Construction of Intelligent Irrigation System for Kiwifruit Planting Base Based on PLC

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Abstract. With the continuous development of the intelligent water conservancy industry, it is urgently to “make up the shortcomings and strengthen the weaknesses” for the traditional water conservancy project construction. This paper takes the kiwifruit planting base in Heilin Town, Ganyu District, Lianyungang City as the control object, and uses Schneider TM221 integrated PLC module as a controller to build an intelligent irrigation system. The system uses sensors to collect data such as irrigation flow, soil moisture, meteorological information, the water level of the reservoir and water quality, and the collected data is monitored by the designed upper computer monitoring software. So that users can switch valves remotely. This system meets users' needs for monitoring during the irrigation process, irrigation quality analysis and improvement of irrigation processes, so as to achieve automatic operation of irrigation, analysis and other processes, and achieve a double harvest of social and economic benefits.

Keywords: PLC module, Soil moisture sensor, Intelligent irrigation, Water conservancy informatization, the Internet of Things

1. Introduction

China is a large agricultural country, and uses a large amount of water for agricultural irrigation. There are also problems of low irrigation efficiency and waste of water. Therefore, it has important practical significance and profound historical significance to achieve "Precision Irrigation", to improve the utilization rate of irrigation water resources, and to establish an efficient intelligent irrigation system by using modern water-saving irrigation technology to transform traditional irrigated agriculture. Promoting automation control in irrigation systems reasonably can not only improve resource utilization, alleviate the contradiction of increasingly tight water resources, but also increase crop output and reduce the cost of agricultural products\textsuperscript{[1, 2]}.  

In recent years, the Internet of Things has attracted widespread attention, and is called the third wave of the world's information industry after computers and the Internet. The Internet of Things is a new type of information network, which realizes intelligent identification, positioning, tracking and
monitoring by collects objects that need to be monitored, connected, and interacted in real-time according to the agreed communication method of sensor network, radio frequency identification system, infrared sensor, laser scanner, global positioning system, and by connects things with things, things with people by means of various access networks and the Internet that exchanges information. The core of the Internet of Things is: any object has an address where it can be found, and any object can be controlled and communicated, that is, comprehensive perception and intelligent processing and control [3-5].

This paper builds an intelligent irrigation system based on PLC and the Internet of Things technology. With PLC as the lower computer and PC as the upper computer, the system uses a large number of sensor nodes to construct a monitoring network to collect data such as irrigation flow, soil moisture, meteorological information, the water level of the reservoir and water quality, and the collected data is monitored by the designed upper computer monitoring software. According to the irrigation decision factors, determined based on the soil moisture, the system minimize the waste of irrigation water within a controllable range and play a role of high yield, high efficiency, high quality, and water saving. At present, the intelligent irrigation system has been applied to the kiwifruit planting base in Heilin Town, Ganyu District, Lianyungang City, and has newly added reservoir water level, water quality monitoring, water intake control, water supply control, water metering, soil moisture and weather monitoring, monitoring center and software platform construction, etc. Through the comprehensive utilization of technologies such as sensing, communication, network, computer hardware and software, water management science and decision support, agricultural water conservancy engineering, etc., we have build an intelligent water-saving irrigation system that integrates features such as water-saving priority, intelligent monitoring, automatic control and visual display.

2. The system structure
The overall structure of the intelligent irrigation system is divided into four parts: the presentation layer, the function layer, the data layer, and the execution layer. The overall architecture is as follows:
3. The system design

3.1. The overall function design of the system

The overall function design of the system is as follows:

(1) Real time information monitoring. All kinds of information in the irrigation area are monitored. The types of monitoring points include the water level of the reservoir, water quality, flow, soil moisture in the field, valve switch, valve opening, meteorological information, etc.

(2) Information communication. Based on the Internet of Things technology, using PLC as the controller, build field automation Internal communication network of the system through serial communication technology (RS485) and Modbus, and using the optical fiber communication network of the established video monitoring system to achieve field-to-center network communication.

(3) Historical and real-time data management. Based on the B/S structure, design a web page to display the historical data and the real-time data of the monitoring points. The real-time data is displayed through map labeling and tabular form. The historical data is displayed in line chart and tabular form.

(4) Real-time irrigation forecast model. In the intelligent irrigation system, the value of soil moisture in the field is used to determine whether irrigation is needed. With the value of soil moisture preset, when the actual value deviates from the preset value, the system could automatically judge the magnitude of the deviation and forecast the field irrigation flow.

(5) Valve monitoring and control. According to the real-time irrigation forecast results, users can switch corresponding valve and monitor the instantaneous flow and valve opening of the field valve at the same time.

(6) File management. In order to realize the file management of water dispatching in irrigation area, provide chart file download and print interfaces to the basic information, monitoring information,
water consumption information, soil moisture information, water level information, valve information, etc. while the system is working.

3.2. The design of the system hardware

3.2.1. The design of the local PLC control cabinet. The size of the local PLC control cabinet is 2200*800*600mm. After the installation of the cabinet is completed, directly plug water level, electric butterfly valve, electromagnetic flowmeter, pressure gauge, water pump control and other signal transmission cables into the cabinet. What’s more, the PLC control cabinet in the pumping station is connected to a set of electric butterfly valves and electromagnetic flow meters, and each PLC control cabinet in the field is connected to two sets of electric butterfly valves and electromagnetic flow meters. The main control module is Schneider TM221 integrated PLC module, which is equipped with the necessary RS485 communication module and analog module.

The PLC module directly collects signals, and after logic operations, sends output control signals to each execution element to control and monitor the corresponding valve and flow. At the same time, in order to realize remote control, connect the local control unit to the network by a switch installed in the control cabinet. There was a manual control cabinet in the pumping station, the main circuit of the manual control cabinet is powered on and cut off by the button on the automatic control cabinet, and the pump is controlled by the manual control cabinet. A 7-inch touch screen is installed in each local control cabinet to control and monitor the corresponding valve and display all motor running status and water level signals. You can also display all the above parameters through the remote host software. All the above parameters can also be monitored by remote upper computer software.

3.2.2. The design of soil moisture station. In order to monitor the irrigation effect of the entire irrigation area and effectively realize the control and flow regulation of each valve, install HRC-1 soil moisture monitor designed and manufactured by Jiangsu Nanshui Water Technology Co., Ltd. in key areas in the irrigation area (as shown in Figure 2), and use the Internet of Things technology to monitor soil moisture. The measuring range of the monitor is a circle with the tube as the center and the radius of 10cm. Based on the principle of FDR, according to the frequency change of the electromagnetic wave in different dielectric constant materials, the moisture content of the measured soil is calculated by the mathematical model. It has the characteristics of continuous monitoring, high accuracy of data, simple installation of instruments, no damage to soil structure and no radioactivity, and free measurement of soil water content in different depths.

![Figure2](image)

**Figure2.** Composed of HRC-1 soil moisture monitor

3.3. The design of the system software

The system is based on a mixed software architecture of C/S and B/S. As shown in the Fig.3, the background database uses Microsoft SQL Server 2012, the development language uses .Net (C #) language, the development environment is Microsoft Visual Studio 2010, and the front-end presentation layer uses the current Microsoft's Silverlight technology.
The system comprehensively considers the factors of simulation and testing. Based on the changes in soil moisture after irrigation, the sampling period is set to 5 minutes. The specific process of the intelligent irrigation water-saving system is: collects the value of soil moisture by the sensor network, and then compares the value with a set lower limit. If it is less than the lower limit, open the solenoid valve for watering operation. Because the soil seepage is slow, in order to avoid misjudgment, it is generally necessary to select the soil moisture value after stopping irrigation to determine the output. Then, continue to collect the soil moisture value, and then compare it with the lower limit value. If it is still smaller than the lower limit value, continue to the next cycle.

3.3.1 Data monitoring system. Design human-computer interaction interface based on Intouch software to achieve data collection and valve monitoring. Software requirements:

(1) Data is received and stored in real time. Including original message storage, real-time data change storage, historical data storage every 5 minutes.

(2) Over-limit data alarm. Firstly, set a hierarchical alarm, the alarm data is displayed in different colors, and the alert value can be edited and modified; determine the level of the real-time data, pop up an alarm window on the operation interface, play the alarm sound, close the user after confirmation and store the alarm information in the library. Including time, data name, current value, alert value, over-limit value, alarm level.

(3) Display the real-time data of the switch status and flow of each valve, the pumping station, the soil moisture station, the automatic water quality monitoring station, and the meteorological station.

3.3.2 Information platform. Concentrated comprehensive display the real-time data of the switch status and flow of each valve, the pumping station, the soil moisture station, the automatic water quality monitoring station, and the meteorological station.

3.3.3 The design of the database. According to system functions and information categories, the database is divided into a monitoring database, a decision database, and a basic database.

The monitoring database contains real-time data tables of monitoring points and pump valve switching records.

The decision database includes a flow data table, a water level record table, a water quality record table, a sentiment data table, and a meteorological data table.

The basic database includes a basic information table, a user information table, and a basic parameters table required for real-time irrigation forecasting. The basic information table stores the station number, name, and type of the monitoring point.
4. The system application

4.1. The general situation of test area

Vegetation restoration in Hilly and mountainous areas has always been a difficult task in Ganyu District of Lianyungang City. Combined with the development of efficient forest and fruit industry and the concentration of policy funds for agricultural projects, the county has supported and built kiwifruit, blueberry, cherry and other characteristic industries in Helin, banzhuang, Lizhuang and other places for many years.

The kiwifruit planting base in Fulin Village, Heilin Town, Ganyu District has an irrigated area of 1,200 acres. The planting crop is kiwifruit, and the irrigation form is sprinkler irrigation. The project area is divided into three areas. Area 1 has an irrigated area of 550 mu. The source of irrigation water is Xishaoling Reservoir. The proposed new pumping station of Xishouling Reservoir No. 1 is used for water extraction irrigation. For the Matantou Reservoir, the existing Matantou Reservoir No. 3 pumping station is used for water lifting and irrigation; the area 3 is 290 acres, and the irrigation water source is the Chendantou Reservoir. It is planned to locate Area 3 as a kiwifruit planting base.

4.2. The layout of monitoring points

Kiwifruit is a kind of perennial deciduous Liana fruit tree. The root of kiwifruit is fleshy root. It likes to wet and is afraid of waterlogging. It adapts to the warm and humid micro acid soil. This biological characteristic of kiwifruit results in that the traditional mode of fertilization and irrigation can not meet the physiological needs of kiwifruit very well [6, 7]. Therefore, automatic irrigation can be realized by soil moisture, suitable water upper and lower limits and Internet of things technology. At the same time, based on the information engineering layout of kiwifruit planting base and the field division (the field is divided into 15 blocks), combined with the topography and climate conditions of the irrigation area, the type and location of monitoring points are determined, including a total of 16 pipeline flow monitoring points, 16 remote valve control points, 6 soil moisture monitoring points between the fields, 1 water level monitoring point, 1 water quality monitoring point, and 1 meteorological monitoring point. The actual layout of monitoring points as shown in Fig.4.

![Intelligent irrigation system for kiwifruit planting base](image)

**Figure. 4** Monitoring software interface of kiwifruit planting base

4.3. Application

The intelligent irrigation system is applied to the kiwifruit planting base, and the human-computer interaction interface is designed based on the Intouch software (as shown in Fig.4). The intelligent irrigation system mainly controls the irrigation water consumption and the irrigation valve switch. In
Fig.4, the color of the valve indicator of NO.11 field and NO.15 field is green, which indicates that the valve is open. And the corresponding pipe has showed that the water is flowing. The direction of water flow is from the pumping station to the corresponding valve and field. The application process found that the intelligent irrigation water-saving system can effectively adjust the soil humidity and minimize the waste of irrigation water within the controllable range by PLC, and well meet the moisture required for crop growth, which has achieved high yield, high-efficiency, high-quality and water-saving effect.

5. Conclusions
Designed an intelligent irrigation system based on PLC and Internet of Things technology, using serial communication technology (RS485) and Modbus communication technology. The system has the advantages of reasonable design, reliable operation and strong practicability. It can well meet the requirements of intelligent irrigation control, solve the problems of large waste of traditional irrigation water resources and poor stability, and achieve the purpose of water-saving irrigation. Irrigation has a high practical application value.

The system has effectively analyzed the irrigation decision factors, comprehensively considered the accuracy, practicability and operability requirements, selected soil moisture as the basis for irrigation decision, established an experimental platform, and applied the system to the kiwifruit planting base in Heilin Town Irrigation area to realize the automation of farmland irrigation.

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