**Estimating canopy characteristics from ground-based LiDAR measurement assisted with 3D AdelWheat model**

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Phenotyping is rapidly evolving from a small set of destructive measurement and visual notations of few simple traits to massive characterizations derived from high-throughput non-invasive proximal or remote sensing techniques. Meanwhile functional structural plant modeling (FSPM) integrates the physiological and morphological information from organizational scales to the canopy level. The combination of new phenotyping techniques with FSPMs is expected therefore to estimate a set of FSPMs parameters corresponding to traits of interest. LiDAR (Light Detection And Ranging) is recently exploited for detailed 3D description of the canopy structure, especially over dense canopies with small elements such as wheat and barley. In this work, we propose to use a model-assisted phenotyping approach to improve our understanding of the interaction between laser beam and canopy. It leads us to develop inversion algorithm to retrieve canopy traits.

A discrete LiDAR scanning simulator was first developed based on PlantGL, a 3D plant modeling python library. The footprint and the geometrical configuration of the LiDAR are explicitly accounted for. The LiDAR simulator was validated over an artificial crop made of 45 artificial plants. Actual LiDAR measurements were performed over the same scene. Results proved that the simulator generates a 3D point cloud having the same statistical properties as those derived from the actual LiDAR measurements. Then a synthetic experiment was completed to demonstrate the potentials of model assisted phenotyping. 3D wheat canopy scenes were generated with AdelWheat model for two contrasting development stages corresponding to thermal time 500 °C•day and 1500 °C•day across a wide range of combination of the model parameters (242 cases replicated 20 times). The scenes were transformed into 3D point clouds using the LiDAR simulator. A set of 50 independent cases were generated in addition to evaluate the performances of the method. Results demonstrate that emerging properties could be retrieved with a good accuracy from the 3D map including the leaf area index (LAI) ($R2 = 0.85$ and rRMSE = 6.11%). The retrieval of other parameters will be discussed with due attention to the complexity of the comparison of simulated 3D point clouds with the measured ones.