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Integrated Water and Fertilizer Irrigation Device based on Internet of Things

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Abstract

The integrated irrigation device of water and fertilizer based on the Internet of Things designed in this project applies technologies such as Internet of Things technology, wireless communication technology, sensor technology and data transmission technology. The device can monitor the soil moisture content of the relevant soil, and upload the relevant data to the cloud data platform of the Internet of Things in real time, and carry out the precise proportion of water and fertilizer according to different growth periods of different crops. The device is equipped with a positioning module and high-definition camera, which can provide real-time feedback on the location of the device and the surrounding environment. Users can grasp the location and spraying situation of the equipment in real time, and command the device at the mobile phone APP or PC at any time to achieve a more efficient fertilization effect. Achieve highly intelligent, refined and efficient agricultural production.

Keywords

Web Visual Interface; Precise Ratio of Water and Fertilizer; Soil Integrated Sensor; Data Transmission Module.

1. Introduction

Intelligent water-fertilizer integrated irrigation technology is a modern agricultural science and technology. Around 1970, agriculturally developed countries such as the United States and Israel have established irrigation systems covering the whole country[1]. After entering the 21st century, foreign intelligent water-fertilizer integrated irrigation systems have developed rapidly with the support of sensor technology, Internet of Things technology, wireless transmission technology and other technologies[2]. In the 1980s, China successfully developed the first generation of water-fertilizer integrated irrigation equipment[3]. Since 1995, the state has increased its support for the integration of water and fertilizer technology, and after the 21st century, China began to closely combine theoretical research with technological development, and realized the training of professional and technical personnel and the development of serialized equipment. Despite the progress made, there are still some problems in the application of intelligent water-fertilizer integrated irrigation technology, such as the low timeliness of sensor data transmission, the difficulty of equipment installation, the poor adaptive ability of equipment, and the lack of theoretical basis for the mixed ratio of water and fertilizer[4]. Therefore, it is of great practical significance to design a new integrated water and fertilizer irrigation device based on the Internet of Things. This paper aims to introduce the design and application of a new type of water and fertilizer integrated irrigation device. The device uses the Internet of Things technology to upload the data monitored by the sensor to the cloud data platform in real time[5]. The device adopts modular design, perfectly adapts to various terrain, and constantly improves the database through big data technology, which is suitable for a variety of crops.

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2. System Introduction and Function Introduction

The device uses STM32G431 single chip microcomputer to control the overall circuit for overall control, and adopts solar power supply system to ensure that the device can operate for a long time under no-light conditions to achieve safety and pollution-free, and dynamically monitors the concentration of nitrogen, phosphorus and potassium in soil and soil humidity by setting SIS10 soil comprehensive sensor[6]. The data is transmitted to STM32 for data processing, and the sensor data signal is transmitted by the LoRa module equipped with the device to the central host through MQTT protocol for ultra-long distance, and then transmitted by the central host to the cloud data platform. The content of nutrients required by different crops in different growth periods is analyzed through the big data platform, and then the data is fed back to the MCU. Control the water and fertilizer integrated device for accurate water and fertilizer ratio. At the same time, through the design of the Web visual interface, users can view the relevant data in real time, and achieve "regional data sharing and national data networking" on the basis of realizing the accurate ratio of water and fertilizer. At the same time, the ATGM332D-5N module is used for positioning and navigation. Combined with the Web visual interface, users can grasp the device position and spraying situation in real time, so as to realize the simultaneous operation of multiple devices. Users can command the device at the mobile APP or PC terminal at any time to achieve a more efficient fertilization effect[7]. On this basis, through the application of artificial intelligence technology, it can also achieve "cross-regional, fully automatic and intelligent" operation, greatly reducing manual input. Greatly improve the manual working environment and reduce the amount of manual use, and achieve highly intelligent, refined and efficient agricultural production.

3. The Overall Structure and Principle of the System

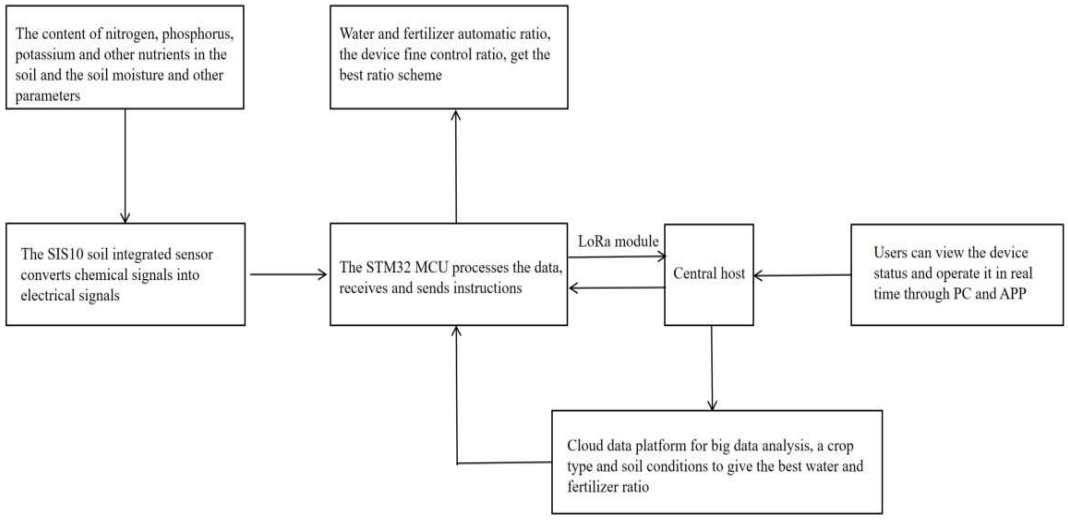

Fig. 1 Project development process diagram

The main body of the research is divided into six modules: main control module, power management module, adjustable nozzle module, soil detection module, positioning module and data transmission module.

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3.1. Main Control Module

We choose to use STM32G431 module as our main control module, with built-in RS485 bus to control related electrical appliances, such as motor, pump and intelligent nozzle. At the same time, the relevant communication protocol is used to communicate with the relevant module, and the relevant data monitored by the sensor is transmitted to the cloud data platform in real time through the MQTT protocol. At the same time, the PCB integrated circuit board is designed independently to ensure the continuous and stable operation of the system.

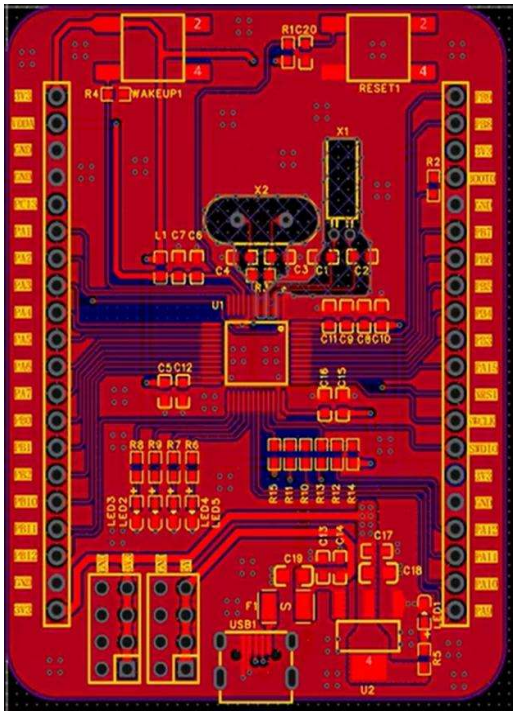

Fig. 2 Design PCB layout independently

3.2. Power Management Module

Our power management module includes solar power supply version, power converter and DC-DC step-down module. 220V voltage is divided into 220V, 12V and 5V power nodes by the power cord connected to the circuit of the built-in power management module. In the condition of light, the solar panel continuously generates electricity, and the device continuously provides power for the device when running. The power management module provides stable power supply for each module.

3.3. Adjustable Sprinkler Module

The spray Angle of the nozzle can be controlled by adjusting the corresponding mechanical device on the nozzle. At the same time, according to the different crops and the dry and wet conditions of the soil, the control module adjusts the knob to control the density of the water. At the same time, the baffle and U-hook of the nozzle can be adjusted according to the demand at the same time, so as to control the spraying range. The use of pure copper thread connection, not easy to corrode, durable.

3.4. Soil Detection Module

SIS10 soil integrated sensor (N, P, K, moisture, conductivity, temperature, salt) has stable performance and high sensitivity, and is an important tool for observing and studying soil water and salt changes and nutrient changes. Suitable for soil moisture monitoring, water-saving irrigation, greenhouse, soil rapid measurement, plant culture, fine agriculture and other occasions. The sensor has the following characteristics: soil nitrogen, phosphorus and

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potassium, water, conductivity, temperature, salt multi parameters can be selected; It can be used for the conductivity of water and fertilizer integrated solution, as well as other nutrient solution and matrix; The electrode is made of specially treated alloy material, which can withstand strong external impact and is not easy to damage; Completely sealed, resistant to acid and alkali corrosion, can be buried in soil or directly into water for long-term dynamic detection; High precision, fast response, good interchangeability, probe insertion design to ensure accurate measurement, reliable performance; Perfect protection circuit and a variety of signal output interface optional.

3.5. Positioning Module

The positioning module selects the ATGM332D-5N series module, which is the general name of the 12X16 size high-performance BDS/GNSS constellation positioning and navigation module series. This series of module products are based on the fourth generation of low-power GNSS SOC single-chip AT6558, supporting a variety of satellite navigation systems, including China's BDS (Beidou Navigation Satellite System), the United States GPS, Russia's GLONASS, the European Union's GALILEO, Japan's QZSS and satellite augmentation system SBAS (WAAS, EGNOS, GAGAN, MSAS). AT6558 is a real sense of six-in-one multi-mode satellite navigation positioning chip, including 32 tracking channels, can receive GNSS signals of six satellite navigation systems at the same time, and achieve joint positioning, navigation and timing. The ATGM332D-5N series module has the advantages of high sensitivity, low power consumption and low cost, which is suitable for on-board navigation and handheld positioning, and can directly replace the Ublox NEO series module.

3.6. Data Transmission Module

In terms of data transmission module, ATK-LORA-01Lora module is selected. LoRa module is a kind of LPWAN communication technology, and it is a kind of ultra-long distance wireless transmission scheme based on spread spectrum technology adopted and promoted by Semtech. At present, the global free frequency band has 433, 868, 915MHz and so on. LoRa module communication technology is the most characteristic, high sensitivity, long transmission distance, low power consumption, network nodes and so on. In summary, it is low power consumption, long distance, anti-interference. Under the same conditions, the LoRa module has a longer transmission distance than the WIFI module. As a low power wide area network LoRa technology, wireless communication distance can reach several kilometers, or even more than ten kilometers.

4. Project Related Research Data

Table 1. Nitrogen fertilizer required for different growing seasons of some crops (kg/mu)[8]

Nitrogen fertilizer requirements for different crops (Kilogram per mu)	potato	corn	tomato	wheat	soybean
early growth stage	30-40	25-30	30-50	10-20	15-25
metaphase growth stage	45-50	45-50	45-60	35-40	45-50
late growth stage	30-35	60-70	20-30	30-35	25-30

Table 2. Phosphorus fertilizer required for different growing periods of some crops (kg/mu)[9]

Phosphate fertilizer requirements for different crops (Kilogram per mu)	potato	corn	tomato	wheat	soybean
early growth stage	45-60	30-45	15-20	30-45	15-20
metaphase growth stage	45-50	50-55	20-30	35-40	30-45
late growth stage	45-60	60-90	30-45	60-90	60-80

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Table 3. Potassium fertilizer required by different growth periods of some crops (kg/mu)[10]

Nitrogen fertilizer requirements for different crops (Kilogram per mu)	potato	corn	tomato	wheat	soybean
early growth stage	30-45	10-25	10-25	15-20	15-25
metaphase growth stage	45-60	20-30	20-25	30-40	40-50
late growth stage	45-60	30-45	35-45	55-60	60-70

(Note: The above data is only for reference, the specific fertilization plan needs to be determined according to the specific situation, including soil properties, crop varieties, growing environment and other factors).

5. Product Related Technology Development

In the embedded program development of the system hardware: our team will further use STM32CubeMX and Keil to compile code. Realize a variety of functions based on single chip microcomputer. Such as the realization of soil quality collection, analysis, control of sprinkler to soil irrigation and fertilization, real-time transmission of sensor data to the Internet of Things cloud data platform, solar power supply and other functions.

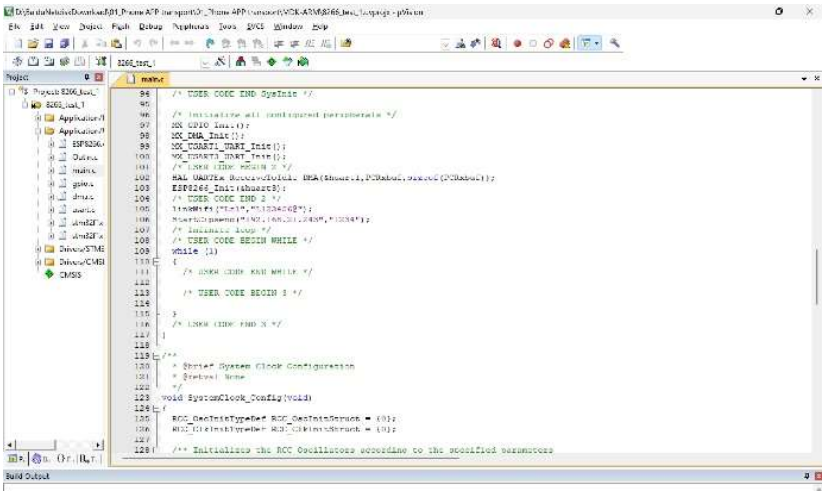

Fig. 3 Keil develops the interface

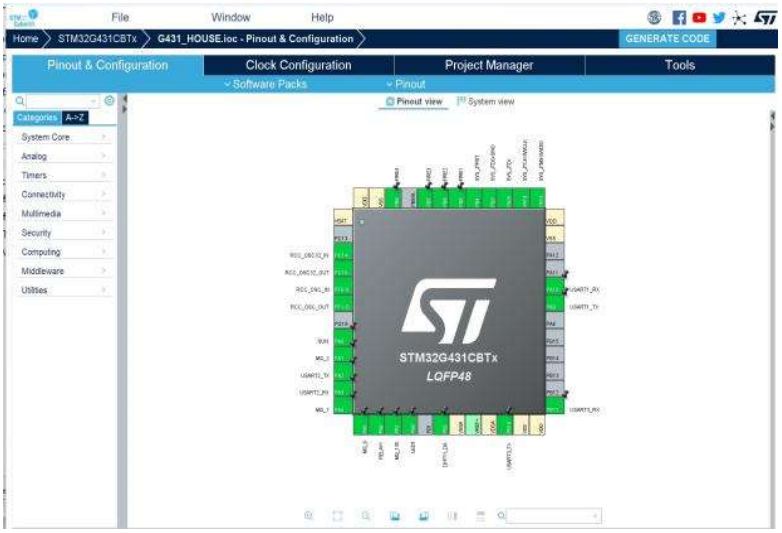

Fig. 4 STM32CubeMX development interface

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(2) In terms of data collection, processing and transmission: sensors collect environmental parameter data and upload it to the cloud platform of the Internet of Things through MQTT protocol. At the same time, by designing a Web visual interface, users can observe relevant data in the soil in real time to better carry out soil irrigation[11] . Sensor-related data is transmitted to the central host, and then the data is transmitted to the Iot cloud data platform through the data transmission module. Transmission parameter data mainly include: soil nitrogen, phosphorus and potassium concentration, water, conductivity, temperature, salt and other data. The analysis and comparison of the control module is mainly based on the previously input and collected environmental data to find out whether the soil lacks a certain element or component, and adjust the concentration of the sprayed pesticide to supplement the lacking element and component in the soil.

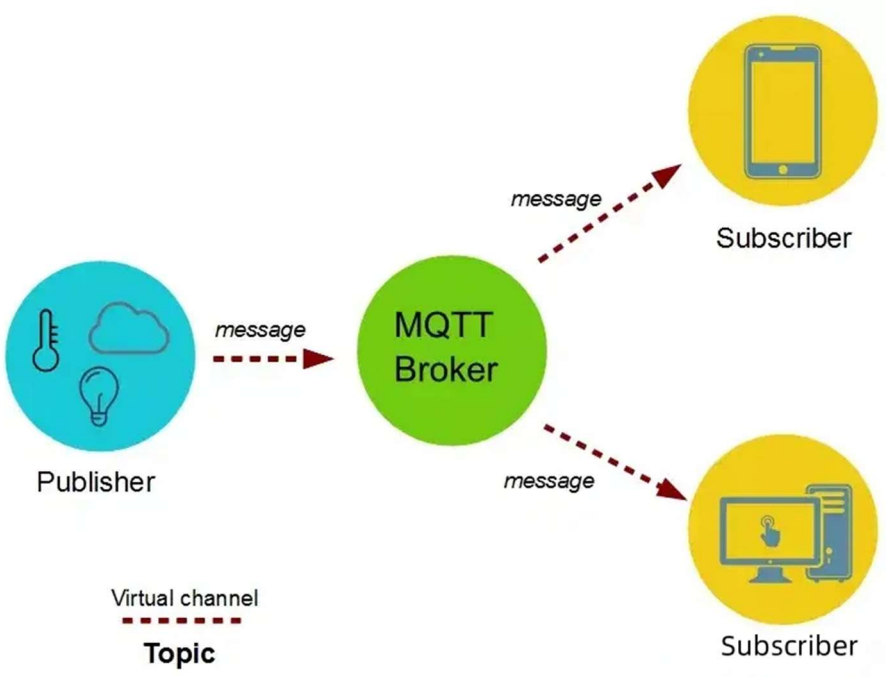

Fig. 5 Iot cloud platform development interface

6. Conclusion

The design of the project is a new generation of comprehensive water and fertilizer integrated irrigation device based on the Internet of Things, the application of Internet of Things technology, wireless communication technology and sensor technology, to achieve agricultural visual remote diagnosis, remote control and other intelligent operations, which are mainly used in arable land across the country. The device adopts vehicle-mounted structure design, which is easy to move the spraying device, and adopts solar power supply system to ensure that it can still operate for a long time under no light conditions. Independent design of PCB integrated circuit board to ensure the continuous and stable operation of the system. Through the LoRa module, the data is transmitted to the central host, and then the central host transmits the data to the cloud data platform, which can accurately match the water and fertilizer according to the different growth periods of different crops. Through the design of the Web visual interface, users can view the relevant data in real time, so as to achieve "regional data sharing and national data networking". The device is equipped with a positioning module and high-definition camera, so that the user can better control the device, and realize the "one-to-one" or "one-to-many" control of the device. At the same time, through the application of artificial

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intelligence technology, it can also achieve "cross-regional, fully automatic, intelligent" operation, and truly realize smart agriculture.

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