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Original Article

Smart IOT Application for Agriculture

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Abstract — *In this paper, an automated system has been developed to determine Smart Farming System application with the evolving technology, i.e. IOT (The Internet of Things). The following activities are carried out in our report. First, monitoring environmental conditions to improve the yield of the crops. Second, Monitoring the status of crops in the field to check the growing condition of the crops. Third, analyze the field status for seasonal crops. The feature of this report includes the development of a system that can monitor temperature, humidity and moisture in agricultural field through sensors using Arduino micro-controller and in case of any discrepancy, will send an SMS notification as well as a notification on the application developed for the same to the farmer's smartphone using Wi-Fi/3G/4G. The data generated by these sensors are stored and processed in a cloud platform for IoT called 'ThingSpeak'. As these sensors generate a huge amount of data, Big Data Technologies are being used for data analysis. The Algorithm developed in this project address these problems by offering a MapReduce Architecture for handling sensor data and providing different types of analytics for farmers that they can use for smart farming.*

Keywords - *IOT, Arduino, ThingSpeak, data analysis, MapReduce, smart farming.*

I. INTRODUCTION

India is a land of agriculture. Two-thirds of the population rely upon agriculture for their livelihood. It is the basic foundation of the economic development of the country. Agriculture also provides employment opportunities to a very large percentage of the population. Agriculture is not a very promising occupation, as there is no guarantee that crops will be healthy and farmers could make a profit out of it; most of the farmers do cultivation alongside other occupations instead of taking farming as a primary occupation. This leads to poor care of the crops as the time these farmers could allocate to these crops is very limited in their busy schedules.

The Internet of Things (IoT) is the connectivity of physical devices, vehicles, home appliances, and other items embedded with electronics, software, sensors, actuators, and network, which allow these things to attach and interchange data, generating opportunities for the more direct merging of the physical world into computer-based systems, resulting in reduced human intervention. By the year 2050, the global population is set to reach 9.6 billion. So, to nourish this much population, the farming industry must adopt IoT technology. The demand for more food has to be met against the challenges such as intense weather conditions and exhaustive farming practices. Smart farming based on IoT technologies enhances crop production in the farming industry. So, this is the report that solely concentrates on making the farming process more efficient and accurate by analyzing the different conditions of the farmland. It not only helps in easing the farmer's jobs and making their life better but also helps in saving a variety of environmental resources.

The main aim of the proposed system is to provide these farmers with an IoT build automation system that tries to resolve the data generated through various sensors, thereby saving time, resources, money and manpower. Firstly, the proposed system will monitor the field's temperature, humidity, and moisture, and with the help of our Algorithm, it will inform farmers whether the field is dry or wet. Secondly, it will take RGB values of the leaves through the colour sensor, and with the help of our Algorithm, it will provide information on whether the leaf is healthy or not. Thirdly, the system will take Ph values of soil which provide information about the nutrients which are present in the soil, these data are taken from the electrochemical sensor, and our Algorithm helps farmers to know which types of crops are suitable for that particular field.

The following papers have been cited during the literature survey to understand the different applications of computer systems in allied areas of the present work carried out.

(Muhammad Ayaz et al., 2019) have highlighted the potential of wireless sensors such as Leaf Sensor, Stem Sensor, Temperature Sensor, Humidity Senor for better growth of plants. IoT devices and communication techniques associated with wireless sensors encountered in agriculture applications are analyzed in detail.

(Dr N. Suma et al., 2017) have focused on GPS based remote controlled monitoring, moisture & temperature sensing, intruders scaring, security, leaf wetness and proper irrigation facilities. It makes use of wireless sensor networks for noting the soil properties and environmental factors continuously.

(Dr R. S. Kawitkar et al., 2016) The highlighting features of this paper include smart GPS based remote-controlled robots to perform tasks like weeding, spraying, moisture sensing, bird and animal scaring, keeping vigilance, etc. Secondly, it includes smart irrigation with smart control and intelligent decision making based on accurate real-time field data. Thirdly, smart warehouse management which includes temperature maintenance, humidity maintenance and theft detection in the warehouse. Controlling of all these operations will be through any remote smart device or computer connected to the Internet, and the operations will be performed by interfacing sensors, Wi-Fi or ZigBee modules, camera and actuators with microcontroller and raspberry pi.

(Sunil Kumar Khatri et al., 2019) The IoT sensors used in the proposed model are an air temperature sensor, soil pH sensor, soil moisture sensor, humidity sensor, water volume sensor etc. a simple architecture of IoT sensors that collect information and send it over the Wi-Fi network to the server, their server can take actions depending on the information.

(Prof. Swati Nikam et al., 2019) The automatic disease detection system is used to automatic detection and identifies the diseased part on the leaf images, and it classifies plant leaves disease using image processing techniques. Some important steps are used for detection like feature extraction, segmentation, and clustering leaf images for efficient disease detection by using IOT, and for classification of images, we are using the genetic Algorithm.

(Anne-Katrin Mahlein et al., 2018) Have focused on Optical techniques, such as RGB imaging, multi- and hyperspectral sensors, thermography, or chlorophyll fluorescence, have proven their potential in an automated, objective, and reproducible detection systems for the identification and qualification of plant diseases at early time points in epidemics. Recently, 3D scanning has also been added as an optical analysis that supplies additional information on crop plant vitality. The most relevant areas of application of sensors-based analyses are precision agriculture and plant phenotyping.

(Apeksha Thorat et al., 2018) Leaf disease can be detected by camera interfacing with RPI. Immediate status of a farm like a leaf disease and other environmental factors affecting crops like humidity, temperature and moisture is sent using WIFI Server through RPI to the farmers. The paper presents the study of IOT techniques to engross the use of technology in Agriculture.

(Mohanraj I et al., 2018) The paper proposes an e-Agriculture Application based on the framework consisting of KM-Knowledge base and Monitoring modules. To make profitable decisions, farmers need information throughout the entire farming cycle. The required information is scattered in various places, which includes real-time information such as market prices and current production level stats, along with the available primary crop knowledge.

(Niranjan G Hegde et al., 2019) Have focused on bringing an enhancement in the field of precision agriculture by achieving better results in predicting crop yields as compared to the work already done in the field. With the use of machine learning techniques with proper optimizations and fine-tuned selection of the classifying Algorithm, a system can be built that considers the data set comprising soil conditions, weather conditions of the past, builds a statistical model through learning and thus seeks to provide accurate and precise decision help with respect to the crops that can be grown profitably during the upcoming period of time. The output of this work would produce within the system a set of rules (Knowledge base, which learns with more training from data sets) that helps the farmers pick the most reliable crops to be grown for the present external factors.

(Ram Krishna Jha et al., 2018) This paper focuses on field monitoring using IoT devices which would provide live soil moisture, humidity, and temperature of the field to the farmers. An individual would be able to take prompt action to manage the field based on the data received from the field. An Arduino Microcontroller board with soil, temperature and humidity sensors is used to collect the data from the field on the fly from a remote field. The data, once received, are analyzed and discussed. This work invoked to take a preventive measure for loss of crop and increase the productivity of the crop.

(Xinglong Jia et al., 2018) This system is based on image processing technology and uses MATLAB as the main processing tool. Besides, digital image processing, mathematical statistics, plant pathology, and other relative fields are also considered. Traditional threshold segmentation methods are introduced. Improved histogram segmentation method, Disease Recognition System Based on Multiple Linear Regression, multi-selective interactive image segmentation methods, and overall process of the disease recognition system.

II. PROPOSED METHODOLOGY

The proposed system comprises a set of data, which are then used together as a single system. This section of the paper discusses the implementation of the three-layer of system design. Please note that the focus of this report is on the data specific to India. There is not an in-depth coverage of the data for different countries and regions. However, the Algorithm which we developed will provide the same results for any input data.

For developing our system, we created an architecture of how our Algorithm will provide the required information. Our Architecture is distributed into three layers:

- Sensor Layer: Here, the data generation takes place.

- Service Layer: This layer describes the tools and methods used for data processing.
- Application Layer: It is the user interface layer where farmers can able to see the data of the field and environmental conditions.

A. Data Acquisition

Here we take different samples of data individually for each and every module. The data are generated through sensors to implement different algorithms proposed in the data processing section. The sensors used for data acquisition are as follows:

a) Temperature Sensor

The DHT11 is a basic, ultra-low-cost digital temperature sensor. It uses a capacitive humidity sensor and a thermistor to measure the surrounding air and spits out a digital signal on the data pin (no analog input pins needed). We use the DHT11 to sense the temperature of the surroundings, which helps us in the proposed Algorithm.

b) Humidity sensor

The DHT11 is a basic, ultra-low-cost digital humidity sensor. It uses a capacitive humidity sensor and a thermistor to measure the surrounding air and spits out a digital signal on the data pin (no analog input pins needed). We use the DHT11 to sense the humidity of the surroundings, which helps us in the proposed Algorithm.

c) Colour Sensor

The TCS3200 is a programmable colour light-to-frequency converter/sensor. The sensor is a single monolithic CMOS integrated circuit that combines a configurable silicon photodiode and a current-to frequency converter. The output is a square wave (50% duty cycle) with frequency directly proportional to light intensity (irradiance). We use the colour sensor to sense the colour of the leaf to determine whether it is healthy or diseased.

d) Arduino

The Arduino UNO is a widely used open-source microcontroller board based on the ATmega328P microcontroller and developed by Arduino cc. The board is equipped with sets of digital and analog input/output (I/O) pins that may be interfaced to various expansion boards (shields) and other circuits.] The board features 14 Digital pins and 6 Analog pins. It is programmable with the Arduino IDE (Integrated Development Environment) via a type B USB cable. It can be powered by a USB cable or by an external 9-volt battery, though it accepts voltages between 7 and 20 volts. Here we are using the Arduino in order to process the data that is being collected from the sensor through the Arduino IDE.

e) Cloud platform

Here, we make use of the "ThingSpeak" cloud platform to send the sensed data to the cloud. This data sent is plotted against the graph to view the change in the temperature, humidity, and colour, depending on the data that is plotted against the graph.

f) Hadoop MapReduce

MapReduce is elastic, scalable, efficient and fault-tolerant for analyzing a large set of data, highlights the features of MapReduce in comparison to another design model, which makes it a popular tool for processing large scale data.

B. Data Processing

This section proposes 3 different concepts for 3 modules, respectively. The concept proposed for processing data are

a) Day-wise identification of soil status for Timing Irrigation

The soil moisture plays a major role in detecting whether a field is dry or not. We have used a soil moisture sensor, as it provides the soil moisture value of the field precisely. Also, we have used the DHT11 sensor, which provides the temperature and humidity values of the surroundings. The parameters that are collected from the sensor are sent to the cloud platform through the ESP8266 WIFI Module connected to the Arduino Board

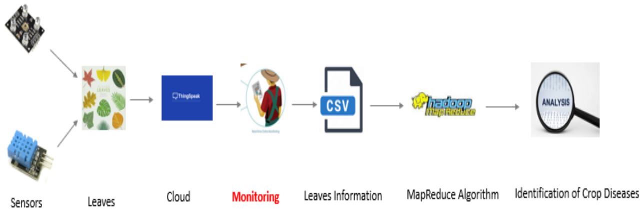


Fig.1 Proposed work for Module 1

The data which is recorded for analysis in the cloud platform is converted into a CSV file which the Hadoop MapReduce takes input for data processing. We calculate the average value of the soil moisture and check with our Algorithm to analyze whether the field is dry or wet. Figure 1 shows the architecture diagram for Module 1.

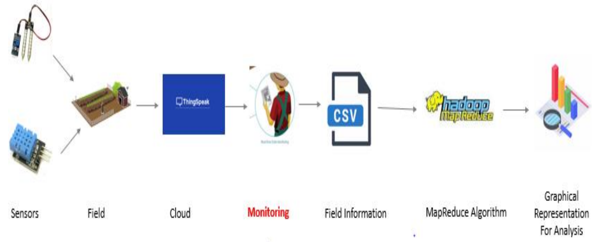


Fig.2 Proposed work for Module 2

Algorithm 1: Day-Wise identification of Soil Status for timing Irrigation.
Input: CSV file generated from ThingSpeak Platform
Output: WET or DRY
Description: Threshold value to identify the field as WET is when average soil moisture > 50%
Step 1: Start
Step 2: Creating a CSV file from ThingSpeak.
Step 3: Pre-processing the data for getting accurate result
Step 4: if(avg_soil_moisture > 50%)
Display Date with "WET"
Else
Display Date with "DRY"

Step 5: Display Data for different scenarios (Ex: This outcome can also be helpful for farmers to know electricity consumption of month)
Step 6: END

b) *Identification of plant disease*

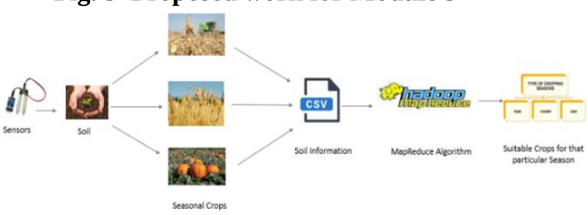
The colour sensor is used to sense the RGB values of different leaves. Initially, we have taken 9 samples of leaves to test our Algorithm. The parameters that are collected from the sensor are sent to the cloud platform through the ESP8266 WIFI Module connected to the Arduino Board. The data which is recorded for analysis in the cloud platform is converted into a CSV file which the Hadoop MapReduce takes input for data processing. We identify whether the given leaves are healthy or diseased. Figure 2 shows the architecture diagram for Module 2.

Algorithm 2: Identification of plant disease using the colour sensor.
Input: Data acquisition.
Output: Diseased or Healthy.
Description: Given colour range (RGB value) for the leaf to be healthy is when the obtained RGB value is in Between the range of its min and max RGB value.
Step 1: Start
Step 2: Input leaf for data acquisition.
Step 3: Sense the colour of the leaf using the colour sensor.
Step 4: if(min RGB value < RGB value < max RGB value)
Display “Leaf is healthy”
Else
Display “Leaf is Diseased”
Step 5: Display the output.
Step 6: Stop

c) *Identification of suitable crops for a field*

Electrochemical sensor is used to sense the PH value of the field, which determines the nutrients present in the soil. Also, the DHT11 sensor is used to identify the temperature of the surroundings, which helps us to know the environmental conditions of the field. The parameters that are collected from the sensor are sent to the cloud platform through the ESP8266 WIFI Module connected to the Arduino Board. The data which is recorded for analysis in the cloud platform is converted into a CSV file which the Hadoop MapReduce takes input for data processing. The PH values distinguish what type of crops are suitable for the given field. The DHT11 sensor helps us to provide the Season of the crops. Figure 3 shows the architecture diagram for Module 3.

Fig. 3 Proposed work for Module 3



Algorithm 1: Identification of suitable crops for a field.
Input: Data Acquisition.
Output: Season of the crop with the type of the crop (Rabi, Kharif, Zaid)
Description: Given PH value of soil provides nutrition value of the soil which decides which crops are suitable for a particular field.
Step 1: Start
Step 2: Creating a CSV file from ThingSpeak.
Step 3: Pre-processing the data for getting accurate result
Step 4: if(avg_PH >= 4.0 && avg_PH <= 5.5)
Display Season as Winter with suitable crop type as Rabi
Else if(avg_PH > 5.5 && avg_PH <= 6.5)
Display Season as Monsoon with suitable crop type as Kharif.
Else
Display Season as Summer with suitable crop type as Zaid.
Step 5: END

C. Data Visualisation

It consists of different means of visualizing the data that we processed. The output of the HDFS can be converted into a CSV file, for which we can provide a graphical analysis of the field to the farmers through a user interface.

III. RESULTS AND DISCUSSIONS

We have successfully interfaced IOT enabled sensors with Arduino Uno for data generation, after which that is stored into cloud platform "ThingSpeak". For Data processing, we have used Big data technology to implement our Algorithm. The images of implementation are presented in the report. The generated data is converted into a CSV file on which we have performed our MapReduce algorithm.

A. Monitoring the soil status

We have generated real-time data with the help of IOT enabled sensors. Table 1 shows the sample data which is present in the CSV file. We have taken soil moisture, temperature, and humidity values into consideration.

Table 1. Sample Data Generated through sensors for Module 1

Date	Time	Sr_No	Temperature	Humidity	Soil Moisture
2020-03-13	05:33:22 UTC	1	33.1	26.9	87
2020-03-13	05:34:22 UTC	2	33.1	27.9	88
2020-03-13	05:35:22 UTC	3	33.3	27.8	89
2020-03-14	05:43:12 UTC	4	34.4	26.9	21
2020-03-14	05:44:12 UTC	5	34.5	25.9	22
2020-03-14	05:45:12 UTC	6	34.6	25.9	23
2020-03-15	05:21:42 UTC	7	35.4	27.8	47
2020-03-15	05:22:43 UTC	8	35.2	27.2	48
2020-03-15	05:23:43 UTC	9	35.2	27.3	50

Table 1 is given as input to our MapReduce architecture for day-wise identification of soil status for timing irrigation. Figure 4 shows the output of the Algorithm, which gets stored in the Hadoop distributed file system (HDFS).

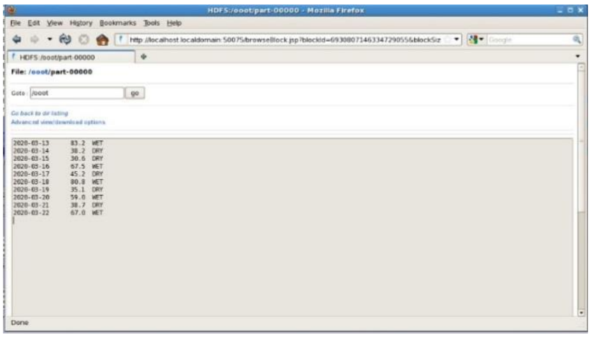


Fig. 4 Output of Module 1 in HDFS

B.Analyzing the crop status

We have collected 9 sample leaves, out of which 2 samples are normal, and 7 samples are diseased. The images of the data acquisition of the leaves colour data are mentioned in our report. The RGB values of leaves were taken into consideration, after which we performed our Algorithm to identify whether the leaves were healthy or diseased. Table 2 shows the sample data of the leaves with their corresponding RGB values.

Table 2. Sample Data Generated through sensors for Module

Leaf	Min RGB value			Max RGB value			Obtained Colour Value		
	Red	Green	Blue	Red	Green	Blue	Red	Green	Blue
1	-20	10	20	10	45	40	-16	39	23
2	76	94	68	82	119	68	114	115	80
3	109	115	91	114	124	97	142	115	80
4	125	136	102	131	141	108	142	64	23
5	10	20	20	30	50	30	22	34	23
6	93	107	87	93	124	91	190	111	85
7	82	94	68	87	98	68	109	124	119
8	85	100	70	88	130	78	255	136	68
9	80	115	102	83	120	105	66	39	57

Table 2 is given as input to our MapReduce architecture for the identification of plant disease using the colour sensor. Figure 5 shows the output of the Algorithm, which gets stored in the Hadoop distributed file system

(HDFS).

Fig. 5 Output of Module 2 in HDFS

C.Analyzing the field status

The field values are generated through electrochemical sensors, which helps us to extract the PH values of the soil. Table 3 shows the sample data which is present in the CSV file. We have taken the PH value of the soil to figure out which crops are suitable for the particular field.

Table 3. Sample Data Generated through sensors for Module 3

Date	Time	Sr_No	PH	Temperature
2020-03-13	07:33:22 UTC	1	7.4	27.3
2020-03-13	07:34:22 UTC	2	7.5	27.3
2020-03-13	07:35:22 UTC	3	7.2	27.4
2020-03-14	07:43:12 UTC	4	6.9	26.5
2020-03-14	07:44:12 UTC	5	7.0	26.5
2020-03-14	07:45:12 UTC	6	6.9	26.6
2020-03-15	07:21:42 UTC	7	7.3	29.8
2020-03-15	07:22:43 UTC	8	7.2	29.7
2020-03-15	07:23:43 UTC	9	7.1	29.7
2020-03-16	07:32:42 UTC	10	7.2	30.0
2020-03-16	07:33:43 UTC	11	7.2	30.1
2020-03-16	07:34:43 UTC	12	7.3	30.2

Table 3 is given as input to our MapReduce architecture for the identification of suitable crops for a field. Figure 6 shows the output of the Algorithm, which gets stored in the Hadoop distributed file system (HDFS).

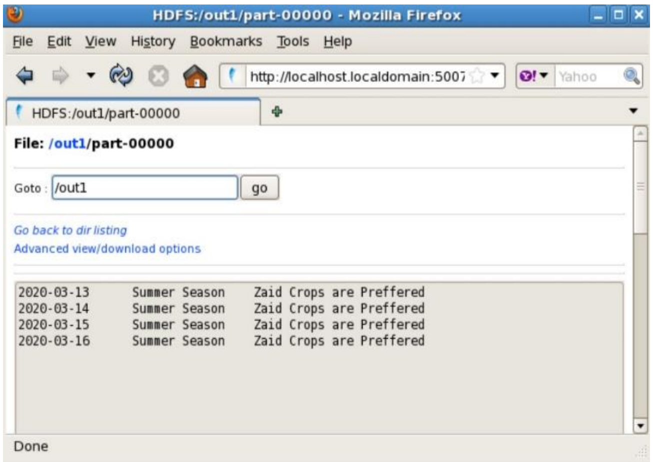


Fig. 6 Output of Module 3 in HDFS

IV. CONCLUSION

The focus on smarter, better, and more efficient crop growing methodologies is required in order to meet the growing food demand of the increasing world population in the face of the ever-shrinking arable land. This project considered all these aspects and highlighted the role of various technologies, especially IoT, in order to make agriculture smarter and more efficient to meet future expectations. For this purpose, a system is developed to determine the quality of the leaves. The avenue for further work in this area is the point to use the image processing techniques along with the proposed system to make it more efficient and also accurate to determine the values and to define whether the leaves are diseased or healthy. To build an extended version of the system, we can use the image processing technique that detects the kind of disease the leaf is affected with and classifies the different diseases among the leaves. Here we can build an automated system so that it is useful for large-scale production and helps in the early detection of the diseases that help the clients for the better performance and enhances the crop yield. Time is the critical factor for soil nutrient detection since the variability of soil nutrient levels may be quite high over time. Due to complex soil pre-treatment and chemical analysis, standard testing time for NPK is time-consuming. Electrochemical sensor rapidly responds to targeted ions in minutes, suitable for in-field rapid detection. The advantages of potentiometric electrochemical sensors stimulate the interest in applications in soil nutrient detection. They have the potential for automated multi-targeted rapid detection of soil nutrients. Advanced engineering technologies have opened our minds and provided new approaches for soil testing to follow the KISS (Keep It Simple and Stupid) principle to treat the complex soil testing procedures with simpler methodology at a lower cost.

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