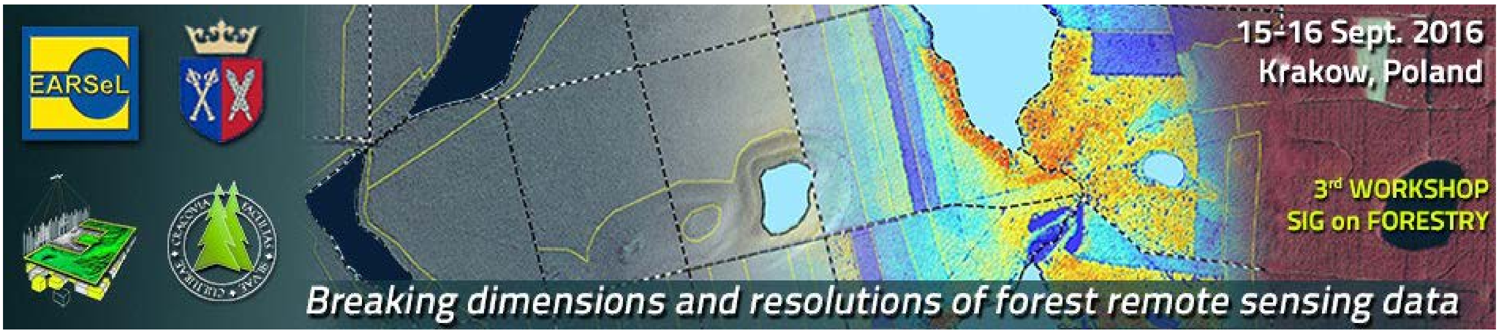

Conference Agenda

Overview and details of the sessions of this conference. Please select a date or location to show only sessions at that day or location. Please select a single session for detailed view (with abstracts and downloads if available).

Session Overview

Session

YSDF_O_2: Young Scientist Days on Forestry - Oral presentation 2

Time: **Thursday, 15/Sep/2016: 1:30pm - 3:15pm**
Session Chair: **Adrian Ochtyra**, University of Warsaw, Poland
Session Chair: **Dr. Piotr Tompalski**, University of British Columbia, Canada

Location: **Workshop room V EDU**
Workshop room V EDU, basement

Presentations

Template matching as a tool for Araucaria angustifolia (Bertol) Kuntze recognition using ALS data

João Paulo Pereira[1], Veraldo Liesenberg[2], Marcos Benedito Schimalski[2], Holger Weinacker[1], Barbara Koch[1]
[1]Chair of Remote Sensing and Landscape Information Systems, FeLis, University of Freiburg, Germany; [2]Department of Forest Engineering, Santa Catarina State University, Brazil; joao.pereira@felis.uni-freiburg.de

*Araucaria angustifoli*a, also known as Paraná's pine or araucaria, is an important and endangered southern Brazilian tree species from the *Araucariaceae* family. There is a lack of information about its ecology and sustainable management tools. In addition, the natural occurrence area of this species is around 7.700 km^2. Araucaria has high quality wood and edible seed production. However, due to prohibitive legislation that restricts forest management, most landowners avoid araucaria's regeneration. In an attempt to solve this issue, recent remote sensing technologies, such as airborne laser scanning (ALS), have been important assets to this cause. The ALS system is assembled in an airplane, helicopter or UAV (Unmanned Aircraft Vehicle) having four main components: i) LASER system (responsible to emit and receive LASER pulses); ii) inertial measurement unit (to monitor the three axes oscillations of the aircraft during flight); iii) a GNSS system (to provide the location of the aircraft during the flight); and iv) a computer system to store the collected data. This system is capable of mapping large areas with the outcome being a three-dimensional point cloud that can provide several different variables (e.g. tree count, tree measurements, species classification, forest structure, etc). Therefore, this study aims to use the advantages of the ALS to provide the *Araucaria angustifolia* trees location, both in dense forest and open field, and to assist in the elaboration of a scientific based sustainable management plan. The null hypothesis is that ALS data is capable to provide enough information to the point where *A. angustifolia* trees in dense forest areas can be counted with sufficient precision. To test this hypothesis a template matching algorithm is being implemented. Template matching is a high-level machine vision technique, which identifies parts of an image (base image) that match a predefined template (sample images). In this study, the base image consists of a 0,30m geometric resolution canopy height model (CHM) derived from ALS point cloud with average density of 7 points.m^{-2}. In total, 30 araucaria templates were selected and compared to the base image. To compare the templates with the base image, normalized fast correlation was employed in order to detect trees that could be *A. angustifolia.* Initial tests have shown that normalized fast correlation is efficient in *A. angustifolia* detection, where 78% of the trees were correctly recognized. However, there are still several omission errors, which indicates the need of further improvements, complementary analysis and the algorithm calibration. The next step is to find a better calibration for the algorithm to increase the hit rate and to reduce both omission and commission errors. If this algorithm proves to be efficient it will allow a better knowledge of the amount of araucarias in a certain area and their respective location. This information is very useful and can be used to obtain dendrometric information (total tree height, crown diameter, DBH and basal area). Such variables are very expensive and time consuming to be obtained by traditional forest inventory procedures and are key information when developing a forest management plan.

3D GIS tool for visualization and analyze of detailed forest inventory data

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The basic of forest management is to know the exact amount of forest resource. Methods for modeling the forest were started develop since the presence of foresters. During the forest modeling process, the goal is to create an accurate and comprehensible dataset with the minimum of manual field work to be efficient. Most of the traditional methods are using forest compartment based inventory which could provide only rough estimations of the real forest parameters from manual sampling methods. Since economy came into view more in forest sector the need of detailed forest inventory is necessary. Various automated terrestrial and aerial remote sensing methods have been developed to collect data over forests. The level of detail in the extracted forest parameters with these methods are ranging between individual trees and forest compartment level. These datasets are containing spatial information about the position of stems and canopy dimensions. But the raw dataset of forest parameters itself does not satisfy all of our needs. Several forest visualization systems exist with various functions for forest modeling. People recognize spatial patterns better in realistic visualizations than in raw data. Individual tree based models in a realistic environment are helping the user to get more information about the structure of the modeled forest. For this purpose, we planned and created a modeling tool to aid the forest inventory data by visualization with computer vision. During the research we used existing methods to get forest parameters from remote sensed data. These derived datasets were used for the modeling as an input as well as traditional field surveyed data. We developed a 3D GIS tool which allows the user to create visualization from the preprocessed remote sensed data with lower level of visualization detail directly. It is generating the stem and the canopy objects for individual trees with information about the objects attributes. The tool also provides 3 dimensional data analysis function for the tree models. Growing space indexes could be derived using the generated canopy and stem models within the tool. In case of artificial plantations where the stem positions are known from the planting scheme the tool itself could derivate parameters by using height surface model and field reference data automatically. Thematic output options are available to get more details about the investigated forest parameter like height or tree species. Uneven aged natural forest, artificial plantation, short rotation coppice and ice damaged natural forest types were used during the development as a training site in Hungary. These training sites were surveyed with different type of modern geomatic methods. Stem positions and canopy projections were derived from ALS, image based 3D point clouds and field surveyed data inputs. The outputs of the used tree surveying methods were integrated into the tool. During the design the goal was to create an easy to use tool to aid the forest inventory for more detailed data visualization.

Automatic branch measurement using Terrestrial Laser Scanning

Jiri Kristian Pyörälä[1], Xinlian Liang[2], Mikko Vastaranta[1], Ville Kankare[1], Markus Holopainen[1], Juha Hyyppä[2]
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Introduction. An accurate method to automatically detect branches and measure their diameters using point clouds is required to introduce practical solutions for wood quality assessment of standing trees by means of Terrestrial laser scanning (TLS). Information about wood quality is needed to enhance the value and sustainability of wood procurement processes.

Method and material. The automatic branch detection method developed for this paper included 1) detection and modelling of the stem, 2) detection of branch points, and 3) modelling of the branches. The accuracy of the method was tested with two mature Scots pine trees (*Pinus sylvestris* L.) using a data acquisition method used in practical forest field measurements. The trees were scanned with TLS on two sides at distances of 4-6m. The trees were felled and every branch's diameter was measured manually with callipers for reference. Branch diameters were also measured manually using the point clouds.

Results. The detection rates were 79% and 68% and diameter accuracies 79.5% and 54% using the manual and automatic methods, respectively. Branch diameters measured using TLS point clouds were underestimations in general.

Discussion. The detection rate expectably decreased towards the tree top. The factors impacting the detection and estimation accuracy, e.g., scanning settings, are discussed. For example, beam divergence is identified as one of the main reasons of the inaccurateness in the branch diameter measurements.

Conclusion. The results indicate that the method described in this paper can be used to estimate the main branch structure of single trees. The automatic method was fast and yielded similar accuracies compared to the manual point cloud measurements. In collection of TLS data for branch modelling purposes, dense point clouds with coverage on all sides of the trees are required – closer distance than that used in this study would probably improve the results. In further studies, it should be tested whether the method can be used for generalizing tree-level branch structure models over larger areas in area-based-approach (ABA) with airborne laser scanning (ALS), and whether it would yield sufficient accuracies in wood quality assessment applications.

The Study on Estimation of Forest stock Volume in Hong Kong

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Forest stock volume is an important property of forest resources, is an important symbol of forest biomass and carbon sequestration, and is an important part of forest resources monitoring. Based on remote sensing technology for forest resources, particularly forest volume monitor, give full play to its advantages such as macroscopic, fast, time saving ,labor saving and other advantages, has very important significance and great potential. The purpose of this study is to timely, accurately grasp the current status and trends of forest resources, dynamic monitoring of forest resources to achieve, especially to provide monitoring volume scientific means for the forest. My research select TM remote sensing images, topographic maps and forest inventory data with Hong Kong administrative region. By using remote sensing software ERDAS IMAGINE and ENVI, Geographic information system software ARCGIS, and statistics analysis tools SPSS and Matlab. With the remote sensing technology as the foundation, TM image preprocessing, remote sensing variables extraction, forest types, vegetation index and forest volume extraction. Based on geographic information system technology is secondary for vector data acquisition and processing, using GIS Spatial analysis methods to extract topographical factors such as slope, aspect. Supplemented by the GPS navigation technology, conduct field investigations on the ground. By using the theory of mathematical statistics, regression analysis method is adopted. Analysis the various factors of remote sensing which affecting the forest. Using multiple collinearity diagnosis and principal component analysis methods for model variables filtering and the least square method of stepwise for regression model. The classification error matrix precision for evaluating. The average accuracy of the forest stock volume is 84.3%, can be used as a county-level administrative units of forest resources survey of regional volume using the statistical data.

Bare-ground surface extraction from Fused UAV images and Terrestrial laser scanner

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We present the workflow to extract ground surface from low-cost Unmanned Aerial Vehicle (UAV) images and Terrestrial Laser Scanner (TLS) point clouds. UAV systems with camera sensors provide a trustfully high resolution spatial datasets. However, the image-based 3D points are not sufficient to generate point cloud under density forest areas and often contains only maximum altitude value of tree in point cloud. Due to the lack of ground surface point under density forest, detailed digital terrain model (DTM)'s generation is not possible. Hence the point cloud has to include points from ground; we propose the ground based laser scanning technology to combine from image based point clouds with this technique. Not only to combine point clouds are important, but also filtering the point cloud from the tree or non-ground object points.

In this study, we had performed UAV flight and acquired images from the multirotor platform which includes conventional Canon Power shot camera. TLS point cloud gathered from single station and 360 degree with field of interested area. Further analysis is ongoing to detect landslide monitoring from integrated and filtered point cloud data with multi-temporal data.

Digital terrain models differencing and three-dimensional point cloud comparison will be able to perform after integrated point clouds.

The developed method accurately integrates the point cloud from georeferenced UAV image-based and georeferenced TLS point clouds.

The experimental results show that TLS derived point clouds georeferenced with Ground control points (GCPs), the accuracy of global positioning of UAV imagery can be improved with alignment methods. Simultaneously, the accuracy of GCPs which acquired from GNSS surveys were used to geo-referencing of TLS have the same to point clouds accuracy under ± 2 cm.

Scale-dependent mapping of stand structural heterogeneity from airborne LiDAR data

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Heterogeneity in forest structure, naturally occurring or induced by disturbance, is continuous in space and time. In practice, heterogeneity in structure is quantified from ecological or forest inventory data; often bound to observations made on sample plots. For any given location, the plot-based quantities of structure are known to vary for different plot sizes due to differences in unobserved neighborhoods at plot boundaries. This scale dependence may confound relationships between the forest structural indices and their predictors in regressions affecting the resulting map accuracies. In this study, we first investigated for plot size effects on variability in forest structure described by forest structural indices. We thereafter explored the relationship between the indices of structure and heterogeneity and the plot sizes in forest stands with varying degrees of structural complexity. Finally, the observed plot size effects were modeled statistically and multiple regressions used to map structural complexity and heterogeneity over unobserved parts of the study area from airborne LiDAR data. Three forest structural indices were considered: the aggregation index of Clark and Evans, the Structural Complexity Index and the Enhanced Structural Complexity Index. We used inventory data from one fully mapped 28.5 ha plot in a semi-natural mature deciduous forest stand and 23 fully mapped one-hectare inventory plots spread in different temperate forest types in central Germany. To study the plot size effects, the structural indices were quantified on the basis of 18 plot sizes from 0.1 to 9.8 ha simulated on the 28.5 ha plot and 10 plot sizes from 0.1 to 1 ha simulated on the 23 one-hectare inventory plots. A fixed effects analysis was used to model plot size effects across levels of stand complexity. In addition, a structural equation model was used to explain the effect of differences in the plot sizes on multiple regressions between LiDAR derived canopy metrics and the forest structural indices. Resultant map accuracies were assessed using the Root Mean Square Error (RMSE) and the True Skills Statistic (TSS) in a leave-one-out cross validation procedures for larger plot sizes and an independent set of data collected on 500 m^2 inventory plots. Preliminary results show that all structural indices were influenced by the plot size and LiDAR data is a good predictor of forest structural complexity and heterogeneity (RMSE ≈ 20%). The highest map accuracy so far (TSS ≈ 0.71) has been obtained at the scale shown by the structural equation model to have minimal effects of spatial cofounding. These findings are relevant to optimize plot sizes for efficient inventory of components of forest structure as well as for the design of natural resource inventories. The structural complexity and heterogeneity map produced for the study area will be relevant for guiding further ecological and forest management planning.

ALS for terrain mapping in forest environments: an analysis of Lidar classification algorithms - YSDoF

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Modern remote sensing tehnology enables the recording of accurate geomorphological data with the capability to efficiently cover large areas. However, the presence of vegetation makes the use of remote methods for terrain mapping difficult or even impossible. LiDAR can be a solution for forestry projects, as the laser pulses can cross the entire forest canopy to reach the soil underneath. In order to obtain an accurate terrain model the resulting data must be processed, so as to determine which returns are at ground level. Various algorithms have been developed for this purpose, of academic or commercial interest, open-source or proprietary.

This paper aims to provide a performance analysis of multiple algorithms for raw LiDAR data classification. By classification we refer only to the labelling of points as GROUND and NON-GROUND, since the purpose of this research is estimating the accuracy of the resulting geomorphological data. Algorithm performance is reviewed for the case of mountainous terrain, characterised by moderate and steep slopes and forest vegetation of a generally high consistency. Emphasis is placed on open-source and/or free solutions.

The study area is located in the Lotru valley of the Southern Carpathian Mountains in Romania, where ALS data was recorded in 2011 with an airflown RIEGL LMS-Q560 sensor. In this area test plots with variable terrain conditions were chosen.

To estimate algorithm performance, the effect of point classification accuracy on the products that are of interest in a forestry workflow (such as Digital Elevation Model and products derived from it: slope and aspect maps, landform classification) is analysed. The following methodology is applied: a DEM is generated from the classified point cloud and compared with a model generated from data recorded by total station survey. The Root Mean Square Error (RMSE) of the elevation values is then calculated for every test area. Since numerous parameter values for the algorithm are tested, their effect on the accuracy of the resulting data is evaluated, and the combination of values that leads to the smallest RMSE is determined.

The best result for each algorithm is further analysed. The spatial distribution of errors and the effect of using different interpolation methods are assesed, and the correlation of the RMSE with factors such as terrain slope, relief fragmentation or vegetation cover. Furthermore, for scenarios where lower resolution data is sufficient, the degree to which the accuracy is improved (or not) when the DEM is interpolated at coarser resolutions is investigated. Analysis of this kind is also applied to the derived products previously mentioned. We also consider algorithm robustness, or the capability to produce results of a similar accuracy in different terrain conditions.

To conclude, an estimation of the performance of LiDAR classification algorithms is made for conditions specific to forest environments (very few or no buildings, moderate or steep slopes, fragmentary relief and a low density of ground level pulse returns due to vegetation). Finally, some recommendations regarding ALS data classification for forestry purposes are given, and further improvements for our research are considered.

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Bare-ground surface extraction from Fused UAV images and Terrestrial laser scanner

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Keywords: UAV, TLS, Bare ground, DTM, Filtering

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