IMPLEMENTATION OF A DEEP LEARNING-BASED APPROACH FOR DETECTING AND LOCALISING AUTOMATICALLY GRAPEVINE LEAVES WITH DOWNY MILDEW SYMPTOMS

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Abstract:

Context and purpose of the study – Grapevine downy mildew is a disease of foliage caused by Oomycete *Plasmopara viticola* an endoparasite that develops inside grapevine organs and can infect virtually every green organ. Downy mildew is one of the most destructive diseases in wine-growing regions, drastically reducing yield and fruit quality. Traditional manual disease detection relies on farm experts. Human field scouting has been widely used for monitoring the disease progress, however, is costly, laborious, subjective, and often imprecise. In this sense, computer vision technologies and artificial intelligence provide a suitable alternative to improve the current disease detection techniques. Therefore, this study aims to validate a deep learning-based approach for detecting and localising automatically leaves with downy mildew symptoms.

Material and methods – Fourteen commercial blocks (different grapevine cultivars) located in northern Spain were assessed to generate a comprehensive dataset for validating the deep learning algorithm. All analysed blocks presented downy mildew symptoms with different levels of intensity. RGB Images of the canopy were taken manually using a conventional camera. The images were acquired during different daily hours and under contrasting light conditions. YOLOv4 (You Only Look Once) was the deep learning algorithm analysed in this study. YOLOv4 model was trained using a heterogeneous dataset populated by RGB images obtained from the different vineyard blocks under different conditions to increase the robustness of the model. The RGB images were carefully labelled manually by an expert, selecting leaves with visible downy mildew symptoms. The labelled images were divided into two datasets, using 80% for training and validating and 20% for testing. The images used for training were divided into 1500 x 1500 pixel sub-images obtaining 15 sub-images per image and the sub-images were resized to 640x640 pixels. Data processing and deep learning modelling were performed with Python programming language and the Darknet neural network framework. The metrics used to evaluate the model were mean Average Precision (mAP), F1-score and Intersection over Union (IoU).

Results – The results of YOLOv4 for detecting leaves with downy mildew symptoms are promising. In the testing process applied on full images (2560x1728 pixels), the model presented a mAP of 67%, an F1-score of 0.69 and an IoU of 62%. When the number of real infected leaves (labelled by an expert) was compared with the predicted number of infected leaves the model reached a determination coefficient R^2 of 0.93. The accuracy of the method to determine the number of infected leaves was similar across the whole range of infections. This indicates that the model fits appropriately to all conditions tested. Also, the analysis of the localization indicates that leaves with apparent symptoms were detected correctly by the model.

Keywords: Artificial intelligence, deep learning, Disease detection, Precision viticulture, YOLOv4.