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Remote sensing of selected geometric parameters of apple trees using unmanned aerial system equipped with laser scanner

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Unmanned Aerial Vehicle (UAV) combined with special sensors creates a tailored Unmanned Aerial System (UAS), applications of which are expanding in different domains. UAS may cover a medium-size area and provide products of much higher spatial resolution at a lower cost than ground surveys or classical manned airborne surveys. The use of UAS in agriculture has been rapidly increasing, specifically in farm management and precision agriculture. However, a passive optical sensors (camera) are used in most of applications.
In this study we present an experiment, in which a small UAS equipped with laser scanner acquire a high-density point cloud (4000 points per m2) for an apple orchard. 40 million LiDAR points were automatically classified to ground and non-ground (vegetation) points, in order to generate Digital Terrain Model with 1x1 m grid size and calculate normalize heights for 16 million non-ground points. The normalized point cloud was automatically processed with a developed software in order to identify trees, delineate crown contours, determine tree heights and crown base heights. The data processing strategy combined alpha-shape algorithm, principal component analysis and detection of local minima on crown profile.
By means of geodetic surveying equipment we obtained reference measurements of determined parameters for 50 selected trees. Using an ortophotomap with a ground sample distance equal to 0.1 m, we also identified location of all trees in the orchard. The methodology of processing LiDAR data allowed for successful identification over 99% of trees in the orchard. The accuracy of tree height determination and crown base height determination was 0.09 m, and the correlation coefficients between LiDAR data analysis and field measurements were 0.96 and 0.70, respectively.