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| **Enhancing the Validation of Drone LIDAR Forest Biomass Retrieval Algorithms through a Comprehensive Simulation Framework** |
| The quantification of above ground biomass is pivotal in forest ecology and management, underpinning the assessment of forest health, productivity, and sustainability. Despite advancements in Terrestrial LiDAR technology enabling the automated extraction of detailed structural attributes, its application remains largely confined to smaller regions (<1 ha). This limitation underscores the necessity for more scalable methods that can extend the benefits of LiDAR technology. Our research aims to address this by focusing on the validation of drone-based LiDAR (UAV-LS) algorithms for woody volume estimation (underpinning woody biomass estimation), specifically through the evaluation of RayExtract, a component of the open-source RayCloudtools library.  RayExtract is at the forefront of deriving woody volume metrics from plot-level LiDAR point clouds, offering a pathway to rapid and extensive biomass assessments. However, the validation of such algorithms has been hindered by a notable scarcity of reference data at the required scale. To tackle this challenge, we have developed a novel validation framework that incorporates UAV-LS simulations of three synthetic forests across a gradient of structural complexity. These synthetic forests are representations or digital twins of diverse long-term monitoring Terrestrial Ecosystem Research Network (TERN) sites in Australia. This approach allows for an exhaustive and precise evaluation of algorithm performance at multi-hectare scales, assessing the impact of data quality, sensor specifications, and survey methodologies on the accuracy of woody volume estimations across a spectrum of simulated forest environments. Preliminary results indicate an inverse relationship between point density and woody volume estimation when compared to the synthetic reference.  Utilizing this validation framework, our study demonstrates the efficacy of RayExtract in deriving accurate woody volume information from a range of input qualities, showcasing its potential for application in broad-scale (100’s ha) forest management initiatives. Our research contributes to improving the accuracy of forest biomass measurements, thereby facilitating better-informed decisions in carbon accounting, timber production, forest health monitoring, and ecological research. Furthermore, this framework offers a promising foundation for the ongoing evaluation and refinement of algorithms dedicated to any structural measurement from LiDAR data. UAV-LS will be a critical component facilitating large-scale calibration and validation of remote sensing satellite methods of 3D forest structure and aboveground biomass. |