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High-throughput plant height measurement using UAV-based LiDAR and Digital Photogrammetry

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Abstract: Plant height is a critical indicator for monitoring plant growth status and productivity estimation. Accurate measurement of plant height through a high-throughput manner is crucial for precision agriculture and field-based plant phenotyping. Manually measuring plant height is time-consuming and labor-intensive, and it only provides the height information at each sampling point but cannot tell the detailed within-field spatial variations. LiDAR and digital imagery-based photogrammetry have been increasingly used in plant phenotyping in recent years thanks to the developments in Unmanned Aerial Vehicle (UAV) and sensor technology. LiDAR point clouds can be directly used for plant height extraction, digital imagery-based photogrammetric point clouds can also be used for derivation plant height. The goal of this study is to investigate the potential of UAV LiDAR and digital photogrammetry in measuring plant height of different crops at multiple growth stages. To this end, a high resolution 32 channel LiDAR and digital cameras mounted on DJI Matrice 600 Pro UAV were employed to collect data from agricultural fields in Missouri, USA. Canopy Surface Models (CSM) and Digital Terrian Models (DTM) are generated from LiDAR and digital Photogrammetry point clouds, respectively, then plant height is derived by subtracting DTM from CSM, the UAV-based plant height is compared against manually measured height to evaluate the accuracy and performance of LiDAR and digital photogrammetry technologies. This study proved that UAV-based LiDAR and digital photogrammetry are important tools in sustainable field management and high-throughput phenotyping.