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RESEARCH ARTICLE

IoT based Soil Quality Monitoring for An Efficient Irrigation

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A B S T R A C T

The yield of agriculture primarily depends on the soil moisture, soil fertility and the use of suitable fertilizers. The method of manually measuring the soil nutrients is inaccurate in the current scenario due to laps between soil samples collected at the field and measuring in the laboratory. IoT has made changes in so many fields to monitor the data remotely despite of existing wireless technologies like Zigbee, GSM, etc. In this work an effort is made to collect the data related to various soil nutrients from agriculture filed using multiple sensors. Once the data is monitored and collected at the control center helps to apply a machine algorithms to take the appropriate decision for an efficient crop yield. In the proposed system, the sensors connected to the node at the field measures the macro nutrients of the soil, temperature and humidity of the soil. The nutrition majorly required for the growth of the plant is nitrogen (N), potassium (K), and phosphorous (P) amount present in the soil. In this work a microcontroller with WiFi is used to interface various sensors and display the measured value in the LCD. This application will provide a user interface to monitor the fertilizers, irrigation and humidity control.

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Introduction

Agriculture is the main significant sector for Indian Economy. Indian agriculture accounts for 18% of India's GDP and provides income for 50% of the country's workforce. In this new era, the farmer can use technology to exert control over adapting crop management and water use dynamics. Farmers have obtained new technology and tools to increase their profits with both the birth of SaaS and cloud technologies, increasing the number of discerning consumers and unprecedented temperature values over the past few years. Unfortunately, many farmers are still using traditional farming methods, leading to low crop and fruit yields. But wherever the automation used people were replaced by automatic machinery. Most papers imply using the sensors that collect data from multiple sensor types and then use wifi to send it to the cloud storage. The data gathered offers additional information on specific environmental conditions, which then in turn allows monitoring the system. The monitoring of environmental conditions is not adequate and comprehensive to enhance agricultural productivity.

Knowing their soil concentration can give rise to nutritional deficiency or abundance in soils used to endorse plant production. Moisture sensors are quite essential devices for environmental measurement of moisture. Technically, the device is used to measure atmospheric humidity. A hygrometer detects observations and analyses the temperature of humidity and air. The ratio of humidity content in the air at a specific air temperature to the highest amount of humidity content is called relative humidity. When looking for safety, relative humidity becomes an important factor. Irrigation is the application at the required intervals of controlled quantities of watering plants. It helps grow crops, sustain landscapes, and revegetate deranged soils in dry areas and less than average rainfall periods. It has certain needs in agricultural production, including frost protection, weed growth in grain fields, and soil acquisition avoidance. In agricultural production, temperature plays an important role. It has a profound impact on crop growth, development and yields, pest and disease incidence, water needs, and fertilizer needs. Weather factors contribute to the optimum growth, growth, and yield of crops.

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The aim of the work is to implement an IoT based system for soil nutrients monitoring using sensors with objectives to capture the data from temperature, humidity and NPK sensors and to provide the suggestions and precautions for the captured input data. Improper use of fertilizers in turn results in poor quality in fruits, vegetables lagging in color, size, taste, and even quantity. It is essential to choose the crop depending on the soil type to avoid excessive use of fertilizer.

By knowing the soil moisture content (ș) agricultural producers can make timely decisions of when to start and when to stop water application, to optimize water use, and produce a good quality crop [1]. Muthunoori Naresh et.al [2] implemented a system with ARM7 controller for the monitoring of the data remotely with additional module for Wifi configuration. P. Prema.et al [3] used various sensors to get the soil parameters and displayed in the LCD locally. These irrigation management techniques and instruments vary for their accuracy, labor intensity, cost, and simplicity of use. Previously many studies have been conducted to evaluate soil water devices both qualitatively and quantitatively for setup requirements, maintenance, initial cost, accuracy, and data interpretation [4]. At the same time, the sensor industry coupled with rapidly advancing computer technology has resulted in a variety of new sensors for irrigation scheduling. The newly-designed sensors monitor soil moisture content continuously and on a real-time basis. In particular, the timing and amount of irrigation are important factors for efficient on-farm water management. Scientific irrigation scheduling (SIS) is distinct in using crop evaporation and transpiration data, as well as soil moisture-based sensor technologies to precisely calculate when and how much to irrigate

Methodology

Various sensors are placed in the soil to get the soil nutrients and the signals are given to the analog to digital convertors. The digital signals obtained from the ADC are processed and sent to the cloud for using IoT protocols. Many third party cloud service providers are giving the facilities like storage and algorithms for the analysis of data. The analysis helps to predict the type of crop selection based on the environmental condition to get maximum yield. The methodology further involves the utilization of Raspberry Pi to process the data using one of the machine learning algorithms as shown in the block diagram of implementation in fig1. In this system the algorithm is created and trained based on a set of pre-defined input data and the prediction of the output is carried out. The predicted output is displayed using the Liquid Crystal Display (LCD) unit. Depending on the predicted output suggestions will be given for different crop types and based on the weather conditions the type of the irrigation system useful for the crop is suggested.

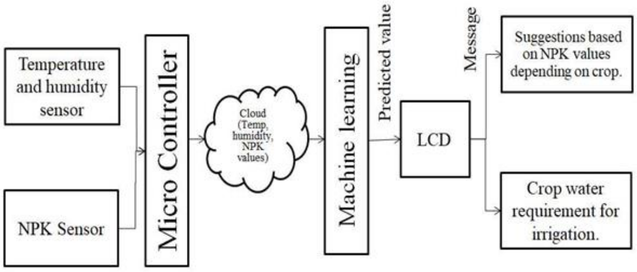

Fig. 1. Block diagram of the proposed system

The algorithm for collecting the data using sensors and uploading data to the cloud is given in the following flow diagram in fig.2. Using the statistical data for efficient yield of crop various thresholds are defined and used to display on the LCD.

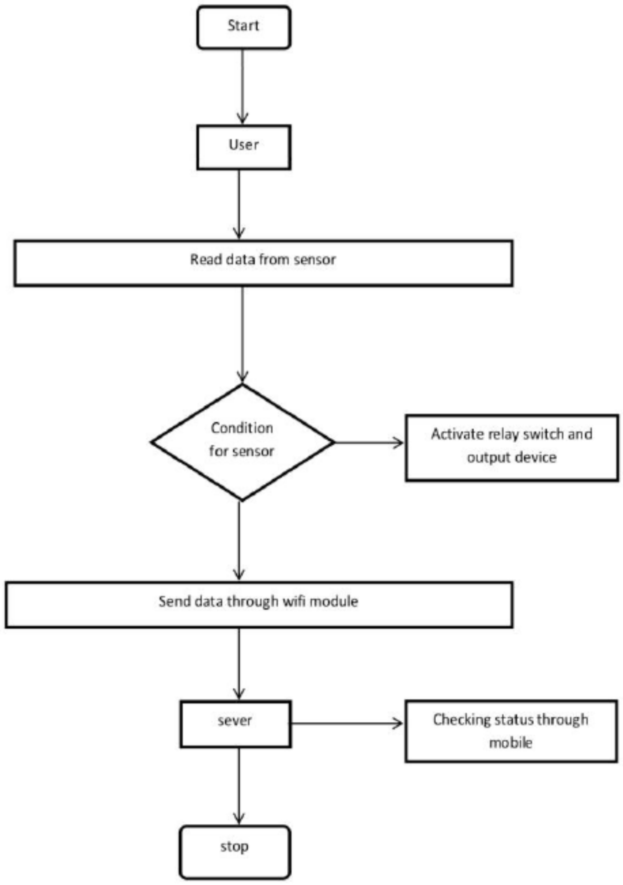

Fig. 2. Flow diagram for the algorithm

Implementation of the system

1.1 Sensor Data Acquisition

1.1.1. Temperature and Humidity Sensor

The connection of the DHT22 is shown in fig.3, in which the VDD pin is connected to supply voltage while the DATA pin is connected to the serial input of the microcontroller unit. Pin 3 is given no connection because the component is being used as a sensor. GND pin is connected to GND. The data from the sensors is captured continuously and recorded using the microcontroller unit

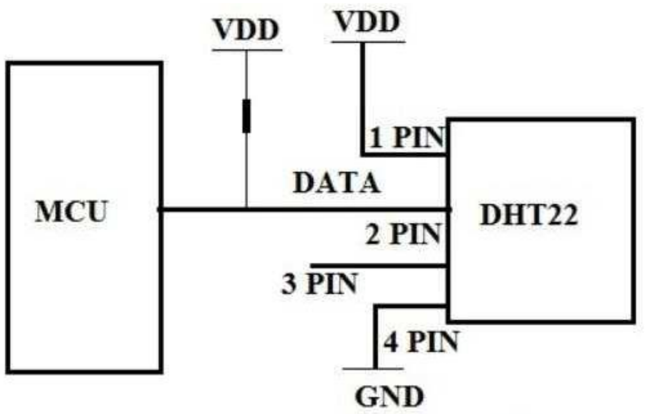

Fig. 3. DHT22 sensor connection with Micro Controller

1.1.2. NPK Sensor

The internal working principle of NPK sensor is shown in fig.4.The microcontroller triggers the optical transducer to collect the data at discrete intervals. The optical transducers is providing the status of the data using three LEDs as shown in table1.

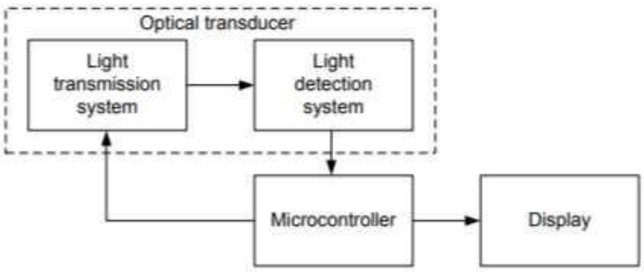

Fig. 4. Optical Transducer block diagram

Table 1

Nutrient	Absorption wavelength (nm)	LED type	Wavelength (nm)
Nitrogen (N)	438-490	LED 1	460-485
Phosphorus (P)	528-579	LED 2	500-574
Potassium (K)	605-650	LED 3	635-660

1.1.3. ThingSpeak

Thing speak is a third party service provider for cloud. The raspberry pi configured with wifi gets an IP address to get connected to the cloud. To provide the security to the data thingspeak is generating Channel Ids for each service and read and write API keys for the exchange of data between sensor node and cloud. To make use of various sensors data, thingspeak provides various fields which are mapped to the sensors. Each field is updated every 15 seconds to get the currents value from all the sensors and the data can be imported in excel sheet form. Thingspeak also provides the visualization of data in graphical mode for all the fields configured. It also provides the user to apply complex algorithm for data analysis using MATLAB to take the appropriate decision for the efficient yield of the crop.

Results and Discussions

The implemented system helps in obtaining the information about the nature of the soil to find the right crop for their yield with the assistance of Raspberry pi board along with few sensors like NPK Sensor, humidity sensor, and temperature sensor to collect the data from those sensors and sends to cloud storage to store the values of the respective sensor. We have acquired the sensor data and observed it using ThingSpeak. The following are the plots that are obtained over some time.

Temperature Plot

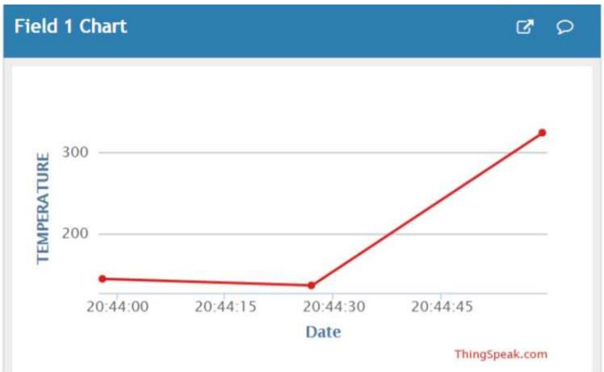

Fig. 5. Temperature Sensor Data Plot

The temperature data obtained using thing speak is shown in fig.5. The dat from the sensor is updated every 15 seconds.

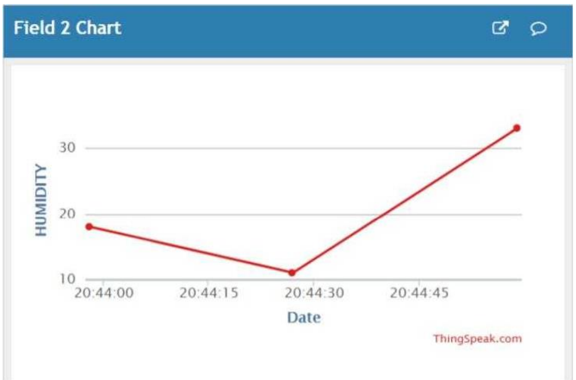

Fig. 6. Humidity Sensor Data Plot

The humidity is configured in thing speak to collect the data in field 2 as shown in fig6.

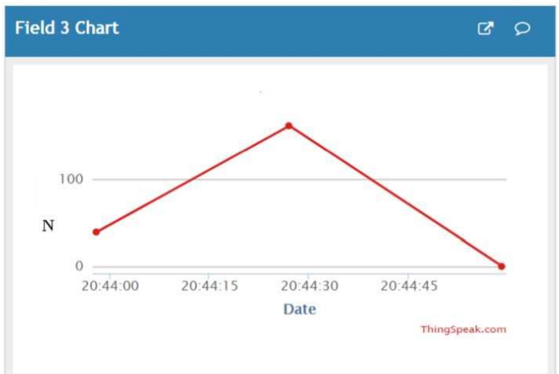

Fig.7. Nitrogen Nutrient Plot

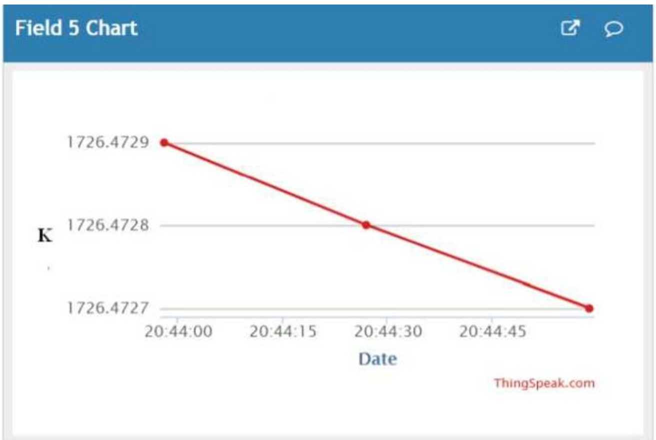

Fig.8. Potassium Nutrient Plot

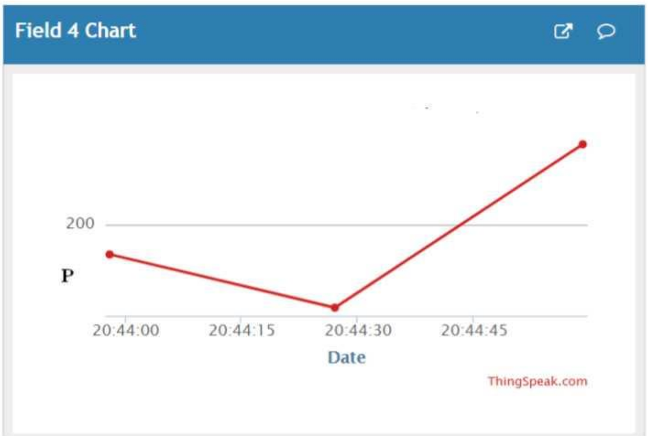

Fig.9. Phosphorous Nutrient Plot

The above shown is the samples of sensor data over some time.

6.1 Soil study

Fig.10. Input sensor data for case 1

Fig.11. Input sensor data for case 2

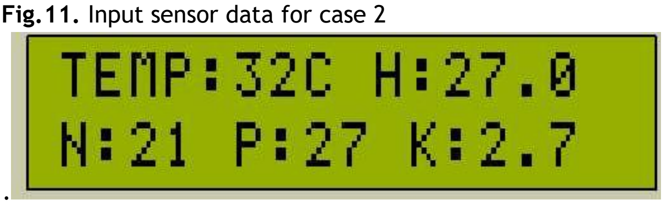

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Fig.12. Recommended results for case 1

Fig.13. Recommended results for case 2

Fig.14. Input sensor data for case 3

Fig.15. Recommended results for case3

Soil study of different cases for measures data and recommended data are shown in fig10 to fig.15.

Conclusion

Using the data obtained from the sensors we have implemented the algorithm to recommend the crop depending on the nutrient levels to strengthen the percentage of crop yield. And by choosing the right crop for the soil along with the type of the best irrigation system to use, the crop yield will increase without the use of unnecessary fertilizers to balance the PH of the soil. It will reduce the risk of unnecessary crop diseases and water problems like wastage of water can be reduced by choosing the right irrigation system.

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