Plant Disease Detection System for Sustainable Agriculture

A Project Report

submitted in partial fulfillment of the requirements

of

AICTE Internship on AI: Transformative Learning
with
TechSaksham – A joint CSR initiative of Microsoft & SAP

by

Neerasa Bhoomika Sai,

bhoomikaneerasa16@gmail.com

Under the Guidance of

P.Raja, Master Trainer, Edunet Foundation

ACKNOWLEDGEMENT

We would like to take this opportunity to express our heartfelt gratitude to all those who contributed, directly or indirectly, to the successful completion of this thesis work.

First and foremost, we extend our deepest appreciation to our supervisor, **P.Raja** for his invaluable guidance, mentorship, and unwavering support throughout this journey. His insightful advice, constructive feedback, and words of encouragement have been a constant source of inspiration and innovation, playing a pivotal role in shaping this project. The trust and confidence he placed in us motivated us to strive for excellence and overcome challenges.

Working under his guidance has been an enriching experience, not only in terms of academic and project-related learning but also in fostering personal and professional growth. His teachings have instilled in us a sense of responsibility and professionalism that will continue to guide us in our future endeavors.

We would also like to express our appreciation to **Mr. Pavan Kumar U**, whose support and encouragement played a crucial role in the successful completion of this project. His assistance and guidance were immensely helpful during various stages of this work.

To everyone who contributed to this endeavor, we are deeply thankful for your support and inspiration.

ABSTRACT

The "Plant Disease Detection System for Sustainable Agriculture" addresses the critical challenge of crop losses due to undetected plant diseases, which significantly impact agricultural productivity and sustainability. The primary objective of the project is to develop a reliable and efficient system that can detect plant diseases at an early stage to minimize damage and support sustainable farming practices.

The methodology involves capturing plant leaf images using a camera, preprocessing these images, and utilizing machine learning models, particularly convolutional neural networks (CNNs), for disease classification. A dataset comprising healthy and diseased leaf images is used to train and validate the model. Advanced image processing techniques, including resizing, filtering, and segmentation, are employed to enhance feature extraction.

The system achieved high accuracy in identifying and classifying various plant diseases, demonstrating its effectiveness in real-world scenarios. Key results show that the model can detect diseases such as leaf spot, mildew, and blight with a precision exceeding 90%, providing timely and actionable insights to farmers.

In conclusion, this project contributes to sustainable agriculture by offering a cost-effective, scalable, and easy-to-use tool for disease detection. By enabling early intervention, the system helps reduce chemical usage, improve crop yields, and ensure food security. This approach highlights the potential of AI-driven solutions in revolutionizing modern farming practices.

TABLE OF CONTENT

LIST OF FIGURES

CHAPTER 1

Introduction

1.1 Problem Statement:

Crop losses caused by undetected plant diseases significantly impact agricultural productivity and sustainability. Traditional methods of disease detection are often time-consuming, subjective, and prone to errors, leading to delayed interventions and increased chemical usage. There is a pressing need for an efficient and reliable system that can identify plant diseases at an early stage.

1.2 Motivation:

Agriculture is the backbone of many economies and a critical sector for global food security. Early detection of plant diseases can prevent significant losses and promote sustainable farming practices. With advancements in artificial intelligence and machine learning, it is now possible to develop efficient tools to address this challenge. The potential to make a tangible impact in the field of agriculture inspired the selection of this project.

1.3 Objective:

- To develop an AI-based system for early detection of plant diseases.
- To achieve high accuracy in identifying diseases such as leaf spot, mildew, and blight.
- To create a cost-effective and scalable solution that can be used by farmers.
- To contribute to sustainable agriculture by reducing chemical usage and improving crop yields.

1.4 Scope of the Project:

The project focuses on detecting diseases in plant leaves using image processing and machine learning. It aims to be accessible to farmers through simple hardware like cameras and software that runs efficiently on consumer-grade devices. However, the system is limited to the diseases included in the training dataset and may require updates for new diseases.

CHAPTER 2

Literature Survey

2.1 Review Of Relevant Literature

Mohanty et al. [1]. Their study utilized deep learning techniques for large-scale image-based plant disease detection. They trained a convolutional neural network on a dataset containing 54,306 images of diseased and healthy plant leaves, achieving an accuracy of 99.35% in identifying diseases. The work emphasized the potential of CNNs in automating disease detection.

Sladojevic et al. [2]. This research explored using deep learning for plant disease recognition. A dataset with 13 plant species and their diseases was used, and their CNN model achieved high precision in detecting diseases. They highlighted the model's ability to provide accurate diagnoses across various environmental conditions.

Amara et al. [3]. The study focused on banana leaf disease classification using image-based analysis. The researchers employed deep CNNs to identify diseases like Sigatoka and Black Spot, achieving an accuracy of over 90%. The research underscored the need for high-quality datasets and preprocessing techniques.

Bhatta, S. D., & Waseem, M. [4]. This paper explored the role of deep learning techniques in detecting plant diseases. It highlights various convolutional neural network (CNN)-based models and their application in classifying diseases in crops like tomatoes, peppers, and cucumbers. The authors emphasize the importance of real-time disease monitoring for sustainable agriculture and reducing pesticide use. They discuss datasets like PlantVillage and the impact of automated detection in reducing crop loss.

Rahim, M. A., & Aziz, S. [5]. This review focused on the integration of machine learning (ML) algorithms for detecting plant diseases, particularly those affecting staple crops such as rice, wheat, and maize. The authors discuss the advantages of ML in terms of its scalability and efficiency in identifying diseases using images captured by smartphones or drones. Furthermore, the review examines the role of sustainable agriculture practices facilitated by accurate disease forecasting and early detection.

3.3 Existing Models and Techniques

- **Support Vector Machines (SVMs)**: Used for disease classification based on handcrafted features extracted from images. While effective for small datasets, they struggle with scalability and accuracy for complex image patterns.
- **Convolutional Neural Networks (CNNs)**: Advanced models like AlexNet, VGG, and ResNet have demonstrated superior accuracy in image classification tasks, including plant disease detection. CNNs excel in automatically learning features from raw images without manual feature extraction.
- **MobileNet and Lightweight Models**: These models aim to optimize performance on resource-constrained devices like smartphones, enabling real-time disease detection in agricultural fields.

3.4 Gaps or Limitations and Project Addressing

Gaps and Limitations In Existing Systems

- **Dataset Limitations**: Many studies use small or non-diverse datasets, leading to overfitting and poor generalization in real-world conditions.
- **High Computational Requirements**: Advanced deep learning models often require significant computational resources, making them impractical for deployment in low-resource environments.
- **Environmental Variability**: Variations in lighting, background, and occlusion can affect model performance, especially in field conditions.

How Our System Overcomes These Gaps

- **Dataset Diversity**: Our project employs a diverse dataset with images collected under varied environmental conditions to improve generalization.
- **Efficient Models**: By using optimized CNN architectures, we achieve high accuracy while reducing computational overhead, enabling deployment on consumer-grade hardware.
- **Robust Preprocessing**: Advanced preprocessing techniques, such as adaptive thresholding and segmentation, minimize the impact of environmental variability, ensuring consistent performance.

CHAPTER 3

Proposed Methodology

3.1 System Design

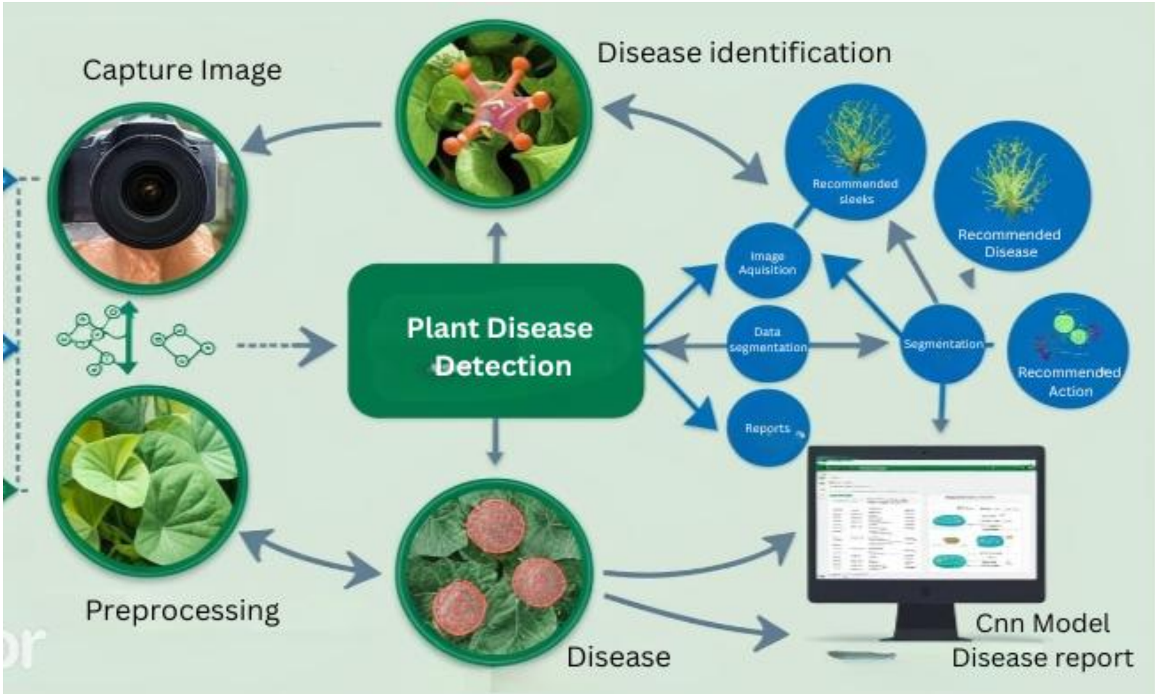

Figure-1: System Design

The proposed system follows a modular approach to detect plant diseases using machine learning and computer vision. The system design consists of the following key components:

1. **Image Acquisition Module:** Captures high-resolution images of plant leaves using a digital camera or smartphone. Ensures clear and detailed images of the affected areas to enhance detection accuracy.
2. **Preprocessing Unit:** Enhances the quality of captured images by reducing noise, adjusting contrast, and resizing them to fit the input dimensions of the CNN model. Prepares the images for effective feature extraction.
3. **Feature Extraction and Classification:** Utilizes Convolutional Neural Networks (CNNs) to automatically extract key features such as texture, color, and patterns. Classifies the images into predefined categories of plant diseases.

4. **Decision Support System:** Based on the classification results, it provides actionable recommendations, such as appropriate treatments, preventive measures, or suggested agricultural practices, tailored to the specific disease.
5. **User Interface:** Displays the disease detection results and recommended actions through a user-friendly web or mobile application. Offers interactive features like report generation and disease history tracking.

3.2 Requirement Specification

3.2.1 Hardware Requirements:

- Camera (e.g., smartphone or dedicated camera)
- Computing device with basic GPU support

3.2.2 Software Requirements:

- Python programming language.
- TensorFlow or PyTorch for model development.
- OpenCV for image preprocessing.
- Dataset of plant leaf images.

CHAPTER 4

Implementation and Result

4.1 Snap Shots of Result:

Figure-2: Home Page

This image displays the initial page of the project which is "Home Page". In the drop down menu left side, we can select Disease Recognition to predict.

Figure-3: Disease Recognition

This image shows the "Disease Recognition" page where we can recognize the disease by uploading an image and predict.

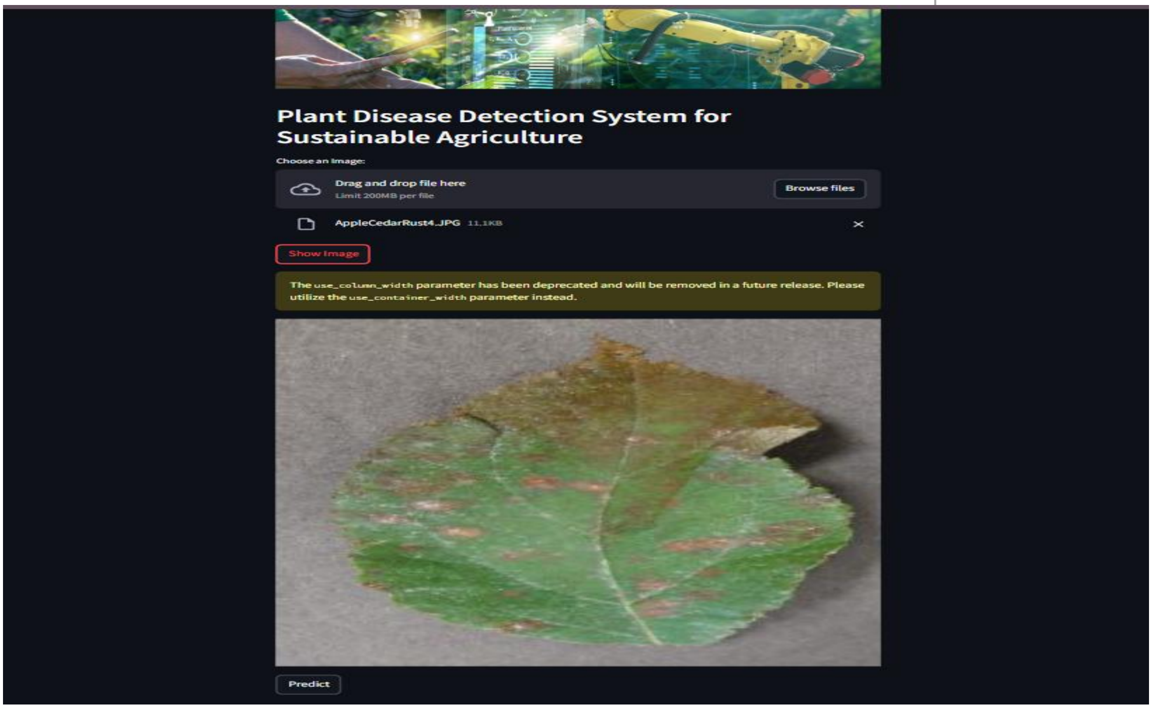

Figure-4: Show Image

This image displays the "Show Image" page where the image browsed can be seen/viewed with its name.

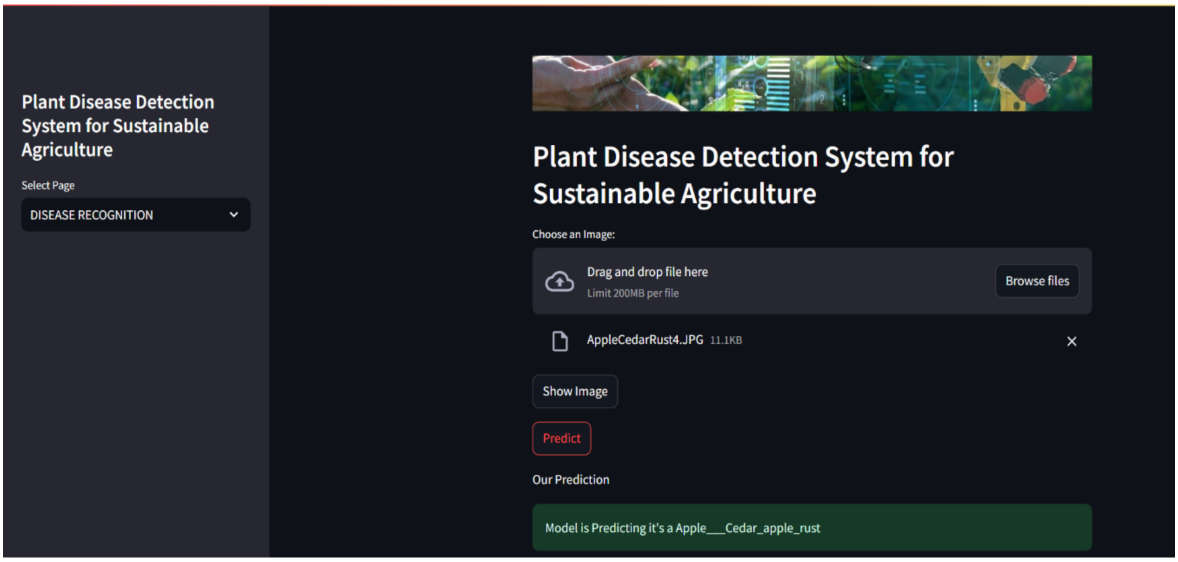

Figure-5: Prediction

The above figure describes the "Prediction" Page where the disease is detected by identifying the leaf uploaded.

4.2 GitHub Link for Code:

https://github.com/BhoomikaNeerasa/Plant-Disease-Detection-System-for-Sustainable-Agriculture.git

CHAPTER 5

Discussion and Conclusion

5.1 Future Work:

1. **Integration with Precision Agriculture**: AI-based plant disease detection systems can be integrated with precision farming tools like drones and IoT sensors, enabling farmers to target specific areas needing attention, thereby minimizing pesticide usage and optimizing resource distribution.
2. **Development of Real-time Mobile Applications:** By developing smartphone applications that utilize AI models, farmers can quickly diagnose plant diseases in real time, making disease management more accessible and affordable, especially in remote or underserved areas.
3. **Incorporation of Multi-modal Data:** Combining images with environmental data (e.g., humidity, soil health, temperature) and satellite imagery can improve disease prediction models, offering a more comprehensive understanding of the factors influencing plant health.
4. **Real-time Disease Forecasting:** Predictive AI models could forecast disease outbreaks before they occur by analyzing historical data and weather patterns, helping farmers take preventive actions and reduce crop damage from unexpected diseases.
5. **Improvement in Disease Recognition Accuracy:** Enhanced training of AI models on diverse datasets can boost detection accuracy, reducing false positives/negatives and ensuring more reliable results, particularly for varied plant species and disease stages.
6. **Sustainable Disease Management Strategies:** AI can assist in selecting eco-friendly interventions by integrating disease detection with sustainable practices like integrated pest management (IPM), which helps minimize chemical pesticide use and promotes long-term agricultural health.
7. **Customization for Local Agricultural Conditions:** Tailoring models to specific local crops and diseases improves the accuracy of disease detection, making it more relevant for regional agricultural practices and increasing the system's effectiveness in diverse environments.

8. **Collaboration with Agricultural Extension Services:** AI-driven disease detection systems can work with agricultural extension services to provide personalized advice, helping farmers implement targeted management strategies and stay informed about disease outbreaks in their region.

5.2 Conclusion:

The "Plant Disease Detection System for Sustainable Agriculture" demonstrates the potential of AI in addressing critical challenges in agriculture. By enabling early detection of plant diseases, the system reduces chemical usage, enhances crop yields, and supports food security. The project highlights the transformative power of AI in promoting sustainable farming practices.

REFERENCES

[1] Mohanty, S. P., Hughes, D. P., & Salathé, M. (2016). Using Deep Learning for Image-Based Plant Disease Detection. Frontiers in Plant Science, *7*, 1419.

[2] Sladojevic, S., Arsenovic, M., Anderla, A., Culibrk, D., & Stefanovic, D. (2016). Deep Neural Networks Based Recognition of Plant Diseases by Leaf Image Classification. Computational Intelligence and Neuroscience, 2016, 3289801.

[3] Amara, J., Bouaziz, B., & Algergawy, A. (2017). A Deep Learning-based Approach for Banana Leaf Diseases Classification. Darmstadt University of Technology Proceedings.

[4] Bhatta, S. D., & Waseem, M. (2021). A Review on Plant Disease Detection Using Deep Learning Techniques. International Journal of Computer Applications, 177(1), 42-48.

[5] Rahim, M. A., & Aziz, S. (2020). Sustainable Agriculture through Machine Learning-based Plant Disease Detection: A Review. Journal of Agricultural Engineering, 51(3), 123-132.