Capturing forest structure using UAV based LiDAR.

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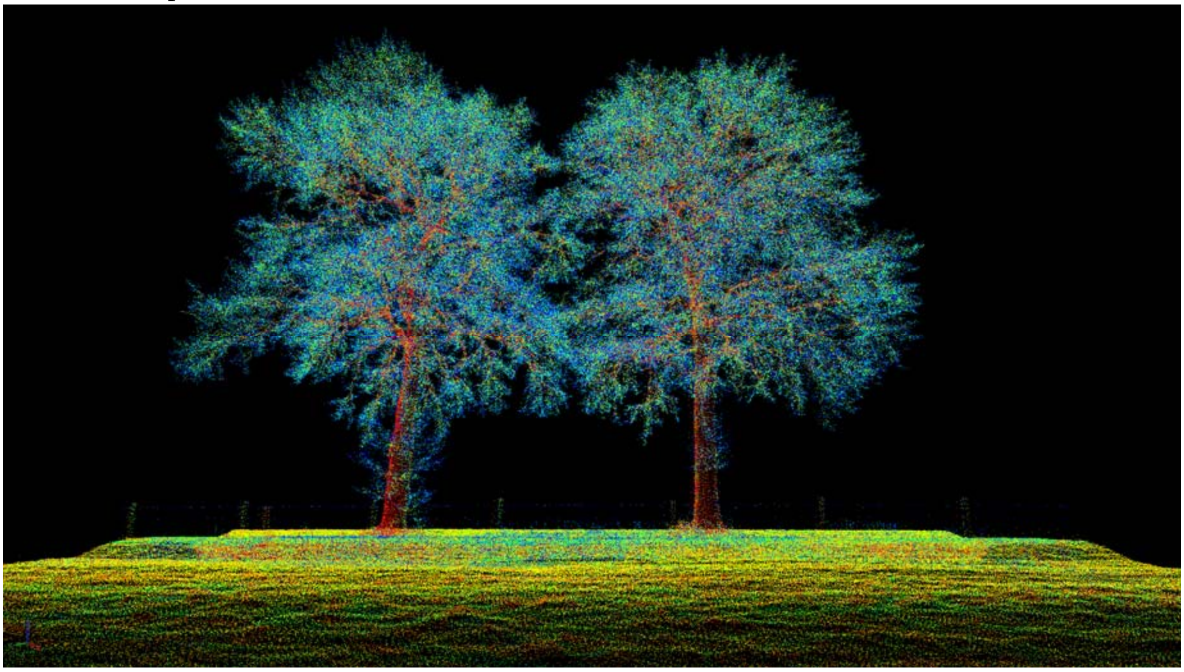
Abstract: Laser scanning has allowed us to understand forest three dimensional structure, and how this changes through time. Technological improvements have brought the quality of both Airborne laser scanning (ALS) and Terrestrial laser scanning (TLS) to a level where it can be used operationally, which resulted in nation-wide ALS pointcloud datasets that are publically available and an increasing amount of forestry plots scanned with TLS worldwide. This offers great potential for analysis of forest structure and tree architecture. First, there is the characterization of forest canopies by the spatial and vertical distribution of the point cloud data. Comparison through time shows that these measurements are well suited to capture phenological changes throughout the growing season. If the point clouds have a sufficient point density, individual trees can be reconstructed using Quantitative Structural Models (QSMs), thus allowing accurate estimates of tree volume and tree architecture. In parallel to TLS, a lot of development has been going on in the field of Unmanned Aerial Vehicles (UAVs). In several campaigns we combined the acquisition of TLS data with simultaneous hyperspectral image acquisition from UAVs and reconstruction of the Top of Canopy geometry using Structure-from-Motion techniques based on RGB photographs. Being able to capture larger areas in a short time is a major benefit of UAVs. However, these acquisition techniques have the limitation that they can only measure and reconstruct the forest canopy, and not the tree architecture which limits good estimates of biomass, and description of forest structure along the vertical profile.

With the recent availability of the UAV based LiDAR system RiCopter (RIEGL LMS) we are combining the LiDAR and UAV technologies. The system consists of an octocopter, with a maximum take-off weight of 25 kg, which allows operation without legal restrictions in most countries. The UAV is designed and optimized to carry the Riegl VUX-SYS laser scanner, a complete miniaturized airborne laser scanning system of low weight and compact size for flexible use in UAV, helicopter, gyrocopter and ultra-light aircraft installations. The system consists of the RIEGL VUX-1UAV laser scanner, an IMU/GNSS system, a control unit and up to 2 optional cameras. The measurement performance of this VUX-SYS results in survey grade measurement accuracy. By varying the flight height and speed, and scanner pulse rate, point densities of thousands of points per m^2 can be achieved.

The first acquisitions for tree rows and individual trees have shown us that we are able to reach a point density and accuracy comparable to TLS point clouds, within a fraction of the time, potentially allowing us to upscale very detailed LiDAR based monitoring to large areas (>10 hectare within a single flight). Preliminary 3D modelling results from UAV LiDAR allow QSM reconstruction to study tree architecture. The first flights over larger forest plots have been performed and showed a good alignment of scanning data for the ca 5 ha plot, which was recorded in a 20 min flight. Simultaneous to the flights, TLS acquisition was done for area plots with different tree species. A comparison of the point cloud datasets will be done on the level of individual trees and at the stand level to assess differences in point distribution along the vertical profiles, due to the different viewpoints and scanner configurations. How this influences forest parameter retrieval is what we will investigate and present, which will show if UAV-based LiDAR will be a possible tool of the future for retrieving forest structure parameters over large areas.

Keywords: RiCopter; UAV based LiDAR; TLS-UAV based LiDAR comparison

Abstract Graphic



Abstract Figure. Individual trees acquired with the RiCopter VUX-SYS system.