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Vineyard Row Segmentation through Pixel-Based Deep Learning and Object-Based Image Analysis (OBIA)

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Abstract
Canopy segmentation in orchards is crucial for obtaining vegetation biometric parameters, especially when using high-resolution images from Unmanned Aerial Vehicles (UAVs). Current agricultural scene segmentation methods include Object-Based Image Analysis (OBIA) and pixel-based deep learning (DL) techniques leveraging artificial neural networks. This study assesses the performance of the U-Net method compared to an OBIA method, namely the Gaussian Mixture Model (GMM), and against the unsupervised clustering algorithm K-Means. UAV-based multispectral RGB-NIR images were captured in a vineyard located in the northwest of Sicily. After extracting the pure canopy pixels, the normalized difference vegetation index (NDVI) has been calculated. These were compared with canopy agronomic data collected during the two growth seasons of 2021 and 2022, focusing on a specific phenological stage BBCH65. Canopy parameters such as leaf area (LA) and leaf chlorophyll content (LCC) were taken into consideration. The results demonstrate that the U-Net semantic segmentation model outperforms OBIA method employing GMM classifiers and K-Means in extracting canopy pixel information. Through semantic segmentation of the images, the U-Net method achieves remarkable results, with an overall accuracy of 90 %, an F1_score of 88%, and an mIoU of 80%.The accuracy in extracting only the pure canopy pixels demonstrated by the U-Net method justifies the consistent correlation results between the NDVI index and canopy parameters such as Leaf Area (LA) and leaf chlorophyll content (LCC), with determination coefficient values of (r=0.85) and (r=0.86) respectively. The methods used in this study define that segmentation and classification methods can significantly influence the canopy biometric parameter estimation.

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