Smart Management of Crop Cultivation using IOT and Machine Learning

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Abstract - *Agriculture is the basic and most important profession of our country as it balances the food requirement and also the essential raw materials for several industries. The implementation of smart technology in agriculture practices needs to be focused on for better land productivity. Internet of Things (IoT) technology has brought a revolution to each and every field of common man's life by making everything smart and intelligent. The development of Intelligent Smart Farming devices based on IoT is day by day turning the face of agriculture production by not only enhancing it but also making it cost-effective and reducing wastage. The aim of this paper is to propose a Novel Smart IoT based Agriculture system that can assist farmers in crop management by getting Live Data (Temperature, Soil moisture content) for efficient environment monitoring which will enable smart farming and increase their overall yield and quality of products. The Agriculture system proposed in this paper is an integration of the concepts of Machine learning and IOT using an Arduino board and various sensors, through which live data feed can be obtained and accessed online on Thingspeak.*

***Keywords*: Agriculture, Smart farming, KNN Prediction, NodeMCU, IOT, Sensors, Machine Learning, Analytics.**

1. INTRODUCTION

Internet of Things has marked its importance in all fields and the strength and adaptability of IoT has changed and nowadays it is being used by a normal user. It has developed numerous methodologies to make our living easier and more comfortable like smart living, e-health services, automation and even smart education. As the world is trending into new technologies and implementations it is a necessary goal to trend up in agriculture also. The World Bank says we'll need to produce 50% more food by 2050 if the global population continues to rise at its current pace. But the effects of climate change could see crop yields falling by more than a quarter. So autonomous tractors, ground-based sensors, flying drones and enclosed hydroponic farms could all help farmers produce more food, more sustainably at lower cost. Thus, the need for smart agriculture is increasing exponentially.

To observe the growth of the crop under varying real-world conditions (e.g., soil quality, environmental conditions, etc.), typical crop studies involve phenotyping to understand the key factors (e.g., the pH levels of soil, the rate of Nitrogen depletion) affecting growth. Such studies are conducted in natural outdoor environmental conditions and locations where plants are growing, by varying irrigation and the application of fertilizers/additives. Internet of Things (IoT) technologies can lower the cost and increase the scale of such studies via the collection of related time series data from sensor networks, spatial data from imaging sensors, and human observations recorded via mobile smart phone applications. For example, IoT devices can help to capture the pH levels of soils and the rate of Nitrogen depletion as time-series data, and share it among interested researchers and growers for further analysis.

The proposed model deals with predicting crop suitability by gathering information from sensors that present the following values:

- Temperature of the environment
- Humidity of the environment
- Moisture content of soil
- Light Intensity
- Gas Presence

1.1 Existing Systems

A full fledged research was done and the following existing systems were found to show various implementations of machine learning algorithms using IOT to retrieve accurate crop predictions.

A paper presented an approach with three recommendation systems based on past data. Since efficiency of random forest algorithm is higher than naïve bayes and ID3, it uses random forest algorithm to predict appropriate crop based on current NPK value of soil.[1]However random forest algorithm doesn't deal with large number of categories in categorical variable. Another crop rotation recommendation system is described in this paper which uses FP tree. It also provides recommendation for appropriate fertilizers using sufficiency method.[2] However this method would put additional pressure on soil to match its fertility with required conditions thus degrading the soil condition.

Another system proposes recommendation systems for predicting suitable crops based on NPK values of soil. [3]The system provides the notification using SMS service which include the recommended crop. Naive bayes algorithm is used to predict most suitable crop. However computation of naïve bayes is more complex when compared to KNN algorithm.

2. PROPOSED SYSTEM

The sensors to be used are:

- Temperature and Humidity Sensor (DHT11)
- Gas and Smoke Sensor (MQ2)
- Soil Moisture Sensor
- Light Intensity Sensor

The sensors mentioned above are added to the field for which the readings are needed to be calculated. The DHT11, MQ2, Soil Moisture Sensor, Light Intensity Sensor sends the readings in real time to the cloud server which in which the processing occurs. The data accumulated in the cloud is displayed to the user in a webpage. Machine Learning Algorithm(KNN) is used to calculate the crop which is best to grow in the particular field based on the values received at real time. A standardized dataset containing the minimum requirements for a particular crop is maintained and is used for the prediction of the crop. The data is also plotted in real time so that the user can get an idea as to how the current conditions are and threshold for the crop which is predicted. The system also consists of a Virtualization Page where each data collected from the field is plotted with respect to the time of arrival to the cloud server. The system will also send an email informing about the condition of the crop.

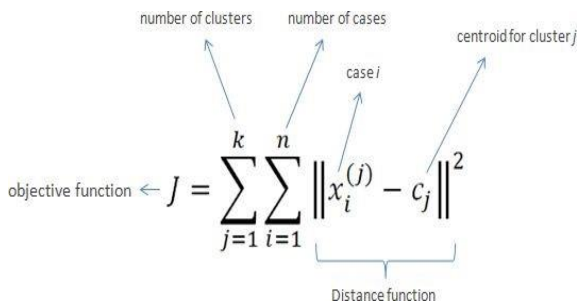
2.1 ALGORITHM

KNN Clustering: k-NN is a type of instance-based learning, also called as lazy learning, where the function is only approximated locally and all computation is put on hold until classification. The neighbours are taken from a set of objects for which the class (for classification) or the object property value (for regression) is known. This can be thought of as the training set for the algorithm, training step is not required as such. The training examples given as inputs are vectors in a multidimensional feature space, each with a class label. The training phase of the algorithm consists only the feature vectors and class labels of the training samples.

In the classification phase, k is a user-defined constant, and an unlabelled vector (a value) which is classified by assigning the label which is most frequent among the k training samples nearest to that value point.

The reason for considering this algorithm for classification are its advantages:

- Implementation is simple.
- Classes do not have to be linearly separable in space.
- Classifier can be updated at that moment at very little cost as new instances with known classes.
- The parameter is few which are distance metric and number of k.



$$J = \sum_{j=1}^{k} \sum_{i=1}^{n} \left\| x_i^{(j)} - c_j \right\|^2$$

Fig. 1: kNN algorithm formula for calculation

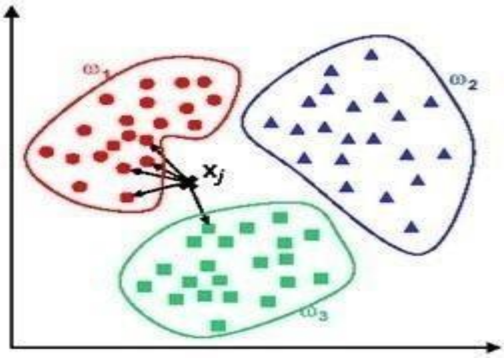


Fig. 2: Cluster formation in kNN

2.2 HARDWARE COMPONENTS

NodeMCU

NodeMCU is an open source IoT platform primarily used as a mode of Internet communication. It includes firmware which runs on the ESP8266 Wifi System on Chip, and hardware which is based on the ESP-12 module. The term "NodeMCU" is used to refer the firmware rather than the development kits. The firmware uses the Lua or Arduino scripting language. It is based on the eLua project, and built on the Non-OS SDK for ESP8266. It uses open source projects, such as lua-cjson, and spiffs.

DHT11

The DHT11 is a low-cost digital temperature and humidity sensor used with Arduino products. It uses a capacitive humidity sensor and a thermistor to measure the surrounding air, and sends a digital signal on the data pin to the Arduino board. It is fairly simple to use, but requires careful timing to receive the data. The only downside of this sensor is that the user can only get new data once every 2 seconds, so when using library, sensor readings can be up to 2 seconds old.

MQ2

MQ2 gas sensor can be used to detect the presence of LPG, Propane and Hydrogen, also could be used to detect Methane and other combustible steam, with low cost and suitable for this said application. Sensor is sensitive to flammable gas and smoke. The smoke sensors requires 5V power. Smoke sensor indicates the content of air by voltage. More smoke meaning more voltage. A potentiometer is provided to adjust the sensitivity. Sn02 sensor is used, which is of low conductivity, when the air is clean. But when smoke exists in air, an analog output is produced based on the concentration of smoke. The circuit also carries a heater. Power is given to heater by the VCC and is grounded by GND from power supply. The circuit has a variable resistor.

Soil Moisture Sensor

The Soil Moisture Sensor is a simple sensor for measuring the moisture in soil and similar plasmatic materials. The two large exposed pads connected to chip function as probe for the sensor, acting as a variable resistor. The more water means that is in the soil means the better the conductivity between the pads will be and will result in a lower resistance, and a higher signal value will be out.

Light Intensity Sensor

A light sensor is a device used for measuring the intensity or brightness of light. One of the most common that can be used when building a light sensor is a photoresistor. Photoresistors, which also called light detecting resistors are made from cadmium sulfide cells that are sensitive to visible and near infrared light. The resistance of a cadmium sulfide cell varies inversely with the amount of light incident upon it i.e, bright light causes a low resistance between the two leads of the cell and low light creates a higher resistance. This module is mainly adjusted to calculate the intensity of the light from sun falling on the field.

2.3 DATASET USED

Government of Tamil Nadu under National Agricultural Development Project (NADP) have funded for establishing Tamil Nadu Agricultural Weather Network (TAWN) by installing 385 AWS, 224 in the first phase and 161 in the second phase.The Agro Climate Research Centre (ACRC), Directorate of Crop Management(DCM), Tamil Nadu Agricultural University (TNAU), Coimbatore in collaboration with Department of Agriculture, Tamil Nadu established the TAWN. In the network, numerous types of agricultural related weather parameters from 385 AWS are collected at hourly interval and hosted in this website.

This data is taken as training set for the kNN machine which is setup, which would use this data to form the k-Neighbour clusters. The real-time data points are then put in the kNN machine to determine the nearest neighbour which would yield the result of crop that would be optimum to grow on that field during that period of time.

2.4 METHODOLOGY

The main aim of the suggested system is to take various sensor readings from the soil and predict the type of crop that is the most suitable to grow for that particular type of soil. The project has three main components:

i) The Front End- A website, which is used to access the Dashboard displaying the values from the sensor, the Visualization of the data that is accumulated and the Crop Prediction, where the user is suggested with the suitable crop by the given parameters.
ii) Firebase Cloud- The data taken from the sensors are sent and stored in the Firebase cloud interface from which the data is read and analyzed.
iii) The Hardware- The different sensors which are used to collect various data from the soil and its environment are connected to the

NodeMCU module which sends the data to the Firebase cloud. The data is sent at fixed intervals to avoid overloading the cloud.

Thus, the data is collected from the sensors and stored in the Firebase cloud. This data is accessed using a website, where data can be analyzed using Visualizations and also crop suitables for that particular soil can be predicted. The real time readings can also be viewed along with the average reading.

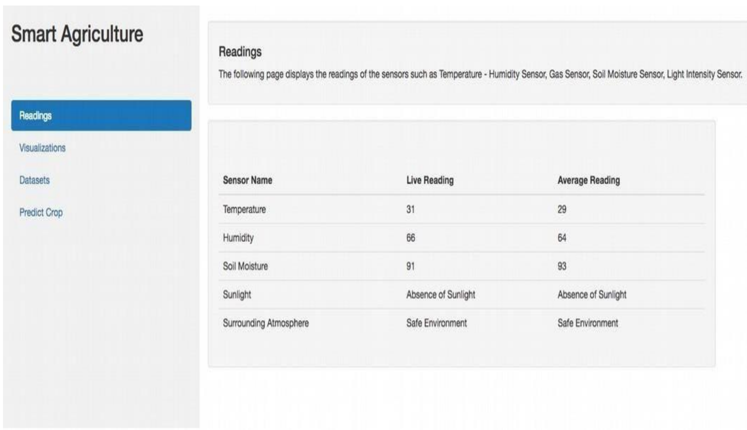


Fig. 3: Front end

3. CONCLUSIONS

The system was programmed to be trained from the given dataset by the Machine Learning algorithm from the dataset given and the accuracies are listed below. The results were noted.

Table 1. Values obtained from a soil instance(in real time).

Temperature	Humidity	Soil Moisture	N-P-K
29	59	90	2-1-1

Table 2. The threshold value for the crop predicted.

Crop	Temperature	Humidity	Soil Moisture	N-P-K
Rice	27.5	70	75	2-1-1

Thus, by using the real time values obtained from the field and running the algorithm on them, the most suitable crop for a particular land at a given time is predicted.

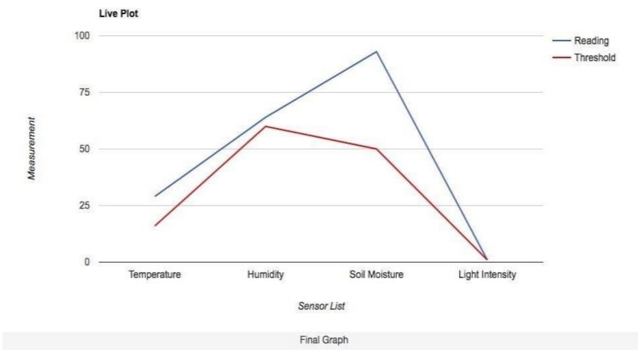


Fig. 4: Threshold vs actual crop value

The proposed system can be of immense use to farmers in the following ways:

- Through the web application, the farmer can easily send available soil N-P-K content as well as the crop and soil variety in the web application portal.
- The website can be easily accessed by farmers from any location and at any time and allows end users to remotely monitor and control their connected farm.
- Smart Agricultural practices have great potential to generate additional income. This model is particularly profitable with low initial investments.
- Furthermore, since the system provides greater climate adaptation and mitigation, when considering these factors the overall benefit of adopting the model is even greater.

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