Incorporation of Allometry into Single-Tree Remote Sensing with LiDAR and Multiple Aerial Images

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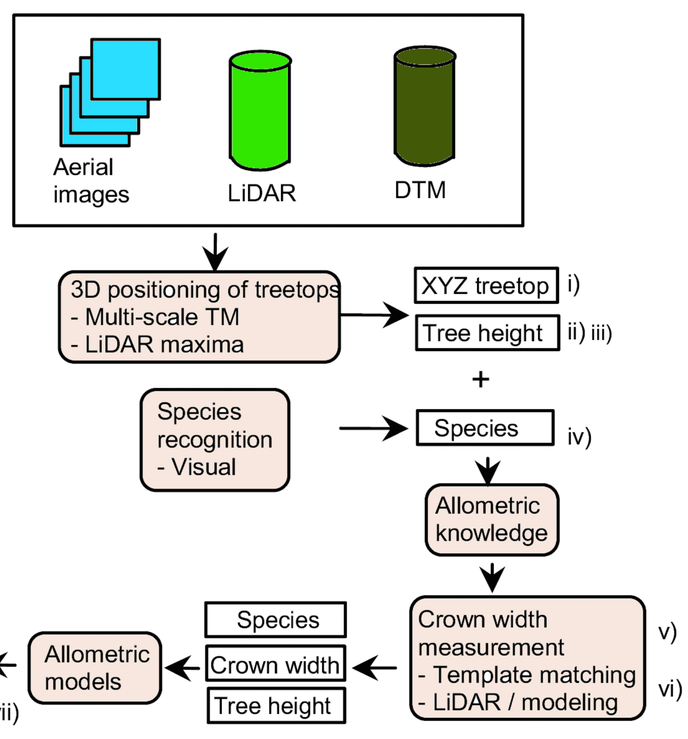
1 INTRODUCTION

SINGLE-TREE REMOTE SENSING, STRS

- STRS aims at the substitution of field measurements and mapping of individual trees with cost-efficient airborne observations.
- Input: Images, LiDAR data, knowledge, operator intervention
- Output: 2D/3D tree maps with records consisting of position, species, height and stem diameter



STRS-system developed and applied in this study.

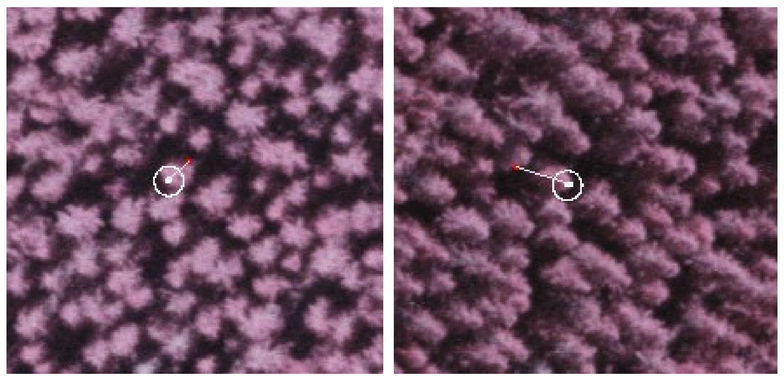
- Usage: Foresters are interested in tree merchantable stems characterized by species, length and diameter/tapering.

- Stem diameter requires indirect allometric estimation using crown dimensions, tree height and tree species as predictors

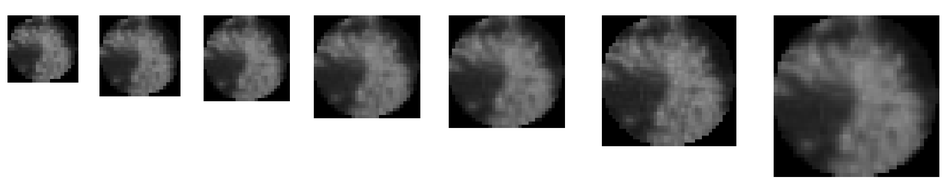
- STRS is ill-posed because of scene complexity, occlusion and shading ⇒ Semi-automatic systems with embedded knowledge about targets, maximal degree of automation and accurate measurements

2 NEW METHODS

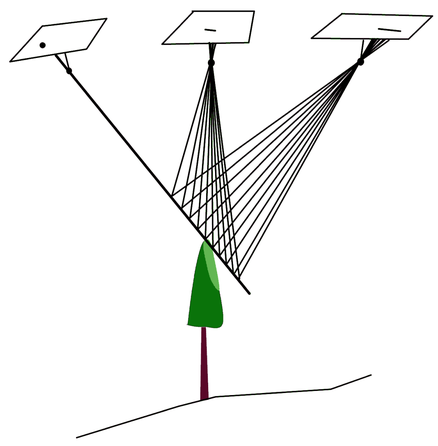
2.1 Semiautomatic photogrammetric 3D treetop positioning, height estimation and crown width estimation using multi-scale template matching

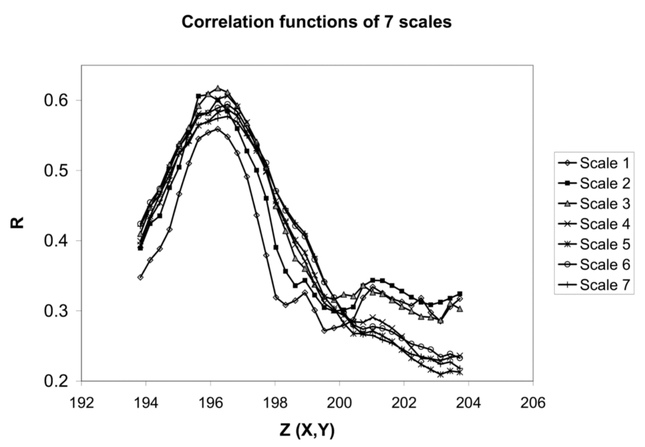


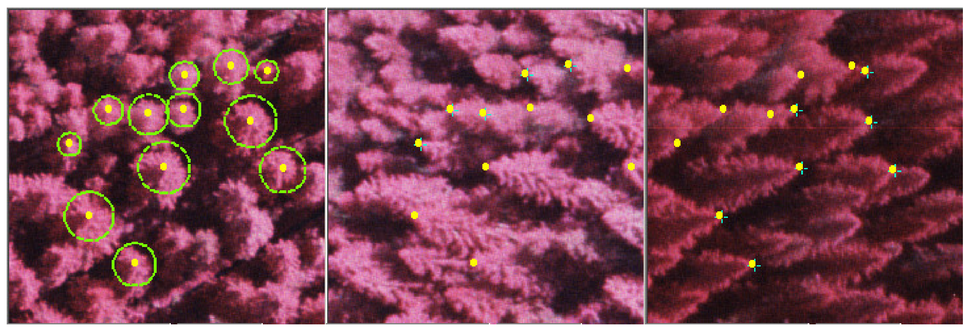
1. Manually map one tree top. A large crown. For the M images, capture elliptic templates T_M.



2. Resize and smooth all the templates, in K=1..N scales. Results in N×M templates T_{MK}

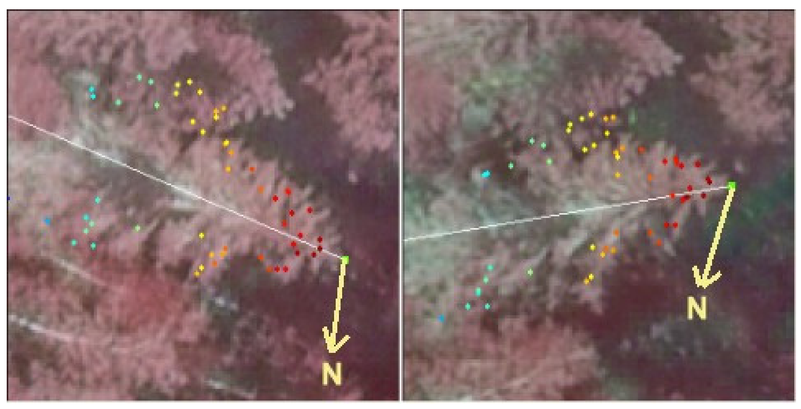






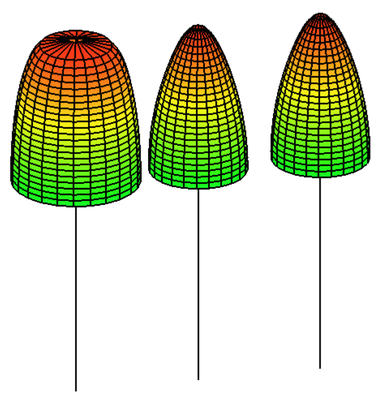
3. Using a reference image and manual treetop observations: Apply template matching to get **3D treetop positions** in all views and **a crown width estimate** in the near-nadir view

2.2 Measurement of crown width by adjustment of a parametric crown model with the LiDAR point cloud



LiDAR points superimposed in an image pair of a spruce.

Sliced.



Basic forms: Birch, Pine, Spruce

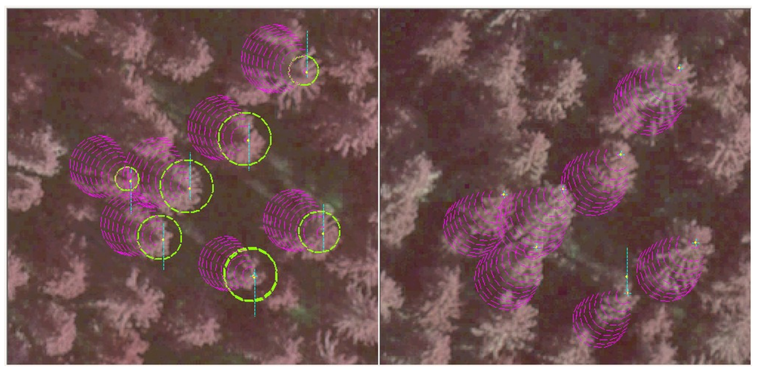
1 Treetop position from imagery (2.1) gives trunk position and tree height

2 Species resolved from images

3 Species and height give basic crown form and size

4 Consider sparse LiDAR hits as observations of crown radius

5 Iteratively fit a model to the data



Results: 3D treetop positions, crown width estimates using template matching and adjusted crown models. 1-3 seconds per tree.

3 EXPERIMENTS - RESULTS

Multi-scale TM:
Height accuracy < 0.8 m
Tree positions < 0.5 m
Crown widths: often unreliable and biased

LiDAR-based crown modeling:
Improves stem diameter estimation accuracy to 14% RMSE
Underestimation of true crown extent / diameter
Needs improvement in dense canopies: geometric filters