AI-Driven Detection and Treatment of Tomato Plant Diseases Using Convolutional Neural Networks and OpenAI Language Models

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Abstract

This study presents an AI-based system combining Convolutional Neural Networks (CNNs) for tomato plant disease detection and GPT-3.5 for treatment recommendations. It achieves a training accuracy of 99.85% and validation accuracy of 88.75%, offering farmers actionable insights for sustainable agriculture. The integration of real-time diagnostics and treatment guidance makes this system a valuable tool for improving crop management and reducing economic losses.

Introduction

Tomato plants are essential to global agriculture but are highly susceptible to diseases caused by bacteria, viruses, and fungi. These diseases lead to reduced yields and significant economic losses. Manual detection methods, though common, are labor-intensive and prone to errors, making them impractical for large-scale farming. This study presents an AI-driven system that integrates Convolutional Neural Networks (CNNs) for detecting tomato plant diseases with GPT-3.5 for providing actionable treatment recommendations. The system is designed to support sustainable agriculture by enabling early, accurate disease detection and effective management.

Materials

The Kaggle dataset comprises 11,000 labeled tomato leaf images categorized into 10 classes. Data augmentation techniques such as rotation and flipping were applied to improve generalization

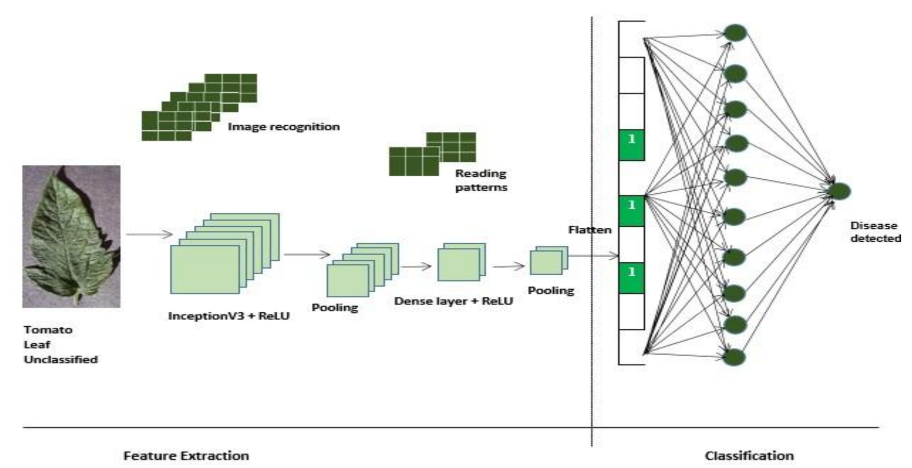

Fig. 1. The Model Architecture

Methodology

The system leverages the InceptionV3 CNN architecture for disease detection and GPT-3.5 Turbo for generating treatment recommendations. The model was trained using categorical cross-entropy and stochastic gradient descent, with early stopping to prevent overfitting.

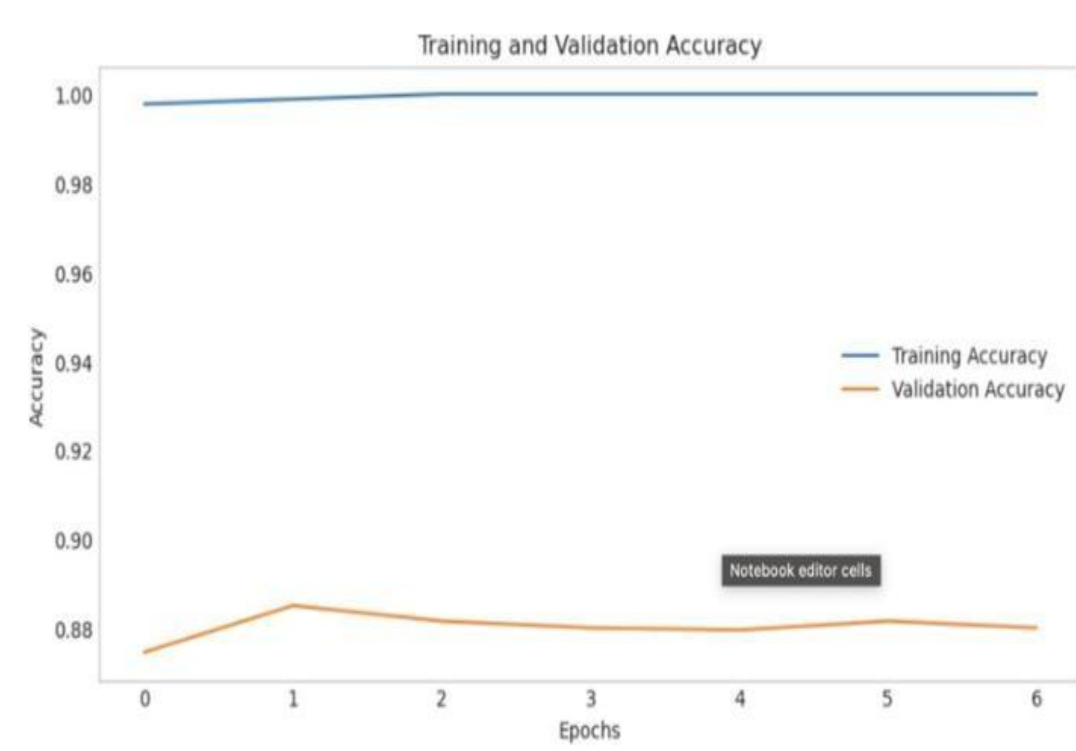

Fig. 2. The Training and Validation Accuracy

A Streamlit interface was developed, enabling real-time image uploads and providing instant diagnostic results alongside actionable treatment suggestions.

Results

The model achieved a training accuracy of 99.85% and validation accuracy of 88.75%, with high F1-scores across most categories. The confusion matrix reveals strong classification accuracy, with minimal misclassification

Fig. 3. The Training and Validation Loss

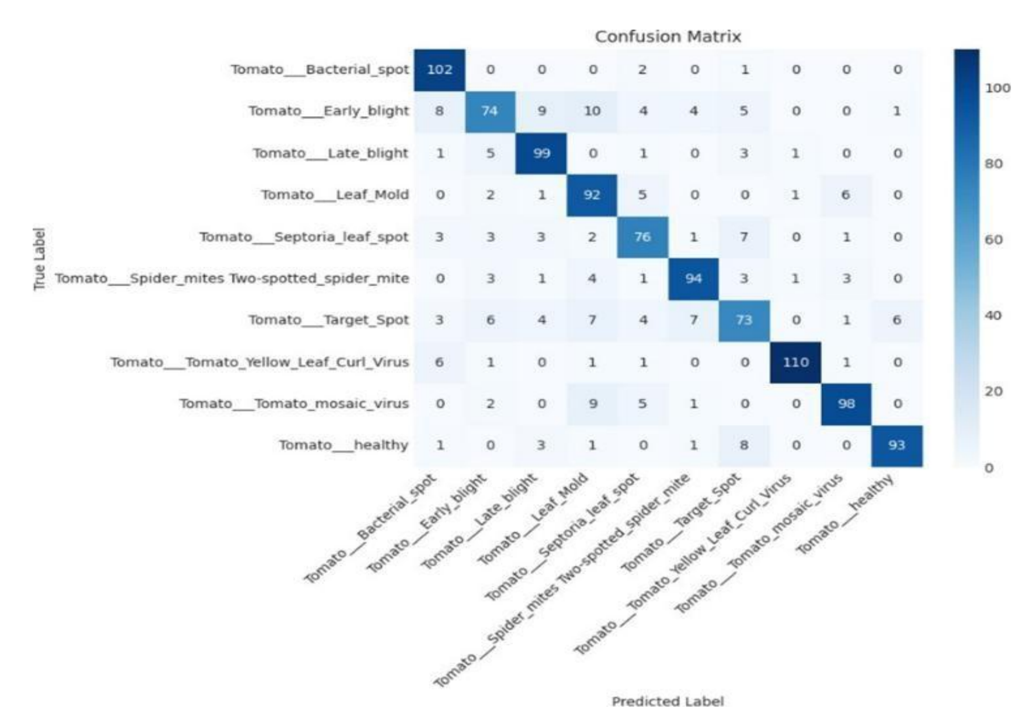

Fig. 4. Confusion Matrix

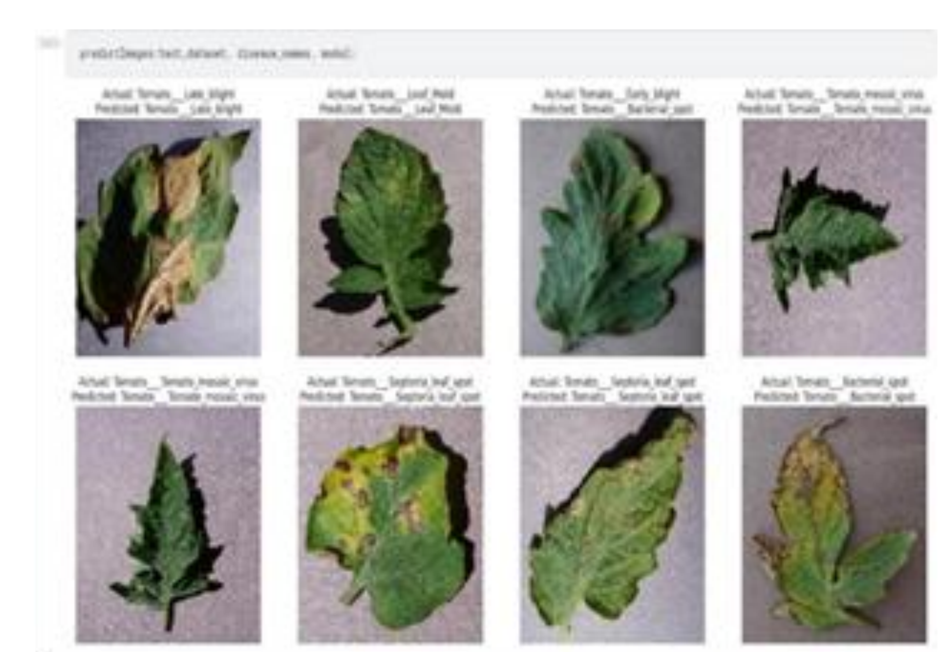

Fig. 5. Sample Outputs

Conclusion

This system combines CNN-based disease detection with GPT-3.5-powered treatment recommendations, offering a scalable and practical tool for managing tomato plant diseases. It improves diagnosis accuracy while providing actionable insights. Future work will focus on expanding datasets, offline functionality, IoT integration, and adapting the system for other crops.

Recommendations

Efforts should prioritize dataset expansion to include diverse environmental conditions. Offline and mobile-compatible systems are essential for broader accessibility. Integrating IoT sensors for real-time monitoring and extending diagnostic capabilities to other crops will enhance its impact on sustainable agriculture.

Acknowledgements

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