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UAV-based LiDAR and Multispectral images for forest trait retrieval

Luigi Vignali, Cinzia Panigada, Giulia Tagliabue, Beatrice Savinelli, Roberto Garzonio, Roberto Colombo, Sergio Cogliati, Rodolfo Gentili, Sandra Citterio, and Micol Rossini
University of Milano-Bicocca, Department of Environmental and Earth Sciences, Italy (luigi.vignali@unimib.it)

Woodlands cover 41% of the surface of the European Union and contribute to human well-being through the ecosystem services they provide. However, their extension and condition are under threat due to the impacts of climate change. Forest traits are commonly used in ecological and climate studies for the assessment of plants health status. In this contest, the use of unmanned aircraft vehicles (UAVs) is rapidly developing for forest monitoring and inventory. UAVs allow to acquire high spatial resolution data using different sensors, as LiDAR or optical sensor, with low operational costs. The main focus of this contribution is integrating LiDAR and multispectral data to detect and classify single trees and retrieve forest traits at tree scale employing machine learning approaches. The study area is a natural reserve located in the Ticino Valley Regional Park, in eastern Lombardy along the Po river (Italy). An intensive field campaign was conducted in the summer of 2022 to collect forest traits (leaf chlorophyll concentration - LCC and leaf area index - LAI) and UAV data. The UAV mounted a DJI L1 LiDAR sensor and a MAIA S2 multispectral camera. First, the individual trees were identified using the “lidR”, “rLidar” and “ForestTools” R packages. Each tree was then classified using a Random Forest classifier with an accuracy of 84% (Kappa coefficient =0.74). For the retrieval of the forest traits of interest, different machine learning regression algorithms (MLRAs) were tested. LAI was best estimated by the Gaussian Processes Regression (GPR), (R^2=0.903, nRMSE=8.66%) and the Canopy Chlorophyll Content (CCC = LAI x LCC) by the Support Vector Regression (SVR) (R^2=0.8327, nRMSE=9.1684%). MLR algorithms showed satisfactory performances in plant trait retrieval in forest ecosystem from UAV, opening interesting perspectives for forest monitoring, both at leaf and canopy level except for the LCC.