Title: LeafAI: Interpretable plant disease detection for edge computing

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Abstract: In real-world agriculture, healthy plant leaves are significantly more common than diseased ones. This natural class imbalance presents challenges in automated plant disease detection, as analyzing each leaf with computationally intensive deep-learning models is problematic, leading to inefficiency and increased resource consumption. To tackle this challenge and promote sustainable AI solutions, this study presents an iterative, hybrid AI approach that boosts computational efficiency, interpretability, and scalability for real-time disease detection. This hybrid system operates in two stages: first, a lightweight traditional machine learning classifier performs binary classification to quickly separate and exclude healthy leaves, followed by a deep learning model (ResNet, DenseNet, MobileNet, and EfficientNet) that classifies the specific disease in the smaller group of diseased leaves. This two-stage method minimizes computational load while maintaining high classification accuracy. Additionally, this study uses Explainable AI (XAI) methods, particularly Gradient-weighted Class Activation Mapping (Grad-CAM), to generate heatmaps. These heatmaps highlight the image areas that most significantly influence the model's predictions, thereby improving transparency and refining the feature extraction process. The proposed hybrid model, comprising Logistic Regression and Mobilenetv3, offers up to 77.6% faster inference than conventional deep learning models with only about 3% accuracy loss. For a large-scale test of 1,227 images on an entry-level laptop, the hybrid model reduced the total inference time from 4,548 seconds to just 1,010.13 seconds, with minimal CPU load. By addressing class imbalance, optimizing inference efficiency, and incorporating explainable AI, this work contributes a scalable, sustainable, and trustworthy solution for plant disease detection in precision agriculture..

Keywords:

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