Crop Health Management Using Internet of Things

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ABSTRACT

Machine learning is everywhere throughout the whole growing and harvesting cycle. It begins with a seed planted in the soil, soil preparation, seeds breeding and water feed measurement and it even ends when robots pick up the harvest determining the ripeness with the help of computer vision. One of the machine learning algorithms is Deep Learning. It is one of the major techniques for image processing and data analysis with promising results and large potentials. Deep learning provides high accuracy, outperforming existing commonly used in image processing techniques. Agriculture is the backbone of developing countries like India; hence this field should be given utmost care and attention using latest technological advancements like Internet of Things (IoT). Implementation of smart ways for better agriculture has paved way for this emerging field of Smart Agriculture. Smart Agriculture enables farmers to do agriculture by monitoring the field for pests, insects, sudden change in environment due to global warming, etc from remote area like their houses. Internet of Things (IoT) based solutions are being developed to automatically maintain and monitor the agricultural farms with minimal human involvement. The article presents the important of crop and it control and verifies the crop with the pesticides at the initial stage. The retrieved data will be stored in the cloud and this information is gathered through communication between the sensor and the base station. The experimental framework and simulation design suggest that the basic functions of the monitoring system of the Internet of Things (IoT) for agriculture can be realized.

Key Words: IoT, Raspberry Pi, ThingSpeak, Agriculture, Sensors.

1. INTRODUCTION

Internet of Things (IoT) is ecosystem of connected physical objects that are accessible through the internet. The ‘thing’ in IoT could be an automobile with built-in-sensors, i.e. All of the objects have their unique IP address and they can easily accessible through those IP addresses. IoT are applicable in various fields including agriculture. The applications of IoT are Smart Cities, Smart Environment, Smart Water, Smart Metering, Security and Emergency, Industrial Control, Home Automation, E-Health etc.

Most of the farmers, even today are not aware of the proper usage of fertilizers, proper usage of water for farming, etc., and if this is taken care of, then the other problems can be tackled easily. This can be effectively done by a real time analysis of the field environment parameters like temperature, humidity, light-intensity over the field.

This paper implemented by the use of Raspberry Pi. The Raspberry Pi is credit-card sized computer that plugs into a computer monitor or TV, and uses a standard keyboard and mouse. The board itself contains both Wi-Fi (Wireless) module and Local Area Network (Wired) east-to-use hardware and software. We used dht11 Temperature and Humidity Sensor to monitor the temperature changes. DHT11 integrated with a 8-bit microcontroller. Then we used soil moisture sensor to collect the volumetric water content in soil. We used PIR sensor and Rain drop sensor to sense the motion and to collect the rainfall data respectively. We used ThingSpeak cloud to store the real time progress. ThingSpeak is an IoT cloud platform service that allows analyzing live data streams in the cloud.

By using this monitoring system we can expect the increase in production and prevention from various problems. First we made one IoT device that can capable to collect DHT11, Soil moisture, PIR and Rain drop sensor data. Then automatically puts the collected sensor to the cloud. Then we download the ThingSpeak Android Application to monitor the real time progress of our monitoring system through the android application.

2. RELATED WORK

[1] They design wireless system for monitoring the current environmental conditions such as temperature, humidity, rainfall levels, and wind direction instantaneously. By using the past stores data they made future predictions in weather. From this paper we've extracted the performance and working of the temperature, humidity and rainfall sensing data and included these data in the farming of radish crop which extended the implementation of the farming system.

[2]This paper presents agriculture monitoring system based on WSN with IP cameras to have close vision of plants. In this paper they have used monitoring system based of wireless sensor network which would increase the working model and principle of the project our analysis is even simpler than the processes mentioned in this paper. To make the implementation we have used Artificial intelligence which can be a better way to get accurate results at the end and will have a good functioning.

[3]Our main motto of the paper is to develop a smart farming method for the cultivation of the radish crop, collecting random sensor data of the farm would no help in monitoring the crop. We have designed a system in which we've taken selected sensors which would help us in monitoring the crop and these are the only sensors which we need in order to cultivate the radish crop. They design IoT based multiple sensor monitoring system with the help of various sensors required by storing the data randomly collected from the field.

[4]They have studied and designed various applications for the monitoring of the crop health. The developed applications were Smartphone apps in agriculture based on their working software like Android and IoS. In our study we've come to a conclusion that building just an application does not help in getting good results in smart farming. We need to study, analyse and understand the crop cultivation from seed till harvesting and need to work according to that. In our paper we've designed an app for getting the triggering and checking the condition of the crop from any remote place with machine learning and artificial intelligence included in the research.

[5] They have worked on usage of framework in farming. Regarding the Internet of Things frameworks used in the farming domain the work demonstrates the architecture of the management system of information for the smart farming process.

[6]This paper explains that through what means we can connect sensors network and agriculture using Internet of Things and create connections among agronomists, farmers and the crops excluding their geographical presence or differences. This paper reports the total designing of the sensor networks in connecting the agriculture and IoT.

[7]This paper describes about the wireless sensor networks and Internet of things in precision agriculture. They mainly focus on the smart technologies and agriculture-based applications. The author has also proposed a new way design of the irrigation system. The farmers can efficiently identify and verify the various kinds of fertilizers, irrigation, and all other essential requirements. They have used the wireless sensor network in red bayberry greenhouse using the soil moisture sensor and temperature sensor.

[8] In this paper we develop an affordable system which when developed will give us an insight into the real time condition of the crop. The system leverages the internet of things (IoT) and machine learning to produce an affordable smart farming module. The system uses state-of-the-art methods in order to improve the accuracy of the results and automate the monitoring of crops thereby requiring minimal human interventions. IoT is used to connect the ground module which includes the sensors to the cloud infrastructure. In the cloud, machine learning based real-time analytics is performed to predict the future condition of the crops based on its past data.

[9] This paper proposed an implementation of BMS (Big Data Application Machine Learning-based Smart Farm System) with emphasis crop productivity and the importance of farmer's income increase. Increasing crop productivity is also important to increase essentials income, enhance farmer field-level insights, actionable knowledge to produce when the crop is the best quality or selling it with a good price. In the smart farm system proposed in this paper specially in case of big data science, need to consider data analysis and machine learning as the most important steps and then we can include the value of big data science.

[10] In this paper they have discussed about the research work to guide them in sowing the reasonable crop by deploying machine learning, one of the advanced techniques in crop prediction. They have used Naïve Bayes, a supervised learning algorithms puts forth in the way of gaining the results. The seed data of the crops are collected here, with the appropriate parameters like temperatures, humidity and moist content. They have developed a mobile application for android. The users are encouraged to enter the parameters like temperatures and their location will be taken automatically in this application in order to start the prediction process.

[11] This paper explains about the support provided by the IoT and Machine learning techniques in the agriculture data collection, processing, and decision making services for the smart farming. This paper also describes about the general trends for applying smart farming techniques and its challenges and recommendations to cultivate differently in the desert areas of Saudi Arabia.

[12] In this paper they have proposed a model for smart irrigation system which predicts the water requirement for a crop, using machine learning algorithm. The decision tree algorithm an efficient machine learning algorithm is applied on the data sensed from the field in to predict results efficiently. The results obtained through decision tree algorithm are sent through a mail alert to the farmers, which help in decision making regarding water supply in advance.

[13] In this paper they have investigated the growth stimulation of radish sprouts using no thermal atmospheric pressure. They discharged plasmas and low pressure O_2 RF discharge plasmas. Seeds of radish sprouts are irradiated by one for the irradiation is 15-60% longer than those without irradiation. Reactive oxygen species may be involved in the growth simulation mechanism.

[14] This paper presents an experimental study on promotion of germination of radish sprout seeds with two kinds of pulse power technique, dielectric barrier discharge (BDB) in air and high current pulse(HCP) in water. They have confirmed that the germination rate is also improved by the HCP treatment. The germination rate is 60% for 30 min-HCP and It is also 60% for 60-min-HCP. The difference in the mechanism of the sprout promotion between the DBD and the HCP treatments will be discussed.

3. SYSTEM ARCHITECTURE

The hardware model is as given below, the sensors is exactly as per the diagram.

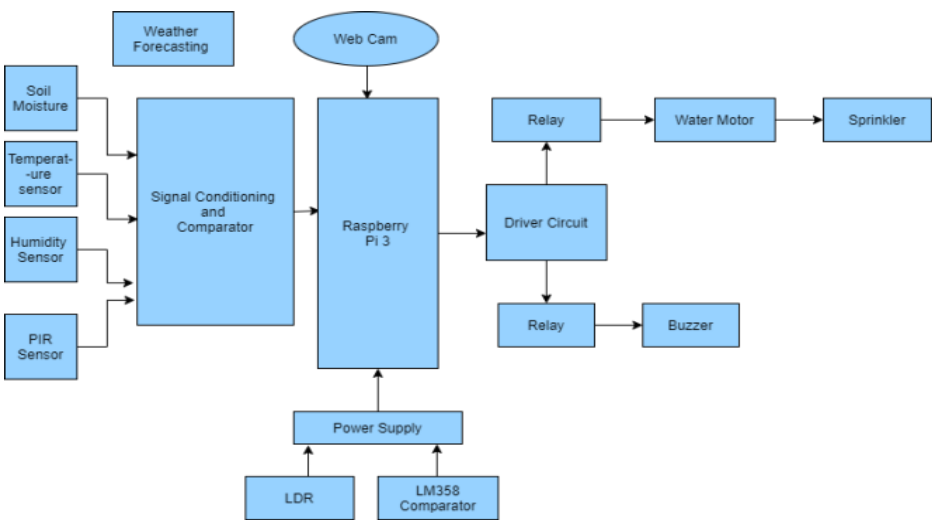

Figure 1. System Architecture

We have designed the system architecture in such a way that as soon as we see the architecture we can clearly understand the figure and can get an overall idea regarding the design. As we see the structure we will get to know the main point or what the project is designed for. We have used various sensors to retrieve the data from the crop for monitoring its health throughout its growth time period. We specifically have designed this system in order to monitor the health and growth of the radish crop from sowing process till harvesting process. As seen in the figure we have used Raspberry Pi module for interfacing the sensors.

The components used are as follows:

- **Light Detecting Resistor (LDR):**The LDR is a photosensitive device used to measure light intensity. When in dark, the resistance is very high, but the resistance falls heavily when exposed to light.
- **Soil Moisture Sensor:** This sensor is used to measure the content of water of soil. When there is shortage of water the module output is at higher level, else at lower level. It works at 5V, 20mA.
- **4 channel Relay module:** A relay is a module used to drive a component, which uses large amount of current, using a small amount of current. It works at 5V, 10A. Relays can work either as switches or as amplifiers, to amplify the small amount of current generated by the sensors.
- **6V to 9V DC Water Pump:** This is a mini water pump, working at voltage range of 6V-9V DC. Its work is to pump suck in water through a nozzle and pump id out with greater force, through another nozzle.
- **Raspberry Pi:** It is a low cost, credit-card sized computer that plugs into a computer monitor or TV, and uses a standard keyboard and mouse. The board itself contains both Wi-Fi module and Local Area Network which is easily to both hardware and software.
- **DHT11 Sensor:** Digital Humidity and Temperature sensor which gives the accurate result of the temperature which is present in the surroundings.

4. WORKING METHODOLOGY

We connect and program the Raspberry Pi, Soil Moisture sensor, DHT11, PIR and Rain drop sensor to sense the temperature, humidity, soil moisture, and motion detection and to upload sensor data automatically to the cloud.

- **Setting up ThingSpeak cloud:**

  Thingspeak is an IoT analytics platform service that allows you to aggregate and analyse live data streams in the cloud. Thingspeak is an open IoT platform for monitoring the data online. This system uses ThingSpeak cloud to store the sensor data automatically. To use the ThingSpeak cloud we should create one free account and add a new channel with two fields temperature and humidity respectively. After that copy the write API key from the ThingSpeak cloud. Put the write API key in your code.

- **Machine Learning algorithm:**

Machine Learning is a form of AI that enables a system to learn from data rather than explicit programming. However, Machine learning is not a simple process. As the algorithms ingest training data, it is then possible to produce more precise models based on the data. A machine learning model is the output generated when you train your machine machine-learning algorithm with the data. After training when we provide the model with an input, we will be given an output.
There are various approaches to machine learning:

1. Supervised learning
2. Unsupervised learning
3. Reinforcement learning
4. Deep learning

Deep learning technology accurately detects the presence of pests and diseases in the crop. The machine learning algorithm CART also can accurately predict the chances of having the pest attacks or diseases in the future. Neural Network Toolbox provides algorithms, previously trained models and various applications to create, train them and visualize and to simulate the deep neural networks.
For the training sets which are smaller to develop we can easily use the deep learning just by performing the transfer learning with pertained deep neural networks (eg. Google Net) and import models from the Tensor Flow.

Features	CART	C4.5	ID3
Types of data	Continuous and nominal attributes data.	Continuous and categorical	Categorical
Speed	Average	Faster than ID3	Low
Pruning	Post pruning	Pre-pruning	No
Boosting	Supported	Not supported	Not supported

About CART Algorithm:

- The Representation for the CART model is a binary tree.
- CART is known as **Classification and Regression Tress for Machine Learning.**
- This is your binary tree from algorithms and data structures, nothing too fancy. Each root node represents a single input variable (x) and a split point on that variable as assuming the variable is numeric.
- The leaf nodes of the tree contain an output variable (y) which is used to make a prediction. Given a dataset with two inputs (x) of height in centimetres and weight in kilograms the output.

- Creating a CART model involves selecting input variables and split points on those variables until a suitable tree is constructed.
- The selection of which input variable to use and the specific split or cut-point is chosen using a greedy algorithm to minimize a cost function. Tree construction ends using a predefined stopping criterion, such as a minimum number of training instances assigned to each leaf node of the tree.

Pruning the tree:

The stopping criterion is important as it strongly influences the performance of your tree. You can use pruning after learning your tree to further lift performance.

The complexity of a decision tree is defined as the number of splits in the tree. Simpler tress are preferred. They are easy to understand you can print them out and show them to subject matter experts and they are less likely to over fit your data.

The fastest and simplest pruning method is to work through each leaf node in the tree and evaluate the effect of removing it using a hold-out test set. Leaf nodes are removed only if it results in a drop in the overall cost function on the entire test set. You stop removing nodes when no further improvements can be made.

More sophisticated pruning methods can be used such as cost complexity pruning also called weakest link pruning where a learning parameter alpha is used to weigh whether nodes can be removed based on the size of the sub-tree.

Difference between CART algorithm and ID3, C4.5 algorithms:

CART does binary splits whereas ID3 and C4.5 and family, exhaust one attribute once it is used. This makes a difference sometimes which means that in CART the decisions are taken on how to split values based on an attributes are delayed.

This means that there are pretty good chances that CART might catch better splits than C4.5.

ID3 as an “Iterative Dichotomises” is for binary classification only. CART or “Classification and Regression Trees”, is a family of algorithms (including, but not limited to, binary classification tree learning). With part ( ), you can specify method=’class’ or method=’a nova’, but apart can infer this from the type of dependant variable (i.e., factor or numeric). Loss functions used for split selection.

CART, when used for classification, selects its splits to achieve the subsets that minimize Gini impurity anecdotally, whereas CART is often used as a catch-all term for decision trees. CART has a very popular implementation in R's rpart package. ?rpart notes that "in most details if follows Bramante. Al (1984) quite closely."

ID3 and C4.5 use Sharon Entropy to pick features with the greatest information gain as nodes. As an example, let us assume we would like to classify animals. We would probably ask more general questions (like "is it a mammal") first and once confirmed continue with more specific questions. CART uses Gini impurity instead. Gini impurity is a measure of the homogeneity of the nodes. If all the data points at one node is belong to the same class then this node is considered "pure".

So by minimizing the Gini impurity the decision tree finds the features of the separate the data.

- **Steps to flash the code using Raspberry Pi :**

  a) Connect Raspberry Pi board with the help of power cable and HDMI cables and open Python IDE.
  b) We need to download the Adafruit Python libraries which is most important for the DHT11 Sensor execution.
  c) We need to connect all required sensors as per the VCC, GND and GPIO pins mentioned in the Python program.
  d) Enter the API key in the Program to write your sensor data to the cloud.
  e) Now, open the command prompt and run the code and you can see the current execution process of the code

  .

5. IMPLEMENTATIONS:

The main aim of this project is to study, analyse and monitor the crop health of radish from sowing process to harvesting process. The crop will be monitored from day-1 till its harvest time. We implement various sensors in the field and collect the data of the crop at several times based on the time intervals. As we mentioned the various types of sensors that we have interfaced like soil moisture sensor, temperature and humidity sensor etc. Sensors placed among the farms monitor the crop for changing in light, humidity, shape and size. Any anomaly is detected by the sensor is analysed and the farmer is notified using e triggering. Thus remote sensing can help to prevent the spread of diseases and keep an eye on the growth of the crop. We will be providing some predefined threshold values so that when the sensors detect other values we can immediately check for the condition of the plant. Under average weather conditions the crop matures in 3-4 weeks, but in colder climatic conditions it takes around 6-7 weeks.

It has some of the specific climatic condition which are needed to be considered:

Temperature: 18-25°C

Rainfall: 100-225cm

Sowing Temperature: 20-25°C

Harvesting Temperature: 18-20°C

PH level: 6.5-7.0

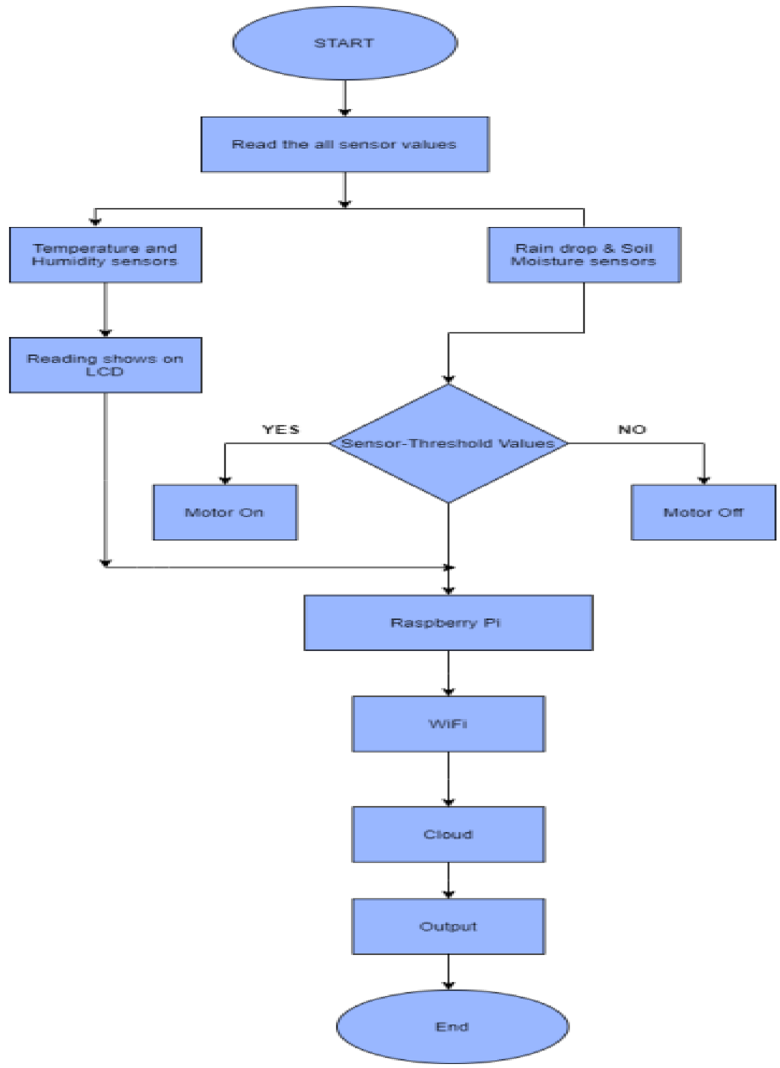

Figure 2. Flow Chart

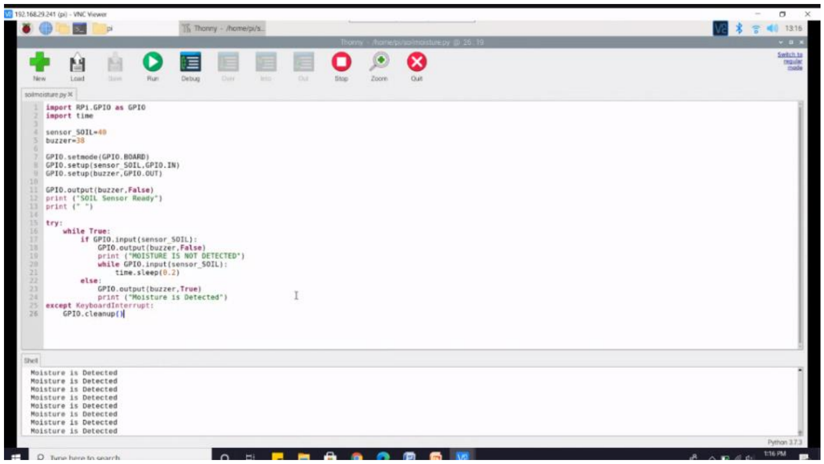

Figure 3. Code the main activity

6. RESULTS AND DISCUSSION

Figure 4. Intial Stage of the Raddish Crop

Figure 5. Growth of the Raddish Crop

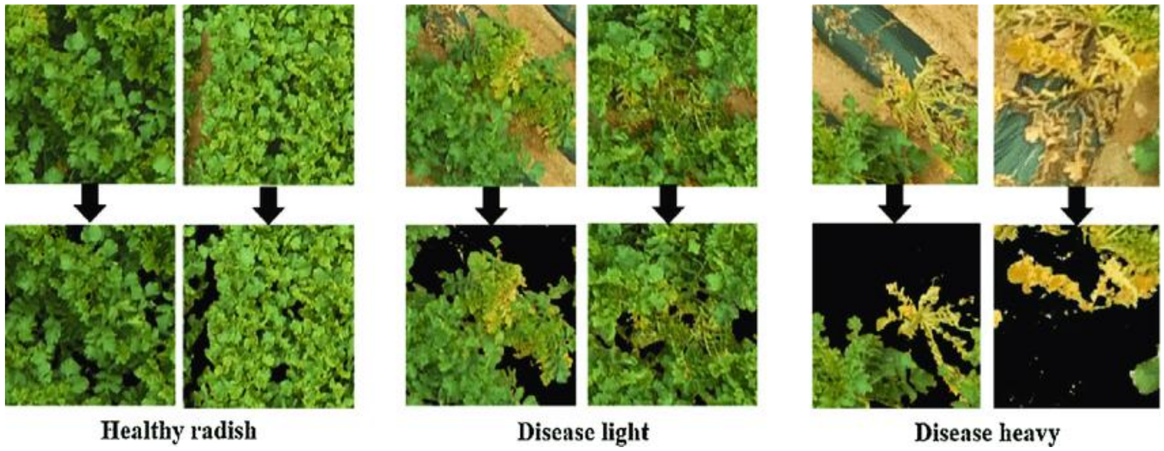

Figure 6. Disease Detected Using ML Algorithm

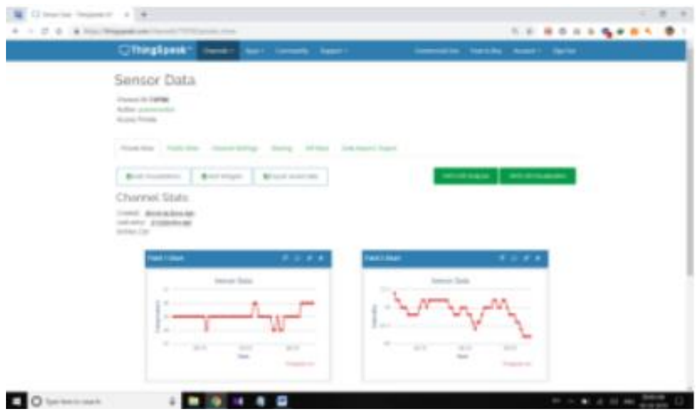

Figure 7. After Successful automatic data upload

7. APPLICATIONS OF THE SYSTEM:

[1] Monitoring of soil moisture percentage, temperature, humidity to prevent crop damages. We can use this system to monitor any kind of crops.
[2] Use this system to monitor concrete setting.
[3] Monitoring of room temperature like vegetables and fruits warehouses.
[4] Use this system to monitor building moisture levels.
[5] Monitoring the temperature of machines in factory to prevent machines from damages.

8. CONCLUSION

The paper implement a simple and low price monitoring system by means of temperature & humidity sensor DHT11, Soil moisture sensor and Raspberry Pi board to collect environment changes and transmit this data to the cloud through Wi-Fi and monitor the real time progress through the cloud. The stick has high efficiency and accuracy in fetching these live data. The agriculture stick being proposed via this paper will assist farmers in increasing the agriculture yield and take efficient care of food production as the stick will always provide helping hand to farmers for getting accurate live feed of environmental results.

9. FUTURE SCOPE

Future work would be focused more on increasing sensors on this stick to fetch more data especially with regard to Pest Control and by also integrating GPS module in this system to enhance this agriculture IoT technology to full-fledged Agriculture precision ready product.

10. ACKNOWLEDGEMENT

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