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Low Power Cost Effective Automatic Irrigation System

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Abstract

Background/Objectives: Indian agriculture is dependent on the monsoons which is not a reliable source of water, so there is a need for an automatic irrigation system in the country which can provide water to the farms according to their moisture and soil types. **Methods/Statistical Analysis:** The objective of this paper is to develop a low cost power effective sensor based automatic irrigation system which is integrated to the microcontroller unit. The sensors used in this paper are soil temperature sensor and humidity sensor SHT1X. These sensors are interfaced to the Wireless Sensing Unit (WSU) and the entire unit was placed under the soil. It will transmit the sensor value to Wireless Interface Unit (WIU). The main motive of using WIU is to receive the sensed value from WSU and to activate the solenoid valve as well as to send a message to the mobile and also sends an email to the account of the user located in the remote area if the received value is greater than the threshold. The SMS and email are sent using GPRS module interfaced with the wireless interface unit. **Findings:** The irrigation system is tested under various temperatures and different levels of humidity for several plants in all conditions. The soil moisture sensor limits the water content in a particular area. **Conclusions:** The throughput obtained in wet and normal conditions are proved to be intuitive. Developing country like India sending SMS and email to authorize person is understandable.

Keywords: Arduino, Raspberry pi, SHT10 Sensor, SIM900A, Solar Panel, Solenoid Valve, Zig-Bee Modules

1. Introduction

All human beings, animals and plants need water for survival. It is one of the basic needs for everyone. Most of the agriculture systems face water wastage as the major problem. Today agriculture uses 85% of water for irrigation purposes only. In Irrigation the water management plays an effective role. The agricultural fields are affected by over and under irrigation due to insufficiency of water and rainfalls. This effect may increase due to increase in population growth and food demands. Water shortage is one of the major problems in present day scenario[1]. Optical and IR images of plants bring in few plant monitoring systems to the market[2]. Water conservation using several methods reduced the use of these plants monitoring systems[3]. There are many techniques for controlling water wastage. Ditch irrigation scheme is the first among them in which digging ditches and planting seeds is done uniformly[4]. There are certain siphon tubes which use the movement from main ditch to the canals. Drip irrigation is one of the vital methods for irrigation in which water drops at the root zone of plant[5]. Sprinkler system is an irrigation based system which uses sprinklers, sprays or guns on the tubes. The water flows through the tubes and at some ends where sprinklers are present which sprinkle the water in such areas. Sprinklers are activated based on the sensors for temperature and humidity which go beyond the threshold value and are present at the roots. Rotary systems are the best suited for larger areas. Mechanically driven sprinklers are connected to these rotor systems so that the water can reach over a 100 feet radius. So, sprinklers are used to reduce the amount of water needed as they cover large radius. By using infrared thermometers remote canopy

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temperatures can be known and this helps us to automate the cotton irrigation system[6]. A threshold temperature is taken as a reference to compare with the monitored canopy temperatures and based on that comparative result the system triggers. To obtain the optimal results in cotton yielding process and in effective utilization of aqua resources the entire field is automated instead of manual monitoring. A WSN based wireless network has been used which operates in European ISM UHF band to collect the data to a single processing point to validate the biological models in viticulture applications[7], the main drawback of this model is that the used UHF range is less compared to Zig-bee. There is an alternative parameter called Plant Evapo Transpiration (ET), used to estimate the crop irrigation needs. The combination of two terms such as evaporation and plant transpiration gives the information about the whole process. The process of vaporization of water to air from soil, canopy[8] is called Evaporation. The process of vaporization of water from leaves, stems and flowers is called Plant Transpiration. The system which considers ET as a parameter will allow the water savings up to 42%[9]. In recent years WSN nodes became more popular because of applications such as in vehicle monitoring and to control the robots. Measurement of the soil moisture content is done in the paddy fields by using TINY OS based IRIS nodes[10].

There are several solutions to measure the data in the irrigation field; the most popular one is Zig-bee transmission of data from end devices. But using these devices the distance between the two nodes are limited between 10 to 100 meters only. So most of the applications uses GPRS based systems to transmit the data to the remote area[11]. The Zig-bee based transmission is used in the agricultural field in order to collect data from different sensor nodes. Now a day's wireless sensor networks play an important role in food industry and also in agriculture. The examples of such systems are continuous environment monitoring system and to maintain precision in agriculture RFID based traceability systems[12]. The SIM900A is a GSM/GPRS based wireless modem. The automated irrigation system plays an important role in communication of the temperature, humidity and the soil moisture content values which are sensed from the sensor and send to the remote area[13]. This can be done by using the AT commands. The GSM/GPRS modem is interfaced to the microcontroller unit. For remote monitoring, GPRS based systems are employed on wireless sensor networks for monitoring the temperature and humidity data continuously or periodically[14]. The transmission of the sensors data which is under the root zone of plant to the remote person is done using GSM/GPRS modem[15]. The automatic irrigation system using PIC microcontroller is not cost effective and it consumes more power[16].

2. System Architecture

2.1 Flow Chart

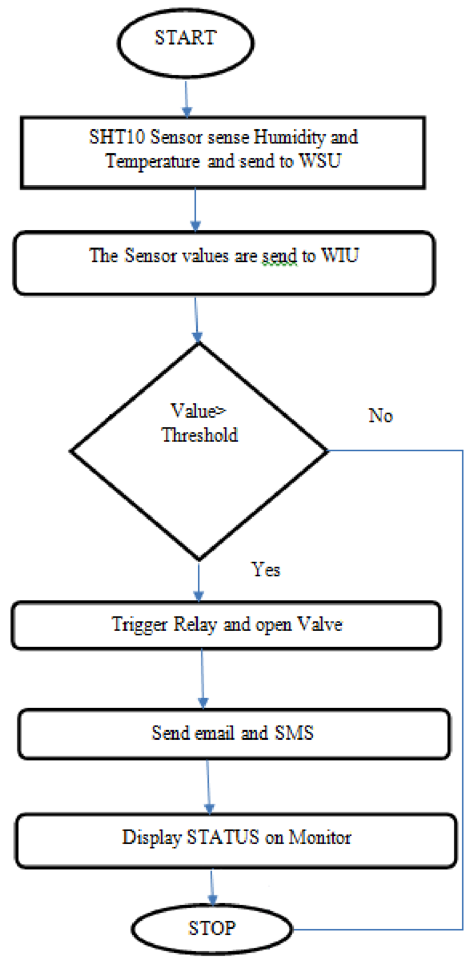

Figure 1. Flow Chart.

The flow chart of the proposed algorithm is shown in Figure 1. The wireless sensing unit is connected to solar panel of 12V. It is used to power up the sensor which is placed under the soil and it is connected to WSU. The SHT1X soil moisture sensor gives the soil temperature and humidity at particular area in field and sends the obtained parametric values to control unit for every 5 minutes. The Zig-bee end device is connected to Arduino receiver and transmitter pin. The control unit receives the data of the sensors sent by the sensor unit through Zig-bee are compared with the predefined threshold value which is programmed in the control unit. When the received data value is greater than the threshold value then the control unit activates the solenoidal valve by triggering the relay. The status of valve is sent to the authorized person through Gmail and SMS connected through GPRS. Whenever the received data value is less than the threshold value then the control unit will display the status of solenoidal valve on display screen.

2.2 Block Diagram

The Block diagram implementation of an automated irrigation system is shown in Figure 2. The automated irrigation system consists of two units one is wireless sensing unit and the other is wireless interface unit. The wireless interface unit consists of Raspberry pi. The solenoidal valve, Zig-bee receiver, GPRS is connected to raspberry pi. The wireless sensing unit consists of SHT1X sensor and Zig-bee transmitter.

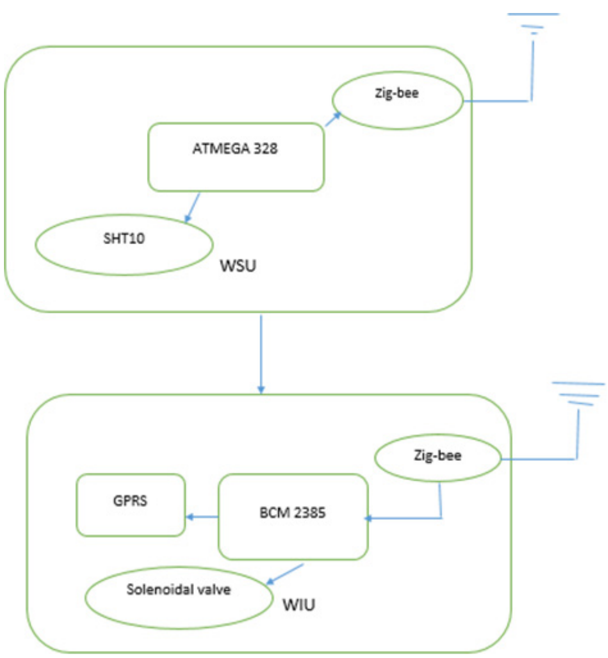

Figure 2. Block diagram.

3. Design Implementation

The solar panel is connected to Wireless sensing unit. By using IC7805 it supply constant 5V to Arduino. The wireless sensing unit is used to measure soil humidity and temperature. The sensor is placed under the soil at a depth of 8cm. The depth of placing sensor varies. It depends upon type of soil and crop. The amount of water required for crop depends upon soil. There are two different types of soil one is black soil and another is red soil. Each gas molecules have a dielectric constant. When a senor is placed under the soil the change in dielectric in capacitor based sensor and change in temperature leads to excite the electrons from ionic bond to valence bond in band gap sensor gives the rise and fall of humidity and temperature readings. The sensor is powered up by supplying 5V. The data pin and clock pin is connected to Arduino. The clock pin is activated from low to high and data pin is activated from high to low. The sensor sends signal to Arduino by activating data pin from high to low. The sensor read humidity by sending a command (0b00000101). The SHT10 sends one byte to Arduino and receives acknowledgement. The sensors send second byte to Arduino and omits acknowledgement to skip cyclic redundancy check. By using equation (1) and equation (2) conversion of humidity value from bit to decimal value is carried out. By using equation (3) converting temperature value from bit to decimal is carried out. The first byte and second byte which are received from the sensor are used to form humidity value and temperature value by using Table 1 and Table 2. To get temperature value the sensors send command (0b000001101).

$$RH_{linear} = c_1 + c_2 .SO_{RH} + c_3 .SO^2_{RH}(\%RH) \quad (1)$$
$$RH_{linear} = c_1 + c_2 .SO_{RH} + c_3 .SO^2_{RH}(\%RH) \quad (2)$$

Table 1. Humidity coefficient

SO_T	c_1	c_2	c_3
12 bit	-2.046	0.0367	-1.5955E-6
8 bit	-2.0468	0.5872	-4.0845E-4

Table 2. Temperature coefficient

SO_T	$d_2(^oC)$	$d_2(^oF)$
14-bit	0.01	0.018
12-bit	0.04	0.072

The Arduino reads the values and send the value to WIU using Zig-bee end device which is connected to receiver and transmitter pin of Arduino. The Arduino supplies power to Zig-bee. The WIU use the microcontroller BCM 2385 is arm11 processer which is built in raspberry pi. The Zig-bee coordinator, GPRS and solenoid valve is connected to raspberry pi. The Coordinator transmitter and receiver pin is connected to raspberry pi UART pins. The solenoid pin is connected to relay Normal Close mode

(NC) and relay is connected to raspberry pi. If the received value is greater than pre-defined threshold valve it will activate the solenoidal valve using relay where relay acts as a switch. The solenoid valve requires 12V of power and to pump water it requires minimum 0.02Mpa to maximum 0.08Mpa pressure. The GPRS sim900 module is connected to raspberry pi. It required 5V to power up and operate at a baud rate of 9600 through serial port. The valve pumps the water when it exceeds threshold value. Once if it reaches below threshold value the valve will close. Using GPRS the status of valve is send to mail using Simple Mail Transfer Protocol (SMTP) and status also send to mobile number using Uniform Resource Locator (URL). If the sensor value is less than the threshold value then it will be displayed on the screen.

4. Results

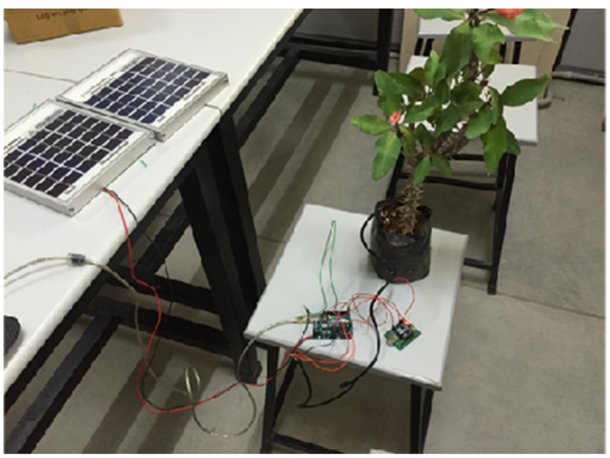

Figure 3. WSU hardware.

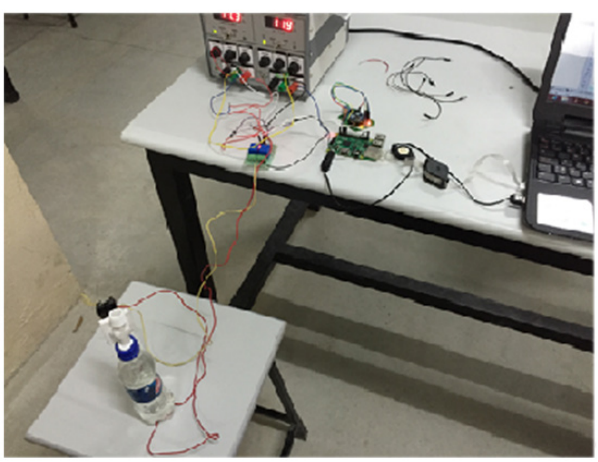

Figure 4. WIU hardware.

Environmental parameters play an important role in irrigation system. The water requirement during summer or winter season is different.

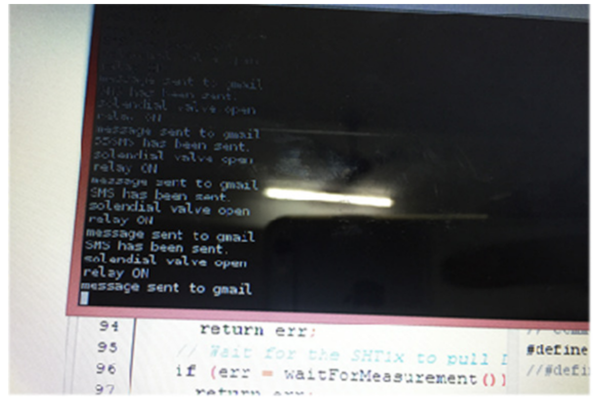

Figure 5. Status display in screen.

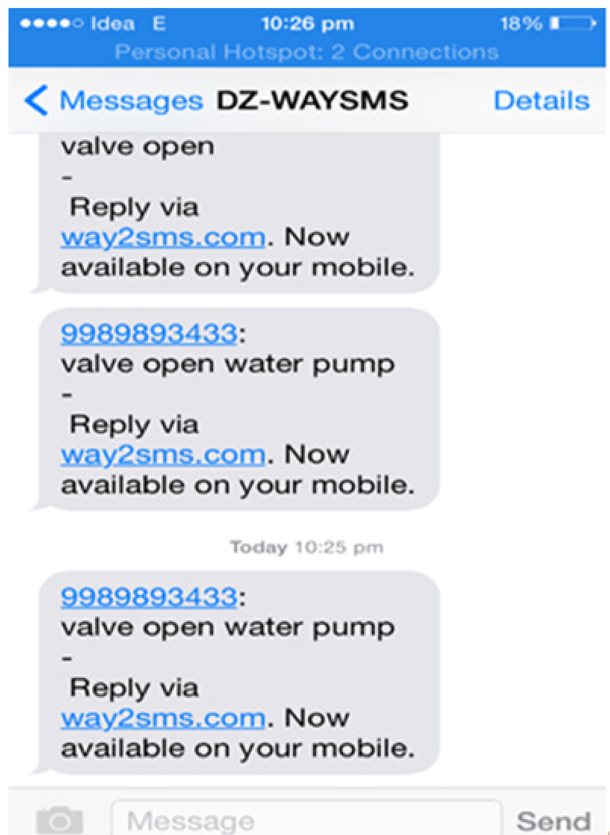

Figure 6. SMS text received.

The wireless sensing unit is shown in Figure 3. The sensor is placed under the soil at a depth of 8cm. Different values of temperature and humidity reading is noted. Most of the values are fallen between **29°C - 38°C**. If soil moisture is less than threshold value then the plant is considered to be in unsafe state. The wireless interface is shown in Figure 4. The unit receives values from WSU and compared it with the predefined threshold value. If it exceeds the threshold value then the relay will trip and LED glows, the valve will open and status of relay will be displayed on the screen as shown in Figure 5. The valve pumps water. The interface unit send SMS and emails text to the owner. The SMS received is shown in Figure 6 and mail received is shown in Figure 9.

By using Simple Mail Transfer Protocol (SMTP) pre-defined message mail is sent to user. The SMTP server will send an email to receiver's email address. To send a message, SMTP protocol has to interconnect with domain name server takes the recipient's email address and translate it into an IP address. The receiver SMTP server examines the incoming message. If it recognizes the domain and the username, it forwards the message to domain POP3. From there it is placed in a mail queue. At that point, the message can be read by receiver.

It is understood from Figure 7 that the temperature varies from the mornin g to evening. Figure 7 is plotted from Table 3.

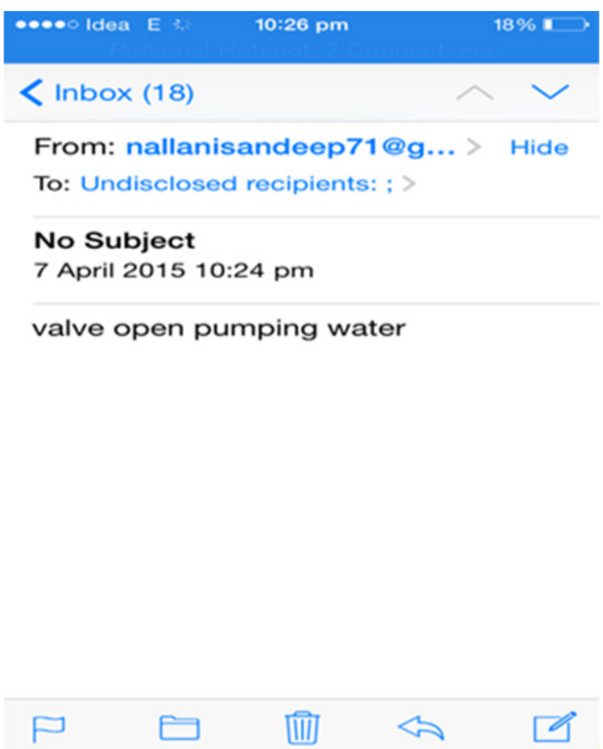

Figure 7. Gmail text received.

As the plant grows water consumption increases from day by day once the growth reaches particular level plant does not need so much of water. So, the threshold values also changes accordingly which is shown in Figure 8. The threshold can be set according to the values obtained under different conditions. The threshold values chosen are in the range of **29°C - 38°C**. The threshold may vary from place to place because it may not be constant in every region. The low power cost effective automatic irrigation system will be helpful for farmers.

Table 3. Humidity and Temperature readings

RH%	C(AIR)	F(AIR)	C(WET)	F(WET)
20	30	86	16	61
35	30	86	19	66
35	35	95	23	73
65	35	95	29	84
80	35	95	32	90

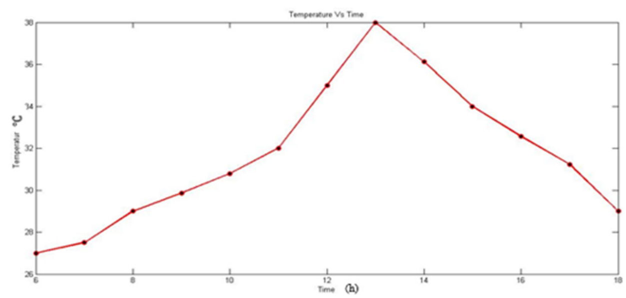

Figure 8. Temperature vs. Time.

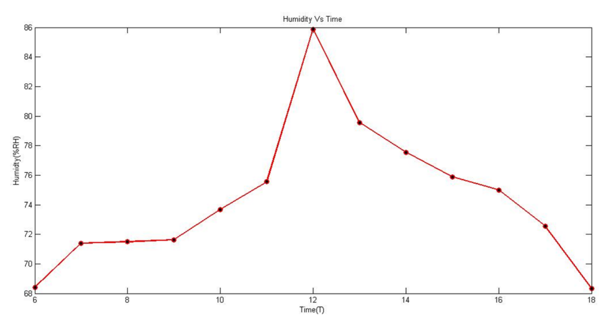

Figure 9. Humidity vs. Date.

5. Conclusion

The automated irrigation system was implemented using the WIU and WSU. The sensor values are transmitted from WSU to WIU through wireless media. The interface unit checks the threshold value and if it exceeds the predefine value then the status of valve is send to the user. The different values for the SHT10 sensor is measured under different climatic conditions and the threshold values are set based on those practical values. This system can be extended by using data base to store the data at the field and the camera to monitor the growth of plant. The overall system is powered up by using renewable energy.

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