Project I: Tree Crown Segmentation

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Background

The study area is located at the Marburg Open Forest which lies southeast of Caldern in the west of Marburg. In the large-scale context it belongs to the low mountain range of western central Hessen. The region itself is referred to as the "Gladenbacher Bergland" and can be characterized as a diverse biological and cultural landscape (NOWAK & WEDRA, 1988). The altitude displays a dynamic structure of mountain ranges and different valley shapes. Geologically, it can be allocated to the Rhenish Slate Mountains with dominance of rocks from new red sandstone and carboniferous. The natural forest vegetation of the study area can be classified either as a wood-rush and beech population or a woodruff and beech population.

The first step to analyze the forest structure and tree competition in the Marburg Open Forest is to obtain reliable information on the amount, distribution and size of the individual trees in this area. Regarding this goal, the method of tree crown segmentation using LiDAR data can be seen as an essential application. In general, the use of LiDAR datasets provides the opportunity for detailed studies of forest condition and dynamics (BARNES ET AL., 2017). By extracting individual tree parameters like count of tree, total height or crown diameter and width the accuracy of forest inventory can be increased (REUTEBUCH ET AL., 2005). As a result, the amount of fieldwork required for forest inventory is not only reduced but also the assessment of forest damage is enabled (CHEN ET AL., 2006).

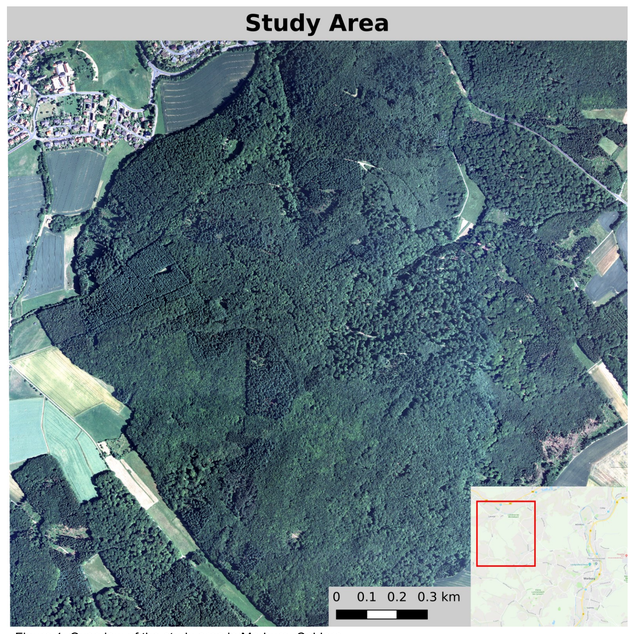

Figure 1: Overview of the study area in Marburg, Caldern.

- **Computing DTM and DSM**
  - Creating Digital Terrain Model (DTM) and Digital Surface Model (DSM) from LiDAR data
- **Computing CHM**
  - Creating Canopy Height Model (CHM) by subtracting DTM from DSM
- **Applying Filter**
  - Applying 3x3 Mean Filter to CHM
- **Validation**
  - Choosing validation area with diverse forest structure
  - Manual validation by setting trunk positions
- **Choosing Algorithm**
  - Choosing Forest Tools Algorithm due to lowest deviation from reality
- **Modifying Algorithm**
  - Improving algorithm results by modifying win function
- **Applying Algorithm**
  - Applying Algorithm to the whole study area
- **Segmentation**

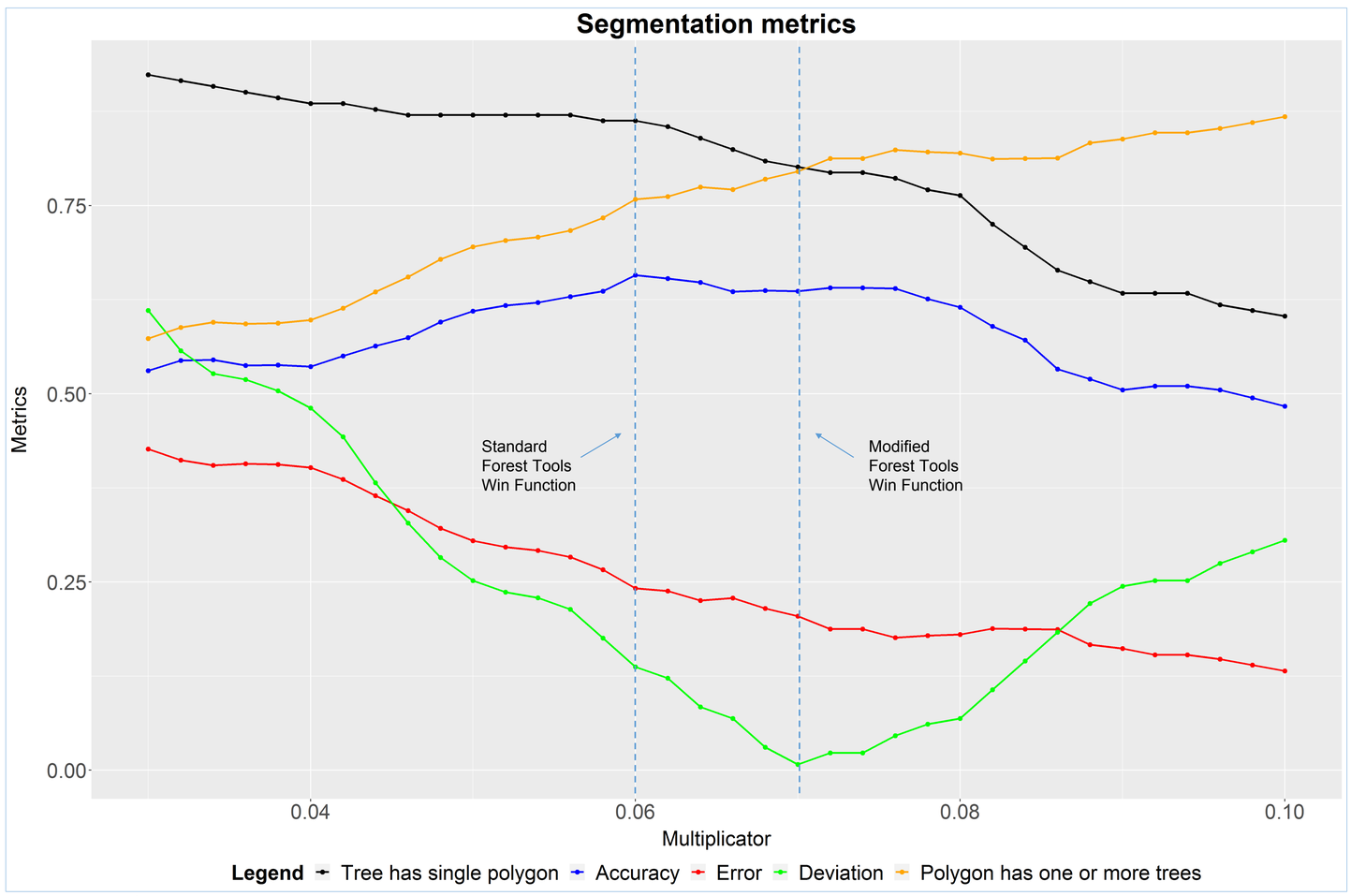

Figure 2: Algorithm performance with changing moving window.

Name	Tree has single Polygon	Accuracy	Error	Deviation	Polygon has one or more Trees
Formula	$\frac{Number\ of\ trees\ with\ their\ own\ allocated\ polygon}{Number\ of\ counted\ trees}$	$\frac{Number\ of\ polygons\ containing\ exactly\ one\ tree}{Number\ of\ all\ created\ polygons}$	$\frac{Number\ of\ polygons\ that\ do\ not\ contain\ a\ tree}{Number\ of\ all\ created\ polygons}$	$\frac{\lvert Number\ of\ all\ created\ polygons - Number\ of\ counted\ trees\rvert}{Number\ of\ counted\ trees}$	$\frac{(Polygons\ containing\ exactly\ one\ tree + Polygons\ including\ more\ than\ one\ tree)}{Number\ of\ all\ created\ polygons}$

Table 1:Used metrics to measure model performance.

Segmentation

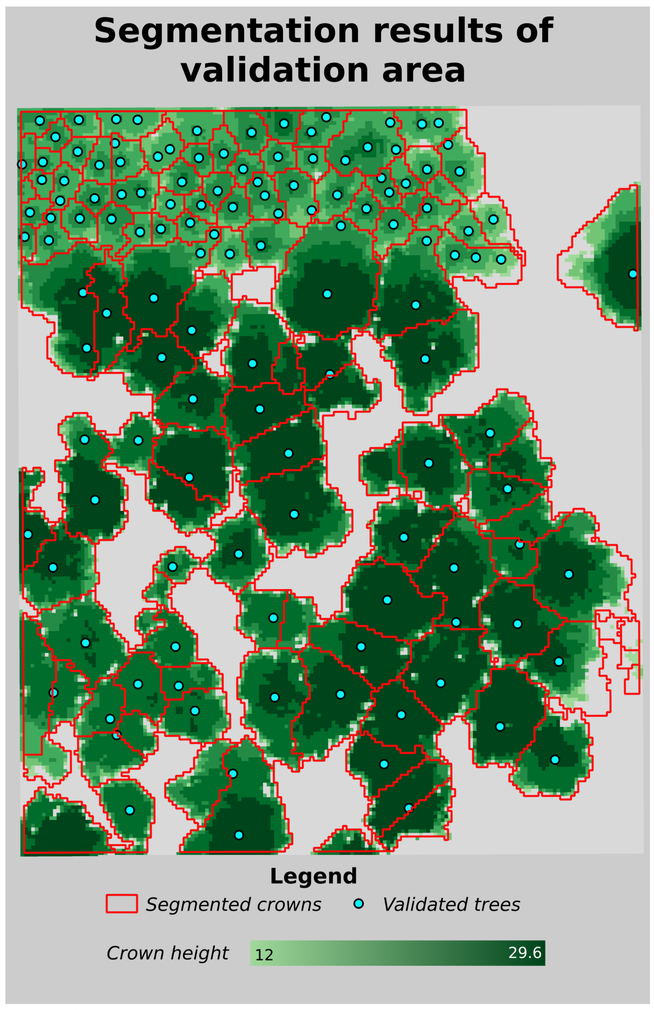

Figure 3: Resulting crown segmentation on the validation area.

Segmentation Statistics

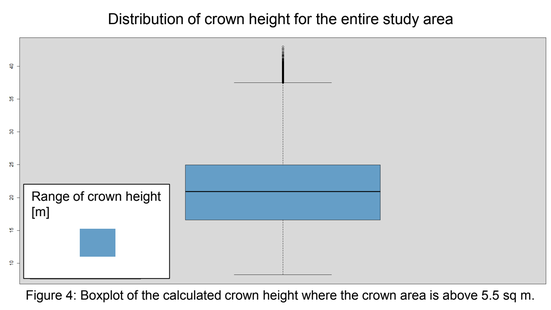

Figure 4: Boxplot of the calculated crown height where the crown area is above 5.5 sq m.

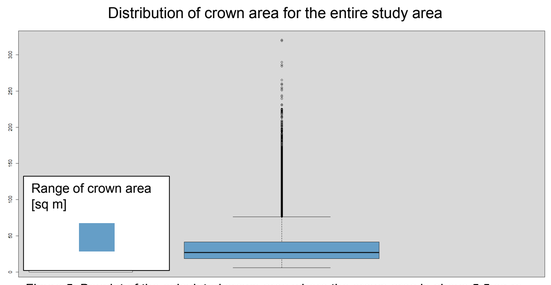

Figure 5: Boxplot of the calculated crown area where the crown area is above 5.5 sq m.

Parameter	Value
Mean Crown Height [m]	21.18
Mean Crown Area [sq m]	33.61
Number of Crowns	79990

Table 2: Summary of crown polygon statistics where the crown area is above 5.5 sq m.

Conclusion and outlook

In this project part the segmentation of tree crowns was done using the ForestTools algorithm by Andrew Plowright (Plowright, 2018). Other segmentation algorithms e.g. the ITC Segment algorithm by Michele Dalponte were also taken under consideration (Dalponte, 2018). The outcome of this project part is a shapefile containing detailed information on several crown properties such as height and area. Finding the ideal algorithm parameters was done by testing a range of combinations and choosing the best suited for the given forest situation (figure 2.).
Results are indicating an accuracy of 65.116% while the error rate is at 18.604%.
Future project parts are including the prediction of tree species using this segmentation as well as other indicators.

Literature

1. BARNES, C., BALZTER, H., BARRETT, K., EDDY, J., MILNER, S., SUÁREZ, J. C. (2017): Individual Tree Crown Delineation from Airborne Laser Scanning for Diseased Larch Forest Stands. In: Remote Sensing. Vol. 9, No. 3. 1 – 20.
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