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AUTOMATED IDENTIFICATION OF TOMATO DISEASES, PESTS, AND DISORDERS USING AI MODELS AND SMARTPHONE APPLICATIONS

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ABSTRACT

Tomato is one of the most important economic crops in many countries, with a substantial global production volume. However, tomato growth is often affected by diseases, pests, and physiological disorders (DPD), which typically manifest as symptoms on leaves, such as specks, yellowing, necrosis, or leaf deformation. These issues significantly reduce tomato yield and quality. Therefore, accurately identifying these symptoms and implementing corresponding management strategies have become crucial. Conventionally, symptom diagnosis has relied on farmers' experience or microscopic examination by experts, which is time-consuming, labor-intensive, and subjective. To address these issues, this study aims to develop an automated system for identifying tomato DPD by using AI models. A total of 12,673 tomato leaf images were collected in the field and annotated by experts. Five models were trained for DPD identification, including: (1) Anomaly Detection Model (ADM) to verify whether the input images contain a tomato leaf, (2) Leaf Type Classification Model (TCM) to distinguish between leaflets and pinnate compound (PC) leaves, (3) Compound Leaf Diagnosis Model (CDM) to detect virus infections and phytohormone damage on PC leaves, (4) Leaflet Diagnosis Model (LDM) to identify 13 categories of DPD on leaflets using the YOLOv9 architecture, (5) Leaf Mold or New Powdery Mildew Classification Model (LPM) to determine whether lesions on the abaxial leaf surface are caused by leaf mold or new powdery mildew. The five models respectively achieved overall accuracy rates of 93.00%, 95.05%, 99.11%, 96.22%, and 98.70%. Additionally, these models were integrated into a chatbot system, enabling farmers to automatically and instantly diagnose DPD symptoms in the field via smartphones. Overall, the proposed system offers rapid, convenient, and fully automated identification of tomato DPD, reducing the workload of experts and improving tomato cultivation management, yield, and quality.

Keywords: Chatbot, tomato, precision agriculture, diseases identification

INTRODUCTION

Tomatoes are the most valuable vegetable crop worldwide. Nevertheless, tomato growth often face diseases, pests, and physiological disorders (DPD) challenges which would reduce tomato yield and quality. Conventional method often relying on farmers'

experience or microscopic examination by experts to manage DPD, which is time-consuming, labor-intensive, and subjective. To address these issues, this study aims to design and implement a smartphone-based system using AI models to identify DPD in tomato plants quickly and accurately.

MATERIALS AND METHODS

Between January 2018 and May 2024, a total of 12,673 images of symptomatic tomato leaves were collected under field conditions by digital cameras and smartphones.

The system consists of two modules: a chatbot interface and a tomato DPD identification service. The chatbot enables users to upload images and receive diagnosis and treatment recommendations in real time. The identification service includes five AI models hosted on Triton Inference Server. (1) Anomaly Detection Model (ADM) comprises two stages. First, in the feature extraction stage, a pre-trained CvT-13 (Convolutional Vision Transformer-13) serves as the teacher model, while a CvT-13 fine-tuned on tomato leaf images acts as the student model. Both models are used to extract feature vectors from the input images. The two extracted feature vectors were compared with reference vectors from pinnate compound (PC) leaves and leaflets to calculate eight Mahalanobis distances as the input to the Support Vector Machine (SVM) classifier for leaf verification. (2) Leaf Type Classification Model (TCM) used the fine-tuned student model which trained in the ADM to distinguish between leaflets and PC leaves. (3) Compound Leaf Diagnosis Model (CDM) adopted CvT-21 to discriminate healthy, viral infected, and phytohormone-damaged PC leaves. (4) Leaflet Diagnosis Model (LDM) used YOLOv9-C to identify 13 categories of DPD presented on leaflets. The model was trained on the labeled dataset which is divided into training and validation sets, following an 8:2 ratio. (5) Leaf Mold or New Powdery Mildew Classification Model (LPM) adopted CvT-W24 to distinguish between leaf mold and powdery mildew II.

RESULTS & DISCUSSION

The ADM achieved an accuracy of 93.00%, confirming its effectiveness in leaf verification. The TCM classified leaflets and PC leaves with an accuracy of 95.05%. The CDM detected virus infections and phytohormone damage on PC leaves with 99.11%. The LDM reached an accuracy of 96.22% for identifying 13 categories of DPD on leaflets. The LPM demonstrated an accuracy of 98.70% in determining similar symptoms between leaf mold and new powdery mildew on the abaxial leaf surface. The LINE chatbot offered an intuitive interface, confirming the feasibility of smartphone-based DPD identification in tomato cultivation.

CONCLUSIONS

This study successfully developed and validated a system for automatically identifying DPD symptoms of tomato on leaves, which integrating five AI models and a chatbot. The system also demonstrate high accuracy and performance that can reduce the workload of experts and enhance the efficiency of managing tomato DPD.