Disease Symptom Recognition and Severity Assessment for Phalaenopsis Orchids

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Abstract

Traditional disease assessment relies on manual visual inspection, which is subjective and often leads to inconsistent results due to variations in human judgment. To address these challenges, this study proposes an automated approach for disease classification and severity grading in Phalaenopsis orchids using the YOLOv8-seg deep learning model. The system integrates instance segmentation with Lab color space analysis, which was found to outperform HSV in distinguishing healthy and diseased leaf regions. By extracting infected areas and calculating the proportion relative to the total leaf area, the model enables precise quantification of disease severity. A standardized grading system was developed, classifying disease severity into five levels (L0–L4) based on defined threshold values. To enhance model robustness and generalization, the dataset was expanded to 6,199 images using diverse data augmentation techniques from the open-source library Albumentations. Three major orchid diseases—soft rot, brown rot, and yellow leaf disease—were examined. Experimental results show high classification performance, with mAP@0.5:0.95 of 93.4% for soft rot, 93.8% for brown rot, and 89.8% for yellow leaf disease. The system also achieved an overall precision of 99.5% and recall of 98.8%. The proposed method offers a robust and scalable solution for automated disease monitoring, reducing the need for expert intervention and enhancing consistency in disease diagnosis. By combining deep learning with color space analysis, this approach supports precision agriculture practices and provides a valuable tool for improving disease management strategies in orchid production.

Keywords: Phalaenopsis orchids, YOLOv8-seg, disease severity grading, Lab color space, image processing.

INTRODUCTION

Orchids hold a significant position in the international flower market, known for their high market shares in countries such as the Netherlands, Japan, and the United States. The sustained growth and economic value of the orchid industry underscore the importance of advancing cultivation and management practices. Therefore, developing automated disease spot detection and grading technology is crucial for enhancing the competitiveness and international image of orchid industry. The YOLOv8 model has shown excellent performance in plant leaf disease detection and classification tasks on PlantVillage and PlantDoc datasets, achieving a mAP of up to 98.2% in classification and region annotation (Qadri et al., 2023). The CIELAB (Lab) color space, constructed based on human visual system color transmission

characteristics, is commonly used for objective color measurement, closely approximating human color perception. Thus, it can simulate human eye perception in image segmentation (Giuseppe et al., 2022). Color thresholding segmentation based on the Lab color model more accurately distinguishes diseased regions of rice leaves, outperforming Otsu and K-means methods, making it suitable for automated detection and classification of plant diseases (Kappali et al., 2023).

MATERIALS AND METHODS

This study employed YOLOv8-seg for instance segmentation, coupled with a diverse data augmentation strategy to enhance segmentation and classification accuracy. The training epoch was set to 150, and the AdamW optimizer was selected to strengthen generalization capability. Data augmentation techniques included random rotation, translation, scaling, shearing, horizontal and vertical flipping, mosaic, mixup, and copy-paste. Additionally, adjustments in saturation and brightness were incorporated to improve the model's adaptability to various disease lesion morphologies and lighting conditions.

The Lab color space was utilized for separating diseased and healthy regions. In the Lab color space, L represents lightness, the a* axis represents the green-to-red component, and the b* axis represents the blue-to-yellow component. The Lab color space effectively separates luminance and color information, which helps maintain consistent color judgment under different lighting conditions. This study adopted a strategy of independently calculating the disease spot area for each leaf, avoiding area errors caused by merged calculations of multiple leaves. For grading, the "highest grade principle" was applied, where the grade of the leaf with the highest disease proportion in a single plant was used as the overall evaluation indicator, as shown in Fig. 1. The formula for calculating leaf disease proportion is as follows:

$$Disease\ Proportion = \frac{Diseased\ Area}{Total\ Leaf\ Area} \times 100\% \tag{1}$$

where:

Diseased Area: refers to the area of the leaf affected by the disease.

Total Leaf Area: refers to the overall area of the leaf, including both healthy and diseased regions.
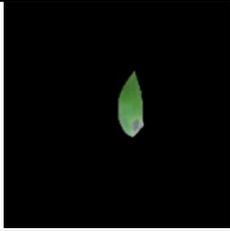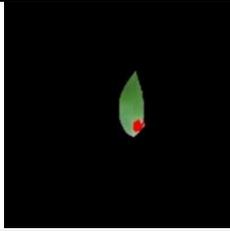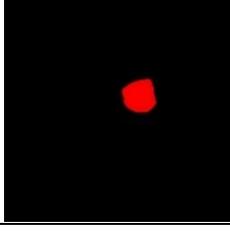

Fig.1 Labeling process of diseased regions.

As shown in Table 1, the original predicted image with bounding box, the isolated diseased leaf, the segmented diseased area in red, the calculated proportion of diseased area to total leaf area, and the assigned severity level. A standardized grading system classifies severity

into five levels, from L0 to L4, based on defined threshold values.

Table 1　YOLOv8-seg disease symptom detection model test results.

Predicted image	Diseased leaves	Diseased area	Proportion of diseases to leaves	Level
			7.61%	L1
			31.73%	L3
			99.68%	L4

RESULTS & DISCUSSION

The test results of the YOLOv8-seg model for Phalaenopsis orchid leaf symptom detection were evaluated using multiple metrics, including IoU (Intersection over Union), Precision, Recall, and mAP@0.5:0.95. The model achieved a Precision of 99.5%, Recall of 98.8%, and mAP@0.5:0.95 of 92.3% for all symptom categories, demonstrating extremely high segmentation and identification capabilities. Among the individual symptom categories, brown rot had a mAP@0.5:0.95 of 93.8%, soft rot 93.4%, and yellow leaf disease 89.8%, all showing good performance.

CONCLUSIONS

The proposed method provides a robust and scalable solution for automated disease monitoring, reducing the need for expert intervention and enhancing consistency in disease diagnosis. By combining deep learning with color space analysis, this approach supports precision agriculture practices and provides a valuable tool for improving disease management strategies in orchid production. This system contributes significantly to the digital transformation of agricultural practices in orchid industry, offering a precise and efficient tool for maintaining plant health and optimizing production yields. Future work could explore the integration of real-time monitoring devices and further validation across a wider range of environmental conditions.

ACKNOWLEDGEMENTS

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