A remotely operated Soil Monitoring System: An Internet of Things (IoT) Application

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Abstract— The main objective of this paper is to develop a remote soil monitoring system for an agricultural environment. The monitoring of soil parameters like moisture, temperature and the pH of irrigation water form an important factor in determining the agricultural output assessment. Efficient monitoring of these parameters ensures high and stable agricultural output. This paper investigates a remote soil monitoring system using Arduino and the GSM network. The sensors attached to the Arduino acquires the parameter data for the above and then sends it to the client mobile through an SMS via a GSM network. Primarily, the stored data will provide the repository of soil data for further analysis of the health of the soil for a particular region and finally it will provide the health of the soil for the whole country.

Index Terms— Arduino, GSM, IoT, MODEM, Sensors, SMS.

I. INTRODUCTION

IN today's world of technological advances the use of manual methods to monitor various parameters is becoming a thing of the past. The various cellular, online and Wi-Fi networks are being used to monitor various parameters which affect the day to day life of humans. With the advance of network connectivity a new form of technology emerged named the Internet of Things. The internet of things is a recent technological development that visualizes a near future in which objects of everyday life will be equipped with microcontrollers, sensors, transmitters, receivers for digital communication and with suitable protocol stacks that will make them be able to communicate with one another and with users thus making them an integral part of the internet [1]. The 'things' in the internet of things may refer to simple everyday objects like watches, sensors etc. The Internet of Things (IoT) basically connects living and non-living things through the internet. IoT allows people and things to be connected anytime and at any place via any path, network or service [2]. This paper proposes a system to monitor the parameters of soil such as temperature, moisture and acidity which play an important part role for smart cultivation and monitoring of these parameters is important to get a high and efficient agricultural output. It deals with the continuous monitoring of the above-mentioned parameters by using three different sensors namely soil moisture sensor, soil temperature sensor and a pH sensor with the help of an Arduino microcontroller. The input of the sensors are collected and processed by Arduino microcontroller to achieve the moisture, temperature and pH content in the soil. The above data are sent to a remotely located CPU/ mobile phone/iPad through a GSM modem. . It is used for continuous monitoring of soil parameters and analyze them to improve the stable and efficient crop production. The technology is used for the above system is a modern technology which involves smart sensing and Internet of Things (IoT) where GSM-SMS mode of communication is used. The SMS mode is used as it is the most frequently used and widely available real time communication mode with low data requirement which is important for rural areas in a country like India with limited 3G or 4G connectivity [3].

II. SYSTEM ARCHITECTURE

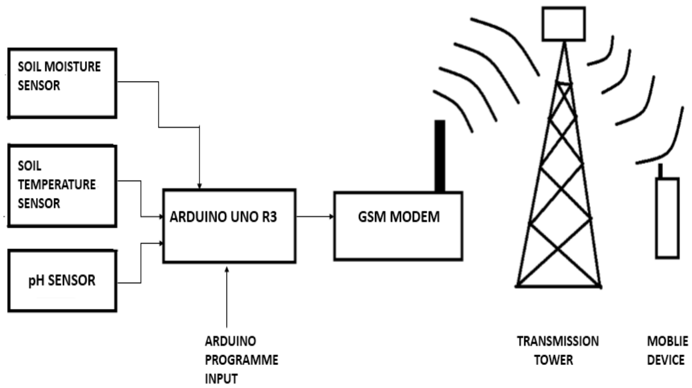

Figure 1: Block Diagram of Remote Soil Monitoring System

As shown in figure 1 the system comprises of three sensors whose data is collected by the Arduino. The Arduino sends the collected data to the GSM modem and the GSM modem sends the data to the mobile phone of the user via the GSM network using a SIM card. The system can operate autonomously once the connections have been made and the program has been uploaded to the Arduino. This system requires no manual input during operation so it can be used in remote areas where manual monitoring of soil and irrigation water parameters are not possible. The program of the system runs in an infinite loop so it continuously feeds the data collected to the mobile phone of the person who will monitor the irrigation system.

A. ARDUINO UNO

The Arduino Uno is a microcontroller board based on the ATmega328P microcontroller. It has 14 digital input/output pins, 6 analog inputs, a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It is powered by simply connecting it to a 7 to 12 Volt DC supply. Each of the 14 digital pins on the Uno can be used as an input or output. By default they measure from ground to 5 volts. This makes the Arduino suitable for small scale senor applications. The Arduino software includes a serial monitor which allows simple textual data to be sent to and from the Arduino board. The ability of the Arduino to communicate with other devices and send data makes it the ideal device to be used in this system as the Arduino can send the data collected from the sensors to the GSM modem via the RX and TX pins. The Arduino Uno is programmed by using the Arduino software (IDE) [4]. The Arduino is used in a wide range of applications, as it is durable requires low power supply so it is ideal for use in remote sensing applications.

B. SOIL MOISTURE SENSOR

The soil moisture sensor uses a LM393 comparator to estimate the amount of moisture (content) present in the soil. It shows a high output level in moisture deficit soils and a low output level in high moisture content soils. The operating voltage is ideally 5 volts for the sensor. It has both the digital and analog output modes the LM393 comparator chip board has a potentiometer for calibration. In the analog mode the initial output is divided in to 1024 bits which are then converted by the program to give a relative moisture percentage of the soil. It has a 4 wire output interfacing. The output corresponding to maximum moisture is 0 and the output corresponding to minimum moisture is 1023. The Arduino program converts this output to a relative moisture percentage by using the reference of 0 output as the 100% moisture and 1023 output as 0% moisture.

The following formula is used:

m= sensorValue / 1023.0

Relative moisture percentage = (1 – m) * 100 (1)

Where 'sensorValue' is the output of the moisture sensor.

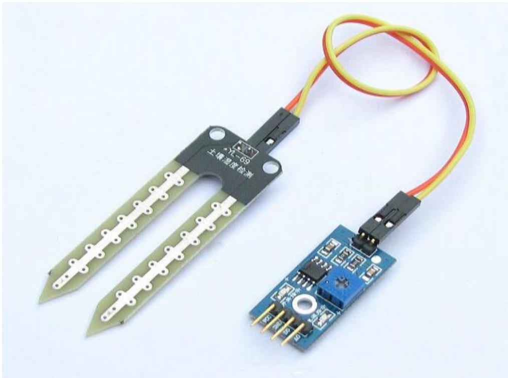

Figure 2: Soil Moisture Sensor (with LM 393 Comparator)

C. SOIL TEMPERARURE SENSOR

The temperature sensor is a one wire sensor that uses a 4.7 kΩ pull up resistor to give the output. It is a waterproof sensor and it can be operated either with a 5 volt external supply or in the parasite mode without a local external power supply. The DS18b20 communicates over a 1-Wire bus, which by definition requires only one data line (and ground) for communication with a central microprocessor. It has an operating temperature range of –55°C to +125°C and is accurate to ±0.5°C over a range of –10°C to +85°C [5]. The sensor requires the one-wire header file to be included in the Arduino program while being used in the circuit.

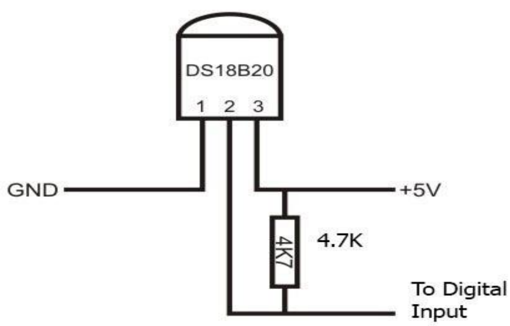

Figure 3: Connection diagram for the temperature sensor

D. pH SENSOR

The pH sensor is used to measure the pH of the water used in irrigating the fields. The sensor consists of a connecting probe and a sensor shield used for the interfacing of the probe to the Arduino board. The sensor gives a pH value in the range of 0-14. The ideal measurement range for the probe is between pH 3 to 10. The values of pH below 2 or above 12 are impossible to determine using this probe due to its limitations, but the pH range required for measurement in the module never goes in to the too acidic or too basic range so the limitations do not cause a hindrance in the system as they fall out of the range of measurement required. The pH electrode has a single cylinder that allows direct connection to the input terminal of a pH meter, controller or any pH device that has a BNC (Bayonet Neill–Concelman) input terminal. The pH sensor shield forms an interfacing device between the probe and the Arduino board. It contains the calibration potentiometers and also the output interfacing links. The sensor shield needed calibration which is done with the help of the potentiometer present in the shield. Then, the pH output voltage of the sensor shield is converted to its true pH value by the Arduino program using the formula:

Voltage = 5 / 1024.0 * measure;

Po (output) = 7 + ((2.5 - voltage) / 0.18) (2)

Where ‘measure’ is the output voltage of the pH sensor. [6]

Figure 4: The pH Sensor (with probe and shield)

E. GSM MODEM (SIM 900A)

The GSM MODEM is used to send/ receive messages and make/receive calls just like a mobile phone by using a SIM card by a network provider. This is done by plugging the GSM shield into the Arduino board and then plugging in a SIM card from an operator that offers GPRS coverage. The SIM900A delivers GSM/GPRS 900/1800MHz performance for voice, SMS, Data, and Fax in a small form factor and with low power consumption. The communication can be done easily with the shield using the AT commands. The GSM library contains many methods of communication with the shield. This version of the board makes the connection of the shield with the Arduino Uno board by connecting its TX to digital pin 0 (RX) of Arduino and digital pin 1 (TX) of Arduino to RX of shield.

Figure 5: GSM Modem (SIM 900A)

III. WORKING

The Arduino formed the central processing unit of the system all the sensors and the GSM MODEM were connected to the Arduino. The program was loaded to the Arduino via the USB cord. The connection of the GSM modem to the Arduino was done after the program had been completely uploaded to the Arduino board as otherwise there would be an error in compilation of the program. The GSM modem was powered via a 12 Volt source and a simple 2G sim card was used for communication. A bread-board was used in the module to simplify the connections and also to connect the 4.7 kΩ pick up resistor for the soil temperature sensor.

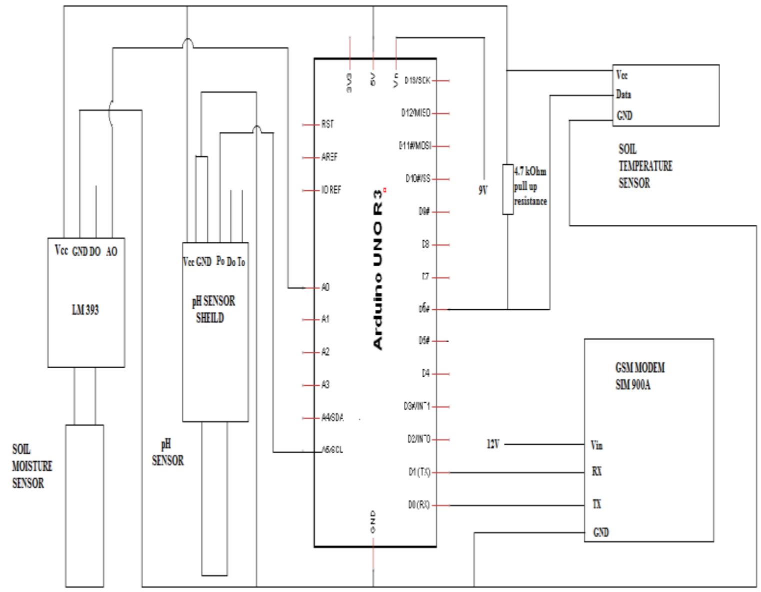

Figure 6: The circuit diagram for the system

The connections were done as shown in the figure 6. The calibration of the pH sensor was done by removing the probe and then making a short circuit between the small BNC hole and the External part of the BNC. During the calibration the power supply was to the sensor was kept on and a voltmeter was connected between the ground and the pH output pin (Po). The blue potentiometer close to the BNC plug was adjusted so that a pH of 7 (under the shorted condition pH automatically becomes 7) gave a voltage of 2.5 volt. Then the formula as mentioned in equation (2) was used to determine the correct pH value.

The Arduino programming language is java, C/C++ all of which are advanced computer languages. The header files for the various sensors were included in the beginning of the program.

The program logic can be defined in the following steps:

- The program begins by initializing the pins and by including the library files for the sensors.
- Then set baud rate was set and the sensor values were read and they were converted into their required parameter forms.
- The GSM modem was activated to the SMS mode and the mobile number and the sensor values were sent to it.
- The infinite loop was run with a delay set by calculating the Arduino clock frequency.

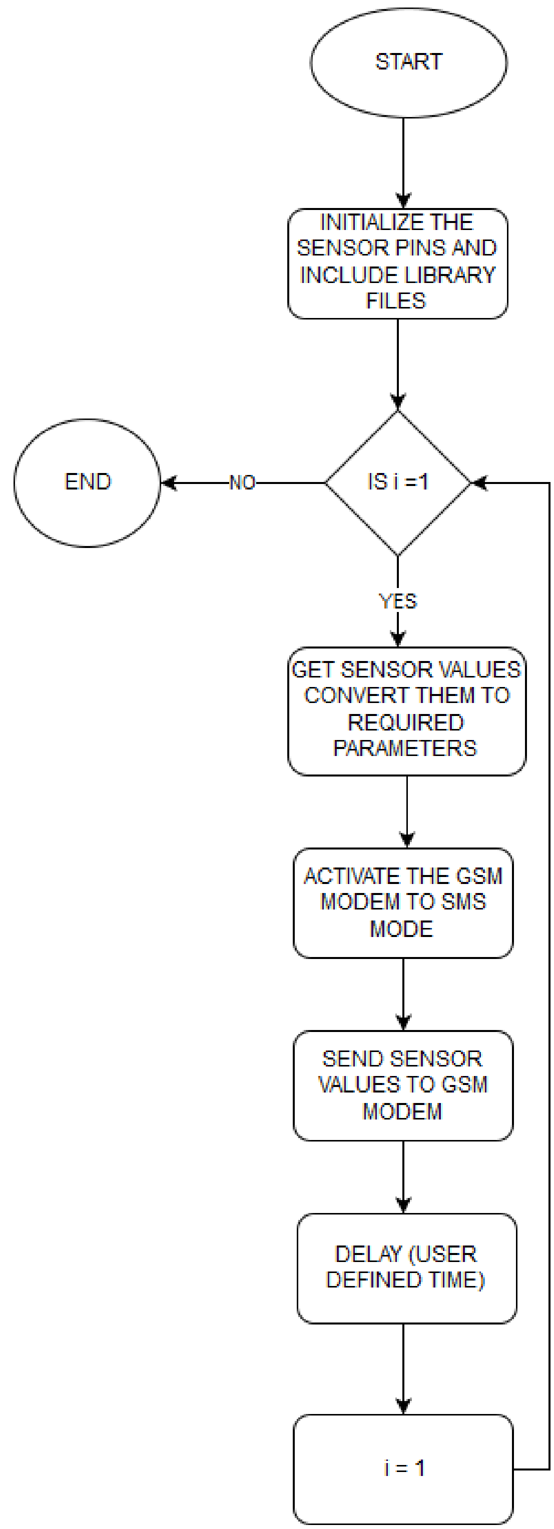

Figure 7: Flow diagram for the Arduino program

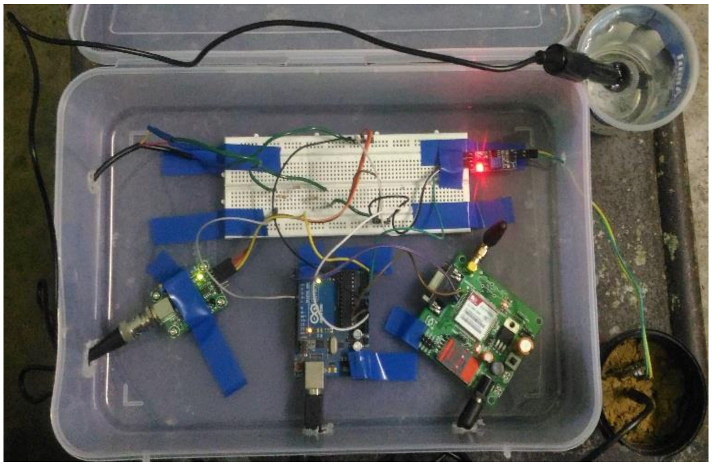

Figure 8: Model set up of the system

IV. RESULTS

The following data were obtained for a soil sample which was tested for three days during the month of May 2016 at NIT Durgapur. The soil sample tested was coarse in texture and there was scattered rainfall over the course of those three days.

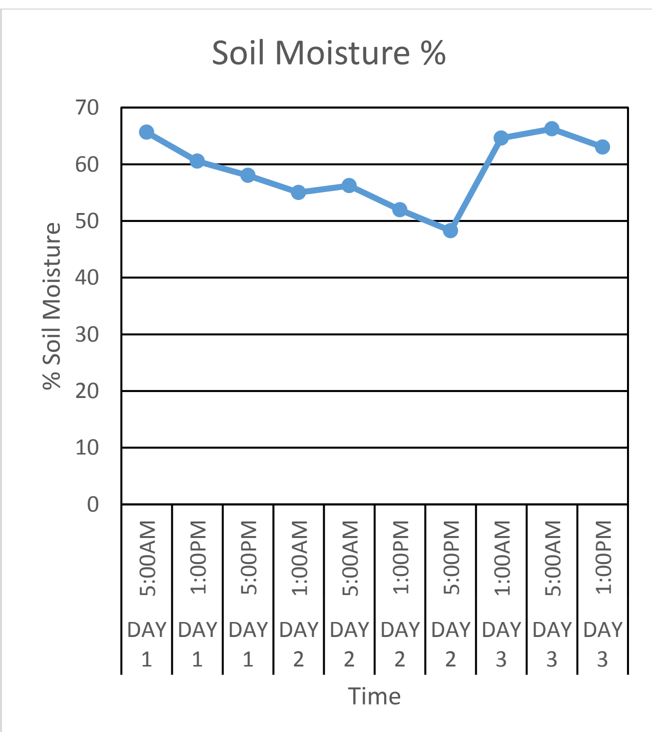

Figure 9: Graph showing the soil moisture %

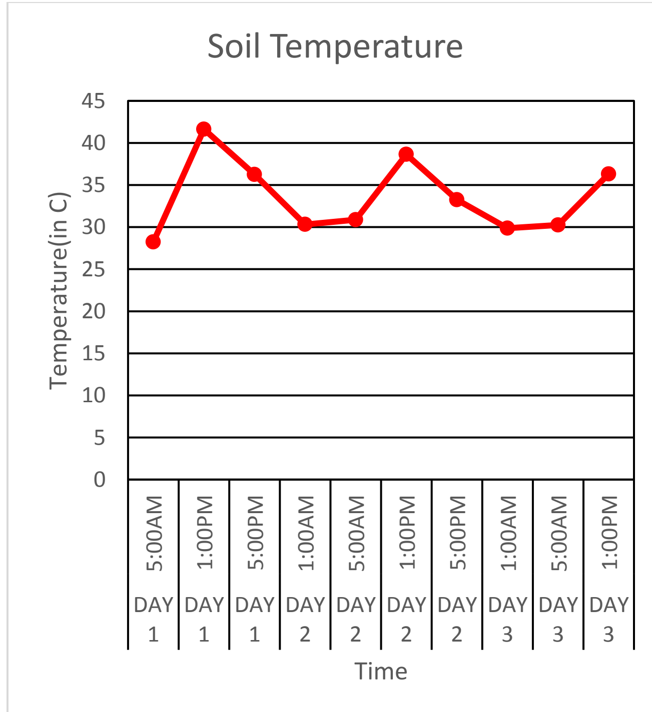

Figure 10: Graph showing soil temperature

As seen from the results the soil moisture varies to a wide extent in soils and that it directly depends upon the amount of rainfall or irrigation. The temperature varies widely too and reaches its peak during afternoon.

V. CONCLUSION AND FUTURE PROSPECTS

The soil moisture and temperature both show wide variations during the course of a day. As both of them are important factors that determine the agricultural output so remote monitoring system such as the one demonstrated in this paper are of great importance in improving agriculture and irrigation. The system is automated and can operate independently once the program has been loaded to the Arduino. It is very useful for monitoring of soil in remote areas as it uses a GSM network to transmit data this ensures it can send data over a wide distance by consuming less amount of power.

The prototype developed is in its nascent stage and thus there is a huge scope of improvement. The following points may be taken into account while developing the system further:

- The system can be upgraded by using better sensors to improve the quality of readings of the parameters.
- The system can be improved to provide better protection to the sensors as they may be used during harsh weather conditions.
- Provision for storing the readings from the sensor can be provided.
- Monitoring of the other aspects of soil like certain mineral content can also be developed to improve the usefulness of the system.

VI. References

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