



European Association of
Remote Sensing
Laboratories



Laboratoire de Planétologie
et Géodynamique de Nantes
UMR-CNRS 6112



8th EARSeL SIG Imaging Spectroscopy Workshop

Nantes, France

8 – 10 April 2013

ABSTRACTS

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Tree species mapping within unmanaged closed forest reserves in Flanders (Belgium) using hyperspectral and LiDAR imagery to support forest management

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Keywords: hyperspectral, LiDAR, crown delineation, classification, forests

In the context of sustainable forest management for multiple purposes, there is little doubt that the need for accurate resource information available at regular time intervals is still ongoing. In recent years, the efficiency with which such detailed forest information is collected steered remote sensing research towards the development of automated processes for fine-scale tree species mapping. The development of such automated routines is a typical example that is not only the area of interest to researchers but likewise to forest organisations and management agencies. In the framework of the monitoring programme of the Flemish forest reserves, since the year 2000 INBO (the Flemish Research Institute for Nature and Forest) is collecting individual tree information via costly and time-consuming field campaigns. In the absence of management, the forest reserves are characterized by growth stage diversity, high crown closure, multi-layering of the canopy and the non-existence of a pre-ordered spatial tree distribution. Given the associated high financial and human efforts INBO would greatly benefit from a more automated inventory process. As part of the larger research project HYPERFOREST we aim at developing optimized segmentation and classification algorithms using hyperspectral and LiDAR data to support sustainable forest management in these unmanaged forest reserves.

Fine-scale tree species mapping typically requires a tree crown delineation followed by classification. There are a number of different conceptual approaches to the problem of automated tree crown delineation. These approaches proved to be successful within relatively simple forests, including natural or plantation conifer forests and orchards, with small species diversity and tree crowns that are typically symmetrical and circular in shape with a single bright point near the centre. In these forests, individual tree crowns can be well delineated resulting in high classification accuracies at the tree-scale level. However, those approaches are less applicable in structurally complex and closed forests. Classification accuracies at the individual tree-scale often decrease beyond the acceptance level for forest organizations and management agencies. Therefore, we propose an optimized delineation methodology suitable for closed-canopy forests where the individual tree crowns can hardly be discriminated. Delineation is based on the synergy of LiDAR and hyperspectral data. First, the LiDAR-derived canopy height model is used to divide the forest into height strata based on a number of object-based decision rules. Afterwards, spectrally homogeneous units are segmented within these height strata based on a selection of hyperspectral bands. For the classification, several classifiers as support vector machines, random forest and artificial neural networks are compared. An in-depth analysis is also performed on the effectiveness of different LiDAR returns and channels (elevation and intensity) for increasing the accuracy of the classification obtained with hyperspectral images.

The research is carried out on two forest reserves in Flanders: Kersselaerspleyn and Wijnendale forest. Over these forests, full-waveform LiDAR data with the Riegl LMS Q560 full waveform laser scanner (point density > 10 points/m², wavelength 1560 nm) and hyperspectral imagery with the APEX sensor (spatial resolution 1.5 m, 313 bands, wavelengths 370 – 2500 nm), were acquired during the summer of 2010 and 2011. Reference data on species composition were measured by INBO in the context of the monitoring program of the Flemish Forest Reserves.