Individual tree detection as input information for Natura 2000 habitat quality mapping

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1. Introduction

Woodlands and forests make up a substantial part of the ecosystem in Europe and are home to a wide range of species. Indicators suggested for monitoring of habitats include age structure and/or diameter distribution as well as tree species composition (MCPFE, 2007), which all benefit from a description of the forest at a sub-stand level.

Remote sensing is one option to acquire this information for large areas. Data from airborne laser scanning (ALS) are 3D coordinate measurements of light reflections from the ground and other objects. The analysis of the ALS data is often done by aggregating the data into raster cells, extracting features for each raster cell, and relating the features to the information of interest, for example forest variables. This can successfully be done to estimate for example mean tree height (Wulder *et al.*, 2012). However, dense ALS data contain detailed 3D information from which tree crowns may be identified. This has the potential to provide information about individual trees and their properties, for example their tree species (e.g., Holmgren & Persson, 2004).

In this study, individual trees are delineated from ALS data in a forest area in the landscape Uckermark in north-east Germany. Features of the delineated trees may be used for classification of coniferous/deciduous trees as well as habitat trees.

2. Material and methods

2.1 ALS data and processing

As a part of Natura 2000 mapping, ALS data were collected in spring 2011 (May 5th and 6th, leaf-on) and in early spring 2012 (March 22nd, leaf-off). The average point density was 21.8 echoes/m² for the leaf-on and 16.9 echoes/m² for the leaf-off flight. A digital terrain model (DTM) was derived from the data to calculate the height above the ground of each return.

2.2 Tree crown delineation

The delineation of the tree crowns was done by segmentation of a correlation surface model for trees in the topmost canopy layer followed by ellipsoidal tree model clustering of the ALS returns in 3D, both for trees corresponding to the segments from the surface model (i.e., in the topmost canopy layer) and for trees and larger shrubs below.

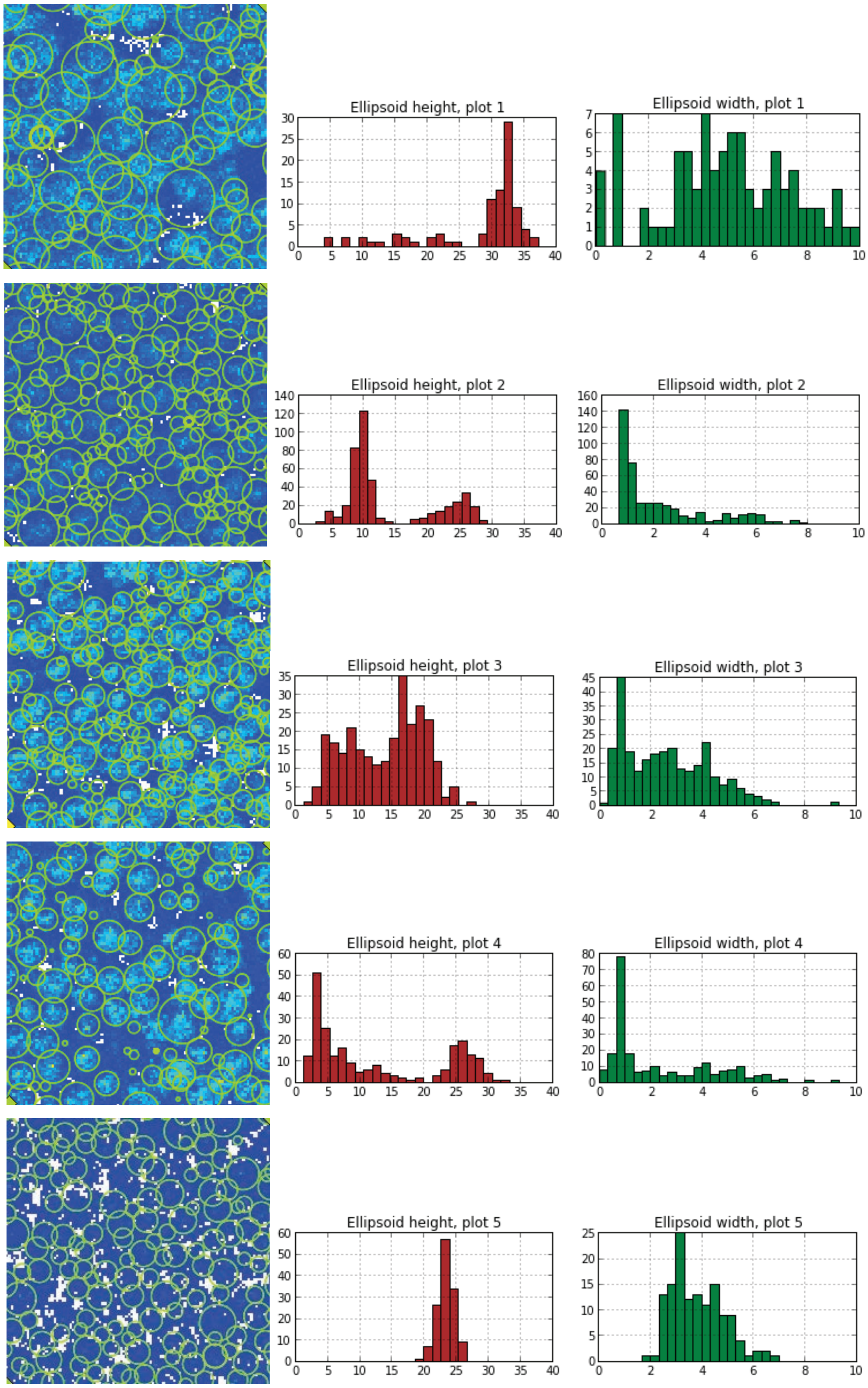

Figure 1: The GIS visualization of delineated tree crowns upon an ALS-derived raster background (point count), together with distributions of fitted ellipsoid heights and widths in [m] on corresponding plots.

The aim of the segmentation was to establish one segment for each tree crown in the topmost canopy layer from the laser returns. A surface model was derived from the laser returns and

the surface model was delineated with watershed segmentation. The result was delineated segments containing the tree crowns and horizontal center points corresponding to tree tops.
The aim of the clustering was to establish one cluster for each tree crown in the topmost canopy layer and additionally one cluster for each tree crown and larger shrub below. The algorithm was based on k-means clustering using ellipsoidal tree crown models and utilizing information from the segmentation. Each cluster was described by its 3D center point and comprised the laser returns assigned to it. The idea was that the cluster center should represent the 3D midpoint of the living crown.
For each delineated tree crown, features were derived to describe the height and width of the tree crown, the height distribution (i.e., percentiles of the height above the ground of the returns), and the mean amplitude of the returns.
Figure 1 shows some visualizations of delineated tree crowns, overlaid upon a raster background calculated from the ALS data (point count). The plots were selected manually to represent some different types of forest, homogeneuous within plot. The histograms of ellipsoid heights and widths (corresponding to heights and widths of the identified trees) show interesting distributions of those attributes and a potential for further investigation to understand relevant habitat quality parameters.

3. Discussion and outlook

The features of the delineated tree crowns (i.e., height, width, statistics of the height distribution, and intensity) can be used to characterize tree species or groups of tree species (i.e., coniferous and deciduous trees). The different layers of trees can be mapped and described from the delineated tree crowns, providing information on the height/age/growth distribution. Habitat trees may also be identified assuming that the proportion or size of their tree crowns deviates from other trees. The degree of naturalness of a forest can be assessed by searching for repetitive patterns of trees that are typically associated with artificial plantations. Absence of repetitive patterns indicates a higher degree of naturalness.
Since these properties are difficult to derive without knowledge of the individual trees, the delineation can contribute new information for habitat mapping and monitoring. Habitats can be characterized and new possibilities to detect unknown habitats may be opened.

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