Deep-Machine Learning Integration for Enhanced Pest Detection in *Mangifera indica* (Mango)

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***Abstract*—Mango (Mangifera indica), the third most widely consumed fruit in Sri Lanka after banana and papaya, has experienced steady growth in cultivation and yield; however, pest and disease infestations still cause substantial yield losses and degrade fruit quality. Since most pests inhabit mango leaves, early and accurate leaf-based detection is crucial for effective crop management, yet traditional manual inspection remains time-consuming, labor-intensive, and often unreliable due to pest evolution and limited expert availability. To address these challenges, this study proposes an automated pest detection framework that integrates deep learning–based feature extraction with machine learning classification. The research uses ten classes from the MangoPestClassification dataset, consisting of real-world images of healthy and pest-affected mango leaves captured under diverse environmental conditions to represent realistic field scenarios. Pre-trained convolutional neural network (CNN) models, VGG19, ResNet50, InceptionV3, DenseNet121, MobileNetV2, and UNet, are employed to extract discriminative image features. These features are then classified using Logistic Regression, Random Forest, and Support Vector Machine (SVM) classifiers. This hybrid deep-learning–machine-learning approach ensures both strong feature representation and efficient classification. A 10-fold cross-validation strategy is applied to ensure reliable performance evaluation. Experimental results show high accuracy and robustness across model combinations. ResNet50 features with Logistic Regression achieved 96.65±1.06% accuracy using 200 images per class, while ResNet50 features with an SVM (RBF kernel) yielded 99.09±0.30% accuracy with 1,000 images per class. Overall, the findings highlight that ResNet-based feature extraction combined with either SVM (RBF) or Logistic Regression offers an effective and practical solution for automated mango pest detection, reducing dependence on manual monitoring.**

Keywords*—Automated crop monitoring, Deep learning, Machine learning classification, Mango pest detection, ResNet feature extraction

I. Introduction

Mango (Mangifera indica) is one of the most widely cultivated fruit crops in tropical and subtropical regions, playing a crucial role in agricultural economies and food security [6]. Despite its significance, mango productivity in Sri Lanka and elsewhere is severely constrained by pest and disease infestations, which negatively affect yield, fruit quality, and farmer income [9]. These issues often lead to substantial post-harvest losses, even though multiple strategies have been introduced to enhance production. While pests attack various plant parts, including fruits, stems, and bulbs, the majority inhabit or feed on leaves, making leaf-based analysis essential for early and accurate diagnosis. Traditional pest detection relies heavily on manual observation by experts, a process that is labor-intensive, time-consuming, and prone to human error, particularly as pest species continue to evolve and mango production expands [5]. The growing scale of cultivation, coupled with a shortage of trained personnel, has rendered manual inspection increasingly ineffective. As a result, there is a pressing need for automated, reliable, and cost-effective pest detection systems. Integrating advanced machine-learning and deep-learning techniques offers a promising pathway to enhance detection efficiency and accuracy, ultimately improving the resilience and productivity of mango cultivation in Sri Lanka.

Recent advances in AI and computer vision have significantly enhanced precision agriculture, with deep learning achieving strong performance in image-based pest and disease detection [7]. However, these models typically demand large datasets and high computing power, which limits their practicality in many agricultural settings. To address this challenge, hybrid methods that use deep networks for feature extraction and classical classifiers such as SVM, Random Forest, and k-NN for final prediction have gained attention [8]. These approaches offer a balanced trade-off between accuracy and efficiency, enabling reliable detection even with limited data and computational resources, and making them more suitable for real-world agricultural applications.

In this study, we propose an automated mango leaf pest detection system that integrates deep learning–based feature extraction with traditional machine learning classifiers. Using a curated dataset of healthy and pest-infected leaf images, the system evaluates multiple feature extractors and classification models to determine the most accurate and efficient combination for reliable pest identification.

The remainder of this thesis is organized as follows. Section 2 reviews recent techniques for pest detection. Section 3 presents the background concepts relevant to this study. Section 4 describes the proposed methodology, detailing the techniques employed to achieve effective pest detection. Section 5 discusses the experimental results and provides a comprehensive analysis. Finally, Section 6 concludes the thesis.

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