INTELLIGENT WATER-SAVING IRRIGATION SYSTEM FOR CASSAVA FIELD USING FUZZY CONTROLLER

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ABSTRACT

This paper presents the design and implementation work of an automated irrigation control system based on the ARM 32-bits CortexTM M3 microcontroller using fuzzy controller. This system uses soil humidity values in the plant root zone and relative humidity values in the air to control the amount of water to apply to the cassava field. We focus on fuzzy control technology to intelligent water-saving irrigation. Each sensor module was installed at router node and its sensory data was sent to coordinator node via wireless communication module which operates in the 2.4 GHz. This wireless sensor network was powered by solar cell module which is suitable for the remote farm area where a typical power supply is inconveniently available. After commissioning in the laboratory and the field, it is showed that an automated fuzzy irrigation control system is stable and reliable and can fully meet the design goals and criteria.

1. INTRODUCTION

Cassava is considered one of the most important economic crops in Thailand, because this plant is resistant to drought and easy to grow even the soil is poor. In addition to be food the cassava can also be used in ethanol producing which is renewable energy as well. Then the cassava is widely popular plant for Thai farmers. In the past, most of the water problem in Thailand during the dry season is happening as a normal cycle, however, the climate change causes less precipitation. Therefore, the drought problem in Thailand is more frequent and severe combined with increasing of water requirement. Currently, wireless sensor network (WSN) play an important role in agriculture production. It has been widely used as a tool for precision agriculture. WSN enables farmers to efficiently use the pesticides, fertilizers and water. With the help of several types of sensors, a farmer can collect the information about the soil, water and other related factors and then can take any decision. Therefore, to resolve the drought problem is cassava field, this paper presents the design and implementation work of an automated irrigation control system based on the microcontroller using fuzzy controller.

In previous work, W. Cheng, Q. Xiaojun, Z. Yunhe, Y. Chengbo L. Yanfei [1], proposed an improved design of ZigBee Wireless Sensor Network that the coordinator only deal with the task on the ZigBee network, the rest tasks will be processed by another processor. The processor connected with the Coordinator by RS-232 interface. All data information will be sent to the processor though the serial port. So the processor undertakes the task to deal with data, conserve the network information, and communicate with the host computer for protect the effect of bad real-time, data packet loss, and stability decrease from the coordinator carry too much load.

Application of the artificial intelligent has been utilized in different areas including wireless sensor network applications. X. Peng , G. Liu [2], proposed The system build on Fuzzy control and wireless sensor network for water saving irrigation for crop using 2 input parameters (soil humidity and air temperature) for Fuzzy controller and output of this system is time to watering for crop water demand. Y. Liu, L. Kong, B. Xu, T. Du, S. Hou, and S. Kang [3], proposed the design of irrigation control system using the soil humidity of the root plant area at various depths for decide to watering. C. Wang, L. Wang, and J. Qin [4], propose the automated guided vehicle improved vision navigation with Fuzzy Control Algorithm. This navigation system combined the vehicle mechanism characters and the navigation deviation parameters obtained from image processing with the motion and control characteristics of the automated guided vehicle, the Fuzzy Control Algorithm is designed to navigate the automated guided vehicle moving along the road marking line.

1.1 Fuzzy Logic

Fuzzy logic is one of artificial intelligent witch can explain fuzzy or unclear variable by Fuzzy set theory to represent the ambiguity. Thus, the volume of the data detected by the wireless sensor network from farms. Including the collection of statistics such as input from the user represented by fuzzy variables steps of fuzzy (Fuzzification). Using fuzzy variables in the model variant for can using unclear data such as the information is obtained from the farms, Whether the sensor. Or from estimation to various applications (The distance between the nozzle drip), The water holding capacity of the soil, etc. Then, Fuzzy systems to estimate the output from the rule of the relationship between variables Fuzzy of these rules have been converted from the knowledge from expert in the field of irrigation water. The outputs of the inference rules will lead to defuzzy for the numerical value of the rate of irrigation valves. The diagram of intelligent water-saving irrigation system using Fuzzy logic controller is shown in Figure 1.

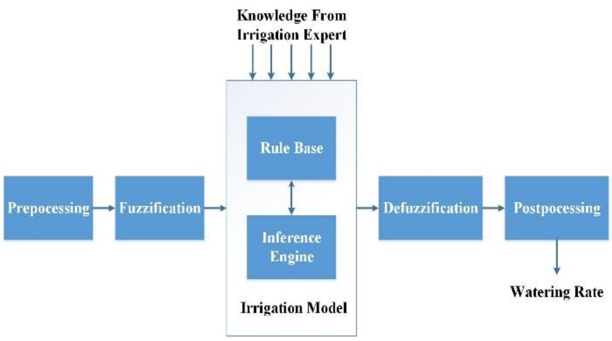

Fig. 1 Block diagram of Fuzzy control

2. EXPERIMENT

In this section, we first give a brief overview of the WSN embedded system architecture and Fuzzy logic controller. Then, the experimental results are shown. The conclusions of our study can be found in the last section.

2.1 Wireless sensor network experiment

Fig. 2 shows diagram of a wireless sensor network. The main microcontroller unit (MCU) of the WSN is the STM32F4 discovery board. It contains read only memory, random access memory, a 12 bit analog to digital convertor (ADC), a 12 bit digital to analog convertor (DAC), timer and few comparators. We have integrated sensors such as relative temperature and humidity sensor, light sensor, soil humidity sensor to the router node. This sensor is connected to the MCU through the I2C interface. Other analog sensors, such as soil humidity sensor and light sensor can be easily connected to the ADC interface of the MCU. The router node is powered by solar panel with 10.0 W. The RF module is ZigBee and takes responsibility of transferring data in the wireless networks. A high power integrated module which covers distance range up to 1.5 Km is suitable for farmland monitor. The coordinator node is connected with the GPRS module to send the data to the remote data center via the mobile network. The coordinator node is receive a sensory data from the router node for determine water demand of cassava and send output signal to control pump.

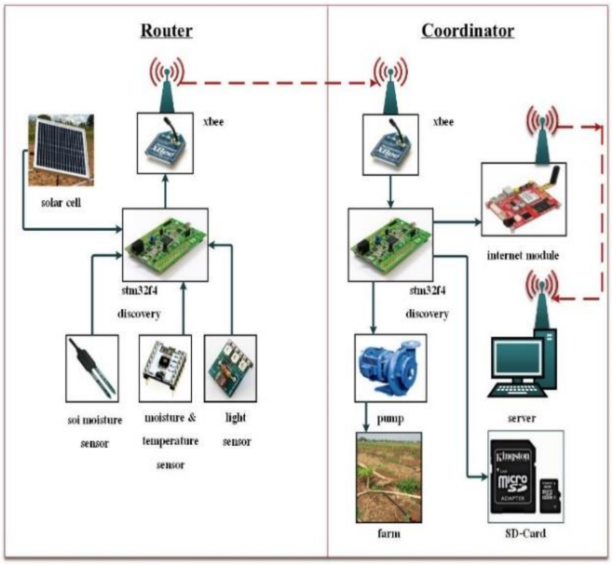

Fig. 2 Wireless sensors network diagram

In this experiment, we demonstrate the efficiency of this scheme under real-world applications with limited number of data samples. The four router nodes were deployed in a farmland environment at Suranaree University of Technology (SUT). The installation shown in Figure 3.

Fig. 3 Router node installation in SUT cassava field

2.2 Fuzzy logic controller experiment

In this work, Fuzzy controller embedded in the WSN coordinator node takes soil humidity values and relative air humidity values as its input and obtained water demand amount of cassava through fuzzy inference. Then, the fuzzy judge and output it to irrigation controller (the duration of pumping). We separate value of soil humidity to be a membership function of three set as dry (D), normal (N) and wet (W). The relative air humidity is separated as dry (D) and wet (W). Typically, Soil humidity stay in the range of fifteen to twenty percent and relative air humidity stay in the range of twenty to seventy percent. After processing the output is shown in the form of time to on pump separate as short (S), long (L) and no operation (NOP). Therefore, the output time can calculate to volume of water in watering. Fuzzy controller diagram is shown in figure 4.

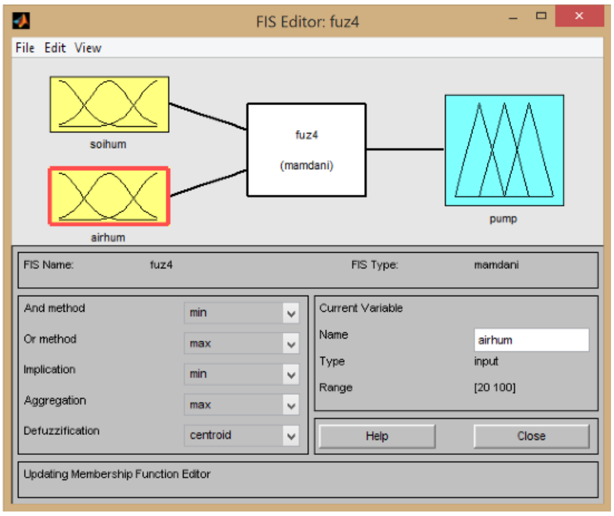

Fig. 4 Fuzzy controller diagram

This simulation base on Mamdani's fuzzy with sixth rule bases. All of rule base is shown in Table 1.

Table 1 Fuzzy control rule table.

Rule No.	Soil Humidity	Relative Air Humidity	Pump Time
1	Dry (D)	Dry (D)	Long (L)
2	Dry (D)	Wet (W)	Long (L)
3	Normal (N)	Dry (D)	Long (L)
4	Normal (N)	Wet (W)	Short (S)
5	Wet (W)	Dry (D)	No Operation (NOP)
6	Wet (W)	Wet (W)	No Operation (NOP)

In this work, the soil humidity is the most important parameters for irrigation controller. Therefore, the output will belong (L) when soil humidity is dry (D) and output is No Operation (NOP) when soil humidity is wet (W). However, If soil humidity is normal, the output is depend on relative air humidity.

3. RESULT

In this topic we mention the experiment as two parts too first is the wireless sensor network result another one is Fuzzy logic controller simulation result.

3.1 Wireless sensor network results

result is data from sixth router node that installed over test area size 9.6 x 78 square meter seen that almost sensors workable. More ever, this system has a data filtering program witch select the data that in the normal range only. Therefore, the data that out of range will ignore. The soil humidity and the relative air humidity from the router node are shown is Figure 5.

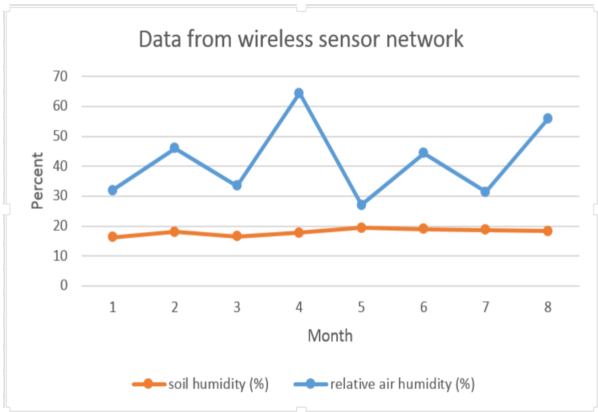

Fig. 5 Soil humidity and air humidity from router node

3.2 Fuzzy controller results

The computed data for the given conditions under case study of our project and the desired results have been validated with MATLAB Simulink. The 3-D surface of Fuzzy results is shown in Figure 6. This surface simply shows the mapping graphically between those two inputs and one output. It has been verified for all possible simulated value of the input variables.

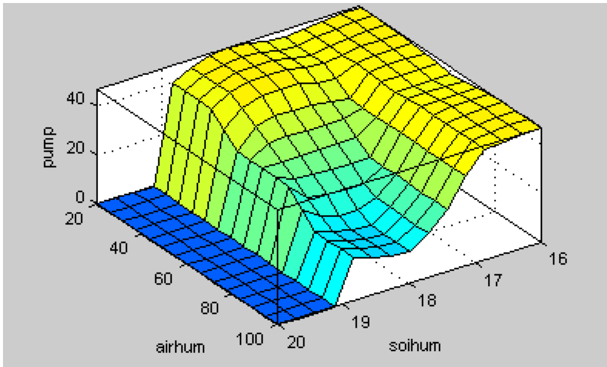

Fig. 6 All of the possible Fuzzy results

In this work, we build a simulator by using real-world inputs from farming area shown in Figure 7. As can be seen, the controller is operated with two inputs namely soil humidity and relative air humidity and one output variable i.e. the duration of pumping. The simulation results are shown in Table 2.

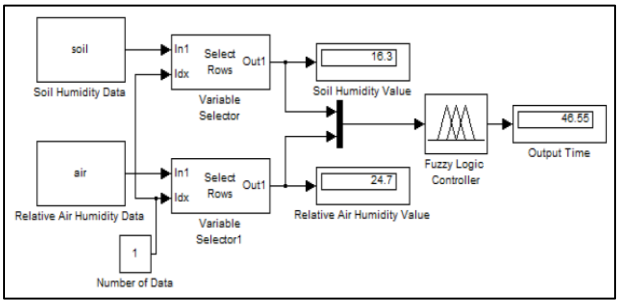

Fig. 7 Simulator with real inputs

Table 2 Real input Fuzzy controller result

Example No.	Soil Humidity (%)	Relative Air Humidity (%)	Pumping Time (minutes)
1	16.3 (D)	24.7	46.5 (L)
2	16.3 (D)	63.3	44.3 (L)
3	17.5 (N)	28.4	40.1 (L)
4	17.5 (N)	64.0	27.0 (S)
5	19.5 (W)	23.7	0.0 (NOP)
6	19.5 (W)	67.6	0.0 (NOP)

Table 3 Cassava field parameters

Parameters	Value
Size of area	750 square meters
Distance between row	2.5 meters
Distance between drip head	0.3 meters
Drip head flowrate	2.5 liters per hour
Amount of water	**87 liters per minute**

In case of example No.1 (Table 2), We can determine amount of water from 87×46.5 = 4,045.5 liters

CONCLUSION

This paper presents the design and implementation of water-saving irrigation control system using fuzzy controller. This system uses soil humidity value in the plant root zone and relative humidity value to control the amount of water to apply to the cassava field. Each sensor module was installed at router node and its sensory data was sent to coordinator node via wireless communication. This wireless sensor network was powered by solar cell module which is suitable for the remote farm area where a typical power supply is inconveniently available. After commissioning in the laboratory and the cassava field, it is showed that an automated fuzzy irrigation control system is stable and reliable and can fully meet the design goals and criteria. The completed system will be deployed and evaluate efficiency of water-saving in the future.

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