EFFICIENTNET-BASED COTTON DISEASE DETECTION AND DISEASE TREATMENT SUPPORT SYSTEM FOR SMART FARMING

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Keywords:
Cotton Disease Detection, EfficientNet, Transfer Learning, Severity Estimation, Treatment Recommendation, Explainable AI (XAI), Smart Farming, Deep Learning

Introduction:

Cotton is a vital global crop and a key part of the textile industry, supporting millions of smallholder farmers. However, its production is significantly affected by diseases such as bacterial blight, leaf spots, pests, and nutrient deficiencies, leading to reduced yield and quality if not detected early. Traditional disease detection relies on manual inspection, which is time-consuming, subjective, and often inaccessible in rural areas, resulting in delayed treatment and increased costs. The CottonCare AI project addresses these challenges by automating disease detection, severity estimation, and treatment recommendation using the EfficientNet-B4 model with transfer learning. It further enhances reliability through Grad-CAM and SHAP-based explainability, providing clear insights into predictions. The system delivers real-time, data-driven recommendations via mobile and web applications, making advanced agricultural support accessible and efficient.

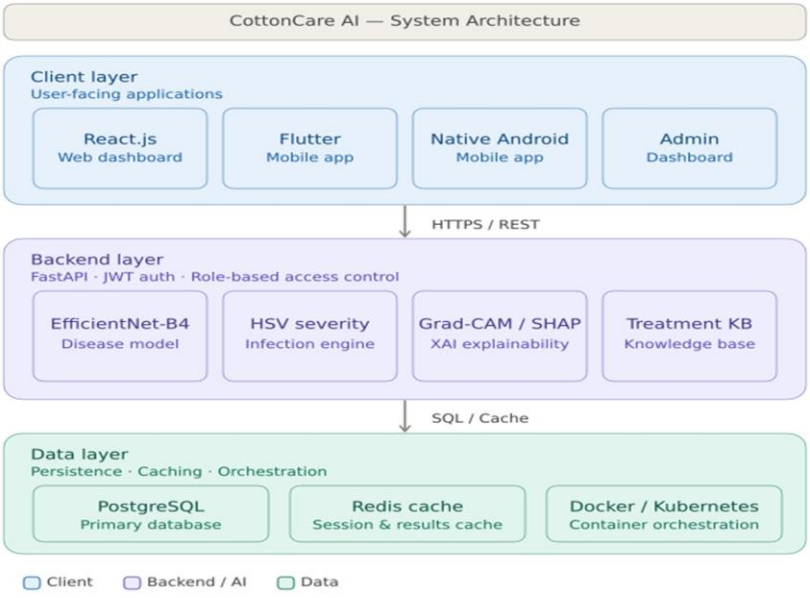

Figure 1: CottonCare AI — System Architecture

Objectives:

1. To develop a fine-tuned EfficientNet-B4 model for classifying cotton leaf diseases, pest infestations, and nutrient deficiencies with high accuracy and low inference latency.
2. To design a preprocessing pipeline with resizing, RGB normalisation, and training- time augmentation to maximise model generalisation across diverse field conditions.
3. To implement a quantitative severity estimation module categorising infections as Mild (<20%), Moderate (20–50%), or Severe (>50%) using HSV colour-space segmentation of infected leaf area.
4. To integrate Grad-CAM and SHAP Explainable AI (XAI) for visually interpretable heatmaps, improving farmer and expert trust in model predictions.

Methodology:

The CottonCare AI system follows a structured end-to-end pipeline consisting of dataset preparation, model training, severity estimation, explainability, and treatment recommendation. The dataset includes 26,108 cotton leaf images across six classes, with a near-balanced distribution, and is split into training (70%), validation (20%), and testing (10%) using stratified sampling. Images are preprocessed through resizing (380×380), normalization, and augmentation techniques such as rotation, flipping, zooming, and brightness adjustment to enhance model generalization. The EfficientNet-B4 model, pre- trained on ImageNet, is fine-tuned in two stages to achieve optimal performance while maintaining low inference latency. A severity estimation module leverages HSV colour- space segmentation to classify infection levels into Mild, Moderate, and Severe, achieving approximately 89% agreement with expert-labelled data. Additionally, a structured treatment recommendation system provides chemical, organic, and preventive solutions based on disease type and severity. The proposed model achieves around 93.9% accuracy with an inference time of ~85 ms, outperforming heavier architectures while ensuring practical usability for real-time agricultural decision support.

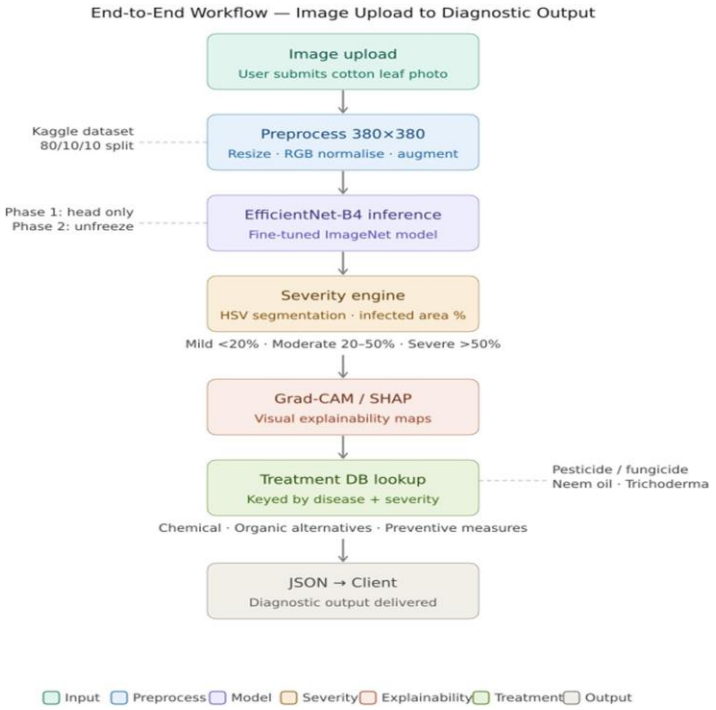

Figure 2: End-to-End Workflow — Image Upload to Diagnostic Output

References:

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Future Scope:

The future scope of this project includes:

1. Expand the disease taxonomy to include stem, boll, and root-level pathologies, and extend the system to additional crops such as wheat, rice, and soybean.
2. Integrate real-time environmental and weather sensor data to enable predictive disease risk modelling before visible symptoms emerge.
3. Develop multilingual and voice-assisted farmer interfaces to improve accessibility for low-literacy users in rural regions.
4. Implement federated learning for continuous model improvement from distributed field data while preserving farmer data privacy.
5. Optimise for edge computing and offline inference on low-resource IoT devices in areas with limited internet connectivity.