Remote sensing of tree structure and biomass in North Australian mesic savanna

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This PHD research aims to develop and assess methods using stereo imagery and laser scanning data, to extract 3D tree structural parameters for estimating biomass/carbon stocks in NT mesic savannas

The reliability of airborne light-detection-and-ranging (LiDAR) for delineating individual trees and estimating above-ground biomass (AGB) has been proven in a diverse range of ecosystems, but can be difficult and costly to commission. Point clouds derived from image matching techniques obtained from unmanned aerial systems (UAS) or stereo satellite imagery could be a feasible low-cost alternative to airborne LiDAR scanning for canopy parameter retrieval.

	ADVANTAGES	DISADVANTAGES
Drone UAS stereo imagery	Accurate estimation of forest attributes for dominant canopy; high spatial and temporal resolution; Mobility and portability; Low cost of equipment	Lower coverage (< 1 km^2); Unable to penetrate the canopy; Need indirect georeferencing for accurate mapping
Airborne laser scanning	Direct data geo-referencing; Provides information from under the dominant canopy; Accurate estimation of forest attributes; Detailed 3D spatial information	Limited information on species diversity and forest health; High cost (> 1000 AUD/km^2)
Stereo satellite optical sensors (WorldView, GeoEye…)	Higher coverage at relatively low cost; Regular temporal resolution and homogeneity in acquisition; Image spectrometry information;	Less precise estimates; Unable to penetrate the canopy; Lower spatial resolution; Need precise indirect georeferencing for accurate mapping

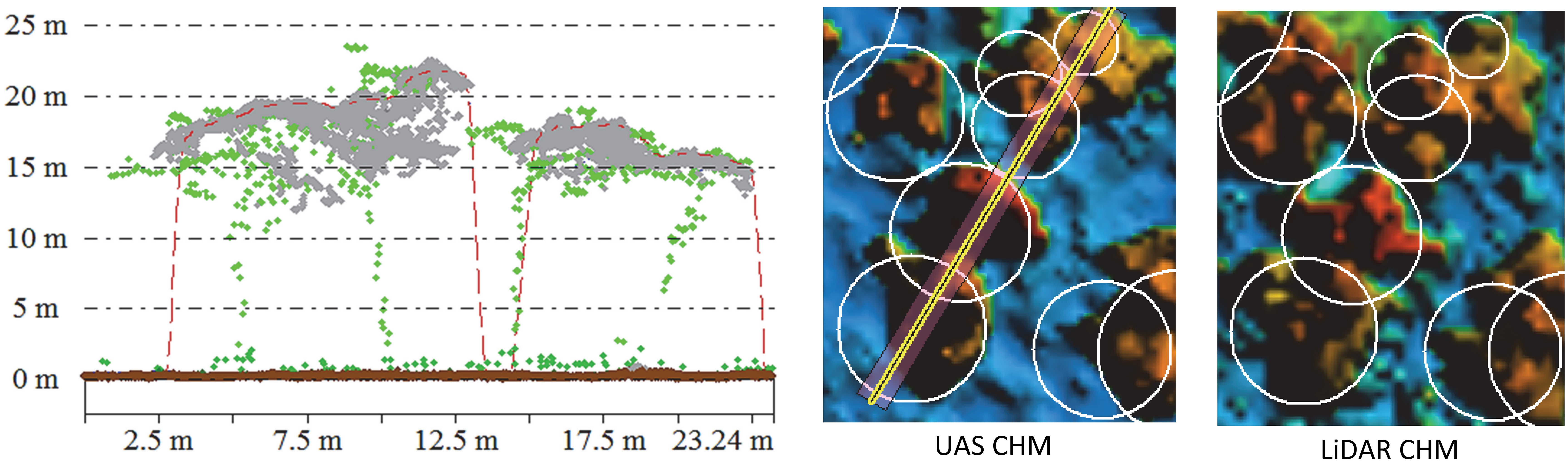

Figure: Horizontal transect of study area subset. Reference LiDAR three-dimensional (3D) point cloud (green dots), image-based derived point cloud (grey dots) and their corresponding 40 cm raster canopy height models (CHM) used for local maxima and watershed segmentation. White circles represent the crowns of reference trees.

The accuracy and completeness of CHMs generated from image-based dense point clouds have a direct effect on individual tree detection performance. In our study, it was primarily related to:

- the accuracy of the bundle-block adjustment;
- the vegetation structure;
- the spatial resolution of the raster CHMs;
- an appropriately sized circular height–crown diameter relationship search window for identifying individual canopies by the local maxima routine;

We found that the canopy maxima and watershed segmentation routines produced similar tree detection rates (~70%) for dominant and co-dominant trees, but yielded low detection rates (<35%) for suppressed and small trees due to poor representativeness in point clouds and overstory occlusion.

We conclude that this low-cost UAS (< $1000) option currently cannot be used for reliable AGB estimation due to unstable sensor internal geometry, which affected the vertical accuracy of extracted CHMs. The GoPro camera, with a gimbal setup and a sufficient number of GCPs, can be used for an acceptable (+/- 1.2 m) height estimation of dominant and co-dominant trees.

Although LiDAR data provides higher tree detection rates and more accurate estimates of tree heights, image matching was found to be an adequate low-cost alternative for the detection of dominant and co-dominant tree stands in Australian tropical savannas.

Reference: "Efficiency of individual tree detection approaches based on light-weight and low-cost UAS imagery in Australian savannas" published in "Remote Sensing" journal (Feb. 2018).

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