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AI-Driven Early Detection and Classification of Crop disease for Precision Agriculture

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Abstract

Early detection and accurate classification of crop diseases are essential for food security, improving yield quality, and reducing economic losses. Recent advances in Artificial Intelligence (AI), especially Machine Learning (ML) and Deep Learning (DL) have transformed disease diagnosis in precision agriculture. This paper provides a state-of-the-art review of AI-driven approaches for early disease detection and classification.

The survey reviews traditional machine learning, CNNs, transfer learning, vision transformers, and hybrid models for plant disease identification using leaf images, hyperspectral data, and multimodal sensing. It also covers datasets, evaluation metrics, data preprocessing, and real-time deployment via edge computing and IoT smart farming systems. The paper also discusses major challenges such as unbalanced datasets, changing environmental conditions, model generalization, explainability, and scalability. It also highlights emerging trends like federated learning, lightweight mobile models, and explainable AI.

This review provides an overview of current methods, performance results, limitations, and future research directions for AI-based crop disease detection in precision agriculture.

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