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Cocoadoctor: deep learning-based cocoa disease detection system

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Abstract

Cocoa production in smallholder systems is increasingly affected by climate variability and the spread of fungal and bacterial diseases, leading to yield losses. Early and accurate disease detection is important for better crop management and more resilient cocoa systems. Recent progress in deep learning makes automated image-based diagnosis possible in field conditions.

This study presents a deep learning framework for classifying cocoa pod conditions using field images. An EfficientNet-B4 model pretrained on ImageNet was fine-tuned using a curated dataset. The dataset combines images from the Cocoa Localisation dataset (Kaggle) with additional non-cocoa vegetation samples to improve robustness. It contains about 5,956 cocoa-related images across six classes: Healthy Cocoa, Moniliasis (Frosty Pod Rot), Phytophthora (Black Pod Rot), Witches' Broom, Corncob Disease, and non-cocoa vegetation. Around 1,000–1,500 background images were also included.

The training process used data augmentation, class balancing, and a two-stage optimisation approach. The model was exported in ONNX format and deployed in a Progressive Web App (PWA) for offline use on mobile devices in the field.

The model achieved an overall test accuracy of 93.95 % and a weighted F1-score of 0.94. Performance was higher for healthy cocoa and non-cocoa classes, with F1-scores of 0.97 and 0.98. Disease classes showed lower but acceptable performance, with F1-scores between 0.74 and 0.89. Adding non-cocoa samples reduced false positives and improved reliability in field conditions.

A mobile and web application, CocoaDoctor (https://cocoadoctor.containers.wur.nl/), was developed to support real-time disease detection and field use.

The system provides a practical tool for cocoa disease screening in smallholder farming. Future work will focus on improving performance for under-represented disease classes, expanding dataset diversity, and testing across different regions. Integration with geospatial decision-support tools will also be explored.

Keywords: Cocoa disease detection, deep learning, image classification, mobile application, smallholder agriculture

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