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A Highly Reliable Soil Moisture Monitoring System for Smart Farming Applications

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Abstract—

Soil humidity is the one of the most important factor for the plant growth. So, the measurement of soil humidity will plays a major role in smart Farming applications. Since soil humidity sensors are applied wet underground and the sensor consists of copper, the rust eats away the copper surface of sensors. Because of which, the sensors won't give you the accurate values. It makes the entire system, to be not reliable. In this paper, we proposed a new type of soil humidity sensor in order to measure the soil humidity values, much accurately and also the proposed sensor will have more life, as it was rust proof. We developed a smart farming system by which we can monitor the soil moisture data through cloud services and it also controls the water pump as per the moisture level present in the field. We compared the System results with existing (resistive) soil moisture Sensor and the proposed (capacitive) soil moisture Sensor. We used raspberry pi as main processing unit to read the sensor data and pushes in to thecloud.

Keywords—Smart Farming; soil moisture; IOT; Resistive Soil Moisture Sensor; Capacitive Soil Moisture Sensor;

INTRODUCTION

With the world's population growing daily, smart farming has become the need of the hour. But a noticeable contrast exists between the idea of smart farming and the actual implementation of it. The smart farm is a kind of farm automation system based on IoT technology. IoT, when applied to agriculture, is the most productive form of a technological revolution we'll see. The use of sensors, cameras and other connected devices can turn every element and action involved in farming into data from which data engineers can pull insights about a specific farm through software algorithms. This includes data on weather conditions, plant health, crop health, mineral level, chemical applications, pest presence and many more. Among the various information of smart farm, soil humidity is the most significant for plant growth and productivity. A soil humidity sensor is vulnerable to moisture because its tips are copper which is easily corroded from soil and moisture. We found out this problem while developing a smart farm system.

To solve this problem, lot of research was happened, few researchers proposed a new type of soil humidity sensor which is last long and cheap with replaceable tips, which uses Korean chopsticks as tips with variable resistance. Even then the values what we are getting from the soil are not that much accurate.

We found a part where abnormal soil moisture values are collected during the process of developing a smart farm system. Abnormal soil moisture data values are from corrosion of the soil moisture sensor. In order to check the corrosion speed of legacy soil humidity sensors, we tested the corrosion of legacy sensors. As a result, corrosion occurred rapidly in the working environment with voltage to measure soil humidity, as shown in Fig. 1. Corrosion occurred in both underwater environments and wet soil environments.

These corroded sensors measured unstable data, making the smart farm data unreliable. This means that the conventional soil moisture sensor can no longer be stably used for a long time.

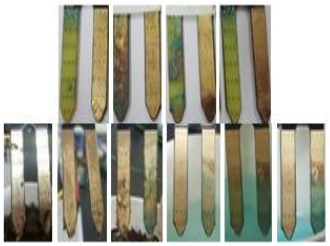


Fig. 1. Corrosive condition of legary soil humidity sensors. First row pictures are 2 months past. The first three pictures of second row are 5 days, 10 days and 20 days past under humid soil. The last three pictures are 5 days, 10 days and 20 days past under water.

To solve this problem, it is possible to coat the tip portion of the sensor with a material not corroded or to use a material which does not cause corrosion. In the case of the coating method, since only electrons smaller than the molecules of water can be transferred, the sensor to be coated has lower sensitivity. From past research [1] the researchers investigated materials that are resistant to corrosion but can be obtained easily and inexpensively in the surroundings. a result, Korean steel chopsticks, vacuum chopsticks, stainless steel rod were selected as a candidate group and it was confirmed whether it could be used at the tip of the sensor. Korean chopsticks are made of compound metal and can be easily obtained at a price within 1 dollar. Furthermore, spoons and forks of similar material can be substituted. Based on this, they proposed a soil moisture sensor with Korean chopsticks with a variable resistance driven by software. After replacing the tips, install the sensor in the underwater environment and design to fix and fix the appropriate resistance of the new tips via resistance setting. The minimum resistance value that stably maintains the value of 750 or more underwater environments is set to the sensor.

But, the problem hasn't been solved yet, because the Korean chopsticks which they used to measure soil moisture are not coated with any rust-proof material, therefore , even though they solved the problem temporarily but its not the permanent solution because they might also effected to rust, if we use them over a specific time. So, we further investigated the problem, we proposed a new sensor which can be used in underwater, underground and it is also rust proof coated.

Types of MoistureSensors

While studying the different types of moisture sensors, we found different advantages and disadvantages of them.

a. Volumetric sensors.

b. Tensiometers.

c. Solid state sensors.

a. Volumetric sensors

Volumetric soil moisture sensors directly measure the amount of water in the soil. This category has the most sensor types: neutron moisture probes, heat dissipation sensors, and the common, di-electric sensors.

Fig 2. Decagon ECH2O 5TM FDR Sensor

Fig 3. Gro Point Pro TDT Sensor

Advantages:

These are incredibly accurate and provide instant data to growers. They are commonly used in research settings and in high-value crops where speed and accuracy justify the higher equipment cost.

Drawbacks:

Due to the technology used, volumetric sensors are the most expensive soil moisture sensors to purchase ($100+ per sensor, $400–1200 for an electronic reader). When installing them in fields they also require calibration to the individual soil type, making installation more cumbersome.

b. Tensio meters

Fig 4. Irrometer SR Tensiometer

Advantages:

Soil particles hold water through either tension or adhesion. Tensiometers are soil moisture sensors that measure this tension between soil particles and water molecules.

Drawbacks:

tensiometers are relatively little expensive equipment (sensors cost about $80–160 per unit1) to incorporate into your irrigation system.

Solid state sensors

These will works by using two electrodes to measure the electrical resistance in the soil. More water in the soil will reduce electrical resistance because the electrical current can pass through the water easier; less water will increase the resistance.

Fig 5. Solid State Moisture Sensor

Proposed Moisture Sensor

Fig 6. Proposed Moisture Sensor

Operation:

The sensor measures the soil moisture levels by capacitive sensing, rather than resistive sensing like other types of moisture sensor. The ability to prevent corrosion is because it is made of a corrosion resistant material giving it a long service life The sensort also includes an on-board voltage regulator which gives it an operating voltage range of 3.3 ~ 5.5V. It is compatible with low-voltage MCUs (both 3.3V and 5V logic). To make it compatible with a Raspberry Pi, an ADC converter is required.

Table 1 comparison between Resistive and capactive type soild state moisture sensor

S.No	Parameter	(Existing) Resistive Type	(Proposed) Capacitive Type
1	Corrosion	Yes	No
2	Data accuracy	Less accurate	Highly accurate
3	Power supply	3.3 to 5v DC	3.3 to 5v DC
4	Cost	Cheap	Cheap
5	Maintenance	yes	Not needed
6	size	Little bigger than capacitive type	Occupies less space
7	Data type	Analog	Analog

smart farming system Implementation with proposed Sensor

Since, the sensor alone can't give you the data directly, we require some kind of intermediate device that has the capability to process the sensor data and able to push the same data into the cloud. We use the Raspberry pi as an intermediate device which can be used to process the information given by the sensor and it also has the capability to push the data into the cloud, but it does require some programming. So we require both, the hardware to collect the data and some software (programming) to push the data into cloud. The hardware implementation is as shown in Fig. 8. It illustrates the overview of a whole proposed Smart farming System. The Moisture sensor node is connected to Arduino,(because raspberry pi requires ADC to read the data from the sensor) then Arduino will be connect to Raspberry Pi and with the help of cloud services, like things peak , we can visualize the data given by the sensor and plot it in a real time

Fig 7. Overview of the system

(a). Soil moisture sensor interfacing with Arduino

Since CSM sensor gives the value in the form of analog value, we must convert the analog value into digital value, before giving it to raspberry pi. So we used analog to digital converter in side Arduino micro-controller for this purpose.

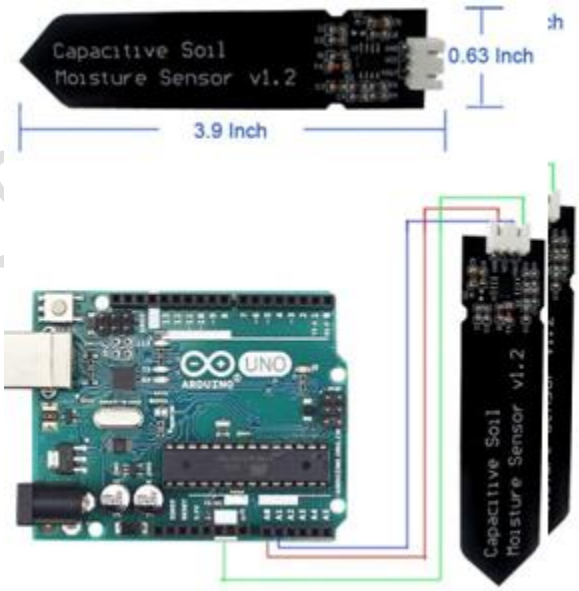


Fig 8. Ardunio and CSM sensor interfacing

(b). Arduino interfacing with raspberry pi

The easiest way to setup the communication between Arduino and Raspberry pi would be, connecting them with an USB cable as shown in figure9.

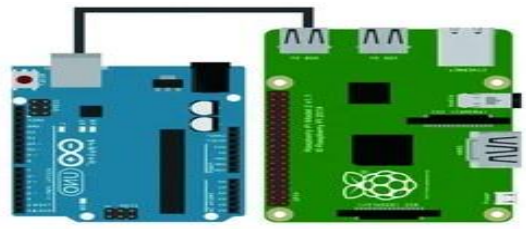
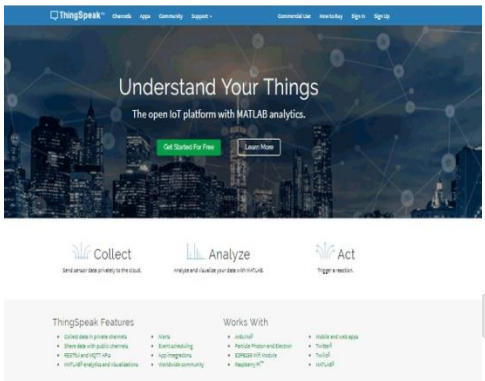


Fig 7. Arduino Raspberry pi USB Communication

(c). Sending data to cloud

There are lot of free cloud services available in the internet, thingspeak is one of the best, as it is very easy to setup with any IOT device.



V.Results

VI. Conclusion

The soil humidity sensor which is one of the most important sensor of the smart farming, and it is vulnerable to corrosion according to measurement principle and usage environment. The proposed sensor prototype is implemented and confirmed that it can be normally used for a long time in an actual environment through comparison with legacy sensors. Corrosion did not occur in sensors providing experimental results up to the present, Since its operation depends on capacitive property, the sensor need not connect directly with the soil, so it provides isolation between sensor unit and power unit . Through ongoing experiments and observations in the future, we plan to check the lifetime and drawback of the proposed sensor and solve this

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