Journal of Education, Teaching and Social Studies
ISSN 2642-2336 (Print) ISSN 2642-2328 (Online)
Vol. 4, No. 2, 2022
www.scholink.org/ojs/index.php/jetss

Original Paper

Development of Mobile Intelligent Sprinkler Irrigation Device Based on IOT

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Received: June 5, 2022 Accepted: June 20, 2022 Online Published: June 27, 2022

doi:10.22158/jetss.v4n2p45 URL: http://dx.doi.org/10.22158/jetss.v4n2p45

Abstract

Sprinkler irrigation is a major aspect of water use. At present, most of the domestic sprinkler irrigation for green lawns and flowerbeds adopts the rocker-arm rotary sprinkler that is common in the market. Aiming at the problem that the rocker arm rotary sprinkler is not intelligent, it is not suitable for areas that require intelligent irrigation, and cannot intelligently manage the sprinkler irrigation area, I understand the principles of various sprinkler irrigation devices on the market, and propose to automatically adjust the sprinkler range to make sprinkler irrigation intelligent and efficient. Precision to adapt to various types of sprinkler irrigation sites. And it is used for lawn or flowerbed irrigation, and can move freely in the irrigation area without being fixed on the ground. Compared with the existing rocker arm rotary sprinkler, it reduces the initial installation cost and post-maintenance cost.

Keywords

Smart sprinkler irrigation, Mobile devices, Internet of Things, Energy saving

1. Introduction

Water resource is one of the most important basic resources of human society. It can be said that it is a substance inseparable from human beings. Human existence requires water, and our life and the operation of economic and social systems are inseparable from the basic material basis of water, my country's per capita freshwater resources are only a quarter of the world's level, making it a water-scarce country. The per capita water resources are less than 2,200 cubic meters, which is only 28% of the world average, and the spatial and temporal distribution is uneven. With the continuous development of my country's economic and social construction, resource water shortage, water quality water shortage and water environment pollution have become important constraints for sustainable economic and social development.

At the same time, rapid urbanization and industrialization pose serious challenges to water use and management. Therefore, strengthening urban water conservation is a strategic task that we should adhere to for a long time.

2. Background Technology of Sprinkler Irrigation Devices in China

In cities, green belt irrigation water is an important part of municipal water use. At present, most of the irrigation of green lawns adopts the common rocker arm rotary sprinklers on the market, which can meet the irrigation needs of an annular area with the sprinkler as the center.

However, the existing rocker-arm rotary sprinkler has the following shortcomings in actual use: 1. The sprinkler is connected to the water pipeline pre-buried in the soil by means of fixed installation. When the green lawn area is large, the sprinkler needs to be It is arranged in an array so that the sprinkler irrigation area can fully cover the entire green lawn, and correspondingly, the water pipelines buried in the soil will also increase accordingly; this will lead to higher installation costs in the early stage and maintenance costs in the later stage; 2. When the water output speed/range cannot be adjusted intelligently, one sprinkler can only irrigate an annular area, and the annular area is prone to stagnant water due to excessive irrigation. There is uneven irrigation, which in turn leads to uneven growth of grass in the green lawn, which affects the overall beauty of the green lawn.

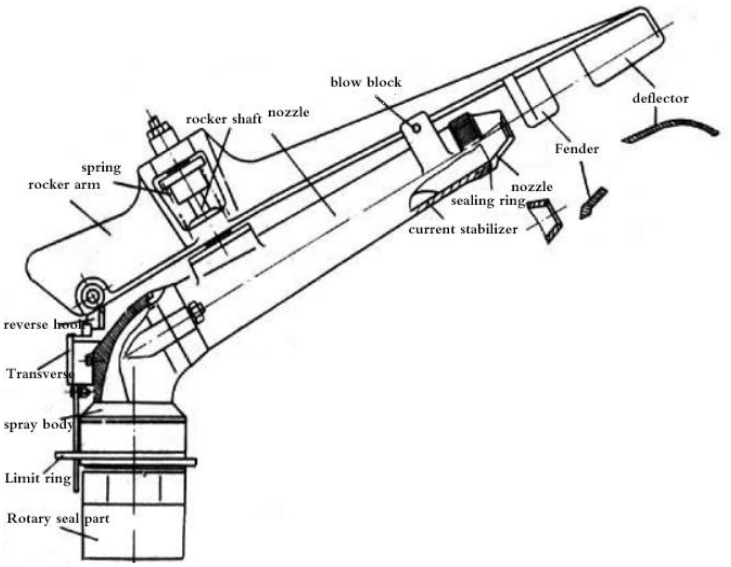

Figure 1. Appearance and Cross-sectional View of the Rocker Arm Rotary Sprinkler

3. The Proposal of Improvement Plan

Focusing on the shortcomings of the existing rocker arm rotary sprinklers in actual use, develop and manufacture a mobile intelligent sprinkler device, including a movable base and a sprinkler mechanism; the movable base includes a base and electric rollers installed at the four corners of the lower end of the base ; Any two adjacent electric rollers are arranged at a right angle; the sprinkler irrigation mechanism

includes a water inlet pipe, a miniature water pump, a middle pipe, a rotary joint, a water outlet pipe, a sprinkler, a bracket, and a rotary drive assembly; one end of the water inlet pipe is connected to the water source, and the other end is connected to the water source. It is connected with the water inlet end of the micro water pump; the water outlet end of the micro water pump is connected with one end of the middle pipe; the other end of the middle pipe is connected with the lower end of the rotary joint; the upper end of the rotary joint is rotatably connected with the lower end of the water outlet pipe; the water outlet pipe is rotated The joint realizes horizontal rotation; the nozzle is fixedly connected to the upper end of the water outlet pipe, its outflow direction is parallel to the horizontal plane, and it rotates synchronously with the water outlet pipe; the bracket is fixedly installed on the base, which is connected with the middle pipe and provides support and support for the middle pipe. Fixed; the rotary drive assembly is arranged between the bracket and the water outlet pipe, and is used to drive the water outlet pipe to rotate.

The rotary drive assembly includes a stepper motor, gear A and gear B; the stepper motor is fixedly installed on the bracket; the gear A is fixedly installed on the shaft of the stepper motor; the gear B is fixedly installed on the water outlet pipe and meshes with the gear A. The sprinkler irrigation mechanism also includes a rotary encoder; the rotary encoder is fixedly sleeved on the water outlet pipe and supported by the bracket, and is used for measuring the rotation speed and rotation direction of the water outlet pipe. The nozzle mechanism also includes a water receiving plate; the water receiving plate is fixedly installed on the water outlet pipe and is located in the height interval between the nozzle and the stepper motor. One end of the water receiving plate is high-end and the other end is low-end., and is located just below the sprinkler head, and the lower end is provided with a drain port for draining the accumulated water in the water tray. It also includes a single-chip microcomputer, a remote control and a panoramic camera; the single-chip microcomputer is directly or indirectly installed on the base, its signal input ends are respectively connected with the remote control, rotary encoder, and panoramic camera for communication, and its signal output ends are respectively connected with the remote control, electric roller, The micro water pump and the stepping motor are connected in communication; wherein, the microcontroller is electrically connected with the micro water pump through the motor drive module to control the start and stop of the micro water pump and the running power of the micro water pump. It includes a power supply; the power supply is installed at the center of the lower end of the base, and is electrically connected to each power-demanding component, thereby providing energy support for the operation of each power-demanding component.

The device is used for lawn or flowerbed irrigation, and can move freely in the irrigation area without being fixedly installed on the ground. Compared with the existing rocker arm rotary sprinkler, it reduces the initial installation cost and post-maintenance cost. And it can automatically adjust the spray range, so that the sprinkler irrigation is intelligent and precise, so as to adapt to various types of sprinkler irrigation places. During the rotary sprinkler irrigation operation, the water flow can be sprayed from the nozzle at different rotation angles at different water flow speeds to spray water shapes

of different shapes, such as squares, triangles and other shapes, which can fully meet the requirements of special-shaped lawns (flower beds).), on the one hand, it has a better water-saving effect, and on the other hand, it can avoid uneven irrigation.

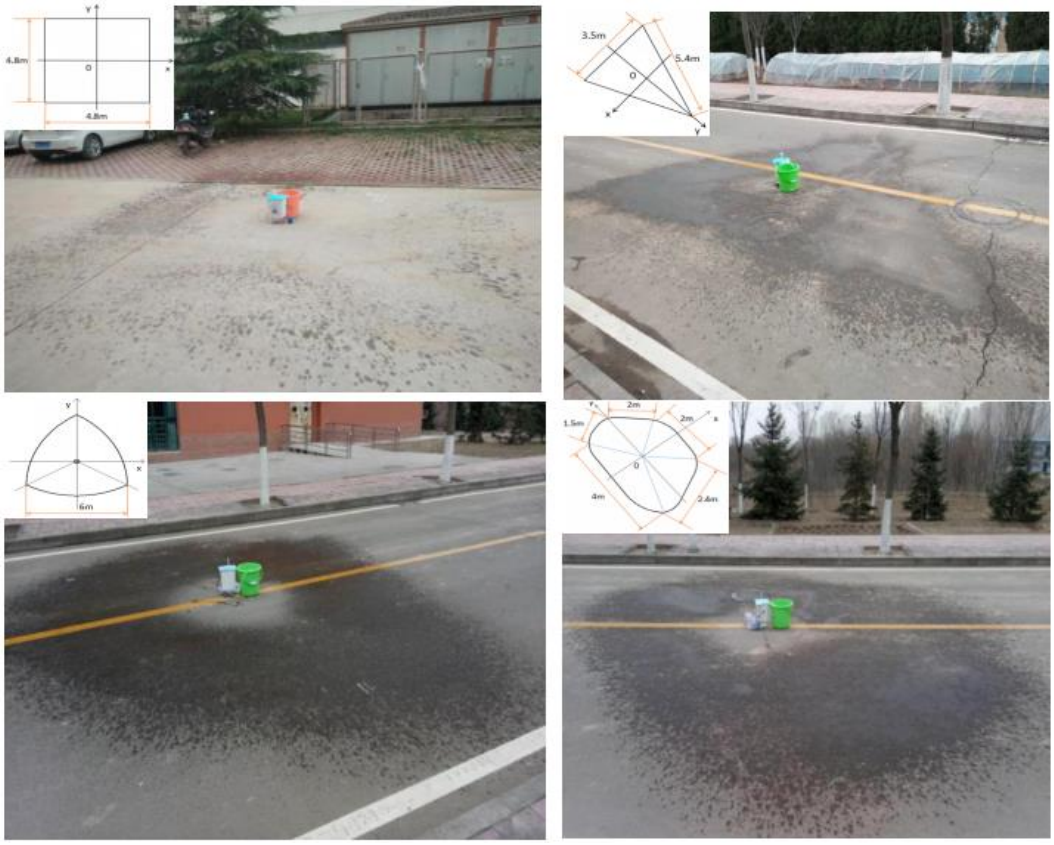

Figure 2. Product Work Effect Diagram

4. Device Workflow

The sprinkler irrigation device adopts the design of mechatronics and is controlled by the circuit module and the mechanical module. In the control circuit, the preset control program is loaded into the STC89C52 single-chip microcomputer, which drives the motor and the incremental rotary encoder to work; in the mechanical system, the motor drives the water spray channel to rotate, and is encoded by the incremental rotary encoder. The sensor detects the rotation angle of the water channel, and feeds it back to the STC89C52 microcontroller to adjust the error, and then continue to execute the drive command. The micro water pump PLD-1205 works under the pulses of different duty ratios given by the feedback control circuit, and pumps the water into the water spray pipe with the corresponding power to realize the intelligent irrigation operation.

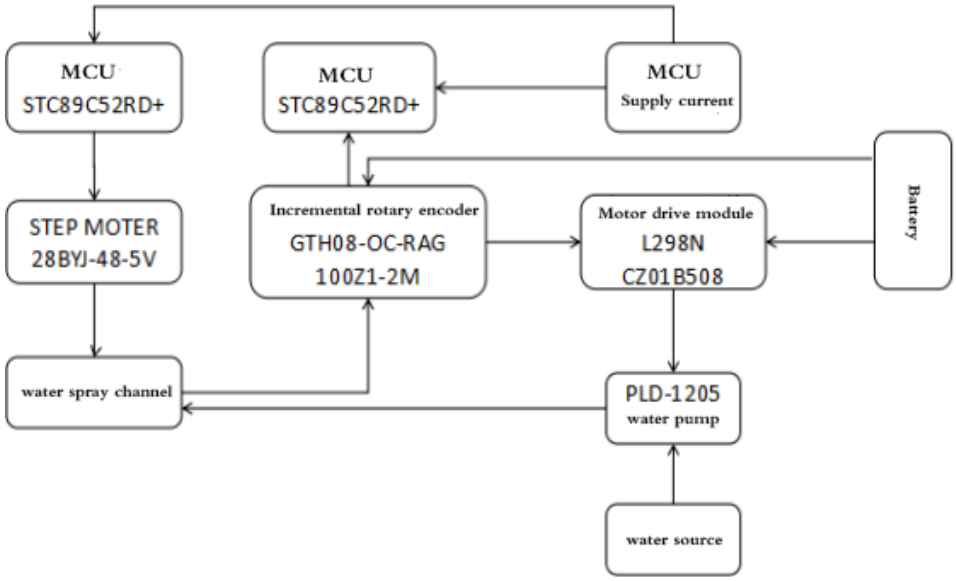

Figure 3. System Principle Block Diagram

The core innovative design of the device is to enable the sprinkler irrigation facilities to automatically adjust the spray range, so that the sprinkler irrigation can be intelligent and precise, so as to adapt to various types of sprinkler irrigation sites. When the device performs 360 ° rotating sprinkler irrigation, the water flow can be sprayed from the water channel at different rotation angles at different water flow speeds to spray water shapes of different shapes, such as squares, triangles and other shapes. Specific implementation: 1. For the sprinkler irrigation area with detailed construction drawings, direct image processing of the drawings is adopted. 2. For the sprinkler irrigation area without construction drawings, firstly use the remote control aircraft to take aerial photography of the sprinkler irrigation area, and process the captured images.

First, establish a mathematical model suitable for any shape of the sprinkler irrigation area, perform image processing on the construction drawings (or captured images) of the sprinkler irrigation area, discretize the edge of the sprinkler irrigation area into a certain number of coordinate points, and bring the discretely formed coordinates into the established general Mathematical model, function construction, the obtained relationship function between sprinkler irrigation range, rotation angle and pump power is converted into a programming language, read into the single-chip microcomputer to execute the program, and realize intelligent irrigation.

Comparison of images after discretization processing: Perform image processing on the construction drawings (or captured images) of the above arbitrary polygonal lawn (or flowerbed) sprinkler irrigation area, so that the edge of the sprinkler irrigation area is discretized into 720 points, which is equivalent to taking every 0.5 °. At one point, a polar coordinate system is established with the geometric center point of the sprinkler irrigation area as the pole. There are 720 polar coordinate (ρ, θ) data, and the discretely formed polar coordinate data is brought into the established general mathematical model, and the function is constructed. The functional relationship between the sprinkler irrigation range and the

sprinkler angle is obtained, and then the relationship is converted into the corresponding single-chip programming language.

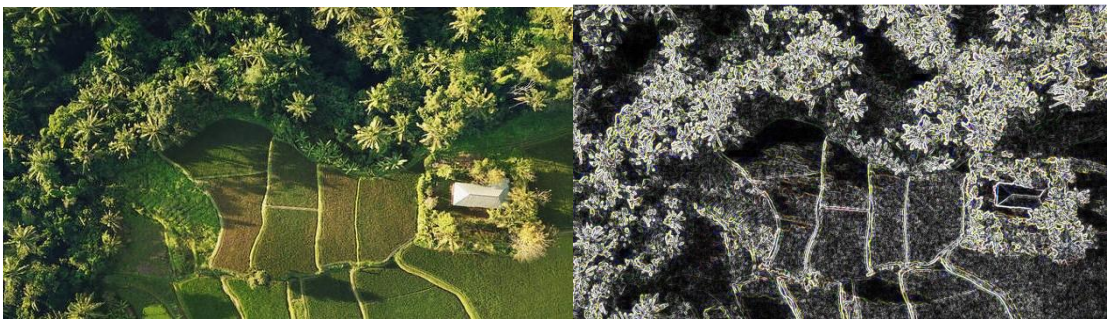

Figure 4. The Edge Discretization of Sprinkler Irrigation Area

The device also has a unique and innovative design in terms of hardware. The rotating part of the device adopts the innovative design of double pipes with fixed outer pipe and rotating inner pipe, which ingeniously realizes the rotation function and ensures the sealing of the device. The structural parts of the installation were all 3D designed by us using Autodesk inventor and 3D printed. The precision of the parts is as high as 0.01mm, which further ensures the sealing of the device and the fit of each structure.

4. Design Scheme

The movable intelligent sprinkler irrigation device includes a movable base, a sprinkler mechanism, a remote control, a panoramic camera, a single-chip microcomputer and a power supply. As shown in the figure, the movable base includes a base 11 and electric rollers 12 installed at the four corners of the lower end of the base 11. The base 11 is a rectangular or square plate. Any two adjacent electric rollers 12 are arranged at right angles. The sprinkler mechanism includes a water inlet pipe 21, a micro water pump 22, a mid-section pipe 23, a rotary joint 24, a water outlet pipe 25, a spray head 26, a bracket 27 and a rotary drive assembly. One end of the water inlet pipe 21 is connected to the water source (the water source is the tap water provided by the fire hydrant or the water storage tank installed on the base 11), and the other end is connected to the water inlet end of the micro water pump 22. The outlet end of the micro water pump 22 is connected to one end of the middle pipe 23. The other end of the middle pipe 23 is connected to the lower end of the rotary joint 24. The upper end of the rotary joint 24 is rotatably connected with the lower end of the water outlet pipe 25. The water outlet pipe 25 is rotated horizontally through the rotary joint 24. The spray head 26 is fixedly connected to the upper end of the water outlet pipe 25, its outflow direction is parallel to the horizontal plane, and it rotates synchronously with the water outlet pipe 25. The bracket 27 is fixedly installed on the base 11, which is connected with the middle-section pipe 23 and provides support and fixing for the middle-section pipe 23. The rotation driving assembly is arranged between the bracket 27 and the water outlet pipe 25, and

is used for driving the water outlet pipe 25 to rotate. The rotary drive assembly includes a stepper motor 281, a gear A282 and a gear B283.

The stepping motor 281 is fixedly installed on the bracket 27, the gear A282 is fixedly installed on the shaft of the stepping motor 281, and the gear B283 is fixedly installed on the water outlet pipe 25 and meshes with the gear A282. The single-chip microcomputer is directly or indirectly installed on the base 11, and its model is STC89C52. Its signal input ends are respectively connected with the remote control, the rotary encoder 29, and the panoramic camera. The water pump 22 and the stepping motor 281 are electrically connected. The microcontroller is electrically connected to the micro water pump 22 through the motor drive module 100 (L298N-CZ01B508 from SGS) to control the start and stop of the micro water pump 22 and the operating power of the micro water pump 22. A power source (not shown in the figure) is installed at the center of the lower end of the base 11, and is electrically connected to each power-demanding component, so as to provide energy support for the operation of each power-demanding component. Preferably, the water inlet pipe 21 is a hose, and the water outlet pipe 25 and the middle pipe 23 are rigid pipes. Preferably, the sprinkler mechanism further includes a rotary encoder 29, which is fixedly sleeved on the water outlet pipe 25 and supported by the bracket 27, which is used to measure the rotation speed and rotation direction of the water outlet pipe 25. The rotary encoder 29 model is GTH08-OC-RAG-100Z1-2M. Preferably, the nozzle mechanism further includes a water receiving tray, which is fixedly installed on the water outlet pipe 25 and located in the height interval between the nozzle 26 and the stepping motor 281. The high end of the water receiving tray is arranged around the water outlet pipe 25 and is located directly below the nozzle 26, and the lower end is provided with a drain port for draining the accumulated water in the water receiving tray.

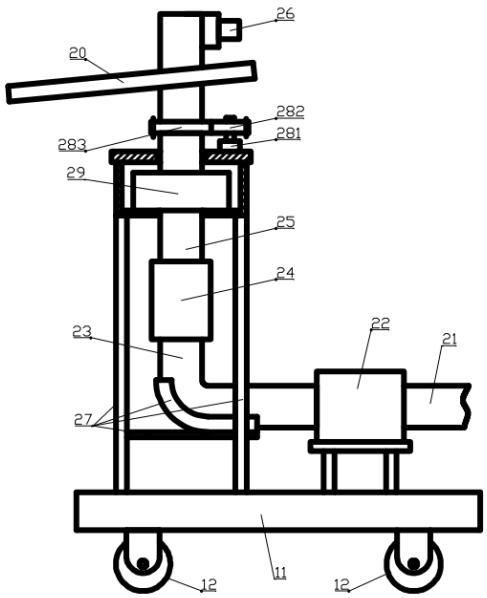

Figure 5. Schematic Diagram of the Structure of the Mobile Intelligent Sprinkler Irrigation Device

5. The Use and Introduction of the Device

First, establish a mathematical model suitable for any shape of the sprinkler irrigation area, perform image processing on the construction drawings (or captured images) of the sprinkler irrigation area, discretize the edge of the sprinkler irrigation area into a certain number of coordinate points, and bring the discretely formed coordinates into the established general Mathematical model, carry out function construction, get the relationship function between sprinkler irrigation range, rotation angle and pump power, convert this function into programming language, and input it into single chip microcomputer.

Example: Perform image processing on the construction drawings (or captured images) of the sprinkler irrigation area of any polygonal lawn (or flowerbed), and discretize the edge of the sprinkler irrigation area into 720 points, which is equivalent to taking a point every 0.5 °, in the sprinkler irrigation area The geometric center point is the pole to establish a polar coordinate system. There are 720 polar coordinate (ρ, θ) data. The discretely formed polar coordinate data is brought into the established general mathematical model, and the function is constructed to obtain the sprinkler range and sprinkler angle. function relationship, and then convert the relationship into the corresponding microcontroller programming language.

The user controls the operation of the electric rollers through the remote control. Since the rotation speed of each electric roller can be controlled independently, the differential steering of the sprinkler irrigation device or driving in any direction can be realized. When the sprinkler device arrives at the predetermined sprinkler position, the single-chip microcomputer invokes the preset program to start irrigation to water the area of a specific shape.

The watering process is as follows: the micro water pump and the stepper motor are started synchronously. After the micro water pump is started, the water from the water source is driven through the water inlet pipe, the micro water pump, the middle pipe, the rotary joint and the water outlet pipe in sequence, and finally sprayed from the nozzle. After the stepping motor is started, the water outlet pipe 25 is driven to rotate to realize irrigation in a specific area. During the irrigation process, the position of the sprinkler irrigation device remains fixed. After the irrigation is completed, move to the next area to be irrigated or return to the operator to charge or add water.

6. Summary

6.1 Product Conception

The traditional rotary sprinkler irrigation device has an unreasonable spray range design, which often results in waste of water resources. The start and stop of spraying is manually operated, which is time-consuming and labor-intensive, and has corresponding defects in the management of flower beds. This design automatically and accurately adjusts the spraying range through the combination of electromechanical and mechanical, so as to realize intelligent irrigation of the sprinkler irrigation range and save water resources. And use sensors to analyze and control the main indicators of sprinkler irrigation such as wind speed, temperature and humidity, and soil moisture to achieve high intelligence,

and realize intelligent management of flower beds and gardens through the intelligent sprinkler irrigation data management platform.

6.2 Resource Perspective

Under the background of water saving, although the more traditional sprinkler irrigation facilities consume renewable, clean and pollution-free electric energy, the electric energy consumed comes from the solar panels of our lower-level sprinkler irrigation devices. This product saves valuable water resources, which is about 20%-35% less than the traditional sprinkler irrigation device. Such a model is undoubtedly feasible in today's "resource-saving, environment-friendly" social and ecological construction.

6.3 Manufacturing Process

The production process of traditional sprinkler irrigation equipment is simple and rough, so that many unqualified products enter the market, and the quality is uneven, making the industry of sprinkler irrigation unsustainable loopholes. The 3D printing process used in this design has an accuracy of 0.01mm, which ensures the precision of sprinkler irrigation in terms of mechanical structure.

6.4 Sprinkler Irrigation Effect

This product breaks the traditional rocker arm rotary sprinkler irrigation mode, realizes automatic and precise adjustment of the spray range, and only sprays to the required sprinkler range. From a simple square flowerbed to a triangle, from a complex pentagram to any shape flowerbed, from a straight edge to a curved edge of the flowerbed, it can achieve precise coverage sprinkler irrigation. Therefore, compared with any sprinkler irrigation facility on the market, it has an unparalleled advantage of saving water resources.

6.5 Customer Experience

Sprinkler irrigation operations with high workload, heavy sprinkler irrigation monitoring, and blind sprinkler irrigation operations without data records are the most troublesome problems for users, and they are also the problems that traditional sprinkler irrigation needs to solve urgently. This design uses a more user-friendly sprinkler irrigation data processing platform to realize intelligent irrigation management, greatly reducing the labor intensity of sprinkler irrigation, making users more assured and more comfortable.

Introduction to Author

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Fund Projects

This project is supported by the research study and innovative experiment project of Hunan university students, photosynthetic ecology-intelligent sprinkler irrigation system based on cloud (S202110555207).

Project leader: Li Kang

Instructor: Ding Lin

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