Design of Intelligent Watering Robot Based on STM32

Ziqi Li[1], Yunhan Li[2]

[1, 2]School of Intelligent Manufacturing, Huzhou College, Huzhou, China
Corresponding Author: Ziqi Li

Abstract: ***Intelligent watering system is widely used in the market of intelligent electronic products, and the technology of intelligent watering is constantly updated. In view of the current research status of household plant maintenance devices, a mobile and innovative intelligent flower watering robot for home use was designed. The robot can autonomously detect the position of the flower pot, and judge whether water is needed and whether the required water amount is reached through the collected soil temperature and humidity, and then control the robot to make corresponding actions to complete the watering task. This design uses STM32F103C8T6 microcontroller as the controller, the use of infrared distance sensor GP2Y0A02YK0F and ultrasonic distance sensor US-100 detection distance signal, using the principle of triangulation method to calculate the distance between the robot and the flower pot, while adjusting the watering Angle. The system uses a capacitive soil moisture sensor to collect soil moisture signals, and transmits the data wirelessly to the robot through the GC433-TC007 communication module of Silicon Transmission Technology to control the robot watering and judge the watering amount. Intelligent watering robot can reduce the consumption of human resources, reduce the intensity of workers watering work, improve the efficiency of pot watering and the utilization of water resources, so as to realize the intelligent pot watering, providing convenience for flower management.***

Keywords: STM32 MCU; Robot; Triangulation; Potted plants

1. Introduction

With the development and progress of science and technology in China, the aging of the society, the shortage of labor force, the disappearance of demographic dividend and other problems appear, resulting in a sharp rise in labor costs. At the same time, more and more people begin to realize the great convenience brought by scientific and technological progress, and gradually begin to accept the integration of intelligent robots into our lives. In order to improve efficiency, people will choose service robots to replace some dangerous or complex work in life, and use robots to change the human way of life, so service robots have a broad application market, such as sweeping robot, medical robot, guide robot and so on. For the popularization of artificial intelligence technology, robots will develop towards the direction of more intelligent and precision. Currently, the development of robots has gradually changed from the manufacturing industry to the field of life.

At present, the traditional flower management is generally used to water the artificial water pipe, and use drip irrigation and small pipe, the efficiency of manual operation is relatively low. The intelligent irrigation technology not only improves the water saving by 50% -75% than the artificial irrigation, but also improves the average value of the irrigated area. In view of the problem that artificial watering of traditional flowers is time-consuming and laborious and cannot reasonably irrigate each flower, in the flower industry, traditional water pipe irrigation and artificial sprinkler irrigation are gradually withdrawn from the stage and replaced by water-saving technologies such as automation, mechanization and micro-spray.

A key issue involved in the study of flower-watering robots is positioning. In view of this problem, some scholars use the kinematic knowledge of mathematical modeling and physics, while some scholars use ultrasonic positioning. Some scholars choose to combine the first two ways of positioning. Liu Jiansheng, Jiao Shuaifeng [1] has designed a flower-watering robot that can move the operating system. The robot can plan paths, provide automatic navigation, and move freely in a flat space. When the robot moves to the target position, combined with the knowledge of physical kinematics for positioning and watering, the working efficiency of the designed mobile flower watering robot can have a qualitative leap.

There are also a lot of studies on the design of intelligent flower watering robots abroad. Scholars use robots to complete the watering task, and prove that this is a feasible way to improve the efficiency of watering. Zhang Maoqing [2] proposed a sliding window strategy for the problem of curse of dimension. Specifically, the watering area is divided into multiple partitions, and each partition is watered separately. They used the Arduino board as the experimental platform to study the automatic watering system of the workshop. The automatic watering system involves several steps, including the design stage, development and manufacturing stage, and installation stage. The second is to test the product, through some of the variables specified before the test. The results show that the system can complete watering, nutrient supply, automatic spray and other functions, and can show the current greenhouse soil moisture and temperature conditions.

Scholars use the microcontroller to combine some novel algorithms to control the robot watering. Mahendra Vucha [3] They are a composite switch control algorithm based on fuzzy control and PID control, according to the collected temperature and humidity and light intensity, calculate the irrigation demand, to achieve better water-saving irrigation effect. After testing, the whole system has excellent control performance and practical application. Xihuan Hong [4] based on STM 32 MCU, ESP8266 WIFI module and

Internet of things technology, realized the system transmission of pot information and watering instructions. Then, by using JavaWeb technology and Mina communication framework, we realized the goal of real-time monitoring of potted environment information and remote intelligent watering. Xingcan Liu et al. [5] developed an indoor breeding flower intelligent watering robot based on STM 32, which realized the functions of intelligent watering, foliar spraying and automatic watering. While Waworundeng Jacquline M.S. and other [6] use Arduino UNO as the main control system, DHT 22 sensor measures the temperature and humidity environment, uses the water pump and DC motor as watering equipment, and successfully designed the micro automatic watering system. Some scholars have also tried to design and control the amount of water the robot. G. S. Hartley, A. A. Ross [7] designed a device that uses the weight of the pots and plants to effectively regulate the supply of water, thus automatically maintaining the constant weight values of the pots and plants. The design can be seen as an example of maintaining good plant growth in small spaces and of effectively measuring water consumption.

2. Overall System Design

Based on STM32F103C8T6 intelligent watering robot using two kinds of sensors to locate for flowerpot, by ranging and Angle of correction accurate to need watering pot, using soil moisture sensor to collect data, through wireless module information transmission to the main microcontroller, after SU processing achieve accurate quantitative watering watering device. The studies involved are as follows:

a) Build an intelligent flower-watering robot model. Using the car model, the main control board is installed on it to control the rotation of the wheel. Secondly, the ultrasonic sensor needs to be installed and the infrared reflective sensor to control the car to find the pot for watering.
b) For the collected information, use STM 32 single chip machine to control the amount of watering system and the use of infrared reflective sensor to feel external factors to judge the distance of watering and how to correct the deviation of watering Angle.
c) Build the simulated test environment of the intelligent flower watering robot, test the corresponding flowerpot in the simulated environment, and use the basic control to achieve the effect of "accurate and quantitative" watering.

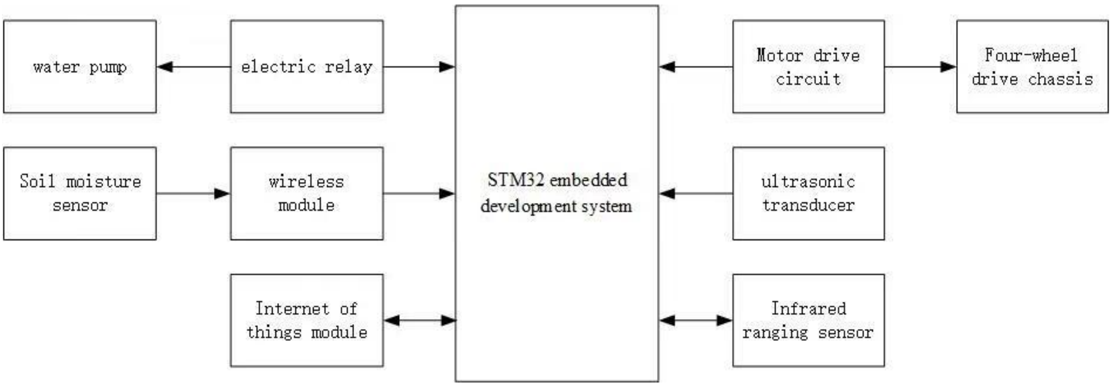

Figure 1: System structure diagram

3. Circuit Design

This project uses STM32F103C8T6 single chip computer as the controller, uses YL-69 soil humidity sensor to measure and collect the humidity data in the soil, and then uses GC433-TC007 module of silicon transfer technology to transmit the data to the single chip terminal by wireless communication. The main controller controls the microcontroller controls the robot to find the pot to be watered. The robot uses ultrasonic sensors to locate the position of the flowerpot, and then instan infrared ranging sensor at each end to avoid deviation from the route during the movement. After the robot stops, it uses a small DC water pump to supply water and water its plants. The overall scheme of this design is shown in Figure.2 The system is divided into eight modules, namely single U module, power module, motor drive module, positioning tracking module, wireless communication module, steering module, soil data acquisition module and watering module. Its various module functions are as follows:

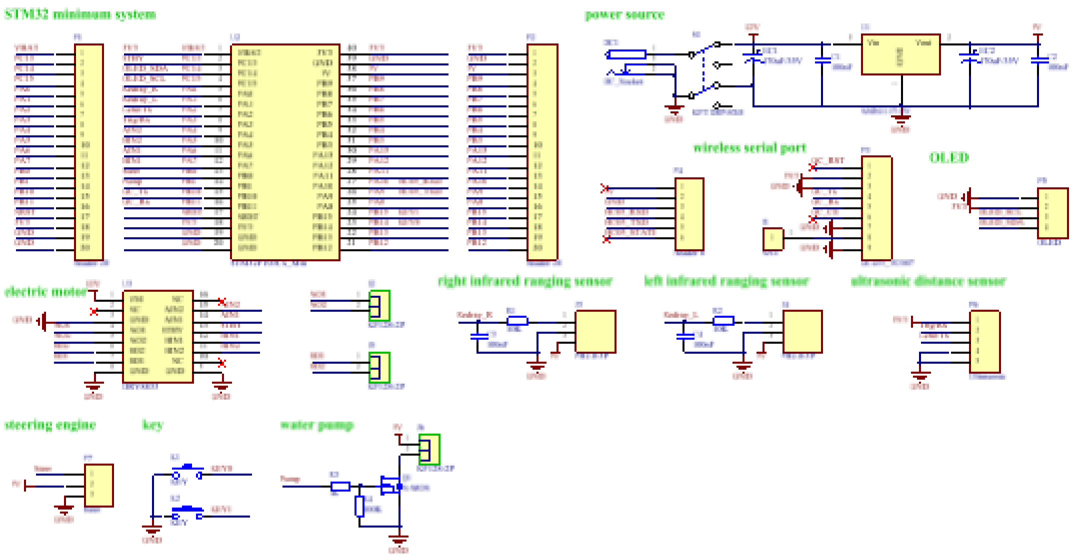

Figure 2: A schematic diagram of the system

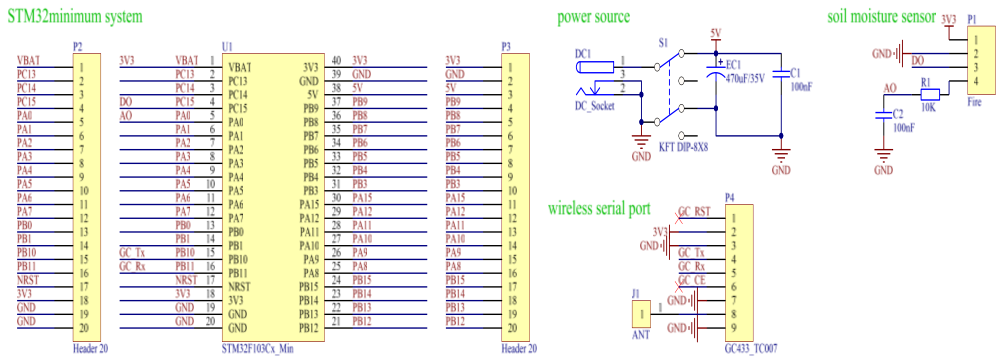

Figure 3: Flowerpot end circuit schematic

4. System Software Design

After initialization, the mobile controls the logistics robot via the IoT module subroutine. The robot automatically follows the trajectory and follows the route. The infrared detection subroutine detects whether the robot has reached the loading point and, if so, sends a command via the radio module to stop the robot and wait for loading. If it is not full, the robot continues to wait until it is. When the goods are full, the conveyor stops and the robot is activated by sending a command via the radio module. The infrared detection subroutine detects whether the robot has reached the unloading area and, if so, sends a command via the radio module to stop the logistics robot and to automatically unload the goods. Throughout the process, the mobile side can check the robot's operating status and control the start/stop via the IoT module subroutine. The overall design of the logistics robot system is shown in Figure 4.

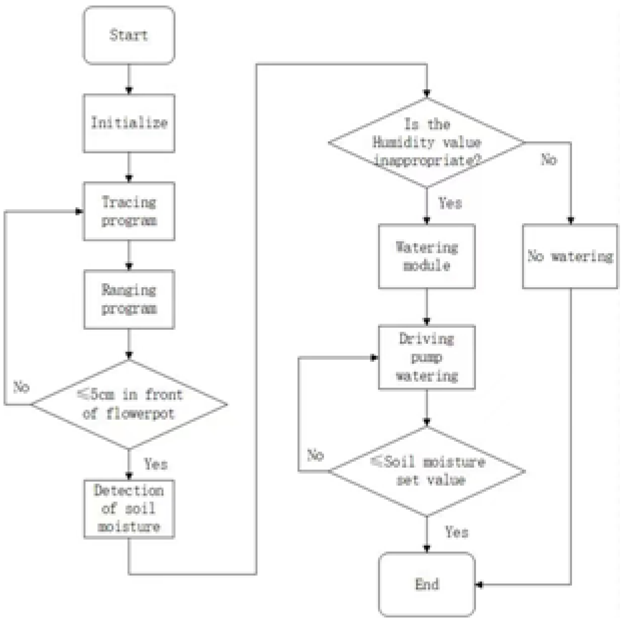

Figure 4: Overall design of the watering robot system

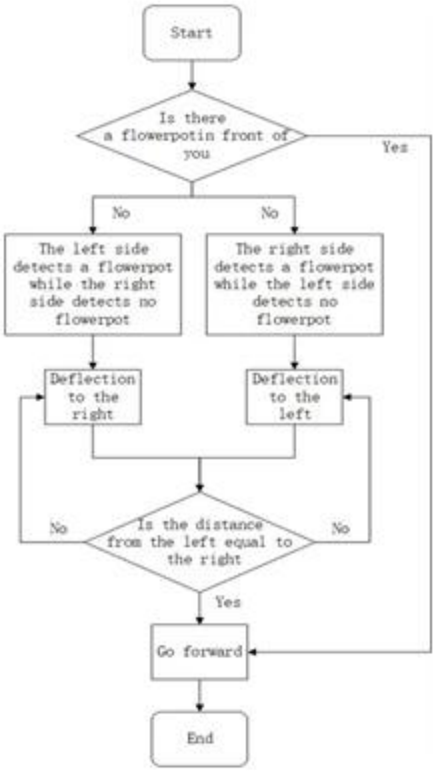

Figure 5: Overall design of the robot

The STM 32 MCU can emit an adjustable signal that can control the steering gear. First need to set the pin for reuse output function, set the PWM clock cycle for 20 milliseconds, when the configuration system output PWM pulse waveform, and after 72 minutes, the timer count clock cycle will change, become 1 microseconds, each after 1 microseconds, the timer counter will add 1, until accumulated to 20000 microseconds is a complete PWM cycle. Output low level when the timer counter value is larger than the RCC 1 register value. By changing the value of the register RCC 1, you can change the working time of the high PWM level, thus adjusting the Angle of the steering gear.

Infrared ranging algorithm is the core point of the program design. Through the infrared ranging sensor to measure the distance between the car and the flowerpot, we can avoid the deviation of the Angle in the track of looking for the flowerpot. Infrared ranging algorithm principle is on the left and right sides of the car each add a infrared ranging sensor, when the left of the infrared ranging sensor detected flowerpot, the right of the infrared ranging sensor didn't detect, the car to the left, when the right of the infrared ranging sensor detected the flowerpot, the left of the infrared ranging sensor didn't detect, the car will turn to the right. First, the infrared emitter emits a beam of infrared light, and when an object, the light reflects back, as shown in the picture. Reflected back infrared light received by CCD detector, will get an offset value L, using the triangle, under the premise of the known emission angle a, set the offset distance for L, the central moment of X, and the filter focal f, the distance between the sensor to the object D can be calculated by geometric relationship. When the distance of D is very close to the object, the value of L increases relatively, so the values of the object distance of D and L are inverse relationships. But when it is beyond the detection range, the sensor cannot detect the data. The focus of the principle is whether the CCD detector can identify very small L values, and whether the resolution of the measured CCD can determine the accuracy of the L value. So the farther the detection distance, the higher the resolution requirement for CCD. According to the triangular formula,

$$D = \frac{f(L+d)}{d} \qquad \#(4.1)$$

The distance of the measured object can be derived. When the ultrasonic sensor pulse signal, the timer began to work, due to concern to ultrasonic attenuation characteristics, and air damping affect ranging accuracy, change the frequency of the sound wave, when the frequency is 40 kHz, transmission efficiency is the best, oscillation frequency can be controlled by adjusting the resistance.

$$f_0 = \frac{1}{2.2 \times C1 \times (R_2 + RP_1)} \#(4.2)$$

The distance of the measured object can be derived. When the ultrasonic sensor pulse signal, the timer began to work, due to concern to ultrasonic attenuation characteristics, and air damping affect ranging accuracy, change the frequency of the sound wave, when the frequency is 40 kHz, transmission efficiency is the best, oscillation frequency can be controlled by adjusting the resistance.

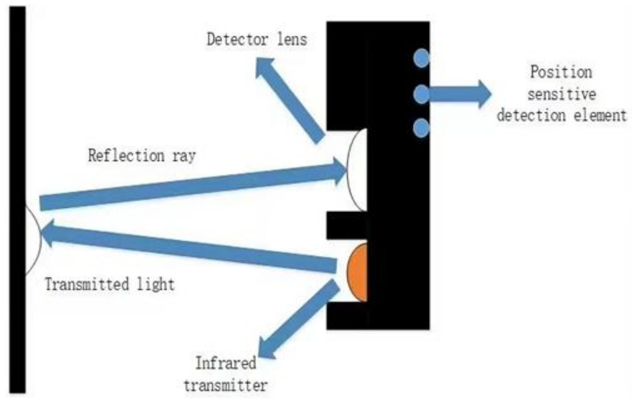

Figure 6: Principle diagram of ranging method

5. Experiments

STM32F103C8T6 Burning is to download CH340, serial line, serial line TXD RXD, serial line RXD TXD development board, especially note, the initial value are 0, but BT0, BT1 to buy 0,01 is high level, power supply, 0 is low level, grounding, then check whether the download success, check whether is corresponding port, download burning program, connect development board and serial line, connect to the computer, find the port in the burning program, download according to the steps. The debugging of hardware circuit is a common problem in the circuit design process, such as whether the welding is wrong, whether the short circuit. The hardware equipment of this design is welded on PCB board. AD drawing software is used to design PCB board according to the PCB diagram. The finished physical product is shown in the following figure.

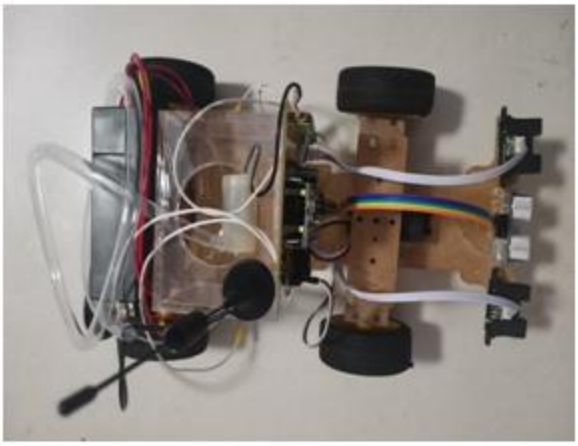

Figure 7: Drawing of finished physical products

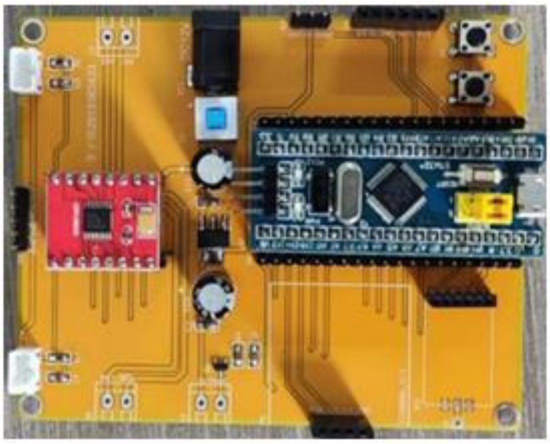

Figure 8: Finpicture of physical PCB board

Because the system design needs to put the water storage device, so the use of four-wheel drive car as a mobile platform, will have a certain stability, will not cause the loss of water in the process of movement, resulting in a short circuit on the motor. DRV8833 There are two H bridge drives, which can drive two motors to operate at the same time, so control the IO port of the two motors connected to the single chip unit, when the system is placed 1, can control the positive and reverse operation of the motor. Working under the input of the PWM mode, this circuit adjusts the current of the motor winding. After the PWN signal is input to the xIN 1 and xIN 2 pins, the voltage output value of the xOUT 1 and xOUT 2 pins can be controlled, so that the positive and reverse of the motor is controlled by the input of the PWM signal. This design is to verify whether the flower watering robot runs stably in the process of finding the path of the flowerpot, testing the movement of the flower watering robot at the flowerpot end, and the test results are shown in Table 1.

Table 1: Robot tracking tests

Test sequence	Distance of the robot from the flower pot(cm)	Whether the robot can accurately stop at the front end of the pot
1	10	Yes
2	30	Yes
3	90	Yes
4	120	Yes
5	150	No

Test results proved that the watering robot in the process of looking for flowerpot occasionally appear error, after inspection is the distance between the flowerpot and watering robot is too large, and affected by the environment such as light, after adjusting the accuracy of the flowerpot, can be relatively smooth complete the watering task.

The microcontroller at the flowerpot end receives the soil moisture information, and then transmits it to the car end through the wireless module to control the movement of the car. This design is to verify whether the flower-watering robot can receive the water shortage signal from the soil end

The test results show that through the signal transmitted by the wireless module, the car end can receive the water shortage signal at the flowerpot end and operate normally. The flower-watering robot can have a high judgment ability and complete the function of automatic watering more smoothly. Place the humidity measuring sensor in the soil of the pot and power on the system at normal room temperature. At this point, the values related to the plant growth state in the soil can be observed through the APP on the mobile phone, and certain limits can be set for these values, so as to achieve the role of real-time monitoring, as shown in Figure .9.

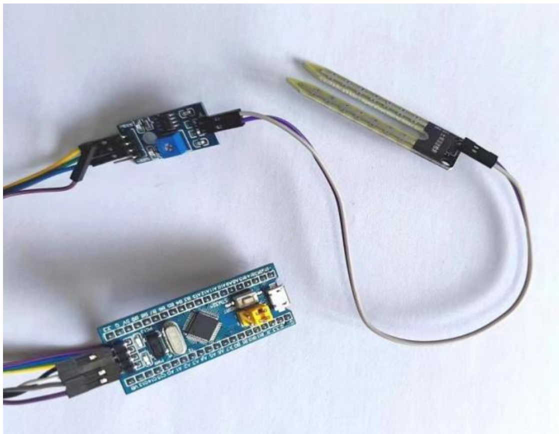

Figure 9: Figure of the finished product at the pot end

In this design, the Internet of Things module is responsible for transmitting the running state to the mobile terminal, and can control the start and stop of the flower watering robot on the mobile terminal. When the user needs the robot to water, the robot can be controlled remotely on the mobile phone. The water pump watering test is shown in Table 3. Secondly, the temperature and humidity data of the soil in the flowerpot can be displayed on the mobile phone, so as to remotely monitor the growth status of the plants in the flowerpot, as shown in Figure.10.

Figure 10: Display figure of soil numerical monitoring of mobile phone APP

6. Conclusion

This project designed a based on STM 32 single chip computer robot, based on the single chip computer technology, combined with sensor technology, intelligent control, etc., can automatically search for indoor water shortage plants, and automatic watering, based on the "intelligent flower robot" not only can not only effectively save water resources, improve the utilization of water resources, at the same time can effectively alleviate the development difficulties caused by the lack of water resources, optimize the growth environment of plants.

References

[1] Liu Jiansheng, Jiao Shuaifeng. Design of mobile watering robot based on ROS [J]. Modern Electronic Technology, 2022,45 (14): 122-126.
[2] Zhang Zhan, He Xiang, and Xu Yuhao. Design of household intelligent flower-watering robot system based on UWB positioning [J]. Modern Property (China Ten Journal), 2018, (07): 58-58.
[3] Mahendra Vucha， K Jyothi， Kiran Kumari， R Karthik. Cost Effective Autonomous Plant Watering Robot[J]. International Journal of Recent Technology and Engineering (IJRTE)，2019，7(05):67-69.
[4] Xihuan Hong，Xiaoqiao Luo，Censong Liu. Remote Intelligent Watering System Based on Internet of Things[C]//.Proceedings of the 2nd International Conference on Robotics， Control & Automation Engineering (RCAE 2019)，2019:62-66
[5] Xingcan Liu，Hao Yin and Chen Zang. Design of Intelligent Watering System Based on STM32[J].Academic Journal of Engineering and Technology Science，2019，2(01):1499-1504.
[6] Waworundeng Jacquline M.S. ， Suseno Novian Chandra ， Manaha Roberth Ricky Y. Automatic Watering System for Plants with IoT Monitoring and Notification[J]. CogITo Smart Journal ， 2019 ， 4(02):316-316.
[7] G. S. Hartley，A. A. Ross. An Automatic Watering Device for Small Potted Plants[J]. Journal of Horticultural Science，2015，42(01):109-111.