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Crop Disease Detection and Recommendation System

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Abstract— In the era of rapid technological advancement, agriculture is undergoing a digital transformation. Our Crop Disease Detection and Recommendation System helps farmers identify crop diseases and provides recommendations for crop and fertilizer selection through three key services: Disease Detection, Crop Recommendation, and Fertilizer Recommendation. Using a Convolutional Neural Network (CNN) with a 96.69% accuracy, the system precisely identifies diseases in crops such as apple, corn, grape, potato, and tomato. Additionally, it employs machine learning algorithms, including Random Forest and Naive Bayes, to provide highly accurate crop recommendations (99.09%) based on soil and climate data. This system revolutionizes agricultural decision-making by offering actionable insights to enhance crop resilience, optimize resources, and promote sustainable farming.

Index Terms— Accuracy, Classification, Crop Detection, Crop Recommendation, Deep Learning, Disease Detection, Fertilizer Recommendation, Testing, User-Friendly.

INTRODUCTION

Agriculture forms the backbone of our society, providing sustenance and livelihoods for billions of people worldwide. However, agricultural productivity faces numerous challenges, including crop diseases, fluctuating market demands, and the need for sustainable practices. In response to these challenges, we present our project: the Crop Disease Detection and Recommendation System.

Our project aims to leverage the power of technology to address key issues faced by farmers, specifically focusing on disease detection and crop and fertilizer recommendations. By harnessing the capabilities of machine learning and data analytics, we seek to empower farmers with actionable insights to enhance crop health, optimize yields, and ensure sustainable agricultural practices.

The Crop Disease Detection and Recommendation System comprises three essential services:

1. Disease Detection: Utilizing state-of-the-art image processing and machine learning techniques, this

service identifies and diagnoses diseases affecting crops. By analyzing images of diseased plants, the system provides accurate and timely detection of crop ailments, enabling farmers to take proactive measures to mitigate their impact.

2. Crop Recommendation: Through sophisticated data analytics and machine learning algorithms, this service offers personalized recommendations on crop selection based on factors such as soil characteristics, climate conditions, and market trends. By aligning crop choices with local conditions and demand, farmers can optimize their yields and maximize profitability.

3. Fertilizer Recommendation: Fertilizers play a critical role in maintaining soil fertility and supporting healthy crop growth. This service analyzes soil composition, nutrient levels, and crop requirements to deliver tailored recommendations on the type and application of fertilizers. By optimizing fertilizer usage, the system promotes efficient resource utilization and environmental sustainability.

Through the integration of these services, the Crop Disease Detection and Recommendation System aims to revolutionize agricultural practices, empowering farmers with the knowledge and tools needed to overcome challenges and thrive in an ever-changing agricultural landscape. By fostering sustainable practices and enhancing productivity, our project contributes to the resilience and prosperity of farming communities worldwide.

Literature Survey

In the paper titled "Intelligent Crop Recommendation System using Machine Learning" [1], authors Priyadharshini A, Swapneel Chakraborty, Aayush Kumar, and Omen Rajendra Pooniwala have addressed the critical issue of farmers' inability to make informed decisions about crop selection, leading to economic hardships and migration from agricultural areas. The proposed system aims to assist farmers in India by leveraging machine learning models to recommend suitable crops based on factors such as soil conditions, sowing season, and geographical location. By considering environmental parameters and economic factors, the system provides predictive insights on crop sustainability and recommends profitable crops, thereby reducing the risk of crop failure and increasing productivity. Through the integration of machine learning techniques and data mining, the system achieves high accuracy in crop recommendation, as demonstrated by various algorithms with accuracies ranging from 78% to 89.88%. The proposed system not only aids farmers in decision-making but also has the potential to reach millions of farmers across the country through web and mobile interfaces, paving the way for improved agricultural practices and livelihoods. In the paper titled "Plant Disease Detection and Classification by Deep Learning - A Review" [2], the authors Lili Li, Shujuan Zhang, and Bin Wang have provided a comprehensive review of recent advancements in the application of deep learning techniques for the identification and classification of plant leaf diseases. Highlighting the significance of early detection in mitigating agricultural losses, the review explores the evolution and effectiveness of traditional image recognition methods before delving into the benefits and challenges of employing deep learning in this domain. Through an examination of various studies, including those utilizing convolutional neural networks (CNNs), the review underscores the potential of deep learning in automating disease recognition, thereby enhancing efficiency and accuracy. Additionally, the paper discusses the importance of large and diverse datasets, transfer learning, and visualization techniques in improving the robustness and effectiveness of deep learning models. However, it also points out existing challenges such as limited datasets, lack of robustness in some models, and difficulties in early detection using hyperspectral imaging. Overall, the paper serves as a valuable resource for researchers in the field of plant disease recognition and provides insights into future directions for advancing this area of study. In the paper titled "Disease Detection of Plant Leaf using Image Processing and CNN with Preventive Measures" [3], the authors Husnul Ajra, Mst. Khairun Nahar, Lipika Sarkar, and Md. Shohidul Islam have introduced a technique aimed at addressing the significant challenges faced by farmers in detecting leaf diseases of crops such as tomato and potato. Leveraging image processing and convolutional neural network (CNN) models like AlexNet and ResNet-50, the proposed approach demonstrates a comprehensive framework for detecting and classifying leaf diseases while providing preventive measures through a graphical user interface. By applying image processing techniques to collected leaf datasets and utilizing CNN models for classification, the method achieves promising results with high accuracy, particularly with the ResNet-50 model. The paper emphasizes the importance of early disease detection and offers a practical solution to mitigate agricultural losses, thereby presenting a valuable contribution to the field of digital farming. In the paper titled "CNN based Disease Detection Approach on Potato Leaves" [4], the authors Md. Khalid Rayhan Asif, Md. Asfaqur Rahman, and Most. Hasna Hena have proposed a convolutional neural network (CNN) model for effectively detecting diseases in potato leaves, addressing the significant agricultural challenge of potato leaf diseases which cause economic losses to farmers. The study highlights the importance of early detection and intervention to mitigate crop damage. By employing various CNN algorithms including AlexNet, VggNet, ResNet, LeNet, and a Sequential model, the proposed approach achieves a high precision rate of 97% in distinguishing between normal and diseased potato leaves. Through comprehensive research and testing, the model demonstrates its capability in accurately identifying various forms of potato diseases, paving the way for future enhancements such as expanding the dataset to include more diseases and developing an Android application for broader accessibility in agricultural practices. In the paper titled "Detection and Classification of Apple Diseases using Convolutional Neural Networks" [5], authors Asmaa Ghazi Alharbi and Muhammad Arif have proposed a method for classifying healthy apples and identifying common diseases such as apple scab, apple blotch, and apple rot using convolutional neural networks (CNN). Recognizing the economic impact of fruit diseases, particularly in agricultural products like apples, the authors advocate for the use of computer vision and deep learning techniques to automate the detection process, thereby reducing time and costs associated with manual inspection. By collecting a dataset of infected apples from local markets, the proposed framework achieves high classification accuracy, with the best-performing model achieving 99.17% accuracy, demonstrating the efficacy of CNN models in fruit disease detection and classification. The study highlights the potential of CNNs to enhance productivity and quality in the fruit industry while offering insights into optimizing training ratios for improved classification accuracy and reduced time complexity. In the paper titled "Efficient Disease Detection of Paddy Crop using CNN" [6], authors P.A. Harsha Vardhini, S. Asritha, and Y. Susmitha Devi have proposed a system for detecting diseases affecting paddy crops using artificial intelligence and Convolutional Neural Networks (CNN). By storing disease information and sample images in a Raspberry Pi database, the system allows farmers to capture images of crop leaves, which are then compared with the database for disease prediction. Drawing on related studies, the authors highlight the limitations of existing approaches and emphasize the need for a mobile-based disease detection system to enhance accessibility and efficiency. The results indicate the reliability and necessity of the proposed model, utilizing AI to detect diseases promptly and accurately. With wireless technology integration, this system offers cost-effective and user-friendly solutions for farmers, enabling efficient monitoring and control of crops, ultimately contributing to increased yield through smart and effective disease management. In the paper titled "Plant Disease Detection Using CNN" [7], the authors Garima Shrestha, Deepsikha, Majolica Das, and Naiwrita Dey have proposed a CNN-based method for effectively detecting plant diseases, aiming to address the significant impact of crop losses on the Indian economy. Through a comprehensive methodology, the study preprocesses input images, segregates data and labels, and trains the model on a specific dataset comprising both diseased and healthy plant leaves. The CNN architecture employed includes convolution and max-pooling layers, with dropout for regularization and softmax activation for disease prediction. Notably, the proposed method achieves a test accuracy of 88.80%, showcasing promising results for automated plant disease diagnosis. This paper contributes valuable insights into the potential of CNN in revolutionizing agricultural practices and highlights avenues for further research and improvement in plant disease detection techniques. In the paper titled "Tomato Leaf Disease Detection using Convolutional Neural Network with Data Augmentation" [8], authors Nithish Kannan E, Kaushik M, Prakash P, Ajay R, and Veni S have presented a comprehensive approach for detecting diseases in tomato leaves using Convolutional Neural Networks (CNNs). Leveraging transfer learning with a pre-trained ResNet-50 model and implementing data augmentation techniques, the proposed model achieves a high accuracy of 97% in classifying six prevalent diseases in tomato crops. The study emphasizes the importance of early disease detection in plants and highlights the effectiveness of deep learning techniques in addressing this challenge. Despite the requirement for high-performance hardware for model training, the proposed system demonstrates promising results and serves as a valuable tool for farmers to identify and manage tomato leaf diseases efficiently. In the paper titled "Deep Learning-Based Object Detection Improvement for Tomato Disease" [9], authors Yang Zhang, Chenglong Song, and Dongwen Zhang have proposed an enhanced Faster RCNN algorithm to improve the accuracy of recognizing diseased tomato leaves and accurately locating them. The approach involves replacing VGG16 with a depth residual network for feature extraction, enabling deeper extraction of disease features. Additionally, the k-means clustering algorithm is utilized to cluster bounding boxes, enhancing the anchoring process to align with the real bounding boxes of the dataset. Experimental results demonstrate a 2.71% increase in recognition accuracy and faster detection speed compared to the original Faster RCNN, indicating the effectiveness of the proposed method. The study contributes by improving feature extraction networks and anchors, addressing the limitations of traditional methods and showcasing potential advancements for smart agriculture applications. In the paper titled "Rice Leaf Diseases Classification Using CNN With Transfer Learning" [10], authors Shreya Ghosal and Kamal Sarkar have proposed a deep learning architecture for automated detection of rice leaf diseases, aiming to aid farmers in timely disease identification. Recognizing the challenges faced by farmers in manually identifying diseases due to limited knowledge and vast agricultural lands, the authors developed a Convolutional Neural Network (CNN) model based on VGG-16 architecture, utilizing Transfer Learning on a small dataset collected from rice fields and the internet. The proposed model achieved an accuracy of 92.46% in classifying rice leaf diseases, demonstrating the effectiveness of Transfer Learning in enhancing model performance with limited data. This approach holds promise for providing accessible and accurate disease identification solutions to farmers, potentially improving crop yield and quality.

METHODOLOGY

The proposed Crop Disease Detection and Recommendation System is implemented using the following steps:

STEP 1: Data Collection: Gather a diverse dataset of crop images annotated with disease labels, soil samples with corresponding nutrient analyses, and historical crop yield data.

STEP 2: Preprocessing: Clean and preprocess the data to remove noise, normalize features, and prepare it for training machine learning models.

STEP 3: Model Development:

- Crop Disease Detection: Train a convolutional neural network (CNN) on the annotated image dataset to classify crop diseases.
- Crop Recommendation: Develop Crop Recommendation module that utilizes machine learning algorithms to suggest the most suitable crops for cultivation based on factors such as soil type, climate conditions, and market demand.
- Fertilizer Recommendation: Build a regression model that analyzes soil nutrient levels and crop requirements to recommend the optimal type and amount of fertilizer for specific crops and fields.

STEP 4: Integration: Integrate the developed modules into a unified system architecture, ensuring seamless communication and interaction between components.

STEP 5: Interface Design: Design user-friendly interfaces for the system, accessible via web applications to provide farmers with easy access to the system's functionalities.

ARCHITECTURE OF PROPOSED SYSTEM

The architecture of the proposed system is shown in the below Fig.1. The Crop Disease Detection and Recommendation System involves user interaction where farmers upload crop images and input soil nutrient values and climate conditions. After preprocessing the data for consistency, the system uses a Convolutional Neural Network (CNN) to detect diseases in the crop images and a Random Forest Classifier to recommend suitable crops based on soil and climate data. The Disease Detection module classifies crops as healthy or diseased, while the Crop Recommendation module suggests appropriate crops. Additionally, the Fertilizer Recommendation module advises on optimal fertilizer use based on soil nutrients and recommended crops. The system then provides users with disease diagnoses, crop recommendations, and fertilizer advice.

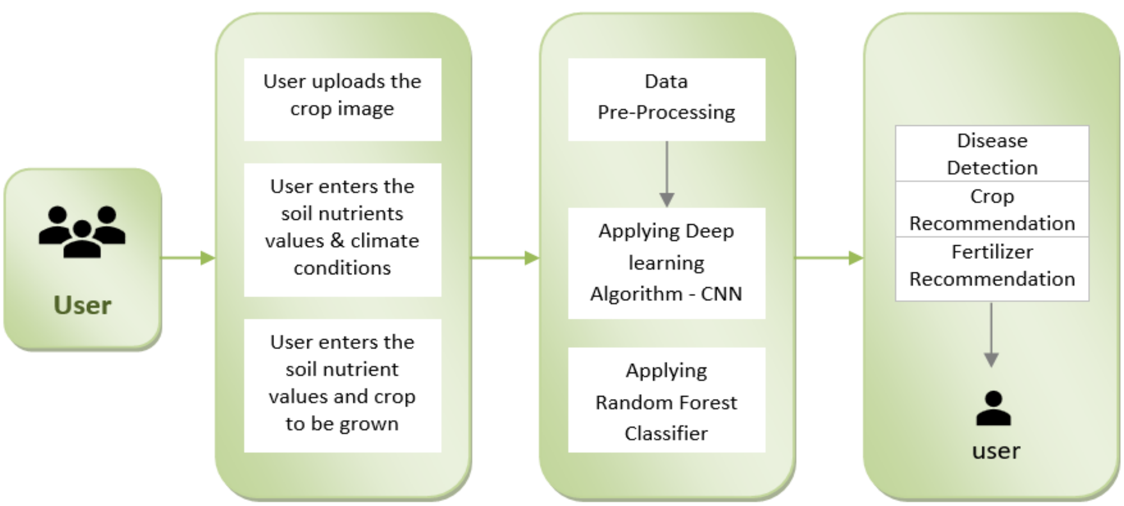

Fig.1. Architecture of the Proposed System

SYSTEM FLOWCHART

The system flowchart of Crop disease detection and recommendation system is shown in the below Fig.2. The system flowchart outlines the user interaction process, starting with user authentication for secure access. Upon login, users access the main menu, offering three primary services: Disease Detection, where users upload crop leaf images for disease analysis and access a detailed dashboard; Crop Recommendation, where users input soil and environmental parameters to receive personalized crop suggestions; and Fertilizer Recommendation, where users enter soil nutrient levels and desired crops to get tailored fertilizer advice. Users can log out at any time to ensure data privacy, and the flowchart ends, marking the conclusion of the interaction process.

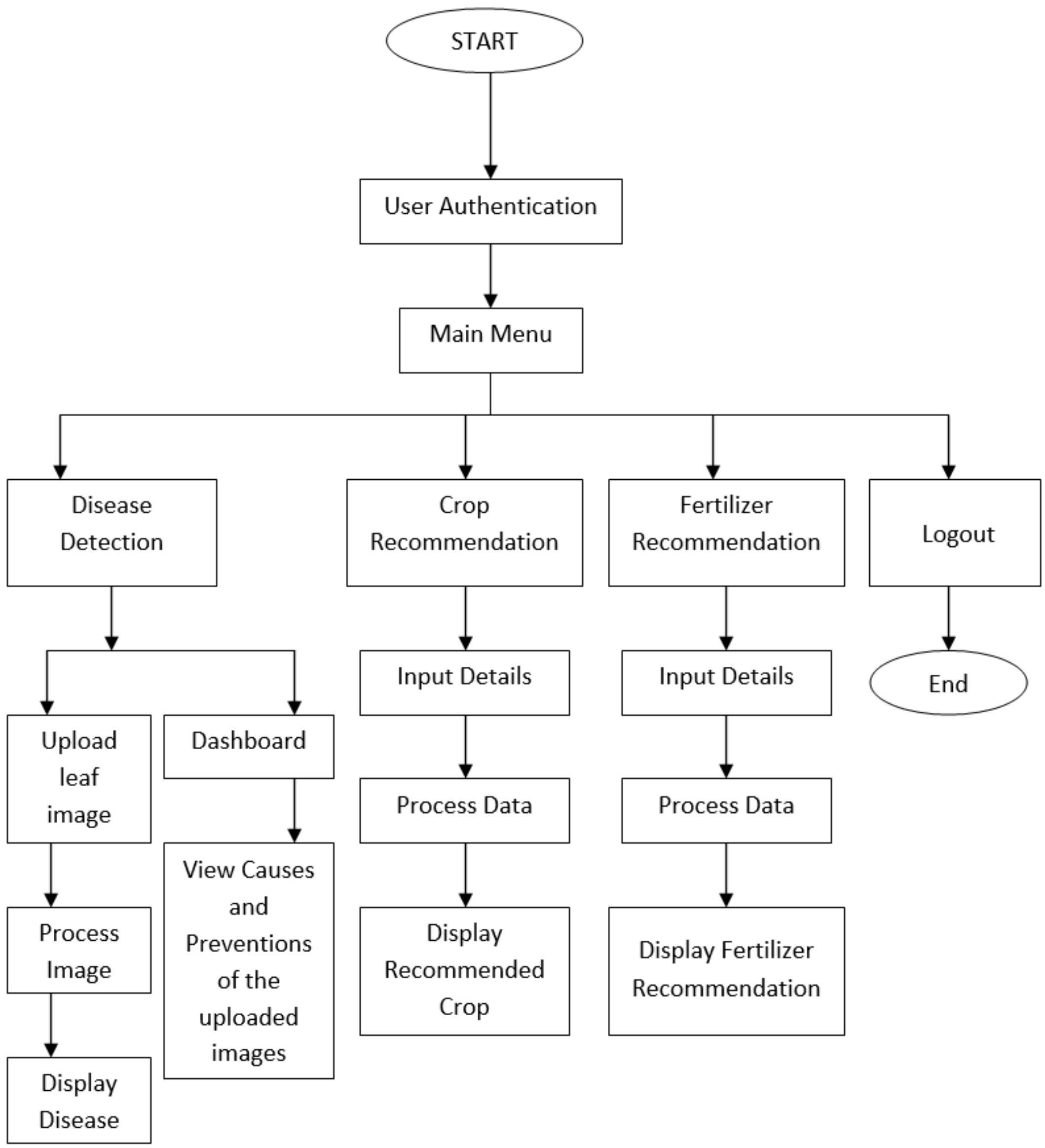

Fig.2. System Flowchart

RESULTS AND DISCUSSION

The graph in the below Fig.3 illustrates the training and validation accuracy of a crop disease detection model over 50 epochs. The x-axis represents the epochs, and the y-axis represents accuracy. The red line shows training accuracy, while the blue line shows validation accuracy. Initially, both accuracies increase rapidly, indicating effective learning. After 10 epochs, they plateau around 0.98-0.99, with minor fluctuations in validation accuracy. The close alignment of the training and validation curves suggests that the model generalizes well to unseen data and is not overfitting. Overall, the high accuracies indicate that the model performs effectively in detecting crop diseases.

Fig.3. Training and Validation accuracy

The graph in the below Fig.4 illustrates the training and validation loss of a crop disease detection model over 50 epochs. The x-axis represents the epochs, and the y-axis represents accuracy. The red line shows training loss, while the blue line shows validation loss. Initially, both the training and validation losses are high, indicating that the model is not well-trained. As training progresses, both losses drop sharply, showing that the model quickly learns to identify patterns associated with crop diseases. Around the 10-epoch mark, the training loss continues to decrease steadily, while the validation loss starts to fluctuate, suggesting that the model is beginning to overfit learning the training data well but not generalizing as effectively to unseen validation data. The fluctuations in validation loss after the 10th epoch highlight the importance of early stopping or regularization techniques to prevent overfitting and ensure the model maintains good performance on new data.

Fig.4. Training and Validation loss

The bar chart shown in the below Fig.5 compares the accuracy of various machine learning algorithms for crop recommendation, including Decision Tree, Naive Bayes, SVM (Support Vector Machine), Logistic Regression, and Random Forest. The x-axis represents accuracy, ranging from 0.0 to 1.0, while the y-axis lists the algorithms. All algorithms show high accuracy, close to 1.0, indicating their effectiveness in crop recommendation. The Decision Tree and Random Forest algorithm has the highest accuracy with 99.09%. Naive Bayes, SVM, and Logistic Regression also perform well, demonstrating that all these models are highly capable of making accurate crop recommendations.

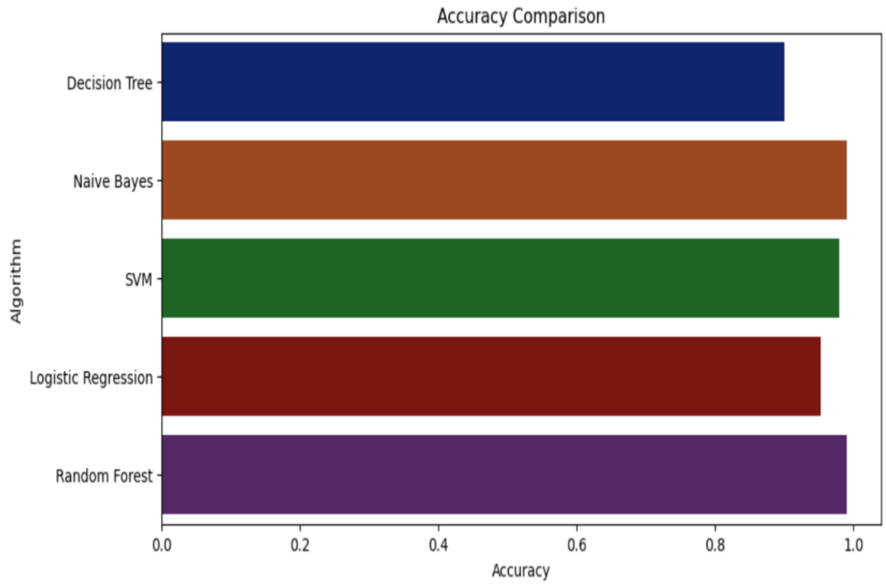

Fig.5. Accuracy Comparison

The disease detection for the sample test data is shown in the below Fig.6. Here the image of the Tomato crop is uploaded which is infected by a fungal disease called ‘Late Blight’. The image is uploaded later the CNN model detects the disease which is present in the sample image.

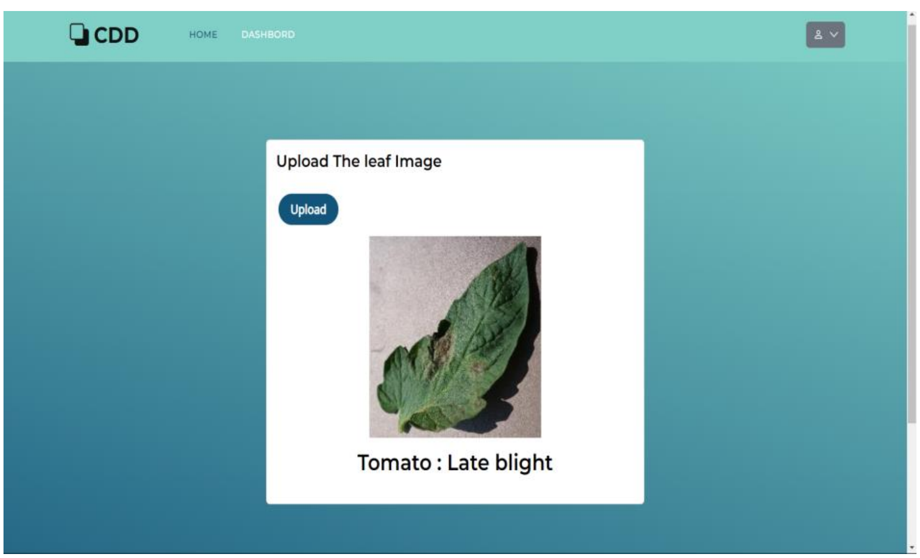

Fig.6. Disease Detection

The below given Fig.6 shows the page for Crop recommendation model. Here the inputs are given by the user such as Soil nutrient values (Nitrogen, Phosphorous and Potassium) and the climate conditions like temperature, humidity, rainfall, etc. Based on the inputs the crop will be recommended which will be suitable to grow.

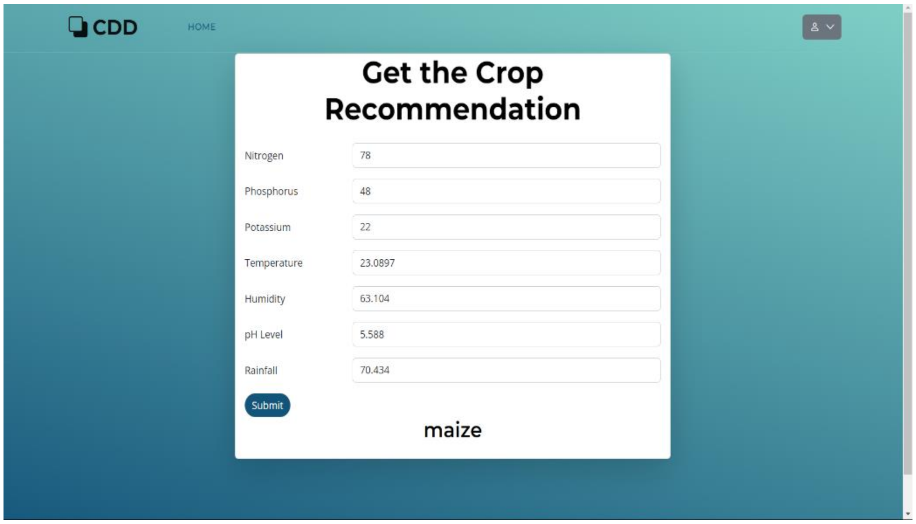

Fig.6. Crop Recommendation

The below given Fig.7 shows the page for Fertilizer recommendation model. Here the inputs are given by the user such as soil nutrient values (Nitrogen, Phosphorous and Potassium) and the crop which the user wants to cultivate. Based on the inputs the fertilizer recommendation will be given, so that the user could increase the nutrients of the soil that is required for the crop.

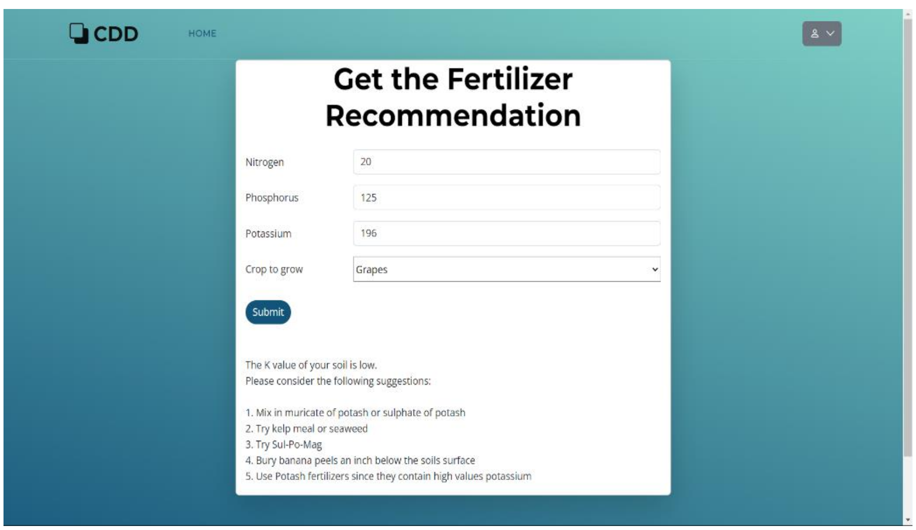

Fig.7. Fertilizer Recommendation

CONCLUSION

The Crop Disease Detection and Recommendation System revolutionizes agriculture by providing actionable insights and tailored recommendations through advanced machine learning, deep learning, and data analytics. It enables informed decisions on disease management, crop selection, and fertilizer application, proven effective in mitigating crop losses and enhancing food security. Integration with IoT sensors and precision agriculture technologies amplifies its impact, addressing climate change, resource scarcity, and promoting sustainable agricultural development.

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