ISSN:2348-2079

Volume-6 Issue-1

International Journal of Intellectual Advancements and Research in Engineering Computations

IOT based agriculture crop-field monitoring system and irrigation automation

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***Abstract*—Internet Of Things (IOT)is a shared network of objectsor things which can interact with each other provided the internet connection. IOT plays an important role in agriculture industry. Smart Agriculture helps to reduce wastage, effective usage of fertilizer and thereby increase the crop yield. In this work, a system is developed to monitor crop-field using sensors (soil moisture, temperature, humidity, Light) and automate the irrigation system. The data from sensors are collected and sent to web server database using wireless transmission. In server database the data are encoded. The irrigation is automated if the moisture and temperature of the field falls below the brink. In greenhouses light intensity control can also be automated in addition to irrigation. The notifications are sent to farmers' mobile periodically. The farmers' can able to monitor the field conditions from anywhere**

With the continuous monitoring of various parameters, the grower can analyze the optimal environmental conditions to achieve maximum crop productiveness, for the better productivity and to achieve remarkable energy savings

I INTRODUCTION

Agriculture plays major role in the economy of the country. More than 70% of Indian population relies on agriculture for their sustenance. As the contribution of agriculture to Gross Domestic product is declining nowadays, we are in urge to increase crop productivity with efficient and effective water usage. In agriculture irrigation is the important factor as the monsoon rainfalls are unpredictable and uncertain. Agriculture in the face of water scarcity has been a big challenge

There are varieties of traditional irrigation systems that has been followed from the past. For instance, in flow irrigation the water resources like tanks or reservoirs are placed at great heights. The water starts to flow automatically down the channel when it is connected to the tank or reservoir. This type of irrigation are mostly used in plain areas. The other type of irrigation is lift irrigation where the fields are at higher level than the water resources. The land is irrigated by lifting waterfrom wells, tanks, canals, rivers using pumps. Nowadays the ground water is also pumped to irrigate the land. Well water irrigation, tank water irrigation, inundation irrigation, furrow irrigation, basin base irrigation are other traditional methods which has been followed from the past.

To improve traditional methods, there has been many systems developed using advanced technologies that help to reduce crop wastes, prevent excessive and scarce watering to crops and thereby increase the crop yield. There are many modern irrigation systems developed so far. One such method is drip irrigation that is used to save both water and fertilizer. Primitive drip irrigation has been used since ancient times. In this method water and fertilizer in the form ofwater droplets are dripped directly to the root of the plants periodically. The design for water application varies according to the crop type. When compared to traditional method it uses 30-50% less water. The other method is pot irrigation which is more suitable for areas having scanty rainfall. The pitchers used here are fixed to the ground up to the neck. The holes are made in pitchers which make the water to percolate around the soil and keep the soil moist for the plants. This method is successful in areas where flow irrigation cannot be used. The other method includessprinkler method which is similar to that of natural rainfall. The water is distributed through a system of pipes and then it is spread into air using sprinkler so that it breaks up into small water droplets that fall into the ground. The pumps supply should be designed in such a way that there should be uniform application of water on the soil surface.

There are some parameters to determine irrigation of crops .The technique ofEva transpiration(ET)depends on climatic changes.ET controllers can be used to schedule irrigation. It has been proved that using ET method the water savings is up to 47%. Soil moisture and temperature of the field are the most essentialparameters. The electromagnetic sensors are used to detect soil moisture. This method saves 53% of water compared to sprinkler irrigation. These sensors are used to create wireless sensor networks WirelessSensornetworks are used to monitor crops and to automate irrigation. The wireless sensor nodes continuously senses the crop field and send it to the coordinator node where decision making is done to automate irrigation based on the field conditions.

These are some methods that have been used so far to improve irrigation system, decrease crop wastage and increase crop productivity. In this work the system is developed using sensors to monitor crop -field and automate irrigation system. The system is tested and gave good results.The wireless transmission of sensor data from field to the coordinator, storing it in a database, controlling field from mobile application and irrigation control are worked very well. The water usage is 90% more efficient than any other traditional and other modern irrigation methods.

II EXISTING METHOD

The existing method in agriculture is the manual method of checking the parameters, in which farmer uses their manpower to identify their growth level of their crop .The farmers themselves check the parameters in their crop field. They uses only the sensor not the advanced level of notification it may consume more time and huge number of manpower .Continuous monitoring of the crops and maintenance is very difficult. Accurate results cannot be obtained. It is impossible to be there in the crop field and analyzing the temperature, humidity,and safety for the crops may not be accurate and satisfied. This may lead to the decrease in crop yield due to insufficient manpower and monitoring.

III PROPOSED METHOD

In this work low cost soil moisture sensors, temperature and humidity sensors, are used. They continuously monitor the field and send it to the web server using NRF24LO1 transmitter and receiver and Ethernet connection at receiver ends. The sensor data are stored in database. The web application is designed in such a way to analyze the data received and to check with the threshold values of moisture, humidity and temperature. The decision making is done at server to automate irrigation. If soil moisture is less than the threshold value the motor is switched ON and if the soil moisture exceeds the threshold value the motor is switched Off. This method can also be used in green houses where in addition light intensity control can also be controlled and automated. The system design is represented in Fig. 1

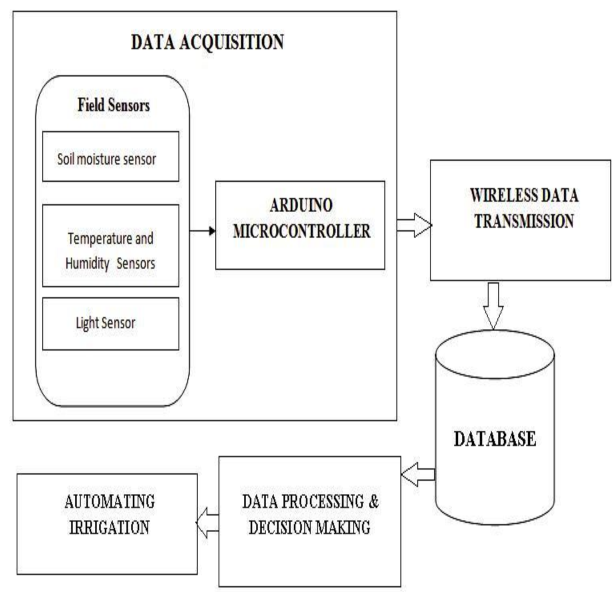

Fig 1. System Design

IV COMPONENTS

A. *Sensors Data acquisition*

The data acquisition from sensors one by one. The sensor is interfaced with Arduino microcontroller and programmed. Once it is programmed it is placed inside a box and kept in the field. The soil moisture sensor has two probes which is inserted into the soil.The probes are used to pass current through the soil. The moisture soil has less resistance and hence passes more current through the soil whereas the dry soils has high resistance and pass less current through the soil. The resistance value help detecting the soil moisture. Fig. 2. Shows soil moisture sensor.

Sukumar P et al., Inter. J. Int. Adv. & Res. In Engg. Comp., Vol.–06(01) 2018 [377-382]

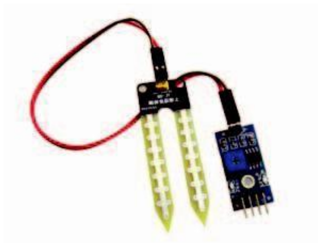

Fig 2.Soil moisture Sensor

The DHT11 temperature and Humidity sensor is used. The total amount of water vapor in air is defined as a measure of humidity. Relative humidity is calculated because when there is a change in temperature, relative humidity also changed. The temperature and humidity changes occur before and after irrigation. The amount of water droplets in air is increased after irrigation. This causes decrease in temperature which in turn increases the relative humidity of the surroundings. The temperature and humidity reading are often notified to the user so that the user can be able to know the field conditions from anywhere. The temperature and humidity sensor can also be used in green houses.DHT11 temperature and humidity sensor is shown in Fig. 3.

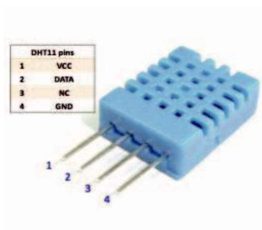

Fig 3. DHT11 Temperature and humidity Sensor

Light sensor is used to detect light intensity of the environment. Light is the major source for crops which is responsible for photosynthesis. Light Dependent Resistor (LDR) is used in which the resistivity decreases with increase in light intensity and vice versa. The voltage divider circuit is designed to measure resistance due to light intensity variations. The voltage level increases with increase in light intensity. The analog reading is taken from the board. It can be used in green houses where artificial lighting is done using any of the incandescent lamps, fluorescent lamps instead of sunlight. Fig. 4. Shows Light Dependent Resistor.

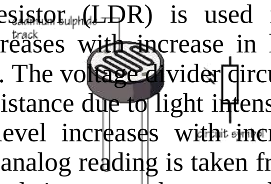

Fig 4. Light Dependent Resistor

A passive infrared sensor (PIR sensor) is an electronic sensor that measures infrared (IR) light radiating from objects in its field of view. They are most often used in PIR-based motion detectors.When the sensor is idle, both slots detect the same amount of IR, the ambient amount radiated from the room or walls or outdoors. When a warm body like a human or animal passes by, it first intercepts one half of the PIR sensor, which causes a positive differential change between the two halves.A PIR-based motion detector is used to sense movement of people, animals, or other objects. They are commonly used in burglar alarms and automatically-activated lighting systems. They are commonly called simply "PIR", or sometimes "PID", for "passive infrared detector".

Fig 5. PIR sensor

B.GSM Module

GSM is a mobile communication modem. It is stands for global system for mobile communication (GSM).It is widely used mobile communication system in the world. GSM is an open and digital cellular technology used for transmitting mobile voice and data services operates at the 850MHz, 900MHz, 1800MHz and 1900MHz frequency bands.GSM system was developed as a digital system using time division multiple access (TDMA) technique for communication purpose. A GSM digitizes and reduces the data, then sends it down through a channel with two different streams of client data, each in its own particular time slot. The digital system has an ability to carry 64 kbps to 120 Mbps of data rates. There are various cell sizes in a GSM system such as macro, micro, Pico and umbrella cells. Each cell varies as per the implementation domain. There are five different cell sizes in a GSM network macro, micro, Pico and umbrella cells. The coverage area of each cell varies according to the implementation environment.

Fig 6. GSM Module

C. Arduino Uno

The Arduino Uno is a microcontroller board based on the ATmega328 (datasheet). It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header, and a reset button. Arduinois an open-source electronics prototyping platform based on flexible, easy-to-use hardware and software. It's intended for artists, designers, hobbyists, and anyone interested in creating interactive objects

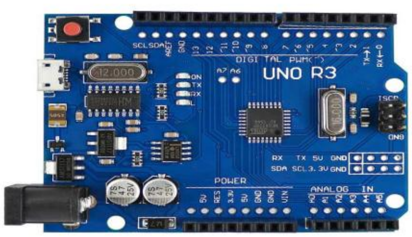

Fig 7.Arduino Uno

D. Automation of Irrigation System

The irrigation system is automated once the control received from the web application or mobile application. The relays are used to pass control from web application to the electrical switches using Arduino micro-controller. A relay is an electrically operated switch. The circuits with low power signal can be controlled using relay. There different types of relays which includes reed relay, solid state relays, and protective relay etc. The relay used here is Solid State Relay (SSR).If an external voltage is applied across the ends the relay switches on or off the circuit.

V INTERFACING FOR THEINTERNET OF THINGS (IOT)

Interfacing with Arduino

Arduino is considered a development board for ESs which consists of an 8-bit microcontroller, USB programming interface, and input/output (I/O) pins [4]. As shown in Fig. 3, the input pins can be digital (0 – 13) and analogue (A0 – A5), while the output pins are only digital (0 – 13). Arduino has an integrated software environment which has a cross-compiler, a debugger and a serial monitor to control the inputs and outputs. The Arduino IDE (integrated development kit) can be downloaded from arduino.cc official portal which is supported by a wide community. The Arduino board itself with some pre-programmed functionality is considered a pure ES. Therefore, shields are used to add the Internet connectivity.

For example, we can add an Ethernet shield or Wi-Fi shield to the Arduino, as indicated by Fig. 4. The shields are easy to attach and configure through libraries. This makes it possible to interact and exchange data with the Arduino through the web. One research article investigated the use of Arduino and Node.js which is a JavaScript interpreter that runs on the server's side to build an IOT applications

VI FUTURE SCOPE

The mobile application is developed in android. The mobile application helps to monitor and control the field from anywhere. The mobile application uses PHP script to fetch data from MySQL database. In MySQL database all the sensor data are stored. The android fetches the data and encode it in JSON format to be displayed in android device. The user interface for the application is designed in a way that enables both the monitoring and control of field from the device. The internet connection should be provided to monitor and control the field.

VIISTIMULATION OUTPUT

While running this project it will detect the soil moisture temperature and humidity of the crop field and display the result in Liquid Crystal Display(LCD). The Fig.8 shows the stimulation output of IOT based crop field monitoring system and irrigation automation

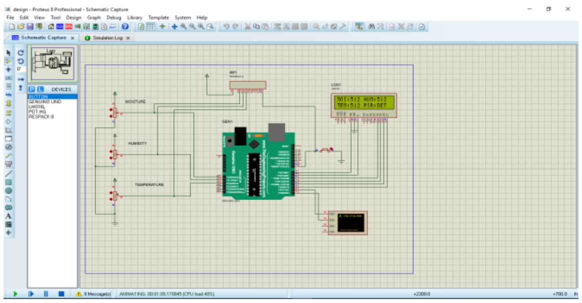

Fig 8. Stimulation output

VIII RESULTS AND DISCUSSION

The system is developed and tested and various conditions. . This system will be more useful in areas where water is in scarce. This system reduces the time consumption and manpower.

The soil moisture is tested in all climatic conditions and results are interpreted successfully. The LDR is tested in all light conditions. Different readings were taken under different condition. The temperature reading was taken at different weather conditions. The wireless transmission was achieved using Arduino and GSM module... The input voltage resistance values for different soil conditions obtained are represented in Table I

TABLE I

SOIL RESISTANCE VALUE (OUTPUT) FROM SOIL MOISTURE SENSOR

Parameter	Condition	Minimum value	Maximum value
Input Voltage	-	3.3V	5V
Output Value	Dry Soil	0 Ω	300 Ω
	Humid soil	300Ω	700 Ω
	Water	700 Ω	950 Ω

A. Analysis of Water and Power Requirement:

After the detailed analysis of implemented irrigation system and other environmental conditions, water requirement per acre can be calculated as below:
Irrigation Factor = 0.55
Evaporation rate = 0.4
Irrigation interval = 1 day Diameter of drip outlet = 3mm
Thus,
Water=(irrigation factor)*(daily evaporation)*(irrigation interval)*(diameter of drip)*10/2.54*0.001 required
= 0.55*0.4*1*10*3/2.54
= 10.39 Cubic-meter/Acre
Water holding capacity for medium grade soil = 189 lit/24 hr.

IXCONCLUSION

The automated irrigation system has been designed and implemented in this paper. The system developed is beneficial and works in cost effective manner. It reduces the water consumption to a greater extent. It needs minimal maintenance. The power consumption has been reduced very much. The system can be used in green houses. The System is very useful in areas where water scarcity is a major problem.The crop productivity increases and the wastage of crops is very much reduced using this irrigation system. The developed system is more helpful and gives more feasible results.

The extension work is the prediction of crop water requirement using data mining algorithms in which we are currently progressing. The prediction helps to supply the right amount of water to the crops.This system is 92% more efficient than the conventional approach

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