Seeing the ground through the trees

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Abstract:
The collection of UAS data for assessing the three-dimensional structure of forests is becoming increasingly common (Dandois et al. 2013, Theil and Schmullius, 2016 , Wallace et al. 2016). Two main sensing technologies: laser scanning and high resolution imagery, have been employed to generate point clouds from which information on forest structure can be extracted. Several points of difference between these technologies have been highlighted within the literature. While LiDAR sensors are capable of providing a more complete description of the vertical structure of a forest, their cost and required expertise in data collection and processing have been described as prohibitive. While collecting and processing high quality imagery has become a relatively simple task, due to presence off-the-shelf plug-in UAV camera systems, the data produced through photogrammetric algorithms has been shown to be missing critical information, in particular an accurate description of the surface of the terrain (Dandois et al. 2013). Approaches to overcoming this shortfall have mainly focused on secondary datasets describing the ground, such as Airborne Laser Scanning data, have been successful but rely on data availability and suffer from inaccuracies in the coregistration process. This research proposes a hybrid sensor package, including a dSLR camera and downward looking laser range finders, and a workflow aimed at describing the vertical forest profile without requiring a high cost/expertise laser scanning sensor package and/or auxiliary datasets.

This paper presents the results of an initial simulation study designed to inform a functioning sensor package. Data was generated from simultaneously captured laser scanning data and dSLR imagery from a multirotor UAV over a 30 x 50 m plot in a dry sclerophyll eucalypt forest. Individual laser range finders are simulated as a data recorded from a single scan angle at/close to the instance of a camera exposure. Information from various combinations of laser range finders (both number and pointing direction) is presented. The resultant point clouds are coregistered to the image based point cloud based on the position and orientation information provided in the photogrammetric solution.

Validation based on the number of ground points retrieved under canopy, GPS located ground control (capture in open sky or near the canopy edge) and derived tree height estimates indicates that 3 laser rangefinders at angles of -25, 0 and +25 provide the optimum configuration in the test area. The use of laser range finders in this configuration reduces the

Root Mean Square Error (RMSE) in DTM height from 0.53 m to 0.41 m. The improvement seen in the DTM areas under canopy (as seen Figure 1) is indicated by the increase in the number of ground points retrieved below canopy from 0.5 points per meter to 3 points per meter. The improvement in the DTM retrieved from the laser range finders is sufficient to reduce RMSE in the measurement of tree height from 1.30 m to 1.01 m in comparison to field measurements, which is similar to that achieved by UAV laser scanning data (0.92 m (Wallace et al. 2016)).

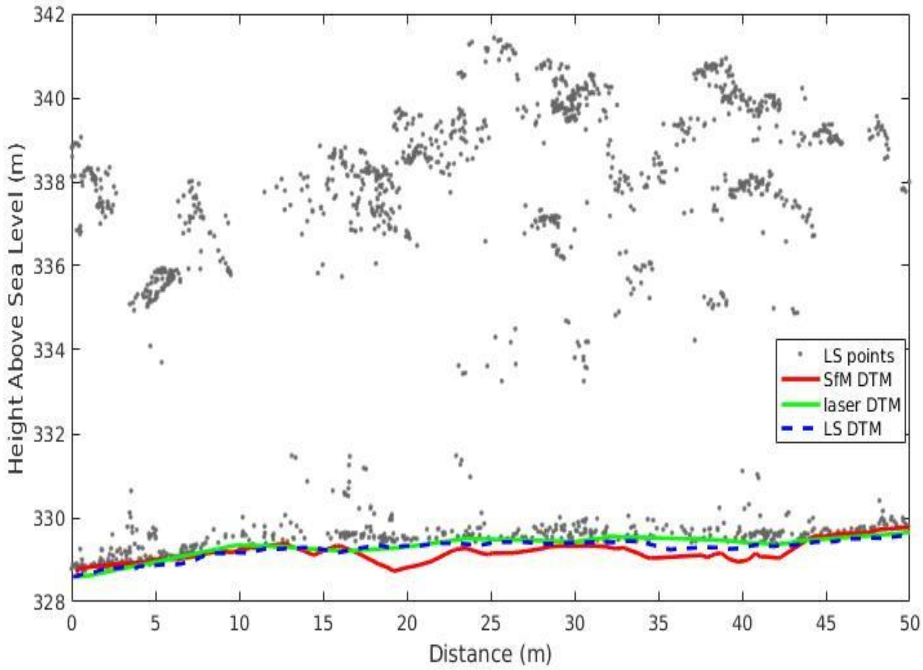

Figure 1. North South transect through the plot area showing the DTM levels extracted by the SfM (red), laser rangefinder (green) and UAV-laser scanner (LS) (blue) approaches. The image based (SfM) DTM exhibits interpolation artefacts between 20 m and 40 m which result in an under estimation of terrain height and an over estimation of tree height.

References:

Dandois, J.P. and Ellis, E.C., 2013. High spatial resolution three-dimensional mapping of vegetation spectral dynamics using computer vision. *Remote Sensing of Environment*, *136*, pp.259-276.

Liang, X., Wang, Y., Jaakkola, A., Kukko, A., Kaartinen, H., Hyyppä, J., ... & Liu, J. (2015). Forest data collection using terrestrial image-based point clouds from a handheld camera compared to terrestrial and personal laser scanning. *IEEE Transactions on Geoscience and Remote Sensing*, *53*(9), 5117-5132.

Thiel, C. and Schmullius, C., 2016. Comparison of UAV photograph-based and airborne lidar-based point clouds over forest from a forestry application perspective. *International Journal of Remote Sensing*, pp.1-16.

Wallace, L., Lucieer, A., Malenovský, Z., Turner, D. and Vopěnka, P., 2016. Assessment of forest structure using two UAV techniques: A comparison of airborne laser scanning and structure from motion (SfM) point clouds. *Forests*, *7*(3), p.62.