  | illumination    | soil PH   |
|---------------------|------------------|-----------|-----------------|-----------|
| orange jessamine    | 20-32            | 50%-60%   | Shade loving    | 4.6-6.2   |
| Gardenia           | 13-28            | 60%-95%   | sun loving      | 5.1-6.1   |
| Clivia              | 15-28            | 60%-80%   | half shade loving | 5.5-6.5  |

In the actual production, the environment of the planting shed changes greatly with the seasons, so it is difficult to maintain the environment in a state suitable for the growth of flowers and obtain high profits. In order to create a healthy environment for the growth of flowers, it is necessary to control the planting environment artificially to minimize the impact of environmental factors on the growth of flowers.

2.1 temperature
The growth and development of all kinds of flowers are completed under certain temperature conditions. According to different requirements of flowers on temperature, they are divided into cold resistant, semi cold resistant and non cold resistant flowers. Generally, the suitable temperature for healthy growth of flowers is 10-32 °C. In this temperature range, the physiological activities of flowers are the most vigorous and the growth speed is the fastest. When the temperature is lower or higher than the appropriate area, the growth will be slow or even stop growing and enter into dormancy.

2.2 moisture
Water is a necessary condition for flowers to transmit nutrients and carry out biochemical reactions and physiological activities. The suitable humidity of most potted flowers is 60% - 95%. In the process of flower cultivation, if the water is insufficient, the leaves and petioles will shrink and droop, resulting in the phenomenon of withering and purples; if the water is too much, it will cause the leaves to turn yellow, at the same time, it is easy to fall, and vulnerable to pathogens. Therefore, over dry or over wet are not conducive to the normal growth and development of flowers.

2.3 illumination
Light is the condition for photosynthesis of plants. Different flowers have different demands on light intensity and light time. In order to ensure the growth of flowers, we should pay attention to adjusting the light and properly use artificial light sources. If there is less light, all the flower operations will stop and eventually face death.

2.4 soil nutrients
The growth of flowers needs a lot of nutrients, including carbon, hydrogen, oxygen, nitrogen and other 10 kinds of elements. The soil should be rich in nutrients, and fertilization must be in place, and the soil acidity and alkalinity should be tested in time to avoid the harm caused by the over acid and over alkali land; at the same time, attention should be paid to turning the soil to avoid soil hardening.
3. **Internet of things application framework**

The Internet of things plays a huge advantage in the fine agricultural management. In the large-scale production of flowers, the Internet of things technology can be used to detect the soil moisture, PH value and the temperature and light of the small environment, so as to obtain real-time information transmission and utilization. The application of Internet of things technology is an obvious hierarchical model as shown in Figure 1.

The physical layer of hardware is based on the hardware node of wireless sensor network, which is responsible for the realization of hardware related functions; the operating system layer adopts TinyOS operating system combined with the intermediate software DisWare of wireless sensor network, which realizes the encapsulation of corresponding functions at the bottom of hardware, which is convenient for calling and processing; the management interface layer is responsible for the management and control of wireless sensor network nodes, and realizes the realizati

The virtual reality presentation layer uses Android studio 3.1.2 software programming to display all kinds of context information to users; the context information management layer aggregates the data uploaded by the underlying sensors and manages all kinds of services that can be provided.

![Figure 1. structure model of Internet](image)

4. **Overall scheme design of the system**

The horticultural intelligent maintenance system uses Internet of things, embedded technology, sensor, blue tooth technology and mobile terminal technology, with STM32F103C8T6 as the control core; in the monitoring part, the wireless sensor module detects the soil moisture, pH value, environmental temperature, humidity, and light intensity, and transmits the collected data to the network coordinator through ZigBee, which is sent to the single chip microcomputer through wired way, and the real time display on the LCD screen; press the key and set the range of environmental factors, and the set moisture value is compared with the detection value of moisture sensor module to control the solenoid valve to automatically water or stop watering; when the ambient temperature does not meet the set requirements, start the fan ventilation to cool down or the heater to heat up; when the photosensitive sensor module detects that the light intensity is insufficient, turn on the LED lamp to supplement the light; when PH sensor detects that the soil pH is abnormal, the buzzer will give an alarm to remind the grower that the soil needs to be fertilized. At the same time, the app program is developed based on Android technology, which can be controlled on the mobile terminal by using smart phone. The whole system is composed of main controller, wireless detection module, ZigBee wireless repeater module, display module, key module, control module, blue tooth communication module, APP module and power module. The structure diagram is shown in Figure 2.
5. Hardware design

The control core of the system is a 32-bit microcontroller based on arm 7 architecture [5] STM32F103C8T6 single chip microcomputer, with CPU working frequency of 72 MHz, 64KB flash memory, 20KB SRAM, USB interface and can bus. Signal acquisition is completed by wireless sensor module, each sensor module is composed of battery, MCU (micro controller), sensor and RF module. The performance parameters of the sensors used in the system are shown in Table 2.

As a display, LCD has the advantages of low power consumption and rich display content. The output device is controlled by the relay. The relay can control the high current device with small current [5]. Therefore, the relay is driven by the triode. When the output of MCU control pin is low, the triode is on, the relay coil is powered, its normally open contact is closed, and the corresponding control module starts to work [6].

The network coordinator adopts CC2530 chip system which integrates microcontroller, host and application program [7]. CC2530 combines the excellent performance of radio frequency (RF), and has the characteristics of low cost and high cost performance.

At present, there are two main ways of communication: WiFi and bluetooth. Compared with Bluetooth module, WiFi consumes more power and is not suitable for portable Internet of things system. In bluetooth 4.0, dx-bt05 bluetooth [8,9] module is used, including CC2541 chip. There is no byte limit for

| sensor name             | model   | performance parameter                                                                 |
|-------------------------|---------|----------------------------------------------------------------------------------------|
| moisture sensor         | TPSAR-SM| Measurable humidity range 0 ~ 100% RH, resolution 0.1% RH, accuracy ± 2% RH            |
| soil PH sensor          | JXBS-3001-PH | Generally, the measurement range of pH sensor is 0-14, the accuracy is ± 0.01, and the response time is less than 15s |
| illuminance sensor      | JXBS-6001-GZ | The range is 0-65535lux, and the accuracy is ± 5% (25 ℃)                               |
| temperature and humidity sensor | SHT10 | The temperature measurement range is -20 ~ 70 ℃, the resolution is 0.5 ℃, the humidity measurement range is 0% ~ 100% RH, and the resolution is 2% RH. |

receiving and sending, and the standby power consumption is only 100ua. It has become the most preferred module in the Internet of things communication. Android and ISO system support this
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Bluetooth module, and the response speed is also fast, which provides guarantee for real-time detection parameters.

6. System software design
The system collects data through sensors and transmits it to STM32 for processing and display. For the first login of Android mobile app, it needs to be paired with the hardware device and connected automatically for subsequent use. Then the main interface will be displayed. Select entering the UI interface to display the monitoring data in real time. At the same time, the best maintenance parameters can be set according to the types of flowers to be cured.

6.1 design of acquisition terminal software
The acquisition terminal uses keilu Vision 5 programming environment and adopts high readability and portability of C programming language [10], including system module initialization program, data acquisition and serial communication program. The system first initializes each functional module, and then starts to collect the detection signals of soil humidity, PH value, ambient temperature and illuminance sensors, and repeatedly collects them within the effective time interval. When the data is determined to be collected, the data will be sent to the coordinator, and finally the coordinator will send the data to the main control center through the serial port.

6.2 server side programming
In order to feedback the collected data to the handheld mobile terminal in time, we need to design a distributed web server back-end based on the Internet. Select the servlet service framework based on J2EE, which have three-tier framework of model - > View - > controller, and carry out the low coupling development. The idea software development environment compiles the JSP language background program, which can meet most of the network transmission needs. The background service system and the upper computer software communicate through current TCP, which greatly reduces the risk of packet loss and frame loss. J2EE is the background framework, and Tomcat version 7.0 is used as the server baseruntime.

In order to save and read the data set transferred by the lower computer, select MySQL lightweight database, import the user list, sensor data aggregation list and system error log table in bulk. The server software is responsible for receiving the data collected by STM32, and then build a TCP network [8] server through the network protocol, and forward the collected data. The software flow chart is shown in Figure 3.

6.3 design of Android mobile terminal software
Android studio version 3.1.2 programming environment and Java &kotlin programming language are adopted for handheld mobile terminal app, including Android development environment construction, login interface design, parameter setting interface and monitoring interface design. The system flow is shown in Figure 4. The app program design adopts the modular design idea, including sensor data monitoring module, manual control field equipment, automatic control settings, alarm threshold and basic settings.
7. system test

In order to verify the reliability of the intelligent maintenance system, we insert the humidity sensor into the Junzi orchid pot. Junzi orchid likes to be warm and humid. By pressing the key, we set the humidity range to 60% - 80% RH. When the humidity is lower than 60%, we water automatically. When the humidity is higher than 80% RH, we stop watering. By observing the experimental phenomena and analyzing the experimental data, we verify the feasibility and accuracy of the system. In fact The expected plan has been made.

After the successful login of mobile APP, the data fed back by each sensor can be monitored. The humidity data curve in a certain period of time is shown in Figure 5. After entering the parameter setting interface of the mobile phone, the set parameters and the collected data will be compared in depth. If the system finds that the data from the sensor is not within the set range, it will automatically control the operation of the output device.
When the plant growth index is abnormal [11], the control and processing equipment of the intelligent maintenance system can realize intelligent light supplement, water supplement, temperature rise, temperature drop and alarm, and overcome the problems of insufficient light and maintenance experience restricted by indoor environment. Improve scientific planting guidance for ‘urban farmer’[12], so that people who can't grow flowers don't need to learn and can become a planting expert. It has a profound impact on personalized planting and the application of the Internet of things.
8. Design summary and Prospect
The design of intelligent horticultural maintenance system based on STM32 and Android is an intelligent device to control the growth of plants according to the detection results of soil moisture, PH value, environmental temperature, humidity and illumination. The experimental results show that the design cost is low, it is convenient for large-scale production and promotion, and the intelligent degree of maintenance device is high, which will provide a high cost-effective maintenance device for the intelligent maintenance of horticulture, with a broad prospect of promotion.

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