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FloraScan: Plant Disease Detection Using Machine Learning and Transfer Learning

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Abstract: Agriculture is an important sector that supports the livelihood of many people, especially in developing countries. However, plant diseases can reduce crop productivity and cause losses to farmers. Identifying these diseases at an early stage is important so that proper treatment can be given on time.
In this project, we developed **FloraScan**, a web-based system that detects plant diseases from leaf images using deep learning techniques. The system uses a Convolutional Neural Network (CNN) with transfer learning based on MobileNetV2 to classify diseases in tomato, potato, and bell pepper plants. Users can upload an image of a leaf through the web interface, and the system predicts the disease and also provides basic information such as possible treatments and preventive measures.
The model achieved an accuracy of around **97.22%**, which shows that deep learning can be useful for early plant disease detection.

Keywords: Plant Disease Detection, Deep Learning, CNN, Transfer Learning, MobileNetV2, Agriculture

I. INTRODUCTION

Agriculture is an important sector in many developing countries and provides livelihood to a large number of people. However, plant diseases continue to be a major concern, as they can reduce crop productivity by around 20%–40% and lead to significant losses for farmers. Because of this, identifying plant diseases at an early stage becomes important so that proper treatment can be provided on time. Traditionally, this process is carried out by experts through manual observation, but it can be time-consuming and is not always easily accessible, especially in rural areas.

In recent years, machine learning and deep learning techniques have been increasingly used to address this problem. Mohanty et al. [1] showed that Convolutional Neural Networks (CNNs) can effectively classify plant diseases from leaf images with high accuracy. Similarly, Ferentinos [2] applied deep learning models to multiple crops and achieved good results. Lightweight models such as MobileNet, introduced by Howard et al. [4], are useful because they provide accurate predictions while requiring less computational power. Machine learning is also being applied in other agricultural areas such as soil fertility prediction and crop price forecasting [10], [11].

In this work, we developed **FloraScan**, a web-based system that uses a CNN with transfer learning based on MobileNetV2 to detect diseases in tomato, potato, and bell pepper plants. The proposed model achieves an accuracy of approximately **97.22%**, which shows that deep learning can be effectively used for early plant disease detection.

II. RELATED WORK

Several studies have explored the use of machine learning and deep learning techniques for plant disease detection. According to Mohanty et al. [1], Convolutional Neural Networks (CNNs) can effectively identify plant diseases from leaf images by learning important visual patterns. Their work shows that deep learning models are well-suited for image-based disease classification.

Ferentinos [2] applied deep learning models using different CNN architectures and achieved high accuracy across multiple plant species. In a similar approach, Sladojevic et al. [3] used CNN-based methods for automatic disease detection, where features are extracted from leaf images and then classified into different categories.

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The MobileNet architecture, introduced by Howard et al. [4], is designed to reduce computational complexity while maintaining good classification performance. This makes it suitable for applications that require fast and efficient image processing.

Chen et al. [5] explored transfer learning for plant disease identification and found that it improves model performance, especially when the dataset is limited. Similarly, Arsenovic et al. [6] combined deep learning with data augmentation techniques to improve classification accuracy.

Shrestha et al. [7] presented a review of different plant disease detection methods and emphasized the importance of automated systems in agriculture. Li et al. [8] developed a web-based system that allows users to upload leaf images and receive disease predictions remotely.

Fuentes et al. [9] proposed a real-time detection system for tomato diseases using deep learning, showing its effectiveness in practical agricultural environments.

In addition to disease detection, machine learning techniques have also been applied in other agricultural areas. Raut and Mittal [10] worked on soil fertility prediction and crop recommendation using machine learning techniques, while Raut and Soni [11] explored crop price prediction using similar approaches.

Overall, these studies indicate that deep learning and transfer learning techniques are highly effective for plant disease detection and support the development of systems like FloraScan for accurate and accessible solutions.

III. PROPOSED SYSTEM & METHODOLOGY

The proposed system, **FloraScan**, is designed to detect plant diseases from leaf images using deep learning techniques. It provides a web-based platform where users can upload images of plant leaves and get predictions about possible diseases. The main aim of this system is to help farmers and agricultural users identify plant diseases at an early stage and take the necessary preventive actions.

For this system, a dataset of plant leaf images is used to train the model. The dataset includes images of three plant species: tomato, potato, and bell pepper, covering both healthy and diseased leaves. Before training, basic preprocessing steps are applied to prepare the data. All images are resized to 224 × 224 pixels and normalized to improve model performance.

The trained model is then integrated into a Flask-based web application. The frontend allows users to upload leaf images, while the backend processes the input and generates predictions using the trained model. The result is displayed to the user along with basic information about the disease, such as symptoms and possible treatment suggestions.

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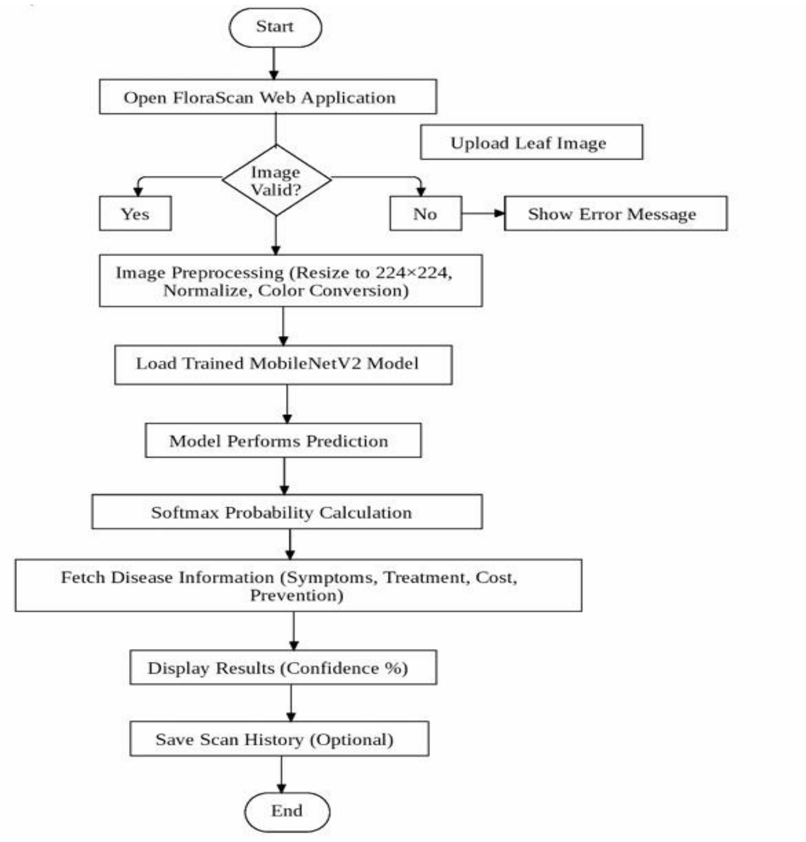

Figure 1: System Architecture

ALGORITHM SELECTION:

Convolutional Neural Network (CNN): Convolutional Neural Networks are commonly used for image classification tasks. In this system, CNN is used to extract important features from plant leaf images such as color patterns, textures, and shapes. These features help the model in identifying different plant diseases more accurately.

MobileNetV2 (Transfer Learning): MobileNetV2 is a lightweight deep learning model that uses depthwise separable convolutions to reduce computational cost while maintaining good accuracy. In this work, MobileNetV2 is used through transfer learning, where a pre-trained model is fine-tuned for plant disease classification. This helps improve performance and also reduces the training time.

Training and Testing: The dataset is divided into two parts: training and testing. Around 80% of the data is used for training the model, while the remaining 20% is used for testing. The training data helps the model learn patterns from the leaf images, and the testing data is used to evaluate how well the model performs.

During training, the model learns to recognize different disease patterns from the images. Once the training is complete, the model is able to predict the disease class when a new leaf image is uploaded by the user. The prediction results are then shown through the web interface.

IV. RESULTS AND ANALYSIS

I. Using CNN Model:

The proposed FloraScan system uses a Convolutional Neural Network (CNN) with transfer learning based on MobileNetV2 for plant disease detection. The model was trained on the prepared dataset of plant leaf images including tomato, potato, and bell pepper plants. The dataset was divided into 80% for training and 20% for testing.
After training the model, the testing dataset was used to evaluate its performance. The model successfully classified most of the diseased and healthy plant leaves. From the evaluation results, the model achieved an overall accuracy of approximately 95%–97% in plant disease classification. This indicates that the CNN-based approach is effective in identifying plant diseases from leaf images.

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II. Using Transfer Learning (MobileNetV2):

Transfer learning was applied using the MobileNetV2 architecture, which is a lightweight deep learning model designed for efficient image classification. The pre-trained MobileNetV2 model was fine-tuned using the plant disease dataset. After fine-tuning the model, the classification performance improved compared to the basic CNN model. The MobileNetV2 model provided better accuracy and faster prediction time. From the experimental results, the model achieved approximately 97% classification accuracy, demonstrating the effectiveness of transfer learning for plant disease detection. From the above analysis, it can be concluded that the MobileNetV2-based transfer learning model provides better performance for plant disease detection compared to the basic CNN model.

Table 1: Performance Summary of the Proposed Model

Phase	Train Accuracy	Val Accuracy	Train Loss	Val Loss	Learning Rate	Test Accuracy
Feature Extraction	84.57%	88.88%	0.4684	0.3895	1×10^{-4}	—
Fine-Tuning	95.20%	95.31%	0.1820	0.1481	1×10^{-5}	—
Final Evaluation	—	—	—	0.0880	—	97.22%

The performance results show that the model accuracy improved significantly during the fine-tuning phase. The validation accuracy increased from 88.88% during feature extraction to 95.31% after fine-tuning. The final model achieved a test accuracy of 97.22%, demonstrating the effectiveness of transfer learning using MobileNetV2 for plant disease detection.

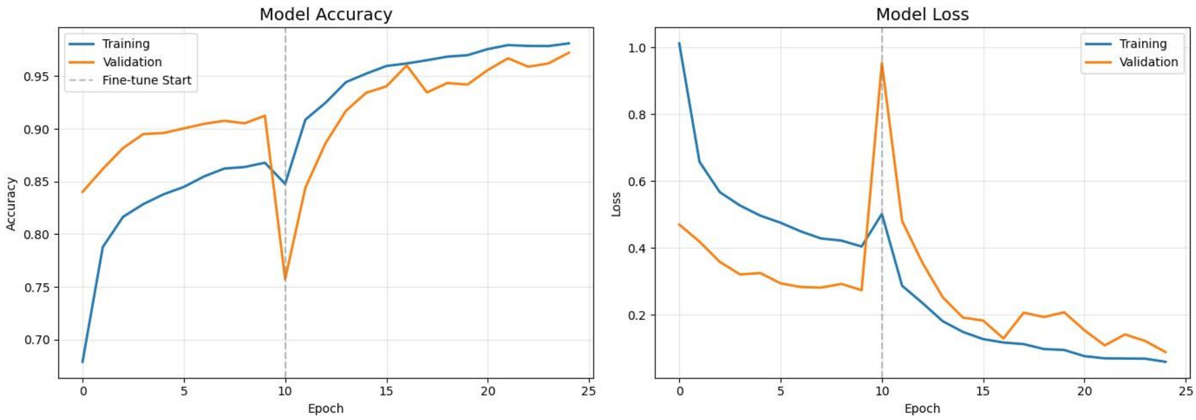

Figure 2: Training and Validation Accuracy Graph

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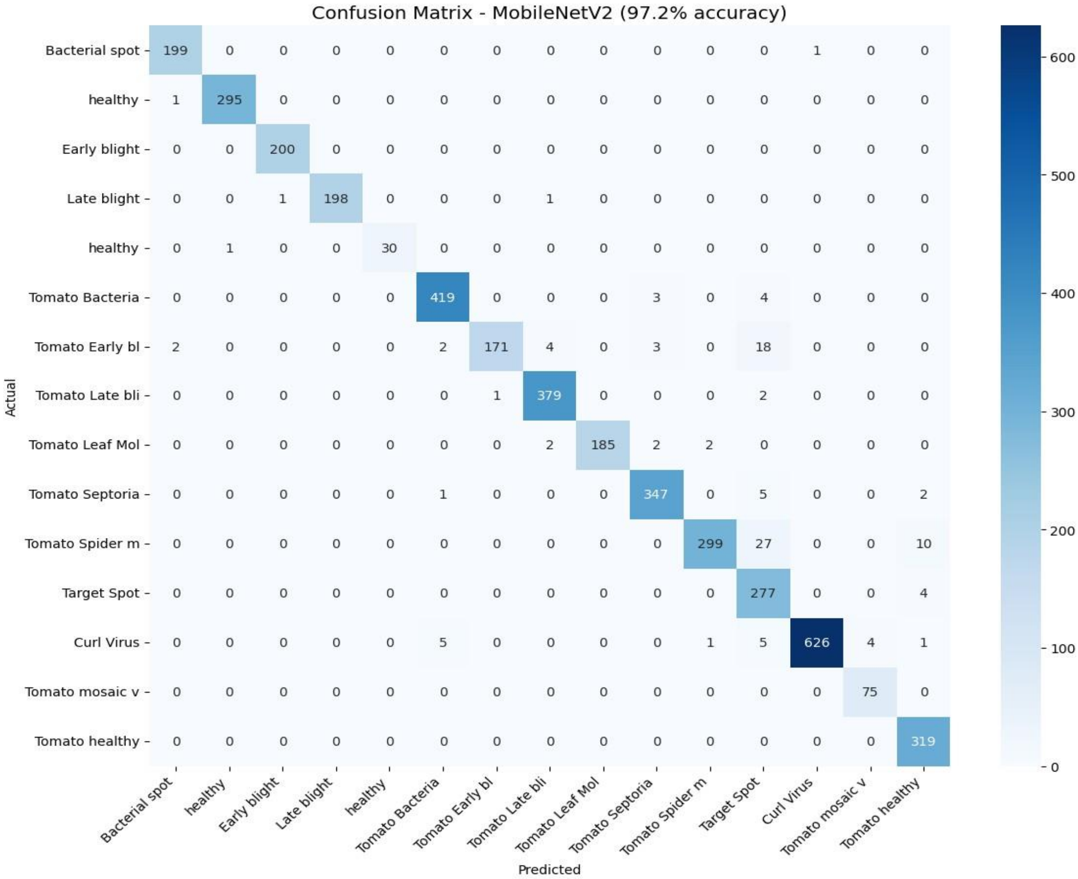

Figure 3: Confusion Matrix for 15-Class Disease Classification

Performance Metrics Analysis:

The performance of the proposed model was also evaluated using precision, recall, and F1-score metrics. These metrics help measure the classification performance of the model for different plant disease classes.

The results show that the model achieves high precision, recall, and F1-score values, indicating reliable disease classification performance.

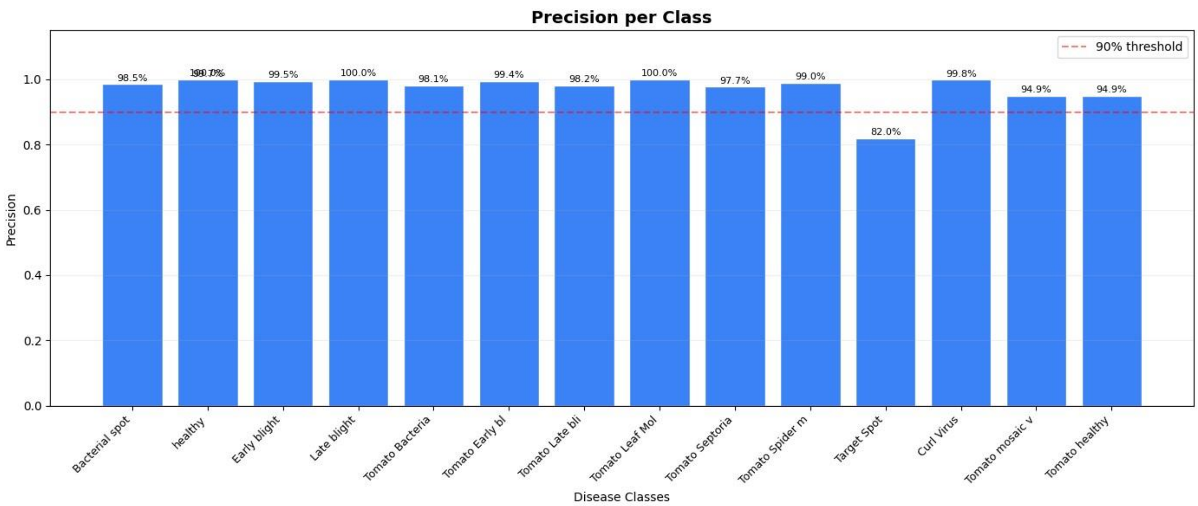

Figure 4: Precision Score

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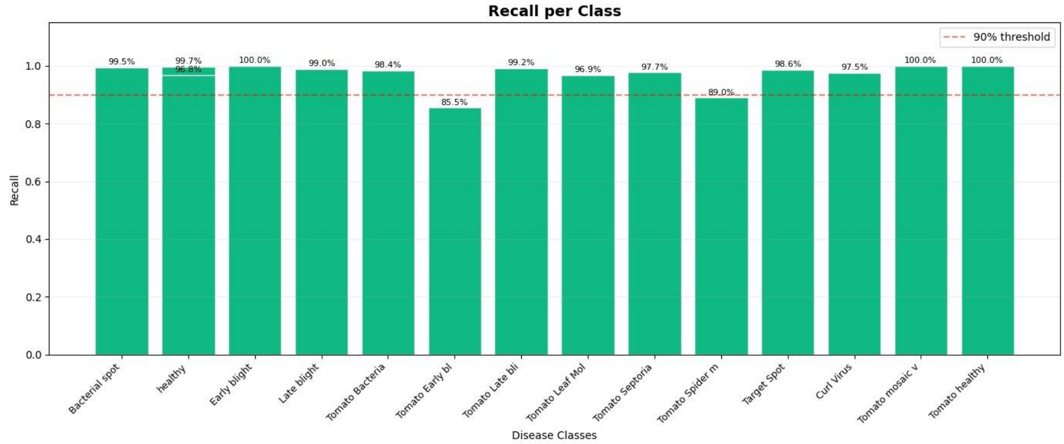

Figure 5: Recall per Class

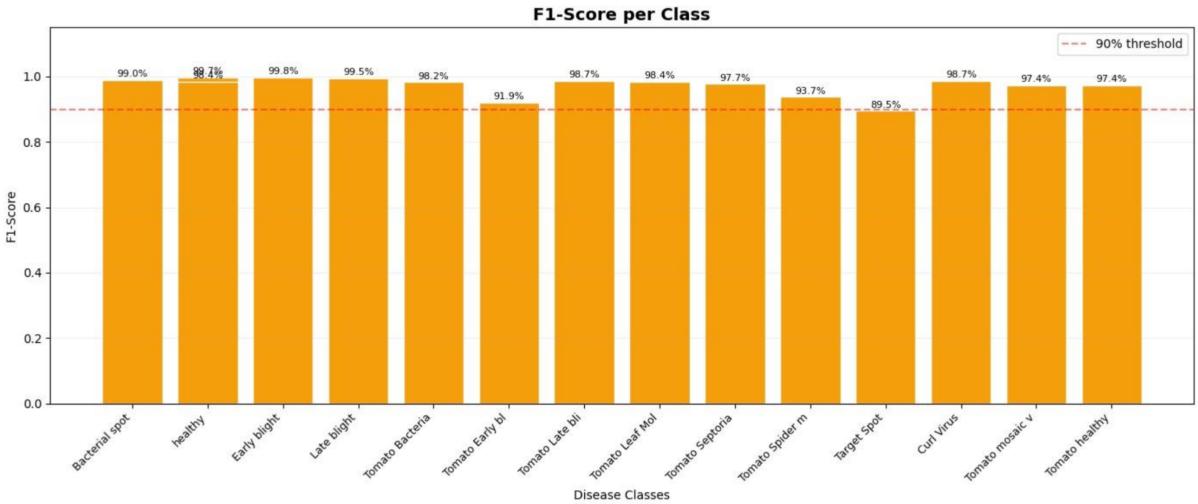

Figure 6: F1-Score per Class

Figure 7: FloraScan Home Page

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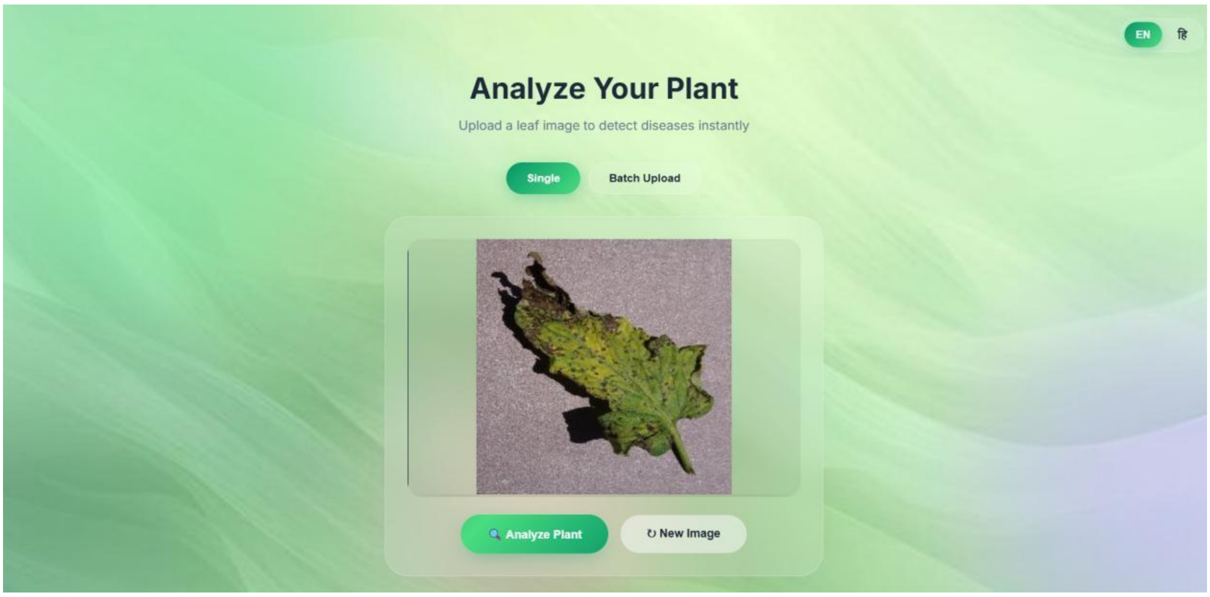

Figure 8: Leaf Image Upload Interface

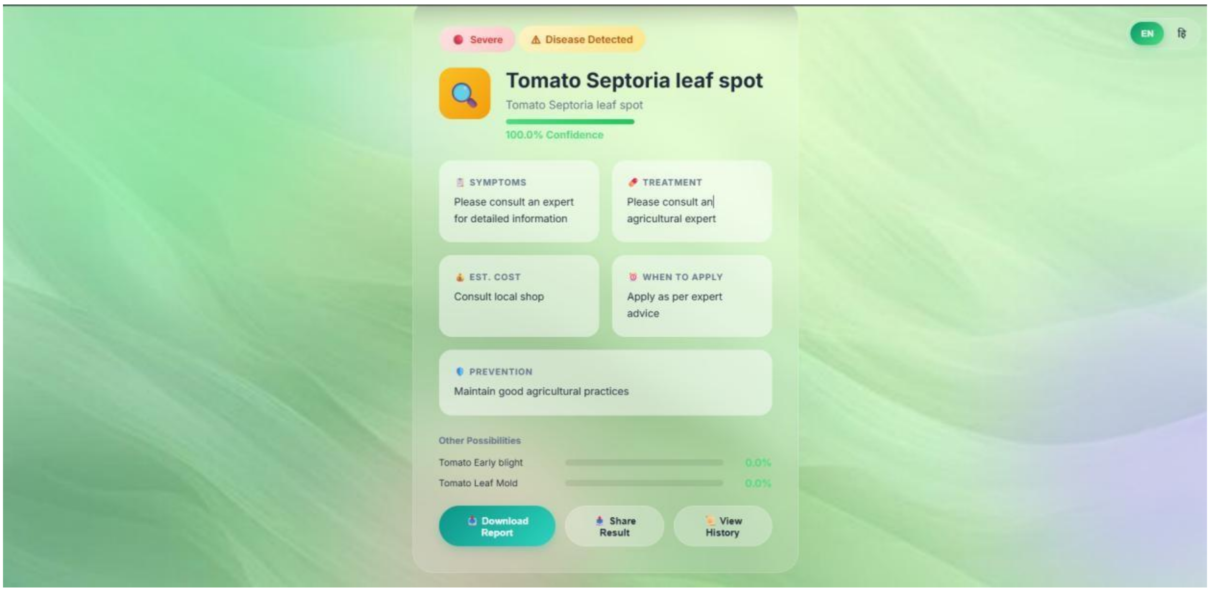

Figure 9: Prediction Result Page

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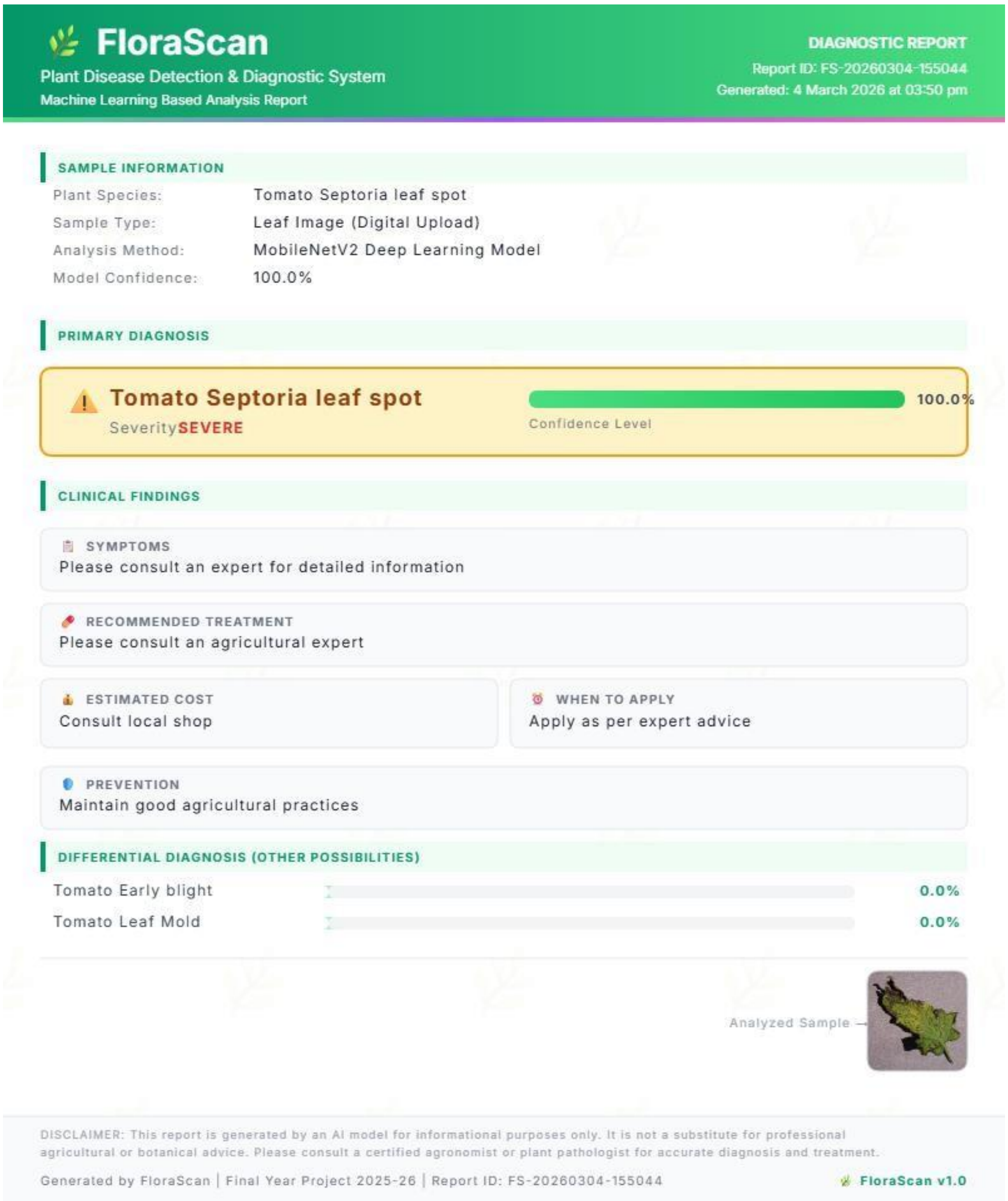

Figure 10: Generated Disease Detection Report

V. CONCLUSION

The proposed system, **FloraScan**, is developed to detect plant diseases at an early stage using deep learning techniques. It uses a Convolutional Neural Network with transfer learning based on MobileNetV2 to classify diseases from leaf images. The web application is designed to be simple and user-friendly, allowing users to upload leaf images and receive predictions along with basic treatment suggestions.

The results obtained from the model show high accuracy in disease classification, indicating that the approach is effective. Overall, the system can assist farmers and agricultural users in identifying plant diseases quickly and taking timely preventive measures to improve crop productivity.

In future work, the system can be improved by including more plant species and a larger dataset to further enhance its performance.

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