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Automated Irrigation System for Production of Sugarcane using Interactive Voice Response System

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Abstract: *The basic resources for crop production are climate, water, and soil. Economical utilization of these resources is crucial for optimum crop production. Climate determines the quality of a crop as an environment for various floras moreover because of the accessibility of water for crop production and alternative uses. Soil serves as a reservoir for water and nutrients. All plants need water to live, grow and supply satisfactory yields to fulfill human desires. For satisfying continuously increasing demand of food necessities, rapid improvement in production of food technology is important. Agriculture is the only source to cater for the growing and dynamic demand in food production. Automation in agriculture is only way to increase the productivity of food as well as to control the use of water. This study proposes an automatic irrigation system based on voice commands for illiterate farmer. Besides this, the system also includes a soil moisture sensor. The control unit is based on the Arduino controller and relays connected to the motor. By the use of automation, sufficient and proper amount of water is provided to the plants.*

Keywords: *Arduino Uno R3, GSM GPRS Module, IVRS, Motor, Relay, Soil Moisture sensor.*

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I. Introduction

The water needed by crops can be provided by several methods such as precipitation, soil wetness storage within the crop root zone or obtained as ooze from higher reaches capillary contribution of wetness from shallow water level or by irrigation. The relationship between crops, climate, soil, and water involves several biological, physical and chemical processes. The extent to which the higher limit of crop's productivity is reached is deeply influenced by the supply of water in amount and time, as well as periods of water shortage throughout the vital periods in its growing phase. The irrigation system has to be designed and managed to satisfy the crop's water demand in amount and time to achieve optimum yields. In the conventional agriculture system, a critical appraisal of water demand for water is important for scheduling irrigation and in designing farm irrigation. The system automatically provides water to crop. Water requirement of crops defines the amount of water required to satisfy the water losses through evapotranspiration of a disease-free crop below non limiting soil conditions, together with soil, water and fertility and achieving the complete at intervals potential below a given soil atmosphere in a given time. It's usually expressed in water-depth units or depth-area units per unit area. Water needs include evapotranspiration and unavoidable losses of water like deep percolation. It additionally includes the necessity of pre-sowing irrigation. Water requirement in irrigation is the quantity of water, exclusive of precipitation and contribution of soil moisture stored in the crop root zone also, the upward flow of water to root zone from saturated zone below that is required for normal crop production. The basic requirement of water is a function of soil moisture deflects as influenced by evapotranspiration, soil and plant characteristics. In several crops, there are critical periods in their physiological growth stages when inadequate soil moisture would be prejudicial to their growth.

II. Technical Background

In [1], authors have presented an efficient technique for water management. Automated irrigation system makes use of a network of sensors to get the data from the field. The farmer receives the information on his mobile phone in the form of an SMS. Another method includes the use of a webpage to deliver the information to the farmer

In [2], authors proposed a system to monitor the Greenhouse parameters like humidity, temperature, soil moisture, a control system based on WSN is needed. An IoT based control system is comprised of greenhouse data acquisition PIC Microcontroller, along with temperature, humidity and moisture sensor. In the Wireless sensor network, there may be possibility of failure of nodes because of the power drained or addition of new nodes or may be change in location of nodes due to physical movement, which further results in collision and energy consumption. Compressive sensing (CS) can reduce the number of data transmissions and balance the traffic load of the networks. Compressive sensing is used for reducing the energy consumption of sensor nodes and also to reduce the congestion in the network. This increases the efficiency of the network system.

In [3], the farmer can save his time by turning on/off the motor with just a phone call from his cell phone. The power detection unit and battery backup unit at the field messages back the information about the power availability and the moisture content of the soil to the farmer's phone. The action taking place in the field is messaged to the farmer through the modem

In [4], authors presented the aim, is to monitor and control the farm atmosphere remotely using android application. In this proposed work the system will be developed using sensors that will monitor the crop field condition and automate the irrigation. Various sensors would be deployed in the field will collect the data from the field. The sensors would be interfaced with the Arduino microcontroller

In [5], the system proposed use of temperature and moisture sensor at suitable locations for monitoring of crops. The sensing system is based on a feedback control mechanism with a centralized control unit that regulates the flow of water on to the field in real time based on the instantaneous temperature and moisture values. The sensor data would be collected in a central processing unit which would take further action. Thus by providing the right amount of water, we would increase the efficiency of the farm. The farmer can also look at the sensory data and decide the course of action himself.

In [6], authors have introduced the burden of manual irrigation by the farmer has migrated a lot. Still, there is a problem to turn ON and OFF the motor during night times. The idea is to design a system using the Internet of Things (IoT) technology to control the irrigation system. Here GSM module is used to communicate with the server.

III. Water Requirement of Sugarcane Crops and Irrigation Management

Sugarcane (saccharum officinarum) is the most important source of sugar in the world. The crop requires a long, warm growing season with a high incidence of radiation and adequate soil moisture, followed by dry, sunny and fairly cool but frost-free ripening and harvesting periods. Nearly 70% of the area under sugarcane in India is irrigated but this constitutes only about five percent of the irrigated area of the country. Sugarcane usually occupies the land for about 10to 18 months and thus necessitates adequate irrigation for realizing its potential yields.

Sugarcane has an extensive fibrous root system, with roots most extensive in the upper 60 to 90cm of sol; some roots may extent to depth as much as 240 cm in well drained, deep loamy soils moisture extraction is greater in the upper 120 cm, decreasing rapidly below that depth. Rooting patterns will vary with soil type and drainage conditions.

Average soil moisture in the first 60 cm should generally be kept at a level of above 66% of total available moisture. However, during winter time in north India, temperatures are too low for growth, and available soil moisture levels need only to be maintained at about 50% level in root zone. The water requirement of sugarcane crop is estimated in table I.

TABLE 1 calculation of the consumptive use (CU) of water for sugarcane crop at Delhi (28°N)

Months	Mean monthly temperature (°f T)	Monthly crop coefficient (K)	Percent day light hrs (P)	Monthly consumptive use (inches)
Jan.	55.7	0.75	7.38	3.08
Feb.	60.4	0.80	7.02	3.39
March	69.3	0.85	8.39	4.94
April	80.6	0.85	8.69	5.95
May	88.0	0.90	9.48	7.51
June	92.3	0.95	9.41	8.25
July	87.1	1.00	9.60	8.36
August	84.2	1.00	8.18	7.73
Sept.	82.8	0.95	8.33	6.55
Oct.	76.6	0.90	8.01	5.52
Nov.	66.0	0.85	7.25	4.07
Dec.	56.7	0.75	7.24	3.08

In north India, planting is mostly done with the commencement of spring season (February- March). In Maharashtra and parts of Karnataka, the crop is planted in December-February, October-November and July-August for 12, 15 and 18 months crops respectively, optimum growth in sugarcane is achieved between 22°c and 30° c minimum temperature for active growth is about 20°c. However, for ripening a relatively lower temperature in the range of 20 to 10°c, which has a significant influence on the reduction of vegetative growth and enrichment of sucrose in the cane, is preferable. The growth period ranges from 9 moths with harvest before winter frost to 24 months in Hawaii. In general, the growing period is between 15 to16 months. The first crop is usually followed by 2 to 4 ratoon crops, each taking about a year to mature. Adequate soil moisture throughout the growing period is important to obtain high yields.

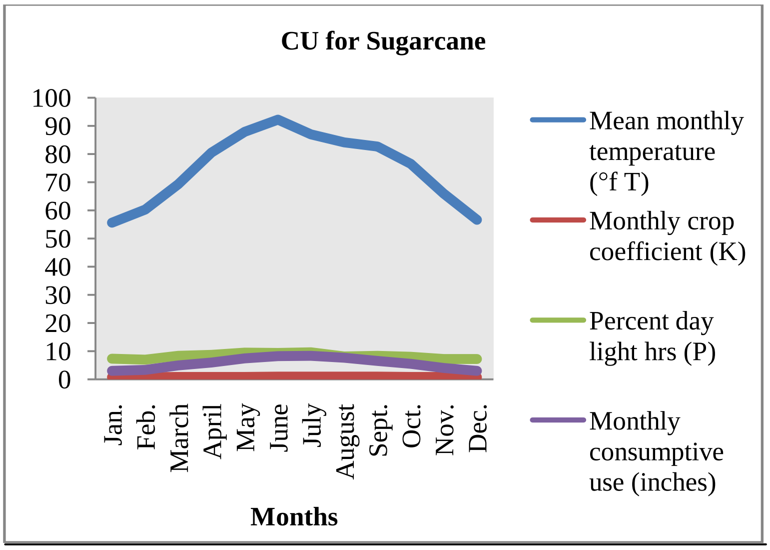

Fig. 1 Graph of Consumptive Use of Water (CU) for Sugarcane Crop

IV. Implementation of Automated Irrigation System

The proposed system has two main units; one is controller unit and the other is field information unit. Controller unit transmits the sensor data to the information unit. The field server unit receives sensor data from controller unit.

A. Controller Unit

Figure 2 depicts proposed block diagram of controller unit. The Microcontroller used is Arduino board to which all the modules are integrated.

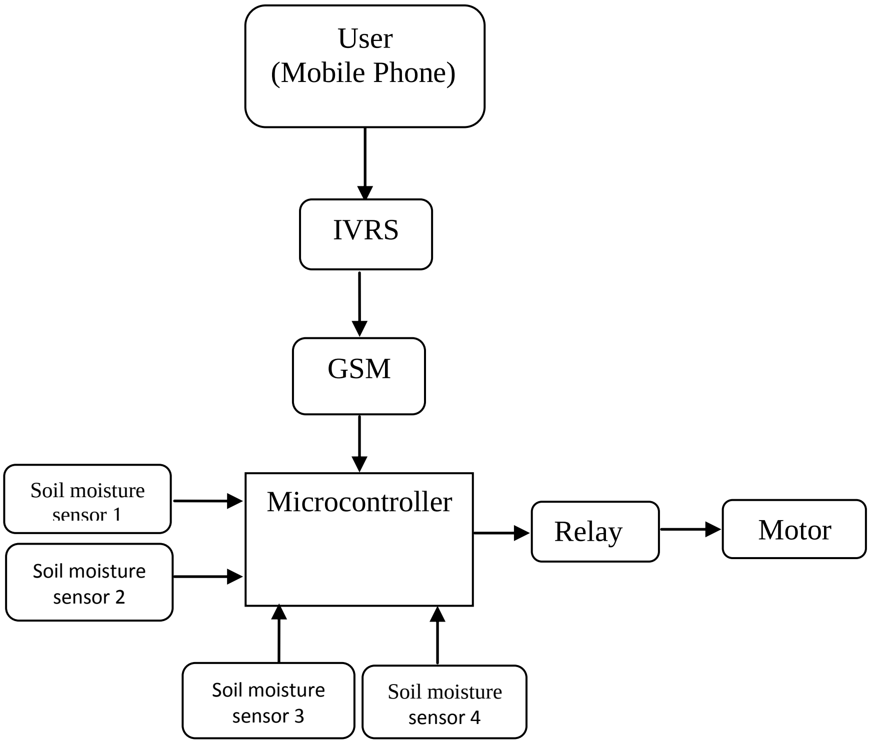

Fig 2. Working Model of Automated Irrigation System

At first, the call is generated through IVRS from the user to a registered number to turn ON the motor. On receiving call by GSM, the system makes some voice commands to direct the used to choose the required language and control the motor using keypad ("1" for "ON" and "0" for "OFF"). On receiving the call and getting the input, the system will check for the presence of water and electricity and it will switch ON the motor. When the moisture level exceeds the threshold level, the device has an intelligent system that will make a call to inform the farmer to switch OFF the motor.

When farmer wants to turn ON the motor, he makes a call to the registered number in the GSM Module. Call is routed and connected through IVRS. The system makes vocal commands stating to choose the required language by pressing the numbers from keypad. Again a vocal command makes a voice command stating to Press 1 to "ON" the motor or Press 2 to "OFF" the motor. Then the motor will be "ON". The farmer can again make a call and OFF the motor. If the farmer forgets to make a call to "OFF" the motor and if the moisture in the soil reached the threshold level, the System will switched "OFF" motor automatically.

B. Field Information Unit

The figure 3 depicts working model of field information unit of automated irrigation system. Arduino Uno is a platform independent open source hardware and software which is used as microcontroller

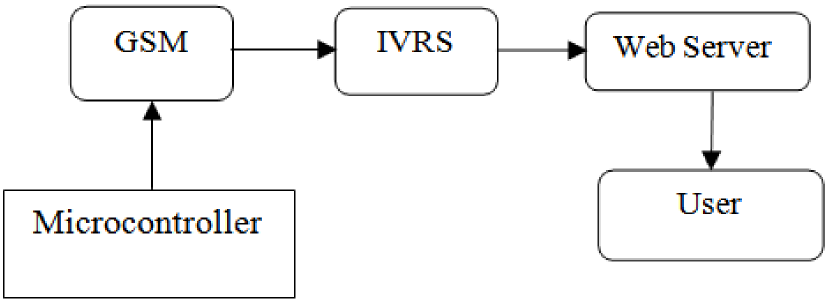

Fig 3. Working Model of Field Information Unit

Microcontroller (Arduino) collects the analog input from the sensors, analyzes it and activates the actuators (Relay and Motor). Meanwhile, the data gather by the sensors will be sent to an HTTP web server via the GPRS GSM module. Timely updates regarding the status of field are sent to web page. The System will make a call and intimate the farmer that the motor is switched "OFF" automatically. When the balance in the SIM of GSM module goes low, it will be intimated to the farmer.

V. Performance Analysis

Soil moisture sensor works on the principal of electrical conductivity. When in dry state there is no conduction path for the current but when moisture starts increasing more and more current flow through moist soil. When soil is completely wet, it provides very little resistance. This varies temperature across sensor which is then converted into digital form using Analog-to-Digital Converter (ADC). The detailed mathematical analysis is given below

A mathematical analysis provides the standard results provided by the manufacturer of the sensors. In the project soil moisture sensor was self-made containing resistor circuit and electrode manufactured on PCB. The output from moisture sensor is given by,

$$V_{sensor} = V_s - \frac{M}{30.3}$$

Where,
M – Moisture content, in %
V_{sensor} – Voltage across sensor, in Volts
V_s – Supply Voltage, in Volts

Using this formula, the different values of voltages at different moisture level is calculated.

A. Status of motor according to soil moisture content and rainfall content

The status of motor according to soil content and rainfall content is given in table II

TABLE 2 Moisture Value, Rainfall Content and Motor Status

sr. no	Moisture value	Rain Prediction	Motor status	Message Sent
1	Low	NO	ON	Motor is ON due to low moisture value
2	Low	YES	OFF	Motor is off due to chance of rain
3	High	-	OFF	Motor is off due to high moisture value
4	High	-	OFF	Motor is OFF due to high moisture value

The graph for voltage values from soil moisture sensor against the water supplied, as obtained in Table III is plotted in Figure 4

TABLE 3 Values of Voltage Obtained by Soil Moisture sensor for Different amount of Water Supplied

Water (mm)	Voltage (volts)
0.0	4.80
3.0	2.30
4.2	1.82
5.8	1.65
6.5	1.56
6.7	1.53
7.6	1.45
8.0	1.39

For analysis purpose soil moisture sensor was inserted at depth of one foot near the root zone. It was tested at different water levels to analysis its behavior and shown in table III.

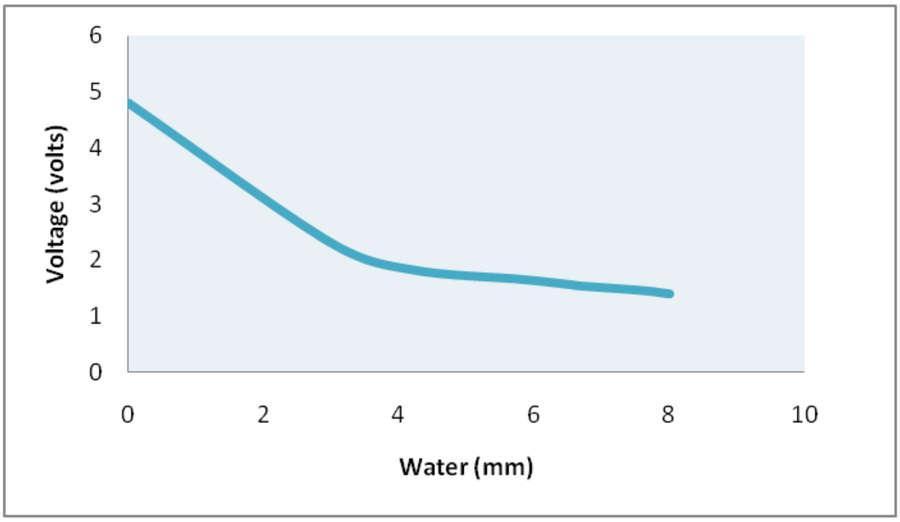

Fig 4. Plot for Voltage Values (V) Obtained by Soil Moisture Sensor for Different Amount of Water Supplied (mm)

VI. Experimental Results

A. Testing of Automated Irrigation System

The Wireless Sensor Node in the observed field with various subsystems. Sensor is used to detect the moisture content and soil fertilities [4]. The output of the sensor is in form of digital, it may be either 0 or 5v. These values are processed through the microcontroller. Whenever the corresponding sensor gives high output then corresponding motor is turned on and water flows to that field. Figure 5 shows soil moisture behavior when motor is in on state

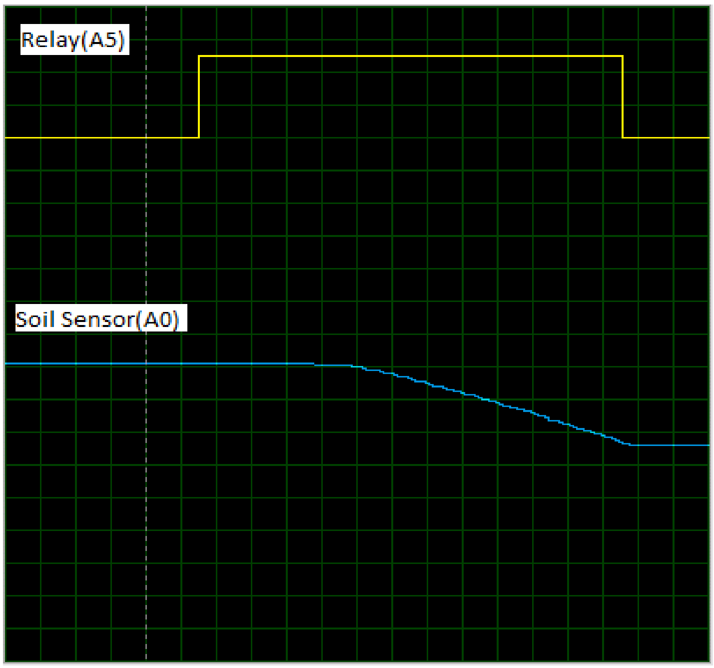

Fig. 5 DSO output waveform of Relay and soil sensor in ON mode

- Signal obtained at Relay is 4.8 volts
- Signal obtained at Soil Moisture Sensor that required time for reduction is 4 sec

Therefore, here is a decrease of 4.8 V in the time span of 4 sec is −1.2 v/sec

VII. Conclusion

The proposed automated irrigation system based on voice commands is designed and tested. The proposed system provides the poor Indian farmers a low cost option to ease their work of irrigation with the help of already available technology of cell phones. The farmer just needs to speak the commands through the cell phone to activate the system at the field. An IVRS is included, so that the farmer need not wait for the message response to know the status of the system. This can greatly save their time needed to travel to the fields in order to switch on/off the motor. Also, the system helps to save water used for irrigation by including the moisture sensor to sense the level of water and automatically switch off the motor. This work will assist the development of smart agriculture and increase the food production.

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