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Combination of Unmanned Aerial Vehicle and Terrestrial Laser Scanner Data for Citrus Yield Estimation

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Abstract : Annual crop production is one of the most important macroeconomic indicators for the majority of countries around the world. This information is valuable, especially for exporting countries which need a yield estimation before harvest in order to correctly plan the supply chain. When it comes to estimating agricultural yield, especially for arboriculture, conventional methods are mostly applied. In the case of the citrus industry, the sale before harvest is largely practiced, which requires an estimation of the production when the fruit is on the tree. However, conventional method based on the sampling surveys of some trees within the field is always used to perform yield estimation, and the success of this process mainly depends on the expertise of the 'estimator agent'. The present study aims to propose a methodology based on the combination of unmanned aerial vehicle (UAV) images and terrestrial laser scanner (TLS) point cloud to estimate citrus production. During data acquisition, a fixed wing and rotatory drones, as well as a terrestrial laser scanner, were tested. After that, a pre-processing step was performed in order to generate point cloud and digital surface model. At the processing stage, a machine vision workflow was implemented to extract points corresponding to fruits from the whole tree point cloud, cluster them into fruits, and model them geometrically in a 3D space. By linking the resulting geometric properties to the fruit weight, the yield can be estimated, and the statistical distribution of fruits size can be generated. This later property, which is information required by importing countries of citrus, cannot be estimated before harvest using the conventional method. Since terrestrial laser scanner is static, data gathering using this technology can be performed over only some trees. So, integration of drone data was thought in order to estimate the yield over a whole orchard. To achieve that, features derived from drone digital surface model were linked to yield estimation by laser scanner of some trees to build a regression model that predicts the yield of a tree given its features. Several missions were carried out to collect drone and laser scanner data within citrus orchards of different varieties by testing several data acquisition parameters (fly height, images overlap, fly mission plan). The accuracy of the obtained results by the proposed methodology in comparison to the yield estimation results by the conventional method varies from 65% to 94% depending mainly on the phenological stage of the studied citrus variety during the data acquisition mission. The proposed approach demonstrates its strong potential for early estimation of citrus production and the possibility of its extension to other fruit trees.

Keywords : citrus, digital surface model, point cloud, terrestrial laser scanner, UAV, yield estimation, 3D modeling
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