Development of Smart Agriculture Monitoring System Using IoT†

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Agriculture is an important sector for developing countries like India. However, the development of agricultural production has been hindered by certain issues related to the use of traditional systems. In the past, much research has been carried out to modernize the agricultural system. However, there is a need for low-cost and easy-to-use technological solutions to the poor farmers of the country. Hence, the paper aims at making the existing agricultural system smart by using IoT. A compact, lightweight and integrated system has been developed comprising multi-sensors to measure all the parameters and continuously monitor the soil content, weather conditions, temperature and humidity. All parameters are real-time monitored over the Internet of Things (IoT), thereby making it remotely accessible from anywhere with the help of an android application. The paper proposes an arduino-based automatic irrigation IoT system which can increase the productivity of the crop eventually. Thus, a basic implementation of some sensors along with wireless networking would come out as a boon to the farmers. The results obtained are considerable and under tolerable ranges.

***Keywords*:** Yield of soil, Internet of Things (IoT), Wireless networking

Introduction

Agriculture is considered as the basis of life for the human species. It plays a significant role in the growth of the country's economy. It also provides sizeable employment opportunities to the people. An increase in the agricultural sector is necessary for the development of the economic condition of our country. From the survey of the United Nations – Food and Agriculture Organizations, the global food production should be increased by 70% in 2050 for the evolving population. So, with the rising population, there is a need for increased agricultural production. To support vast production in farms, the requirement for the amount of fresh water used in irrigation also rises.

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Currently, agriculture accounts for a whopping 83% of the total water consumption in India. Unplanned use of water inadvertently results in wastage of water. However, traditional methods of farming and irrigation are the primary choice of the farmers. These outdated techniques are replaced with semi-automated and automated technologies. The available conventional techniques are: ditch irrigation, terraced irrigation, drip irrigation and sprinkler system. However, wherever automation has been implemented and automatic types of machinery have replaced human beings, the yield has always improved. Hence, there is a need to apply modern science and technology in the agriculture sector for increasing the crop yield. So, to provide a solution to all such problems, it is necessary to develop an automated system that takes care of all factors affecting productivity in every stage. Hence, the paper deals with developing smart agriculture using IoT and given to the farmers.

The paper suggests developing systems that prevent water wastage without imposing pressure on farmers. A compact, lightweight and integrated system has been proposed to aim at making the agricultural system smart.

2. Literature Review

In the past years, significant work has been carried out regarding the advancements of the agricultural system. Suresh *et al.* (2014) developed GSM-based automated irrigation control using rain gun irrigation. An automatic microcontroller-based rain gun irrigation system has been developed, in which the pump starts when the water is drastically needed on that land that saves a large quantity of water. The proposed methodology dealt with a system to overcome under irrigation and overirrigation. Pavithra and Srinath (2014) reported about GSM-based automatic irrigation control system for efficient use of resources and crop planning using an android mobile. The significant features of their system are the system support water management decisions and continuously monitoring of water level with low power consumption. Nikesh and Kawitkar (2016) proposed an IoT-based smart agriculture system with automation and IoT technologies. Smart GPS-based robots perform operations like smart control, decision-making accurate real-time field data and smart warehouse management. However, the system is a costlier solution for the purpose.

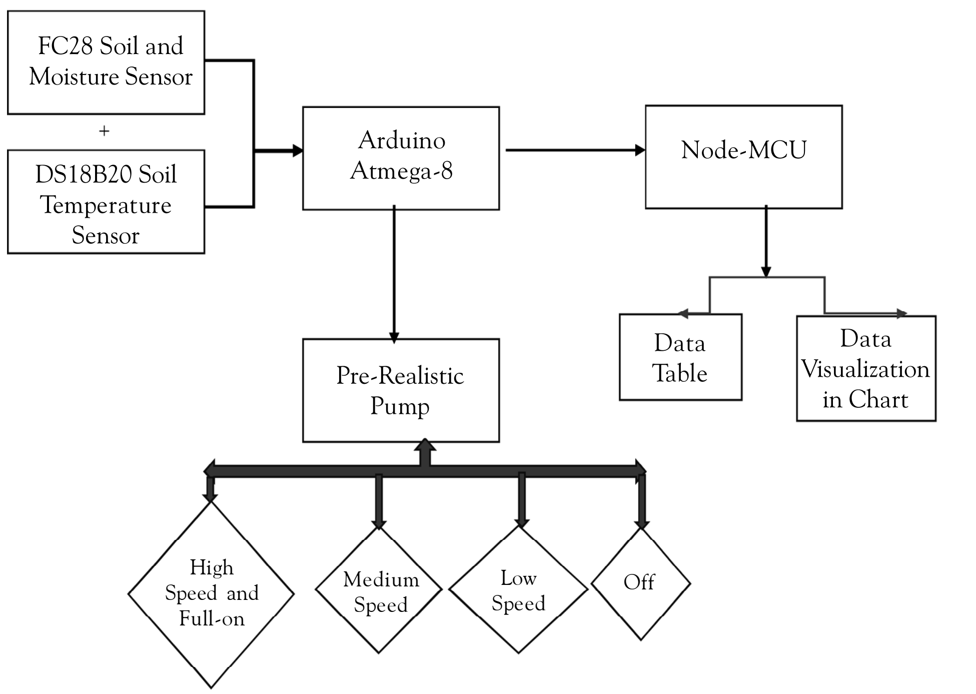
Tanmay *et al.* (2016) stated that the developed system concentrates primarily on the security and protection of agricultural products from attacks of rodents or insects in the fields or grain stores. Security systems are used to provide real-time notification after sensing the problem. The sensors and electronic devices are integrated using Python scripts. The algorithm has been designed based on collecting information to ensure accuracy in notifying the user and activation of the device. The testing has been conducted in 10 sq. m land space where the device is placed at the corner. Nandurkar *et al.* (2014) studied the newer scenario of decreasing water tables and drying up rivers, so the environment needs an urgent utilization of water. To cope with the situation, temperature and moisture sensors have been implemented in a suitable location for measuring irrigation. Joaquín *et al.* (2013) studied the microcontroller-based gateway to control water quality, which is again a very simple solution where a threshold value of parameters has been set, above which the controlling action takes place. Nemali and Van Iersel (2006) and Kim *et al.* (2011) conducted similar research for the development of systems for agricultural lands.

3. Methodology

3.1 The Multi-Sensor System Configuration

The proposed system has multisensors integrated into one module for monitoring the parameters like soil moisture content, temperature and humidity. Figure 1 shows the block diagram of the proposed system. Microcontroller Atmega8 associated with Node-MCU is used for serial communication. Since the microcontroller is the heart of the system, the sensors such as the DS18B20 soil temperature sensor, along with FC28 soil and moisture sensor are interfaced with the microcontroller. The analog data of the sensors are uploaded to the server, where the temperature and moisture content of the soil through the Node-MCU can be monitored.

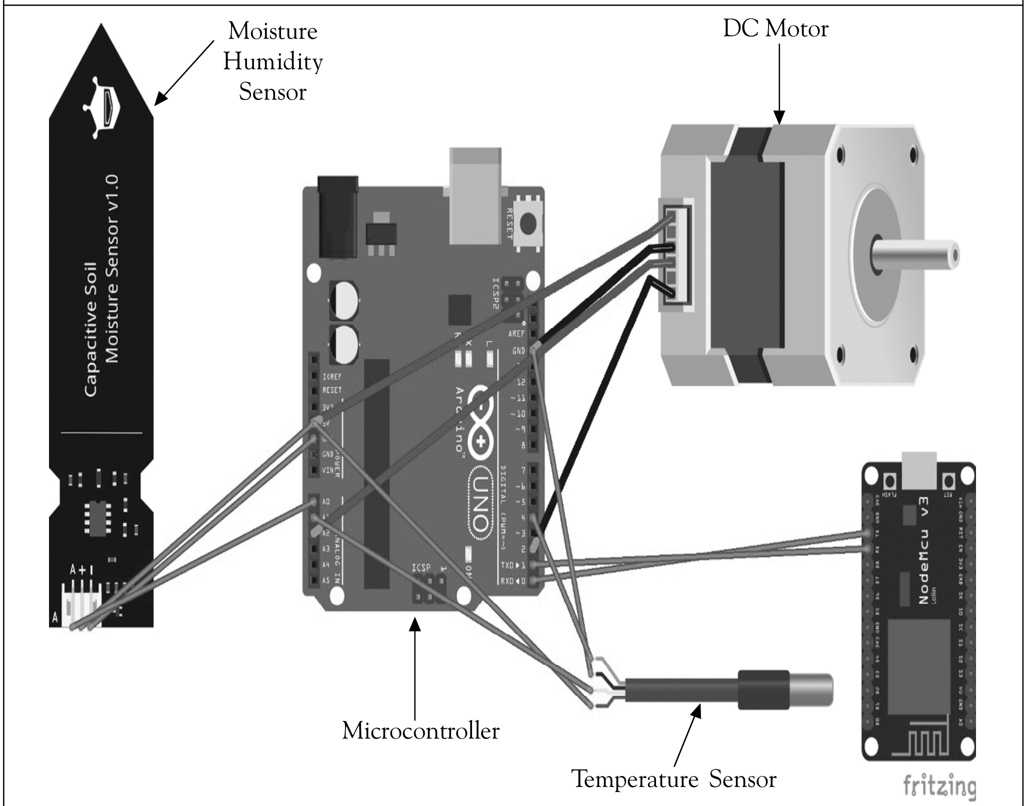
Figure 1: Block Diagram of the Proposed System



Furthermore, according to the monitored temperatures of the soil, the calibrated amount of water is sprinkled over the land using a motor pump, which is again controlled by the microcontroller.

The database has been developed for collecting all the data so that the user can have an appropriate track of the records. Also, plotting the real-time graph on the web platform can be monitored along with this in the server so that it is convenient for the user to keep an eye on his land from anywhere and anytime. Figure 2 shows the internal circuit diagram of the proposed system. The integrated sensor shown in the system can measure the soil temperature and humidity content simultaneously. The analog output of the sensor has been interfaced with the analog inputs of the microcontroller. The additional component DC motor connected to the pump turns on when the soil content becomes dry. It helps to turn on the water supply to the soil automatically. Since the system is connected with the IoT device that is node MCU, the condition of the soil can be monitored remotely.

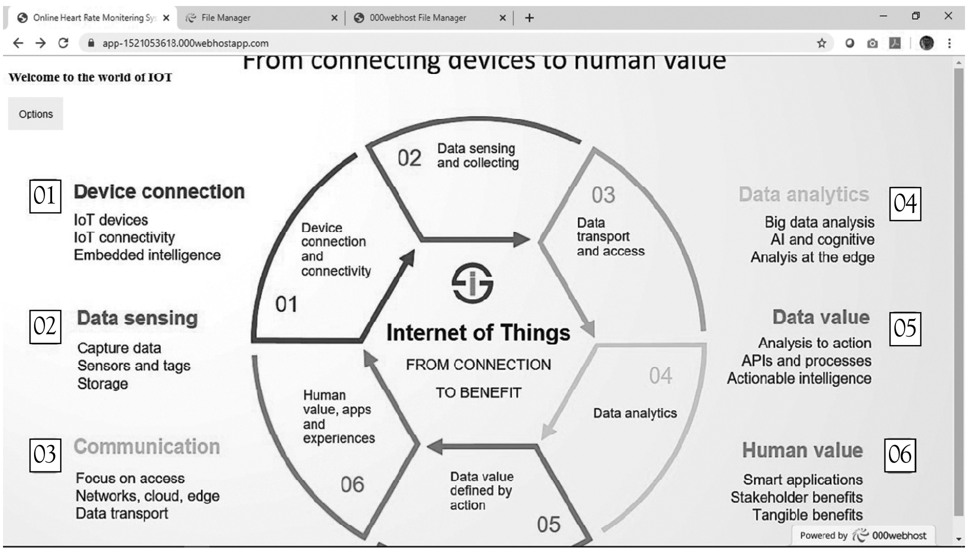
Figure 2: Circuit Diagram of Integration of Sensors



3.2 Working of Web Server

The website for monitoring the data and graph can be easily accessed from any browser on personal computers or mobile phones. Figure 3 shows the designed website page on the cloud platform. On the website, a farmer can track his land and control it in a table as well as see the soil conditions graph in the "view chart option". This graph and the website show data when the prototype is accessed remotely. From this website, if there is massive weather change monitored or anything else that can be required on the field, then it can send an SMS or an email to the farmer's email id. If the farmer forgot to monitor the soil condition, there would be a notification that arrives on his phone to track the data and take the necessary steps as provided by the algorithm. Suppose the farmer could not understand the report, then the farmer can send the link to a soil laboratory to check the data and give scientists opinions to improve the health of the soil. If the farmer needs to search for particular data on a specific date or time, then the person can do the same as we are also keeping the record in hh: mm: ss in the database. Aggregate data is saved on the database, which can even be downloaded for convenience. Therefore, whenever a farmer needs to find data, he can easily search the data by entering the year/number of year/dates. Not only this, we have also made a graph according to the uploaded data which the user can easily find in 'view graph' under the 'options' menu, and neither can be stopped; for convenience, the zoom feature has been provided for more precision. Moreover, finally, these have been implemented on the website by developing some JavaScript code.

Figure 3: The Website Page



4. Results and Discussion

Figure 4 shows the testing of this prototype by bringing various types of soils from different areas. The tests have been primarily conducted on 'arid soil,' 'loam soil,' 'silt soil,' and lastly 'clayey soil.' The physical system shows the different phases of working with various soil content. Figure 5 shows the recorded data on the website page. It shows the data which are being continuously uploaded to the database. This database is made by PHP and HTML using JavaScript language. A search bar has been created to search for the data as per requirement. If someone needs their data in day or month or year basis and hh: mm: ss basis, then they can search for their data on the search bar to get the result. This database automatically refreshes with a delay of 4 s.

Figure 4: Testing of the Prototype in Different Soil Conditions

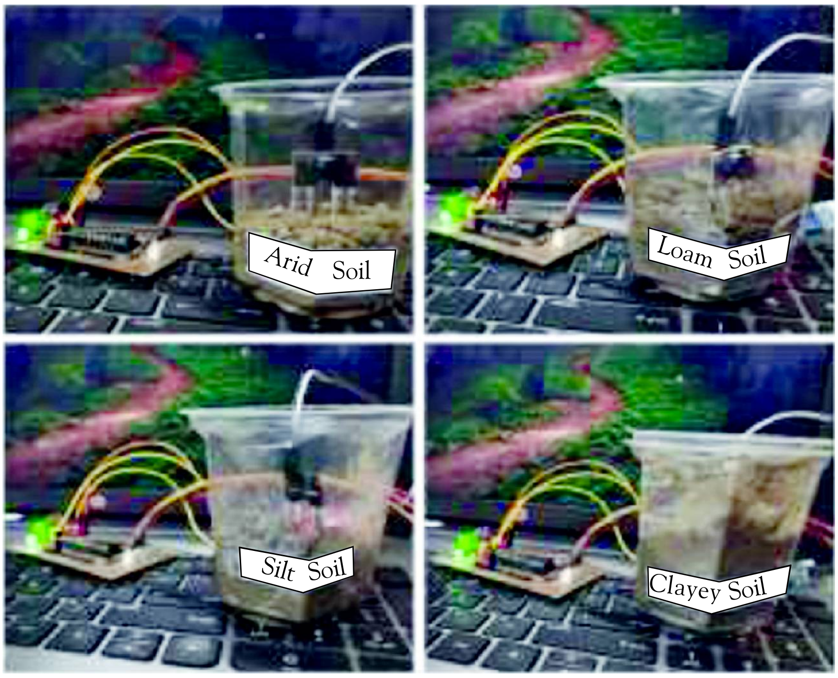


Figure 5: Data Logging in Website

IoT Based Agriculture Monitoring and Smart Irrigation System Table

Type the date in the format of DD-MM-YY or type any values to find

Search..

Serial	Volumetric Water Content	Date	Time
1	347	18-November-2019	09:51:15pm
2	347	18-November-2019	09:51:21pm
3	350	18-November-2019	09:51:27pm
4	346	18-November-2019	09:51:33pm
5	353	18-November-2019	09:51:39pm
6	861	18-November-2019	09:51:45pm
7	120	18-November-2019	09:51:51pm
8	122	18-November-2019	09:51:58pm
9	878	18-November-2019	09:52:04pm
10	52	18-November-2019	09:52:10pm
11	122	18-November-2019	09:52:16pm
12	91	18-November-2019	09:52:22pm
13	878	18-November-2019	09:52:28pm
14	408	18-November-2019	09:52:34pm

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The sensor's values from the temperature sensor and humidity sensor have been acquired, and based on both data, moisture percentage has been calculated. Table 1 shows the data from temperature sensors. At different times, temperature in a whole span of 24 h data has been recorded. The data have been recorded at a short interval of time. On the basis of temperature fluctuation, water necessity fluctuates. When the temperature is higher, then the humidity is also high and soil water vapors away. Depending upon the moisture value, the pump speed is controlled. In the early morning, the temperature will not be high so that the pump speed will be lower or moderate. Table 2 shows the variation in sample moisture values.

Table 1: Variation of Temperature at Different Times

S. No.	Time Span	Temperature (°C)
1.	12 am – 6 am	22 – 24
2.	6 am – 12 pm	24 – 28
3 .	12 pm – 6 pm	26 – 27
4 .	6 pm – 12 am	23 – 25

Table 2: Different Types of Soils and Their Moisture Content

S. No.	Sample 1	Sample 2	Sample 3	Sample 4
1.	13.59	24.68	48.39	67.06
2.	13.69	25.66	48.19	67.96
3.	13.78	28.74	48.09	67.96
4.	13.69	27.12	48.39	67.16
5.	13.88	27.53	48.39	67.06
6.	13.88	26.54	48.39	67.06
7.	13.78	26.36	48.39	67.06
8.	13.88	27.32	48.29	67.06
9.	13.78	25.67	48.39	66.96
10.	13.78	26.66	48.29	66.96
11.	13.88	25.55	48.39	67.06

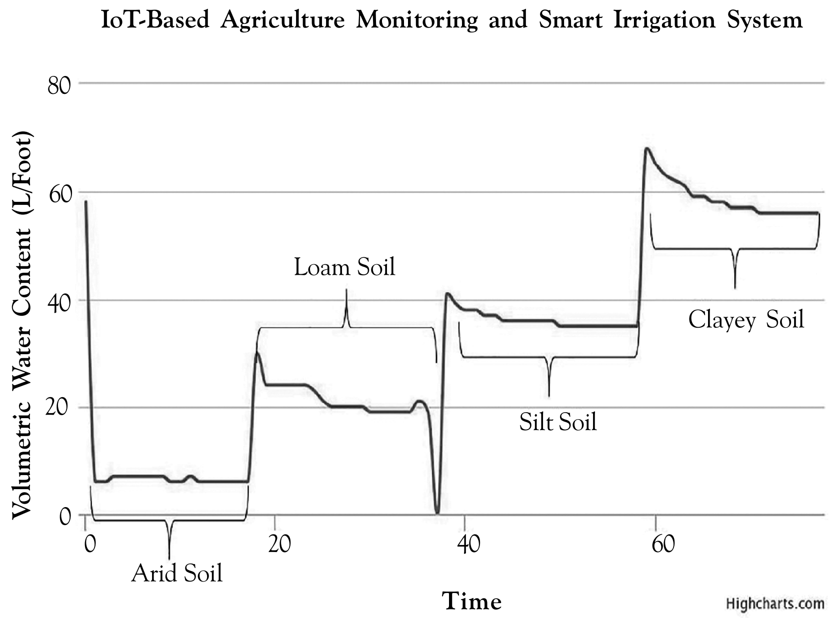
Note: Sample 1: Arid soil; Sample 2: Loam soil; Sample 3: Silt soil; and Sample 4: Clayey soil.

Table 3 shows the pump speed controlling values. From the moisture value, 13-20% moisture means the soil is too much dry, so there is a drastic need for water, hence the pump speed must be higher. For 20% to 30% moisture percentage, the pump speed is at medium speed, for 31% to 55% soil, much lower speed is required. In the case of 55% to 70%, the soil does not need water. So the pump will stop.

Table 3: Pump State According to the Moisture Content		
S. No.	**Moisture Percentage**	**Pump State**
1.	13 – 20	High Speed and Full-On
2.	20 – 30	Medium Speed
3.	31 – 55	Low Speed
4.	55 – 70	Off

Figure 6 is plotted simultaneously according to the sensor reading on the proximity. From this, it is visible in the first interval, the value is around 6 to 7, where we have taken the sample of arid soil. In the next part, the figure slightly elevates, which reflects that it is 'loam soil.' In the next step, the graph further elevates, which states 'silt soil,' and finally, at the last stage, the elevation is maximum, which shows that it is a clayey soil.

Figure 6: Real-Time Graph According to the Readings



According to precise testing, the data from four different soil samples from different areas have been taken and the moisture content has been plotted accordingly from the server. Thus, from rigorous testing, we got the above results, which are quite stable and ideal according to the different kinds of soil conditions. Therefore, the observations are found to be highly accurate and the error percentage is under the tolerable range.

Conclusion

It can be concluded that the developed, low-cost, smart agriculture system can be a boon to the farmers working in remote locations. The sensor's microcontrollers and wi-fi modules are integrated on one system and the webserver is successfully interfaced along with it. Wireless communications have been done in various conditions of weather. This device can be a complete solution to the farmers for their irrigation, temperature and humidity problems in their field. Thus, the system is a potential solution to the issues faced in the existing manual and cumbersome process of irrigation by enabling efficient utilization of water resources. However, the system can be further used in different locations to test its static and dynamic characteristics. Further, the structure needs to be modified to meet the industry standards.

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