Tea Guardian: A novel hybrid deep learning-driven approach for tea leaf disease detection and treatment recommendation

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This study was conducted to assist Sri Lankan tea farmers in managing common leaf diseases, including algal leaf spot, brown blight, and gray blight. These diseases significantly damage crop quality and reduce profitability. Most farmers currently rely on visual inspection and expert knowledge for disease identification, which can result in delays and incorrect treatments. Tea Guardian, a mobile application, was developed to enable farmers to rapidly detect tea leaf diseases and receive treatment recommendations. The system combines two deep learning models convolutional neural networks (CNN) and vision transformers (ViT) to analyze leaf images. This hybrid approach achieved superior results compared to individual models. Due to the computationally intensive nature of the model, the application operates entirely online via a cloud platform, enabling scalable and maintainable processing without relying on mobile device capabilities. The dataset comprised publicly available datasets combined with locally collected Sri Lankan tea leaf images. Preprocessing steps included noise removal, color adjustment, and data augmentation to enhance robustness, while training and testing followed standard dataset splits to ensure reliable evaluation. Our proposed hybrid model achieved 92.57% accuracy, outperforming previous studies. For comparison, traditional CNN models achieved 85.2% – 89.1%, GoogleNet+ approximately 80%, YOLOv5+ around 70%, and ViT vs CNN approximately 87%. The superior performance is attributed to the combination of CNN's local feature extraction capabilities and ViT's long-range dependency modeling, providing comprehensive disease detection representation. The application provides treatment recommendations using both organic and chemical methods to promote environmentally sustainable farming practices. An integrated chatbot offers general tea farming guidance, including best practices and nutrient management advice. Initial usability testing with farmers confirmed the application's accessibility and ease of use, even among users with limited technical expertise. Tea Guardian represents a significant advancement in smart farming technology, presenting a scalable solution for enhancing tea cultivation in Sri Lanka and other tropical regions.

Keywords: *Tea leaf disease, Deep learning, CNN-ViT hybrid model, Mobile application, Precision agriculture*