Exploring Segmentation-based Mapping of Tree Crowns:

Experiences with the Bavarian Forest NP Lidar/Digital Image Dataset

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Introduction

The purpose of image segmentation in general is the delineation of image objects (groups of picture elements) with a meaning in the real world. For forests with complex canopies, getting an initial segmentation to delineate all the different image object patterns [long sinuous shadows, occluded crowns, compact whole crowns, multipart deciduous crowns,...] is infeasable.

The classification of an entity relies upon the context within which it is embedded. Establishing the context of an entity, however depends on the ability to group like entities, and therefore requires some form of classification. The latter is the segmentation problem.(Flack, 1996)

[There is an] interdependence [between] segmentation and classification: classification results are needed as input for a meaningful segmentation, and, vice versa; the segmentation results are required for a good classification (Schneider & Steinwendner 1999).

We explore this interdependence challenge in this poster, and advocate a multiscale and iterative methodology. The context for the problem is individual tree crown mapping using multi-spectral digital images and scanning lidar measurements. For both the segmentation and classification tasks we use the multiscale analysis software eCognition 3.0 from Definiens AG, Munich (http://www.definiens-imaging.com/).

1(a) 3D complexity is a challenge to capture...

Figure 1. CIR digital orthophoto 1:10000 (~20cm GIFOV) over NPBW site 22. The markers show dominant field measured crowns: spruce (yellow) and deciduous (mostly beech, in red) with diameter of marker varying with tree height. Only crowns >15m shown. Note the variety of crown shapes, from disks to occluded crown fragments in the shape of cresents. Occlusion occurs due to mutual shadowing effects.

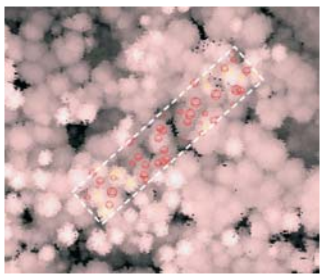


Figure 2. Lidar-based crown model over NPBW site 22 calculated from subtracting winter DTM measurments (1 m grid) from summer DSM (0.5 m grid). The resulting resolution is 0.5 m. Field measured dominant crown markers as in Fig.1.Note that the majority of dominant crowns here have fuller disk shapes.

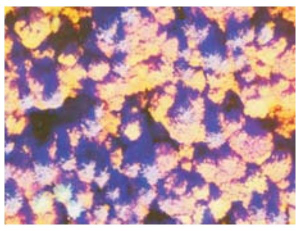


Figure 3. False color composite: Lidar-based crown model on B channel; orthophoto infrared and green on R & G channels. Interpretation: yellow patches are sunlit understory ground (low values on blue channel [LIDAR]). White patches are sunlit crowns (high values in both orthophoto and crown model). Blue patches are shadowed crown, i.e. the portions of the crown that we cannot get from imagery alone. Black is shadowed ground.

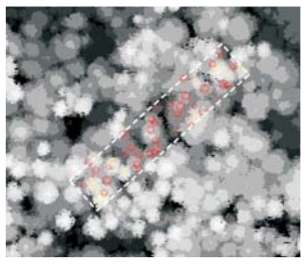
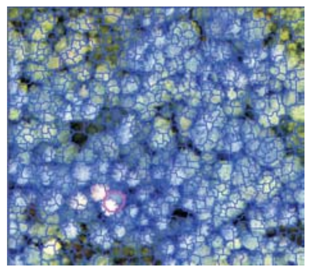


Figure 4. Toposys line scanner RGBI (RGB=b1b4b3) from over NPBW site 22. Markers as in Fig.1. As with the lidar data, the crowns are at least visually better defined than the CIR orthophoto.Note the complexity of the decuiduous crowns.

1(b) Scale parameter...

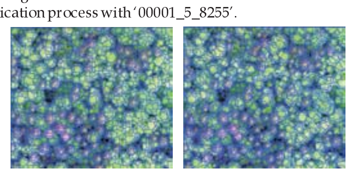


The segmentation method in eCognition (multiresolution segmentation) is a bottom up region-merging technique starting with one-pixel objects. The underlying optimization procedure minimizes the weighted heterogeneity *nh* of resulting image objects as segments are merged in a pairwise clustering process. In Figure 5 (above), we seek an initial segmentation which does not result in image objects such as the example pink object: this image object comprises both understory deciduous crown and dominant dead spruce crown. The segmenatation above was arrived at by weighting only the crown model, setting the 'scale parameter' to 10, color to 0.1, shape to 0.9, smoothness to 0.1 and compactness to 0.9:

RGBICr_SP_ColShpSmoCmp=**00001_10_1919**

2. Classification/Speciation

From Fig.5 we learnt that a scape parameter of 10 was too large, but that otherwise using the crown model alone for segmentation (at least initial segmentation) would be suitable. In Figures 6 & 7 (below) we present two more experiments, this time with different color and shape parameters. On the left the emphasis is on 'compactness' and on the right on 'smoothness'. In the end we chose to begin our classification process with '00001_5_8255'.



First Classification

The segments that we have generated may be thought of as image primatives (Definiens terminology): they are an over-segmentation, parts of what we will eventually consider to be image objects (representations of whole real world objects). The next step is to create a classification scheme (see to right of Fig 8) that captures the range of image objects we would like to deliniate. A simple nearest-neighbour classification worked fairly well, but there was some confusion between spruce and deciduous primatives. We used eCognition's Feature Space Optomisation (right) to help select a feature that would separate these two classes. Figure 8 shows the final first classification.

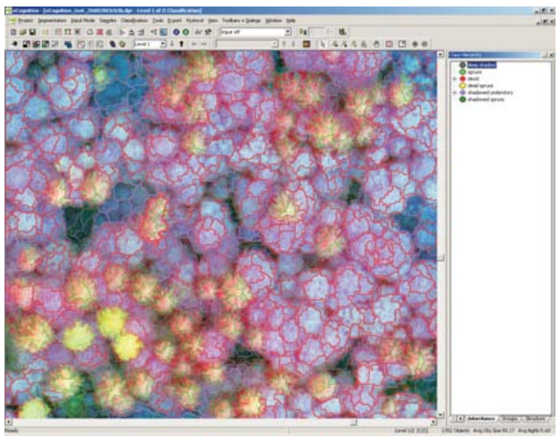
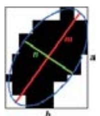


Figure 8

Classification Refinement

In the next step we expanded our classification scheme to incorporate structural differences in two classes: adding crown and sliver subclasses to deciduous and shadowed decidous. We diferentiated between these sub-classes by invoking a fuzzy rule based on 'asymetry' (right). Asymetry would equal 0 for a primative if the shortest axis (n) divided by the longest (m) is equal to 1 (ie. a circle or equal-sided box). Finally, we 'grew' the primatives into image objects using the Classification Based Segmentation tool in eCognition. In this case, all primatives with the same classification that are adjacent were merged and a new segmentation layer created to store them. Figure 9 shows our final (though still preliminary) classification.



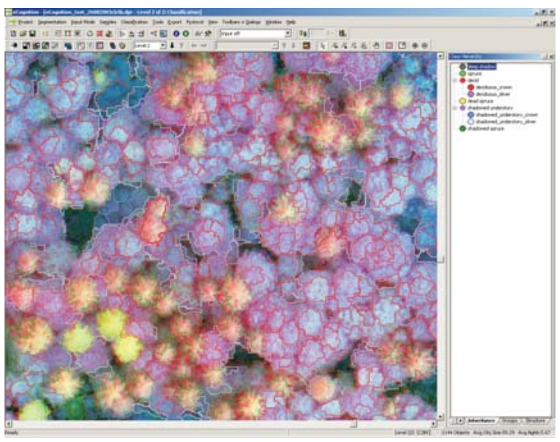
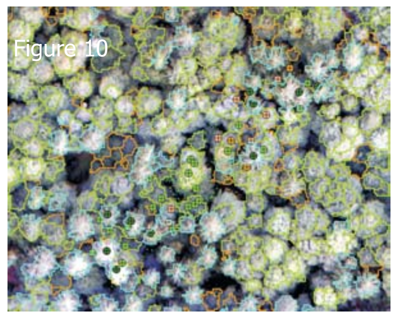


Figure 9

3. Results

The image to the right (Figure 10) shows the eCognition-generated vectors overlayed on the RGBI scanner data with the ground-truth data in an ArcMap view. The ground-truth crowns that are visualised are larger than 20m in height. In the end we tallied only three classes: dead spruce, spruce and deciduous. The tally was performed visually, although we have plans to build and apply an ArcGIS-based accuracy assessment tool to improved classifications and to any classifications we receive from other researchers working on these dataset (see below).

Our preliminary semi-automated method delineated 100% (2/2) dead spruce, 89% of the live spruce (8/9) and 62% (19/31) deciduous crowns. Our next step is to try to divide some deciduous crown 'clumps' and to estimate other crown parameters from out image objects (such as DBH, H, basal area,...).



4. Discussion

1. We demonstrate a multiscale analysis methodology we call multiscale segmentation / object relationship modelling (MSS/ORM: Burnett & Blaschke in press) methodology with which we view image analysis problems as one of identifying image primatives at one scale and building up image objects iteratively.

2. We performed preliminary tests as to the suitability of eCognition softzware for individual tree crown mapping from combined Lidar and mult-spectral airborne imagery. Initial segmentation using eCognition proved to be non-trivial for our complex canopies. We still have many features to test within eCognition and 5 more test sites.

3. The use of the crown model alone worked better for initial segmentation. Combining input datasets often resulted in primatives overlapping multiple classes.

4. We plan to compare our eCognition results to results using template matching and watershed segmentation methods.

5. We encourage researchers to download NPBW data (see below), do individual tree crown analysis and share their successes and problems with us.

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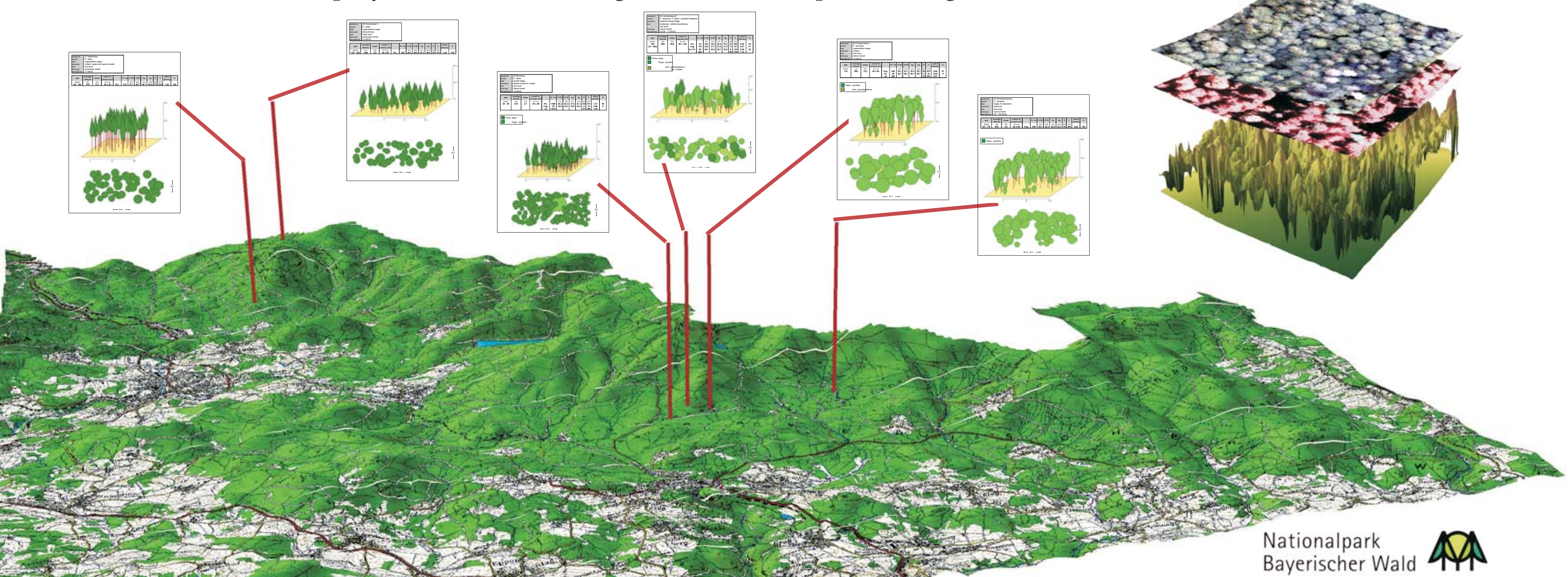
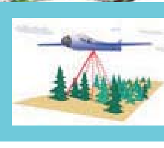
Flack, J. 1995. Interpretation ofremotely sensed data using guided techniques, Ph.D. Thesis, School ofComputer Science, Curtin University of Technology, Western Australia.

W. Schneider & J. Steinwendner 1999. Landcover Mapping By Interrelated Segmentation And Classification Of Satellite Images, International Archives of Photogrammetry and Remote Sensing, Vol. 32, Part 7-4-3 W6, Valladolid, Spain, 3-4 June.

You can download the NP Bayerischer Wald Test Dataset at http://www.geo.sbg.ac.at/LARG/projects/lidar/

Test dataset includes Toposys lidar and RGBI images, scanned orthophotos and ground data.





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