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IoT-based Solar Water-saving Irrigation Robot

Bowen Wu

School of Electrical and Control Engineering, North China University of Technology, Beijing 100144, China

2667307038@qq.com

Abstract

Aiming at the low utilization coefficient of farmland irrigation water, a wheeled robot for solar water-saving irrigation based on the Internet of Things is designed. The system uses solar cells which can be recharged circularly to assist in power supply, thus saving energy. Every time the robot moves for a certain distance in the field, it detects the soil temperature and humidity through the soil temperature and humidity sensor, compares it with the set temperature and humidity threshold, and starts watering when it reaches the threshold, thus achieving the purpose of saving water. The threshold value of temperature and humidity can be set by the instruction sent by the network debugging assistant of the mobile terminal. The current temperature, humidity, dirt, and threshold will be displayed on the LCDsplay module on the robot in real time and sent to the base station through the WiFi module, which will be sent to the remote control terminal. The remote control terminal will remotely set the temperature and humidity threshold to control irrigation according to the real-time situation, thus realizing the convenient process of the Internet of Things controlling irrigation. The experimental results show that the robot can effectively reduce labor input, realize irrigation automation, improve irrigation water utilization coefficient, reduce the production cost, save energy, improve farmland production efficiency and reduce farmers' workload, and it a has certain popularization value in many fields.

Keywords

Energy Conservation; IoT; Irrigation Robot.

1. Introduction

China's intelligent irrigation research is in the initial stage, with a low degree of automation. The main reason is that at present, China's agriculture still mainly depends on artificial irrigation. On the one hand, it greatly reduces the utilization rate of water resources, and at the same time it takes time and effort; On the other hand, the healthy growth of plants needs a certain growth environment provided by the outside world. If plants are watered only according to planting experience and users' direct senses, the water quantity of watering can't be controlled in time or accurately, resulting in unhealthy growth of plants. In this case, this paper designs solar water-saving irrigation wheeled robots based on the Internet of Things. The wheeled robot can be remotely controlled by a WiFi module, and the soil temperature and humidity sensor on the robot can judge the soil temperature and humidity under different moving and fixed conditions, to realize accurate irrigation, save water, and save time and labor.

2. System Principles

This device is mainly composed of an MCU controller module, soil moisture sensor module, LCD module, motor module, WiFi communication module, and solar power module. The control system based on the STM32F103C8T6 microcontroller collects the soil temperature and

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humidity information and then sends out relevant instructions to control the irrigation water quantity of the water pump, so that the soil humidity value can be kept in a certain range and the optimal soil humidity environment required for plant growth can be ensured. Equipped with a display screen and buttons, it can display the soil moisture in real-time, and control the robot's movement by motor and steering gear. The working principle is as follows: When the robot is fixed, the soil temperature and humidity sensor amplifies the collected soil temperature and humidity signal and transmits it to the A/D conversion circuit inside the single-chip microcomputer STM32F103C8T6. After A/D conversion, the soil humidity value is obtained through data processing. According to the collected humidity data, the microcontroller module sends the final processing result to the LCD. At the same time, the microcontroller calculates the irrigation water quantity according to the set temperature and humidity range; The whole system is powered by solar energy and a 24V lithium-ion battery, which can fully meet the power supply requirements of controller STM32F103C8T6 and soil moisture sensor. The mobile terminal and the remote control terminal establish WIFI communication based on TCP communication protocol through the network debugging assistant, to monitor the soil temperature and humidity in real-time and send instructions to the central controller to adjust the irrigation water quantity.

3. System Design

3.1. Electrical Control

The control part is integrated by the central controller and the motion control system, including the robot's main controller STM32F103C8T6, driving circuit, power supply module, temperature, and humidity sensor module, etc. The communication module is responsible for the communication between the robot and the mobile terminal or the remote control terminal, in which the communication information includes the information collected by the camera sensor and the serial command sent by the mobile terminal or the remote control terminal.

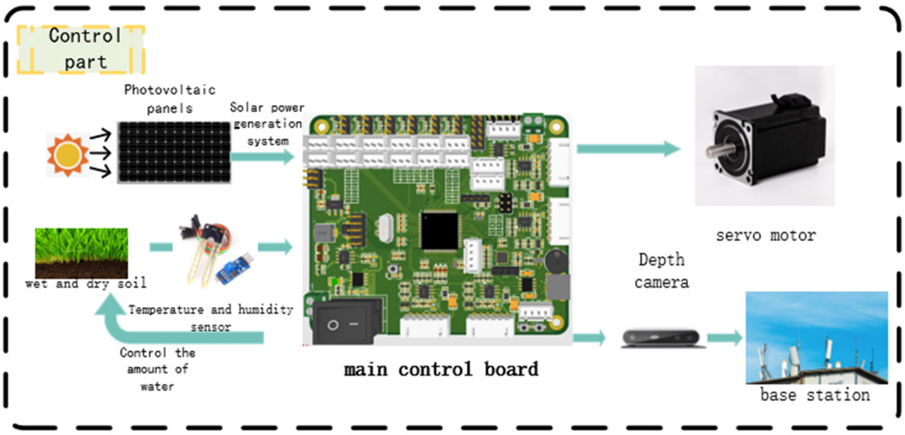

Fig 1. Electrical control part

3.2. The Mechanical Part

Aiming at different application occasions, and we have designed two different mechanical structures. For small farms and our fields, we have designed small irrigation robots to meet basic needs and save costs as much as possible. For large-scale farms, large-scale irrigation is needed, so we have partially reformed the robot structure to meet the basic needs of irrigation so that it can meet the needs of the market and production as much as possible.

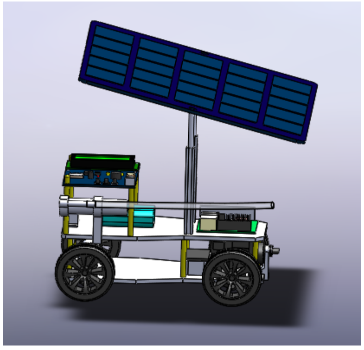

Fig 2. Small irrigation robot

Small irrigation robot consists of chassis suspension part, manipulator pan/tilt part, linear push rod part, and solar panel. The chassis consists of two DC motors and steering gear. The ZX25-370BM motor is used to control the robot to move forward. Its rated voltage is 12V, the rated power is 4W, and the maximum torque is 9kg/cm. Phaeton MG996R steering gear is used to control the direction of the robot. Its working voltage is DC 3V-7.2V, and its working torque is 13kg/cm.

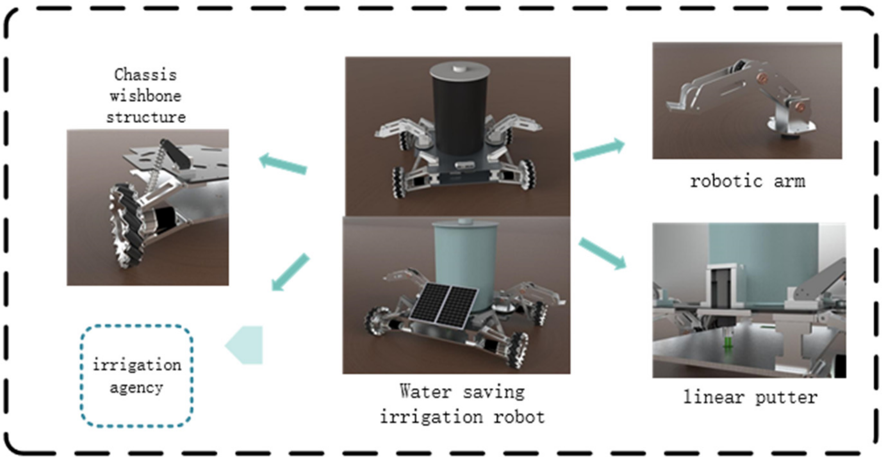

Fig 3. The mechanical part of a large intelligent irrigation robot

The mechanical part of a large intelligent irrigation robot consists of a chassis suspension part, mechanical arm cradle part, linear push rod part, and solar panel. Figure 3 Schematic diagram of large-scale irrigation robot The chassis suspension part adopts double wishbone type suspension, which has upper and lower wishbones. The lateral force is absorbed by both wishbones at the same time, and the strut only bears the weight of the vehicle body, so the lateral rigidity is large so that the trolley can move forward steadily when driving in rugged fields. Moreover, the upper fork arm and the lower fork arm are unequal in length, so the wheels can adapt to the road surface, the tire has good adhesion to the ground, and it is easier to control the movement of the trolley. The manipulator is composed of a tripod head motor at the bottom and two 180 steering engines, which can move in three degrees of freedom. The end of the manipulator clamps the water pipe, which can accurately irrigate each plant and reduce the waste of water resources. The linear push rod is located behind the trolley, and the linear electric push rod fixed on the frame is connected with the soil temperature and humidity sensor. When the trolley is stationary, the push rod is controlled to push the sensor into the soil to sense whether the soil needs watering. In the irrigation part, drip irrigation with the highest water-saving efficiency and irrigation efficiency is used, and a BWP-SW pump is used. Its specific parameters are a power supply voltage of 12V, maximum carrying power of 55W, inlet pipe diameter of 20mm, the outlet pipe diameter of 16mm, and drip hole diameter of 0.3mm The solar panel consists of a titanium mesh-lithium ion-graphene carbon layer. When light particles collide with lithium ions, lithium ions absorb light energy and store it.

3.3. Internet of Things System

The irrigation robot exchanges information with the communication base station and the remote control terminal through the ESP8266 WiFi module. The irrigation robot detects the soil humidity through the soil temperature and humidity sensor and uploads the soil humidity value to the base station, which uploads it to the server through Ethernet (the parameters on the server are set by the monitoring personnel). The server compares the uploaded value with the set value, decides whether to irrigate or not, and sends the comparison result back to the base station, which then sends it back to the MCU, which performs corresponding operations according to the received instructions. The working principle of the system is to collect and upload the soil moisture value three times a day in the morning, middle and evening, and wait for the base station to send the control instruction to carry out the corresponding operation. At other times, it is dormant. If the operator is near the robot, he can connect the WiFi corresponding to the robot through the mobile phone, input instructions, and control the temperature and humidity threshold.On-site information man-machine interaction feedback of irrigation robot is through LCD1602 module. Users can display and drive LCD1602 through the IO port of STM32 single chip microcomputer, and read and write the memory, to achieve real-time display of temperature and humidity information and its threshold information, thus realizing the information feedback process of on-site man-machine interaction. When the robot moves, the movement direction is controlled by the motor and steering gear of the chassis, and the soil temperature and humidity are sampled at regular intervals. After obtaining the soil temperature and humidity, it is compared with a preset threshold, and irrigation is started when it is lower than the threshold. To achieve the purpose of precise irrigation and water conservation. The robot is powered by rechargeable solar cells. The loss rate in the process of electric energy transfer is as low as 0.2%, and the value-added benefit of energy can reach 8 ~ 30 times, thus achieving the purpose of saving electric energy.

4. Energy Saving and Emission Reduction Analysis

Assuming that 50 water-saving irrigation robots are used in large farmland, the photovoltaic power generation of a single robot is about 100W 24 hours a day, so the average annual power generation is 4056.7kWh, saving 1460kg of standard media, and the total power generation during operation (20 years) is 81134kWh, saving 29208kg of standard coal. Table 3 Analysis of Energy Saving and Emission Reduction At the same time, a water-saving robot can save about 19.82m^3 of water source by irrigating 1m^2 per day (depending on the specific crops planted, the data here are common vegetables, for example), so a hectare of farmland can save about 198.2 tons of water per day, which greatly reduces the waste of water resources.

Table 1. Analysis of energy saving and emission reduction

Project	Average annual energy saving and emission reduction	Energy saving and emission reduction during operation (20 years)
Co_2 /tce	4.050	80.89
carbon dust/t	1.103	22.07
So_2/t	0.122	2.434
Nitrogen oxides/t	0.061	1.220

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5. Originality

(1) Each node robot communicates with the remote control terminal through the Internet of Things system and transmits soil temperature and humidity data in real time. Through the self-developed PC software, the temperature and humidity data curve will be displayed in real-time and saved regularly. Meanwhile, the remote control terminal can send the temperature and humidity threshold through the PC software to control watering.

(2) The robot can automatically collect the temperature and humidity of the crop growth environment in real-time, determine the irrigation time and quota for different water requirements, and carry out precise water management, which can significantly reduce irrigation water and improve water use efficiency.

(3) Design two different mechanical structures according to different production occasions, to save cost under the condition of meeting the market demand.

6. Conclusion

Irrigation is mainly to supplement water for cultivated land with insufficient or uneven distribution of natural precipitation, and the quality of irrigation depends on whether a special irrigation plan can be made according to the water demand characteristics of plants, growth stages, climate, soil conditions, etc. Water-saving irrigation robots can reasonably determine the amount of irrigation water according to the actual soil temperature and humidity conditions and can be remotely controlled by the Internet of Things, saving hydropower resources and manpower at the same time. Under the large-scale farmland production scale, it can save a lot of production costs, greatly increase the utilization coefficient of irrigation water, improve the quality of crops, and improve agricultural production efficiency. It can be said that under the larger scale of farmland production, water-saving irrigation robots have great market competitiveness.

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