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CABBAGE YIELD ESTIMATION USING MULTISPECTRAL UAV IMAGERY AND DEEP NEURAL SEGMENTATION

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ABSTRACT

Accurate and efficient yield estimation is essential of optimizing crop management, resource allocation, and harvest planning in precision agriculture. Traditional manual methods are time-consuming, labor-intensive, and often lack spatial accuracy. Recent advances in remote sensing and deep learning offer scalable, non-destructive alternatives for yield monitoring. This study proposed a cabbage yield estimation based on an enhanced unity networking (U-Net) segmentation model utilizing multispectral imagery acquired by an unmanned aerial vehicle (UAV). An UAV equipped with both multispectral and RGB sensors was used to collect high-resolution images over a cabbage field at a flight altitude of 30 m. The UAV flights were strategically planned to ensure full coverage of the experimental area, capturing essential spectral and spatial information. An improved U-Net model was developed to segment individual cabbage heads using multispectral bands, including Red, Green, Blue, Near-Infrared (NIR), and Red Edge. The model was trained with 85% of the labeled data and tested on the 15% data. Segmentation performance was evaluated using intersection over union (IoU), and pixel accuracy, and results were compared with those from RGB image segmentation. Using the validation dataset, the enhanced U-Net model achieved a segmentation accuracy of 92.7%. In estimating cabbage dimensions, the model demonstrated higher precision in predicting length compared to width. When compared with RGB-based segmentation, the visible-band multispectral model produced coefficients of determination (R^2) ranging from 0.78 to 0.94. All root mean square error (RMSE) values were below 3.16, confirming that UAV-based cabbage length and width estimates closely matched manual measurements, validating the reliability for yield assessment.

Keywords: Precision agriculture, cabbage, yield estimation deep learning U Net.

INTRODUCTION

Accurate yield estimation is essential for optimizing crop management, resource allocation, and harvest planning in precision agriculture. For vegetable crops such as cabbage (*Brassica rapa* subsp. *pekinensis*), manual yield assessments are still widely practiced but are time-consuming, labor-intensive, and prone to measurement errors. Moreover, such approaches fail to capture the spatial variability across large fields, limiting their applicability for precision

farming (Kim et al., 2018). UAVs and deep learning–based computer vision models enable scalable and non-destructive solutions for crop monitoring. In particular, multispectral imaging provides valuable information on canopy vigor, plant structure, and morphology beyond the visible spectrum. Machine learning models were widely applied in crop phenotyping, offering pixel-level segmentation with high accuracy. This study aimed to develop and evaluate a UAV-based multispectral image segmentation framework using enhanced U-Net segmentation model for cabbage yield estimation.

MATERIALS AND METHODS

Field experiments in a cabbage field used a commercial UAV at 30 m altitude, equipped with RGB and multispectral sensors to capture high-resolution imagery with sufficient overlap for mosaicking. Radiometric corrections and orthomosaic generation were performed. A subset of images was manually annotated to present cabbage heads, with data augmentation was applied to enhance robustness. An enhanced U-Net, optimized for multispectral inputs, was trained and evaluated using pixel accuracy and IoU (Wiratama et al., 2020). Morphological analysis extracted head dimensions, and yield was estimated via correlations with manual measurements. Accuracy was evaluated using coefficient of determination (R^2) and root means square error (RMSE) with the field data.

RESULTS AND DISCUSSION

Enhanced U-Net achieved high segmentation accuracy, with a mean pixel accuracy of 92.7% and IoU values confirming reliable cabbage head delineation. Compared to the RGB-based approach, the multispectral model showed higher R^2 values between 0.78 and 0.94. RMSE values remained under 3.16 cm, indicating effectiveness for yield evaluation.

CONCLUSIONS

UAV-based multispectral imaging with enhanced U-Net enabled accurate cabbage yield estimation, achieving high segmentation accuracy and correlation with field data. The approach offers strong potential for real-time, non-destructive yield estimation, with future work extending to larger fields, growth stages, and crop types.

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