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Design and Development of IoT based soil moisture sensing system

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Abstract:

The growth and its yield of the crops depend on the factors like Soil Moisture, Humidity, Temperature, etc. In the agriculture field, soil moisture is a vital parameter for the growth of the plant. Continuous monitoring and maintaining the required level of the soil moisture in the field leads to an increase in agricultural productivity. Internet of Things (IoT) is a modern technology, which is used widely in various fields like Military, Industries, domestic, education, medical care, and agricultural fields. In this proposed system, IoT technology is used for continuous monitoring of soil moisture levels in the agricultural field. The user can easily get real-time data through their Mobile phones. Based on the data collection, the irrigation schedule can be planned. The proposed system is compact, easy to handle, portable, Robustness, access anywhere to get data and economically benefited. The design and construction of the proposed system are done by using components like Microcontroller, Moisture sensors, LCD (Liquid Crystal Display), GPS (Global Positioning System), and mobile app.

Index Terms **– Soil Moisture, GPS, IoT, Continuous monitoring.**

I. INTRODUCTION

Agriculture contributes about 17-18% to India's GDP and to increase agricultural productivity by adapting the latest technologies of artificial intelligence, machine learning, IoT and IT technologies [1]. The soil is the primitive component of any types of agricultural activities. The root of the crops absorbs the various nutrients; water (moisture), mineral matters, etc. are taken from the soil. The depth of soil profile which is important for plant growth is 100-200 cm. Some crop root length is 120cm. The soil contains various minerals and organic matter, air, water, moisture, nutrients, pollutants, Ph, thermal conductivity, temperature, electrical conductivity, color, texture, structure, and bulk density. The soil moisture can influence the properties and soil moisture distributions. Some of the properties are Soil Texture, soil structure, bulk density, soil color, thermal conductivity and electrical conductivity. The soil water content and soil water potential are types of soil moisture contents. The weight of the soil remains the same when the soil can be heated between 100-110 degrees Celsius meanwhile the soil content water is evaporated from the soil.

In agriculture, soil moisture is a primary factor to support plant growth in farm productivity. If the plant area has less moisture can result in yield loss and plant death. High moisture it causes root disease, the continuous monitoring of soil moisture for long duration crops is a challenging task. To maintain the required level of soil moisture, the field needs proper water irrigation. Soil moisture sensing system is used to help irrigators to identify and maintain the required moisture level.

The existing system, the moisture level was identified by Manual work through the dipping of sensors in the Agricultural field. If the farmer needs to identify the entire field moisture level, it is a tedious task for dipping the sensor in various places to acquire the data. The proposed system has the GPS mechanism is used to get the temporal and spatial data regarding a particular location where soil moisture is measured by the proposed system. To overcome the existing system drawback, the proposed system is introduced. The main advantages of the proposed system are continuous monitoring and recording of soil moisture. Based on this result, the farmers can manage the schedule of Irrigation system. The measured value of soil moisture can be access anywhere through the IoT system.

1.1 Measurement of soil moisture content and its methods

Various methods are used to measure soil moisture content. There are Gravimetric method, Neutron scattering method, Gamma attenuation method, TDR, Frequency Domain Reflectometry (FDR), Time-Domain Reflectometry (TDR), Resistive Sensor (Gypsum), Hygrometric techniques[1-2]

1.2 Determination of Moisture Content

The oven-drying method and sand bath method are used to measure the soil moisture contents. In the oven drying method is a definitive method whereas the sand bath method is used when oven drying is not possible. The moisture content of a soil sample is defined as the mass of water in the sample expressed as a percentage of the dry mass, usually heating at 105°C, i.e. moisture content, w = MW/MD x 100 (%), where MW is the Mass of water and MD is the dry mass of a sample. The result can be calculated by using formula of Moisture content, w = (Mass of moisture / Mass of dry soil) x 100% whereas m1 = mass of container; m 2 = mass of container + wet soil; m3 = mass of container + dry soil; m4 = mass of container +dry soil i.e. w =((m 2 - m3)/ (m3 - m1)) x 100 %.

1.3 Soil Moisture Sensor Module

The soil moisture sensor (YL-69) module consists of two large exposed pads function as probes for the sensor, together acting as a variable resistor which is shown in figure 1. The conductivity between the pads will determine the water contents in the soil. If more water content in the soil, the resistance of the sensor becomes low and it increases the conductivity between the pads. The sensor operating voltage is 3.3 to 5 Volts and it contains red and green light indicators for power and digital switch output. It is compatible with various single-chip microcontrollers.

1.4. Arduino Uno

Arduino Uno is a microcontroller board based on the ATmega328P. It is shown in Figure 2. It has 14 digital I/O's, 6 Analog I/O's, 16 MHz ceramic resonator, USB connection and various peripherals. Arduino Software (IDE) is used for coding. It contains various examples with libraries and built-in sketches.

1.5. GPS Receiver Module

Global Positioning System (GPS) receiver is used for tracking or finding the location and it is shown in Figure 3. GPS is the satellite-based system that uses satellites and ground stations to measure and compute its position on Earth. It is also known as Navigation System with Time and Ranging (NAVSTAR) GPS. The radiofrequency of GPS is 1.1 GHz to 1.5 GHz to receive signal and it can compute position and time of particular location. The GPS module gives a standard output of the National Marine Electronics Association (NMEA) string format with a default 9600 Baud rate of Tx pin serial output. The GPS operating power supply in the range of 3.3 V to 6 V, It contains 4 pins are Vcc, GND, Tx (Transmit data serially) and Rx (Receive data serially).

1.6 ESP8266 Wi-Fi module

The ESP8266 is a Wi-Fi module great for IoT and Home Automation projects. The ESP8266 WiFi Module is a self-contained SOC with integrated TCP/IP protocol stack that can give any microcontroller access to WiFi network. It can control I/O's with the help of Arduino Microcontroller. The ESP8266 12-E chip comes with 17- General Purpose Input and Output (GPIO) pins. 17- GPIOs, SPI, I2C (configure in software), I2S interfaces with DMA, UART and 10-bit ADC are peripherals of the ESP 8266 module. It is the most popular IO device and shown in Figure 4.

Figure 1: soil moisture sensor (YL-69)

Figure 2: Arduino UNO Microcontroller

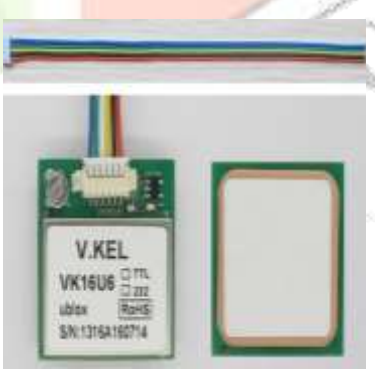

Figure 3: GPS Module

Figure 4: ESP8266 WiFi Module

Figure 5: ThingSpeak with data analyses

II. LITERATURE REVIEW

An IOT based Agriculture Monitoring System is automated the entire agricultural field using Raspberry Pi, Pi camera, motor driver, Temperature sensors, water level sensors and Humidity sensor. The entire system is controlled by ZigBee wireless technology [3]. The greenhouse monitoring system is automated using an IoT-based greenhouse monitoring system with Micaz motes. This system measures the vital parameters of light, temperature, pressure and humidity of greenhouse using wireless sensors network and IoT [4]. Construction of soil moisture and irrigation IoT monitoring system is implementing automatic irrigation and monitoring the soil moisture, temperature and humidity of the environment using IoT. Field Monitoring and Automation using IOT in Agriculture Domain system is consists of KM –Knowledgebase and monitoring models of e-Agriculture applications. This system implemented the monitoring module using TI CC3200 Launchpad interconnected sensors modules with other necessary electronic devices and the Arduino UNO board [4]. Field Monitoring using IoT in the Agriculture system is designed as the preventive measure of crop losses and increases the productivity of crops. This system is developed using various sensors to measure and monitoring vital parameters of Soil moisture, Temperature and Humidity [5]. IoT Based Monitoring System in the Smart Agriculture system is designed using the CC3200 module consists of Microcontroller, Network Processor (NWP) and Wi-Fi. The vital parameters are transmitted through GPRS wireless system to humans with mobile [6]. The soil contains various minerals and micronutrients like zinc, calcium, copper, lead, etc. The plant growth depends on the required amount of fertilizers are applied in the field. The major fertilizers are Nitrogen (N), Potassium (P) and Sodium (K). The defiance of any one of NPK causes the yield loss of crop. So the testing of NPK is important for agriculture. It is a time-consuming task for testing N, P and K individually and also required laboratories for testing of soil. The farmers cannot test the soil contents individually using sensors for measuring N, P and K. So an automated low-cost IoT based Fertilizer system was proposed to test the single sensor can do measure the N, P and K value and sent to formers using IoT in the regular intervals. This system also implemented the fuzzy logic and mamdani interference procedure to drive the conclusion about the efficiency N, P and K. This system is implemented using the NPK sensor by incorporating the colorimetric principle using Light Emitting Diode (LED) and Light Dependent Resistor (LDR). Development of fuzzy logic, embedded system and Raspberry pi 3 using python are incorporated to analyses the proportions of N, P and K [7]. The continuous monitoring of Soil moisture, Soil temperature, air temperature, Ultraviolet (UV) light radiation and relative humidity of ground and environmental sensing of crops are required for precise agriculture systems. The system was developed with a smart algorithm with various sensors that are wirelessly collected over the cloud using web service and a web-based visualization and to realize the autonomous irrigation system [8]. The demand and production of agriculture is a wide gap. Reduce the demand and supply gap by adapting the latest technologies of intelligence robot and IoT. The Robust weed detection technique was developed to eliminate the health risk of herbicide and the laborious task of manual weeding methods. This system contains an authentic-time robot that can distinguish the crop and classification of the weed plant. The detection of weed plants is implemented by a deep neural network of the convolutional neural network (CNN) algorithm and this system also delivers 90% accuracy. The weed detection system was developed by Raspberri Pi microcontroller, Pi camera, DC motors, Sprayer and data server[9]. IoT is also implemented for optimal future management of crop growth using hardware, web application, and mobile application [10]. Agriculture is enhanced with a solar-based smart farm irrigation system in which farmers were facing acute water scarcity and power shortage. The solar-based smart system with IoT and Labview software is evolving, distributed solar energy resources can be operated, monitored and controlled remotely [11]. Smart Farming is making cost-efficient for farmers and reduces crop wastage [12]. The embedded system designed by using LPC2148 microcontroller to overcome limitations of agriculture farming to control the drip irrigation. This system is implemented using RFID, motor pumps and Soil moisture sensors for indicating the soil condition status where the soil is wet or dry [13].

III. METHODOLOGY

The Soil Moisture Sensors yield the real-time data in the form of analog. The conversion of Analog to Digital (A/D) and data conditions are done by using Aurdino Uno Microcontroller. The Microcontroller is used for the acquisition of real-time soil moisture by using a soil moisture sensor. The Arduino Integrated Development Environment (IDE) is a cross-platform application is supported high-level programming languages C and C++. The IDE makes easy to write code and upload the source program to the board. It contains Libraries and cores. The GPS and GSM are connected to the microcontroller by using AT command to receive the location of measured data and it can send SMS through the smart mobile. The samples are measured from Low moisture to High moisture contents of the soil. The farmer can get the processed data through their mobile app with the help of Wireless Fidelity (Wi-Fi) Technology. The App designed to store the data for further study and farmers can easily make the decision regarding the irrigation schedule. This system can give real-time data of soil moisture along with GPS data. Block diagram of the proposed system is shown in Figure 6. The Soil moisture system is connected to ThingSpeak software. It is act as an interface between the Soil moisture system and the GUI interface to visualize and analyze real-time data streams in the cloud with the help of Wi-Fi. It is also an IoT analytics platform service.

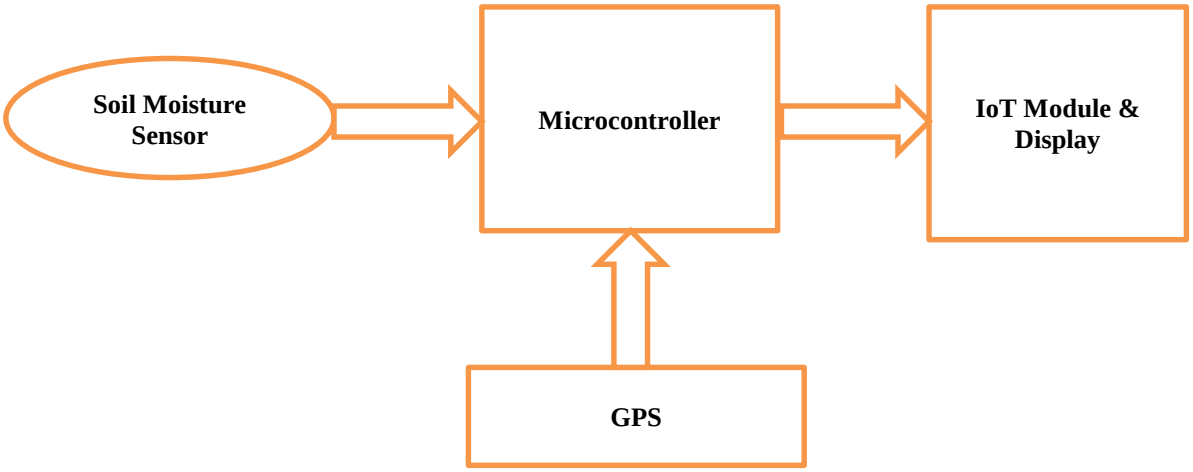

Figure 6: IoT Based Soil Moisture Sensing System

IV. RESULTS AND DISCUSSION

The data presentation of the system describes the performance and execution of the soil moisture measuring methods. The results were carried out using several samples ranged from the low-level moisture to high-level moisture of a soil sample. The proposed system was able to produce the accurate soil moisture data along with the location of the samples using Global Positioning System (GPS) and their result was displayed in the smart mobile with the help of IoT technologies was shown in Figure 7. The working model of the proposed system is shown in Figure 8 & 9. The soil moisture sensor is dipped into the sample soil and displays the soil moisture = 4% i.e. low moisture content in the soil. The display message of result has shown that the soil moisture is 94% delivers the high soil moisture content in the test sample of soil along with GPS location. Another part of the result also shows 73% of soil moisture in the test sample of moderate level of moisture along with date and time details for further reference. By using the GPS, the farmer can easily get the soil moisture level of each part in the wide agricultural field. So that, farmer can maintains the required level of irrigation for crops in the entire agriculture field.

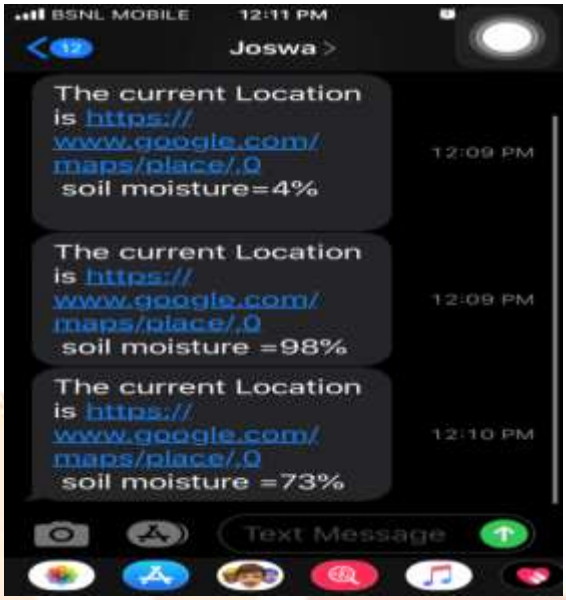

Figure 7: GPS location & Soil moisture contents of samples are displayed in Smart mobile

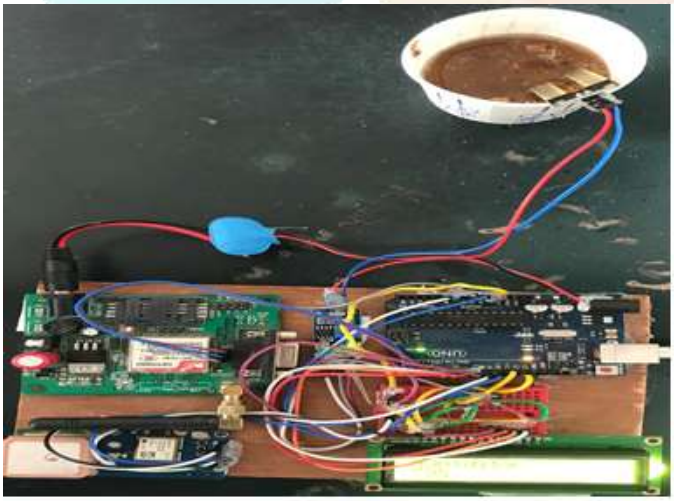

Figure 8:Wet soil moisture measurement of the Proposed system

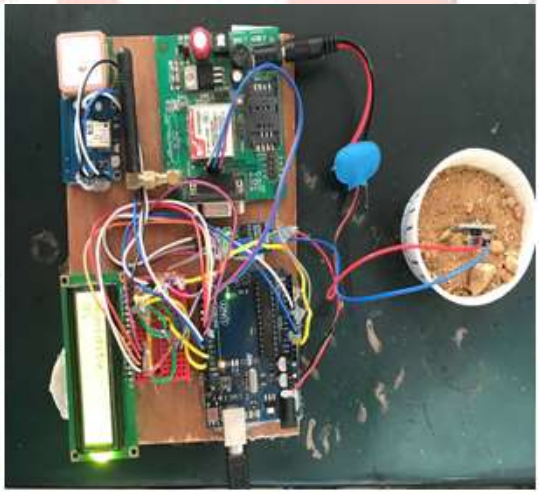

Figure 9: Dry soil moisture measurement of the proposed system

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