Project Report

on

AI ASSISTED PLANT DISEASE DETECTION, CROP AND FERTILIZER RECOMMENDATION SYSTEM

Submitted as a part of the course curriculum for

Bachelor of Technology

in

Computer Science

Submitted by

SEJAL GUPTA (2000290120140)

YASH SRIVASTAVA (2000290120197)

HARSH SRIVASTAVA (2000290130076)

Under the Supervision of

Prof. Raj Kumar

(Asst. Professor & Additional Head, CS)

KIET Group of Institutions, Ghaziabad

Department of Computer Science

Dr. A.P.J. Abdul Kalam Technical University

2023-2024

DECLARATION

We hereby declare that this submission is our work and that, to the best of our knowledge and belief, it contains no material previously published or written by another person nor material which to a substantial extent has been accepted for the award of any other degree or diploma of the university or other institute of higher learning, except where due acknowledgement has been made in the text.

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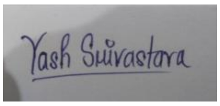
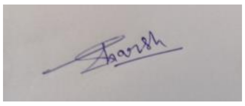
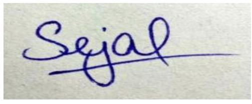


Name	: Yash Srivastava	Harsh Srivastava	Sejal Gupta
Roll No.	: 2000290120197	20002901300076	2000290120140
Date	:		

CERTIFICATE

This is to certify that Project Report entitled "**AI ASSISTED PLANT DISEASE DETECTION, CROP AND FERTILIZER RECOMMENDATION SYSTEM**" which is submitted by **Harsh Srivastava, Yash Srivastava, Sejal Gupta** in partial fulfilment of the requirement for the award of degree B. Tech. in Department of Computer Science of Dr A.P.J. Abdul Kalam Technical University, Lucknow is a record of the candidates own work carried out by them under my supervision. The matter embodied in this report is original and has not been submitted for the award of any other degree.

Date: **Supervisor Signature**

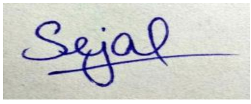
Prof. Raj Kumar

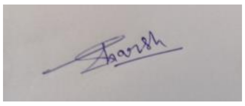
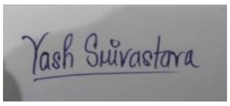
(Additional Head-CS)

ACKNOWLEDGEMENT

It gives us a great sense of pleasure to present the synopsis of the project *"***AI ASSISTED PLANT DISEASE DETECTION, CROP AND FERTILIZER RECOMMENDATION SYSTEM**" undertaken during B.Tech (CS) fourth year. We owe a special debt of gratitude to Prof. Raj Kumar (Asst. Professor & Additional Head, CS), Department of Computer Science, KIET Group of Institutions, Delhi- NCR, Ghaziabad, for his/her constant support and guidance throughout the course of our work. Her sincerity, thoroughness and perseverance have been a constant source of inspiration for us. It is only his/her cognizant efforts that our endeavors have seen the light of the day. We also take the opportunity to acknowledge the contribution of Dr. Ajay Kumar Shrivastava, Head of the Department of Computer Science, KIET Group of Institutions, Delhi- NCR, Ghaziabad, for his full support and assistance during the development of the project. We also do not like to miss the opportunity to acknowledge the contribution of all the faculty members of the department for their kind assistance and cooperation during the development of our project.

Last but not the least, we acknowledge our friends for their contribution to the completion of the project.

Signature: 

Date	:			
Name	:	Sejal Gupta	Harsh Srivastava	Yash Srivastava
Roll No	:	2000290120140	20002901300076	2000290120197

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, forecast of plant diseases and an interactive news stream. 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.

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INTRODUCTION

1.1. Introduction

The agriculture industry is essential to every country's economic development, 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 machine learning and artificial intelligence. In a world where digital solutions are taking over more and more, 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 many machine learning algorithms to ascertain, based on soil condition, the optimal crop and amount of fertiliser to apply. 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 reduces crop loss from disease, improves crop quality and production, and mitigates the damaging effects of agriculture on the environment.

1.2. Problem Statement

Agriculture is an integral part of the Indian economy. The Indian agriculture sector employs nearly half of the country's workforce. India is the second largest producer of Tomatoes in the world. Farmers' economic growth is determined by the quality of the goods they make, which is dependent on plant growth and yield. As a result, in the field of agriculture, disease identification in plants is important. Plants are highly susceptible to diseases that inhibit plant development, which has an effect on the farmer's ecology. The use of an automated disease detection technique is advantageous in detecting a plant disease at an early stage. Plant diseases manifest themselves in various parts of the plant, such as the leaves. It takes a long time to manually diagnose plant disease using leaf photographs. As a result, computational methods must be developed to automate the process of disease detection and classification using leaf images.

1.3. Objective

- To study the existing tomato crop disease that can detect disease in Tomatoes by their leaves accurately and detect unhealthy regions of plant leaves.
- Classification of plant leaf diseases using texture features and analyzes the leaf infection.
- To give remedy information to the user. To make these services available on Mobile App this can run on low-level configuration devices.
- To make these services available on Mobile App this can run on low-level configuration devices.

LITERATURE REVIEW

The device can locate a leaf's afflicted region and identify the precise illness that has harmed 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. To improve the precision of illness identification in leaves, we use the Random Forest method and K-Medoid clustering in our system.

In [2], a software solution is introduced that utilises Plant diseases may be swiftly and precisely identified and categorised using image processing.

Agriculture is very important and plays a vital part in a country's economy. 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 high quality 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. Image capture, image preprocessing, segmentation, and feature extraction are the steps in the process [4].

Plant diseases have the potential to drastically lower agricultural product quality and yield. 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]. Early crop health and disease detection information is very helpful in controlling diseases with the right management methods. 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.

The authors of this research describe an intriguing method for determining the amounts of nutrients in soil and provide suggestions for the best kind of fertiliser to apply [7]. Four steps make up the suggested methodologies: suggestion, data analysis, pre-processing, and soil analysis. Utilising an Internet of Things (IoT)-based device, the soil sample is examined. 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]. Plant diseases are a major factor in the decline in both the number and quality of food crops, especially those that impact 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, a median filter is used to pre-process the picture. The Guided Active Contour technique is then used to carry out segmentation [10]. Finally, a support vector machine is used to identify the leaf illness. Fertiliser recommendations are based on the disease-based similarity measure.

The focus of this paper is on [11]. Detecting leaf diseases is a labour-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. Ultimately, a Support Vector Machine (SVM) is used to categorise the picture and detect the illness's existence. [13].

In this paper, the authors propose and implement a system that aims to predict crop yield based on historical data. Machine learning methods like Random Forest and Support Vector Machine are used to agricultural data in order to do this. These algorithms analyse the data and provide recommendations for suitable fertilisers for each specific crop [14]. The development of a prediction model for future crop production forecasting is the primary goal of this work. The use of machine learning methods to forecast agricultural yields is briefly discussed in this article.

We designed our proposed system to effectively analyse soil types, identify leaf diseases, and provide farmers with tailored fertiliser recommendations. This system has the potential to greatly assist farmers in their agricultural practises. Plant diseases, especially those that impact the leaves of plants, are a major factor in lower agricultural yields, both in terms of number and quality[15]. Farmers get significant advantages from the use of intelligent analysis and extensive prediction models in agriculture, as it allows them to plant the right crops at the right 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. This involves finding a balance between crop production, managing plant diseases, promoting economic growth, and implementing strategies to mitigate crop scarcity. Therefore, it is essential to offer symptoms that might aid in the early identification of the illness in order to detect and distinguish plant diseases and provide recommendations for fertilisers[16]. Therefore, the authors have proposed and developed a new Recommendation System for fertilisers to predict crop diseases.

This publication provides an extensive overview of image processing methods for plant leaf disease diagnosis. 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. 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.

This work presents a survey on the method of using image processing to identify leaf diseases. India is primarily an agricultural country, with a significant portion of its population, approximately 70%, relying on agriculture for their livelihoods[17]. 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. 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. In the realm of information and communication technology (ICT), data mining may be used to forecast agricultural output .This means that we can make accurate predictions about the number of crops that will be produced. Through a comprehensive analysis of the historical data, we are able to provide the farmer suggestions for increasing crop productivity. This programme also has a model that analyses leaf textural similarities to forecast the kind of crop disease[18].

GAPS IN LITERATURE

At present, the research on plant diseases and pests based on deep learning involves a wide range of crops, including all kinds of vegetables, fruits and food crops. The tasks completed include not only the basic tasks of classification, detection and segmentation, but also more complex tasks such as the judgment of infection degree. At present, most of the current deep learning-based methods for plant diseases and pests detection are applied on specific datasets, many datasets are not publicly available, there is still no single publicly available and comprehensive dataset that will allow all algorithms to be uniformly compared. With the continuous development of deep learning, the application performance of some typical algorithms on different datasets has been gradually improved, and the mAP, F1 score and FPS of the algorithms have all been increased. The breakthroughs achieved in the existing studies are amazing, but due to the fact that there is still a certain gap between the complexity of the infectious diseases and pests images in the existing studies and the real-time field diseases and pests detection based on mobile devices. Subsequent studies will need to find breakthroughs in larger, more complex, and more realistic datasets.

Exhaustive surveys have been conducted where the limitations of current methods for plant disease detection are summed up. Each of them listed the following challenges:

- data scarcity
- using images acquired in real conditions
- more accurate classification of the disease
- disease stage identification

The complex background is another issue that should be considered when creating the dataset. Computational complexity and memory requirements also deserve special attention. It is still a challenging task to detect simultaneous disorders and to capture images in all of the possible conditions. However, they highlight that it is unrealistic to expect that an automatic disease recognition system can achieve perfect accuracy when used in field conditions.

PROPOSED METHODOLOGY

3.1 Flowchart

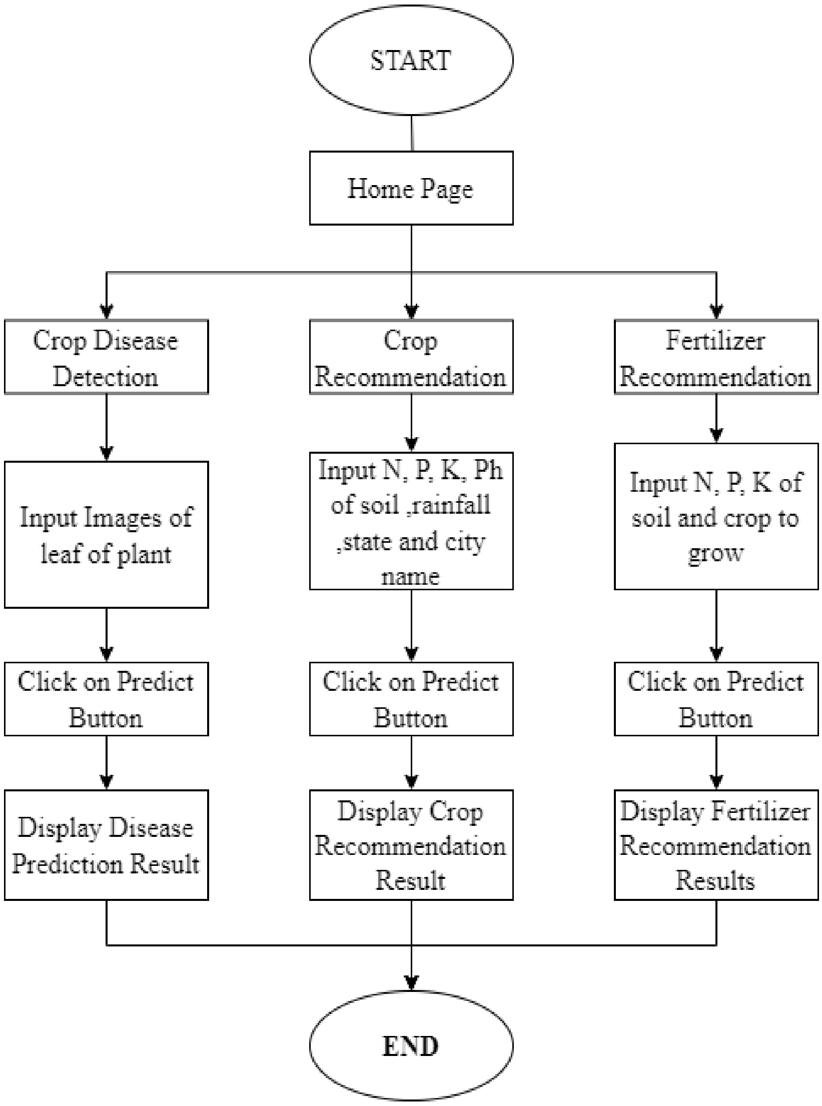

Fig.1.Flowchart for Homepage

3.2 Dataset Used

- The Dataset is collected from open-source website "Kaggle".
- Dataset contains 11k images of 9 tomato disease and 1 healthy class.
- Hence the dataset contains 10 classes of tomato leaves.
- Link: https://www.kaggle.com/datasets/kaustubhb999/tomatoleaf

The data has different types of diseases for tomato leaves.

Here goes the list:

- Tomato mosaic virus
- Target Spot
- Bacterial spot
- Tomato Yellow Leaf Curl Virus
- Late blight
- Leaf Mold
- Early blight
- Spider mites
- Tomato healthy
- Septoria leaf spot

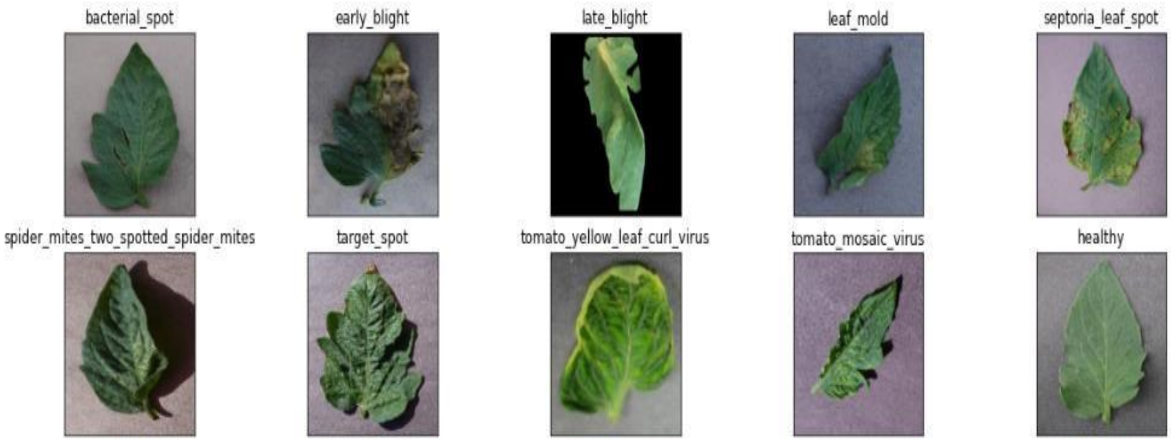

Figure 2: Sample Dataset [10]

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, fertilizer and crop recommendation.

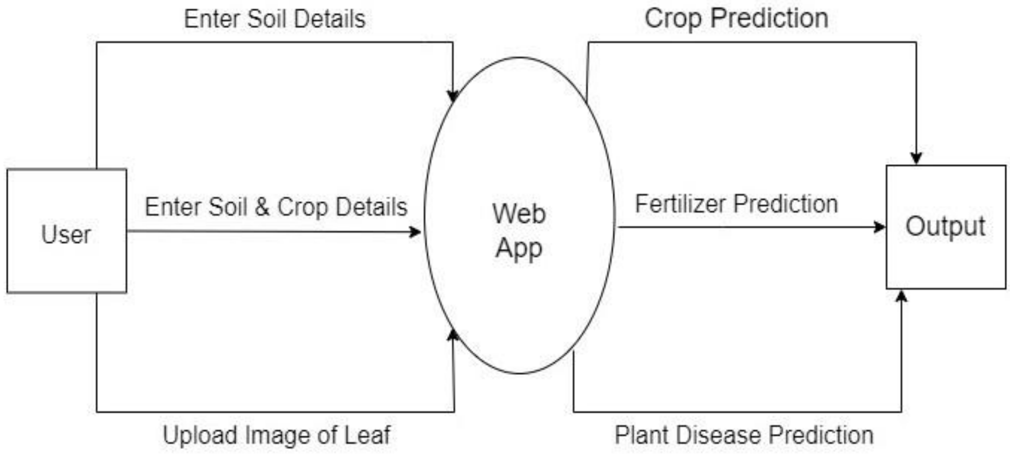

Figure 3: Context Diagram of Our Web Application

By developing a website that recommends crops and fertilizers depending on a variety of factors, including rainfall, ph, state, district, nitrogen, phosphorus, and potassium, In addition to anticipating plant problems, the initiative aims to save farmers time and effort. A number of techniques are used to help in accurate prediction, including Decision Tree, Random Forest, Naive Bayes, Support Vector Machine, and Logistic Regression. 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. The Flask API is contacted with a POST request. This is where the classifier that suggests fertiliser is hosted. After receiving an HTTP response, the front-end displays a fertilizer recommendation to the user. The flow diagram for the same is shown in Fig. 2.

2) Disease Detection: To identify illnesses, the user must either click on a picture or submit it directly. When the picture gets to the back end, the model processes it. After processing the picture, the front end receives an HTTP response. The user receives information about the plant's illness and its remedies.

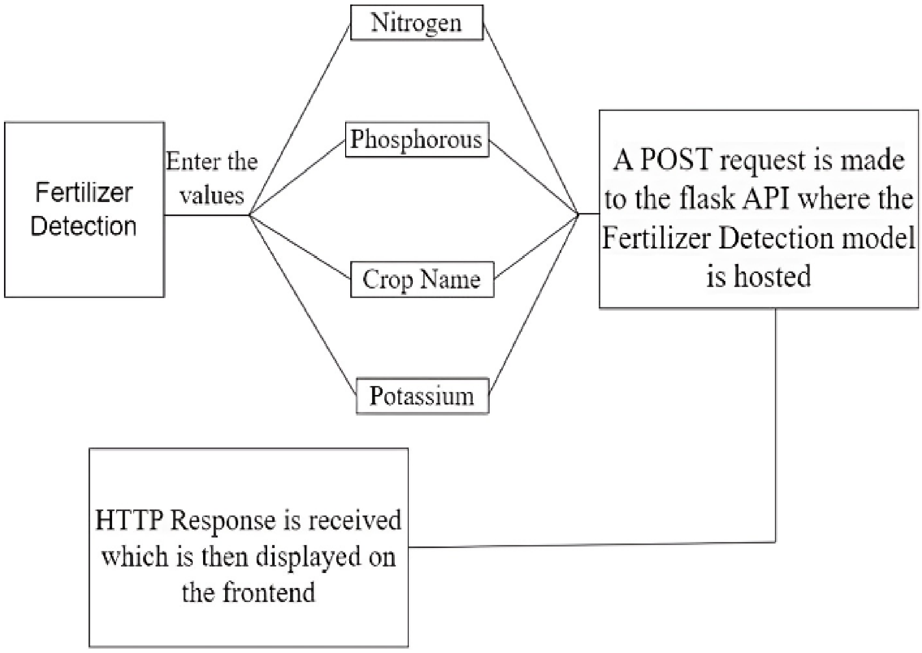

Figure 4: Flow diagram for Fertilizer Recommendation system

3) Crop Recommendation: Entering values for potassium, phosphorus, and nitrogen triggers a post request to the flask API. After the model has finished running, it sends an HTTP response to the front end that indicates the best crop a farmer might plant in the soil to maximise the potential of the land. The flow diagram for the same is shown in Fig. 3.

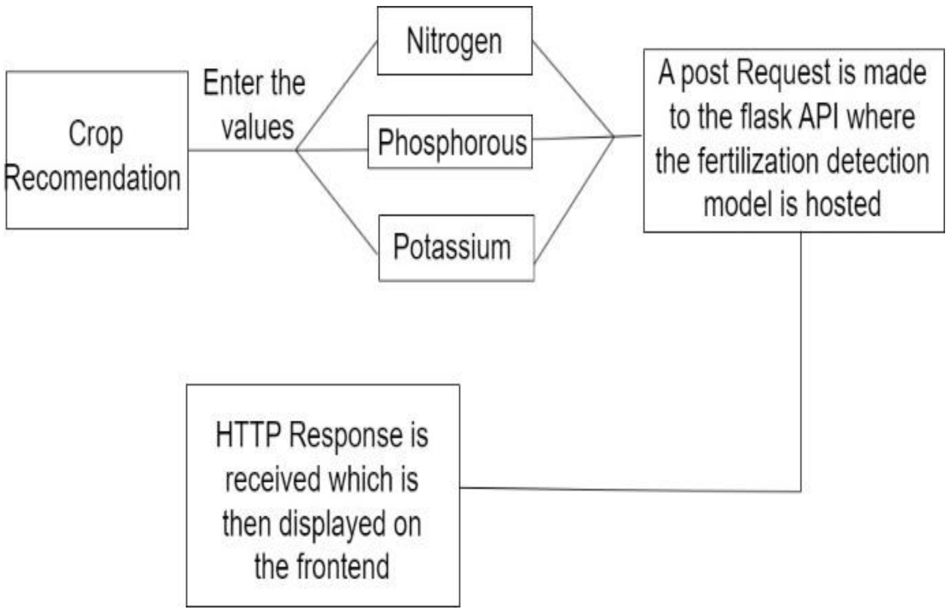

Figure 5: Flow diagram for Crop Recommendation system

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 made up of seven characteristics: Celsius degrees of temperature, N stands for nitrogen content ratio, P for phosphorus content ratio, and K for potassium content ratio in the soil. rainfall measured in millimetres The pH value of the soil and the relative humidity, expressed as a percentage, are both known. The goal is to predict the kind of crop using these seven traits. In all, there are 2200 samples and 22 class labels, some of which are related to rice, coffee, muskmelon, and maize. The dataset is perfectly balanced since each class has 100 samples; thus, no special imbalance control strategies are needed.

Approach: After dividing the dataset into five folds, cross-validation is carried out on each of these folds. We use six models to measure the performance:
• A decision tree with a maximum depth of five with entropy as the criterion.
• Naive Bayes.
• SVM with degree 3 polynomial kernel, 0-1 scaling on the input, and C=3 L2 regularisation parameter.
• The use of Logistic Regression.
• 20 estimators in a Random Forest.
• XGBoost.

2) Disease Identification: Overview of the Dataset: For the identification of leaf diseases, we consider the PlantVillage dataset. Specifically, we use an improved version of the PlantVillage dataset from Kaggle. The collection consists of 87,000 RGB photos of both healthy and sick crops, each with a spread of 38 class labels added to it. There are twenty-six different illnesses and a total of fourteen crops. There are, on average, 1850 image samples each class, with a standard deviation of 104. The dataset has an 80:20 training to validation ratio.
We attempt to predict the crop-disease pair based just on the plant leaf photo. We use a factor of 255 to reduce the size of the photographs so that they are 224 × 224 pixels. On these downscaled photos, we carry out both the model optimization and the predictions.
Approach: Our studies are conducted using ResNet-9. The model has varied sizes and quantities of parameters, and it performs differently on the ImageNet dataset. It has been shown that these pre-trained models outperform a scratch-built model on the PlantVillage dataset.
Starting with a learning rate of 0.01 and an epsilon of 1e-08, we start training using the Adam optimisation strategy in combination with categorical cross-entropy loss. 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. Obtaining the model that performs the best 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: Details of the dataset: We use a unique dataset with four characteristics (pH, K, N, P, and Crop) for fertiliser recommendation. There are 22 distinct crops—rice, maize, coffee beans, etc.—all of which have the ideal N, P, and K levels. The data set displays the suggested soil N, P, and K concentrations for optimal crop development. The required fertilizer for a farmer varies based on whether the soil is lacking in N, P, or K values.
Approach: We have used rule-based classification, a classification technique that predicts classes using IF-THEN rules, to provide the best fertilizer to a plant. A prescription for fertilizer is given

based on the degree to which a plant deviates from its optimum N, P, or K value. We now have six different types of fertilizer recommendations based on whether the N/P/K values are high or low.

TECHNOLOGY USED

4.1 Libraries to be Used

- Tensorflow
- Scikit-learn
- Keras
- Numpy
- Pandas
- Open-CV
- Matplotlib

4.2 List of module

- Image acquisition.
- Image pre-processing.
- Image analysis.
- Feature extraction.
- Disease classification.

Image Acquisition:

The first step is to gather data from a publicly accessible repository. The picture is used as the input for further processing. We've chosen the most common image domains so that we can accept any format as input to our method, including.jpeg, .jpg, and .png. The camera feeds the real-time images directly. a white background is provided for further study, proper visibility, and easy image analysis.The picture is taken in such a way that any distortion is avoided. The photo was not taken in direct sunlight because it would distort the picture.

Image Pre-processing:

The use of computer algorithms to perform image processing on digital images is known as image pre-processing. We can detect the plant by analysing the image with a specific algorithm. We use a similar approach for image processing and detection with a specific algorithm. The image quality is critical in this process; we can't use the algorithm if the image isn't clear.

Image Analysis:

In this phase, the process involves identifying the specific area of interest within the image. The chosen technique relies on differentiating between healthy and diseased regions of a plant leaf based on inherent variations. This method relies on distinguishing features within the leaf to pinpoint the relevant areas, allowing for targeted analysis and assessment.

Feature Extraction:

Feature extraction is a part of the dimensionally reduction method in machine learning, which divides and reduces a large collection of raw data into smaller classes. When we have a large amount of data and need to minimise the number of resources while avoiding errors, this step is critical. As a result, function extraction aids in the extraction of the best feature from large data sets by selecting and combining variables into functions.

Disease Classification:

It is the method of using our qualified deep learning model to recognise plant disease. A digital camera or equivalent system should be used to take an image of the contaminated plant's leaf. Opencv was used to scan the image. Then it determines what kind of plant it is. It determines what kind of disease the plant has after finding it.

RESULTS AND DISCUSSIONS

Crop Recommendation

The results of our crop suggestion trials are shown in Table I. Figure 6 also displays these results as a bar chart for ease of comparison. It is clear that the Random Forest and Naïve Bayes models perform worse than the XGBoost model. It is expected that boosting (RandomForest) and bagging (XGBoost) models will generally perform better in terms of generalization and performance than nonensemble techniques.

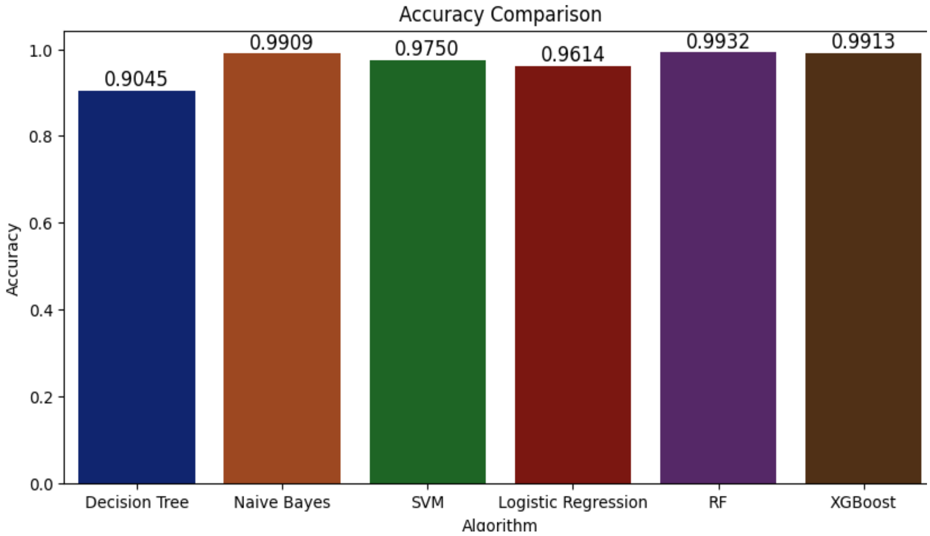

Figure 6: Accuracy comparison chart of different algorithms used in the Crop Recommendation model

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

Table I. Accuracy Comparison of Crop

We selected the RandomForest model, which has a cross validation accuracy of 0.9932, for our application because we can easily understand the feature importances of the features used, which inform us how significant the features are for our categorization.
We discover that the amount of rainfall largely determines the type of crop. After K, P, and N, humidity is the second most significant factor. This suggests that overall water content is the most significant component, with soil quality coming in second. Consequently, by using this model, we can also ascertain which features are essential to the overall crop suggestion of our model.

CONCLUSION

This study proposes a user-friendly web application system that utilises machine learning. 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.
Agriculture has evolved greatly with the integration of plant disease detection, fertilizer advice, and crop recommendation technologies. This research provides farmers with crucial insights for making well-informed decisions through the application of artificial intelligence and machine learning. Early disease diagnosis ensures healthier yields and less crop losses. personalized fertilizer and crop recommendations allow farmers to maintain high yields with less use of resources. The user-friendly chatbot and language translation facilitate seamless communication between various farming communities by promoting knowledge sharing. This all-encompassing strategy effectively combines modern farming techniques with conventional farming methods to promote a strong and sustainable agriculture industry. This method promotes worldwide efforts to produce food sustainably and boosts food security by providing farmers with access to cutting-edge equipment. This strategy gives agriculture optimism amidst its new challenges with its creative approach to improving farming communities' futures and providing ethical agriculture solutions to feed the world.

FUTURE WORK

Subsequent investigations will focus on updating datasets on a frequent basis in order to generate precise projections; this process can be automated in order to avoid the need for manual dataset adjustments. By attaching the system to physical things, it can be transformed into an Internet of Things (IOT) device that can independently monitor soil parameters and determine which crops to grow depending on the results. granting customers access to crop market pricing as of right now. Users from all around the world can communicate in multiple languages thanks to this method.

Finding information on different brands and items that are offered based on the N, P, and K levels is something else we would like to be able to do. This is an additional improvement that might be made to the fertilizer guidelines. In the future, we want to be able to use advanced machine learning techniques to be able to offer suggestions that are more precise than the six types we now offer.

Subsequently, we recognize that the dataset we have employed to classify diseases is not comprehensive. This indicates that only images from the classes the model is already familiar with get good results for our model. When dealing with any out-of-domain data, it won't be able to identify the appropriate class. In the future, this issue must be resolved, and there are two approaches to do so. Finding more datasets at comparable scales that include different crop varieties and/or illnesses, or creating and scaling those datasets via generative modelling, is one way to solve the problem and add them to our training set. This will improve the generalization of our model. The second choice is to build a gateway on our online application where people can upload their own photos and annotate them.

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