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Real time monitoring of crop growth using soil moisture sensor

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Abstract: In this paper, we have addressed the issues which relates to loss of soil fertility and waste of water resource in agriculture. We designed irrigation system based on wireless sensor networks and fuzzy control. The system mainly consists of wireless sensor networks and the monitoring center. All of the nodes in Monitoring area collect the information of soil moisture. Soil moisture is considered as input variable of fuzzy logic controller. The monitoring center receives the signals from wireless sensor network node, and output information controls opening and closing time of the valve in crop areas. The results show that the system achieve real-time monitoring of soil on crop growth, give a right amount of irrigation based on crops growth information.

Index Terms: water-saving irrigation, wireless sensor network, fuzzy control strategy, sensor.

I. INTRODUCTION

India being an agricultural country needs to preserve environment while focusing on high yielding with appropriate watering and fertilizer inputs to crop. [1-2]. Making full use of natural resources, farm monitoring system obtain the optimum condition of plant growth by controlling parameters. and the purpose is to increase crop yield, improve its quality, regulate growth cycle, improve economic benefit. Monitoring system is a complex system, the different kinds of parameter needs automatic monitoring, information processing, real-time control and on-line optimizing.

In recent years, the agriculture industry has got greater progress, and improved agricultural labor productivity. However, we have big difference with developed country in control system area. On the one hand, the introduction costs of foreign advanced control system are too high, and most of them are not suitable for the national conditions of our country; on the other hand, The vast majority of existing control technology is difficult to popularize application.

Therefore, control system that is suitable for Indian environment is to be developed.

At present, system consist of network topology structure evolved from that of centralized to that of distributed, for example, RS485 based measurement and control system is a centralized structure and Field-bus based measurement and control system is a distributed structure.], the most of data acquisition systems adopt the wired collection way which is factitious or prewired. The workload is increased and real-time and validity of the data cannot be guaranteed by means of artificial. With the advent of low cost, low power dissipation sensor and the development of wireless communications technique, it is time to construct wireless monitoring system, this will have great real-significance to realize agricultural modernization.

Soil moisture content is a prerequisite for the crop growth, while excessive soil moisture would cause the rot of crops' roots, took away a lot of fertilizer which will cause water pollution. With the development sensor technology, monitoring and control of soil moisture content had made great progress [3], but there remained two main problems: First, most of irrigation control system worked in a wired manner, using serial bus and field bus technology, therefore it had a complex wiring, installation and maintenance costs. Second, the crop water requirement was a physical quantity with various environmental factors, with a strong coupling and complexity, it was difficult to establish a precise mathematical model, and fuzzy control has good robustness, dynamic response, so it is very suitable for application in irrigation systems and does not depend on accurate mathematical model.

In summary, combined with the advantages of wireless sensor networks and fuzzy control technologies, an intelligent irrigation system was designed. Secondly, the environment factor of influence irrigation volume was analyzed, a reasonable irrigation methods for crop water requirement and soil moisture information is selected.

II. SYSTEM ARCHITECTURE

The system has two parts: a wireless sensor network and monitoring center. Sensor nodes, the controller node, soil moisture sensors, irrigation pipe, spray irrigation and irrigation control valve is deployed in field , system was shown in Fig. 1. ZigBee network (IEEE 802.15.4 standard) with range of 20 m is adopted in mesh network topology [4]. In order to meet the network coverage and reduce the node energy consumption and cost at the same time, we selected a small amount of sensor nodes as routers, to complete the data gathering and routing data from other equipment to the coordinator., data acquisition will control valve can be opened to realize the irrigation when receiving irrigation command.

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Wireless sensor network consisted of sensor nodes, routing nodes and coordinator node, distributed in all regions of the monitoring area [5,6]. Nodes used modular design, the three kinds of nodes used common core modules, and different nodes with different extension modules. The temperature and humidity sensor collected temperature and humidity information; routing nodes was responsible for routing communication and forwarding data; the ordinator node received data from routing node and sent it to the host computer monitor center through RS232 serial bus.

The monitoring center could record real-time soil moisture content uploading from all nodes, calculate crop irrigation water requirement according to the plant physiology characteristic in different growth period, and output result to relay by wireless sensor network, control opening and closing time of valve, so as to realize the remote automatic adjustment and control for irrigation.

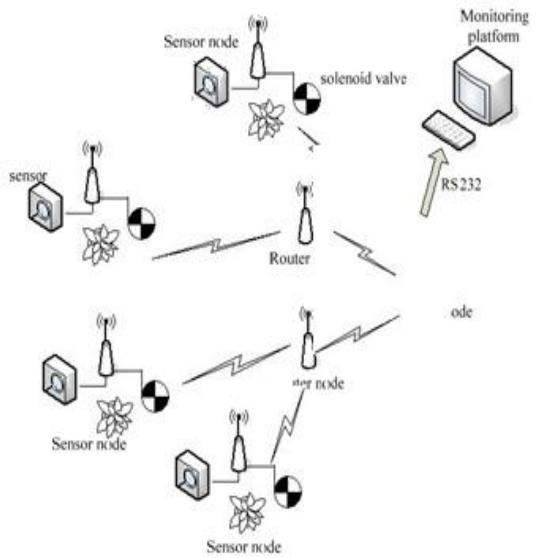

Figure 1. the system architecture

Soil moisture sensor is TDR-3A, The main performance indexes of the sensor are shown in table I.

Parameter	Performance index
humidity	range: 0～100% accuracy: ±2% measuring field: the cylinder which diameter is 3 cm, length is 6 cm around the probe Working voltage : 12V～24V DC Working circuit: 50～70mA, output: 4~20MA

Table I. Sensor Technology Parameters

B. Output Control Module

Irrigation actuator output control signal to the relay, thus control irrigation time of the valve open. This paper adopts NPN triode drives relay, the driving circuit is shown in Fig. 2.

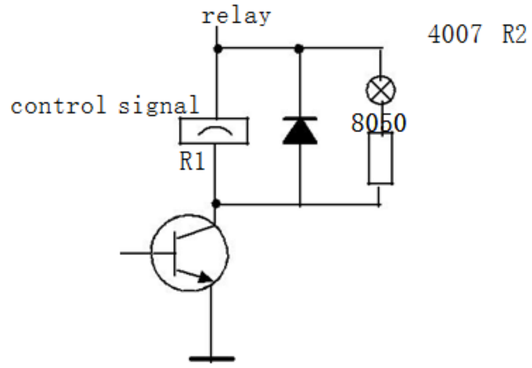

Figure 2 Driving Circuit

IV. FUZZY CONTROL ALGORITHM

we select fuzzy control theory of intelligent control method .Fuzzy control theory does not need to establish accurate mathematical model of controlled object, robust accurate, it is suitable for nonlinear and time-varying system, so it is suitable for using fuzzy control strategy to realize the controlling of the monitoring system.

Whether to construct fuzzy controller reasonably is related to the precision of fuzzy control system, the structure of fuzzy controller is shown in Fig. 4

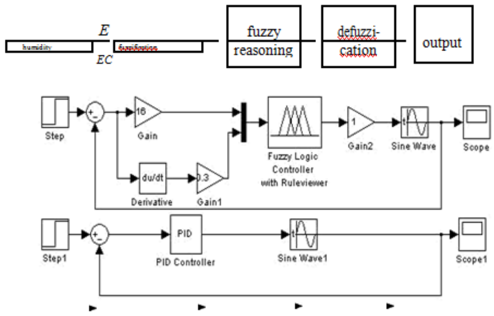

Figure 3. Structure of fuzzy logic controller

E is soil humidity deviation; EC is the rate of change of deviation over time.

The reasoning process is divided into the following steps [7]: first the continuous input, output is converted to a fuzzy subset, its domain is defined, and fuzzy table is set up according to the actual change range of the input output. Establish the knowledge base through the knowledge and experience of experts, and form the fuzzy control rule, use fuzzy table and fuzzy control rule table, the fuzzy control fuzzy control, into the final amount. Calculate the amount of the corresponding fuzzy control; finally, make fuzzy control amount defuzzification for transforming into ultimate control parameters.

Set humidity value is 40 %, the output curve of the fuzzy controller simulation and PID controller simulation are shown in Fig. 5. From the simulation graph we can see that the PID control response speed is faster than the fuzzy control, but overshoot ratio is greater; the fuzzy controller system has more stability relatively, it is more suitable for greenhouse irrigation control.

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Figure 6 Flow of the node program

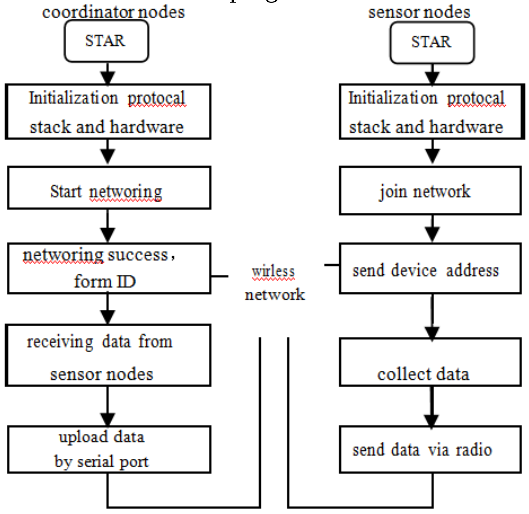

Figure 6 Flow of the node program

B. Design of the Monitoring Platform

The graphical programming language LabVIEW is used for the design of the monitoring platform [19]. Graphical programming can be more intuitive and effective to complete the test task. Designers judge wireless sensor network state through different buttons, at the same time, the tested results from calculation and analysis of scientific is display through the different curves and color. The system includes a connection state,.

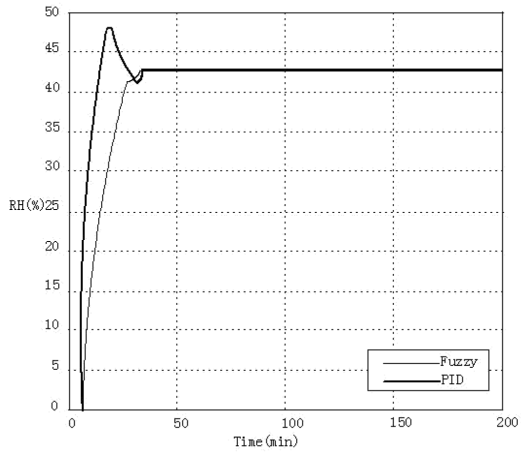

Figure5 .The simulation curves of PID controller and fuzzy controller

V. SOFTWARE DESIGN

Data acquisition, data processing and alarm, data storage and other functions

VI. EXPERIMENTAL RESULT

In order to test the validity of data transmission, we selected an agriculture sightseeing garden located in XuShui, Hebei province as the experimental base.

The base had 10 greenhouses with tomato as the main crops. We selected Mar. 5, 2013 as the test date, and that day was in the tomato blossom period. The test system consisted of two sensor nodes and a sink node.

A Wireless Transmission Test

Wireless transmission test is divided into point-to-point and networking communication test. One coordinator and a sensor node are opened when conduct point-to-point communication test, the distance between these two nodes increase from 30 mile to 300 mile, the sensor node send a frame data to the coordinator node at intervals of 1 minute, write down the number of packets which the gateway node receives within one hour (out of a total of 60).Two sensor nodes are opened when conduct the network communication test, the distance still starts from the 60 miles, add the distance between nodes and coordinator node gradually,, until the two nodes are separated by 300 m, the sensor node send a frame data to the coordinator node at intervals of 1 minute, write down the number of packets which the gateway node receives within one hour (out of a total of 60). The number of packets from coordinator node in different methods is shown in table II.

Table II. The number of packets in different methods

method / distance	point-to-point	networking
30	59	55
60	58	54
90	56	53
120	55	52
150	54	51
180	52	50
210	50	48
240	48	46
270	47	45

From table II, we can see that the distance of network transmission is less than point-to-point test, because all nodes in the network send a packet to the coordinator node after networking, resulting in data redundancy and a lost package phenomenon, especially in the distance of more than 200 miles, due to the influence of the obstacle, the packet reception rate is below to 80%.

B. Soil Water Content Monitoring Test

The moisture content is lower than the setting threshold; continue to start the solenoid valve. The humidity test result is shown in table III.

Table III. The humidity test results

Time	HUMIDITY
	Node 1
9:58	25.1
10:08	25.8
10:29	33.5
11:35	31.6
12:12	28.3
12:58	32.3
13:27	34.8
14:15	30.9
14:48	33.6
15:22	31.4
16:06	34.2
16:54	32.5

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From table III, we can see that soil moisture content has significant change after the irrigation for at least 10 minutes, , the system is running well in the later time, the error between the measured soil moisture content and value is around 2%, which indicated the system could regulate greenhouse temperature and humidity value according to the fuzzy control rules. That was to say, when the plants lacked water, the valve could be opened for irrigation. When humidity met the requirement, irrigation would be stopped, and thereby achieved water conservation. Since node 1 was located in the lower part of the dense foliage of tomato plants, the relative humidity measured by node1 was a little higher than node 2.The measured results basically agreed with the reality, so to achieve the test requirements.

VII. CONCLUSIONS

This design uses wireless sensor network with fuzzy control system in the intelligent water-saving irrigation system, realized a remote on-line monitoring and controlling.. Host computer receives soil water content information collected by the nodes, and transmits information by setting a threshold of open time of solenoid valve, so as to achieve the goal of water-saving irrigation. System can realize automatic real-time monitoring of soil moisture content in crops grow, and combined with crop growth information to irrigate moderately the system. It avoided the waste of water resources; finally it can achieve better productivity, high fficiency and quality, and water-saving.

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