Laser scanner and UAV high-density point clouds for forest inventory and management

Jesús Torralba, Luis A. Ruiz, Pablo Crespo-Peremarch and Juan P. Carbonell-Rivera

Geo-Environmental Cartography and Remote Sensing Group (CGAT), Department of Cartographic Engineering, Geodesy and Photogrammetry, Universitat Politècnica de València, Camí de Vera s/n, 46022 València, Spain. jetorpe@upv.es, laruiz@upv.es, pabcrepe@cgf.upv.es, juacarri@upv.es

Abstract:

Terrestrial laser scanning (TLS) and photogrammetric clouds derived from unmanned aerial vehicles (UAV) can support forest inventory and management by providing highly detailed and high-density under semi-flexible operating conditions data. The acquisition modes of TLS (ground-based) and UAV (airborne) sensors can be complementary, as the UAV aggregates information from the top of the canopy that the TLS cannot register. This study examined the use of TLS, UAV, and the fusion of both point clouds to estimate forest inventory parameters on individual trees. We investigated the measurement of forest parameters in each dataset: (1) by multiple regression models based on point cloud height distribution metrics; and (2) by direct and automatic measurement. Results show that all three datasets estimated total tree height with R^2_{adj} close to 0.90. The diameter at breast height (DBH) obtained an R^2_{adj} of 0.91 using direct measurement with TLS, and this same R^2_{adj} was obtained for biomass by applying the same DBH derived from TLS in an allometric equation. Finally, the trunk volume got an R^2_{adj} of 0.92 using the fusion of TLS and UAV data. It was observed that the error of the TLS heights depends on tree density and crown structure. The angle used in acquiring the UAV images and the occlusion generated by the canopy structure were the main factors affecting the accuracy of the DBH estimates. These results suggest that TLS, UAV point clouds, and the fusion of both lead to promising results in forest parameter estimates to support forest inventories in specific ecosystems.

Keywords: forest point cloud; structure from motion (SfM); point cloud registration; forest structure; tree height; dbh; terrestrial laser scanning (TLS)