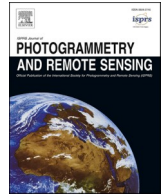


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A CNN approach to simultaneously count plants and detect plantation-rows from UAV imagery

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ABSTRACT

Accurately mapping croplands is an important prerequisite for precision farming since it assists in field management, yield-prediction, and environmental management. Crops are sensitive to planting patterns and some have a limited capacity to compensate for gaps within a row. Optical imaging with sensors mounted on Unmanned Aerial Vehicles (UAV) is a cost-effective option for capturing images covering croplands nowadays. However, visual inspection of such images can be a challenging and biased task, specifically for detecting plants and rows on a one-step basis. Thus, developing an architecture capable of simultaneously extracting plant individually and plantation-rows from UAV-images is yet an important demand to support the management of agricultural systems. In this paper, we propose a novel deep learning method based on a Convolutional Neural Network (CNN) that simultaneously detects and geolocates plantation-rows while counting its plants considering highly-dense plantation configurations. The experimental setup was evaluated in (a) a cornfield (*Zea mays* L.) with different growth stages (i.e. recently planted and mature plants) and in a (b) Citrus orchard (*Citrus Sinensis Pera*). Both datasets characterize different plant density scenarios, in different locations, with different types of crops, and from different sensors and dates. This scheme was used to prove the robustness of the proposed approach, allowing a broader discussion of the method. A two-branch architecture was implemented in our CNN method, where the information obtained within the plantation-row is updated into the plant detection branch and *retro*-feed to the row branch; which are then refined by a Multi-Stage Refinement method. In the corn plantation datasets (with both growth phases – young and mature), our approach returned a mean absolute error (MAE) of 6.224 plants per image patch, a mean relative error (MRE) of 0.1038, precision and recall values of 0.856, and 0.905, respectively, and an F-measure equal to 0.876. These results were superior to the results from other deep networks (HRNet, Faster R-CNN, and RetinaNet) evaluated with the same task and dataset. For the plantation-row detection, our approach returned precision, recall, and F-measure scores of 0.913, 0.941, and 0.925, respectively. To test the robustness of our model with a different type of agriculture, we performed the same task in the citrus orchard dataset. It returned an MAE equal to 1.409 citrus-trees per patch, MRE of 0.0615,

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