Three-dimensional Photogrammetric Mapping of Apples in Orchard based on Point Cloud Instance Segmentation

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Abstract

The assessment of 3D fruit phenotyping traits of apple trees can provide management strategies for growers of apple orchards. The estimation of quantitative distribution of apples in orchard is an important parameter for yield estimation. Since it is hard to quantify them manually, resolving apple phenotyping efficiently is critical for monitoring apple yield and promoting a better management system. Thus in current study, we have developed a novel technology for 3D mapping of three types of apple training system fields. The 3D point cloud of apples was reconstructed using high spatial and temporal multi-viewing images collected by unmanned aerial vehicles (UAVs) based multi-camera system. The extraction of information about individual apple in 3D point cloud was executed using 3D instance segmentation algorithm which includes generalized sparse convolutional neural networks, discriminative loss function, and varying density-based 3D clustering method. The developed apple traits extraction algorithm could measure the 3D position of an individual apple by sphere fitting. The accuracy of the technique was evaluated by comparing its results with manual estimates of number of apples. The results obtained from our method are in good agreement with manual estimates. The average accuracy of apple counting in three types of the fields were ~92 % followed by the linear regression (R2) of 0.92 with root-mean-square error (RMSE) value of 13.93. Thus, 3D spatial distribution of apples were achieved and analyzed by above technique. This research proposes a method that combines 3D photography with 3D instance segmentation to accurately extract individual apples from various types of apple training

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systems in orchards and can also be used to segment and analyze other fruits.

Keywords

Oblique photogrammetry; 3D reconstruction; 3D segmentation; Fruit-level phenotyping; 3D spatial distribution.

Acknowledgement

This work was supported by the Korea Institute of Planning and Evaluation for Technology in Food, Agriculture, Forestry (IPET) through the Advanced Production Technology Development Program, funded by the ministry of Agriculture, Food and Rural Affairs (MAFRA)(32003003) and Korea Smart Farm R&D Foundation(KosFarm) through Smart Farm Innovation Technology Development Program, funded by Ministry of Agriculture, Food and Rural Affairs(MAFRA) and Ministry of Science and ICT(MSIT), Rural Development Administration(RDA)(4210324).