

Deep Learning-Based Detection of Deficiencies and Leaf Diseases in Chili Plants Using Image Processing

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Abstract

Early detection of nutrient deficiencies and foliar diseases is essential to improve chili productivity, especially in rural communities where traditional testing is expensive and inaccessible. This study developed a deep learning system based on offline images to detect macronutrient deficiencies and major leaf diseases in chili plants. A dataset of 12,000+ annotated images covering six classes of agricultural storage and controlled environments was compiled. The six classes were bacterial spot, cercospora leaf spot, curl virus, healthy leaves, nutritional deficiency, and white spot. Images were resized, normalized, and enhanced to improve model robustness. A Convolutional Neural Network (CNN) was implemented in Python, and the dataset was divided into 60% training, 20% validation, and 20% testing subsets. The trained model was implemented with a Gradio interface as a web page, which enables farmers to upload leaf images and get instant predictions using an internet connection. The model achieved 98% training accuracy, 90% validation accuracy, and 89% test accuracy. On the test set, the system reached a precision of 91%, recall of 88%, and F1-score of 89%. This shows that image processing with machine learning can provide an affordable and useful tool for small farmers. Future work will focus on dataset expansion, explainable AI, and lightweight mobile deployment.

Keywords: CNN, Chili Leaf, Digital Image Processing