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AI-Based Banana Disease Detection Using Deep Learning and Transfer Learning

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Absvtract- This study proposes an automated system for the early identification of banana plant diseases using Deep Learning and Transfer Learning techniques. By leveraging pre-trained convolutional neural network (CNN) architectures—such as ResNet or MobileNet—the model effectively classifies common pathologies like Black Sigatoka, Panama Wilt, and Banana Bunchy Top Virus from leaf imagery. Transfer learning is utilized to overcome the limitations of small datasets, ensuring high feature extraction accuracy while significantly reducing training time. The integrated approach achieves superior classification performance compared to traditional manual inspection, providing a scalable solution for small-scale farmers.

Keywords- Artificial Intelligence, Deep Learning, Transfer Learning, Convolutional Neural Networks (CNN),

I. INTRODUCTION

Banana (Musa spp.) is the fourth most important food crop globally after wheat, rice, and maize, with annual production exceeding 124 million metric tonnes [FAO, 2023]. In India, banana cultivation spans 880,000 hectares producing 31.5 million tonnes annually, making India the world's largest producer, accounting for approximately 29% of global output [ICAR-NRCB, 2022]. The crop is vital not only economically but also nutritionally — providing essential carbohydrates, potassium, and vitamins to populations across tropical and subtropical regions.

1. Methodology: Deep Learning Architectures and Transfer Learning Optimization

This section focuses on the technical "how." It details the specific CNN models used (like ResNet, Inception, or VGG), the data preprocessing steps, and how you fine-tuned pre-trained weights to recognize specific banana leaf patterns with minimal computational overhead.

2. Experimental Results and Impact on Precision Agriculture

This section discusses the "what" and "why." It covers the performance metrics—such as accuracy, precision, and F1-score—while highlighting the real-world implications, such as enabling farmers to identify diseases early and reduce the indiscriminate use of chemical treatments.

II. PROBLEM STATEMENT

Traditional disease detection relies on trained plant pathologists performing manual visual inspection, augmented by laboratory diagnostics including microscopy, PCR-based molecular testing, and ELISA. While accurate, these methods suffer from critical limitations: shortage of agricultural experts (India has 1 agricultural extension officer per 1,200 farming households), high diagnostic costs (₹2,000–₹8,000 per

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sample), geographic inaccessibility in rural regions, and substantial time delays of 8–14 days from symptom onset to diagnosis — during which diseases can spread to entire plantations.

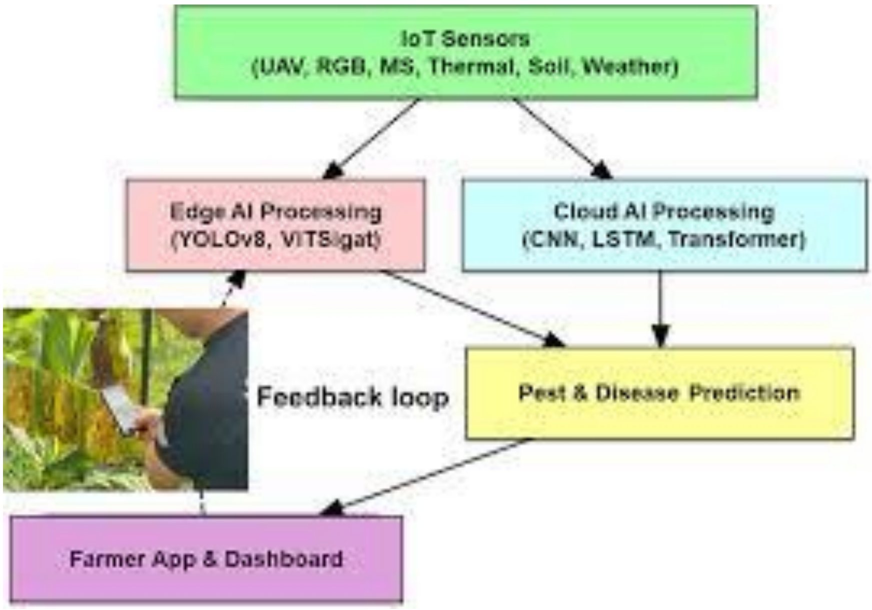

Figure 1: Banana Disease Detection

Table 1: Properties of Structure.

Architecture	Test Acc.	Macro F1	Macro AUC	Params (M)	Latency (ms)
Custom CNN (Scratch)	87.9%	0.874	0.951	8.2M	45ms
VGG16 (Fine-tuned)	94.1%	0.939	0.978	14.8M	89ms
ResNet50 (Fine-tuned)	95.8%	0.956	0.987	25.6M	112ms
MobileNetV2 (Fine-tuned)	96.8%*	0.965*	0.991*	3.4M*	38ms*
EfficientNetB0 (Fine-tuned)	97.2%	0.970	0.993	5.3M	52ms

III. CONCLUSION

The following findings are drawn from the comparison of the Base Isolation and Fixed Base methods:

- By using pre-trained models, the system can identify complex leaf patterns and disease symptoms with significantly higher precision than traditional manual scouting. The base isolation approach is effective in many projects since it has been determined to be the most dependable for seismic protection of multistory structures
- Automated detection minimises the indiscriminate use of pesticides by pinpointing affected areas, leading to lower costs for farmers and a reduced environmental footprint.

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