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Smart Irrigation for Sustainable Agriculture

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Abstract— Soil moisture information plays an important role in environmental monitoring, agricultural production and hydrological studies. Particularly, agricultural yield depends on several growing parameters like temperature, humidity, soil moisture and pH of the soil, etc. In this paper, we have designed and developed a system for measuring and monitoring soil moisture, humidity and temperature by interfacing low-cost soil moisture sensor FC-28, temperature and humidity sensor: DHT11, and using Internet of Things (IoT), Cloud computing and Mobile computing technologies. We have also implemented an online cloud computing system to keep check over soil parameters. Various methods, both laboratory and field including remote sensing are available to measure soil moisture content, but the quickest and better one is with the use of soil moisture sensor electronic devices. For successful irrigation, it is necessary to monitor soil moisture, its temperature and humidity content continuously in the irrigation fields. The soil moisture sensors are used intensively at present because it gives real time readings. Their usage helps growers with irrigation scheduling by providing information about when to water the crops. Efficient irrigation watering helps in saving water, getting better plant yields, reducing dependency on fertilizers and improving crop quality. This research has a real potential to deliver a more productive and sustainable form of agricultural production, based on a more precise and resource-efficient approach. It also promises to reduce the ecological footprint of farming, make farming profitable and boost customer acceptance.

Keywords— Smart Irrigation System; Soil Moisture Sensors; Sustainable Agriculture; Temperature and Humidity Sensors

I. INTRODUCTION

Agriculture is the primary source of livelihood for about 58 per cent of India's population. As per 2016, the agriculture industry contributed 16.9–17.9% to our country's GDP. The Gross Value added by agriculture, forestry and fishing is estimated at Rs 18.55 lakh crore (US$ 265.51 billion) in
FY19[1].

India is expected to become home to more than 1.5 billion people by 2030, and its population is set to reach 1.7 billion by 2050 [2]. A population of this magnitude brings a lot of challenges, increasing food production chief among them. It also affects the agricultural pricing, supply chain, and delivery of food products. These growing and changing demands need to be met by an agriculture industry that is facing labour shortages, rising costs and climate change for farm work. The lack of knowledge and unplanned use of resources such as water in fields affects the quality and quantity of the harvest. The flow of water in the fields can be controlled easily with the help of this precision agriculture project. This paper describes the design and implementation of a reactive network for environmental monitoring. The live results of the moisture, temperature and threshold level were calculated through the sensors used in the project. Analysis of soil parameters can be done and the needed nutrients can be calculated for the soil. The need of water supply of the soil can be calculated and hence appropriate irrigation can be done. Soil moisture sensors are interfaced with an irrigation controller. It prevents irrigation cycles when the soil is already wet, e.g. following a recent rainfall event.

By pairing these systems with increasingly sophisticated IoT-enabled sensors to continuously monitor moisture levels and plant health, farmers will be able to intervene only when necessary, otherwise allowing the system to operate autonomously[3].
Knowing the exact soil moisture conditions on their fields, not only are farmers able to generally use less water to grow a crop, they are also able to increase yields and the quality of the crop by improved management of soil moisture during critical plant growth stages. As an added benefit, they also improve the quality of life for farm workers by reducing heavy labour and tedious tasks. The main contribution of this paper is the design and implementation of smart farming techniques in an Indian district which demonstrated satisfactory results. The long term aim of our research is to develop large networks which can be implemented all over the country.

II. PROJECT DESIGN

A. Overview

The smart-irrigation system is designed to put use of technology into the lesser used field of work which is agriculture. It was mainly built to reduce the daily effort of workers in the fields and for healthy growth of crops by monitoring the moisture of soil and irrigating them accordingly. It helps the crops to maintain an average moisture level as needed and can be changed by the user for different sand types and crops. Our smart irrigation control system includes both hardware and software components. The hardware part mainly consists of a microcontroller and sensors and the software part is mainly used for reading sensor data and storage.

B. Hardware Used

1. *Node MCU*:

Fig. 1: NodeMCU

The name “NodeMCU” combines “node” and “MCU” (micro-controller unit). The term “NodeMCU” strictly speaking refers to the firmware rather than the associated development kits. The firmware runs on the ESP8266 Wi-Fi SoC from Espressif Systems, and hardware which is based on the ESP-12 module. The firmware uses the Lua scripting language.

2. *Temperature and Humidity sensor – DHT 11:*

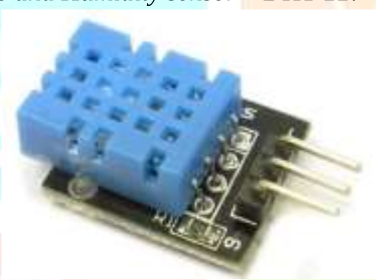


Fig. 2: DHT 11

The DHT11 is a basic, ultra low-cost digital temperature and humidity sensor. It uses a capacitive humidity sensor and a thermistor to measure the surrounding air, and spits out a digital signal on the data pin. It’s fairly simple to use, but requires careful timing to grab data. The sensor is also factory calibrated and hence easy to interface with other microcontrollers. The only real downside of this sensor is you can only get new data from it once every 2 seconds, so when using our library, sensor readings can be up to 2 seconds old [4].

3. *Soil Moisture Sensor – FC-28*:

Fig. 3: FC-28

Soil moisture is basically the content of water present in soil. This can be measured using a soil moisture sensor which consists of two conducting probes that act as a probe. It can measure the moisture content in the soil based on the change in resistance between the two conducting plates. The resistance between the two conducting plates varies in an inverse manner with the amount of moisture present in the soil that means greater amount of output implies lesser moisture content
[5].

4. *Relay 5V:*

Fig. 4: Relay 5V

A relay is an electrically operated switch. Many relays use an electromagnet to mechanically operate a switch, but other operating principles are also used, such as solid-state relays. Relays are used where it is necessary to control a circuit by a separate low-power signal as in our system. The pump is driven by a Node MCU which can pass on very small trigger signals, therefore use of a relay device is must in order to turn on or off the pump.

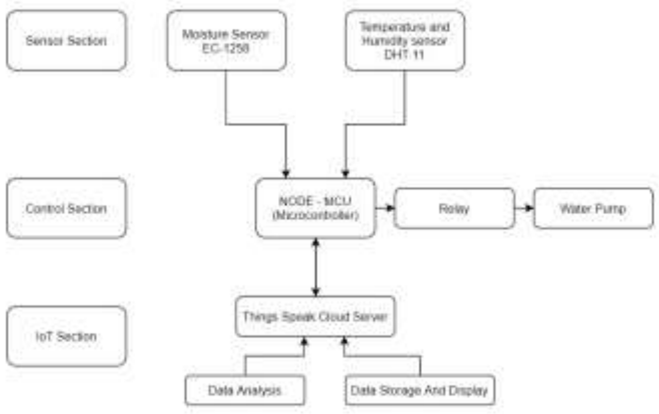
C. Software Used

1. *Arduino IDE*: The Arduino Integrated Development Environment (IDE) is a crossplatform application that is written in functions from C and C++. It is used to write and upload programs which govern the functioning of microcontroller boards.
   Arduino is a great tool for developing interactive objects, taking inputs from a variety of switches or sensors and controlling a variety of lights, motors and other outputs.

2. *Thingspeak*: ThingSpeak is an IoT analytics platform service that allows you to aggregate, visualize and analyse live data streams in the cloud. ThingSpeak provides instant visualizations of data posted by your devices to ThingSpeak. You can automate the system to act on your data and communicate using third-party services.

3. *Adafruit Unified Sensor Library*: It's an Arduino library for the DHT series of low-cost temperature/humidity sensors. This library bears a number of features such as - *a) Inexpensive*: This library is used with low-cost temperature and humidity sensors such as DHT11. The library is free of cost and the cost of sensors is also very less.
   b) Function Calls: The library has inbuilt functions for the ease of user that helps in collecting the data from sensor and thus, using it.

D. Architecture



The Smart Irrigation System is equally dependent on its hardware and software for its effective use. The hardware comprises both the sensors named as Temperature and Humidity Sensor (DHT 11) and Soil Sensor (EC-1258), Node-MCU and the relay-pump circuit. The data is read by the sensors and then is sent to the Node-MCU through the connections made.

The software part comes into work side by side when the Node-MCU further processes the data to turn the pump on or off as per given conditions based on values of moisture levels of soil which is when the data read by the NodeMCU is transmitted to the ThingSpeak Cloud Server via internet with the help of ESP8266 module in built in our microcontroller. Readings transmitted to the cloud server are then analysed to obtain graphs for its convenient study. Simultaneously a database is created and the readings keep on getting stored in it.

III. EVALUATION AND APPLICATIONS

A. Effectiveness

The following graphs (*fig. 5(a),5(b),5(C)*) shows the record of soil moisture sensor and temperature sensor data. It shows the readings of the soil moisture content, humidity and temperature over the time period t.

B. Accuracy

The working of the pump when the signal is sent for dry soil reading consists of delay of milliseconds.

C. Reliability

The soil sensor used in this system determines the amount of soil moisture by measuring the resistance between two metallic probes that is inserted into the soil to be monitored. Its features are:

- Analog output of moisture content.
- Digital output of moisture content with adjustable set-point.
- 3.3 or 5V operation. Low power so may be driven from digital pin on Microcontroller [6].

D. Accessibility

Thingspeak is an open data platform and API for the Internet of Things that enables us to collect, store, analyse, visualize, and act on the data from sensors or actuators from an internet-based cloud application. The primary element of Thingspeak activity is the channel which contains data fields, location fields, and status fields [7].

ThingSpeak is an open data platform for the Internet of Things. The device or application can communicate with ThingSpeak using a RESTful API, and can either keep the data private, or make it public. In addition, ThingSpeak is used to analyse and act on the data. ThingSpeak provides an online text editor to perform data analysis and visualization using MATLAB [8].

At the heart of ThingSpeak is a time-series database. ThingSpeak provides users with free time-series data storage in channels. Each channel can include up to eight data fields. This tutorial provides an introduction to some of the applications of ThingSpeak, a conceptual overview of how ThingSpeak stores time-series data, and how MATLAB analysis is incorporated in ThingSpeak.

Fig. 5(a): Soil Moisture Content vs Time Graph

The graph above shows the amount of moisture in the soil increasing and decreasing over a certain time period due the effective working of water pump when the soil becomes dry or excess wet.

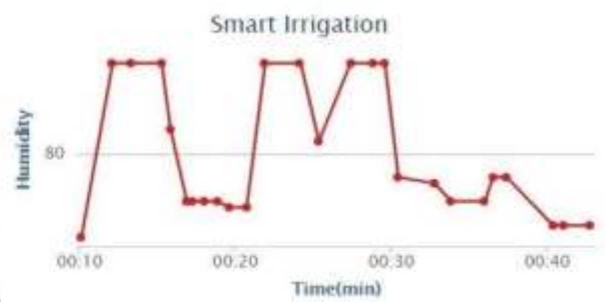


Fig. 5(b): Humidity Content vs Time Graph

This graph shows the Humidity content in the environment over a certain time period and thus it can be observed whether the conditions for the crop is feasible or not.

Fig. 5(c): Temperature vs Time Graph

The graph shows the temperature variation in the environment in a certain time period which can tell the necessary factors for the better yield.

IV. CONCLUSION

In this paper, we have designed and developed a Cloud computing Android system that gives online information about soil parameters like soil moisture, temperature and humidity [9]. A system to monitor moisture levels in the soil was designed and the project provided an opportunity to study the existing systems, along with their features and drawbacks. The proposed system can be used to switch on/off the water sprinkler according to soil moisture levels thereby automating the process of irrigation which is one of the most time-consuming activities in farming [10]. The main objective of this smart irrigation system is to make it more innovative, user friendly, time saving and more efficient than the existing system of agricultural practices. Measuring the parameters such as soil moisture, temperature, humidity values [11]. Since agriculture is a primary market, therefore a sustainable and economic approach is to be adopted for efficient agricultural practice and irrigation scheduling. The use of soil moisture sensors helps growers with irrigation scheduling by providing information about when to water the crops [12]. The main advantage of this is to decrease human involvement and still make an efficient and faster methodology using techniques and equipment that can yield high efficiency. Thus, the system is a potential solution to the problems faced in the existing manual and cumbersome process of irrigation by enabling efficient utilization of water resources thus, preventing the condition of water logging and thereby saving water and improving crop yields to a great extent.

Appendix

The graphs (5(a), 5(b), 5(c)) have been plotted for the common garden soil available in our households.

In the graph 5(a) the soil sensor when not put in soil shows zero reading and when it is put in the soil it shows the moisture content accordingly. The soil moisture content is in Volumetric (%).

The graph 5(b) is plotted in the conditions of non-uniform rainfall to show the variation in humidity in the environment. The Humidity Content's units are grams of **water** vapor per cubic meter volume of air, i.e. (%).

The graph 5(c) is plotted by varying the room temperature to show the variation between temperature and time. The temperature is expressed in degree Celsius.

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