A Hybrid DWT-Enabled MCA and Deep Learning Approach for Enhanced Soybean Leaf Disease Classification

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Early and accurate crop disease identification is critical for improving soybean yield and reducing management costs, particularly in resource-constrained farming environments. This work presents a mobile soybean leaf disease detection framework, featuring a discrete wavelet transform (DWT)-enabled memristive crossbar array (MCA) as a feature-preserving preprocessing stage. The DWT-enabled MCA leverages analog computing for efficient image decompression and reconstruction, achieving high peak signal-to-noise ratio (PSNR > 20 dB) and structural similarity index (SSIM), which retains discriminative visual details essential for downstream machine learning models.

The framework employs a lightweight two-stage deep learning pipeline: where YOLOv8 localizes soybean leaves from complex field images, followed by MobileNetV2 for classifying cropped regions into seven disease classes (e.g., frogeye leaf spot, yellow mosaic, target spot.) and a healthy class. Both models are optimized and deployed via TensorFlow Lite for real-time on-device inference on Android smartphones, ensuring low latency and minimal power consumption. The complete system is implemented as an Android application with multilingual support (English, Hindi, regional languages) and disease-specific advisory information, including treatment recommendations and prevention tips. Experimental results demonstrate improved classification reliability, and high classification accuracy (95.70%), validating the contribution of the DWT enabled MCA framework overall.

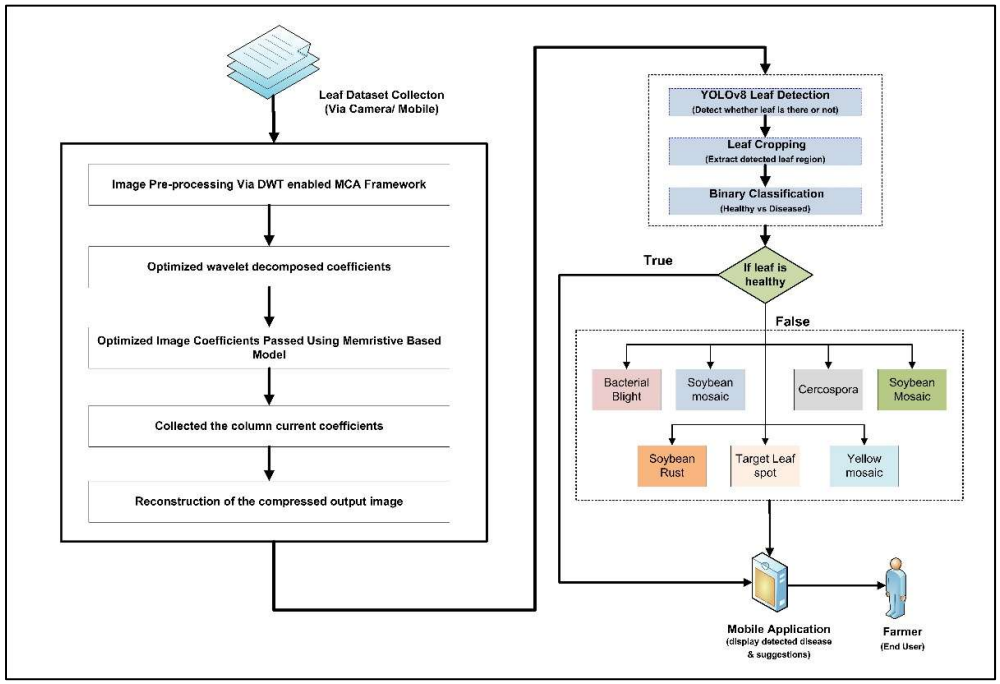

Figure 1: Flowchart of the proposed DWT enabled MCA framework for soybean leaf disease classification.