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Crop prediction and Plant Disease Detection using IoT and Machine learning

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***Abstract*—Agriculture is one of the major occupations widely used in India and it plays a crucial role in the country's development. Improving crop production is considered an important aspect of agriculture as about 60% of the country's total land is used for agriculture to satisfy the requirements of Billion people. Since agriculture plays an important role in most countries, this sector needs to be "smart". If a farmer owns a piece of land, the farmer should be aware about the crops that can be grown in the area, the diseases that might affect the crops etc. Growing crops is a tough job because of the involvement of many different factors like soil type, temperature, humidity and so on. Technological growth in agriculture will increase crop yields. Remote sensing systems, such as IoT systems are increasingly used in smart farming systems and these generate large amounts of data. Systems which can just predict crops by evaluating soil features for a particular time period still exist, but here the proposed project will solve agricultural problems by monitoring fields using sensors for detecting soil characteristics, provide this information to the farmer in real time and introduce farmers to the most suitable crops along with feedbacks on existing crops and plant disease detection, thereby helping them to achieve greater productivity with reduced loss.**

***Index Terms*—Agriculture, IoT, Machine Learning, Big data, Crop prediction, Disease detection, Farmers**

I. INTRODUCTION

Agriculture has a major role in the lives of every individual. It is the first and foremost factor which is important for survival. The dependency on agriculture is over 70% of the rural economy in India. However, the suicide rate for farmers in India is between 1.4 and 1.8 per 100,000 population over a decade. Various reasons have been proposed to explain why farmers commit suicide in India including floods, debt, drought, public health, use of poor quality pesticides due to reduced investment leading to low yields and government economic policies. However several studies have also shown that more than one reason is often associated with farmer suicides. The farmer's decisions about which crop to plant is often overshadowed by intuition and other nonessential factors such as immediate profits, overestimation of the land's potential to produce yields and lack of necessary market knowledge. The need for time is to develop a system that provides predictive information to Indian farmers and helps them make informed cultural decisions about growing crops. Today, we are surrounded by numerous "smart" sensors and intelligent systems that are always connected via the Internet and cloud platforms. The Internet of Things (IoT) model enables the advanced technologies to be available in the productive and social sectors of the society. Timely guidance for predicting future crop and conducting analysis to help farmers will definitely maximize crop yields. In the past, crop prediction was done based on the previous year yield experiences, but the fluctuating weather conditions, soil conditions, etc. that are experienced today affects the yield a lot. Also, the diseases that affect the plants have to be detected at an early stage to increase yield.

Machine learning is the latest technology to power agricultural precision and yield solutions. IoT-based smart agriculture is a system that uses sensors calculating soil moisture, humidity, light, temperature, etc. to monitor land and helps in the automation of irrigation methods. IoT based smart farming is very efficient compared to traditional methods, since here the farmers can observe the conditions of the field from anywhere. This project proposes a system in which the soil conditions are monitored by using sensors and this information is provided to the farmers in real time enabling them to find suitable crops for a particular soil. Plant diseases are detected by analyzing the plant images. Crop feedback will be provided for any existing crops. For example, it will alert the farmer when the soil moisture level is low; the farmer can use sensors to initiate irrigation

II. Literature Review

Reference Paper [1] uses machine learning algorithms like Back Propagation Network and Kohonen Self Organizing Map. The system predicts the crop by checking the soil quality. Dataset is trained to classify the soil type into organic, inorganic and real estate. The accuracy offered by different network learning techniques is compared to reduce error in the result.

Reference paper [2] uses the technique of IoT based smart farming which help farmers in predicting the crops. The system collects live and historic data of temperature and humidity along with information on the type of soil used and the historic rainfall data. The VAR (Vector Auto Regression) model is applied to forecast the time when the farmer is supposed to cultivate. Then the forecasted data is supplied to various machine learning algorithms like Decision Tree,K-NN, Support Vector Machine etc. Finally, the most suitable crop is predicted. The accuracy of the system is enhanced by multiple machine learning algorithms.

In [3], a popular machine learning algorithm called Modified Support Vector Regression is used to determine real time sampling of soil properties. It includes an IoT device (NodeMCU) which is portable, sensors calculating soil moisture and pH, Agri cloud for storage, analyzing the data for processing the crop type using modified Support Vector machine algorithm and a basic web interface, the Agri user interface (AUI). Thus, farmer will know suitable crop to be grown with the help of soil properties suggested.

In [4], Image Processing and Classification is used to detect plant diseases in early stages which helps to increase productivity and reduce the risk of crop failure. For classification of image, the system uses Support Vector Machine (SVM) and Neural Network. Initially image pre-processing is done using techniques like Image Enhancement and Feature Extraction after which K-means clustering algorithm is used. The type and stage of disease is identified using SVM classification technique.

Reference Paper [5] uses zoning irrigation system based on Internet of Things (IoT) to monitor the soil moisture for managing the irrigation. Efficient irrigation management is a challenge faced in agriculture. Here the aim is to optimize the environment for cultivation and reduce water wastage and energy consumption. The values from the sensor is compared with the corresponding value in the database by the system and it sends an ON/OFF command to the user.

Reference Paper [6] uses the ARIMA model to predict the temperature, moisture and pH values to suggest crop. In this, values from the database are taken as input and the values in some future time is predicted. This is used for crop prediction. Then K means algorithm is performed on the predicted values for classification thus creating k clusters of crops. KNN algorithm can predict top N suitable crops.

In [7], the machine learning algorithm, K-nearest neighbors (KNN) algorithm, takes real time values based on which the crop that grows best in the particular field is suggested. A standardized dataset of crop requirements is maintained. Sensors are used to take real time readings and the values are sent to a cloud server. The algorithm suggests the best crop for the field.

In [9], the trained dataset is used and Supervised and Reinforcement models of machine learning is implemented to find the crop quality factor based on values of weather and soil that is present in the database. During varying weather conditions, reinforcement models (Markov Decision Process, Q learning etc.) are used. The right period of sowing, reaping and harvesting is predicted which can enhance the production.

In [11], it is discussed about how ELM essence should be integrated to achieve faster learning speed and short calculation time with minimal human intervention. Recently, the feed-forward neural network operates with slow calculation time and additional profitability. This process can be improved and optimized using a neural network with a feed-forward algorithm. This article has discussed the future ELM extensions for a few applications based on function approximation. The article provides information on the different classification ELM types. The main purpose of the article is to explain the different ELM types for various applications.

In [12], empowerment of neural networks for in-depth learning to have a precise artistic state that greatly chases even human performance is described. In-depth study enables training to directly separate tasks from available documents in the form of text, image, or audio. The paper introduces a study on the learning depth of neural network architectures used in different systems to have a precise classification along automatic feature extraction.

III. Proposed System

The main aim of the system is to help farmers to make decision while predicting crops. The study uses various factors like temperature and rainfall data to predict crop. For greater accuracy in crop prediction, the project analyses temperature and humidity of the field with the help of a DHT-22 sensor and other data regarding the rainfall and soil type is obtained from Google or various government websites. The prediction of crop is done using a supervised machine learning algorithm. The accuracy for the system is obtained through increased number of data sets and through different machine learning techniques.

Along with the most suitable crop, the system can also predict diseases in plants by uploading images of the infected region. An application is used by the farmer to communicate with the system. The farmer can also get suggestions to improve current crop, like level of irrigation required, by comparing real time and optimal values.

Hardware components like DHT-22 (Digital sensor and humidity sensor) is used in the project to monitor live temperature and humidity. DHT-22 sensor is very small and has low power consumption compared to other models. Also, it offers better range for measuring temperature and humidity along with better accuracy of ±0.5% and ±2% for temperature and humidity respectively. To measure the surrounding air, it uses capacitive humidity and a thermistor which spits out a digital signal on the data pin.

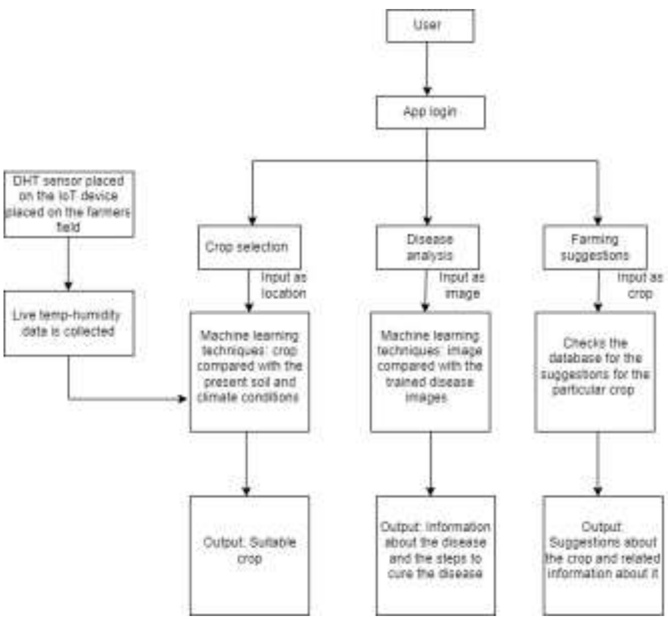

Fig. 1. Proposed system of the crop prediction application

A. Working

Farmer logs in to the application and enters his location, the size of the field and the type of soil available for farming. Both inputs are further processed. The field is used as an input to collect historic data from the specified location. Weather and temperature data, as well as the amount of rainfall in the region, are gathered through government websites or third-party applications. The IoT gadget can be used by the farmer to regularly check the values. The IoT device is made up of a DHT-22 sensor that measures temperature and humidity and is connected to a NodeMCU through an ESP8266 WiFi module. Now, the temperature, humidity and rainfall, as well as the soil characteristics entered by the farmer, are fed into the Random forest algorithm and compared with the pre-trained data. Finally, the most accurate result, i.e., the most suited crop, is provided to the user.

The other functionality of the system is to detect crop diseases. The photo of the infected region is to be uploaded into the system via the application used by the farmer. The image is then processed and the most possible disease is identified with the help of Scale-invariant feature transform algorithm (SIFT).

If the farmer requires feedback on existing crops, the current crop is given as input. The real time values of various factors are collected using the sensors and compared to the optimal values calculated from the database and feedback is provided. For example, if the moisture content of the soil is low, the farmer is notified to increase the irrigation.

IV. Methodology

This paper deals with the use of IoT and machine learning algorithms to predict and improve various agricultural practices. The farmer can select between various options like prediction of the most suitable crop, receive feed-backs on improving the existing crop and detect plant diseases. The farmer is provided with the sensors which can be used to regularly check values and receive recommendations.

Various sensors like pH sensor, humidity sensor and moisture sensor are used to collect the required data. DHT-22 is used for projection of live temperature and humidity. Machine learning algorithms along with trained datasets is used for classification and to identify the optimal conditions for different crops. To identify the plant diseases, image input of the plant is taken from the farmer. For feedback services in existing crops, the crop name is taken as input from the farmer.

Random Forest algorithm is used for training and prediction of data. Other comparable algorithms like Support vector machine and KNN offers lower accuracy of prediction than Random Forest Algorithm. Based on various experiments, Random forest algorithm provides an accuracy of 99.% while SVM and KNN provides 98.6% and 97.8% respectively.

For plant disease detection, image pre-processing and other enhancement and processing techniques are used to make the image suitable for analysis. Scale-invariant feature transform (SIFT) algorithm is used to detect and describe the local features of the image. This is then compared and matched with images in database to identify the correct disease.

MongoDB is used for data storage purposes. Flutter framework is used for development of the application. The various machine learning algorithms are run with the help of Google cloud architecture. Node.js is used to write the NodeMCU code.

The use of various machine learning algorithms and IoT techniques will help the farmer to cultivate high yielding crops with constant monitoring. This is beneficial not only for the farmer but also for the entire economy. High yield and efficient management using automated techniques will prevent wastage of resources in terms of land, water and effort. Usage of highly accurate and trained techniques will avoid the selection of crops by the farmer being clouded by one's judgment and will result in efficient usage of land.

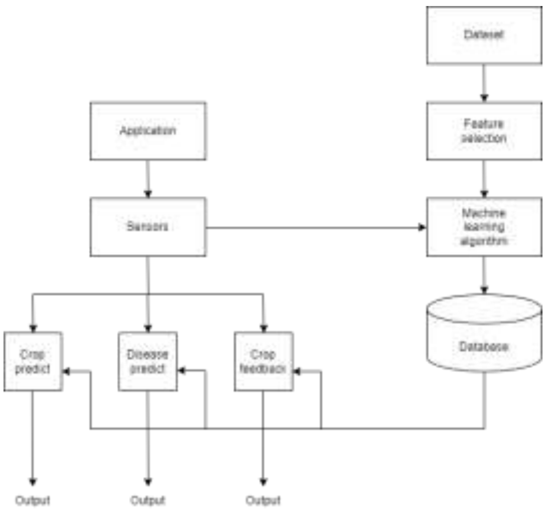

Fig. 2. Flowchart of evaluation methodology

V. IMPLEMENTATION

The project is aimed at developing a system that helps the farmer using machine learning and IoT techniques. Through this, the farmer is provided with information to improve the agricultural practices and thereby increase the yield. The important tasks for the project include developing various features like providing feedback for existing crops, prediction of the most suitable crop and detection of plant diseases. An app is developed and real time soil and environmental characteristics are collected for this purpose with the help of sensors and NodeMCU. The dataset to be trained has to be created which will then be trained using a suitable machine learning algorithm. This data is then used along with sensors to compare and provide feedbacks to improve existing crop and predict better yielding crops. Image processing has to be implemented with the help of user input of the plant image, which will undergo pre-processing before giving the final output.

The dataset for training is obtained from Atharva Ingle. (2020 December). Crop recommendation dataset, Version 1. Retrieved 2021 December from https://www.kaggle.com/atharvaingle/crop-recommendation-dataset/metadata. Feature extraction is performed on this dataset to select only the required features as shown in the table. A sample section of the dataset is shown in Fig.3.

Of the many crops available in the dataset, the optimal values for some crops are shown in Fig.4.

To calculate different soil and environmental characteristics, sensors are used. The historic rainfall and weather conditions are collected from online third party applications. This data is compared with the trained data to make a comparative

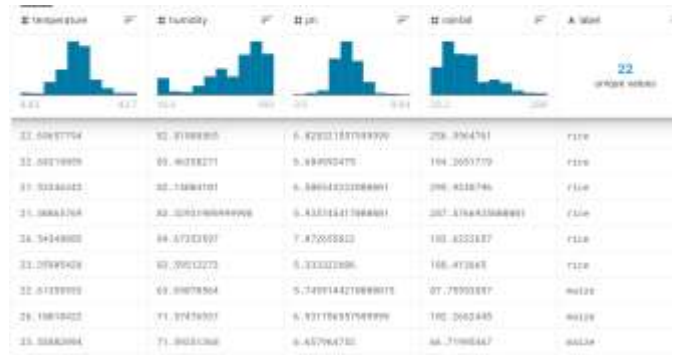

Fig. 3. Sample Data set used

Crop	pH	Moisture	Humidity	Rainfall	Temperature
Rice	7.0	18%	75-80%	226cm	21.7
Maize	6.5	13%	55-65%	70cm	25
Watermelon	6.0	60%	70%	30cm	25

Fig. 4. Optimal values of selected crops

study and predict a suitable crop. Upon training, the data similar to Fig.4 will be received and further it will be used for the classification purpose.

Here, the values received from the sensor readings are given in Fig.5.

pH	Moisture	Humidity	Rainfall	Temperature
7.1	18%	78%	210cm	22

Fig. 5. Values retrieved from sensor

These values are passed onto the classifying machine learning algorithm and the output received is ‘Rice’. From Fig.4 and Fig.5 it is clear that the sensor readings and the optimum values of ‘Rice’ are more comparable than other crops in the database. This comparison is depicted by the graph in fig.6. The rainfall data collected also comes in range with the optimal values for rice.

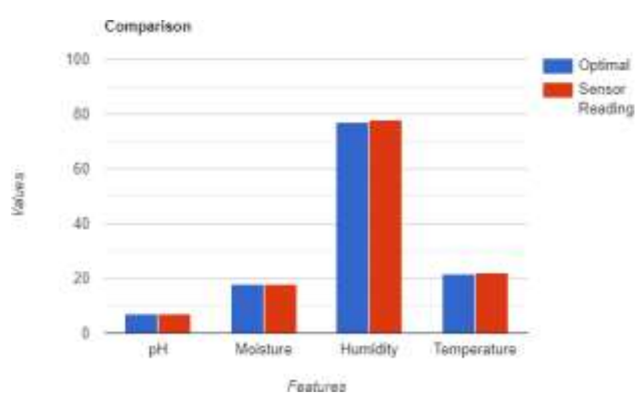

Fig. 6. Graphical Comparison between optimal and sensor values of features

This output is provided to the user through the application as shown in fig.7.

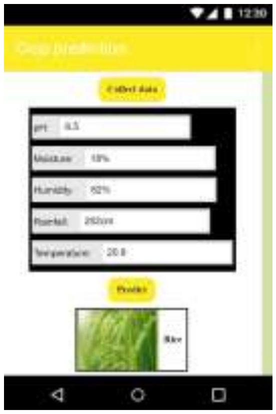

Fig. 7. Crop prediction

For plant disease detection user input of infected leaf image is collected and then uploaded to the application. Various image processing techniques are performed before using SIFT algorithm to detect the disease. This is depicted in Fig.8.

Fig. 8. Disease Detection

To provide feedback on existing crop the user has to input the desired crop. Real time values are collected through sensors and compared with the optimal values found in the trained data. The user will be notified of the factors whose values are found to be out of range. The data comparison provided to the user is shown in Fig.9.

The other application interfaces created are given in Fig.10 and Fig.11.

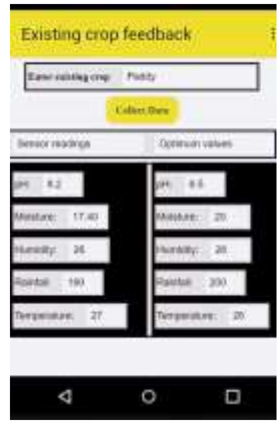

Fig. 9. Crop Feedback

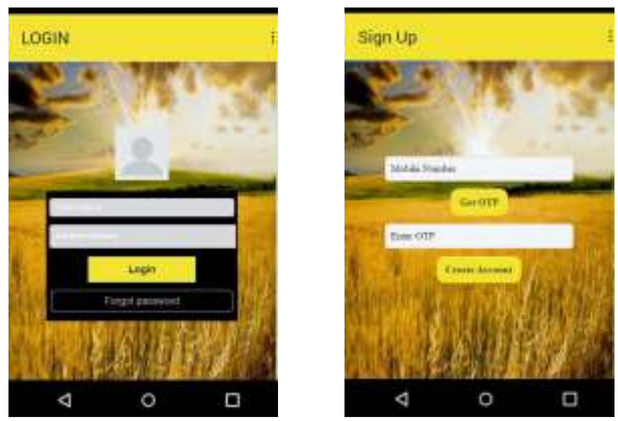

Fig. 10. Login and Sign Up

Fig. 11. Home Page

VI. CONCLUSION

In this project, we have proposed an innovative approach to smart agriculture using two emerging technologies: the Internet of Things and machine learning. This project mainly focuses on the prediction of crop along with plant disease detection. A dataset is used after feature selection to train the data using Random forest algorithm which offers high accuracy. The various features selected are temperature, humidity, soil moisture, rainfall and pH. From the sensor readings retrieved, the most suitable crop is predicted with the help of the classifying algorithm. Here, the sensor values were comparable with that of the data trained for the crop ‘Rice’. The algorithm correctly predicts the crop which is discussed with the help of comparative study of optimal values of the crop and sensor readings acquired. Plant disease detection is achieved with the help of SIFT algorithm and various image processing techniques. Feedbacks for existing crops is provided by comparing the trained value for a crop and the sensor readings taken.

The system helps the farmer to increase productivity and efficiency. The model can be further developed for precision agriculture inside a poly-house. The sensors will help to identify the current feature values and recommend changes. In a particular controlled environment, the system can be used to predict the right crops that can be cultivated. Thus, it can be concluded that the system can provide a solution for current agricultural problems related to crop selection and be developed to suit various emerging developments in the sector.

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