Tree Species Mapping Using Airborne Hyperspectral Remote Sensing

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1. Introduction

Remote sensing technologies offer the capability to rapidly map large areas. The tree species delineation of forests is a very essential step in forest mapping and inventories, however the remote sensing based classification produce forest map with different accuracy level. The hyperspectral data produce valuable information for tree species classification. The main objective of this research is to classify different tree species and their health status by means of airborne hyperspectral remote sensing.

2. Materials and Methods

2.1 Study Area

The study area is located in the Sopron Mountains, situated West – South-West from Sopron, Hungary (~47°40'N, 16°30'E), the altitude is between 200 and 560 m above sea level.

A more detailed investigation was carried out in the Hidegvíz-völgy Forest Reserve. This ER-46 Reserve is one out of 71 forest reserves in Hungary, situated in the North-West corner of Hungary, between Sopron and the border of Austria. This reserve is one of the smallest one in the country. The core area is 19.7 hectare and the buffer area is 37.2 hectare. The investigated forest is a mixed forest, with oak (*Quercus petraea*), hornbeam (*Carpinus betulus*), beech (*Fagus sylvatica*), spruce (*Picea abies*), larches (*Larix decidua*), and others. The health status of the spruce is the worst, because of the bark beetle disease (Horváth 2002).

The last detailed field-survey was carried out in 2013, during a geodetic practical course for forestry students, resulted the tree positions, species, diameter at breast height (DBH), social and health status, and crown sizes for more than 2000 trees.

2.2 Hyperspectral Survey

The hyperspectral survey for the administrative border of Sopron and its surrounding settlements was carried out by an Aztec Piper airplane using AISA Eagle II sensor on the 26th of August, 2011. All the surveyed data were pre-processed, atmospherically and geometrically corrected by Envirosense Ltd., the data collection was supported by our University's TÁMOP-4.2.1.B project called 'Urban Ecology'. This project made the ENVI 4.8 image processing software also available.

2.3 Theoretical Background of the Classification

The reflectance of the plants is unique, because of the wavelength-selective absorption of the compounds. For that reason some material is recognizable on the basis of the spectrum-profile (Csorba, 2011).

In case of plants, the structure of the leaves determines the spectral profile. A smaller part of the radiation is reflected by the cuticle wax, and the bigger part gets into the leaf. Between the epidermis and the columnar parenchyma, and in the spongy mesophyll the light is dispersed and as a transformed radiation, it is reflected or let through the leaf. The characteristic of the spectral profile is mainly determined by the chlorophyll molecule, because its main absorption wavelength is about from 420 nm to 435 nm in the blue range, and from 660 nm to 643 nm in the red range. (Király 2007) In the near infrared range predominate the chlorophyll effect, the fluorescence of the chlorophyll. (Bácsatyai 2001) This effect results a steep rising in the spectral profile, the “red edge”. (Figure 1)

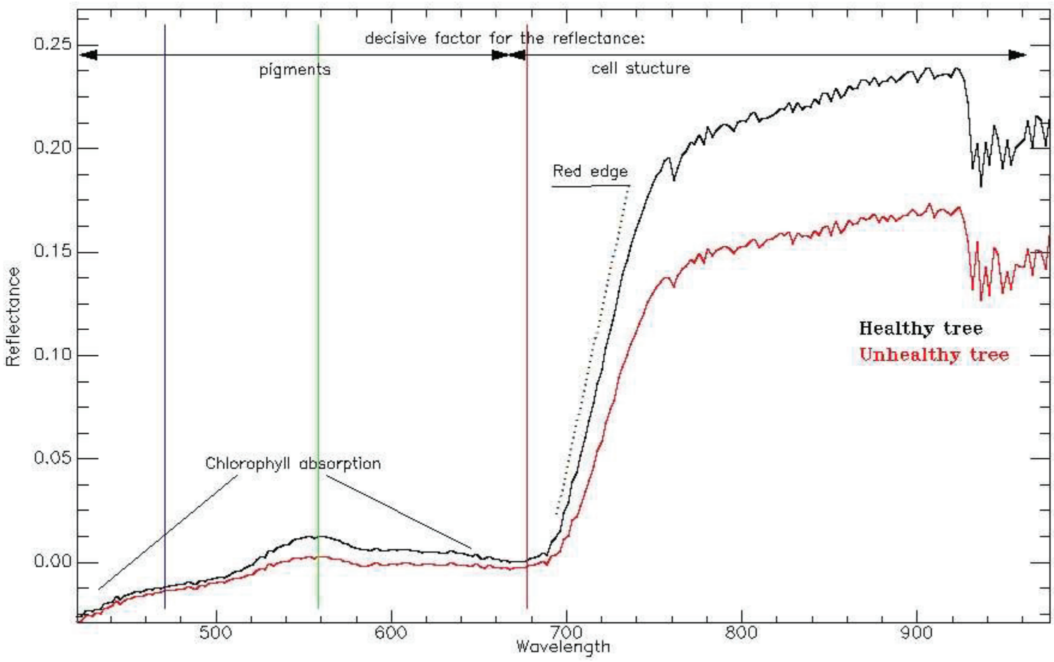

Figure 1: Spectral profile of leaves.

2.4 Classification

Supervised classifications were used to separate four tree species: European beech (*Fagus sylvatica*), sessile oak (*Quercus petraea*), European larch (*Larix decidua*) and Norway spruce (*Picea abies*). The training areas were derived from the reference field-survey in the Forest Reserve. A Minimum Noise Fraction (MNF) transformation was applied first. Several different classification methods were tested, such as Support Vector Machine (SVM), Spectral Angle Mapper (SAM) and Minimum Distance classification.

The chlorophyll effect depends on the health of the plant, so it gives opportunity to estimate the health status of the trees. In this study, we used three different vegetation indices to measure the “red edge” of the tree’s spectral profile. The well-known broadband index: the Normalized Differenced Vegetation Index (NDVI), and two narrowband indices: the Modified Red Edge Normalized Differenced Vegetation Index ($mNDVI_{705}$) and the Modified Red Edge Simple Ratio index, mSR_{705}) were used.

3. Results

The area of the Forest Reserve was analysed with two different classification methods. We tried to use the original hyperspectral images without MNF transformation. The accuracy was 80% with SAM classification, and 55.66% with Minimum Distance classification. We have tried to create Spectral Library based on this area, but it produced low accuracy, because of the noise of the data, and atmospheric effects.

The best accuracy for tree species classification was achieved by Support Vector Machine Classification (SVM) after Minimum Noise Fraction transformation (MNF). The overall accuracy of the result was 93.11%. This result seems very good, but the size of the reference area was too small, so the real accuracy can be lower.

The health status of the trees was analysed in the case of European beech (*Fagus sylvatica*), but the separability based on the applied vegetation indices between healthy and unhealthy beech trees was unsatisfactory. Some other index should be created and tested and better reference data is also necessary for this kind of investigation in the near future.

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