An Iot Based System for Remote Monitoring of Soil Characteristics

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Abstract- *Robot remote monitoring of soil parameters will be an emerging trend which will have the potential to transform agricultural practices and increase productivity. Temperature, moisture and humidity content of soil are the basic parameters which help in characterizing the soil and therefore in taking proper decisions regarding fertilizer application and choice of crops sown. For soil moisture content estimation, the inverse relation between soil resistance and soil moisture has been utilized and corresponding circuitry has been developed. The determination of soil temperature is done using the dedicated sensor working on the wire protocol. The system is integrated with Bluetooth and Wi-Fi for the transfer of data to a nearby cell phone. The entire system is developed on Arduino Uno R3 platform.*

Keywords- Moisture, Temperature, WI-FI, Bluetooth, Arduino, Internet of Things.

I. INTRODUCTION

Internet of Things (IoT) is a concept and paradigm that enables interaction among objects pervasively present in an environment. Internet of things today, has reached many different areas, taken different forms and uncovered a multitude of applications. These applications permeate into practically all areas of our lives. The development of an IoT based infrastructure that facilitates precision agriculture is one such application that has acquired high attention. To be successful, a farmer must maximize per acre yield, reduce spoilage from inadequate or overuse of fertilizers, reduce the risk of crop failure and minimize the operating costs. Effective management of input resources like water, fertilizers and seed quality is the key to achieve this success. Many farms around the world - particularly those in developing countries are small, comprising of only a few acres. These smallholder farmers continue to follow conventional farming practices and often face the brunt of high crop losses, low yield, inferior quality of farm produce etc. Conventional methods like crop investigation and soil analyses are very time consuming. By using IoT and data based decisions and by predicting the implications of each and every decision, a farmer can reap high profits and use his field more efficiently. This is a means of assisting farmers in optimizing yield, minimizing input costs and reducing environmental impact on crop growth.

There has been a pressing need to provide real time farm information like soil moisture, temperature and Humidity. These are vital soil parameters that influence overall crop growth and in turn the farm produces. Monitoring of soil moisture in different areas of a farm can help in overall irrigation management. Different crops require different irrigation strategies and using real time data of soil moisture a farmer can increase yield by maintaining optimal soil moisture for a specific crop. For example, while waterlogging is threatening for the life of most of the crops, it is a must for paddy farms. Sometimes the standing water in paddy fields gets heated by sunlight and negatively affects crop growth. To avoid such situations, farmers drain off the warm water and refill their paddy fields with fresh water. Real time soil moisture and temperature monitoring can be used to alleviate some of these problems faced by farmers [1].

In this work, a device for remote monitoring of soil characteristics through smartphones and Sensor Robot is proposed. The proposed device is reliable, cost effective, power efficient, and works in real time. By means of Wi-Fi or Bluetooth communication, the sensor node sends data to Microcontroller and Microcontroller will send data to a nearby smartphone, where an application, BT Terminal, is used to view the soil characteristics. Soil sensor calibrations will show satisfactory results and the device can be used with reliability. This work makes an important contribution by proposing a reliable and feasible IoT based device for remotely monitoring soil characteristics and takes a step forward in the integration of IoT and agriculture to achieve the goal of smart agriculture.

A general trend found in the above mentioned studies was that electrical or electromagnetic sensors were used for measuring temperature, Humidity and moisture content of soil. However there has been an inability in implementing an inexpensive, precise and a real time sensor system for this purpose [1].

The contents of this paper are organized as follows. Section II deals with literature survey. It discusses the various previous implementations in soil characteristics measurements. Section III deals with proposed system It discusses the Microcontroller Unit (MCU), firmware flowchart, sensor design specifications and power supply, sensor calibration procedures details along with resulting calibration curves. Section IV describes the results of our work. In section V, we discuss future scope for research in the area of agricultural IoT. We present some specific domains within agricultural IoT that require more attention and have higher potential for further work. Section VI presents the conclusion of this work.

II. REVIEW OF RELATED LITERATURES

Soil Infiltration Rate as Another Parameter for Automated Irrigation System Based on the manual entitled “Irrigation Water Management: Training Manual No. 1 - Introduction to Irrigation”, water infiltration is the process in which the surface water infiltrates into the soil. While the infiltration rate is the velocity in which it can absorb water from rainfall or irrigation and it can be expressed in millimeters per hour. This can be used as an indicator to check the water absorption in a soil profile in a given span of time. In relation to irrigation systems, according to the article entitled “Maximizing Irrigation Efficiency and Water Conservation”, it stated that the one of the causes of surface ponding is applying water rate that exceeds the soil infiltration rate. Moreover [5].

The effects of soil temperatures between 15 and 30 °C on plant growth, nodulation and nitrogen fixation in seedlings of Casuarina cunninghamiana Miq. Inoculated with Frankia from two different sources were examined. The optimum soil temperature for the growth of plants dependent on symbiotic nitrogen fixation was 25 °C. Decreasing the soil temperature below 25 °C markedly decreased plant growth that was reliant on symbiotically fixed nitrogen; effects on the growth of plants supplied with mineral nitrogen were much smaller. At 15 °C there was no response in plant growth to inoculation after 148 d, whereas plants supplied with nitrogenous fertilizer were 10 times the weight of inoculated plants. Nodulation was delayed at 15 and 20 °C with nodules formed at 15°C fixing no nitrogen in these studies. The production of fewer nodules at 20 °C than at 25 °C was partly compensated by the production of larger nodules. Nodule growth at 20 to 30 °C was a prime determinant of nitrogen fixed, with the exception of one Frankia at 20°C.The amount of nitrogen-fixed g"^ nodule was the same for the two Frankia sources at 25 and 30 °C, differences in effectiveness being due to nodule development. However, differences in the effectiveness of the two Frankia sources at 20 °C were related to differences both in nodule development and in nitrogen-fixing ability. The absence of nitrogen fixation at 15 °C would be expected to limit the natural distribution of Casuarina species reliant on symbiotically fixed nitrogen to areas where soil temperatures exceed 15 °C for a major part of the potential growing season [2].

Obstacle detection (OD) techniques for collision avoidance applications in automobiles and unmanned aerial vehicles have been of research interest in the recent years. This technical idea is transferred to develop a local navigation system for the visually impaired individuals which are the focus of this paper. Several types of equipment and approaches namely sensors, Computer Vision (CV) methods, micro-controllers etc. are used for detecting obstacles in the path. To enable an utmost collision free mobility of the users we intend to use Ultrasonic (US) sensors and CV systems on a smartphone to detect and alarm the user of any obstacle in the path. In this paper, the accuracy of detection of 3 obstacles and estimating their distance from the user using US sensors is determined. Further, the quality of object detection techniques using two OD algorithms is tested on a PC for further application of the best performing algorithm in combination with the US sensors for our major goal of developing a local obstacle-free navigation system for the visually impaired using mobile devices like smartphones [6]

III. SYSTEM DESIGN

The objective to design the proposed system is to collect soil sample and measure its temperature and humidity remotely in real-time through smartphones. The block diagram of proposed system is shown in Fig. 1. The system is developed on Arduino UNO platform. It has three basic blocks viz. microcontroller block, sensing block, and communication block. Microcontroller is the heart of the device. It is responsible for controlling the sensing and communication blocks of the device and reading soil parameters such as moisture, temperature. It is also responsible for sending the data acquired from the sensors to a smart phone via Bluetooth or Wi-Fi. In the proposed device we have used Arduino UNO which is a Microcontroller unit (MCU) of the development boards. The MCU used in this work has an additional feature of low power consumption. This is implemented in the form of several power saving modes such as standby mode and sleep mode. When powered on, MCU initializes the peripherals to be used to control and manage the sensing and communication blocks of device. MCU takes samples from sensors one by one and also checks if the device is connected or not. If it is, it transfers data to mobile, otherwise takes another sample. We have also implemented hibernate mode in the device keeping in the mind the fact that the device has to be used in outdoor applications, which we have used the standby mode. In standby mode controller's use is minimized as it draws a current of about 0.1mA. The controller goes into standby mode for six hours after every one hour of data transmission. The sensing unit contains various agriculture sensors to measure moisture, and temperature of soil sample. These sensors are interfaced with a 10 bit ADC of MCU. DHT11 is used as soil temperature sensor, which is a digital sensor based on the Dallas's one wire protocol.

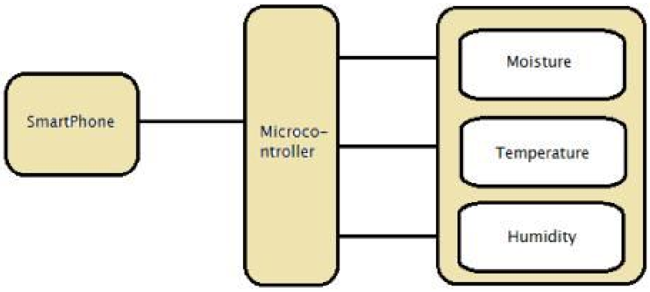

Fig 1. System Design

It codes temperature data using 12 bits, and thus provides a high level of accuracy. The soil moisture sensor is designed using the inverse relation between soil resistance and soil moisture.

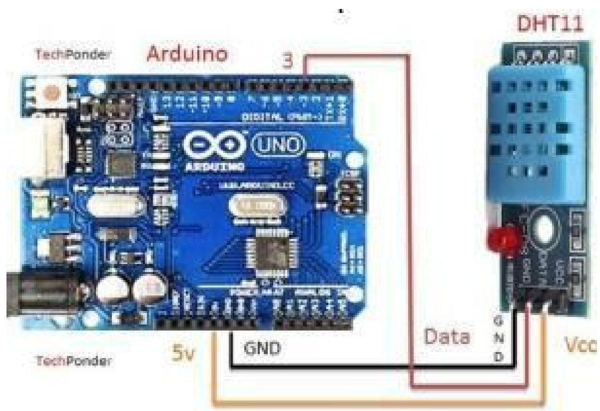

Fig 2. Temperature Sensor Connection Design

The Arduino Uno is a microcontroller board based on the ATmega328. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 Hz ceramic resonator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started. The Uno differs from all preceding boards in that it does not use the

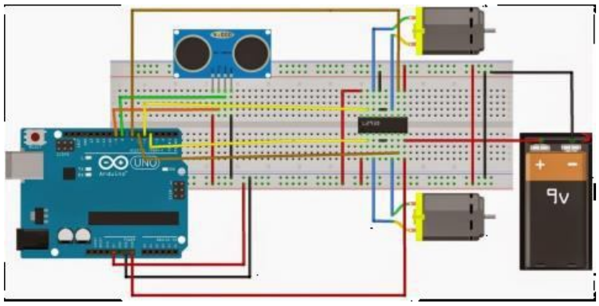

Fig 3. Motor shield Connection Design

FTDI USB-to-serial driver chip. Instead, it features the Atmega16U2 programmed as a USB-to-serial converter.

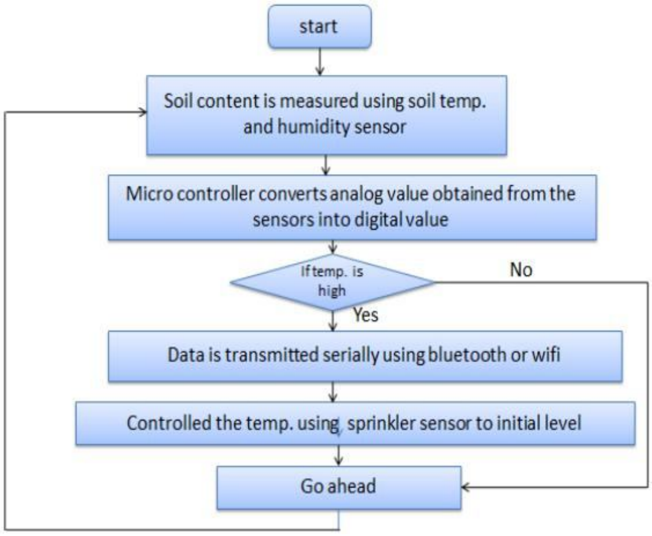

Fig 4. Data Flow Diagram

The proposed system works as follows. When powered on, MCU initializes the peripherals to be used to control and manage the sensing and communication blocks of device. MCU takes samples from sensors one by one and also checks if the device is connected or not. If it is, it transfers data to mobile, otherwise robot will go ahead and takes another sample. We have also implemented hibernate mode in the device keeping in the mind the fact that the device has to be used in outdoor applications [1].

The system is powered using two 1.5V AAA batteries. In the present prototype, these batteries can last up to 30 days, after which they are recharged and used again. In future, we intend to work on integrating solar power into the system to make it self-sufficient in terms of power usage [1].

The moisture sensor uses the principle of inverse relation between soil moisture and soil resistance. More the soil resistance, lesser its moisture content and vice versa. The soil moisture sensor was tested with various samples of completely dry, intermediate, and completely wet soils. The completely wet soils returned a voltage value ranging from 2.62 to 3.21 Volt, whereas the completely dry soils gave rise to a maximum of 0.4 Volt. Moderately wet soils returned a voltage reading in approximately a linear relationship with the degree of soil wetness. Using this trend, the calibration equation was formulated in Eqn. (1), where ADC_Value is simply the analog voltage read by the ADC –

Moisture Content = (ADC_Value/3.3)*100 (1)

Soil temperature sensor, DS18B20, is a commercially Available, digital, high precision, and water proof sensor. It uses 12 bits to encode soil temperature and so, even the slightest soil temperature variation can be detected accurately. For our application, there was no need to further calibrate the soil temperature sensor.

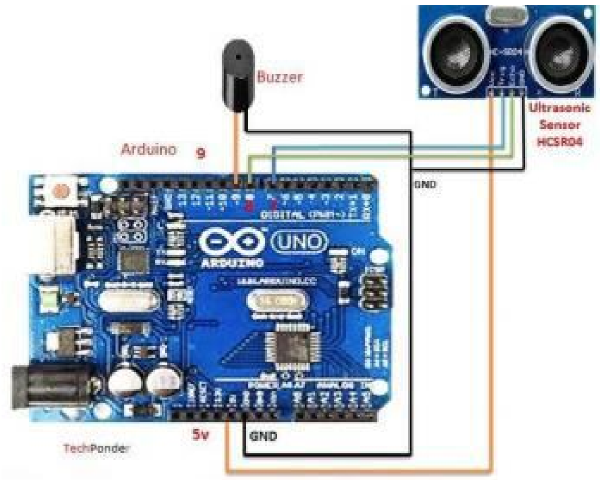

Fig 5. Ultrasonic Sensor Connection Design

The distance check algorithm enables us to infer on the accuracy of the distance estimation using US sensor. Findings show that the error rate using US sensors is quite low and is hence further usable for ground-level change detection considering the error rate for necessary calibration. The results of quality estimation experiments indicate that the Canny's algorithm performs better than the MOG algorithm in identifying the presence of objects in the image. Also the number of actual objects out of the total detected objects is higher using Canny's algorithm. The detection of absence of objects was however detected better by the MOG algorithm. But as far as safety of the user is concerned, alarming the user about presence of the object is crucial which is done better by the Canny's algorithm. This is further confirmed by the higher FNR values by MOG which indicates that false trigger was higher using MOG's algorithm. Thus Canny's algorithm is useful in our case where an OD algorithm ensuring safe identification of obstacle in the path of the user is a crucial requirement. However, further optimization of the algorithm is required to reduce the false positives. The Canny's algorithm also fulfills the requirement of a computationally inexpensive algorithm and hence its applicability on mobile devices needs to be further tested by comparing its run-time on a PC. It is seen that detection of objects using Canny's algorithm is approximately twice faster than MOG algorithm. Further, tests are required by running the OD test on smartphones. The findings of the experiments in this paper are used as the basis for further application of the best performing algorithm to build an OD system. In addition to this, the MOG algorithm which is a supervised detection technique is a potential candidate for building a classification and recognition system. This needs to be further tested and compared with the other state-of-the art classification techniques to determine the best performing technique [6].

IV. RESULT OF WORK

While discussion found that system could have advantages and disadvantages as Irrigation system to maintain temperature, Less human interaction, Remote Monitoring, Automated Design,

High profit and efficient. Disadvantages would be Robot maintenance, Power usage.

V. FUTURE SCOPE

As technology advances, so does the requirement for food, which is directly related with the increasing population. There is an immense potential in the agricultural domain for the application of emerging technologies such as IoT, cloud computing, robotics, GIS and remote sensing, among others. Here, we list some specific areas, which are among the most important ones for further research work relating to ICT in agriculture. The findings of the US sensor precision is further used for detecting objects in the path as well as to detect the change in the ground level. The best performing OD technique would be further used for building an optimized OD system which is a part of our current work. Further, building an object classification and recognition system is also a part of our future work using the presented technical idea to develop a navigation system for the visually impaired

VI. CONCLUSION

In this work, an IoT based system for soil Temperature, and moisture measurement has been presented. Sensor designs for Temperature and moisture have been successfully studied. The system has been developed on Arduino UNO board, with Bluetooth or WI-FI being used for communication with farmer's smartphone. Further work is underway for integrating WPAN for networking.

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