Machine Learning for Effective Pest Detection in *Mangifera indica* (Mango) Crop Protection

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***Abstract*—*Mangifera indica*, a key fruit crop in Sri Lanka, supports both agriculture and rural livelihoods but suffers significant losses from pest infestations. Early pest detection is crucial to reduce damage, yet manual inspection is laborious and inefficient for large farms. Advances in artificial intelligence enable automated pest detection, offering a more accurate and efficient approach to mango crop protection. This study presents a machine learning approach for automatically detecting pests on mango leaves, providing farmers and agricultural experts with a practical tool for timely intervention. The study uses ten classes from the MangoPestClassification dataset, with 1,000 images per class, comprising real-world images of healthy and pest-affected mango leaves captured under diverse environmental conditions, thereby representing realistic field scenarios. To prepare the mango leaf images for classification, three feature extraction techniques were applied: Histogram of Oriented Gradients (HOG) to capture shape and edge information, Bag of Features (BoF) to represent local descriptors, and Wavelet transforms to analyze texture and frequency components. These extracted features were then used to train and evaluate three machine learning classifiers: Support Vector Machines (SVM), Random Forest, and Logistic Regression. To ensure robust and reliable performance, 10-fold cross-validation was employed, providing an accurate assessment of the models' classification capabilities. The experimental results indicated that with 200 images per class, the best performance was achieved using HOG+Wavelet with Random Forest at an accuracy of 81.20%, while with 1000 images per class, HOG+PCA with SVM (RBF) reached 91.64%. Overall, HOG-based features combined with SVM (RBF) or Random Forest provide the most reliable framework for mango pest classification and establish a strong foundation for practical automated detection systems. The study highlights the potential of machine learning to enhance pest monitoring in mango cultivation. By minimizing reliance on manual inspections and enabling early pest detection, the proposed method can contribute to increased yields, better fruit quality, and more sustainable mango farming practices in Sri Lanka.**

***Index Terms*—*mangifera indica*, pest classification, machine learning, feature extraction, automated detection**

I. Introduction

According to the Department of Census and Statistics (2023), the average area under mango cultivation in Sri Lanka increased by 6.9% between 2018 and 2023, reaching 28,372 hectares compared to the 2002–2007 average [4]. During the same period, national mango production exhibited a significant growth of 12.2%, accompanied by a 5% increase in yield per hectare [4]. These trends highlight the growing economic and nutritional importance of mango cultivation, particularly for smallholder and large-scale farmers, and underscore the crop's role in national agricultural development. The increasing scale of mango farming not only reflects rising domestic demand but also emphasizes the potential for export-oriented growth, making effective crop management practices essential to sustaining productivity.

The full yield potential of different mango varieties is significantly constrained by insect pests, highlighting the importance of effective pest management strategies [6]. Most pests of mango cause foliar damage during their larval stage, when feeding activity is at its peak. Such damage typically manifests as skeletonization, rolling, or webbing of leaves, which also serve as shelters for the majority of larvae [14]. Traditionally, pest detection has relied on the visual inspection of leaves-either by identifying pests present on the foliage or by recognizing pest-induced damage. However, this method is labor-intensive, time-consuming, and prone to human error [1]. In many cases, by the time visual symptoms become evident, pests have already caused significant damage, reducing fruit quality and yield. Inconsistent monitoring, combined with delays in implementing control measures, often leads to severe infestations that require more intensive chemical treatments, thereby increasing production costs and environmental impact. Moreover, smallholder farmers frequently lack access to timely expert advice or advanced monitoring tools, further limiting the effectiveness of conventional pest management strategies.

These limitations highlight the urgent need for more efficient and accurate pest detection methods. Early and precise identification of pest infestations can enable farmers to adopt targeted interventions, minimize chemical usage, and prevent the spread of pests across orchards. The adoption of automated detection technologies, including image-based and machine learning methods, has the potential to transform pest management by providing rapid, scalable, and reliable monitoring solutions. Such approaches not only reduce labor requirements but also improve decision-making in crop protection, thereby supporting sustainable mango production and enhancing the economic viability of the sector.

The present study focuses on the early detection of ten common mango pests that are prevalent in Sri Lanka. Figure 1

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