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Multi-Temporal Biomass Estimation of Vegetable Crops Using Unmanned Aerial Vehicles

Supriya Dayananda, Thomas Möckel, Michael Wachendorf

University of Kassel, Grassland Science and Renewable Plant Resources, Germany

Abstract

3D point cloud analysis of imagery captured by unmanned aerial vehicles (UAV) are depicted to be a valuable tool for estimation of crop phenotypic traits (e.g. crop height) in several crops. Spatial information about these traits can be used to derive information about other important crop characteristics (e.g. biomass), which could not be derived directly from the point clouds. Previous approaches have often only considered single date measurements using a single point cloud derived metric for the respective trait. The aim of this study was to assess the applicability of UAV imagery by capturing the crop height information of three different vegetable crops (eggplant, tomato, and cabbage) during a complete crop growth period to infer the biomass. Additionally, the effect of crop development stage on the relationship between estimated crop height and field measured crop height was examined. The study was conducted in an experimental layout at the University of Agricultural Sciences in Bengaluru, India. The three crops height and the biomass were measured at five sampling dates during the crop growth period from February to May 2017. Each plot was measured using an UAV, equipped with a photo camera. Using a structure from motion approach a 3D point cloud was created for each crop and sampling date. In total 14 crop height metrics were extracted from the point clouds. Machine learning methods were used to create prediction models for vegetable crop height. The study demonstrates that the monitoring of crop height during an entire growth period using several crop height metrics of biomass with more detailed estimates of crop height and biomass is better than single date and single metric approaches. Altogether the results of the study encourage that UAV based remote sensing tools can be used to effectively measure vegetable crop biomass in larger areas. In future studies, the interrelated effect of other phenotypic traits (e.g. leaf area index) on the relationships found should be tested.

Keywords: 3D point cloud and phenotypic traits, unmanned aerial vehicles

Contact Address: Supriya Dayananda, University of Kassel, Grassland Science and Renewable Plant Resources, Steinstrasse 19, 37213 Witzenhausen, Germany, e-mail: supriyaD@uni-kassel.de