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Agriculture Productivity Enhancement System using IOT

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Abstract

Agriculture sector is the backbone of Indian economy. The major challenge in agriculture is to promote the cultivation in the farm and deliver it to the end consumers with the best possible quality. In order to achieve ever increasing quantity and quality demands, technological innovations must be explored. The traditional methodologies can be integrated with latest technologies as Internet of Things (IoT) and Wireless Sensor networks (WSNs) to enable various applications in Digital Agriculture Domain.

Rice is the most important food crop of India. Over 90% of World's rice is produced and consumed in Asia-Pacific region. It has served as a host of number of diseases and insect-pests. The major ones causing economic losses in any rice growing country are: bacterial, fungal and viral diseases. Temperature and type of the soil are the major components to be considered for optimal growth. Based on these components, a system is proposed that mainly focuses on the methods to predict the various diseases affecting the crop growth and to inform the farmer, the ratio of pesticides to be used to reduce the risk caused by excessive usage of pesticides both on human health and environment.

This system uses Supervised Machine Learning Algorithm such as C4.5 for classification analysis.

1. INTERNET OF THINGS (IoT)

1.1 INTRODUCTION

The "Internet of things" (IoT) is becoming an increasingly growing topic of conversation both in the workplace and outside of it. The Internet of Things (IoT) is a system of interrelated computing devices, mechanical and digital machines, objects, animals or people that are provided with unique identifiers and the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction.

The IoT allows objects to be sensed or controlled remotely across existing network infrastructure, creating opportunities for more direct integration of the physical world into computer-based systems, and resulting in improved efficiency, accuracy and economic benefit in addition to reduced human intervention. Each thing is uniquely identifiable through its embedded computing system but is able to interoperate within the existing Internet infrastructure.

Typically, IoT is expected to offer advanced connectivity of devices, systems, and services that goes beyond machine-to-machine (M2M) communications and covers a variety of protocols, domains, and applications.

1.2 IMPORTANCE OF IOT IN AGRICULTURE

The Internet of Things (IoT) is transforming the agriculture industry and enabling farmers to contend with the enormous challenges they face. New innovative IoT applications are addressing the issues in agriculture by increasing the quality, quantity, sustainability and cost effectiveness of agricultural production. Of the many advantages IoT brings to the table, its ability to innovate the landscape of current farming methods is absolutely groundbreaking. IoT sensors capable of providing farmers with information about crop yields, rainfall, pest infestation, and soil nutrition are invaluable to production and offer precise data which can be used to improve farming techniques over time.

1.3 WHY IoT IN AGRICULTURE?

The IoT is set to push the future of farming to the next level. The Internet of Things is a huge opportunity for farmers to monitor their crops and increase productivity.

For farmers and growers, the Internet of Things has opened up extremely productive ways to cultivate soil and raise livestock with the use of cheap, easy-to-install sensors and an abundance of insightful data they offer.

Prospering on this prolific build-up of the Internet of Things in agriculture, smart farming applications are gaining ground with the promise to deliver 24/7 visibility into soil and crop health, machinery in use, storage conditions, animal behavior, and energy consumption level.

Today, more than ever before, farmers, ranchers, and conservationists need a method to more effectively utilize and conserve resources. The most effective way to do this is through actionable data, and utilizing Machine to Machine communication makes the ongoing collection of that data simple and affordable.

Agriculture Internet of Things helps in increasing crop productivity by way of managing and controlling the activities. One of them is Integrated Pest Management.

1.4 INTEGRATED PEST MANAGEMENT

Often the farmer's hard work is destroyed by pests leading to huge monetary losses. To prevent such situation, Agriculture Internet of Things is useful. This system monitors and scans the environmental parameters & plant growth. Further this data is utilized by pest control sensors that are capable of predicting pest behavior. This will help the farmers to reduce the damage done by pests on a large scale.

Thus Pest Management & Control works on the fundamental bases which are as follows –

Observation

Inspection

Identification

Record Tracking

2. OBJECTIVES OF THE PROPOSED SYSTEM

- To improve plant productivity.
- To identify the diseases depending on environment.
- To achieve efficient utilization of the pesticides.

3. ANTICIPATED TECHNOLOGIES

- The following technologies will be used for implementing the Proposed System.
- Web Application : PHP, Cloud MongoDB, JSON
- Mobile Application : Android, Cloud MongoDB
- Data Analysis : R-Programming, Cloud MongoDB
- IoT Technologies: Arduino, and Sensors - DHT11, Soil Moisture Sensor, Soil pH Value Sensor , ESP8266 (Wifi Sensor)

4. INNOVATION

- To achieve the above mentioned objectives, the proposed system will be implemented through IoT Technology.

- Connection establishment is the first step where Arduino will be connected with DHT11, Soil Moisture Sensor, Soil pH Value and Wi-Fi Sensor representing a node.
- Nodes like these are installed at different locations in paddy field. The data captured through these nodes are collected and stored in Cloud MongoDB database.
- The stored data will then be analyzed by using Decision Tree Algorithm with R-Programming and Cloud MongoDB.
- The pattern obtained will get stored into Cloud MongoDB which predicts the damage going to be caused to the field and shows the combination of pesticides to be used to reduce the harm caused by excessive usage of pesticides at the later stage.
- This information will be displayed through mobile application to the end user (farmer).
- Web Application dashboard periodically monitors Quality of Soil, and forecasts the Weather.

5. PROTOTYPE DESIGN

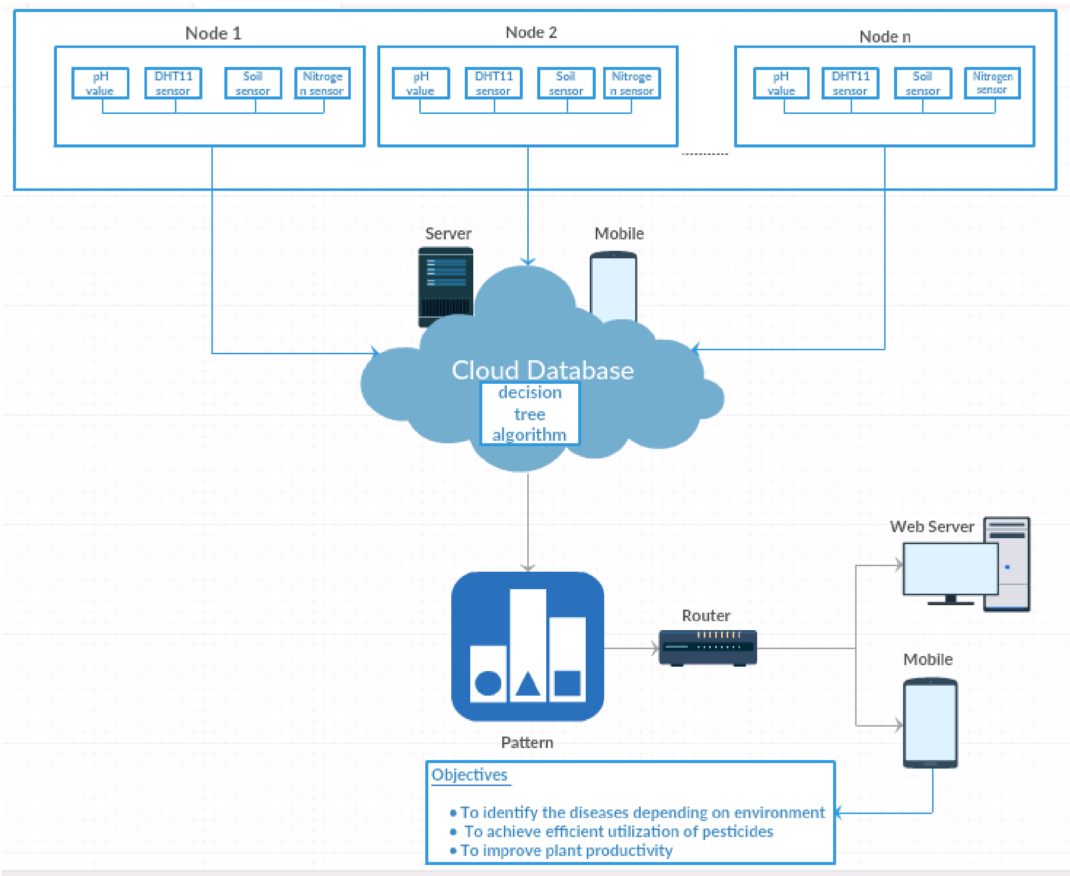

Figure 1: Architecture of the Proposed System

Here, the proposed architecture specifies that, on the top most level is the set of nodes where each node consists of Arduino circuit and sensors connected together. The nodes periodically collect the sensed data. The nodes then transmit the data to the cloud database. The client server application designed, use the data stored in the cloud DB, and generates interesting patterns. These measures are processed by the server using decision tree algorithm and send the desired output to the client (farmer) mobile or web application through smart phone.

6. MODEL OVERVIEW

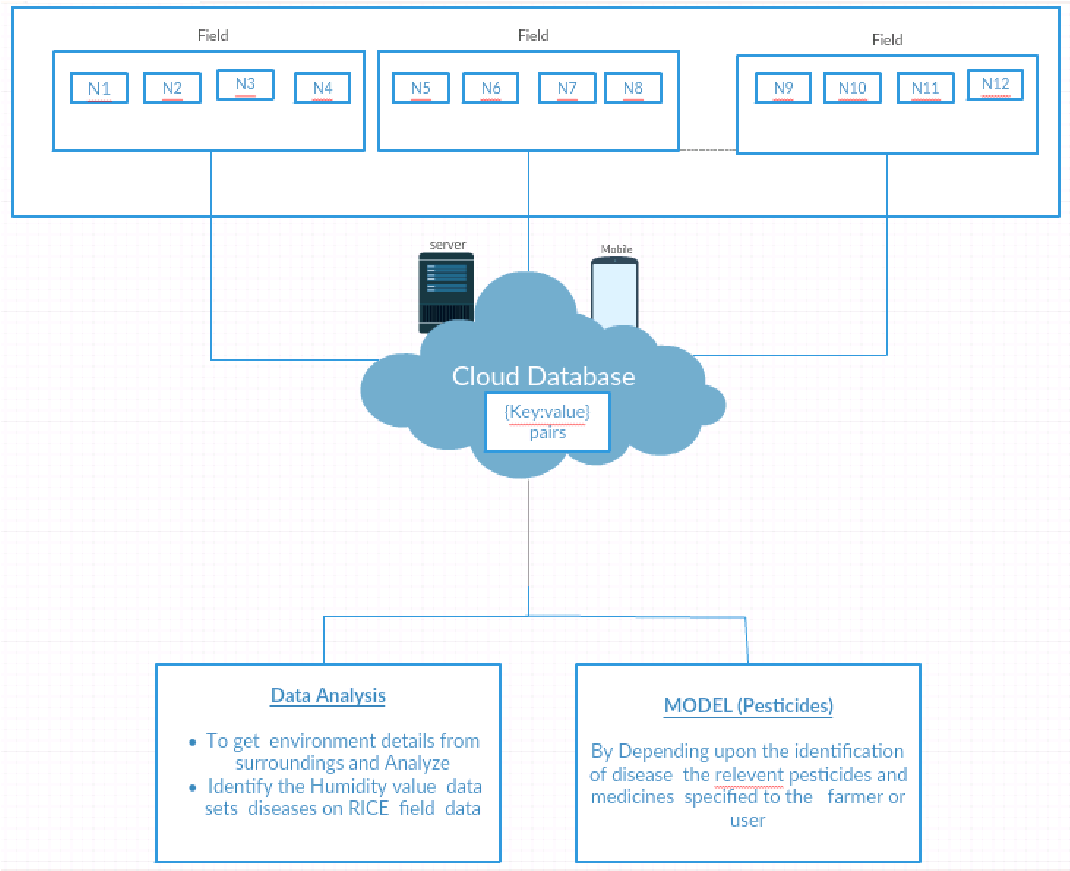

Figure 2: Model Overview

In the Proposed model, A node is a combination of pH sensor, DHT11 (Temperature, Humidity) sensor, Soil moisture sensor and Nitrogen sensor. Nodes are then installed in agricultural fields. A field may contain multiple nodes depending on the farm size. The data collected such as temperature, soil moisture, humidity from these sensors is stored in the cloud database.

7. NODAL REPRESENTATION

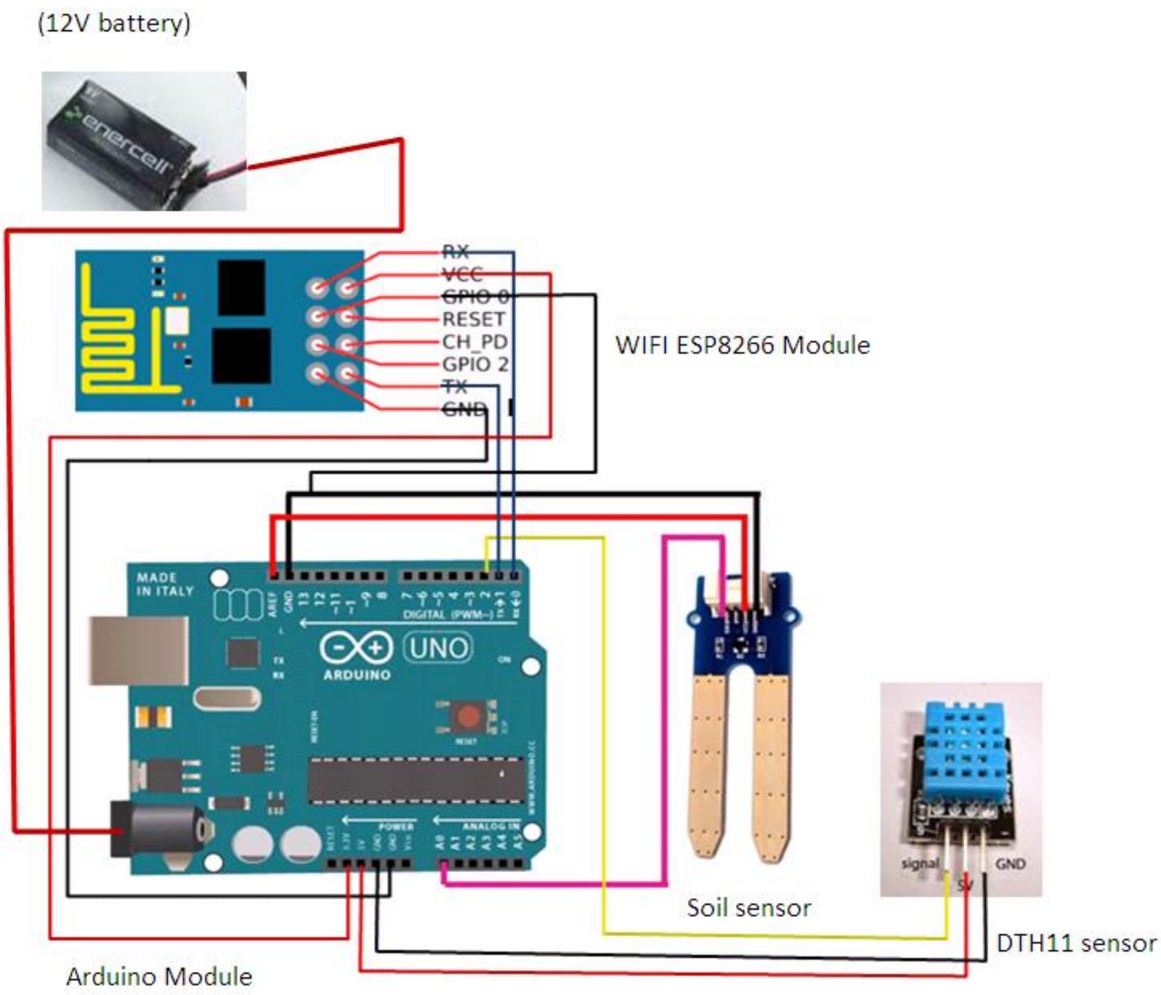

Figure 3: Reperesentation of Node

As shown in the above circuit diagram, The circuit consists of five major components Power Supply (Battery), ESP8266 (WIFI Module), Arduino UNO board, Soil Moisture sensor and (DHT11) Temperature and Humidity sensor.

To begin with, the WIFI module consists of 8 pins. In this,

1) The GND pin of the WIFI module is connected to the GND of the Arduino UNO board.
2) TX and RX pins of the WIFI module is connected to the TX and RX pins of the Arduino UNO board correspondingly.
3) VCC pin of the WIFI module is connected to 3.3v of the Arduino UNO board.
4) GPIO 0 pin of the WIFI module is connected to the GND of the Arduino UNO board.

Connections between Arduino UNO board and Soil moisture sensor:

1) The 5v pin of the Arduino UNO board is connected to the VCC pin of the soil moisture sensor.
2) The GND pin of the Arduino UNO board is connected to the GND of the soil moisture sensor.
3) The A0 pin of the Arduino UNO board is connected to the Analog Data pin of the soil moisture sensor.

Connections between Arduino UNO board and temperature and humidity sensor (DHT11):

1) The GND pin of the Arduino UNO board is connected to the GND of the DHT11.
2) The 5v pin of the Arduino UNO board is connected to the VCC pin of the DHT11.
3) The digital pin 2 of the Arduino UNO board is connected to the Data pin of the DHT11.

The total circuit is connected to 12v battery for power supply.

8. RESEARCH METHODOLOGY

Based on the prototype design, there is a need to analyze the data and predict the harmful diseases affecting the farm. Predicting the right disease from the real time data is very difficult. So, to effectively forecast the disease, the mechanism being adopted is C4.5 machine learning decision tree algorithm .

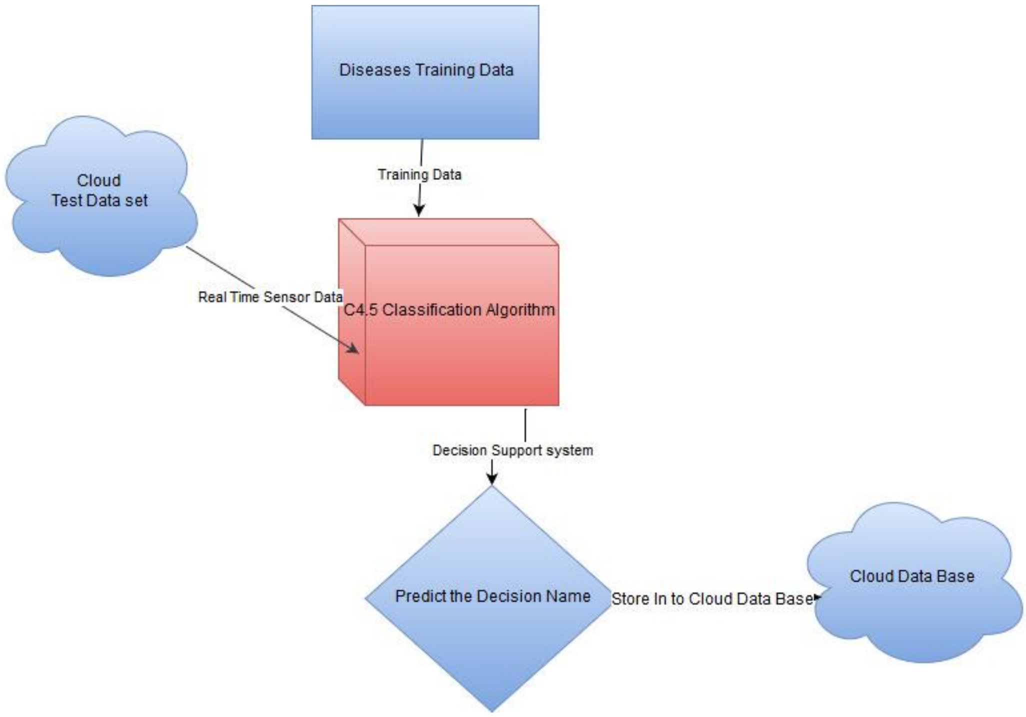

Figure 4: Data Model for Diseases Identification Process

Decision tree algorithm contains the characteristics like: 1) describing the Pattern Recognition process, 2) and to learn (or to "teach" a machine) how to classify objects, through the analysis of an instances set, whose classes are known.

Depending on the classes of an instances set (or training set), several algorithms may discover the way the attributes-vector of the instances behaves, to estimate the classes for new instances. One manner to do this is through Decision Trees (DT's).

C4.5 builds decision trees from a set of training data in the same way as the traditional algorithm ID3, using the concept of information entropy. The training data is a set of already classified samples. Each sample consists of a p-dimensional vector , where they represent attribute values or features of the sample, as well as the class in which falls.

At each node of the tree, C4.5 chooses the attribute of the data that most effectively splits its set of samples into subsets enriched in one class or the other. The splitting criterion is the normalized information gain (difference in entropy). The attribute with the highest normalized information gain is chosen to make the decision. The C4.5 algorithm then recurs on the smaller sub lists.

This algorithm has a few base cases.

- All the samples in the list belong to the same class. When this happens, it simply creates a leaf node for the decision tree saying to choose that class.
- None of the features provide any information gain. In this case, C4.5 creates a decision node higher up the tree using the expected value of the class.
- Instance of previously-unseen class encountered. Again, C4.5 creates a decision node higher up the tree using the expected value.

Pseudo code of C4.5

1. Check for the above base cases.
2. For each attribute *a*, find the normalized information gain ratio from splitting on *a*.
3. Let *a_best* be the attribute with the highest normalized information gain.
4. Create a decision *node* that splits on *a_best*.
5. Recur on the sublists obtained by splitting on *a_best*, and add those nodes as children of *node*.

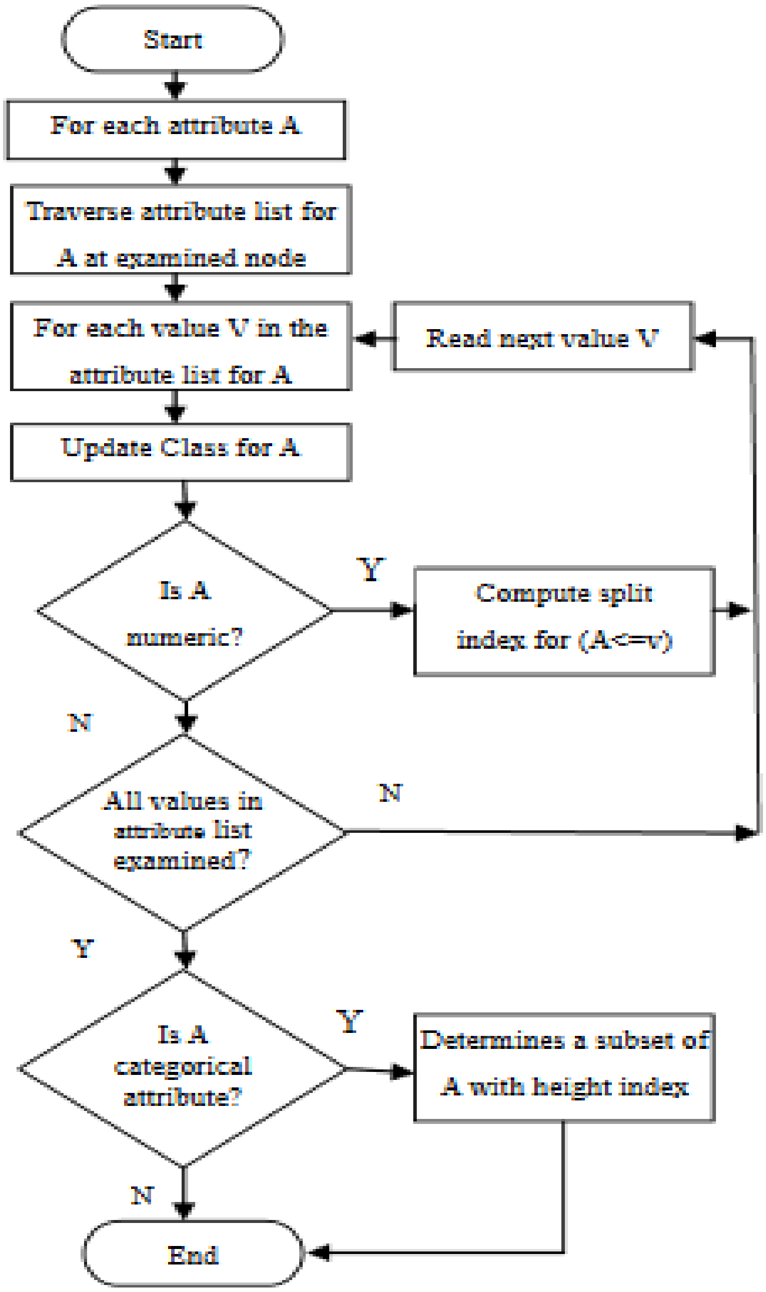

Figure 5: C4.5 - Flow Diagram

SNO	TEMPERATURE	HUMIDITY	SOIL MOISTURE	DISEASES
1.	High	High	Wet	Sheath Blight
2.	Low	High	Wet	Bacterial Blight
3.	Low	High	Moderate	Rice Blast
4.	Low	High	Wet	Sheath Rot
5.	Low	High	Moist	Brown Spot
6.	Low	High	Moist	Narrow Brown Spot
7.	High	High	Moist	Bacterial Leaf Streak

Sample Training Set:

Here the training data carried out as a diseases data sets as shown below. The training data set is applied to c4.5 classification algorithm and evaluates the model to test the real time data set.C4.5 algorithm prunes the real-time data set and constructs the decision tree to generate the rules.

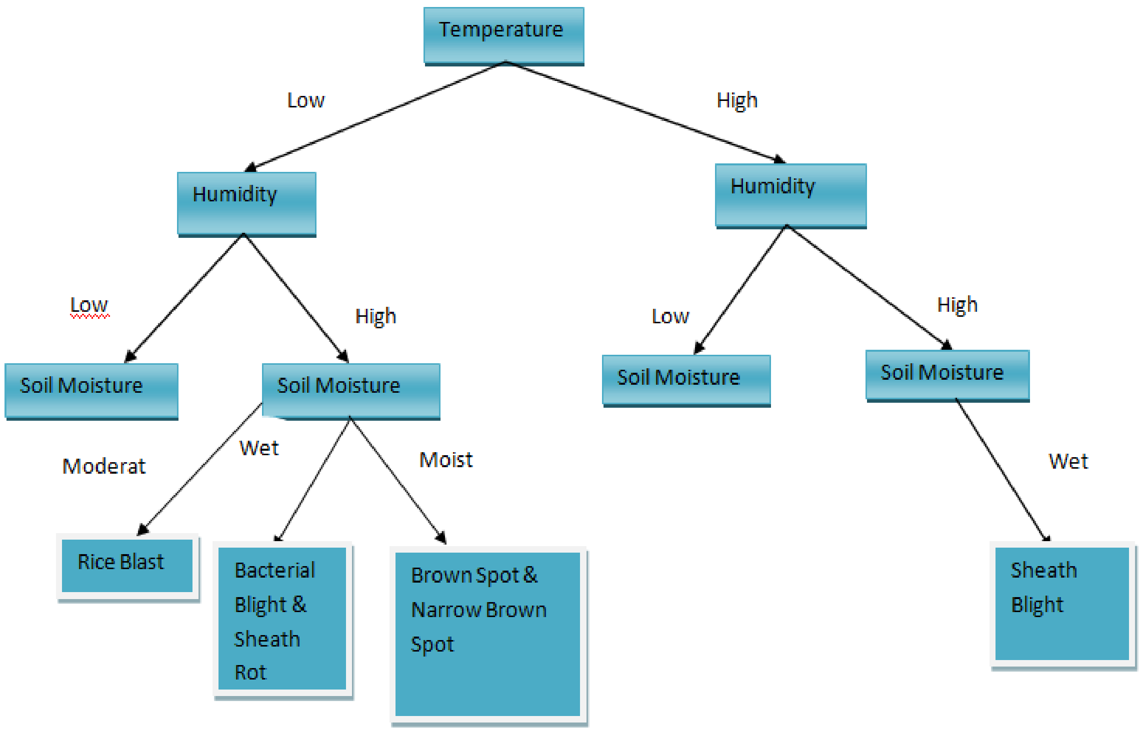

Figure 6: C4.5 Pruning the decision tree and rule generation

9. CONCLUSION

To promote the cultivation in the farm and deliver it to the end consumers with the best possible quality and to achieve ever increasing quantity and quality demands, technological innovations must be explored. The traditional methodologies can be integrated with latest technologies as Internet of Things (IoT) and Wireless Sensor networks (WSNs) to enable various applications in Digital Agriculture Domain. Hence a new IoT based Agriculture System is proposed to overcome the economic losses by predicting and preventing the harmful diseases affecting the farm. This system informs the farmer, the proportion of pesticides to be used to enhance the agricultural growth and productivity. It also helps in reducing the risk drawn from over usage of pesticides by adopting the Supervised Machine Learning Algorithm such as C4.5 for classification analysis.

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