PROCESS ORIENTED OBJECT-BASED ALGORITHMS FOR SINGLE TREE DETECTION USING LASER SCANNING

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Outline

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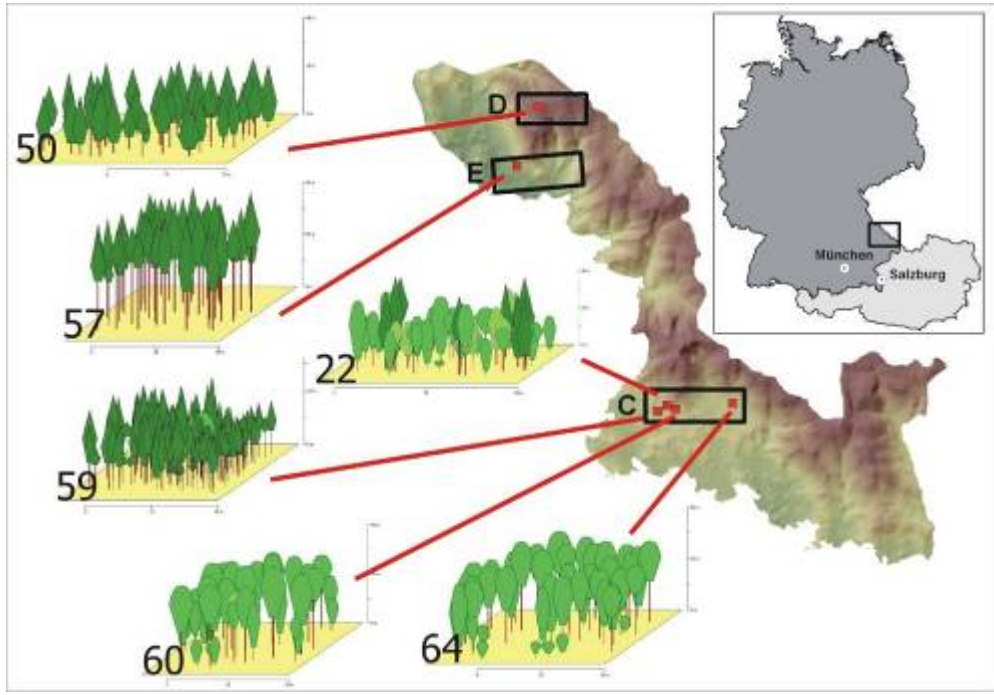
- **Test site and data**
- **Algorithms for segmentation and classification:**
  - Pre-segmentation and -classification
  - Local maxima algorithm
  - Object growing algorithm
- **Results**
- **Discussion and outlook**

Approach

- Main goal: tree identification and tree crown delineation using new process oriented object-based algorithms.
- Problems occurred in earlier studies - a segmentation algorithm based on homogeneity was not successful for tree crown delineation
  ➔ assumption that a centre-weighted segmentation algorithm might be better suited to forest applications.
- The individual algorithms were programmed in Definiens' Cognition Network Language (CNL) available in the most recent version of the eCognition software.
- Single algorithms are combined to form a complete "ruleware" for automated information extraction.

Test site

- Bavarian Forest national park which is located in south eastern Germany along the border to the Czech Republic.
- Six plots were chosen from a set of 44 reference sites, established either between 2001 and 2002
- Representing different forest types
- Same datasets as in a previous study to ensure the comparability of the different approaches (Tiede et al. 2004)



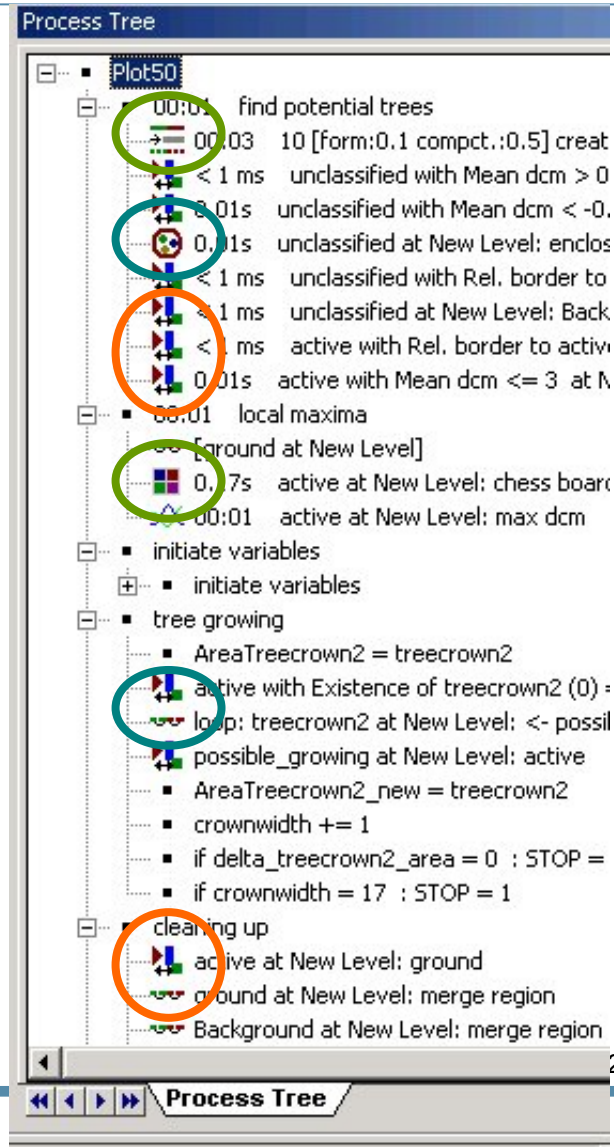
Data

- Size of the six test plots varied (20 x 50 to 20 x 100 meters):
- Field measurements for each plot were available including tree positions at the ground with an accuracy of several centimetres.
- Laser scanning data for each plot were recorded by the airborne LiDAR system ”Falcon” from TopoSys GmbH with an average point density of 10pts/m². First and last pulse data were collected during the flights
- The datasets were processed and classified using TopPit (TopoSys Processing and Imaging Tool) software to interpolate a Digital Surface Model (DSM) and a Digital Terrain Model (DTM).
- The work in this study was done using a nDSM - derived by a subtraction of DSM and DTM - with a ground resolution of 0.5 m.
- Image data for visual accuracy assessment only

Algorithms for segmentation and classification

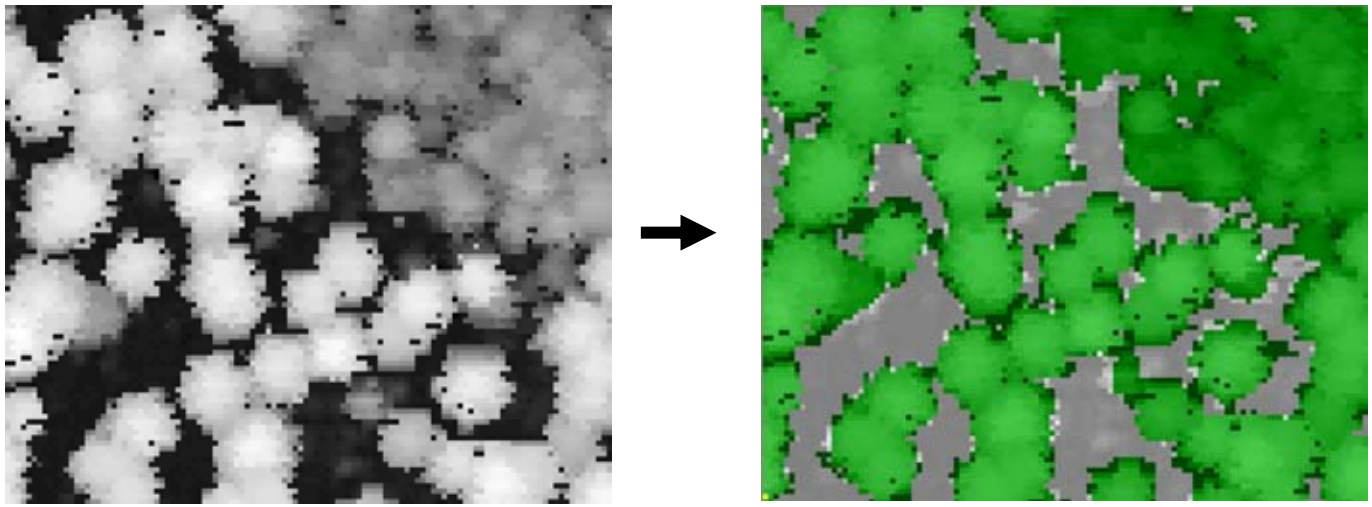
- "Ruleware" development
- Combining different algorithms in one process tree

segmentation, object-related modelling and classification



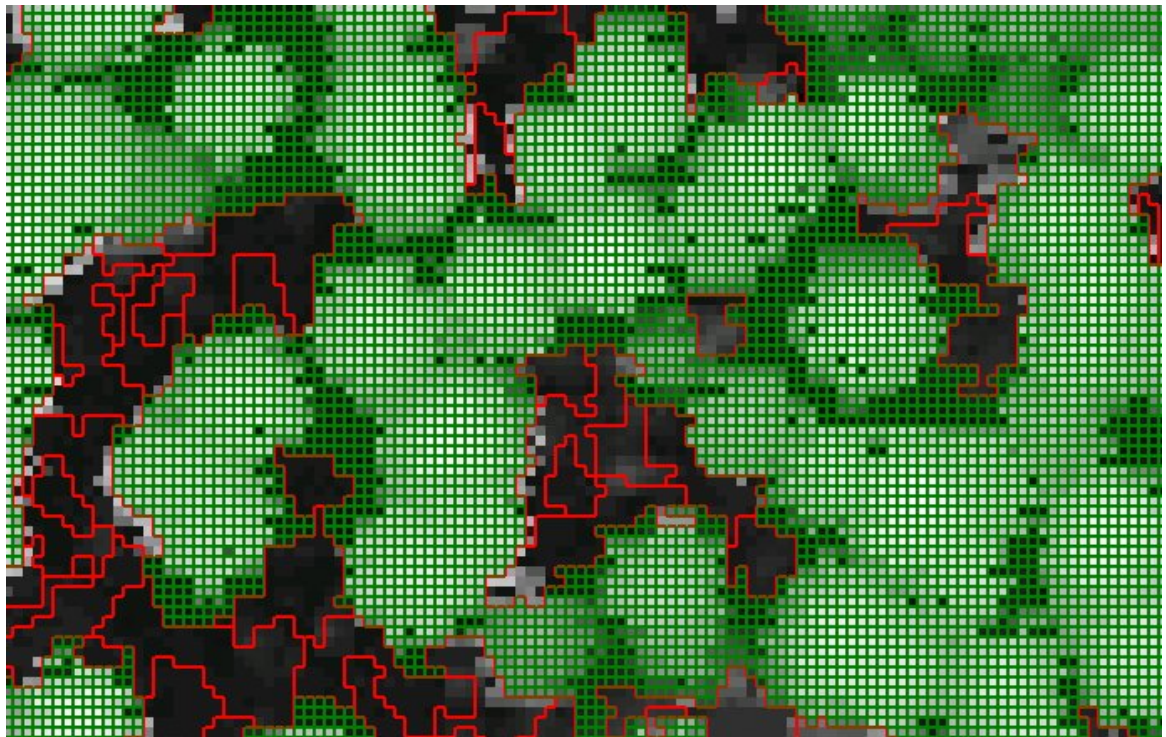
Pre-segmentation and -classification

- Coarse pre-classification using a multiresolution segmentation algorithms
- Differentiation of two classes:
  - ground/non-tree and tree area



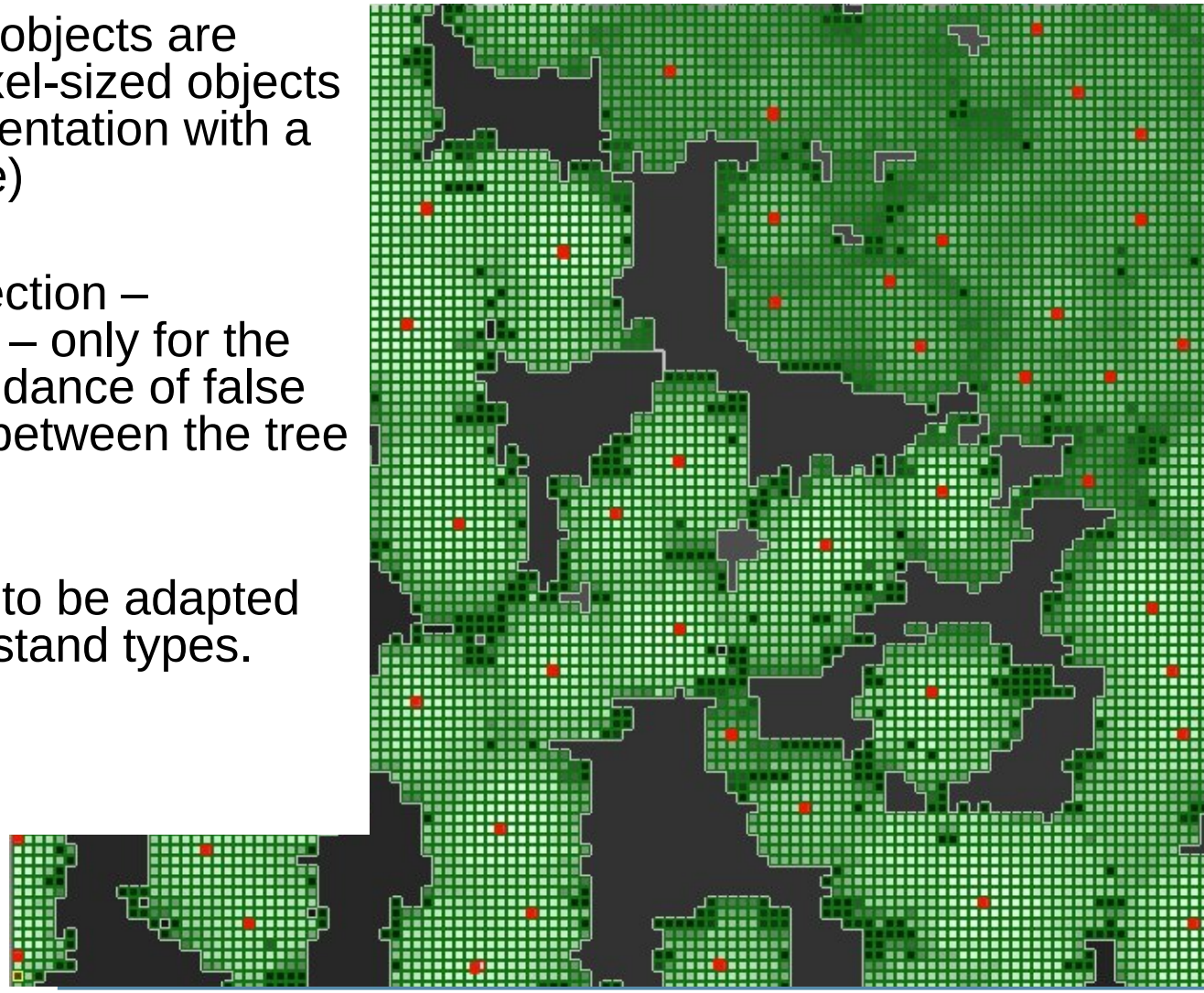
Pre-segmentation and -classification

- New concept of using an **image object domain** allows focusing on the pre-classified tree crowns
- Leads to a performance gain, more complex algorithms can be limited to sub areas of the dataset
- Possibility of different segmentation algorithms and varying object size in one level



Local maxima algorithm

- Pre-classified tree objects are broken down to pixel-sized objects (chessboard segmentation with a minimal object size)
- Local maxima detection – assumed tree tops – only for the tree objects ➔avoidance of false positives in areas between the tree objects
- Search radius has to be adapted for different forest stand types.



Object growing algorithm (delineating of tree crowns)

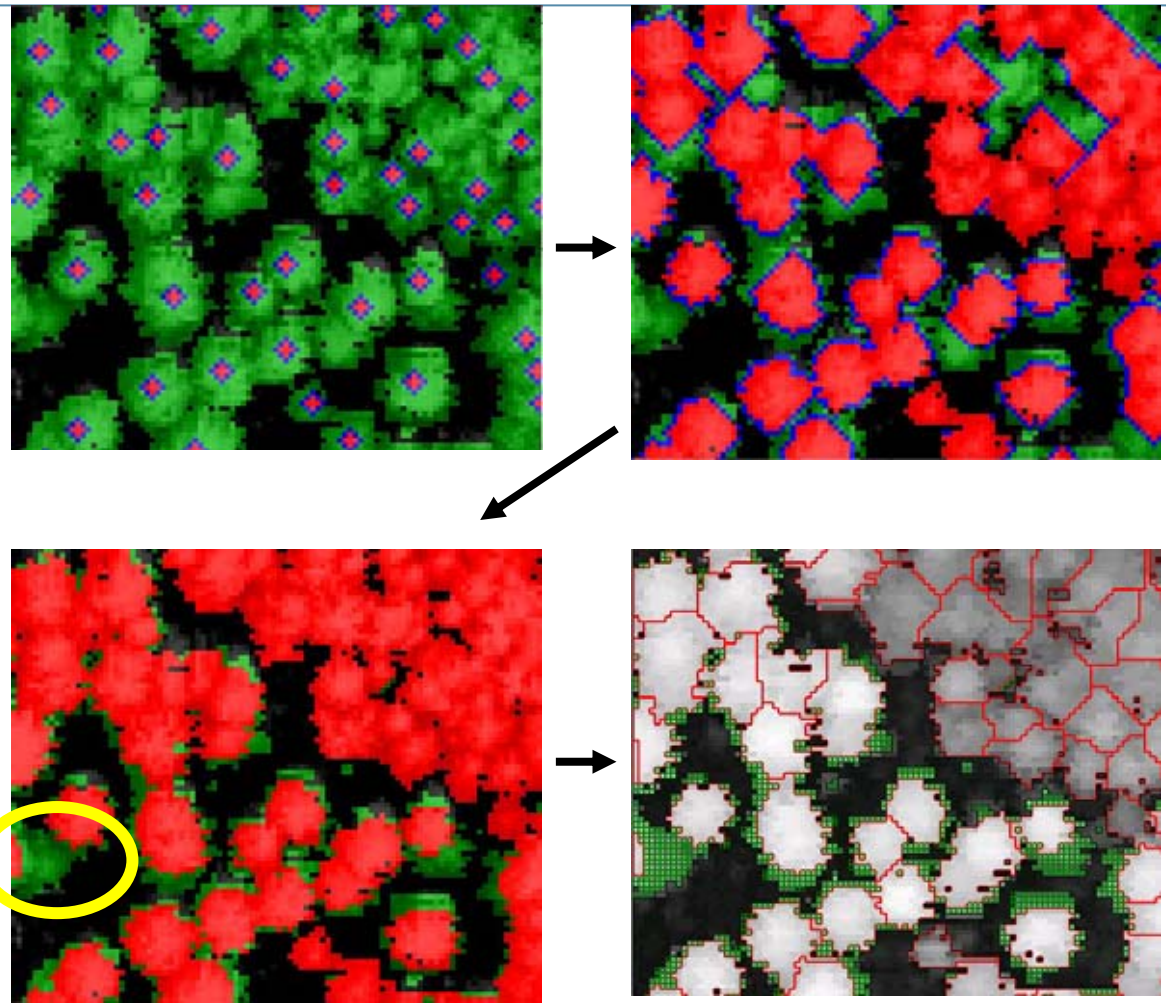
- Local maxima are used as “seed” points to build up new meaningful objects
  - Use of a looping process structure to select and merge candidate neighbouring objects
  - Simultaneous object-growing

    ➔ more accurate separation of the extracted crowns instead of treating the objects sequentially

- Variables are used to implement stopping criteria and to coordinate object growth

- Candidate neighbouring objects are taken into account if:
  - difference in height between the regarded objects does not exceed a certain limit
  - maximal crown width is not reached

Object growing algorithm (delineating of tree crowns)

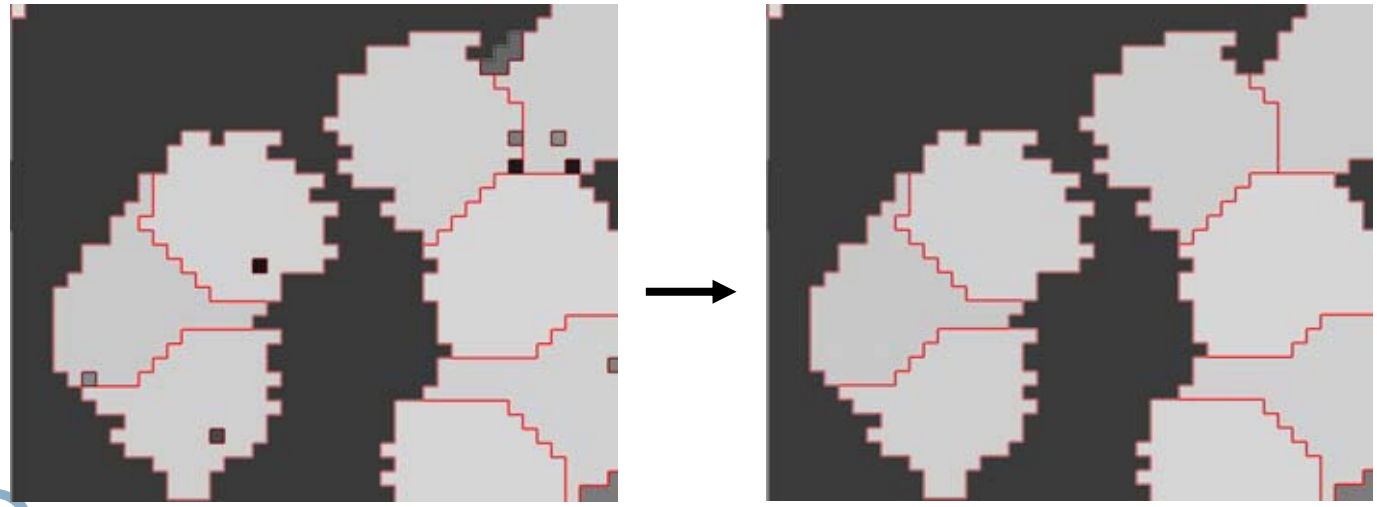


Pre-classified tree objects,
but not build up to a tree crown object

Object “cleaning”

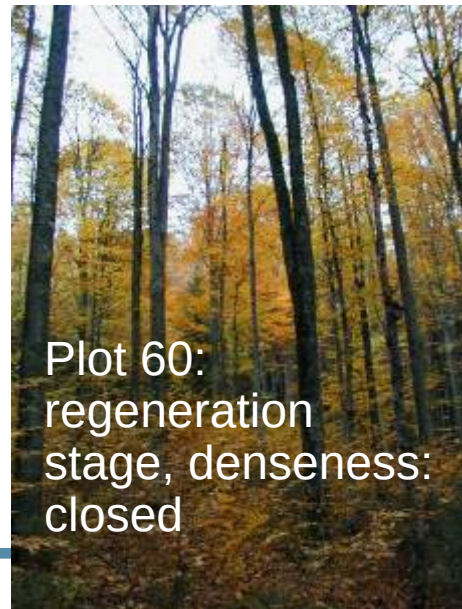
- Tree crown objects partly contain holes or empty spaces
- Subsequent “cleaning” process was applied to classify / and merging these holes according to the surrounding objects.
- The objects have specific attributes and mutual relations

  ➔spatial relationships (e.g. “find enclosed by”) can be used to find all holes which are surrounded by a tree crown image object.



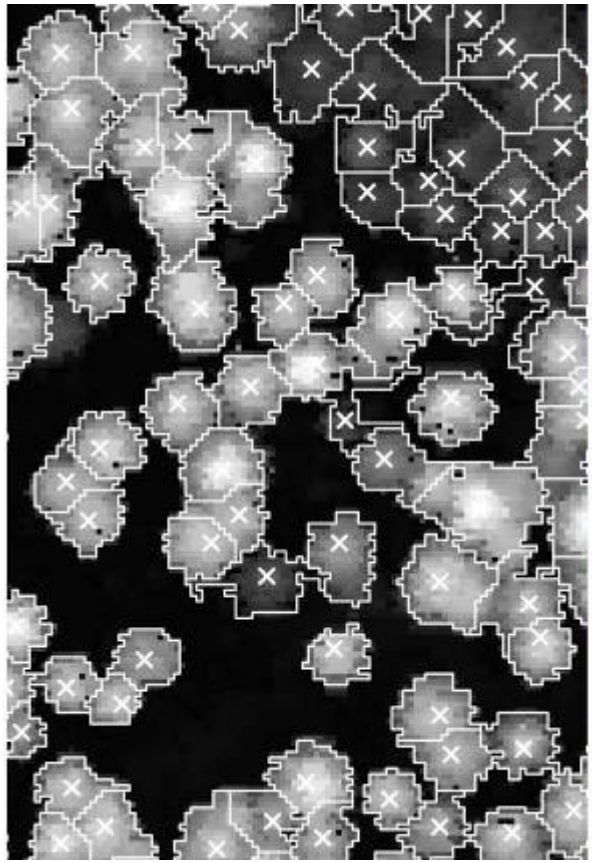
Results – Tree identification

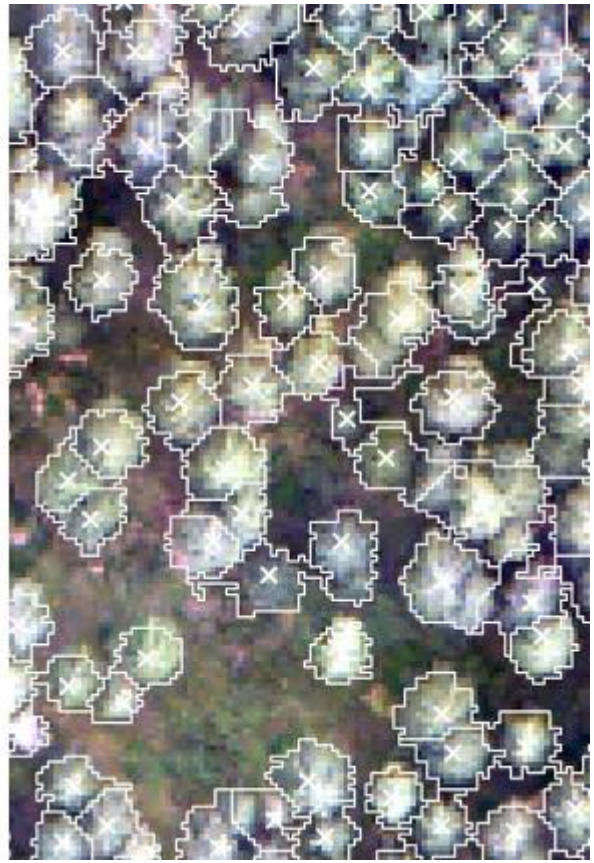
Sample plot	Field measurements	Local maximum calculation		% of found dominant trees
	Dominant trees	Dominant trees	False positives	
Plot 22: mature mixed forest	32	24	0	75.0
Plot 50: sub-alpine well spaced mature spruce	43	35	1	81.4
Plot 57: mature spruce	44	31	0	70.5
Plot 59: juvenile spruce	79	72	4	91.1
Plot 60: mature beech	30	20	1	66.7
Plot 64: mature beech	38	33	3	86.8
Sum of all plots	266	215	9	80.8



Results – tree crown delineation

- **Accuracy assessment for the delineation of tree crowns was carried out only visually so far**
- **mainly good results for dominant trees and well spaced conditions**
- **➔ strongly linked to the local maxima results**



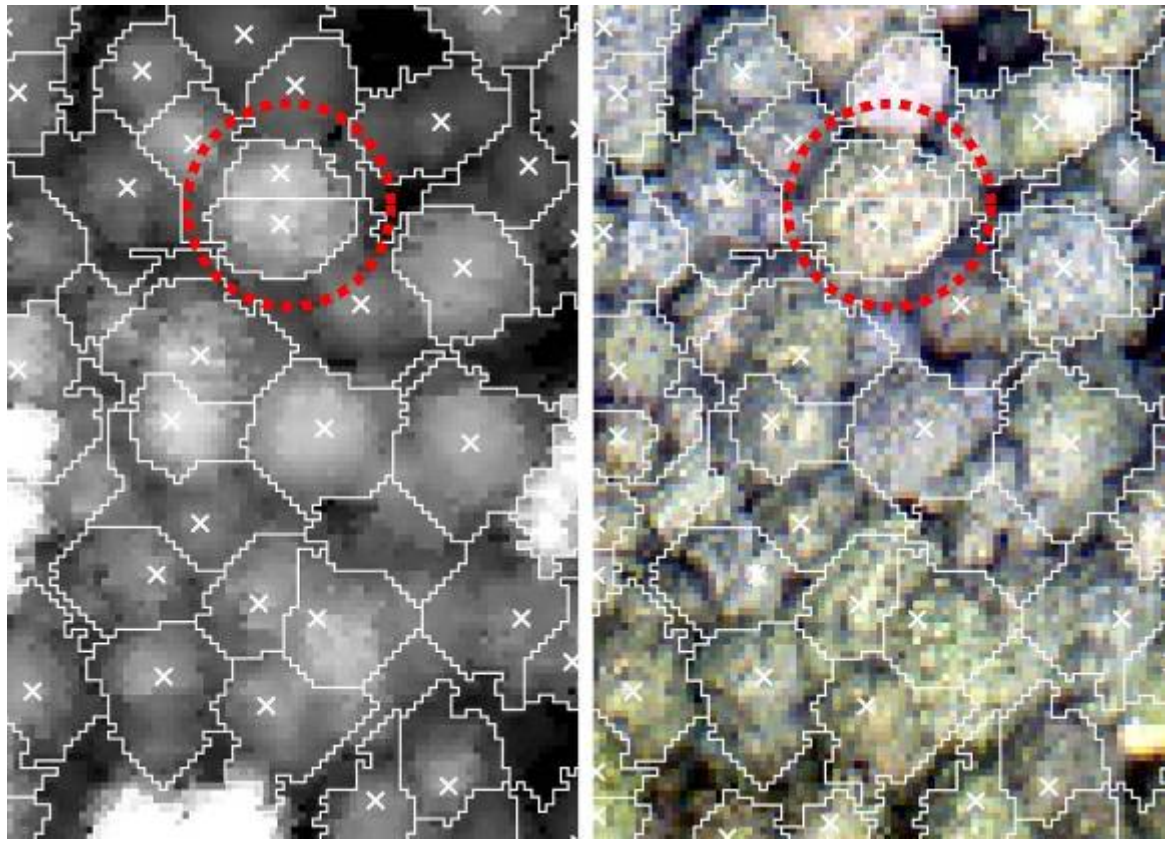


Results – tree crown delineation

- **Problems in dense deciduous forest stands**
- **Local maxima method used to find "seed" points partially failed when the shape of the tree crowns tended to be rather flat than conical**

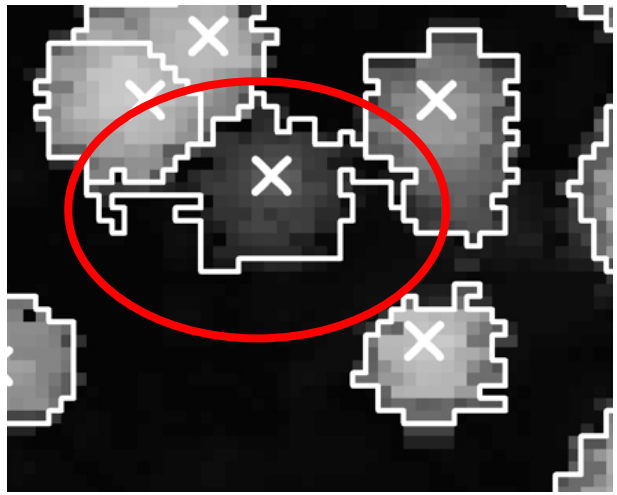
  ➔ representation of the crown in the LiDAR data is not clearly distinct

  ➔ non-recognised tree crowns or doubles.



Results – tree crown delineation

- **delineated objects are sometimes not compact or grow to next located areas**
- **Use of a growing limit (crown width limit) could solve the problem partly**
- **➔ use of an object shape parameter is considered (e.g. Shape Index)**



Discussion and outlook

- New possibilities are extending the eCognition software package to a modular, process oriented programming language

  ➔ different segmentation algorithms, image object domain concept, looping structures

  ➔ new and complex opportunities for single tree detection *I* delineation

- Disadvantages of a segmentation algorithm based on homogeneity concerning the detection of non-homogeneous objects have been overcome

Discussion and outlook

Still: **Object-based accuracy assessment is needed**

- "Classic" accuracy assessment techniques from pixel-based remote sensing are not fully satisfying for quantifying the accuracy of delineated tree crowns
- "when can we identify an object in one data set as being the same object in another data set?" (geometric overlap, shape-area relations, centroid movements, etc.)
- Currently, additional studies are being conducted to include an object-based accuracy assessment

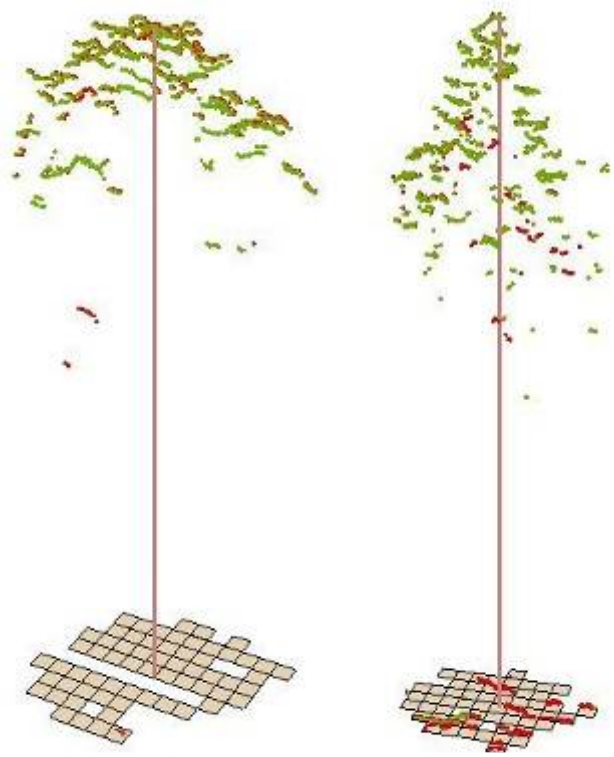
  ➔for example to compare automatically delineated crowns and manually delineated crowns by an interpreter with the help of a new tool called LIST (Lang et al., in press)

Discussion and outlook

Future goals:

- Single tree classification on a species level, using additional information (e.g. image data or raw LiDAR point data)
- Automated system, where in a first step - on a higher level – forest stand types will be delineated and separate modules for each stand type will be implemented

  ➔ automatically adaptation for different stand types
- Deriving a type of 3D metrics from raw LiDAR point data using the delineated tree crowns to provide a three-dimensional forest structure on a single tree level



Announcement

BRIDGING REMOTE SENSING AND GIS
1st Conference on Object-Based Image Analysis
July 4-5, Salzburg, Austria
mailto: obia@agit.at | web: www.agit.at/obia

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References

- Lang, S., Schöpfer, E., Langanke T. (in press). Combined object-based classification and manual interpretation – Synergies for a quantitative assessment of parcels and biotopes. Geocarto International.
- Tiede, D., Burnett, C. and Heurich, M. (2004). Objekt-basierte Analyse von Laserscanner- und Multispektraldaten zur Einzelbaumdelinierung im Nationalpark Bayerischer Wald. In: S. Strobl, T. Blaschke, G. Griesebner (Hrsg.), Angewandte Geoinformatik 2004, Wichmann Verlag, Heidelberg, Germany, pp. 690–695.