AIRBORNE LIDAR SCANNING FOR FOREST BIOMASS ESTIMATION

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Forests provide ecosystemic services e.g. through sequestration of CO_2 and as repositories and generators of biodiversity, as well as economic value through production of wood, and biomass in general. Sustainability of forests management must be monitored through suitable indicators, mapped into GIS. Remote sensing is instrumental in complementing expensive and slow on-site ground surveys, and in spatialization of such data, and data obtained from satellites, airplanes and helicopters have been used for many years. RPAS-based remote sensing has the specific characteristic of yielding very high-definition data, though on relatively limited areas, playing a role that is half way between ground-based and long-distance survey methods.

The Department of Information Engineering, Electronics and Telecommunications (DIET) of "La Sapienza" University of Rome, in collaboration with Oben srl, a spin-off enterprise dedicated to drone-based aerial surveys, has been working for several years on innovative techniques for aerial surveys and data processing and interpretation, collaborating with public and private research institutions in forestry, most notably the Universities of Molise and Florence.

In this contribution, we present results of forestry surveys based on a laser scanner carried on a drone, aimed at estimation of biomass.

fig. 1 – Oben's octocopter carrying the LIDAR

The Yellowscan laser scanner, developed specifically for integration on drones, was the first very light (2kg) fully integrated LiDAR on the market, and Oben was the first third-party user operating it for commercial and scientific purposes. Its main performance specification are 20.000 points/sec, about 70-100m range (depending on surface reflectance), up to three echoes acquired. Oben mounted it on a relatively large octocopter (assembled in-house) weighing approximately 16kg at take-off, and measuring 1.8m in diameter, with 20 minutes autonomy, registered for specialized operations in Italy. It was employed in missions for scientific programs in Italy (in particular PRIN project IDEM, and archaeological surveys with the University of Sassari), in the European Space Agency contract SAFEDEM for mapping and indicators extraction in assistance to humanitarian demining operations, and for commercial surveys such as profiling of river beds and mountain area rock walls. Operational characteristics of the aerial system allow for scanning about 0.5km^2 per day, depending on characteristics of the site. In some cases, operation of the LiDAR mounted on a light conventional helicopter is preferred, allowing for larger area coverage, and easier authorization in critical areas, according to airspace regulations.

The case studies presented in this contribution were performed in the ongoing European LIFE project "FreshLIFE - Demonstrating Remote Sensing Integration in sustainable forest management" (https://freshlifeproject.net/) aimed at demonstrating, in four study sites in Italy,

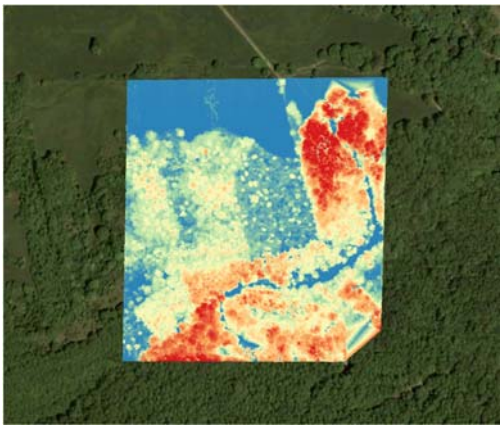

fig. 2 – A CHM superimposed on Google Earth

integration of data obtained through ground-based forest inventory techniques with remote sensing data, for spatial estimation at small-plot scale of indicators of sustainable forestry management.

The raw data obtained from the scan is organized in a natively 3D, accurately georeferenced point cloud. Echoes are obtained not only from the top of the canopy, but also from its lower layers, from trunks, and, most importantly from the ground. E.g. even in quite dense forest cover, with 25m-tall trees covering completely the surface, a cloud containing 50-100 points/m^2 has about 1-10 points/m^2 on the ground. Such densities are as much as one order of magnitude greater than what is normally obtained using conventional aircraft.

For forestry management the most important and basic product obtained is a Canopy Height Model (CHM). This is built as the difference between the Digital Surface Model (DSM) obtained as a rasterized higher envelope of the cloud, and the Digital Terrain Model (DTM) obtained from the points automatically classified as belonging to the terrain starting from the lower envelope. Rasters at 0.3-0.5m resolutions were produced.

The CHM can be used for heuristic estimation of biomass, that is related to wood yield, and to capacity of CO_2 sequestration.

More detailed analysis of the cloud can yield fine description of the forest, down to individual tree segmentation and characterization, and diversity statistics extraction.

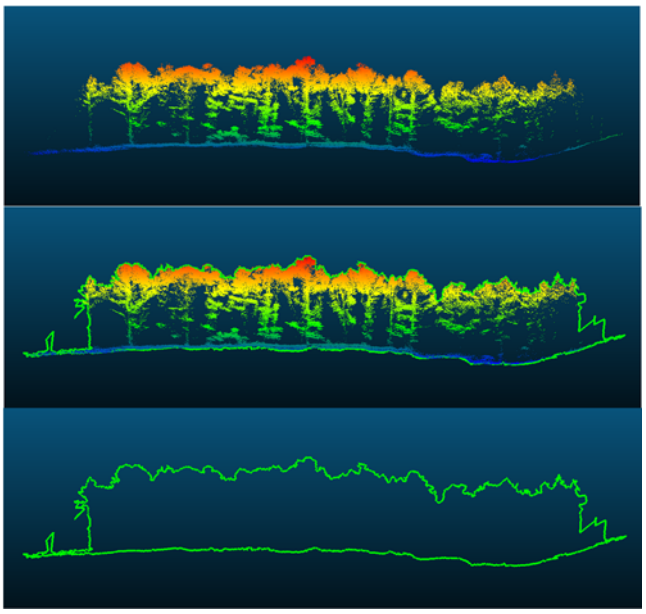

fig. 3 – CHM extraction
From top to bottom: section of the point cloud, higher and lower envelopes superimposed, section of the DSM and DTM

Collaboration between public and private research institutes, and commercial enterprises proved instrumental to the purposes of these projects.

Keywords:
RPAS, drone, LiDAR, forestry management, indicators, biomass

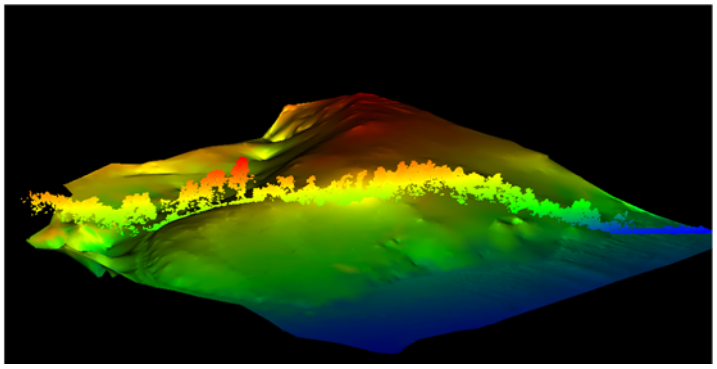

fig. 4 –DTM obtained under vegetation cover
A section of the point cloud superimposed over the DTM