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Smart Agriculture Irrigation Control Using Wireless Sensor Networks, GSM and Android Phone

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Abstract: This study presents a smart agriculture irrigation control using Wireless Sensor Networks (WSNs), GSM and Android phone supporting android applications and a system for plant disease monitoring. Now a days the significance of Wireless Sensor Network (WSN) and android phones has been emerging significantly. In early days the agricultural farming methods were more complicated and costlier. In this system the optimized data are collected from the wireless sensor nodes and then the data are analyzed for an expert irrigation scheduling using fuzzy logic in order to optimize water usage. The fuzzy logic approach is used and implemented using Arduino UNO board. This system is also used to check whether the plant is affected by any disease from its leaf image using image processing techniques and tested using MATLAB. The system mainly consists of Zigbee, GSM, sensors, controller and motor. The data from different sensors are aggregated to repeatedly monitor the soil moisture level, temperature level and humidity level in the farmland and the plant health status. Once the information is received by the sensor node, it is transmitted to the wireless node through a wireless protocol. This system uses Zigbee wireless module for data transmission from the end devices to the web server node. With the information from the web server node the farmer can monitor and control the irrigation automatically using android application.

Kev words: Android phone, arduino uno, irrigation control, plant disease monitoring, sensors

INTRODUCTION

The objective of the study is to devise an integrated system in the form of plant growth monitoring and controlling the irrigation to improve the productivity in agriculture. India is the land of agriculture in which approximately 75% of Indian population is connected with agriculture. Automation techniques are established in order to increase the quality and quantity of crop yield. But the production is reduced due to reduction in landscape and increase of pest and plant disease. Efficient water management is a major concern in many cropping systems. Plant disease causes major production and economic losses in agriculture. The important reason is because of unplanned use of water due to which a significant amount of water goes to waste. Automating farm irrigation allows farmers to apply the right amount of water at right time regardless of the availability of labor to turn valves on or off and to know the plant growth status. Now a days automation has implemented in all the fields like industries, home automation, agriculture etc. Distributed field sensor based irrigation systems offer an eventual solution to support irrigation supervision that produces maximum yield with water saving systems. Smart agricultural system is an superior technology for farmers to boost the productivity of the crops yield with low cost system (Sigrimis *et al.*, 2001). A soil moisture detection system based on ZigBee wireless network is proposed in (Kim *et al*., 2008). The study deals with monitoring soil moisture content and had no control function for irrigation. The IEEE 802.15.4 standard defines the physical and MAC-layer interface and can operate in either master-slave or peer-to-peer networks arrangement (Lin, 2011). The soil moisture monitoring system based on ZigBee, through controlling solenoid valve to control soil moisture rate in irrigation area, but need the support of electricity (Ahonen *et al.,* 2008). In this study a wireless sensing element network connected to central node Zigbee, that successively is connected to a Central watching Station (CMS) through General Packet Radio Service (GPRS) or world System for Mobile (GSM) technologies. The system additionally obtains Global Positioning System (GPS) parameters associated with the sector and sends them to a central watching station. The fuzzy control is proposed to monitor the greenhouse system. The framework examines the compelling path

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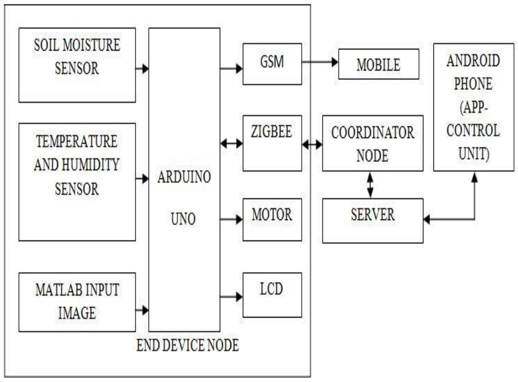

Fig. 1 : General block of the system

utilized as a part of performing recognition of grape sicknesses through leaf highlight assessment (Narvekar *et al.,* 2013). The application of texture analysis and classification of the plant leaf diseases is proposed propsed (Arivazhagan *et al,* 2013). From this method the plant diseases will be known at the initial stage itself and therefore the intimidator management tools will be used to solve intimidator issues whereas minimizing risks to individuals and the surroundings.

MATERIALS AND METHODS

System description: The smart agriculture irrigation controlling and plant disease monitoring system has four major units: End device node, coordinator node, web server node and mobile (controlling unit). The end device node consists of zigbee, arduino controller, GSM, motor, plant leaf image soil moisture sensor, temperature sensor and humidity sensor. The block diagram of the smart agriculture irrigation control and system for plant disease monitoring is shown in Fig. 1.

The end device node consists of GSM, sensors, leaf image, arduino controller, ZigBee and motor. ZigBee is used as end device as well as the coordinator device in the wireless sensor network node. It is used for the data communication in the network. The data is collected from each sensor continuously and then the data is transmitted to the coordinator node. The coordinator node is connected to the web server system via RS232 serial data bus. The data acquirement is done in the web server for real time monitoring of the farmland parameters. From the server the data can be obtained and viewed in the android phone by means of android application and then the control signal is sent automatically to the coordinator node via server from the android application. Whenever the end devices receive the signal from coordinator node, it acts according to the received signal whether to on the motor of off the motor. The motor on and off process for irrigation is framed using Fuzzy Logic System. The controller is programmed based on the rules framed using fuzzy logic system. Accordingly this system helps the farmers to control the motor and water usage according to the farmland requirement even through remote monitoring of the agricultural field.

Problem statement: Agriculture irrigation control and plant disease monitoring has lot of problems involved in it. There are many disadvantages in the existing methods are traditional agricultural methods were costlier and manual monitoring of the agriculture field was difficult. Water utilization efficiency is extremely low i.e., crops were over irrigated or less irrigated. Accuracy was a major defect in manual irrigation system. To overcome the problems in traditional agricultural methods the proposed method is been implemented based on automation in agricultural system and plant disease monitoring system was developed to remotely monitor and control the irrigation in the agricultural field which will save the water and labor cost. Increase in accuracy is done using sensors to measure the farmland parameters like soil moisture, temperature, humidity and water flow by knowing the water holding capacity of the soil in each field and the water requirements and response of each crop grown. Using this effective farmland monitoring system irrigation scheduling can be done accurately. This system provides a long term sustainable solution for automatic irrigation control and plant disease monitoring system.

Components: The smart agriculture irrigation control and plant disease monitoring is a cost effective solution for automation in agricultural field. Components used in the proposed research are as follows.

Soil moisture sensor: The moisture sensor is used to detect the moisture level of soil to know whether there is water content in the soil where the sensor is placed and it is commonly used in an automatic watering system. The moisture sensor has two probes which are used to measure the moisture level and these values are obtained by the microcontroller.

Humidity and temperature sensor: This sensor module consists of a humidity capacitive sensing element and a NTC temperature sensor which used to measure the

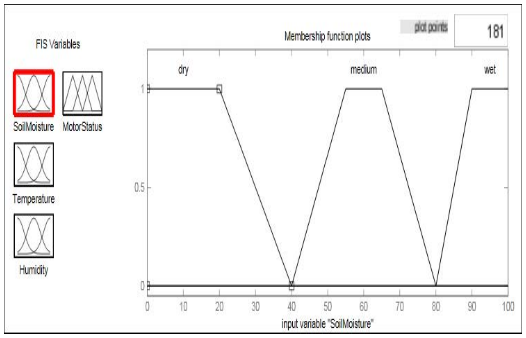

Fig. 2 : Membership functions for moisture

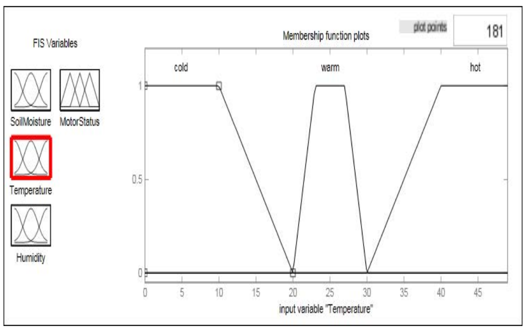

Fig. 3: Membership functions for temperature

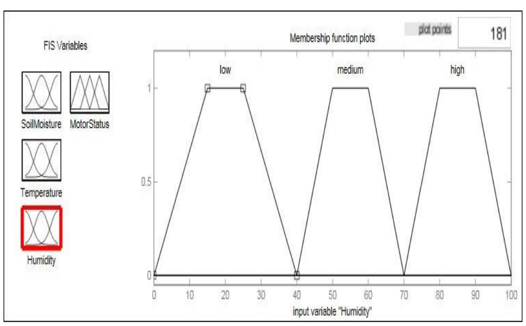

Fig. 4: Membership functions for humidity

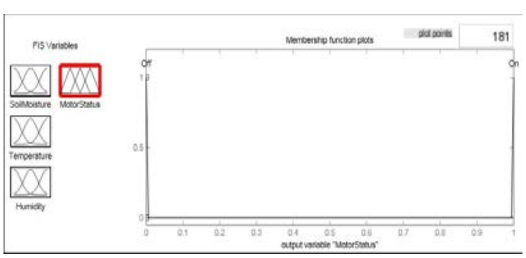

Fig. 5: Membership functions for motor status

atmospheric moisture content and atmospheric temperature present in the field. The measured values are obtained in digital signal and given to the controller. It has rapid response, excellent quality, anti-interference ability, high accuracy.

Arduino UNO microcontroller: The Arduino UNO is a microcontroller board with Atmega328P. It has 40 pins in which there are 6 analog input pins, 14 digital input/output pins in which 6 pins can be used as PWM output pins, a USB plug, an external power supply, a reset button, a serial out and a serial in pin used for data transmission to the server. It is a simple C programming, low cost and easy handling. The Arduino is used to read the different sensor data to control the system.

GSM SIM 900: This is a GSM/GPRS-compatible Quad-band cell phone which works on a frequency of 850/900/1800/1900 MHz and which can be used to access the Internet and also for oral communication and for SMSs. The TTL serial interface is in charge of communicating all the data relative to the SMS received and can be either AT standard or AT-enhanced SIM Com type. The module is supplied with continuous energy of 5 V.

Zigbee: Zigbee CC2500 Module is a transceiver module which provides easy to use RF communication at 2.4 GHz. It can be used to broadcast data at 9600 baud rates from every standard CMOS/TTL source. It is widely used in wireless applications.

Mathematical modeling: The fuzzy inference system is a rule based system. The most common method used in fuzzy inference system is Mamdani method. Rule base system is used to produce the outputs according to the given input for the system (Ross, 2009). In this study, 3 input parameters are considered and each parameter consists of 3 membership functions as shown in below equations. The number of rules is calculated based on each input parameter's membership function. Hence, each parameter consists of 3 membership function; the total number of rules framed is 27 rules. The membership function values and the fuzzy rules are framed by resarcher's assumption based on the fuzzy inference concept. The input membership functions are formulated using trapezoidal function which is shown in Fig. 2-4 and the output membership function is formulated using triangular membership function which is shown in Fig. 5. The fuzzy table represents the various categories of the input and output parameters which is shown in Table 1.

Table 1: The fuzzy rule table with various categories of the input and output parameters

Rules	Soil moisture	Temperature	Humidity	Motor status
1	Dry	Cold	Low	On
2	Dry	Warm	Low	On
3	Dry	Hot	Low	On
4	Dry	Cold	Medium	On
5	Dry	Warm	Medium	On
6	Dry	Hot	Medium	On
7	Dry	Cold	High	On
8	Dry	Warm	High	On
9	Dry	Hot	High	On
10	Medium	Cold	Low	Off
11	Medium	Warm	Low	Off
12	Medium	Hot	Low	On
13	Medium	Cold	Medium	Off
14	Medium	Warm	Medium	Off
15	Medium	Hot	Medium	Off
16	Medium	Cold	High	Off
17	Medium	Warm	High	Off
18	Medium	Hot	High	Off
19	Wet	Cold	Low	Off
20	Wet	Warm	Low	Off
21	Wet	Hot	Low	Off
22	Wet	Cold	Medium	Off
23	Wet	Warm	Medium	Off
24	Wet	Hot	Medium	Off
25	Wet	Cold	High	Off
26	Wet	Warm	High	Off
27	Wet	Hot	High	Off

Input membership function: Membership functions for moisture measurement:

$$\text{Moist}_{\text{dry}}(x) = \begin{cases} 1, & x \le 20 \\ \frac{40-x}{20} & 20 < x \end{cases} \quad (1)$$

$$\text{Moist}_{\text{medium}}(x) = \begin{cases} \frac{x-40}{15}, & 40 < x \le 55 \\ 1, & 55 \le x \le 65 \\ \frac{80-x}{15} & 65 \le x < 80 \end{cases} \quad (2)$$

$$\text{Moist}_{\text{wet}}(x) = \begin{cases} \frac{x-80}{10} & 80 < x < 90 \\ 1, & 90 \le x \le 100 \end{cases} \quad (3)$$

Membership functions for temperature measurement:

$$\text{Temp}_{\text{cold}}(x) = \begin{cases} 1, & 0 \le x \le 10 \\ \frac{20-x}{10} & 10 < x \le 20 \end{cases} \quad (4)$$

$$\text{Temp}_{\text{warm}}(x) = \begin{cases} \frac{x-20}{3}, & 20 < x < 23 \\ 1, & 23 \le x \le 27 \\ \frac{30-x}{3} & 27 \le x \le 30 \end{cases} \quad (5)$$

$$\text{Temp}_{\text{hot}}(x) = \begin{cases} \frac{x-30}{7} & 30 < x < 40 \\ 1, & 40 \le x \le 49 \end{cases} \quad (6)$$

Membership functions for humidity measurement:

$$\text{Hum}_{\text{low}}(x) = \begin{cases} \frac{x}{15}, & 0 \le x < 15 \\ 1, & 15 \le x \le 25 \\ \frac{40-x}{15}, & 25 < x < 40 \end{cases} \quad (7)$$

$$\text{Hum}_{\text{medium}}(x) = \begin{cases} \frac{x-40}{10}, & 40 \le x < 50 \\ 1, & 50 \le x \le 60 \\ \frac{70-x}{10} & 60 < x \le 70 \end{cases} \quad (8)$$

$$\text{Hum}_{\text{high}}(x) = \begin{cases} \frac{x-70}{10}, & 70 \le x < 80 \\ 1, & 80 \le x \le 90 \\ \frac{100-x}{10}, & 90 < x \le 100 \end{cases} \quad (9)$$

Output membership function: Membership functions for water valve operation:

$$\text{Motor status}(x) = \begin{cases} \text{off}, & x = 0 \\ \text{on}, & x = 1 \end{cases} \quad (10)$$

The fuzzy rule set and the fuzzy rule viewer is shown in Fig. 6 and 7.

Plant disease detection: The rapid and precise method for plant leaf disease detection is done using the k-means (Kajale, 2015) which is based on segmentation. Automatic classification of plant leaf status is been implemented and the general flow for plant disease detection is shown in Fig. 8. The different sample images tested in Matlab are shown in Fig. 9 and 10.

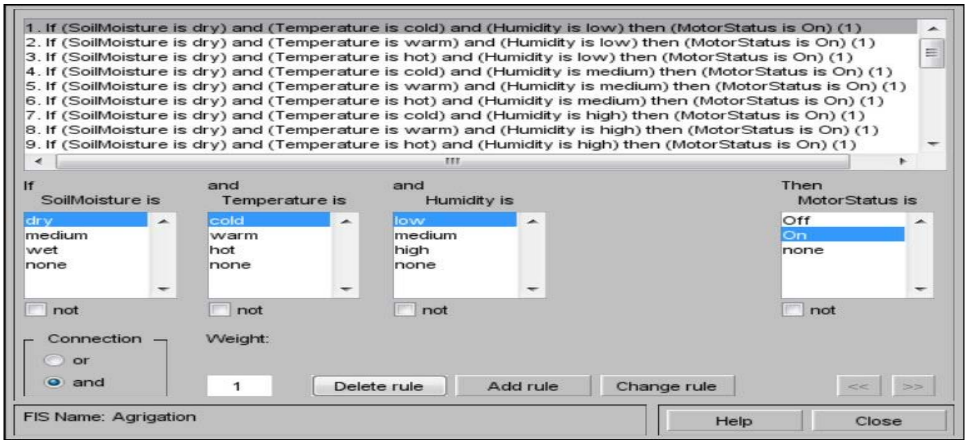

Fig. 6: Fuzzy rule set window

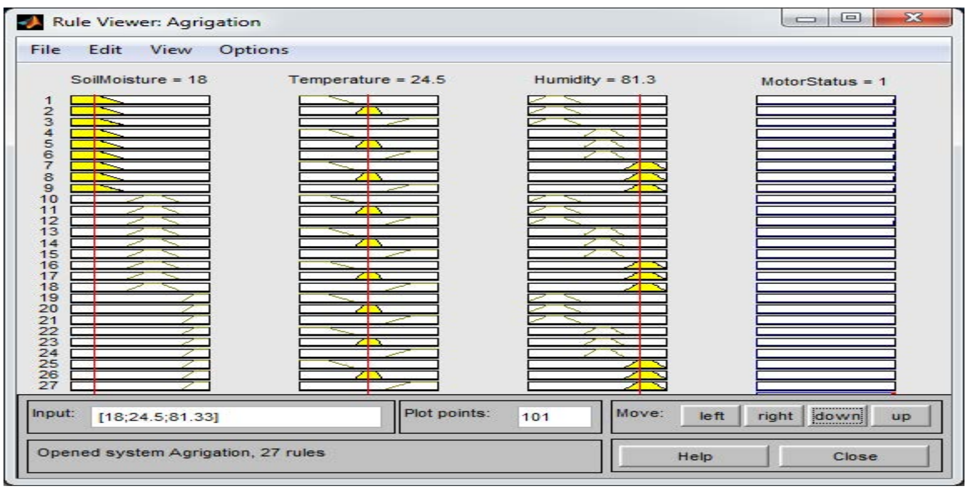

Fig. 7: Fuzzy rule viewer window

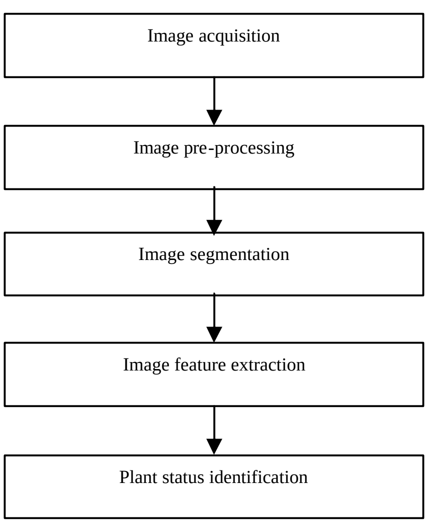

Fig. 8: Flow chart for plant disease detection

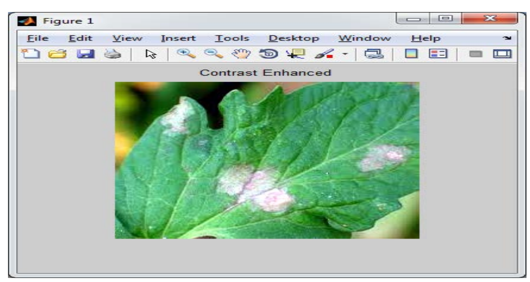

Fig. 9: Sample image of a diseased leaf

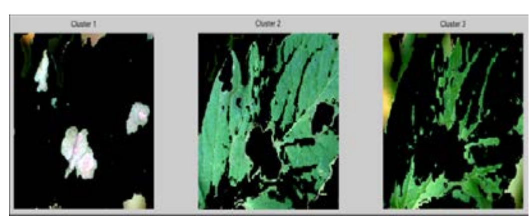

Fig. 10: Clustered leaf images

Fig. 11: Message box with leaf status

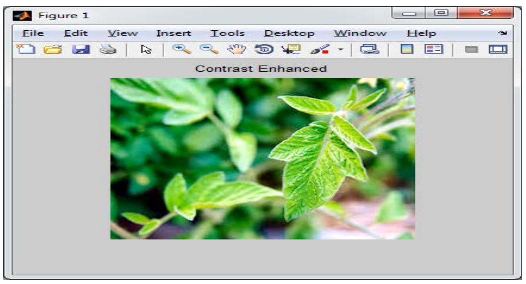

Fig. 12: Sample image of a healthy leaf

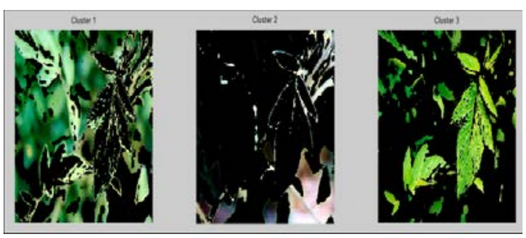

Fig. 13: Clustered leaf images

Fig. 14: Message box with leaf status

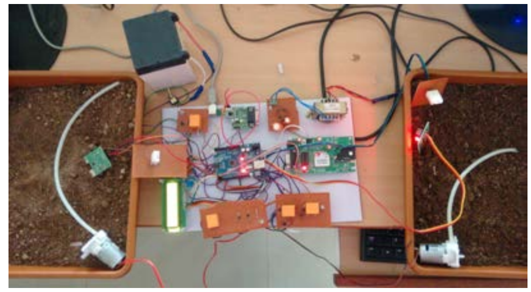

Fig. 15: Transmitter section

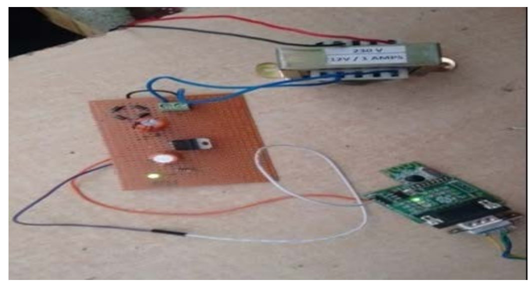

Fig. 16: Receiver section

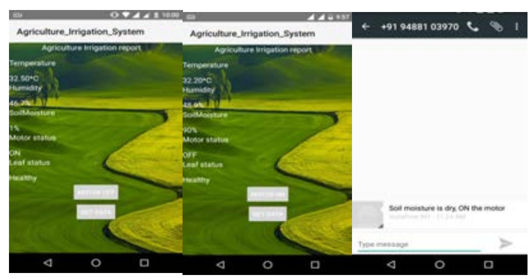

Fig. 17: Android application result with obtained data and message from gsm to the farmer mobile

Fig. 18: Web page for Agriculture irrigation control and plant disease monitoring system

RESULTS AND DISCUSSION

The proposed work has been programmed using MATLAB simulation tool and Arduino programming. The hardware setup is shown in Fig. 15 is implemented by using Arduino microcontroller and the results are obtained in the android phone application which is shown in Fig.16. and 17 shows the message from gsm to the farmer mobile when there is no response from the android application.

Fig. 19: Login page

Fig. 20: Web page results based on the field paprmeter data

The proposed research has a wide range of real time application in near future, since it was tested under various input conditions with the prototype model and the obtained results were accurate. The web page result of the proposed work has been shown in Fig. 18-20.

CONCLUSION

The agriculture irrigation control and plant disease monitoring is the most significant region of agriculture. This study largely focuses on fuzzy logic control to obtain higher level of accuracy to expertly use the water for irrigation process. The simulation result defines the water usage according to the field parameters in the agricultural field. The hardware implementation and irrigation control through android application has been implemented. By implementing this system in real time we can achieve excellent results such as low manual labor cost and effective usage of water for irrigation with the android application.

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