Smart Crop Prediction using IoT and Machine Learning

Archana Gupta
Computer Engineering
K.J. Somaiya Of Engineering
Mumbai, India

Dharmil Nagda
Computer Engineering
K.J. Somaiya Of Engineering
Mumbai, India

Pratiksha Nikhare
Computer Engineering
K.J. Somaiya Of Engineering
Mumbai, India

Atharva Sandbhor
Computer Engineering
K.J. Somaiya Of Engineering
Mumbai, India

***Abstract*— Agriculture is a key economic driver. It is a key to healthy biosphere. People depend on a wide range of agricultural products in almost all aspects of life. Farmers need to cope with climate change, and meet rising demands for more food of higher food quality. In order to escalate the yield and growth of crops, the farmer needs to be aware of the climatic conditions, hence aiding its decision of growing the suitable crop, under those factors. IoT based Smart Farming improves the entire Agriculture system by monitoring the field in real-time. It keeps various factors like humidity, temperature, soil etc. under check and gives a crystal-clear real-time observation. Machine learning in agriculture is used to improve the productivity and quality of the crops in the agriculture sector. Use of appropriate algorithms on the sensed data can help in recommendation of suitable crop.**

Keywords*— *Agriculture, IoT, Machine Learning, Farmers.

I. INTRODUCTION

Agriculture plays a vital role in the Indian economy. Over 70% of the rural households depend on agriculture. Agriculture is an important sector of Indian economy as it contributes about 17% to the total GDP and provides employment to over 60% of the population. Indian agriculture has registered impressive growth over last few decades.

However, farmers' suicides in India is worrying. The expressed reasons in order of importance behind farmer suicides were – debt, environment, low produce prices, poor irrigation, increased cost of cultivation, use of chemical fertilizers and crop failure. A farmer's decision about which crop to grow is generally clouded by his intuition and other irrelevant factors like making instant profits, lack of awareness about market demand, overestimating a soil's potential to support a particular crop and so on. The need of the hour is to design a system that could provide predictive insights to the Indian farmers, thereby helping them make an informed decision about which crop to grow. This calls for the need of smart farming, which requires use of IoT. Application of IoT in agriculture could be a life changer for humanity and the whole planet. Sensor data analytics drives transparency into agricultural processes, as farmers get precious insights on the performance of their fields, greenhouses, etc. Farming powered by Machine Learning with its high-precision algorithms is a new concept emerging today. Aiming to increase the quantity and quality of products, this cutting-edge movement makes sustainable productivity growth for everyone working in the agriculture realm.

With this in mind, we propose system for Smart Management of Crop Cultivation using IoT and Machine Learning – a smart system that can assist farmers in crop management by considering sensed parameters (temperature, humidity) and other parameters (soil type, location of farm, rainfall) that predicts the most suitable crop to grow in that environment.

II. LITERATURE REVIEW

As per Climate Change Crop Yield Assumptions report in [9], Crop Yields are projected to decline, with the larger declines to be expected in several developing economies which includes Southeast Asia (-5 percent) and India (-5 percent). [10] The variation in on-farm losses across regions may be partly explained by the range of reasons which include infrastructure and marketing challenges, unsuitable harvest timing, unexpected harsh climatic conditions and unable to predict suitable crops for farming in such climates. The following comparison is show below:

Rushika Ghadge, Juilee Kulkarni, Pooja More, Sachee Nene, Priya R L in [1] uses unsupervised and supervised learning algorithms like Kohonen Self Organizing Map and Back Propagation Network. Dataset is trained by learning networks to classify it into organic, inorganic and real estate for predicting the type of soil. It compares the accuracy obtained by different network learning techniques and the most accurate result is delivered to the end user. System will check soil quality and predict the crop yield accordingly along with it provide fertilizer recommendation if needed depending upon the quality of soil.

Reference Paper [2] determines real time sampling of soil properties using MODIFIED SUPPORT VECTOR REGRESSION, a popular machine learning algorithm and four modules. The Modules include Sensor interfaced to IoT device, Agri cloud, Analyzing the real time sensor data and Agri user interface (AUI). The first module is portable IoT device (NodeMCU) with soil moisture sensor and pH sensor, environmental sensors. Agri cloud module consists of storage. Analyzing the real time data module is processing of types of crops and small plants suggested using modified support vector machine algorithm. Agri-user interface is a basic web interface. Thus, with the help of soil properties farmer will be able to get types of crops and small plants is grown in farmland with help of Modified support vector machine algorithm.

[3] predicts temperature, moisture and pH value for crop prediction using the ARIMA model. The model takes the values from database as input and then predicts what will be the value of that particular parameter after 1 month. The predicted values are then sent to K means algorithm for classification based on pH value thus creating k clusters of crops having similar pH value. KNN algorithm is used to predict top N suitable crops which are displayed to user.

In [4], Machine Learning Algorithm (KNN) calculates the parameter to suggest 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 sensors 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.

[5] evaluates the crop quality factor based on pre-established weather conditions and nature of soil using the trained set of data and implementing Supervised and Reinforcement models of machine learning. If any unfavorable conditions are perceived ahead of time, the alternative and precautious measures are adopted so as to ensure the wellbeing of the planted crops and agricultural land. Specific measures are also taken to predict the right period of sowing, reaping and harvesting for the overall enhancement of the production which can also be foreseen as a part of the modern agricultural revolution.

Citation	Major Algorithm Implemented	Information Conceived
[1]	Kohonen Self Organizing Map and Back Propagation Network	• Dataset is trained to classify it into organic, inorganic and real estate. • Compares the accuracy obtained by different network learning techniques. Most accurate result is delivered. Predicts the crop yield along with fertilizer.
[2]	Modified Support Vector Regression	• Analyses the real time data and processes different types of crops suggested using machine learning. • With the help of soil properties suggested, farmer will know suitable crop to be grown
[3]	K-nearest neighbors (KNN) algorithm	• Dataset containing the minimum requirements for a crop is maintained. Sensors send the readings in real time to the cloud server • Suggests the crop which is best to grow in the field based on the real time values.
[4]	ARIMA model	• The model takes the values from database as input. Predicts what will be the value (weather) after 1 month to suggest crop
[5]	Reinforcement models like Markov Decision Process and Q learning	• Reinforcement models are used during varying weather conditions. • Predicts the right period of sowing too.

III. PROPOSED SYSTEM

The system aims to help farmers for smart decision while predicting the crops. To increase the accuracy along with live data, historic data for temperature and humidity from government website is also collected and stored. Also historic rainfall data is collected and stored. To be definite and accurate in crop prediction, the project analyzes the temperature and humidity of the field – live data collected using DHT-22 sensor and historic data collected from government website and/or google weather API, type of the soil – used by the farmer and the historic rainfall data. It can be achieved using unsupervised or supervised machine learning algorithm. By learning networks, dataset is trained. The accuracy obtained by different machine learning techniques are compared to get the most accurate result which in turn will be delivered to the end user. Along with the most suitable crop, the system also recommends the fertilizer for that crop. Responsive, Multilingual website is used by farmer to communicate with the system.

Hardware Components:

Digital Temperature & Humidity Sensor: DHT22 sensor is preferred to monitor live temperature and humidity. This sensor is proved to be more precise and accurate. It uses a capacitive humidity sensor and a thermistor to measure the surrounding air, and spits out a digital signal on the data pin to Arduino Uno port pin. The range of DHT22 is 0 to-100 % RH for humidity and - 40 to 80 degree Celsius for temperature.

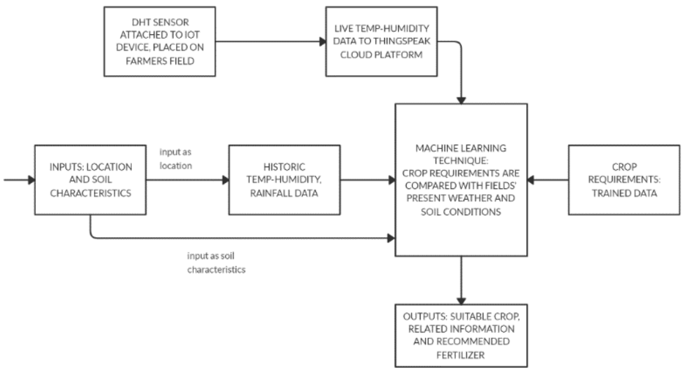

Figure 1. Block Diagram

The functionality of the architecture (Figure 1) is as follows:

In the website, Farmer logins and enters the Location of the field and the type of soil available at the field for farming as input, both the input are processed further.

Location is used as an input to collect the historic data of specified location i.e. the field. The historic data is collected using government websites or third-party applications like APIs for weather and temperature, amount of rainfall in the region.

The live data is collected by placing the IoT device on the field. IoT device consist of DHT 22 sensor – Temperature and Humidity connected to Arduino UNO along with ESP8266 Wi-Fi module. The live data is collected every hour and the stored-on Thing Speak Cloud platform.

The live and historic data is collected. The VAR (Vector autoregression) model is applied on this collected data to forecast the rainfall, temperature-humidity for a period of time when farmer is supposed to cultivate the crop. Now, this forecasted temperature, humidity and rainfall along with Soil characteristic entered by farmer are supplied to three different ML algorithms:- Decision Tree, K-NN, Support Vector Machine wherein the combination of the above results and the predefined data set i.e. actual requirements of the crops present in the crop data store is compared. Finally, by comparing the accuracy obtained by different machine learning techniques, the most accurate result i.e. the most suitable crop is presented to user.

On the website, farmer gets the most suitable crop as an output. Along with this, the end user is provided with all the information about the crop and the best suitable fertilizer.

IV. RESULTS

Training dataset used, contains information about temperature, humidity, rainfall parameters, and the crop pH corresponding to these parameters.

temperature	humidity	ph	rainfall	crop
45.6374671	11.19524988	7.341612619	36.522037	5
31.76167796	57.72743864	6.198411713	82.10434989	2
29.17510907	79.21985592	6.658683067	131.0297066	14
24.39736241	79.26861738	7.014063944	164.2697011	8
23.17124551	52.97841162	6.766184468	153.1201644	9
23.89271875	61.78779413	6.658605362	52.55730112	7
29.70143197	95.65754365	6.078807239	215.1968037	16
24.388717	62.50453062	6.711341147	47.26052494	7
24.32719167	55.84027641	4.956920312	202.281286	4
20.27514686	23.2353604	5.877347515	139.7521543	15

Figure 2. Training set

3 different types of Machine Learning algorithms are applied – Decision Tree, KNN and Support Vector Machine (SVM), and they are compared with respect to their accuracy. Decision Tree has the highest accuracy of all, and is thus used finally to predict the crop.

```
Windows PowerShell
PS C:\xampp\htdocs\crop> python compare.py
Shape of train (1270, 4), shape of test (424, 4)
The accuracy of KNN classification is:  84.90566037735849
The accuracy of Decision Tree classification is:  91.0377358490566
The accuracy SVM Classification is:  88.91509433962264
PS C:\xampp\htdocs\crop>
```

Figure 3. Comparison of the accuracy of the three algorithms

As Decision Tree has highest accuracy, Decision Tree for predicting the crop is used.

Farmer uses the “Smart Crop Prediction” website, to enter the soil pH, locality and the expected month to begin farming.

Figure 4. GUI of Smart Crop Prediction Website

For this, he registers himself, and then logs in to enter the parameters.

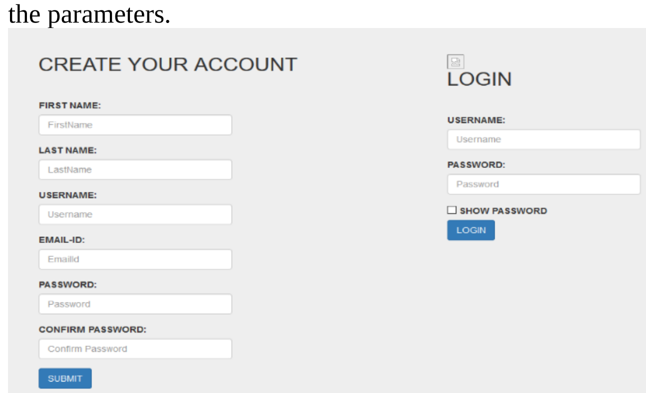

Figure 5. Register and Login page

As per parameters, corresponding historic and live data is retrieved, and Decision Tree algorithm is applied on it.

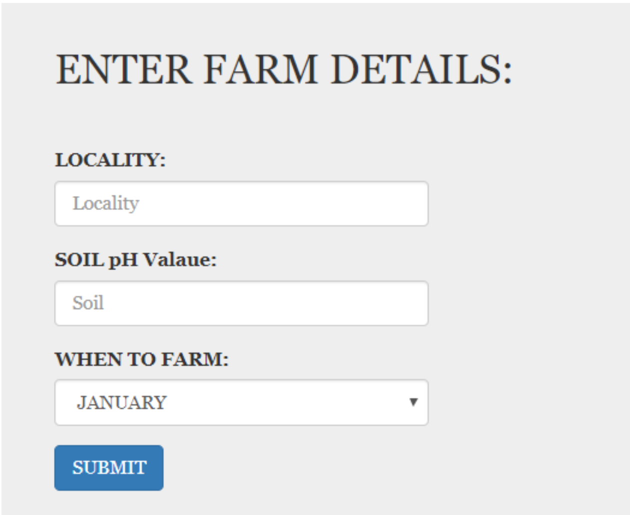

Figure 6. Page where the farmer is redirected, once he logs in

On clicking Submit, the suitable crop is displayed on the screen.

Figure 7. Suitable crop as displayed

Using Google language translator, the farmer can switch to any language, and the website translated into the selected language.

V. CONCLUSION

In this paper we have proposed an innovative approach for smart agriculture using two emerging technologies: Internet of Things and Machine Learning. With the use of both live and historical data helps to increase the accuracy of the result. Also comparing multiple ML algorithms enhances the accuracy of the system. Thus system will be used to reduce the difficulties faced by the farmers and will increase the quantity and quality of work done by them.

VI. FUTURE SCOPE

The system can be enhanced further to add following functionality: Use of soil moisture sensors, environment sensors, pH sensors to increase the accuracy while predicting the crop. Location's market requirements can be consider, and neighbor farmer's crop while suggesting the suitable crop.

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