INDIVIDUAL TREE DETECTION AND HEIGHT ESTIMATION FROM HIGH-RESOLUTION UAV IMAGERY

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Abstract

In this research, UAV (Unmanned Aerial Vehicle) imagery is processed through photogrammetry, resulting in an orthomosaic and a canopy height model (CHM). The orthomosaic is segmented based on spectral characteristics combined with the canopy height model. A watershed segmentation is used to group the segments into tree candidates. These results are compared to ground measurements in terms of location and height.

Methods

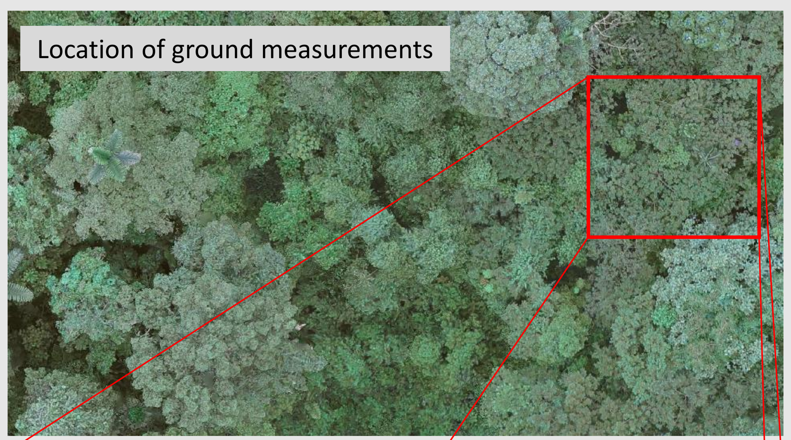
In this research, UAV imagery from Mindo Cloud forest (Ecuador) is processed with Agisoft Photoscan, aligning the separate UAV (Unmanned Aerial Vehicle) images and producing an orthomosaic and a canopy height model (CHM).

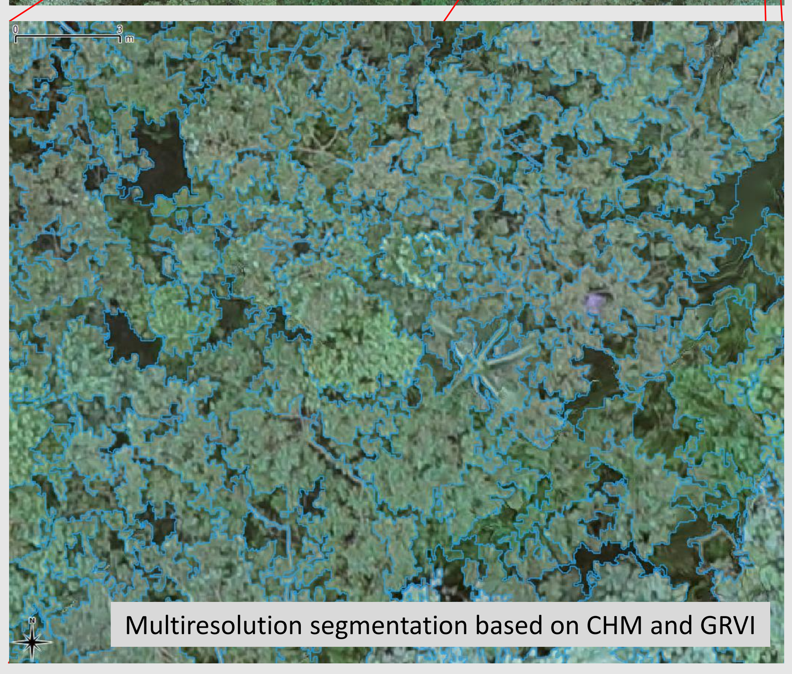
In order to optimize tree detection, the spectral information from the RGB orthomosaic is maximized by making use of the Green-Red Vegetation Index, which calculates as follows:

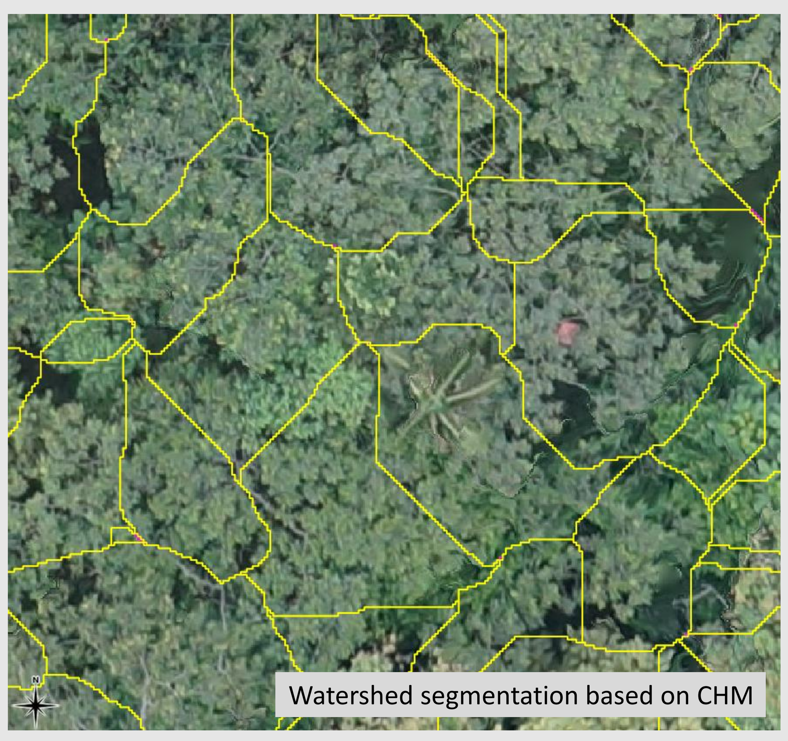
$$GRVI = \frac{\rho_{green} - \rho_{red}}{\rho_{green} + \rho_{red}}$$

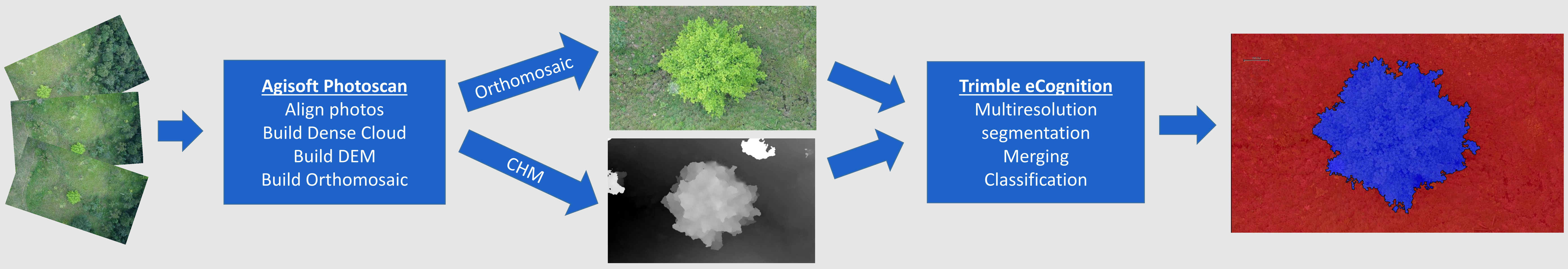
A first (over)segmentation of the orthomosaic is executed based on the GRVI combined with the CHM.

For the second segmentation a median filter is applied on the CHM in order to reduce the number of local extrema. The watershed segmentation uses the local extrema to delineate tree areas. Candidate objects are grouped according this watershed segmentation. The resulting polygons are evaluated in order of location by measuring the distance between the polygon centroid and the ground measurement. The tree height derived from the CHM is compared to the corresponding ground measurement



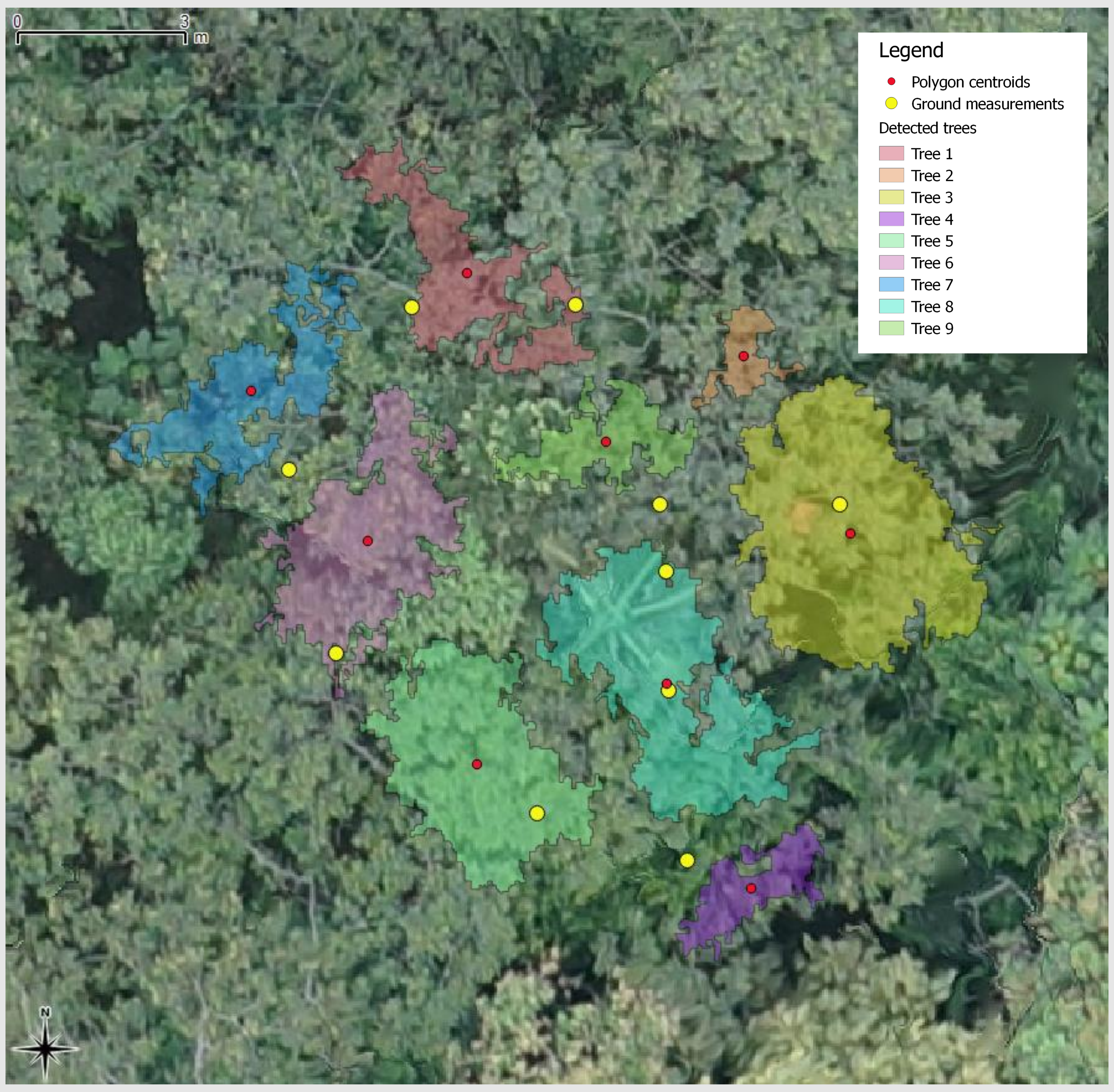




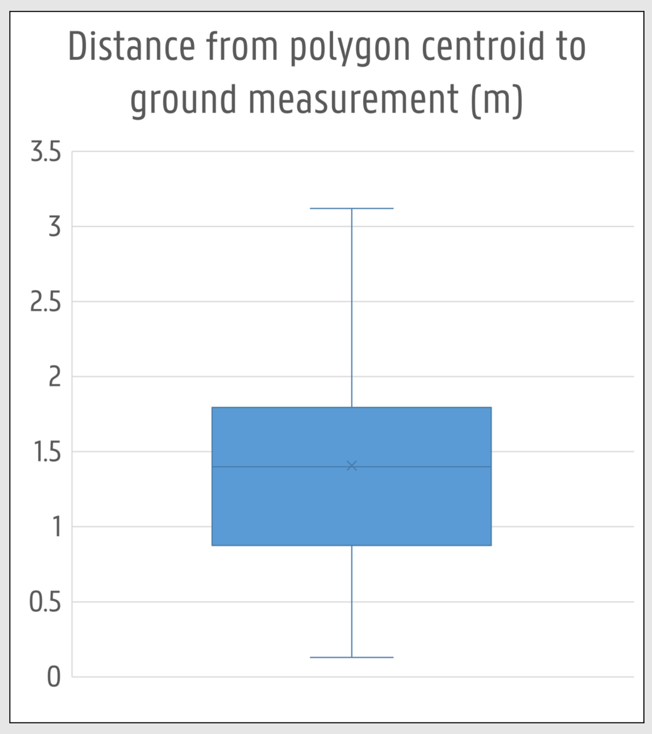


The results from the workflow are compared to the ground measurements in a circular plot with a radius of 5 meter (area +/- 80m²). Of the ten trees higher than 8m (the smaller trees are not visible in the UAV imagery) within the plot, this method detected nine. The detected trees are represented by polygons which cover the greater part of their crown. For each polygon the centroid is calculated to estimate the tree location. Because the stem is rarely located at the centre of the tree crown, or tree might be asymmetrical or crooked, a minimal deviation from the ground measurements is to be expected.

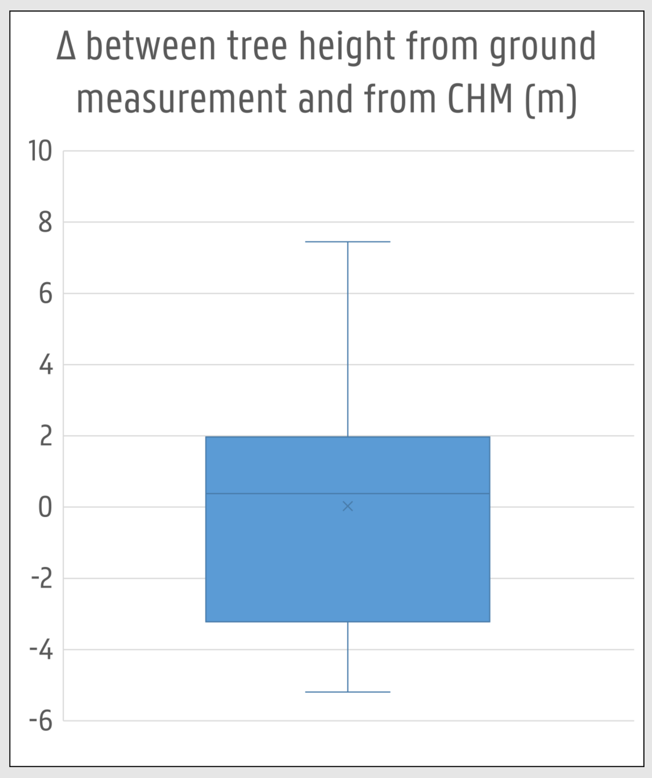
Indeed, tree location was on average estimated to be at 1.41m distance from the ground measurement, however most of the estimations fall within (or very close to) the tree crown polygon). In one case, two trees could not be distinguished due to the lack of variation in the canopy height model (cfr. watershed segmentation).



Tree ID	Distance to Polygon Centroid (m)
1	1.19
2	3.12
3	0.56
4	1.23
5	1.40
6	2.08
7	1.51
8	0.13
9	1.44



Tree ID	Height (m)	CHM (m)	Δ
1	8.33	13.52	-5.19
2	19.46	12.01	7.45
3	13.83	11.84	1.99
5	8.77	7.73	1.04
6	12.70	10.75	1.95
7	8.30	11.33	-3.03
8	9.83	10.76	-0.93
4	9.26	12.67	-3.41
9	13.16	12.78	0.38



While the average difference between the ground measurements and the canopy height model is only 0.03m is this plot, the standard deviation amounts to 3.54 and differences go up to 38% of the total tree height. This can be explained by the fact that both compared tree heights are estimations. Errors on ground measurements can easily go up to 1 or 2 meters, while the CHM is based upon a digital elevation model (DEM) and a digital terrain model (DTM) which makes use of structure from motion (SfM) and more importantly from interpolation. Especially the values of the DTM can be interpolated over a long distance in the case of dense forests.

Discussion & Future Research

UAV imagery proves to be a useful tool to estimate the height and the number of trees in a defined area. Although deviations from ground measurements are not negligible, the canopy height model, combined with the orthomosaic can be applied to make estimations on the number of trees and their height in areas where no other data is available. This automated approach can be applied faster and is cheaper than ground measurements. However, only the top of the canopy is visible (measurable) and height estimations are not very accurate. This approach will perform better in forests which are less dense, uneven and mixed, because it uses the local extrema to find tree tops and holes in the canopy.

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