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Wireless Automated Irrigation System based on a Master Slave Control Structure

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Abstract— **A wireless automated irrigation system to improve the water utilization efficiency and reduce human load in agriculture. Temperature sensor, moisture sensor and rain water sensor are placed in the field to collect in the data in the slave microcontroller. The data collected is wirelessly sent to the master microcontroller through RF module which is then compared to the threshold values of the specific crop stored in the database. The system automatically irrigates the field when the data received is out of the optimum range by opening or closing a solenoid valve attached to the slave microcontroller. In the existing irrigation method the farmer has to be physically present in the field for irrigation. In the proposed system the field is automatically irrigated and prevents the damage of the crop from overflow.**

Keywords—**Irrigation, Wireless, Arduino, Raspberry Pi, nRF24L01, Automated.**

I. INTRODUCTION

This Agriculture is the key element in the Indian economy. For agriculture water is the most important resource. In order to utilize this resource efficiently a technology is devised which can reduce the wastage of water and modernize the traditional irrigation process. The key aspect for advancement of irrigation technology is to increase farmer's convenience and reduce the wastage of water resource. Farmers need to go to the field for irrigation or make channels for the water flow in the field which causes wastage of water and in most cases overflow occurs. There are different types of irrigation techniques: surface irrigation, drip irrigation, localized irrigation and sprinkler irrigation. In surface irrigation, even after the completion of irrigation the moisture stays and less amount of water travels to the root of the crop. In drip irrigation the root zone receives the water continuously which may cause root damage.

To overcome these problems, sensors are used here monitoring the soil parameters. The proposed system requires no human intervention for irrigating the field. In general the design consist of six main components. They are radio, slave microcontroller, master microcontroller, sensors, battery and crop database.

The design focuses on the data from three sensors: temperature sensor, moisture sensor and rainwater sensor connected to an Arduino microcontroller, acting as the slave microcontroller, which also has a solenoid valve connected with it to control the flow of water. The sensors used monitor the soil hourly. The temperature and moisture of the soil is checked and compared with the threshold values preset according to the crop requirements, which on differing from the optimum value stored in the database on the Raspberry Pi can make the solenoid valve to be in open or close state. The decision of opening or closing the solenoid valve is taken by the Raspberry Pi, acting as the master microcontroller. The Raspberry Pi and the Arduino communicate through radio signals. The Raspberry Pi on receiving the soil data runs the algorithm for the decision of opening or closing the solenoid valve for the water flow and sends the same decision to the Arduino through radio signals. In this paper, nRF24L01 module is used due to its small size and low power radio. It operates in the ISM band at 2.4GHz and has a maximum coverage area if 250m in real time. The slave microcontroller, Arduino pro mini is used which has an in- built Analog to Digital convertor (ADC) and capability to power all the in-built peripherals. The master microcontroller, Raspberry Pi model 3 is used which has in built Wi-Fi and Bluetooth and can create and maintain databases. In this paper, we will show the related works and system architecture in Section II and III, the methodology of the design in Sections IV, the results of the paper in Section V and the conclusion in Section VI.

II. RELATED WORKS

In work by Ramya et al [1], a system is created with PIC16F877a microcontroller where the threshold values are set by the farmer using a keypad interfaced with the microcontroller. The system monitors the values periodically and if the data collected does not meet the requirement of the pre-set values the water pump is enabled using a relay driver circuit.

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In work by Kavianand et al [2], a monitoring system is designed to record the data of the temperature sensor, moisture sensor, and pH of the soil and the nitrogen content of the soil using the ARM9 microcontroller which in turn controls the water flow to the soil. Undesired conditions are sent to the farmer's phone via an SMS using GSM module. Sathya et al [3] challenges existing irrigation method and assert that an automated system can perform the same function at a much lower cost. The system is equipped with moisture sensor and water level sensor. When the eater drops below the threshold value the water is made to flow to the soil and an SMS containing the time taken to water the land is sent to the farmer.

Manimaran et al [4] created a system where the master slave technology is used. The slave is only used to collect the data from the sensors and the send to the master microcontroller. The master microcontroller updates the sensor information on a web page using a GPRS module which can be accessed through the internet and the water flow can be controlled. Nikhil et al [5] designed a simplified circuit to irrigate plants using an ultrasonic sensor to check the water level in the reservoir. The system is enabled or disabled using an email which is received on the raspberry pi to open or to close the water pump. The raspberry pi then directs the Arduino to open or close the valve using the relay.

Parameswaran el at [6] proposes a design to measure soil humidity, temperature and pH of the soil with an Arduino microcontroller. The data is sent to the PC with the help of the RS232 cable through serial communication. Kabilan N el at [7] created a system that uses the colour of the plants and images of soil to analyse the water requirement of the soil. A database is created of soil samples of different conditions and the water requirements is each condition. The database is built by extracting different features of the plants from the sample images. This system makes use of Web of Things.

III. System Architecture

In the proposed irrigation system the master microcontroller with receiving RF module is kept indoors within the range of the transmitting RF module to receive data and transmit the decision after running the algorithm. The general system design can be seen in Figure 1.

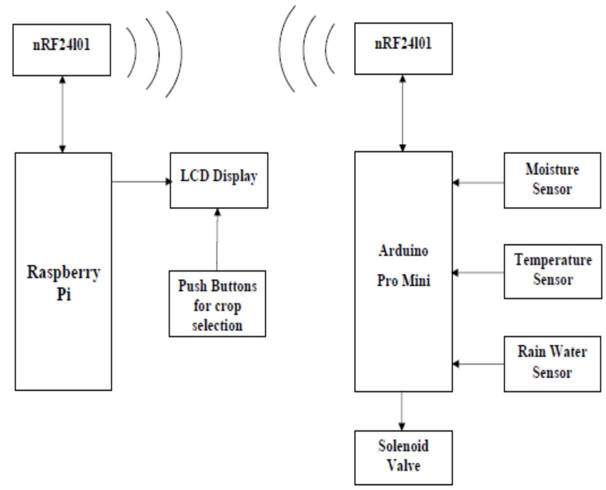

Figure 1. System Architecture

A. *Arduino Pro Mini*

The Arduino Pro Mini 5Volts and 16MHz model uses an Atmega328 low power 8-bit microcontroller. It has fourteen digital input output pins and six analog input pins. The analog pins covert the input to digital values to make it comparable to threshold values.

B. *Raspberry Pi*

The Raspberry Pi model 3 is based on ARM cortex A53 processor with 1GB internal RAM. It has forty general purpose input output (GPIO) pins. It can provide 3.3Volts and 5Volts output to power different devices.

C. *nRF24L01 Module*

The radio frequency module uses 2.4GHz industrial, scientific and medical radio band (ISM Band). It can provide an output of 3.4Volts to 5Volts with a range of 250 meters in real time in open areas.

D. *Soil Moisture Sensor*

The soil moisture sensor is capacitance based sensor to measure dielectric permittivity of the surrounding medium which in soil is the function of water content. The output is a voltage signal between the ranges of 0Volts to 5Volts proportional to the dielectric permittivity. Higher the output lower the moisture content in the soil.

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E. Temperature Sensor

The soil temperature is taken using a DHT11 sensor. It uses a thermistor. The variation in the temperature changes the resistance of the thermistor. The resistance decreases with increase in the temperature.

F. Rainwater Sensor

The rain water sensor detects the presence of rain. It is based in the LM393 op amp. As water falls on the board, parallel path of resistance are created that is measured by the op amp. Output is a voltage value in the 0Volts to 5Volts range. The less the water the higher the voltage output.

G. Solenoid Valve

The cjv23-c12a1solenoid valve is an open or close solenoid valve. Working voltage range is from 12Volts to 24Volts with inlet and outlet paths at right angles to each other. It is normally in closed state, but when there is a potential difference across it the valve opens.

H. Liquid Crystal Display

A 16x2 LCD is an electronic display module and can display sixteen characters in two lines. There are two registers in the LCD, a command register and data register. Command register uses predefined commands and data registers stores the data from the microcontroller to be displayed.

IV. METHODOLOGY

Figure 2 depicts the algorithm of the design which is used for the automated irrigation process and the step by step explanation follows the algorithm.

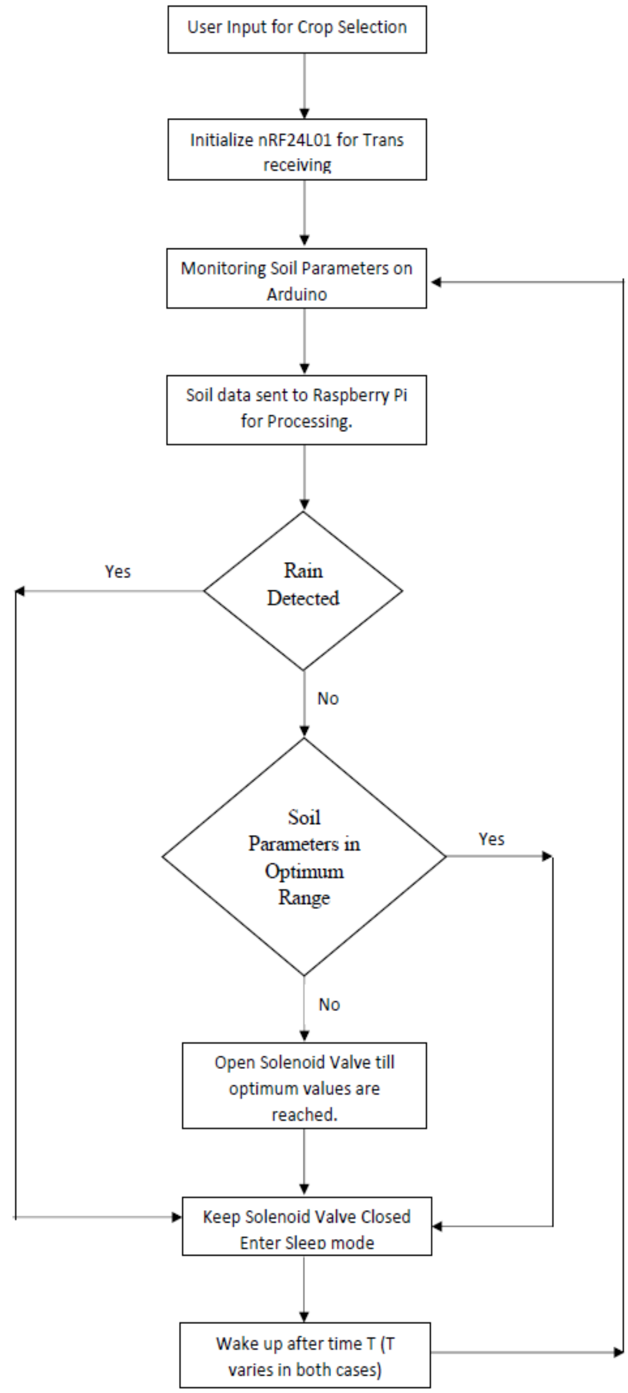

Figure 2. Design Algorithm

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Initially the LCD connected to the Raspberry Pi waits for the input from the user to select the type of crop being used in the field. After the crop is selected by the user the data is pushed to the RF module which initialises the RF module connected with the Arduino microcontroller initiating Arduino to collect data from the soil. The soil parameter data is collected by the Arduino and pushed to the RF module.

The data is then sent to the Raspberry Pi which is received by the RF module and the algorithm is used with the received data. The received data comprises the data from temperature sensor, moisture sensor and rain water sensor.

If the temperature sensor reading or the moisture sensor reading is out of the range of the pre-set optimum values for the crop the solenoid valve opens and water is allowed to flow in the field until the optimum values are attained. If excess moisture is detected in the field even if the temperature is not in the correct range the solenoid valve is closed considering that the temperature will come down due to evaporation.

The values are taken periodically after an hour and system is put in sleep mode automatically to save power. If rain is detected by the system the system directly goes into sleep mode and the period within which the data is changed to two hours until rain stops to increase battery life of the entire system.

V. RESULTS

The Table I shows the results obtained by the hardware test on the soil sample. The moisture and temperature for requirements for the soil for groundnut crop and sugarcane crop have been obtained from various sources.

The test is done on the soil requirements of the sugarcane crop on a sunny day to get the desired output from the hardware test as the temperature requirements of the crop is high.

The optimum temperature and moisture range of the soil for sugarcane crop are as follows

Temp: - 25˚Celcius to 38˚Celcius.

Moisture: - 71% to 83%.

The optimum temperature and moisture range of the soil for groundnut crop are as follows

Temp: - 30˚Celcius to 36˚Celcius.

Moisture: - 60% to 80%.

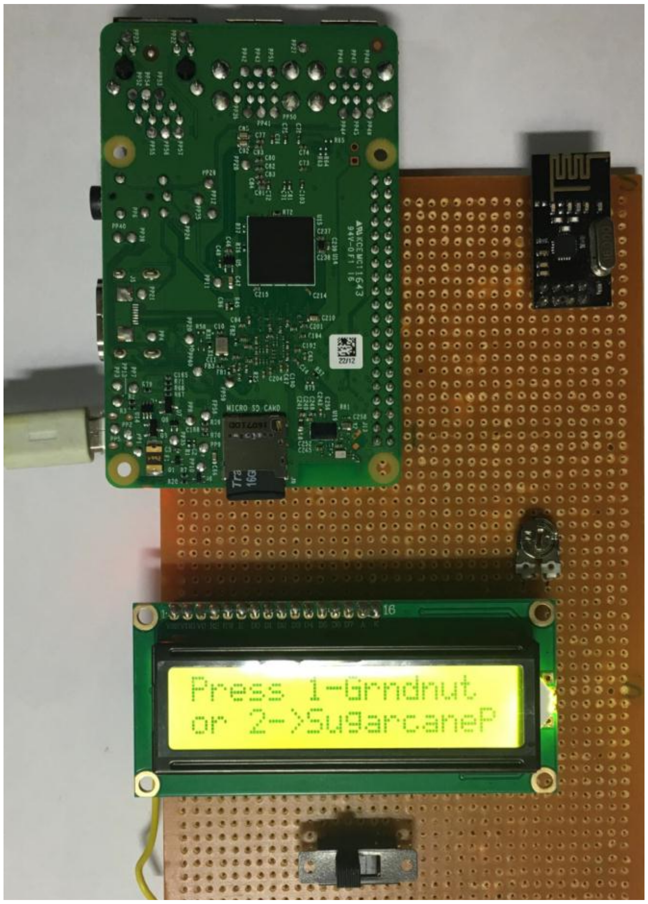

Figure 3. Raspberry Pi (master) Circuit

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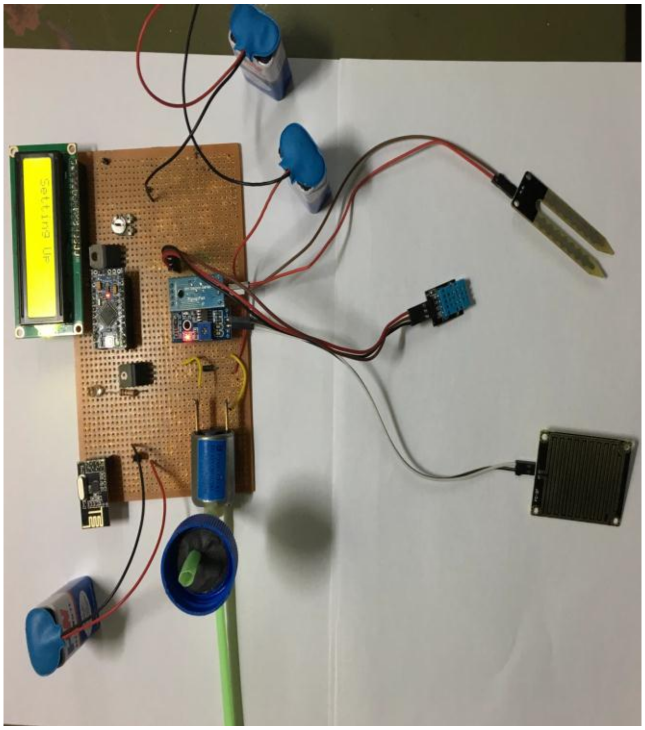

Figure 4. Arduino Pro Mini (slave) Circuit

TABLE I
RESULTS FROM THE HARDWARE TEST

TIME	DEGREE	MOISTURE	VALVE STATUS
07:00 AM	26˚C	77	Close
08:00 AM	28˚C	76	Close
09:00 AM	29˚C	73	Close
10:00 AM	32˚C	70	Open
11:00 AM	35˚C	78	Close
12:00 PM	37˚C	75	Close
01:00 PM	39˚C	72	Open
02:00 PM	40˚C	80	Open
03:00 PM	39˚C	85	Close
04:00 PM	37˚C	84	Close
05:00 PM	36˚C	81	Close

Below Figure 1, Figure 2 and Figure 3 depict the result graphically.

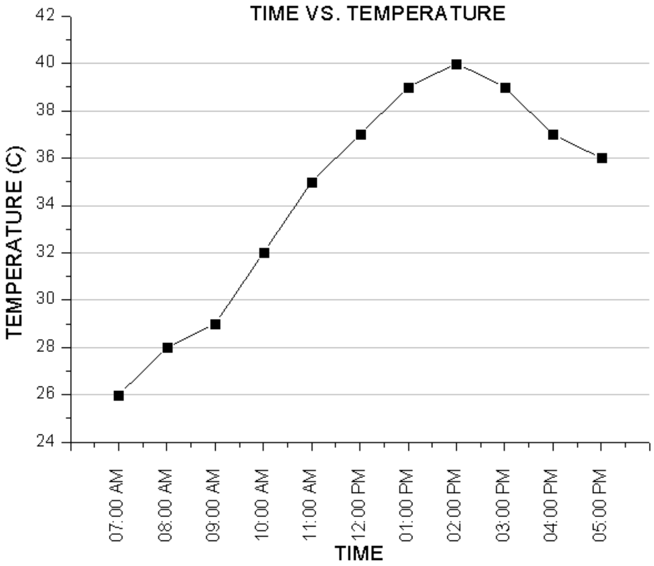

Figure 5. Time versus Temperature

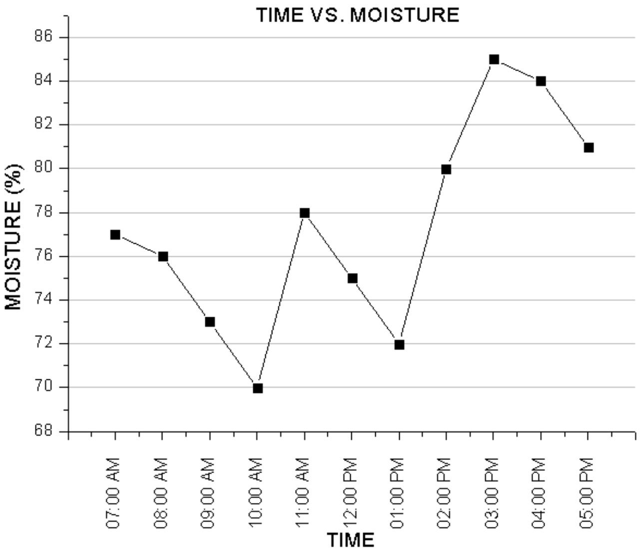

Figure 6. Time versus Moisture

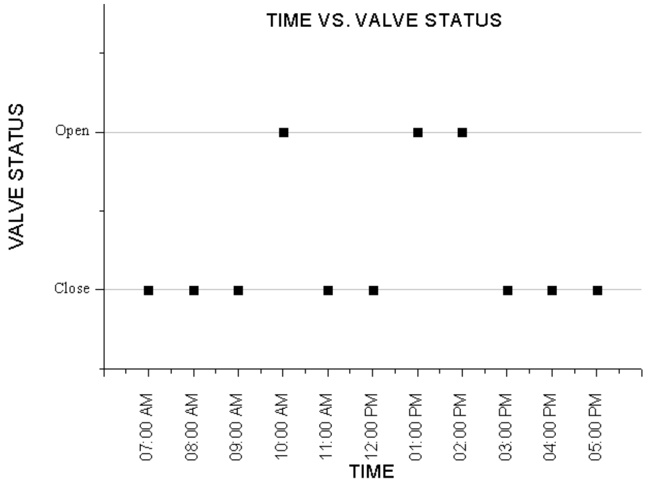

Figure 7. Time versus Valve Status

VI. CONCLUSION

In this paper, the system is designed to wirelessly automate the irrigation process and to require minimal human intervention for irrigation process. Without the help of farmer the water is supplied for irrigation and water is saved immensely.

The database can be further extended to incorporate different crops and their soil requirements as a result this system can be used for different crops. Thereby the cost is also reduced. Furthermore the system can be used dynamically for specific crops by calibrating it based on the database available for different crops.

Results are monitored periodically. The system goes to sleep mode accordingly which reduces battery consumption.

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