Multi Disease Detection in Tomato Leaves Using Deep Learning with Explainable AI (XAI) Techniques

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Tomato leaf diseases substantially reduce crop yield and quality, yet manual identification remains slow, expertise-dependent, and error-prone, motivating the need for automated, accurate, and interpretable detection systems that support timely diagnosis and informed crop management. This study proposes a deep learning framework for classifying tomato leaf diseases that combines high predictive accuracy with model transparency through Explainable Artificial Intelligence (XAI), addressing the practical need for systems that agronomists can trust and verify. A publicly available Kaggle dataset of 16,012 images spanning ten classes, nine diseases (bacterial spot, early blight, late blight, leaf mold, septoria leaf spot, two-spotted spider mite, target spot, tomato mosaic virus, and tomato yellow leaf curl virus) and one healthy class, was split into 80% training and 20% testing sets, with 20% of the training set held out for validation. Two transfer learning models, EfficientNetB0 and MobileNetV2, were trained for 30 epochs using the Adam optimizer with early stopping, following image resizing, normalization, and data augmentation techniques including rotation, zooming, and horizontal flipping. Grad-CAM and LIME were applied to visualize the leaf regions influencing each prediction. EfficientNetB0 achieved 96.77% training accuracy and 95.18% testing accuracy, with a macro-average F1-score of 0.944 and a weighted-average F1-score of 0.952 across the ten classes, confirming balanced performance despite class imbalance. MobileNetV2 achieved 88.94% training accuracy and 88.99% testing accuracy. Grad-CAM and LIME visualizations consistently localized attention on lesion-affected leaf tissue rather than background regions, indicating that both models based their decisions on biologically relevant disease features rather than spurious cues. These results demonstrate that integrating a high-accuracy transfer learning model with XAI produces a classification system that is both reliable and interpretable, offering a practical and trustworthy tool for early disease diagnosis and decision-making in precision agriculture.

Keywords: deep learning, Explainable Artificial Intelligence (XAI), Grad-CAM, LIME, transfer learning