The NEWFOR single tree detection benchmark – A test of LIDAR based detection methods using a unique dataset of different forest types within the alpine space.

Lothar Eysn[1], Markus Hollaus[1]

[1]Vienna University of Technology
Department of Geodesy and Geoinformation
Research Group Photogrammetry
Gußhausstraße 27-29
A-1040 Vienna, Austria
E-Mails: {Lothar.Eysn; Markus.Hollaus}@geo.tuwien.ac.at

1. Introduction

The habitat forest fulfils many ecological and economical functions. Different habitats and species are hosted by the forest which can be related to an ecological function. From an economic point of view forest represents a sustainable key resource which is believed to be climate neutral. To collect information about forested areas to i.e. identify processes within this habitat terrestrial forest inventories (FI) can be performed. In the forestry community FI are a standard to obtain information about forest stands and trees. In most cases these FI are driven by economical aspects and act as an input for forest management tasks. From an ecological point of view FI are mainly carried out to identify natural processes. This is relevant to i.e. identify habitat quality or detect changes. In general the economical interests for these activities are little until now.

Large area tasks as for example harvesting planning or obtaining information for large forest stands are already operational in forest management. The use of remote sensing data and related methods for large area applications has become a standard. This trend can also be seen in the domains of habitat conservation and landscape ecology. In a recent project called Change Habitats 2 (ChangeHabitats2, 2012) the automatically extraction of habitat parameters and landscape metrics from remote sensing data was investigated. Terrestrial FI are still obligatory and probably will never be fully replaceable by automatically methods. Merging information obtained from remote sensing data with FI data could help to reduce the costs of a time consuming inventory. Additionally the spatially limited information of the FI could be linked to larger areas.

The identification of single trees and their parameters is an important task for analysing large forested areas with respect to habitat quality description. Parameters as for example stems per hectare, spatial distribution of trees, tree heights and stem diameters or information about tree crowns as for example a total crown length are of interest. In case of a terrestrial FI these parameters are obtained from measurements based on the single tree level. To obtain such detailed information from remotely sensed airborne data many studies on single tree detection were carried out from the research community resulting in many different algorithms / methods developed in different countries or institutions.

The research project NEWFOR (NEWFOR, 2012) brings together fourteen institutions from six countries within the alpine space working in the field of forestry and remote sensing. The project aims at enhancing the wood supply chain within the alpine space to improve forest timber evaluation and mobilization using new remote sensing technologies. One objective of the project is to test already established as well as new methods that are capable to extract single tree information based on remote sensing data. To test methods established at the project partners and partners outside the consortium a single tree detection benchmark based on airborne laser scanning (ALS) data was initiated. To the authors best knowledge this is the first benchmark ever being performed for different forests within the alpine space. Based on a unique dataset covering different study areas, forest types and structures from different regions in the alpine space the different methods were tested and analysed in a clear and reproducible way.

2. Material and methods

In total 21 study areas in five countries in the alpine space are available in the NEWFOR project (Figure 1). For each study area ALS data and a digital terrain model (DTM) were provided to the benchmark participants. Additionally reference data from FI measurements were available but not handed over to the participants. Only fully calipered FI plots were used.

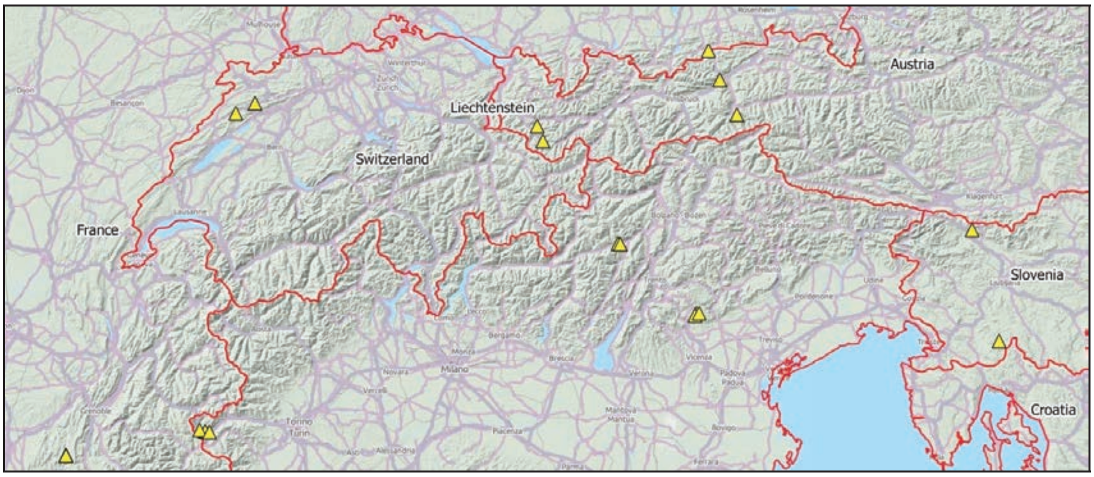

Figure 1: Study areas used for the single tree detection benchmark

Based on these data the participants had to automatically extract single tree information using their algorithm. The minimum requirements for the Benchmark were the detection of tree position and tree height as well as a description of the used algorithm / workflow. The optional requirements for the Benchmark were the extraction of the volume per stem and the extraction of the diameter at breast height.

A fully automated matching procedure between Test trees (partner results) and Reference trees (FI trees) was established for this benchmark (Figure 2).

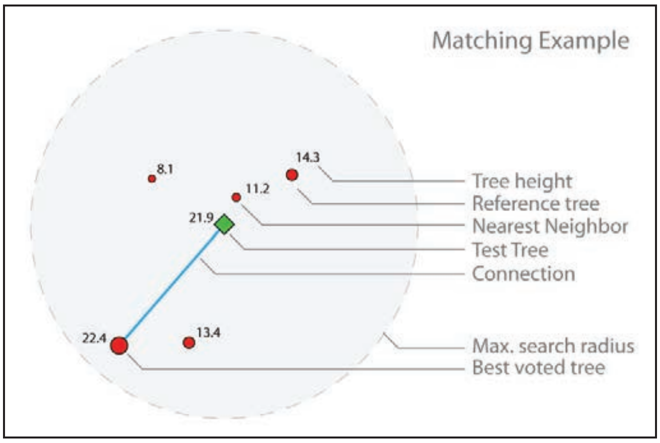

Figure 2: Example for matching trees with the best vote

Only trees inside an Area of Interest were considered for the check to overcome possible detection limitations at the borders of the input ALS data. Starting from the highest Test tree the restricted nearest neighboring Reference trees within a defined neighbourhood were detected. Restricted nearest neighboring means, that there are height criterions and neighborhood criterions which need to be fulfilled to match / assign two trees. Trees with the best neighbourhood and height vote were matched / assigned. This means that not always the nearest neighbouring trees were connected.

3. Results and Discussion

The results of seven institutions were submitted and analyzed within this benchmark. In total 18 study areas of the reference dataset could be used for the matching procedure. Three study areas could not be used because of missing or incorrect data in the forest inventory data. The detection results of each partner were automatically matched against the reference data. The procedure worked for all submitted results.

A visual inspection of the matching results shows a good agreement (Figure 3). The height and neighborhood criterions helped to connect the correct tree pairs in most cases. Especially the height criterion ensured that tall trees are not connected to nearby small trees.

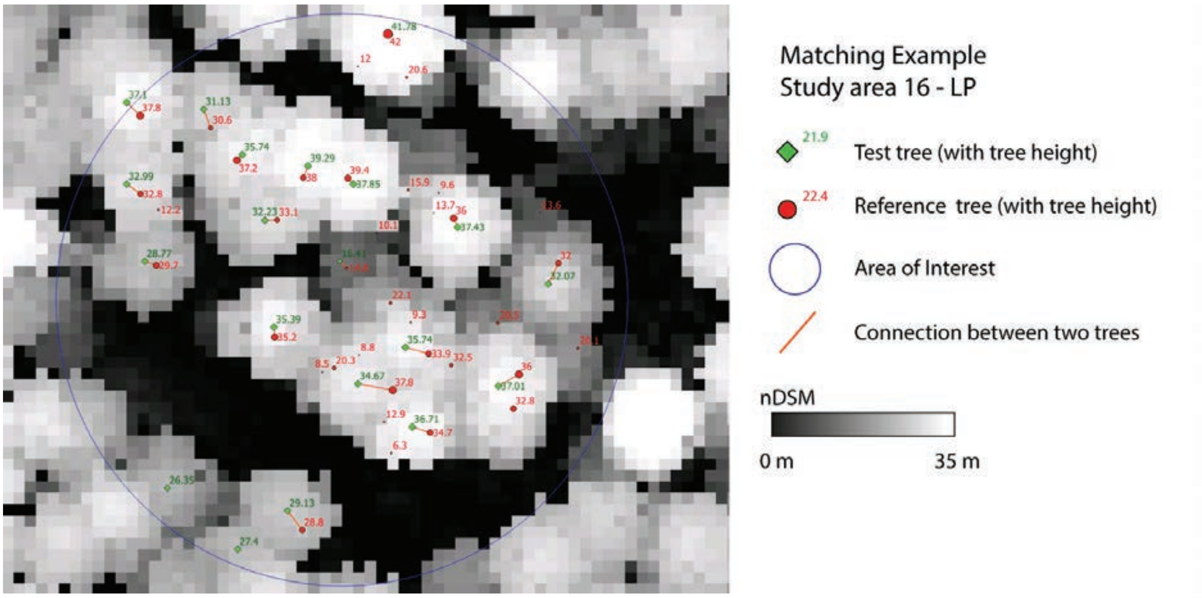

Figure 3: Matching result of participant “LP” for study area 16. The data is displayed as overlay of a normalized surface model (nDSM). The nDSM displays local heights.

A quantitative inspection of the matching results was performed to be able to investigate the results in more detail. For all results the rates of totally extracted trees as well as the rates of correctly assigned trees were derived and visualized. Also the vertical and horizontal accuracies of the matched trees were derived (Figure 4). Additionally a deeper analysis of the results was performed to link the performance of methods, forest structures and type of algorithms.

The goal of this benchmark was to show the potential of existing methods related to tree detection and extraction of different parameters. It could be shown that forest inventory data can be automatically linked to remotely sensed data. The single tree detection results from the benchmark participants are promising in terms of supporting habitat quality description by providing automatically derived forest parameters.

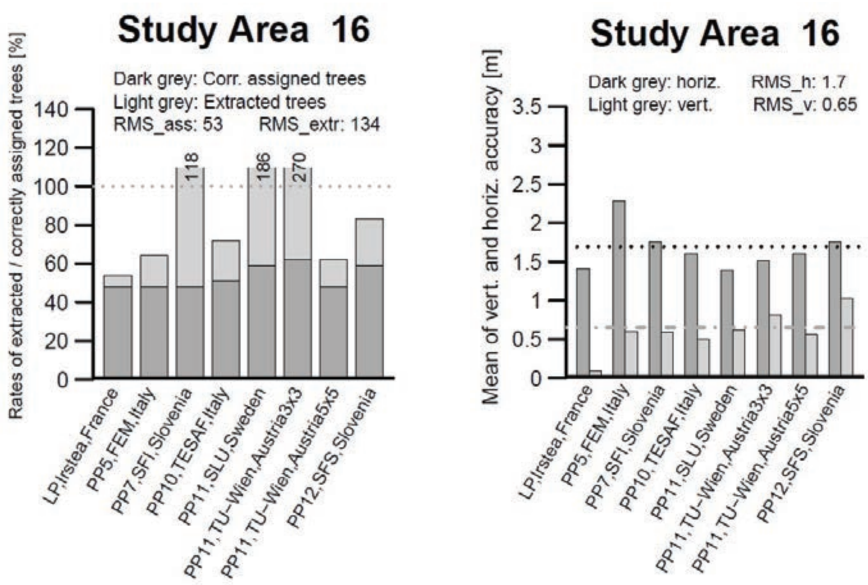

Figure 4: Matching results of all participants for study area 16. The left barplot shows the rates of totally extracted trees in light gray color and the rates of correctly matched trees in dark grey color. The right barplot shows the horizontal and vertical accuracy of the matched trees in dark grey color and light grey color respectively.

Acknowledgements

This study is financed by the project NEWFOR. This project has been co-funded by the European Regional Development Funds and was achieved under the third call of the European Territorial Cooperation Alpine Space Programme 2007-2013.

References

ChangeHabitats2, 2012. Project. 2012. "ChangeHabitats2 - For a Better Tomorrow.", http://www.changehabitats.eu/, last access: 09.04.2014

NEWFOR, P., 2012. Alpine Space Programme, European Territorial Cooperation 2007-2013 - Project NEWFOR, http://www.alpine-space.eu/projects/, last access: 09.04.2014