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Orchard pest prevention and control based on Internet of Things

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ABSTRACT: *The fruit planting industry is the pillar industry of my country's rural economy. With the continuous increase of social income, people's pursuit of quality of life, people's demand for fruit consumption increases, and the demand for fruit quality continues to increase. However, orchard pests and diseases are the main factors affecting fruit quality and yield. Therefore, it is particularly important to realize the control of fruit diseases and insect pests in the process of fruit growth. Traditional orchard pest detection methods are mainly inefficient, highly subjective, rely on manual detection, and have a long detection cycle; prevention and control mainly rely on a large number of sprayings of fruit pesticides with pesticide residues that may exceed the standard. This paper studies the prevention and control scheme of orchard diseases and pests based on Internet of things. The Internet of Things not only collects the environmental temperature, humidity, illumination and carbon dioxide concentration of the orchard, but also realizes the monitoring of diseases and pests through the OV7670 industrial camera. The collected data is transferred to the data center through LoRa for being stored and analyzed. The ozone generation system is designed and implemented. When aphids and other diseases and pests are found, the prevention and control of aphids' diseases and pests can be realized by spraying different concentrations of ozone water. The experimental results show that physical control can achieve faster and stronger effect of disease and pest control, better guarantee the growth and development of fruits, increase fruit yield, reduce the use and residue of pesticides, improve the quality of fruits, protect the ecological environment, and realize smart ecological agriculture.*

Keywords: *The Internet of things, Disease and pest control, Pesticide residue, Orchard, Ozone*

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I. INTRODUCTION

1.1 Research background and significance

Agricultural informatization of the Internet of Things plays a crucial role in the development level and quality of China's orchard planting industry. The realization process of agricultural informatization of the Internet of Things is the result of mutual expansion, deep crossover and full cooperation between traditional agriculture, computer technology, artificial intelligence technology and other advantageous disciplines [1]. In recent years, deep learning, computer vision, big data, artificial intelligence, reinforcement learning and other fields have developed rapidly, and the research results have also provided new ideas for the development of smart agriculture for the modernization and information development of the agricultural field. For a long time, the detection and control of diseases and pests in orchards have been troubling fruit farmers. Due to the failure to detect diseases and pests in time and adopt correct treatment methods to manage diseases and pests, the increase of diseases and pests leads to fruit production reduction or excessive use of pesticides leads to excessive pesticide residues. Orchard disease and pest control based on the Internet of Things combines agricultural intelligence of the Internet of Things with agricultural information of the Internet of Things. Through the informatization of data collected from intelligent monitoring of diseases and pests inside the orchard, and the use of physical deworming devices instead of spraying pesticides, the annual output of the orchard can be effectively increased and the fruit quality can be guaranteed to maximize the interests of fruit farmers.

1.2 Research status at home and abroad

The major diseases and pests encountered by American farms growing apples are apple rot, apple scarab and peach worm, and other diseases and pests include apple bitter pox, apple coal stain, apple brown spot, apple rust, apple fly, Mealybug Kanneri, apple moth, black star moth, etc. [2]. The main prevention and control methods [3-7] are: (1) Regular replenishing of nutrients in the soil and reasonable planting of crops (2) regular cleaning of garbage inside the farm and timely removal of residual branches and rotten leaves (3) planting with high-quality seeds (4) Introducing natural enemies of related diseases and pests into the farm, such as ladybugs, the natural enemy of aphids (5) Using intelligent equipment to adjust environmental parameters inside the farm. Reduce the chance of pest outbreaks. (6) Spraying pesticides for prevention and control, using appropriate amounts of pesticides to deal with orchard pests and diseases.

As early as the middle of the 20th century in China, people began to adopt agricultural management, physical management, biological management and other methods to comprehensively control orchard pests and diseases. Specific measures included cleaning up the internal health of the orchard, artificially capturing pests, trapping and killing flying insects with yellow boards, introducing natural enemies of pests, and treating bacteria with bacteria [8-10].

(1) Physical control [11-12]: when pests are found in field operations, they are handled in time, and diseased branches are cut off and destroyed at any time; Bagging the fruit inside the orchard to avoid pests eating the fruit, using fruit bagging technology can not only increase the yield of the fruit, but also ensure the quality of the fruit and reduce the pesticide residues on the surface of the fruit. From April to September, insect-killing lamps are hung inside the orchard, and the insects' phototaxis are used to kill the pests inside the orchard, which has low cost, quick effect and no pollution to the environment, and can effectively control most of the pests in the orchard.

(2) Biological control [13-14]: Biological control uses natural enemies of introduced pests and bacteriological methods to control pests and diseases inside the orchard. For example, stocking ladybugs inside orchards reduces the damage caused by aphids by feeding on them. The sex attractor can induce the insect pests such as the apple small leaf ringworm, the black star wheat moth, the two-spot leaf mite, the apple whole paw mite, the gold line moth and so on, and kill the male insect timely after induction, reduce the mating rate and control the reproduction of the insect. Different types of microorganisms (fungi, bacteria, actinomycetes) in the natural environment can prevent different kinds of diseases. For example, apple tree rot can be effectively controlled by Saccharomyces yangling Hhs 015.

(3) Agricultural control [8-10]: Topdressing the fruit trees to improve the resistance of the fruit trees to diseases. Fertilizer should be applied once in spring and once in autumn, which can be applied by trench landfill method and water-soluble irrigation method; Strengthen the management of fruit trees, remove old branches and useless branches in time, control the distance between branches, and ensure the internal ventilation of fruit trees. Do a good job in orchard health, reduce the root causes of orchard pests and diseases, centralized treatment of diseased branches, to avoid causing secondary infection of fruit trees. White the trees every autumn to prevent frostbite and prevent pests from climbing into the bark or between branches to overwinter.

At present, the physical and biological methods used mainly include insecticidal lamp and sex attractant. Insect-killing lamp [8] makes use of the nature of insects like photo attractant, uses a light source that makes insects sensitive to a specific light range to attract pests, and locates a high-voltage power grid near the light source to kill pests inside the orchard, reducing the pest index in the orchard farm, so that the number of pests is controlled and the growth rate of the insect population slows down. The insecticidal lamp should be set in the orchard where there is power access and the light is not blocked, and the distance between the insecticidal lamps should be kept between 75 and 90 m; An average of 30 to 45 acres is set up with a worm lamp to lure pests. The lights need to be installed higher than the crop and are suspended from early spring to the end of October each year. The use time is 19:00 daily to 5:00 the next day.

Sex attractant (sex pheromone inducer) [14] The principle of inducing pests is to use the sex hormones of corresponding pests to induce male insects to come to mate through insect sex attractant, and then kill the attracted pests on the grid, thereby affecting the mating and reproduction of normal pests, thereby reducing the number of their offspring populations and achieving the effect of control [14]. It has been proved by experiments that the use of sex lure traps is a more effective method to control the insect pests such as green blind aphids, apple small leaf ringler moth, black star wheat moth, two-spotted leaf mite, leafhopper, golden grain moth, etc. The use of insect sex lure is low cost, low public harm and simple. The use of sex attractant to kill pests can reduce the spraying of pesticides, reduce the pesticide residue on the surface of the fruit, and improve the quality of the fruit, but the technical level is higher.

1.3 Research objectives and contents

At present, China's fruit production and consumption scale is the largest in the world, and the fruit planting industry is of great significance to the development of China's agricultural industry and the increase of farmers' income. This study is based on the orchard disease and pest control system based on the Internet of Things. Through the data information provided by the orchard internal disease and pest monitoring module, the types of diseases and pests in the orchard at this time are determined. Then, by spraying different concentrations of ozone solution to achieve the effect of removing pests and diseases, reduce the use of pesticides, and ensure the quality of fruit to a great extent while ensuring fruit yield. This study is divided into pest monitoring module, monitoring data display module, ozone production module, ozone spray control module and early warning module [7-9].

The main contents of the study are as follows:

(1) Different kinds of sensors are used to monitor the soil moisture, air temperature and humidity, types of diseases and pests and light intensity and other parameter information inside the orchard in real time, and compare with the existing temperature and humidity data of various diseases and pests, and push information to the orchard growers, remind the types of high-incidence diseases and pests at the current stage, and publish some prevention methods of related diseases and pests. Provide authoritative information on pests and diseases.

(2) The data collected by the images were analyzed through deep learning, and the types of diseases and pests collected were obtained. Ozone solutions of different concentrations were deployed according to the different levels of resistance of diseases and pests to ozone concentration, and the killing effect of ozone on agricultural pests and germs was utilized to achieve the prevention and control effect of diseases and pests.

(3) Due to the large area, long distance and complex terrain of the fruit trees, LoRa (Long Range) communication module is used in the orchard to monitor the soil moisture, air temperature, humidity, light intensity, diseases and pests in the orchard. On the mobile side, LoRa is used to connect the OneNET cloud platform to transmit the collected data to the cloud platform in real time, so that the internal information of the orchard can be viewed anytime and anywhere, and the orchard device can be controlled remotely.

II. Overall structure of orchard pest monitoring system

2.1 Functional requirement analysis of orchard pest monitoring system

The orchard pest prevention and control system based on the Internet of Things is based on the Internet of Things technology, and consists of four modules: orchard internal environmental monitoring module, intelligent voice warning module, communication module, and pest treatment module, which displays all kinds of data to orchard growers in real time. The characteristics of the orchard disease and pest control system based on the Internet of Things -- accurate collection and transmission of various types of data inside the orchard, accurate detection of existing diseases and pests inside the orchard, warning module to prompt orchard growers, and use scientific and effective and pollution-free physical and biological methods to remove diseases and pests in the orchard, while improving the fruit constant, Ensure the quality of the fruit [10-15].

(1) Orchard internal environment monitoring module: composed of soil moisture sensor, air temperature, humidity sensor, light sensor, carbon dioxide sensor, soil PH value sensor. The environmental parameters inside the orchard can be monitored in real time, and the measured environmental data can be transmitted to the network layer, and finally transmitted to the planter.

(2) Intelligent voice warning module: When the soil humidity is too low and the air temperature is too high inside the orchard, it will generate an early warning in time to remind the fruit farmer to water the fruit tree and remind him to open the spray device; When monitoring the presence of pests and diseases in the orchard, early warning will be generated to inform the fruit farmer, reminding the need to start the pest treatment module and so on.

(3) Communication module: Due to the wide area inside the orchard, the distance is far. Therefore, this system uses LoRa technology which has the advantages of low power consumption, simple structure, high penetration and long transmission distance to realize the communication in the orchard.

(4) Pest treatment module: This system uses ozone spraying device to achieve the elimination of diseases and pests in the orchard, and the strong oxidation of ozone can realize the inactivation of diseases and pests. It is a harmless pest and disease elimination technology, which can greatly solve the problem of pesticide residues in fruits.

the Internet of Things (IoT) is a new technology that combines various types of sensors and connects the network to realize the interconnection of everything, and realizes the integration of human social life and physical entities. Manage production and life in a detailed and precise non-static way, improve the utilization of social resources and increase the production efficiency of productive forces, adjust and improve the relationship between human society and the natural world. The architecture of the Internet of Things technology is divided into the bottom perception layer, the upper application layer, and the network layer in the middle of the perception layer and the application layer. Figure 2-1 shows the architecture of the Internet of Things.

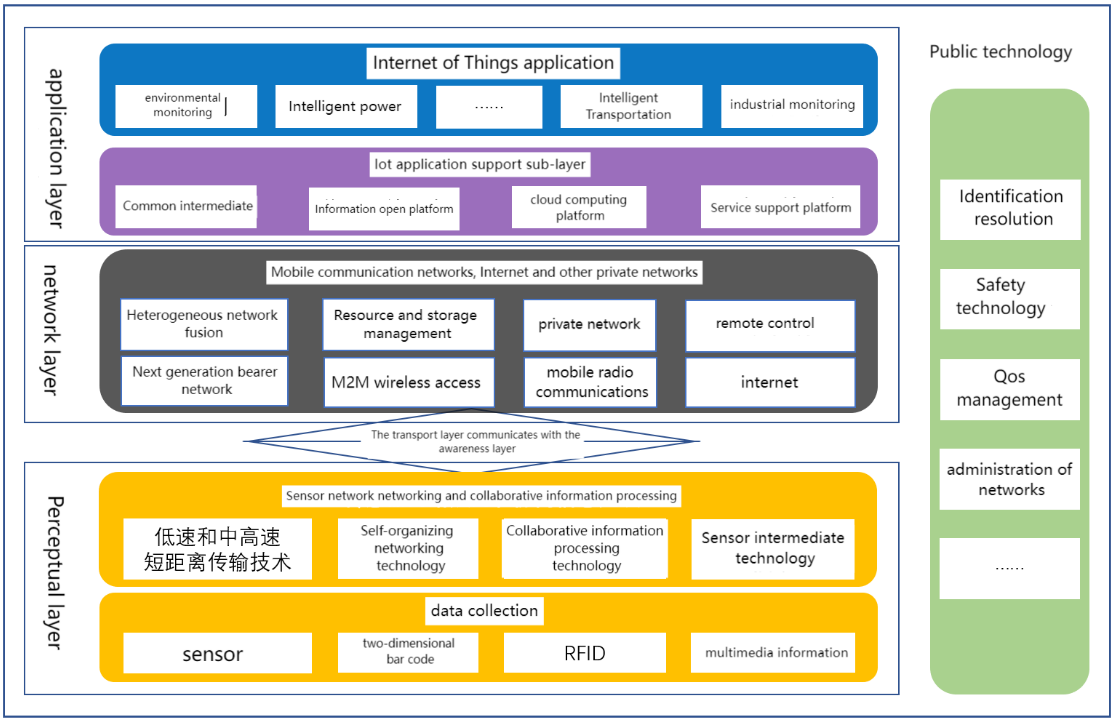

Figure 2-1 iot architecture diagram

2.2 Orchard pest monitoring system overall program

2.2.1 Orchard environment monitoring module

In the Orchard environmental monitoring module, In this research system, pest monitoring equipment is used to detect the types of diseases and pests inside the orchard, soil moisture sensor to collect soil moisture parameters, light sensor to collect light intensity inside the orchard, soil pH sensor to detect soil PH value, carbon dioxide sensor to collect CO2 concentration in the air, and air temperature and humidity sensor to collect air temperature and humidity information.

(1) Soil moisture sensor: Water is an important part of fruit trees. The fruit trees need to consume a lot of water during the daytime when the sunlight is intense and the transpiration of the leaf surface of the fruit trees is intensified. 60%-80% soil moisture is suitable for the growth of fruit trees, and long-term soil water shortage will lead to leaf shedding, branch necrosis, and fruit dryness. Therefore, it is necessary to grasp the soil moisture in real time. In this research system, FC-28 soil moisture sensor is used to collect the soil moisture data inside the orchard. When the soil moisture sensor is working, it will produce a voltage value of 0-5V. The measured voltage value will be transmitted to the ADC pin of the single chip computer, and the single chip computer will convert the analog voltage measured by the soil moisture sensor into a digital voltage, and the digital value will be converted into the accurate data of soil moisture.

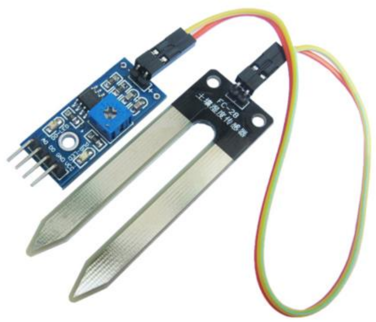

Figure 2-2 Soil T/H sensor FC-28

Soil environment is one of the important indicators for the growth and outbreak of pests. The soil moisture sensor is inserted into the appropriate soil depth to obtain the detailed information of the soil environment, and the specific parameters of the sensor can be accurately obtained through the analysis of soil parameters. The specific parameters of the soil moisture sensor FC-28 are shown in Table 2-1:

Table 2-1 Parameter description of the soil T/H sensor FC-28

Sensor parameter name	Parameter content
power supply	3.3-5V
output signal	Digital signals and analog signals
response time	<1s
Moisture measuring range	0-100%
Moisture measurement accuracy	±3% of reading (0-53% range)
	±5% of reading (53-100% range)
power consumption	<0.15W
supply current	4-20mA

(2) Air temperature and humidity sensor: the temperature, humidity and light intensity of the air inside the orchard are important meteorological environmental data, which can directly display the environmental meteorological conditions required for the growth of fruit trees and the generation and outbreak of related diseases and pests. The data detected by the sensor combined with meteorological data can be used as important reference data for disease and pest monitoring. The DHT11 air temperature and humidity sensor is used in the system. Figure 2-3 shows the sensor.

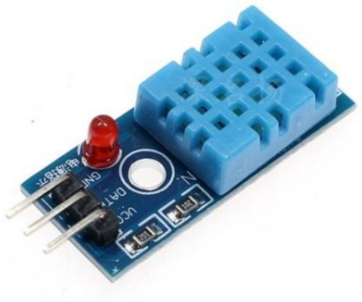

Figure 2-3 DHT11 Air T/H sensor

Appropriate air temperature and humidity can effectively promote the generation of fruit trees and fruit development and reduce the occurrence of fruit diseases and pests. Therefore, real-time grasp of the air temperature and humidity inside the orchard is an important factor to ensure the healthy growth of fruit trees and fruit quality. Table 2-2 lists the specific parameters of the DHT11 air temperature and humidity sensor.

Table 2-2 Parameters of the DHT11 air T/H sensor

Sensor parameter name	Parameter content
supply voltage	3-5.5V
supply current	0.2-1mA（average）
Temperature measuring range	0-50℃
Temperature measurement accuracy	±2℃
Humidity measuring range	20-90%RH
Humidity measurement accuracy	±5%RH
sampling period	1 time/second

temperature resolution	0.1℃
Humidity resolution	0.1%RH

(3) Light sensor: Suitable light can accelerate the photosynthesis of fruit trees, accelerate the development and growth of fruit and the accumulation of sugar in fruit; However, too much light will burn the fruit, resulting in deformity and reduced quality of the fruit. In severe cases, it can burn fruit trees, causing the bark to dry and crack, and the number of short branches to increase. The system uses the light sensitivity of the photoresistor pair to detect the light intensity inside the orchard, and adjusts the light intensity range with the adjustable Diani. When the detected light intensity inside the orchard is higher than the maximum light intensity, the D0 end will output a low level, and the reverse output a high level. Figure 2-4 shows the sensitive photoresistor sensor used in this system.

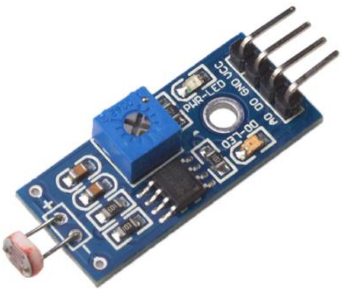

Figure 2-4 Sensitive photoresistor sensor

Table 2-3 lists the parameters of a sensitive photoresistor sensor.

Table 2-3 Parameters of a sensitive photoresistor sensor

Sensor parameter name	Parameter content
supply voltage	3.3V-5V
comparer	wide voltageLM393
output form	D0 switch output (0 and 1)
	A0 analog output (voltage)
Comparator output	Signal clean, good waveform
	Signal driving force is strong, more than 15mA

(4) CO2 sensor: Carbon dioxide (CO2) is a colorless, odorless substance that plays an important role in the process of plant photosynthesis. An appropriate concentration of carbon dioxide can promote photosynthesis in orchards, promote the expansion and growth of fruits and the growth of fruit roots and leaves. The CO2 sensor used in this research system is MQ135 sensor. Figure 2-5 shows the MQ135 sensor.

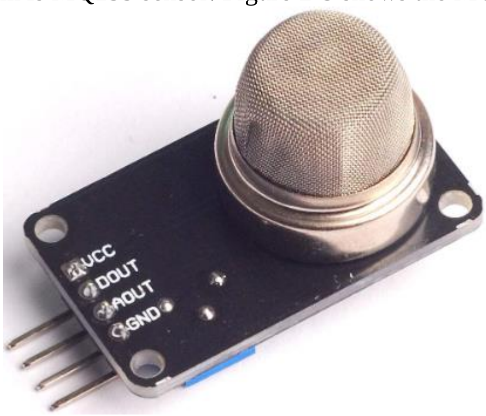

Figure 2-5 MQ135 sensor

2.2.2 communication module

The system uses LoRa technology as the communication module inside the orchard, which can effectively solve the orchard area, distance, complex terrain and so on. LoRa is a low-power wide-area network communication technology, full name Long Range. It is an improved ultra-long-range wireless communication technology based on the extended spectrum technology, which can bring users a simple, long battery life and low power consumption wireless communication method [1]. Table 2-4 lists the technical advantages and key features of LoRa.

Table 2-4 Technical advantages and key features of LoRa

key characteristic	advantage
Low construction cost, small number of base stations, easy to expand	Easy to deploy
The communication distance is over 15km	Long communication distance
Low cost of free infrastructure for frequency bands Low cost of nodes/terminals	Low maintenance cost
Ultra-low current and dormant battery, the battery can be used for more than 10 years	low power dissipation

2.2.3 Pest monitoring module

The pest monitoring module is divided into image acquisition, preprocessing, pest target identification, and result uploading and display. The overall framework of the pest monitoring module is shown in Figure 2-6.

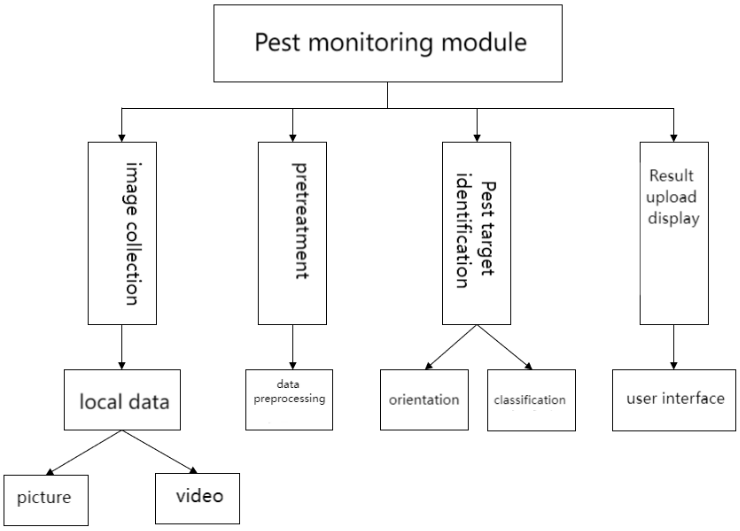

Figure 2-6 Overall framework of the pest monitoring module

(1) Image acquisition: image acquisition provides image data information for the whole system, and the data information comes from local data. There are two types of local data: video data and image data. The data acquisition device is the OV7670 industrial camera with fifo chip. Figure 2-7 shows the image data acquisition device.

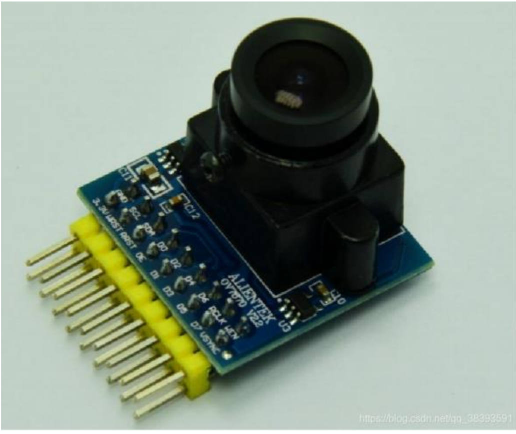

Figure 2-7 Image data acquisition device

(2) Pre-processing: The pre-processing module adopts two methods: grayscale and threshold method. The color images obtained by image acquisition cannot be used immediately, so it is necessary to process these color images in gray-scale, that is, adjust the component values of R, G and B for RGB images. The gray-processed images also need to be further processed. Median filtering technology is used to remove the gray-scale image information for local gray-scale noise, so as to obtain the well-segmented binary image with discontinuity according to the boundary noise. Morphology is used to remove the boundary and finally obtain the well-segmented binary value graph. At this point, the image preprocessing has been completed.

(3) Pest target identification: The images and videos in the orchard are collected according to the specific sampling frequency, and uploaded to the detection platform regularly. The platform will automatically record the image information collected every day, and use the pattern recognition disease and pest image recognition algorithm with model recognition verification and model construction to obtain specific types of diseases and pests, and form the corresponding knowledge base of diseases and pests. The final form of a variety of charts to show orchard growers.

(4) Upload and display of results: By detecting local video files, detecting local picture files, calling local cameras for online image and video detection, uploading the detected video pictures to local storage and displaying them to orchard growers.

III. System hardware design and implementation

3.1 Hardware overall framework

In this paper, STC8F2K64S4 chip of 51 microcontroller is used as the total control chip, and soil moisture sensor, air temperature and humidity sensor, light sensor, CO2 sensor and soil PH value sensor are connected externally to monitor the environmental information inside the orchard. The measured environmental parameter information is displayed on the ili9486 display; When the internal environmental parameter information of the orchard exceeds the threshold value or the occurrence of diseases and pests is monitored, the early warning circuit will be activated; When the occurrence of diseases and pests is detected, the ozone spraying device will be activated, and different concentrations of ozone solution will be sprayed according to different types of diseases and pests. The overall framework diagram of orchard pest prevention and control based on the Internet of Things is shown in Figure 3-1.

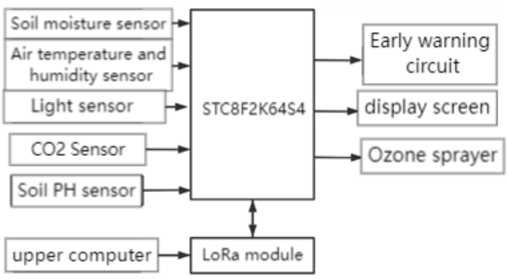

Figure 3-1 Overall framework of orchard pest prevention and control based on Internet of Things

3.2 Sensor acquisition circuit design

The environment inside the orchard is related to the growth of the fruit tree and the development of the fruit, and plays an important role in ensuring the quality of the fruit. DHT11 digital temperature and humidity sensor is divided into a resistive moisture sensing element part and an NTC temperature measuring element part. After the module is started, the user sends the start signal, and the air temperature and humidity sensor will convert the operation mode from the original low-power mode to the high-speed operation mode, and trigger the signal acquisition. Figure 3-2 shows the DHT11 C87032 interface circuit diagram. The moisture content of the soil inside the orchard will affect the resistivity of the soil. The soil moisture sensor inserted in the soil can detect the resistivity of the soil inside the orchard to determine the soil moisture at this time. The smaller the resistivity of the soil, the stronger the conductivity of the soil, and the change in the detected soil resistivity is converted into an electrical signal. Finally, the moisture of the soil inside the orchard is obtained. Figure 3-3 shows the circuit diagram of the soil moisture sensor.

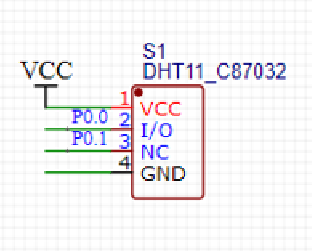

Figure 3-2 Port circuit diagram of the DHT11 C87032

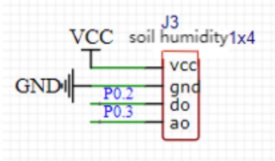

Figure 3-3 Circuit diagram of the soil moisture sensor port

The system adopts GY-30 illuminance sensor, which adopts the principle of hot spot effect, and the detection components are sensitive to low light. The module adopts the IIC communication mode which packages the light intensity data into I standard. Figure 3-4 shows the circuit diagram of the GY-30 interface of the light sensor. This system uses MG811 carbon dioxide sensor, the module will output voltage when working, the higher the output signal voltage, the lower the CO2 concentration in the environment where the module works, and the higher the vice versa. Therefore, through the linear relationship obtained, the change of CO2 concentration in the air can be obtained. Figure 3-5 shows the interface circuit diagram of the MG811 CO2 sensor.

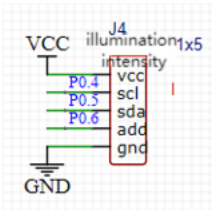

Figure 3-4 Circuit diagram of ports on the GY-30 light sensor

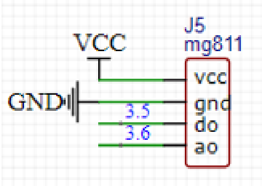

Figure 3-5 Circuit diagram of the MG811 interface of the CO2 sensor

3.3 Overall circuit setup

Figure 3-6 shows the schematic diagram of the overall system circuit configuration.

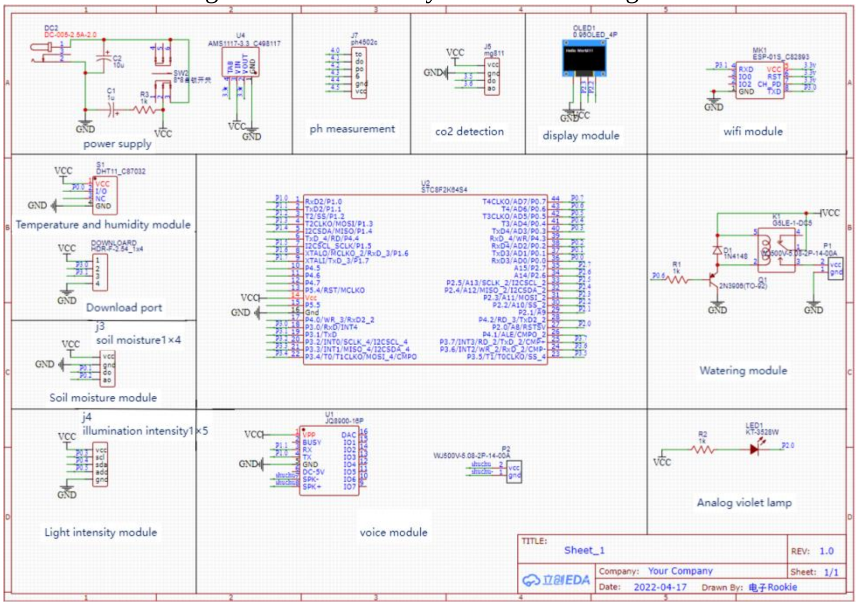

Figure 3-6 Schematic diagram of the overall system circuit configuration

3.3.1 Power module circuit Settings

The power supply module uses A DC power socket. The model is DC-005B-2.5A-2.0. The electrical parameters are 2.5A current and 24V voltage. Figure 3-7 shows the circuit diagram of the DC-005B-2.5A-2.0. Its output voltage is 3.3V, it is a forward low voltage drop regulator, model AMS1117-3.3. Figure 3-8 shows the circuit diagram of the AMS1117-3.3.

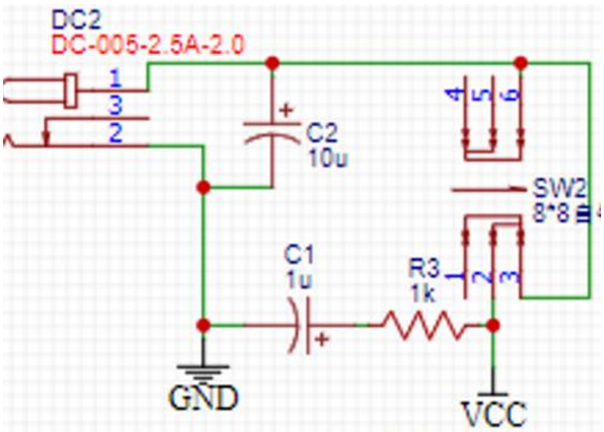

Figure 3-7 Circuit diagram of DC-005B-2.5A-2.0

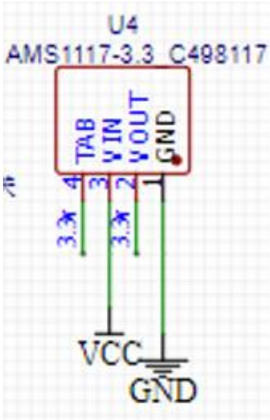

Figure 3-8 Circuit diagram of AMS1117-3.3

3.3.2 LoRa module circuit setup

This system uses SX1268 LoRa module, which is a long-distance, low-power wireless transceiver launched by Semtech in 2013. SX1268 is a high-performance wireless transceiver for the Internet of Things. It has a special LoRa modulation mode, which increases the communication distance to some extent. Operating frequency band :230/400/900MHz; Transmit power :22/30dBm. Table 3-1 lists the main parameters of the SX1268 LoRa module.

Table 3-1 Main parameters of the LoRa module

Name of parameter	Parameter content
Working voltage	3.0-3.6V (3.3V recommended)
Working current	Average value: 80mA
Wireless standard	802.11 b/g/n
security mechanism	WPA/WPA2
networking protocol	IPv4.TCP/UDP/HTTP/FTP
software development	Support customer custom server Provides SDK for customer secondary development
data interface	UART/HSPI/I2C/I2S/Ir Remote Contorl GPIO/PWM

A total of 16 pins are connected to an SX1268 switch. Figure 3-9 shows the pins of an SX1268 switch, and Figure 3-10 shows the circuit diagram of an SX1268 switch. Table 3-2 describes the ports of an SX1268 switch.

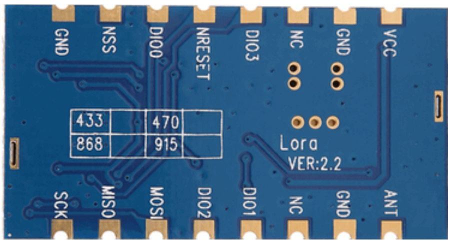

Figure 3-9 Pins of an SX1268 switch

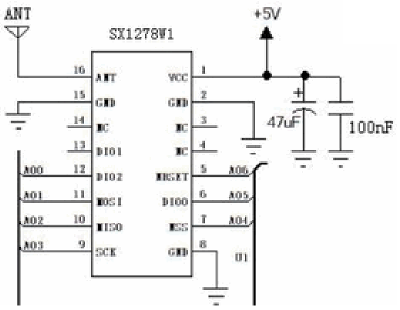

Figure 3-10 Typical circuit diagram of an SX1268 switch

Table 3-2 SX1268 pin definitions

Pin number	Pin definition	description
1	VCC	power connection
2	GND	Power Ground connection
3	NC	suspend in midair
4	DIO3	digital I/O， can be customized
5	NRESET	reset trigger input
6	DIO0	digital I/O， can be customized
7	NSS	SPI Slice select input
8	GND	Power Ground connection input
9	SCK	SPI clock
10	MISO	SPI data output
11	MOSI	SPI data input
12	DIO2	digital I/O， can be customized
13	DIO1	digital I/O， can be customized
14	NC	suspend in midair
15	GND	Power Ground connection
16	ANT	Connect to a 50 euro coaxial antenna

3.3.3 Voice warning module circuit Settings

The voice module used in this system is JQ8900-16P. The USB interface follows the 2.0 standard, the input voltage DC is 2.8-5, 5V, and the level is 3,3 V. The sleeping current is 500uA and the working current is 10MA. Figure 3-11 shows the pins of the JQ8900-16P voice module. Table 3-3 describes the pin functions of the JQ8900-16P voice module. Figure 3-12 shows the circuit diagram of the JQ8900-16P voice module.

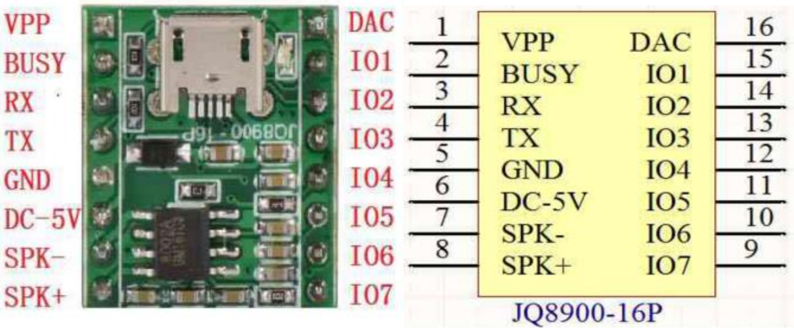

Figure 3-11 Pins of the JQ8900-16P voice module

Table 3-3 Pin description of the JQ8900-16P voice module

Pin name	functional description
VPP	One-line serial port
BUSY	Play indicator light
RX	UART serial data entry
TX	UART serial data out
GND	ground
DC-5V	Module power input
SPK-	trumpet+
SPK+	trumpet-
I07	Departure input 7
I06	Departure input 6
I05	Departure input 5
I04	Departure input 4
I03	Departure input 3
I02	Departure input 2
I01	Departure input 1
DAC	audio output

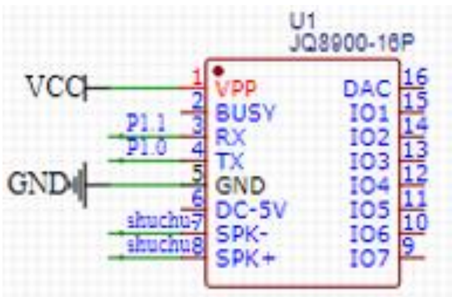

Figure 3-12 Circuit diagram of the Q8900-16P voice module

3.3.4 Watering module circuit setup

The watering module consists of a universal relay and a water pump, of which the universal relay model is G5LE-1-DC5. The relay coil voltage is 5V and the coil current is 79.4mA. Figure 3-13 shows the circuit diagram of the watering module.

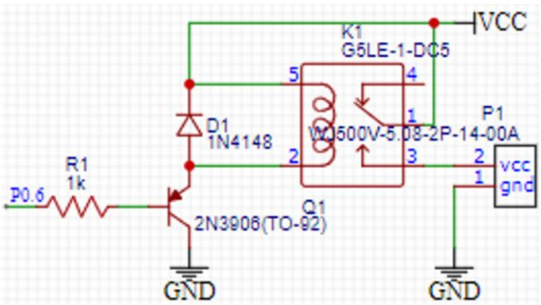

Figure 3-13 Circuit diagram of the watering module

3.4 Structure and assembly of ozone generating device

Ozone is a light blue gas. Ozone is a very strong oxidation and sterilization, its oxidation capacity is very strong, its oxidation capacity to exceed oxygen, at room temperature will automatically decompose into oxygen. Ozone is a highly efficient oxidizing agent that does not produce secondary pollution. Ozone can rapidly oxidize the lipids in the bacterial cell wall, and then enter the bacterial cell interior to react with the lipopolysaccharides and proteins in the bacterial body, change the bacterial cell permeability, and then inactivate them [16-19].

3.4.1 Ozone manufacturing method

(1) Ultraviolet irradiation: The use of ultraviolet radiation to irradiate oxygen, in the process of irradiation will make a part of the oxygen reaction is decomposed into a single oxygen ion, a single oxygen ion recombination to form ozone.

(2) Chemical radiation method: chemical radiation method uses the corresponding radioactive source to radiate oxygen, so that oxygen molecules are decomposed into oxygen ions.

(3) Low voltage electrolysis method: the anode and cathode electrodes are connected in the electrolyte solution, and the ozone molecules will precipitate at the positive extreme during the preparation process.

3.4.2 Structure of ozone generating device

Comprehensive comparison of ultraviolet irradiation, low voltage electrolysis, chemical radiation method. In this research system, ozone is prepared by low pressure electrolysis, and a three-in-one membrane electrode structure is adopted by solid polymer electrolyte technology. In this structure, the cathode chamber and anode chamber are separated by solid polymer electrolyte, and the electrolyte film is closely bonded with the cathode material to form a thin film electrode device, which enlarges the contact area between electrode reactions. The rate of mass transfer between the reactants is further increased, and there is no electrolyte depressurization problem. Figure 3-14 shows the structure of the ozone generating device. The ozone generating device is mainly composed of three parts: electrolytic cell structure, membrane electrode assembly and fluid collector [20-24].

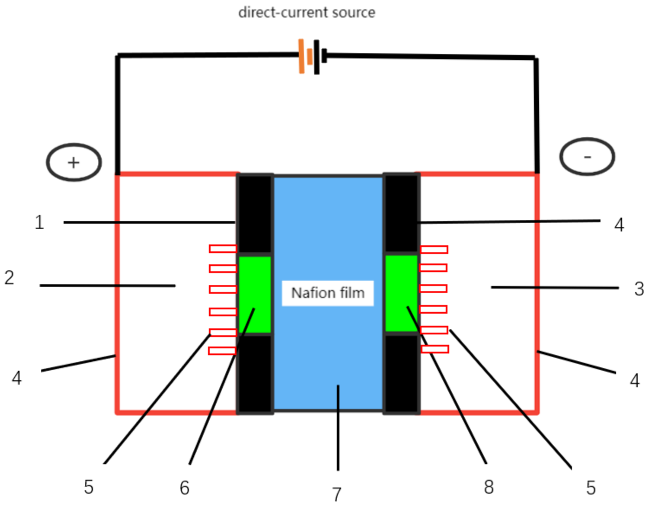

Figure 3-14 Schematic diagram of the ozone generating device

1. Sealing gasket; 2. Anode reaction zone; 3. Cathode reaction zone; 4. Fluid collection; 5.Diversion area 6.Anode material; 7.Nafion membrane; 8. Cathode material

(1) electrolytic cell structure: The electrolytic cell structure of the ozone generating device is composed of a sealing gasket, a cathode reaction zone and a diversion zone. Among them, the diversion area adopts S-shaped flow channel design, on the one hand, it can timely discharge the hot gas and reduce the resistance loss of the pipeline. At the same time, the diaphragm can be fully contacted with the electrolyte to ensure the uniform distribution of the electrolyte in the electrolytic cell. The main function of the sealing gasket is to keep the plate in close contact with the membrane electrode assembly to prevent the electrolyte from being exposed and the gas liquid from mixing [25-27].

(2) Membrane electrode assembly: The main function of Nafion membrane is to block the permeation and mixing of reaction products and provide a road for proton transfer. The anode and cathode material and the Nafion film are in close contact to form a whole, forming the membrane electrode assembly (MEA), which is the core element of ozone production by electrolysis of solid polymer electrolyte. The close contact of the

membrane electrode components is beneficial to improve the energy conversion efficiency and reduce the contact resistance. In order to prevent short circuit between the electrodes, the area of the anode and cathode material should be ensured to be smaller than the area of the Nafion film.

(3) Fluid collector: The fluid collector material of the anode and cathode is generally composed of metal titanium with high mechanical strength, strong corrosion resistance and good conductivity, and its main role is to provide conductors for the transfer of reaction charges and evenly transmit the current to the component of the membrane electrode. The selection of titanium as a fluid collector can increase the permeability and void distance, ensure the gas-liquid conductivity, and ensure that the electrolyte is evenly distributed in the entire area of the activated electrode.

3.4.3 Assembly of ozone generating units

Figure 3-15 shows the assembly structure of the ozone generator. Both sides of the Nafion film are closely combined with the anode and cathode materials to form the membrane electrode assembly. The sealing gasket is between the anode and cathode material and the metal titanium collector, and is sealed between the metal titanium collector and the membrane electrode assembly by compressing the sealing gasket; Under the action of the diversion zone, the electrolyte contacts with the component of the membrane electrode to achieve a uniform distribution of current on the membrane electrode component, which then triggers the electrolytic reaction of the anode and cathode, and produces ozone gas [28-32].

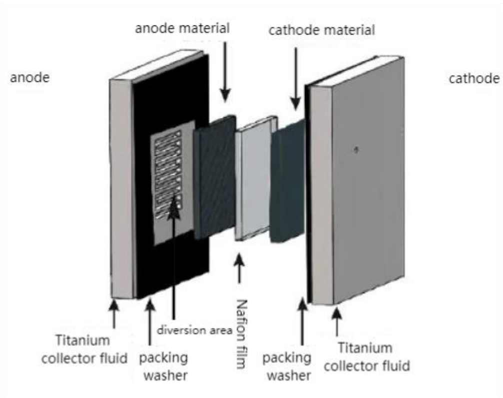

Figure 3-15 Assembly structure of the ozone generator

Figure 3-16 shows the flowchart for producing ozone by low pressure electrolysis. As shown in Figure 3-3, DC power supply is used, and the electrolyte is respectively sent to the cathode reaction and the anode reaction zone by peristaltic pump, and then oxidized in the anode reaction zone to generate oxygen, hydrogen ions, ozone and electrons. Through the external circuit, electrons reach the cathode, hydrogen ions enter the cathode through the Nafian film, and finally hydrogen and electrons undergo a reduction reaction in the cathode to produce hydrogen.

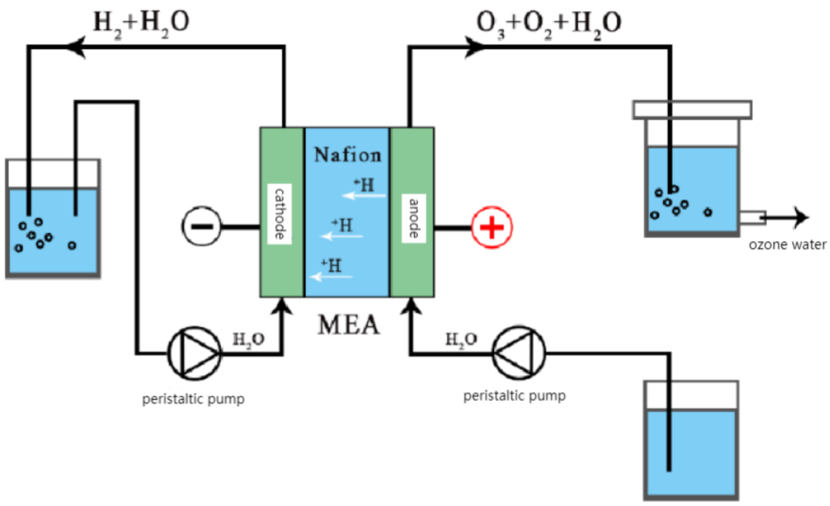

Figure 3-16 Flowchart of ozone preparation by low pressure electrolysis

IV. System software design and implementation

The system software module uses keil5 to program, the program is divided into five modules, respectively, the main program module, voice program module, DHT11 program module, light intensity program module and OLED program module. Among them, the main program module is responsible for calling other submodules, and the main function includes the use of the ADC inside the MCU. The voice program module includes the design of serial port 1 and serial port 2, serial port 1 is used for ESP82866; Serial port 2 is used for the JQ8900. DHT11 program module is used to monitor air temperature and humidity. The light intensity program module is applied to GY-30. OLED works on OLED12864. The DHT11 program module, the light intensity program module and the OLED program module include the writing of the protocol used by the corresponding module, the writing of the module command and the reading of the data.

4.1System main program design

This system is a multi-sensor Internet of Things orchard system, which needs to use multi-sensor technology to collect the internal data of the orchard, use the data collected by a number of sensors, use the fusion technology to effectively classify and identify the collected data, and finally use the fuzzy algorithm for data fusion. Figure 4-1 shows the flowchart of system main program design.

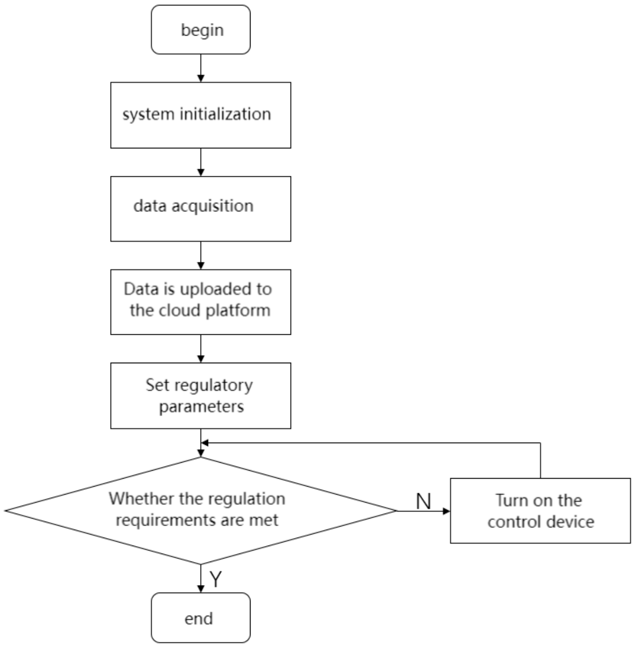

Figure 4-1 Flowchart of the system main program design

After the system starts to run, the system initialization work is carried out first. After that, multiple sensors are used to collect the data inside the orchard. Upload the collected data to the cloud platform for real-time viewing; Compare the collected data with the data parameters set in advance. If the data is not within the safe range, open the control device for regulation. The code running diagram of the main program is shown in Figure 4-2.

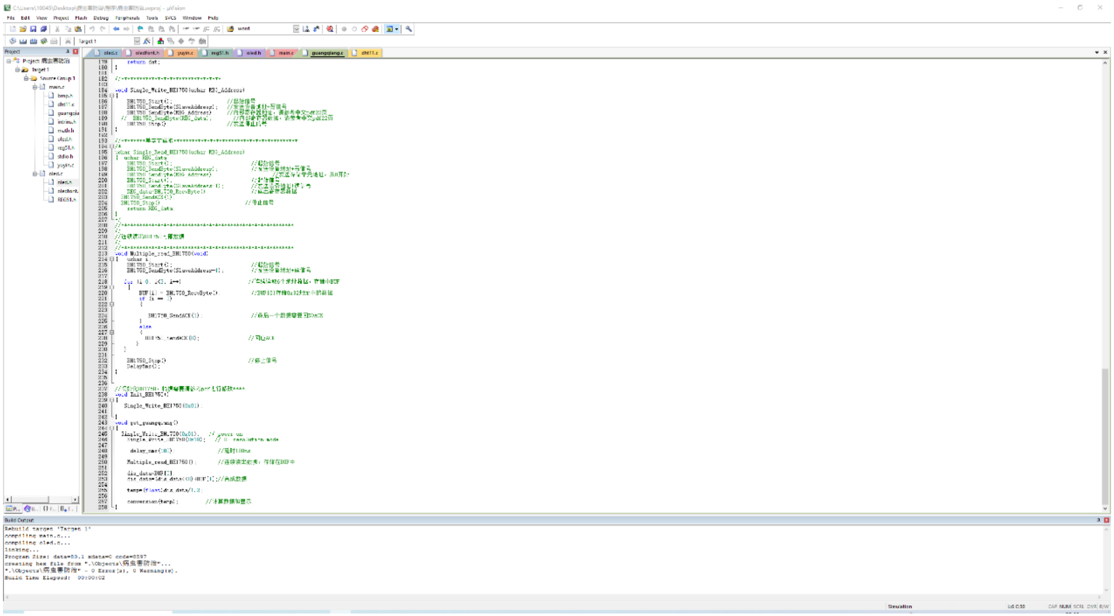

Figure 4-2 Code running diagram of the main program

4.2 System module programming

4.2.1 LoRa module subroutine design

When the LoRa module starts to work, it first sets the interval for uploading data, and determines whether to send packets by comparing the interval for uploading data and the interval for sending data. When the interval for uploading data reaches the interval for sending data, the packets are sent; otherwise, data collection continues. The collected data is processed by algorithms, homogenized, and then added to the message. Then compare whether the sending interval is reached. Figure 4-3 shows the LoRa data processing and uploading process. Figure 4-4 shows the program running diagram of the LoRa module.

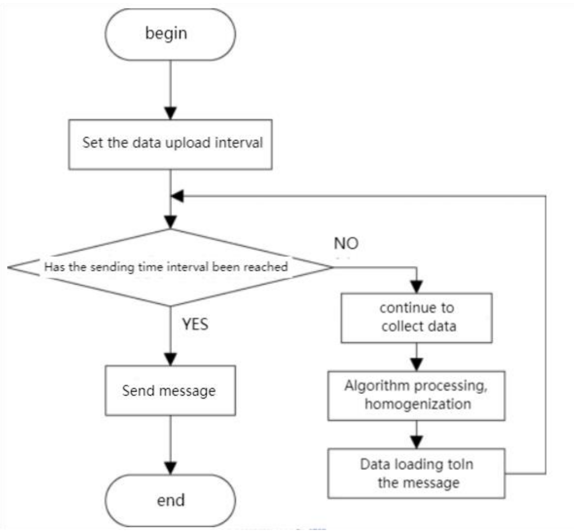

Figure 4-3 LoRa data processing and upload flow chart

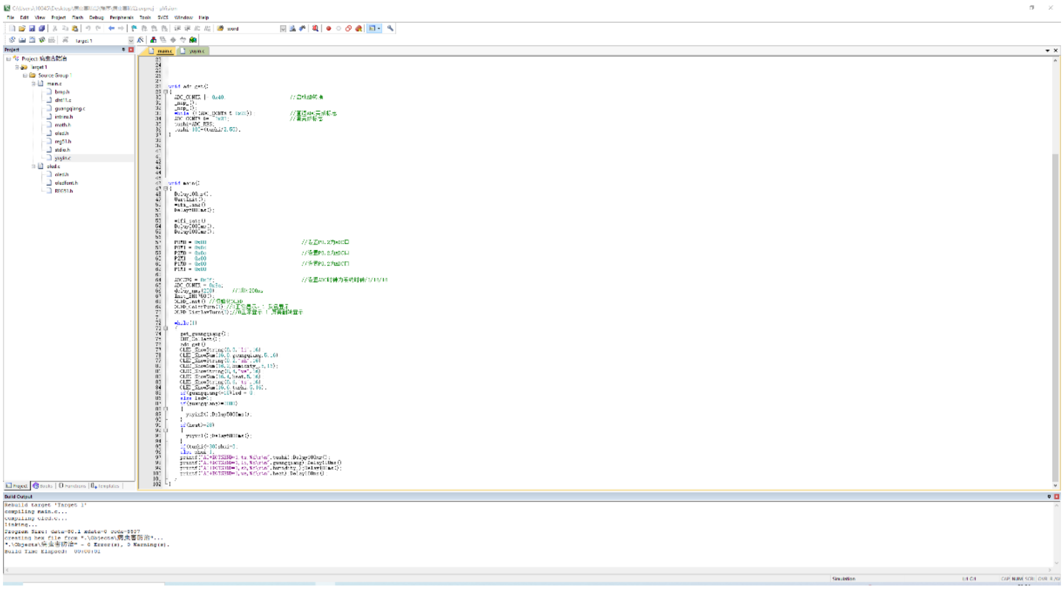

Figure 4-4 Program running diagram of the LoRa module

4.2.2 Temperature and humidity collection subroutine design

The temperature and humidity collection subroutine design module realizes real-time monitoring of air temperature and humidity and soil humidity inside the orchard. In order to improve the accuracy of temperature and humidity monitoring data, the temperature and humidity at this stage is obtained by collecting multiple times in the same time period and calculating the average value. After starting, the module first sets the collection times, and then determines whether the collection times are reached. When the collection times are reached, the average value T of the data is calculated, and the calculated results are stored. If the collection times are not reached, the temperature and humidity data will continue to be collected, and the collection times will be recorded, and then compared with the set collection times n again. Figure 4-5 shows the subroutine design for temperature and humidity collection. Figure 4-6 shows the operating diagram of the temperature and humidity collection code.

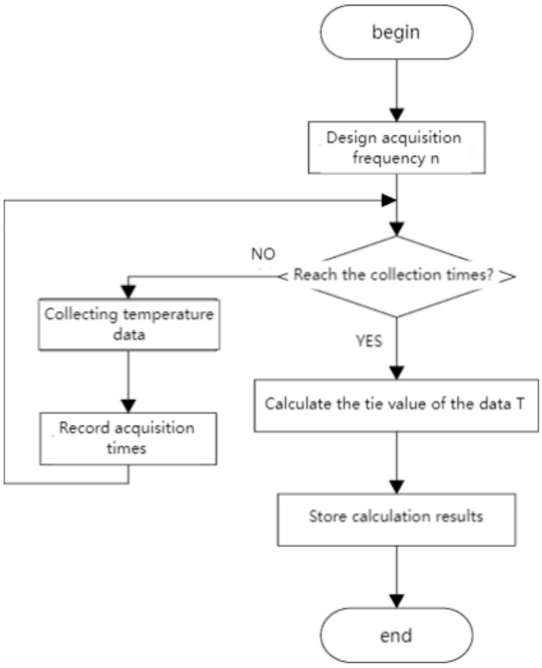

Figure 4-5 Temperature and humidity collection subroutine design diagram

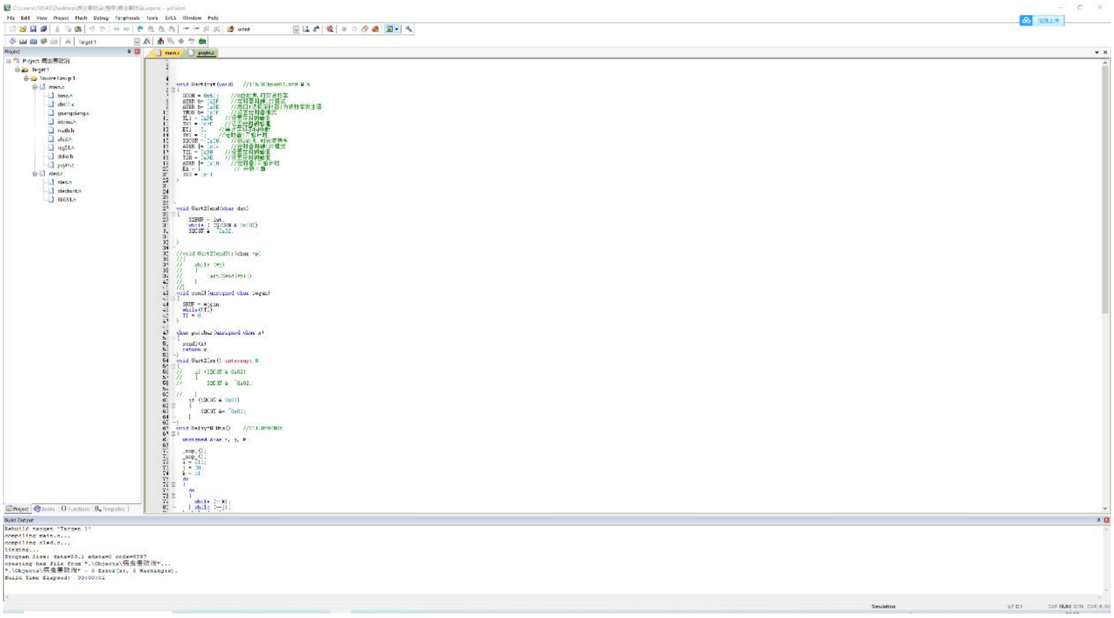

Figure 4-6 Running diagram of the temperature and humidity collection code

4.3 cloud platform

OneNET cloud platform can accept data collected by various sensors through LoRa communication technology, and can accept the environmental parameters inside the orchard in real time. After entering the cloud platform, you need to add products first, enter the product name, select product industry environmental monitoring, select LoRa networking mode, and click OK to create successfully. Figure 4-4 shows the products added to the cloud platform. Figure 4-5 shows the internal diagram of the cloud platform. After entering the product, click the device list on the left, open the connection between the mobile phone hotspot and the orchard disease and pest control hardware system, click real-time refresh data, and you can receive the orchard environment data monitored by the hardware system. The data display page of OneNET cloud platform is shown in Figure 4-6.

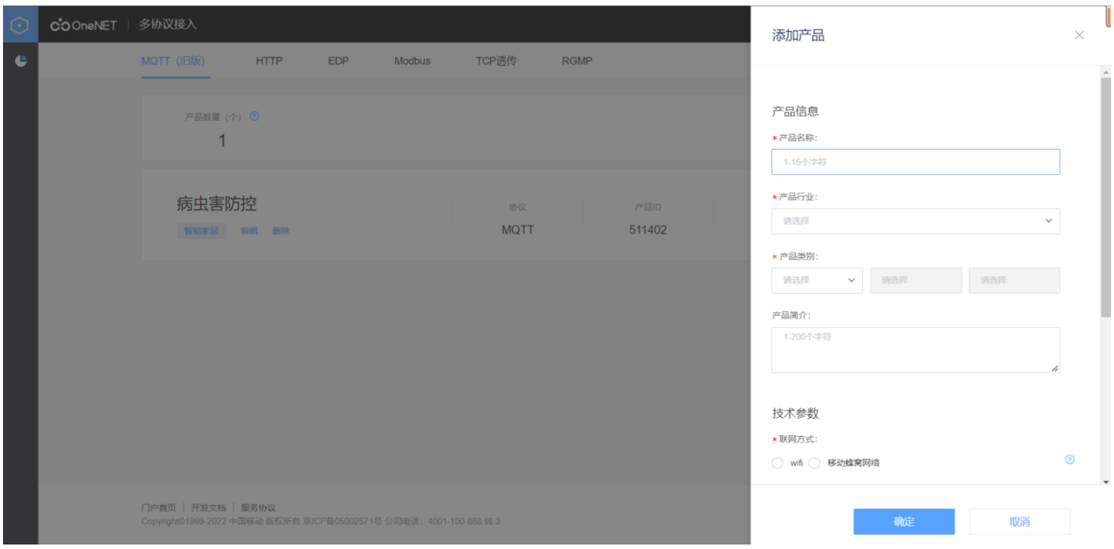

Figure 4-4 Adding a product to the cloud platform

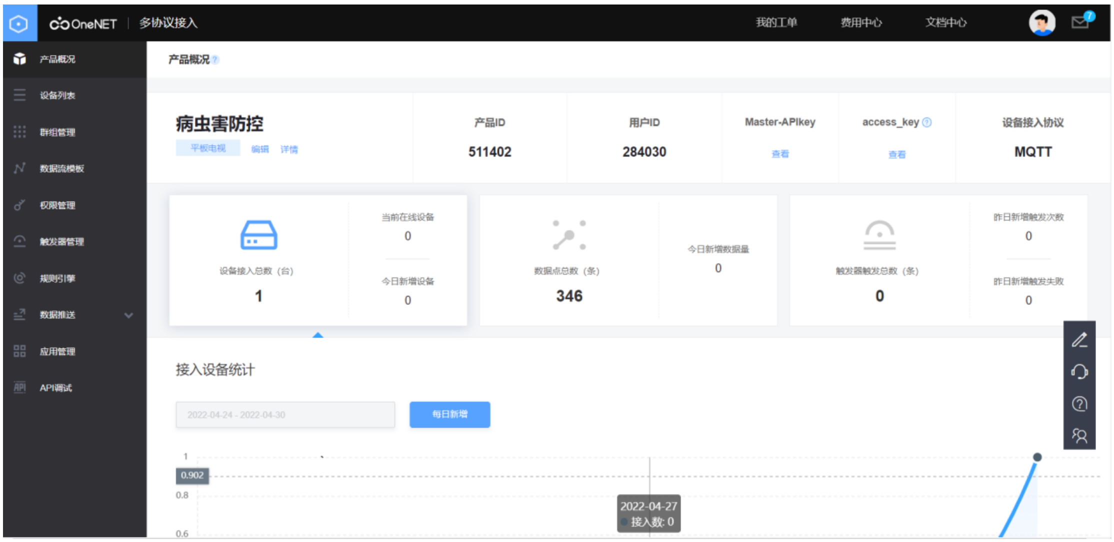

Figure 4-5 Internal diagram of cloud platform products

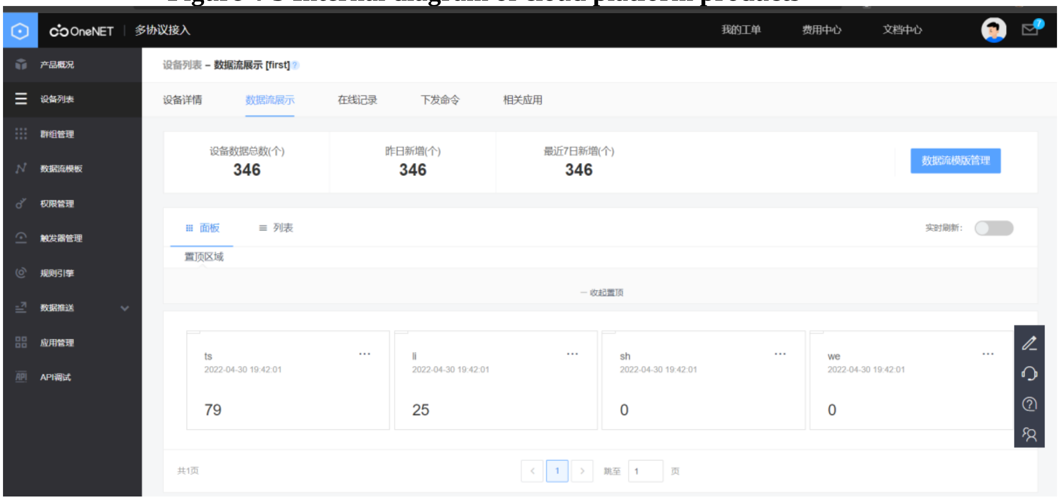

Figure 4-6 OneNET cloud platform data display page

V. System integration and testing

5.1 System physical display

The physical picture of the orchard pest and disease prevention system based on the Internet of Things is shown in Figure 5-1. The OLED display displays the current soil moisture, air temperature, air humidity and light intensity. The LoRa module connects to the mobile phone network and transmits data to the cloud platform. When the soil moisture is too low, a voice warning is issued and the irrigation device is activated. When monitoring the presence of pests and diseases in the orchard, it will spray the corresponding concentration of ozone water through the mist device according to different types of pests and diseases to eliminate pests and diseases.

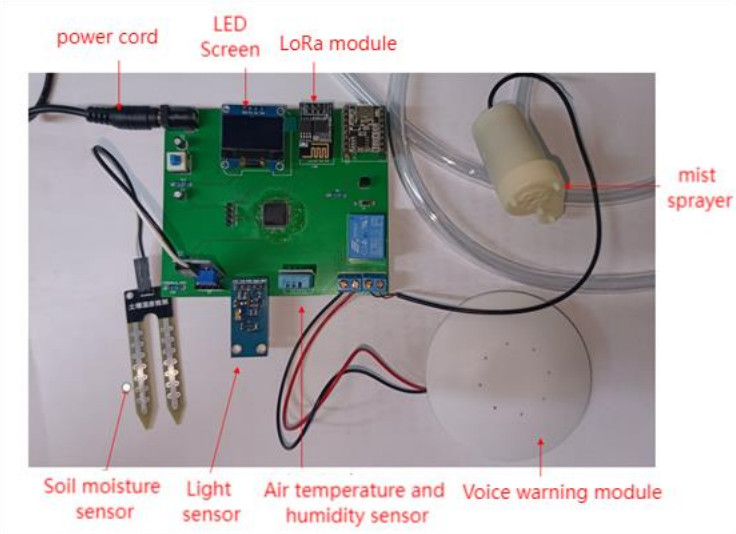

Figure 5-1 Physical diagram of orchard pest and disease prevention system based on Internet of Things

5.2 system testing

Through the data collected by the control system and uploaded to the OneNET cloud platform, the air temperature, air humidity, light intensity, soil humidity inside the orchard, the local pest quantity inside the orchard before spraying ozone solution and the local pest quantity inside the orchard after spraying ozone solution are drawn into a line chart. Figure 5-2 shows the line chart of air temperature data. Figure 5-3 shows the line diagram of air humidity. Figure 5-4 shows the line diagram of the light intensity. Figure 5-5 shows the line diagram of soil moisture data. Figure 5-6 shows the number of local pests in the orchard before ozone solution is sprayed. Figure 5-7 shows the number of local pests in the orchard before spraying ozone solution.

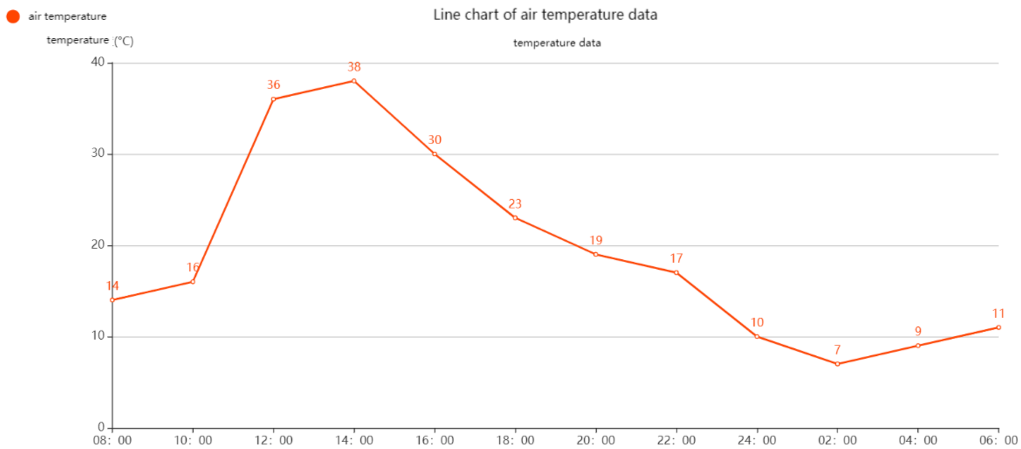

Figure 5-2 Line chart of air temperature data

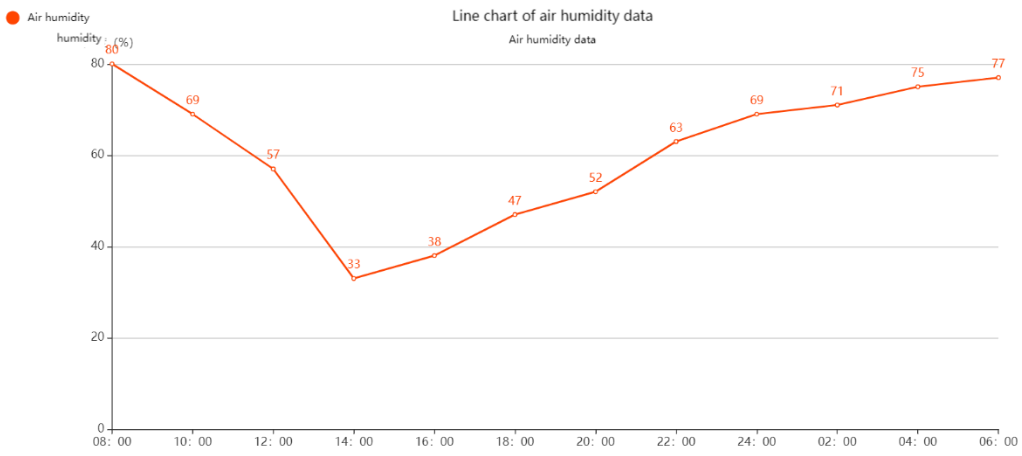

Figure 5-3 Line chart of air humidity

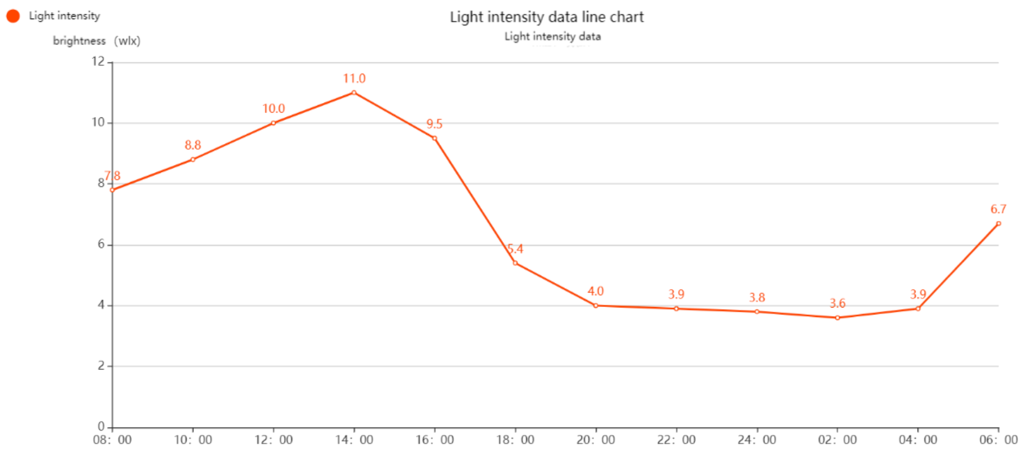

Figure 5-4 Line diagram of light intensity

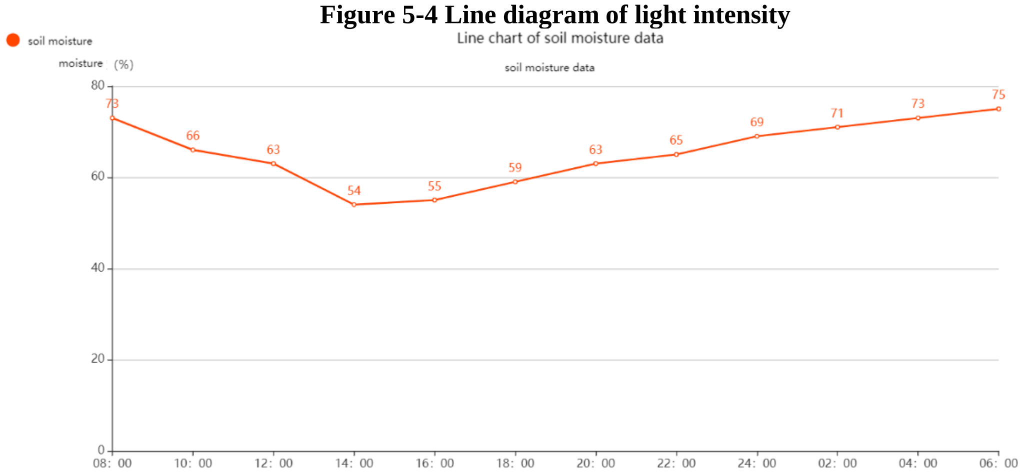

Figure 5-5 Line chart of soil moisture data

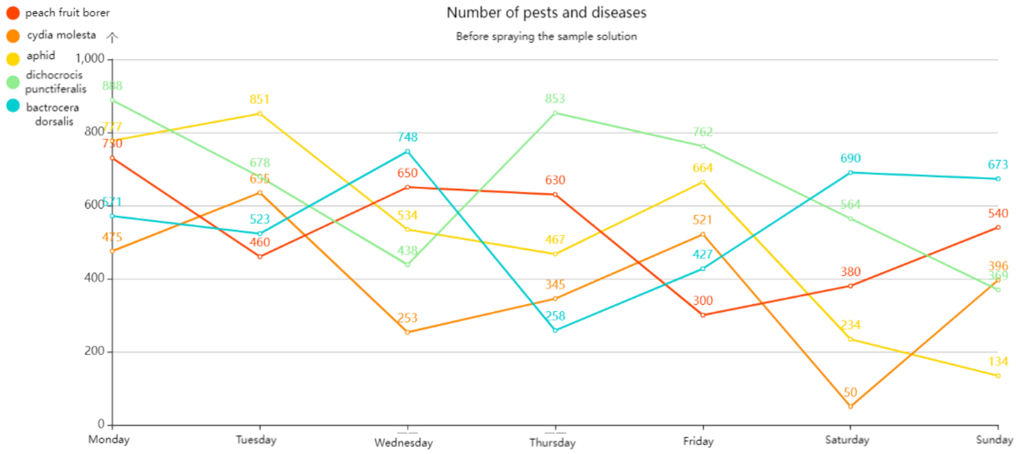

Figure 5-6 Local pest numbers in the orchard before ozone solution was sprayed

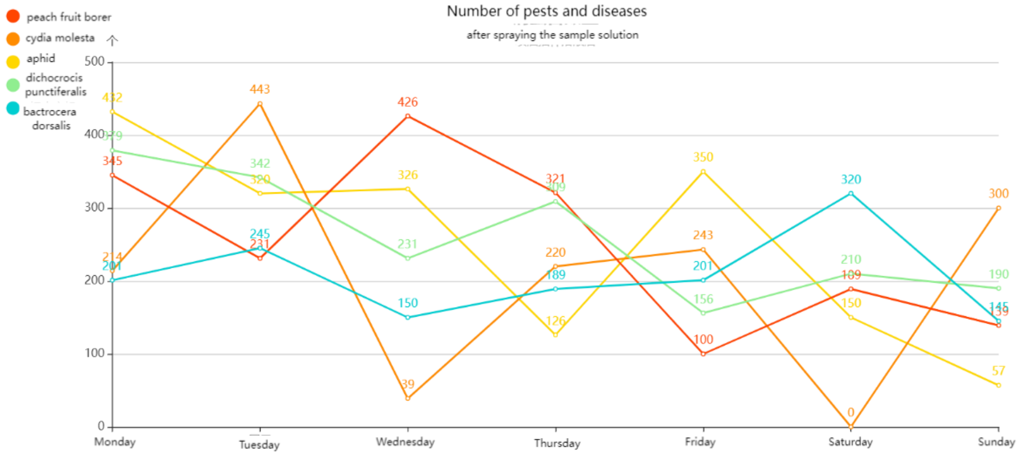

Figure 5-7 Map of local pest populations in orchards before ozone solution spraying

VI. Conclusions

This research system applies the Internet of Things technology to the planting industry of fruit trees, and designs an orchard disease and pest control system based on the Internet of Things. The results include the following aspects.

The development background of China's agricultural Internet of Things technology is deeply analyzed, and the practical application and research status of China's agricultural Internet of Things are analyzed. This paper compares the research of Internet of Things agricultural system and application at home and abroad, and analyzes and discusses the application of Internet of Things technology in intelligent agriculture. Finally, the development trend of agricultural Internet of Things in the future is discussed.

Ozone has strong oxidation, the appropriate concentration of ozone water can destroy the cell wall of bacteria, causing irreversible damage to its DNA or RNA, and then affect the reproduction of bacteria; Ozone water can also damage the cell membrane of pests, which can effectively kill diseases and pests. In this paper, low-voltage electrolysis method is selected to extract ozone, and the three-layer architecture of the Internet of Things is used to spray ozone water inside the orchard.

Build a three-layer architecture of the Internet of Things, and the three-layer architecture of the Internet of Things is divided into the perception layer, the network layer and the application layer. The sensing layer in this project includes soil moisture sensor, air temperature and humidity sensor, CO2 sensor, soil PH sensor and light sensor set inside the orchard. It is used to measure various temperature and humidity parameters, CO2 concentration and the number of pests in the orchard. In the sensing layer, the environmental parameters inside the orchard are collected and uploaded through LoRa, and then the embedded system in the application layer is processed by the upper computer to obtain the environmental parameters inside the orchard as well as the fruit growth rate and quality parameters, and the corresponding database is established.

Build the OneNET cloud platform and upload the collected data to the cloud platform, so that orchard growers can know the various environmental parameters inside the orchard anytime and anywhere in real time, and realize remote control of the orchard equipment through the cloud platform.

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