Comprehensive quantitative tree models from TLS data

M. Åkerblom and P. Raumonen and M. Kaasalainen
Tampere University of Technology
Department of Mathematics
P.O. Box 553, FI-33101 Tampere, Finland

S. Kaasalainen and H. Kaartinen
Finnish Geodetic Institute
Remote Sensing and Photogrammetry
P.O.Box 15, FI-02431 Masala, Finland

Introduction

We propose a modeling scheme for single trees from TLS data. For further details see [1, 2]. The produced model and the modeling process is:

Comprehensive: all tree parts visible in the scan can be reconstructed and in addition unseen parts are interpolated.

Quantitative: its parts are best-fit solutions describing the corresponding parts of the tree.

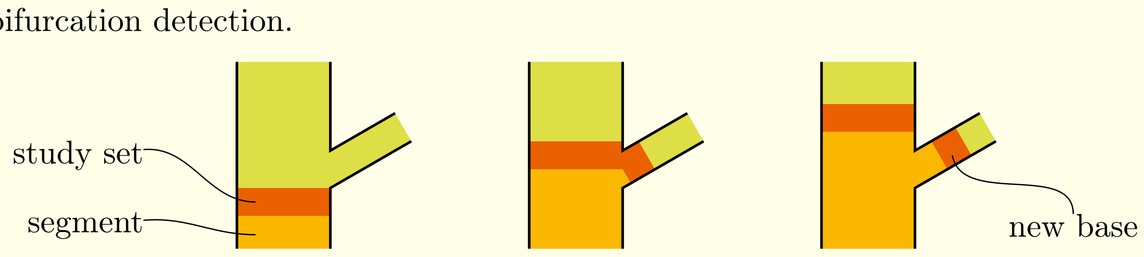
Compact: it is easily stored and manageable, and many attributes can be readily extracted from it any time after its construction.

Automatic: it is constructed without manual operation such that the pipeline processing of a large number of measured trees is possible.

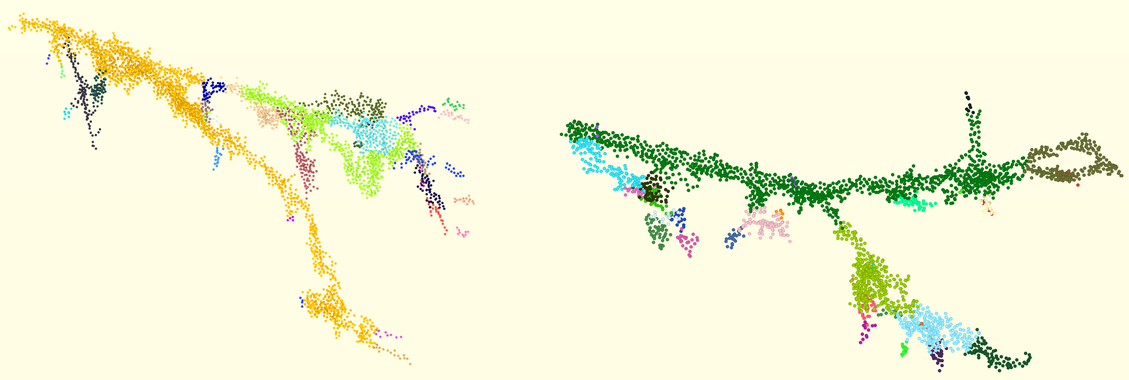
Segmentation

The measurement set is divided into overlapping *cover sets* that present the local properties of the tree surface. Particularly, the neighbour-relation of the cover sets records the local topology and allows extension along the tree. Using these properties the point cloud is divided into components and then segmented into branches.

The segmentation process uses a *study set* whose connectedness is checked to detect bifurcations. The study set is shown in red in the below demonstration of the bifurcation detection.

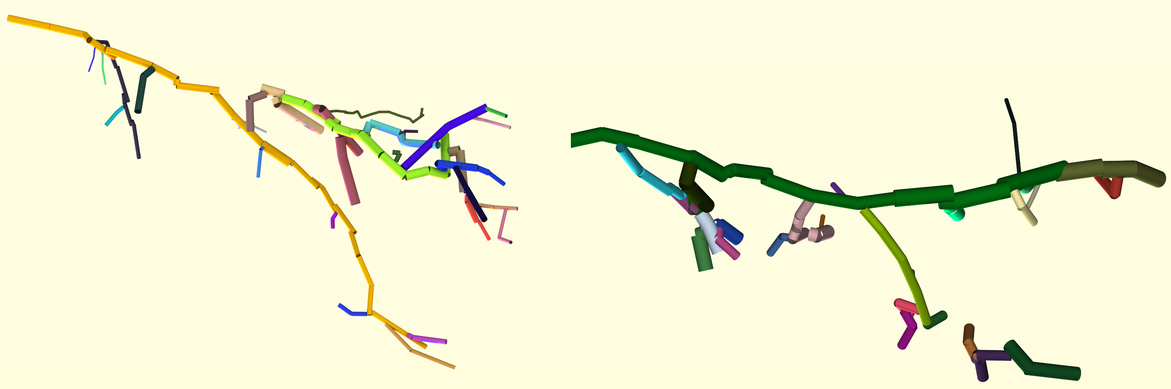


Individual branches are easily detectable and further processed one-by-one. Two segmented tree parts are shown below.



Cylinder fitting

Segments are further divided into smaller *subsegments* that are as straight as possible and have a constant thickness. A cylinder is then fitted to each subsegment to approximate the local surface and volume of the branch. The topology of the segments is transferred to the cylinders and recorded in the model. Cylinders fitted to the segmented parts shown above are visualized below.



Tree models

The produced tree model consists of thousands of cylinders, whose location, orientation and size is known. In addition the topological relations of the branches are stored in the model. When the model has been computed once several tree attributes are easily accessible through the model without the need to revisit the original data set. Such attributes are e.g.:

- total or partial volumes
- branch size distribution
- bifurcation angles and frequencies
- trunk and branch profiles
- branch topology

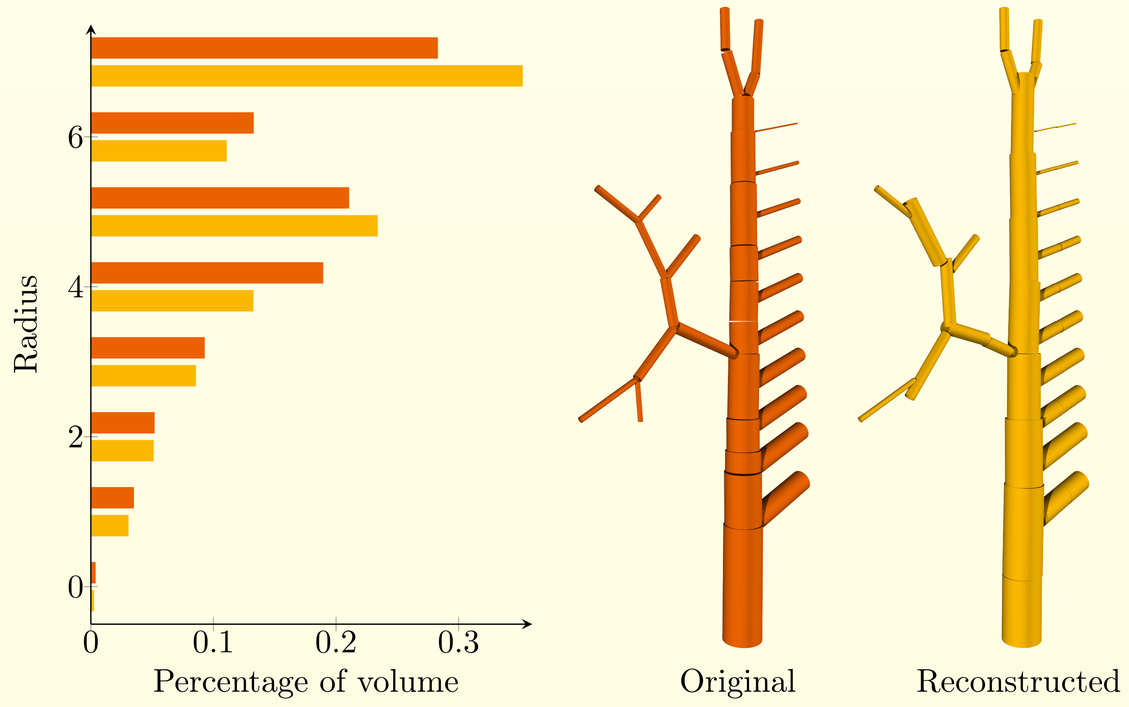
The cylinder model on the left-hand side has been reconstructed from a point cloud with about 1.8 million measurements. The model consists of approximately 8800 cylinders. The model was reconstructed in under 10 minutes on up-to-date hardware.

Validation

The development and validation of the modeling scheme is an ongoing process. Currently two different validation methods have been used:

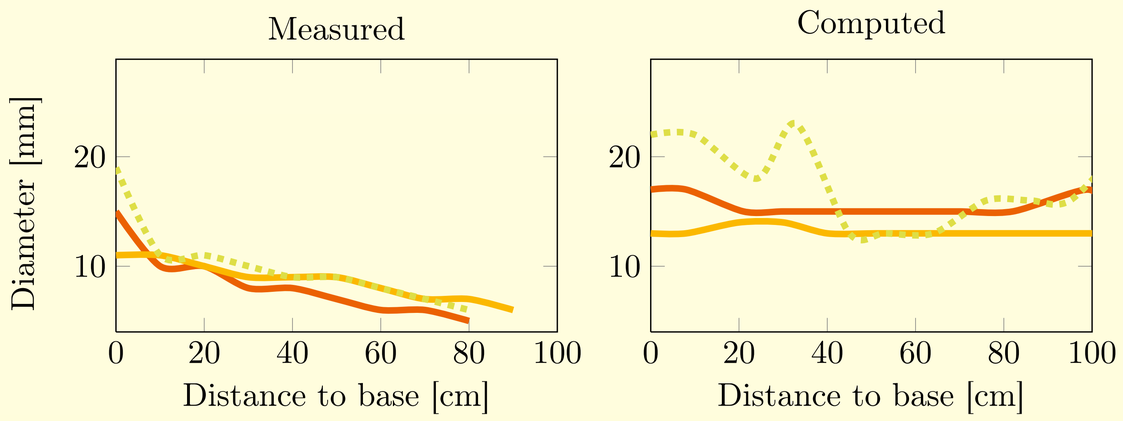
Generated cylinder models

To study the reconstruction capabilities of the method, we have used generated cylindrical tree models, and randomly sampled their surface. A simple example of a tree model and its reconstruction are compared below. Currently we are working on simulating the scanning process more accurately and using more complex tree models in the validation.



Branch profile measurements

With real TLS measurements, the diameter profile of reconstructed branches have been compared to values measured from the scanned trees. Profiles from three different branches of a spruce tree are shown below. The radius of the selected branches is close to the measurement accuracy of the laser scanner.



Further reading

[1] P. Raumonen, S. Kaasalainen, M. Kaasalainen, and H. Kaartinen, "Approximation of volume and branch size distribution of trees from laser scanner data.," *International Archives of Photogrammetry, Remote Sensing and Spatial Information Sciences*, vol. 38, no. 5/W12, 2011.

[2] M. Åkerblom, "Quantitative tree modeling from laser scanning data," M.S. thesis, Tampere University of Technology, 2012, `dspace.cc.tut.fi/dpub/handle/123456789/21012`.

TAMPERE UNIVERSITY OF TECHNOLOGY

Finnish Centre of Excellence in Inverse Problems Research