AI ASSISTED PLANT DISEASE DETECTION, CROP AND FERTILIZER RECOMMENDATION SYSTEM

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Abstract: Agriculture is a cornerstone of India's economy, employing nearly half of its population and contributing significantly to its growth. Understanding the importance of nutrient management for crop productivity is paramount. However, Indian farmers face formidable challenges, including unpredictable irrigation patterns and poor soil quality, often lacking the necessary knowledge and resources for informed decision-making in crop selection and fertilizer use. Crop failures have profound consequences, affecting livelihoods and food security, while also posing risks to the environment.

To address these challenges, our research presents an innovative solution in the form of an open-source, user-friendly web application. This application offers support for crop and fertilizer recommendations, plant disease prediction, and an interactive news-feed. Additionally, our approach incorporates interpretability techniques to elucidate predictions made by our disease detection model, making it a comprehensive tool for farmers and stakeholders in the agricultural sector. Our research endeavours to provide a practical and efficient solution to enhance crop production, thereby contributing to the sustainable development of India's agriculture and economy.

Keywords: Plant disease prediction, crop recommendation system, fertilizer recommendation system.

Introduction

The agricultural sector plays a crucial role in the economic growth of any nation, greatly affecting the lives of a large number of people. In a country like India, where nearly half of the population is employed in agriculture, the importance of this sector cannot be emphasised enough. It not only serves as a source of food for millions of people, but it also plays a crucial role in India's growing economy. By engaging in this sector, citizens have the chance to contribute to the country's progress and development. In India, just like in many other places around the world, agriculture has traditionally been carried out using long-standing practises and methods to take care of the land and enjoy its abundant harvests.

One critical aspect of agricultural productivity hinges on the provision of essential nutrients to plants, the very lifeblood of a thriving agriculture. Just like humans, plants also need specific nutrients in order to grow well. For centuries, farmers have been using different sources to provide these essential elements. Whether it's by using organic manure, relying on the natural qualities of the soil, or applying synthetic fertilisers, the goal remains the same: to give plants the nourishment they require to thrive.

However, achieving success in agriculture is often accompanied by a multitude of challenges. The efforts of numerous farmers, especially in a vast and diverse country like India, face significant challenges due to uncertainty in irrigation, poor soil quality, and a lack of knowledge. Small-scale and traditional farmers often struggle to make well-informed decisions about choosing the right crops and fertilisers. This lack of expertise has significant consequences for their own livelihoods and the overall agricultural industry. Moreover, the consequences of crop failures go well beyond the limits of the farm. When crops are affected by diseases or environmental stressors, it has a ripple effect that impacts both farmers and consumers. When farmers experience agricultural losses, it not only causes economic hardship for them but also leads to food scarcity for consumers. This situation puts additional pressure on an already fragile balance. Apart from these challenges that primarily affect humans, agriculture also has a negative impact on the environment. Unsustainable practises in agriculture contribute to soil degradation, water pollution, and the release of greenhouse gas emissions.

Amidst these challenges, a new dawn is emerging on the horizon of Indian agriculture. This dawn brings with it the promise of modern technology and the transformative power of artificial intelligence and machine learning. In a world increasingly dominated by digital solutions, it is only natural that agriculture should embrace the opportunities presented by technological innovation. And so, our project emerges as a beacon of hope, striving to bridge the gap between tradition and modernity, between uncertainty and knowledge, between economic hardship and prosperity.

Using the ensemble method and smart agriculture, a recommendation model is developed that combines the predictions of different machine learning models to determine the best crop and fertiliser to apply depending on the quality of the soil. The ability to identify diseases is one of the most crucial components of an effective farming system. A farmer typically uses visual observations to keep an eye out for disease symptoms in plants that need to be checked frequently. Many diseases harm the leaves of plants. Farmers face greater difficulties in identifying these diseases, so we use efficient and acceptable image processing techniques with the aid of plant leaf images for disease identification.

Our project utilises advanced machine learning techniques to help farmers assess the quality of their soil, analyse its different characteristics, and, most importantly, recommend the most appropriate crops and fertilisers using data-driven methods. By incorporating artificial intelligence into agriculture, we provide farmers with the ability to make well-informed choices. This helps to minimise crop loss due to diseases, enhance crop yield and quality, and address the negative impact of agriculture on the environment.

Literature Review

The system is capable of determining the affected area of a leaf and identifying the specific disease that has affected it [1]. The prediction of diseases in leaves is accomplished through the utilisation of Image Processing techniques. Various systems have been developed to accurately predict and identify diseases in leaves. In our system, we utilise the K-Medoid clustering and Random Forest algorithm to enhance the accuracy of disease detection in leaves.

In [2], a software solution is introduced that utilises Image Processing to quickly and accurately detect and classify plant diseases.

Agriculture plays a crucial role in the economy of a nation and is of utmost importance. In order to ensure the production of healthy and disease-free crops, various methods are being implemented. Efforts are underway in rural areas to support ranchers in obtaining highquality insecticides and pesticides. During a harvest, diseases often affect the leaves, preventing the crop from receiving the necessary nutrients. As a result, both the quality and quantity of the yield are negatively impacted. In this paper [3], we use programming to automatically detect the affected area in a leaf and provide a more effective solution. We use various image processing methods to determine the affected area of a leaf. The process involves several stages, namely image acquisition, image preprocessing, segmentation, and feature extraction[4].

Plant diseases can significantly reduce the quality and quantity of agricultural products. One of the primary challenges faced by farmers is identifying and detecting leaf diseases. Leaf disease detection plays a crucial role in today's world. Therefore, it is extremely important to identify plant diseases in their early stages. This allows farmers to take appropriate and timely measures to prevent further damage and minimise losses[5]. Having access to early information on crop health and disease detection can greatly help in effectively managing diseases through appropriate control measures. By implementing this technique, the productivity of crops can be significantly enhanced. In this paper, the authors [6] introduce a technique for detecting leaf diseases. They also provide a comprehensive comparison of the advantages and limitations associated with various potential methods.

In this paper, the authors present an interesting technique for estimating the nutrient levels in soil and providing recommendations for the right type of fertiliser to use[7]. The proposed methodologies consist of four stages: soil analysis, data pre-processing, data analysis, and recommendation. The soil sample is analysed using a device that is based on Internet of Things (IoT) technology. Choosing the correct fertiliser at the beginning of the crop cycle is highly beneficial for farmers as it helps maximise the yield of their crops[8].

The development of a country heavily relies on agriculture as a key aspect. Agriculture is a field that many people choose to make a living from. It involves working with and producing various agricultural products[9]. One of the main reasons why the quality and quantity of food crops are reduced is due to plant diseases, particularly those affecting the leaves. When it comes to agriculture, if a plant is affected by a leaf disease, it can significantly hinder its growth and overall agricultural productivity. Detecting leaf diseases is a crucial aspect of preserving agriculture . First, the image is pre-processed using a median filter. Then, segmentation is performed using the Guided Active Contour method[10]. Finally, the leaf disease is identified using a Support Vector Machine. The disease-based similarity measure is utilised in order to make fertiliser recommendations.

The focus of this paper is on [11]. Detecting leaf diseases is a labor-intensive task that demands extensive knowledge of plant diseases and also takes up a significant amount of processing time. Yes, it is possible to utilise image processing in MATLAB for the purpose of identifying leaf diseases. The process of disease identification involves several steps. First, an image is loaded into the system[12].

Then, the image undergoes contrast enhancement to improve its quality. After that, the RGB colour space is converted to HSI (Hue, Saturation, and Intensity) to extract relevant information. Next, features are extracted from the image using various techniques. Finally, a Support Vector Machine (SVM) is employed to classify the image and identify the presence of the disease[13].

In this paper, the authors propose and implement a system that aims to predict crop yield based on historical data. To achieve this, machine learning algorithms such as Support Vector Machine and Random Forest are used on agriculture data. These algorithms analyse the data and provide recommendations for suitable fertilisers for each specific crop[14]. The main focus of the paper is to develop a prediction model that can be used to forecast crop yield in the future. This article provides a concise analysis of how machine learning techniques can be utilised to predict crop yields.

We designed our proposed system to effectively analyse soil types, identify leaf diseases, and provide farmers with tailored fertiliser recommendations[15]. This system has the potential to greatly assist farmers in their agricultural practises. Plant diseases, particularly those affecting leaves, are a significant cause of reduced crop yield in terms of both quality and quantity. The implementation of smart analysis and comprehensive prediction models in agriculture greatly benefits farmers by enabling them to cultivate the appropriate crops at the optimal time. There are several key advantages to the proposed system, including: To ensure a successful harvest, it is important to cultivate the appropriate crop at the optimal time[16]. This involves finding a balance between crop production, managing plant diseases, promoting economic growth, and implementing strategies to mitigate crop scarcity. Therefore, in order to detect and recognise plant diseases and provide fertiliser recommendations, it is crucial to provide symptoms that can help identify the disease as early as possible. Therefore, the authors have proposed [17] and developed a new Recommendation System for fertilisers to predict crop diseases.

The paper offers a comprehensive survey on the detection of plant leaf diseases using image processing techniques. Diseases affecting crops can lead to a significant decrease in both the quantity and quality of agricultural produce. Farmers often find it challenging to identify disease symptoms with the naked eye[18]. In large farms, crop protection is often achieved through the use of computerised image processing techniques. These advanced methods allow for the detection of diseased leaves by analysing their colour information.

In this paper, a survey is conducted on the technique of detecting leaf diseases through image processing [19]. India is primarily an agricultural country, with a significant portion of its population, approximately 70%, relying on agriculture for their livelihoods. Leaf disease detection is a highly significant area of research. There are various types of crops that can be affected by fungi, bacteria, and other microorganisms. One way to address this issue is by employing various image processing techniques to automatically detect the leaves of a plant. India, being a densely populated country, is susceptible to unpredictable changes in climatic conditions, which poses a significant threat to global food resources[20]. Farmers encounter significant challenges during periods of drought. The type of soil has a significant impact on the yield of crops. I would recommend considering the use of fertilisers as it can greatly assist farmers in making informed decisions for their specific cropping needs. There has been an increase in the number of studies. Data Mining can be utilised in the field of Information and Communication Technology (ICT) to predict crop yield. This means that we can make accurate predictions about the amount of crops that will be produced. By thoroughly analysing the previous data, we can provide the farmer with recommendations for improving crop yield[21]. This application also includes a model that can predict the type of crop disease by analysing the textural similarity of leaves.

Methodology

The next subsections include details on the application and machine learning utilized in our research along with information on datasets, training data, and implementation details. First, our product is demonstrated via block diagrams and a flowchart that illustrate how the user interface of the program is created. We next go over the various models we use as well as other experimental components in our machine learning efforts. The following nested subsections are created from the two subsections: plant disease detection, ferlizer and crop recommendation.

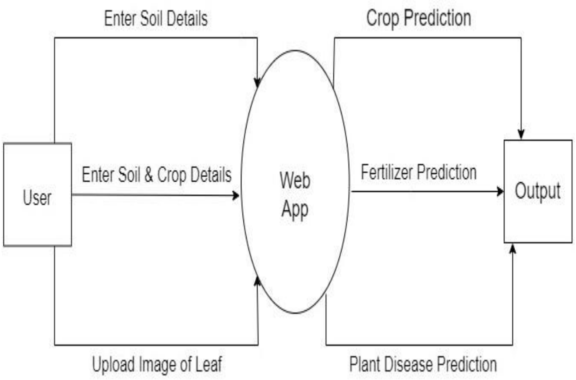

Figure 1: Data Flow Diagram

By developing a website that recommends crops and fertilizers depending on a variety of factors, including rainfall, ph, state, district, nitrogen, phosphorus, and potassium, as well as predicting plant issues, the initiative aims to save farmers time and effort. The methods used include Decision Tree, Random Forest, Naive Bayes, Support Vector Machine, and Logistic Regression, all of which will aid in accurate prediction. Additionally, after we capture a photo of the plant, the algorithm in this proposed system will use the ResNet method to forecast the disease. As a result, this approach will make farming easier while also increasing customer satisfaction.

A. The Application

1) *Fertilizer Recommendation:* The user must provide the name of the crop as well as the amounts of potassium, phosphorus, and nitrogen. It contacts the Flask API using a POST request. This is the hosting location for the classifier used to propose fertilizer. After receiving an HTTP response, the front-end displays a fertilizer recommendation to the user. Fig. 2 shows the flow diagram for the same.

2) *Disease Detection:* The user must either click an image or upload it directly in order to detect diseases. The model processes the image once it reaches the back end. An HTTP response is sent to the front end once the image has been processed. The plant's disease and its treatments are given to the user.

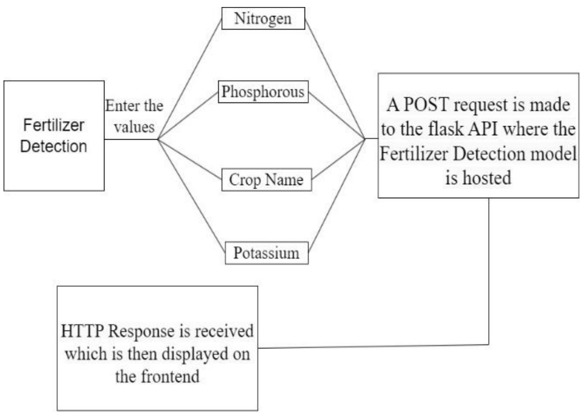

Figure 2: Flow diagram for Fertilizer Recommendation system

3) Crop Recommendation: A post request is sent to the flask API when the values for nitrogen, phosphorus, and potassium are entered. The optimal crop a farmer may plant in the soil to maximize the potential of the land is indicated in an HTTP response that is delivered to the front end by the model once it has completed running.
Fig. 3 shows the flow diagram for the same.

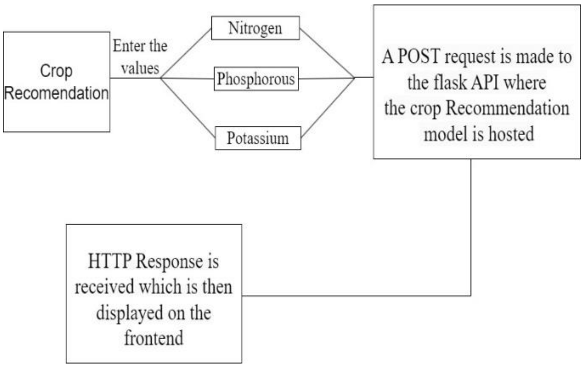

Figure 3: Flow diagram for Crop Recommendation system

B. Machine Learning

1) Crop Recommendation: Dataset Description: This dataset, which was obtained via Kaggle, is very straightforward and includes a small number of helpful features, as opposed to complex factors that influence crop output. It is composed of seven features: temperature in degrees Celsius, N: Ratio of Nitrogen Content in the Soil, P: Ratio of Phosphorus Content in the Soil, K: Ratio of Potassium Content in the Soil, Rainfall in millimeters, pH: the soil's pH value, and relative humidity: a measurement in percentage. Using these seven characteristics, the aim is to forecast the type of crop. There are 2200 samples overall, and there are 22 class labels in total, some of which include muskmelon, rice, maize, coffee, etc. Since there are 100 samples in each class, the dataset is completely balanced and doesn't require the use of any unique imbalance handling techniques.

Approach: The dataset is split into 5-folds and cross-validation is performed on these folds. We test performance with six models:
• Decision Tree with entropy as the criteria and a max depth of 5.
• Naive Bayes.
• SVM with a 0-1 scaling on the input, polynomial kernel with degree 3, and the L2 regularization parameter C=3.
• Logistic Regression.
• Random Forest with 20 estimators.
• XGBoost.

2) Disease Detection: Dataset Description: We take into account the PlantVillage dataset for the identification of leaf diseases. In particular, we make use of an enhanced version of the Kaggle PlantVillage dataset. 87,000 RGB images of both healthy and diseased crops are included in the collection, and each image has a spread of 38 class labels applied to it. There are fourteen crops in all, and there are twenty-six distinct diseases. Every class has, on average, 1850 picture samples with a 104 standard deviation. The training to validation ratio of the dataset is 80:20.

With only the picture of the plant leaf, we try to forecast the crop-disease pair. We downsize the photos to 224 × 224 pixels by scaling them down by a factor of 255. On these downscaled photos, we carry out both the model optimization and the predictions.

Approach: Our studies are conducted using ResNet-9. The model performs differently on the ImageNet dataset and has differing numbers of parameters and sizes. On the PlantVillage dataset, it has been demonstrated that these pre-trained models outperform a model that is built from scratch.

We employ the Adam optimization approach in conjunction with categorical cross-entropy loss during training, starting with a learning rate of 0.01 and an epsilon of 1e-08. Primitive image filters found during pre-training are preserved and the model is kept from diverging by using a modest learning rate. 32 is the batch size that is utilized in training. To get the best performing model on the validation dataset, we additionally employ early halting and model checkpointing depending on the validation loss. We also record how much the model's accuracy increased during training. During training, these models' performance may improve even more.

3) Fertilizer Recommendation: Dataset Description: For Fertilizer recommendation, We utilize a unique dataset that has four features: pH, K, N, P, and Crop. There are 22 different crops, each with the perfect N, P, and K values: rice, maize, coffee beans, etc. The data set shows the recommended levels of N, P, and K in the soil for the best possible crop growth. The required fertilizer for a farmer varies based on whether the soil is lacking in N, P, or K values.

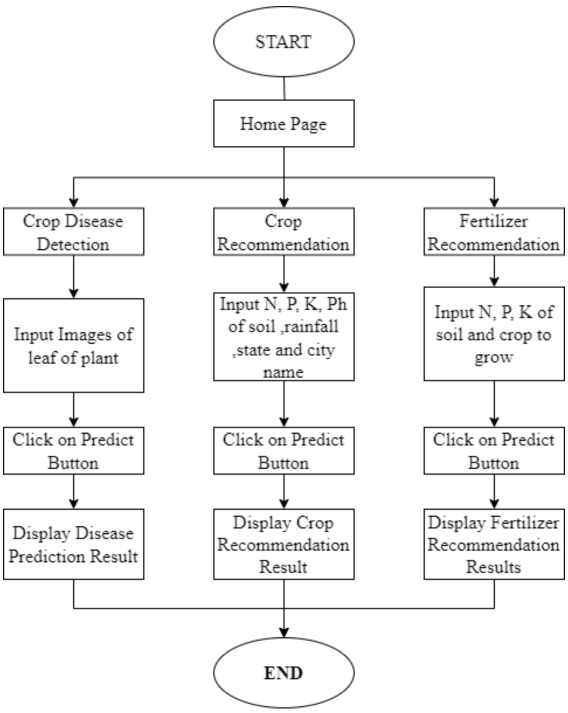

Figure 4: Flowchart Of Homepage

Approach: To provide a plant the optimal fertilizer, we have employed rule-based classification, a classification technique that uses IF-THEN rules for class prediction. A fertilizer is advised based on how far a plant deviates from its optimal N, P, or K value. For our purposes, we have 6 types of fertilizer recommendations currently, based on whether the N/P/K values are high or low.

RESULTS AND DISCUSSION

Crop Recommendation

Table I displays the findings from our crop suggestion trials. For convenience of comparison, these scores are also shown as a bar chart in Figure 6. It is evident that the XGBoost model performs the best, followed by the Random Forest and Naïve Bayes models. Boosting (RandomForest) and bagging (XGBoost) models are anticipated to typically outperform nonensemble approaches in terms of performance and generalization.

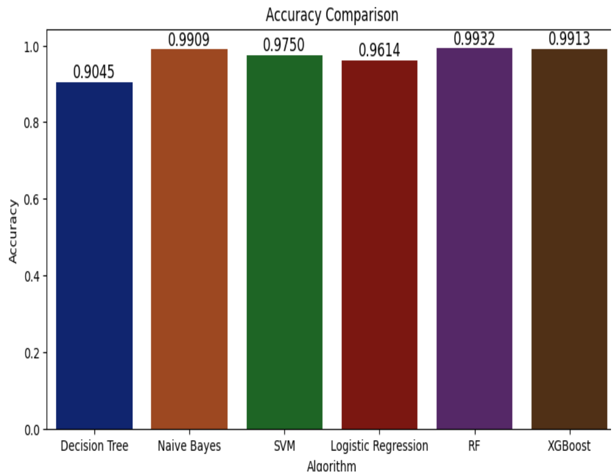

Figure 6: Accuracy comparison chart of different algorithms used in the Crop Recommendation model

TABLE I: Accuracy Comparison of Crop Recommendation models

Model Type	5- Fold Cross Validation Accuracy
Decision Tree	0.9045
Naive Bayes	0.9909
SVM	0.9750
Logistic Regression	0.9614
RF	0.9932
XGBoost	0.9913

Because we can clearly grasp the feature importances of the features utilized, which tell us how significant the features are for our classification, we chose the RandomForest model, which has a crossvalidation accuracy of 0.9932, for our application.

We find that the crop type is primarily determined by the amount of rainfall. Humidity is the second most important factor, after K, P, and N. This indicates that soil quality comes in second place and total water content is the most important factor. As a result, we can also determine which features are crucial to our model's total crop suggestion by employing this model.

Future Work

Future research will concentrate on regularly updating datasets to produce accurate forecasts; this procedure can be automated without requiring manual dataset modifications. Connecting the system to tangible objects to convert it into an Internet of Things (IOT) gadget that can monitor soil elements autonomously and choose which crops to cultivate based on the findings. giving consumers access to current crop market prices. This system enables multilingual communication, making it accessible to users worldwide.

We also want to be able to locate information on other brands and products that are available depending on the N,P, and K levels. This is another enhancement that may be made to fertilizer recommendations. We wish to be able to employ sophisticated machine learning techniques in the future to be able to offer suggestions that are more precise than the six types we now offer.

Next, we understand that the dataset we have used for disease classification is not exhaustive. This means that our model performs well only on the images which are from the classes the model already knows. It will not be able to detect the correct class for any out-of-domain data. This problem needs to be addressed in the future, and there are two ways of going about this. One solution is to find other datasets of similar scales with other types of crops and/or diseases, or generate/scale those datasets using generative modeling, and then add them to our training set. This will allow our model to generalize better. The second option is to allow the users to input their own images by creating a portal on our webapplication to annotate the images themselves.

Conclusion

In this paper, We suggest a machine learning-based web application system that is easy to use. We are able to offer several features with our system, including the detection of crop diseases, fertilizer advice based on a rule-based classification system, and crop recommendation utilizing the Random Forest algorithm. Through the use of forms on our user interface, the user may swiftly supply information and receive their results.

With the integration of crop recommendation, plant disease detection, and fertiliser recommendation technology, agriculture has advanced significantly. Through the use of artificial intelligence and machine learning, this research gives farmers vital insights for making informed decisions. Reduced crop losses and healthier yields are guaranteed by early disease detection. Customised recommendations for crops and fertilisers enable farmers to use fewer resources while maintaining high yields. Smooth conversation is made possible by the user-friendly chatbot and language translation, which encourage knowledge sharing among different farming communities. This comprehensive approach seamlessly blends traditional farming practises with technology to support a robust and sustainable agriculture sector. By giving farmers access to state-of-the-art equipment, this system increases food security and supports global efforts to produce food sustainably. With its innovative approach to enhancing farming communities' futures and providing ethical agriculture methods to feed the world, this approach offers hope to agriculture amid its new challenges.

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