CLASSIFICATION OF HYPERSPECTRAL DATA OF SEMINATURAL ECOSYSTEMS

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KEY WORDS: Hyperspectral data, artificial neural nets, SNNS, Low Beskid Mountains, seminatural ecosystems

ABSTRACT:

The goal of this paper is a progress' presentation of artificial neural networks land cover classifications of the DAIS 7915 hyperspectral data (Zagajewski, Olesiuk, 2009). The research area covers a seminatural ecosystem of the Low Beskid Mountains (the northern Carpathian Mts.) in southern Poland. Applied algorithms base on the SNNS classification of the key polygon (Wiatrowki) using training sets of 60 and 40 original bands (after geometric and atmospheric correction) in different textural windows (1x1, 3x3, 5x5 and 7x7 pixels). The results were compared to the reference sets acquired from ground validation. The best accuracy (92.1%) for test set was achieved using 60 original bands with the 3x3 pixel subpattern size, and for the training set – 93,9% for this architecture.

1. INTRODUCTION

Vegetation cover is a perfect indicator of all other components of biosphere and should be well researched and mapped. This is possible, using hyperspectral data, which provides very good spectral and radiometric resolution. Plant species develop specific adaptations (e.g. pigments, cellulose, lignin, water content, plant tissue structure), which have direct impact on reflectance and it can be quantified using hyperspectral imagery. Vegetation reflectance registered by remote sensing instruments is the average of the reflectance of photosynthetic, non-photosynthetic active parts (i.e. branches, dry leaves), shadow and ground. These elements begin an integral part of plant communities; impede their recognition in case of assuming their spectral properties. To classify such heterogeneous very useful are artificial nets, because they base on whole object characteristics (spectral and neighbourhoods pattern recognition), it is so cold non-, parametric classification, where the relationship between pixels are analysed. This kind of classification can by supported by textural windows (they are sets of neighbours of a classified pixel). Typical window set consist from 1x1, 3x3, 5x5 and 7x7 pixels (matrix of neurons). These relationships between image objects are frequently happen over the seminatural and agriculturally used areas, and traditional classification that uses parametrical approaches does not show satisfying results. This method may be especially useful to separate and classify vegetation communities (Zagajewski et al. 2005, Zagajewski, Olesiuk, 2009).

2. STUDY AREA AND DATA SOURCES

The study was conducted in the Low Beskid Mountains, which constitute one of the most natural ranges in the Carpathian Mts. in Poland. The research area covers the Wiatrowki key polygon of the Bystrzanka catchment (Figure 1.), which extend form 49º34'-49º41'N to 21º01' - 21º09'E. The area constitutes a mountain zone located at the altitude range of 400-750 m a. s. l. The region is agriculturally, but extensively used; with a domination of seminatural forests, meadows, cereal and potato crops.

DAIS 7915 hyperspectral data used in this study was acquired on 29 July 2002 with cooperation with the German Space Agency (DLR) (HySens PL02_05 project). This instrument is a 79-channel imaging spectrometer operates in the wavelength range 0,4-12,5µm with 15 bit radiometric resolution. After the preprocessing the resulting pixel size was 3 meters. During the overflight 3 lines of DAIS images were acquired.

3. METHODS

The classification procedures started from a preparation of reference layers of dominant land cover units (grasslands, wastelands, coniferous, deciduous and mixed forest, tree clumps, orchards, beet crops, potato crops, oat crops, stubbles, arable areas, asphalt roads, side roads, built-up areas, buildings). This stage based on terrain and Spectral Angle Mapping (SAM) (Figure 2.). SAM classification was used to verification land cover map performed in 2002 during the terrain mapping. Endmembers were gained from DAIS imagery (corresponding to the key polygons from the ground measurements). All the polygons represents each class on training area were used to teach nets.

Parallel to this procedure, extraction from all 79 bands covering the VIS-TIR regions of the spectrum was made. First step was visual histogram analysis (inspections bands with severe striping problems) and reselection of 60 spectral bands. Second step was reduction to 40 bands (Figure 2.).

For classification land cover types were applied a multilayer, one-directional network, trained using a supervised back-propagation method. In experiments were used four variable pattern sizes: 1x1, 3x3, 5x5 and 7x7 (Figure. 3.). In per-pixel process number of input nodes was depend of number of bands, but in 3x3 subpattern size window it must be augment by 9 neurons (5x5 – 25, and 7x7 – 49). To defining the number of hidden nodes were used the formula 3Ni+1. Every each class was classified separately, so output nodes was 1, and the value of training land cover polygons takes 1, and rest 0. The teaching parameters were obtained from Kavzoglu

and Mather (2003) papers: the initial weight range [-0.25, 0.25], learning rate 0.2, number of training samples 2500. Trained neural nets were testing on area showing on figure 4 as Test.
Accuracy was measured using ENVI software's algorithms basing on test and training sets (prepared from ground mapping).

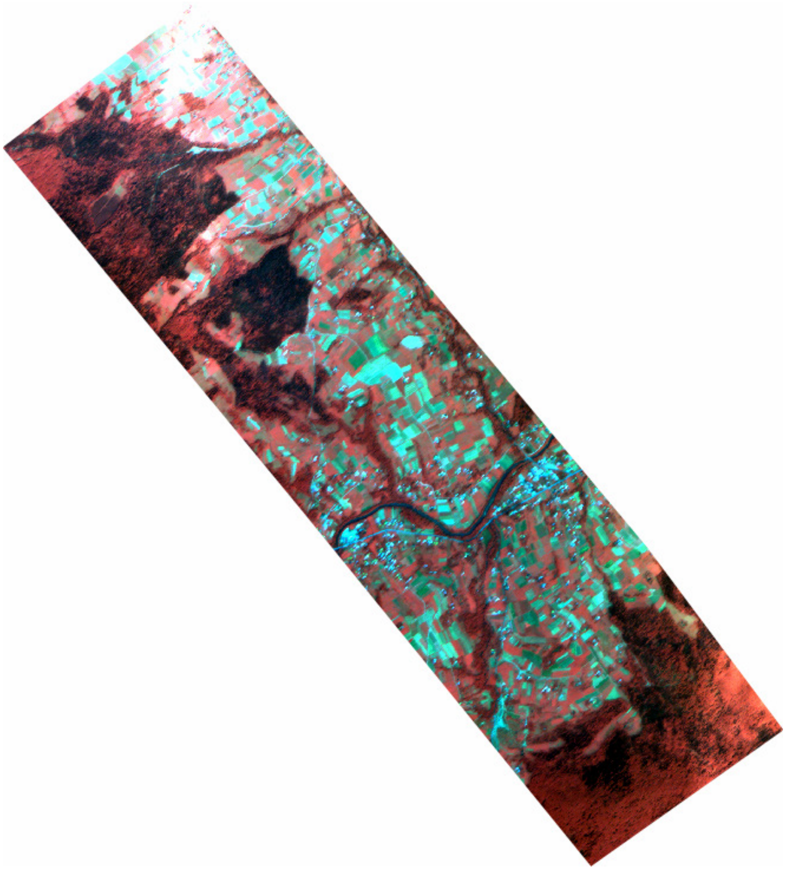

Figure 1. DAIS 7915 RGB 19, 11, 1 composition covering the Wiatrowki key polygon of the Bystrzanka catchment

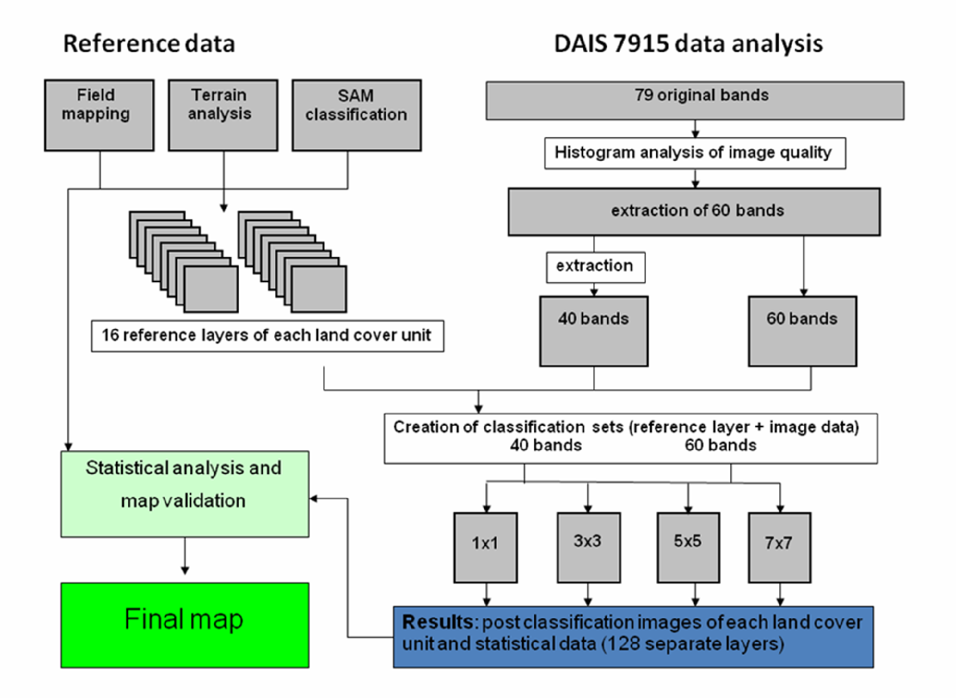

Figure 2. Workflow of the classification

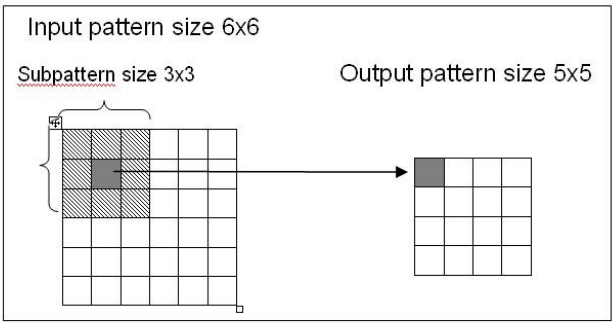

Figure 3. Variable size pattern (source: SNNS user manual; modified).

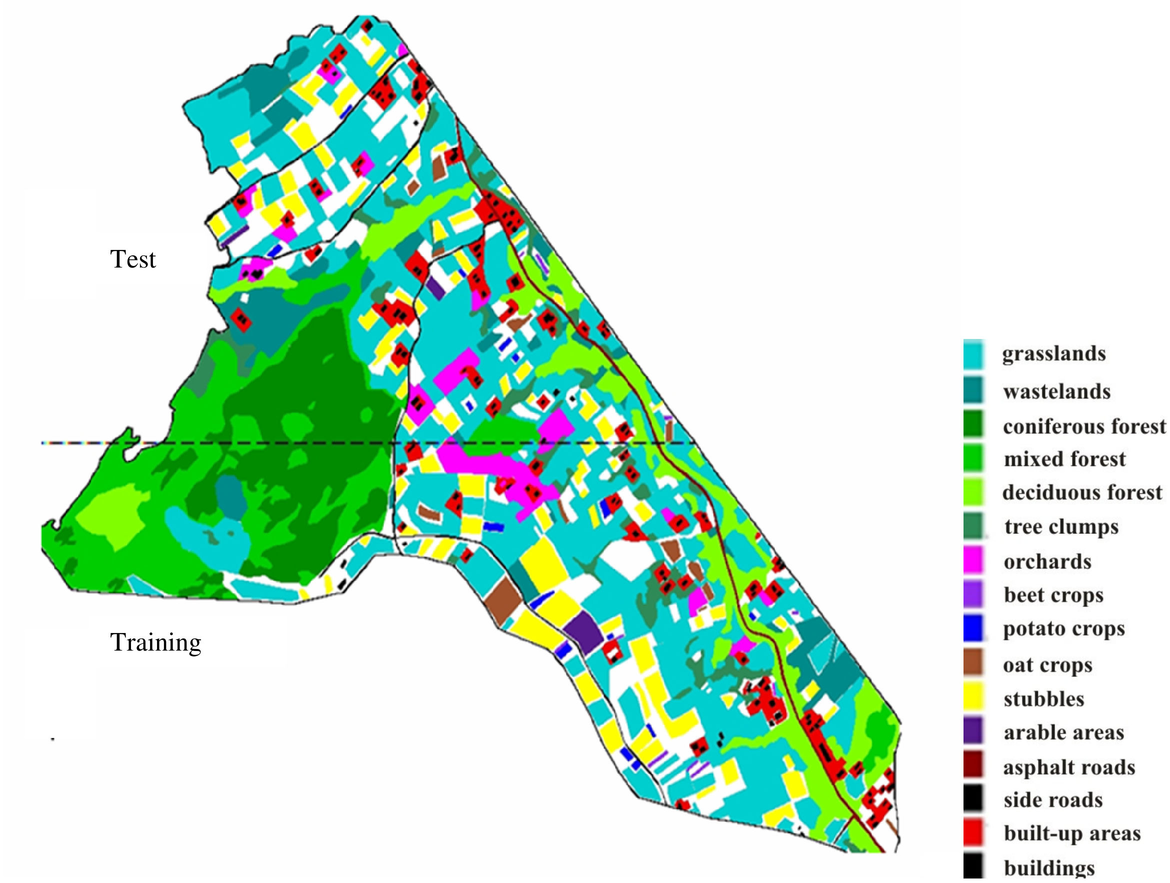

Figure 4. Teaching (Training) and validation (test) set of the Wiatrowki key polygon

4. RESULTS

All single land cover layers were merged to a map basing on higher probability of overlaying polygons (Figures 5 and 6). Overall accuracy was measured pixel by pixel basing on test and training reference layer (Figure 4.). The final results of Wiatrowki key polygon is showed in Table 1. Generally the sixty-band set of input data offered higher accuracy (more than 2%), and the 3x3 and 5x5 window size (including textural information) process gives better results than per-pixel (1x1) and 7x7 windows. The textural window is better for heterogeneous land cover units. Increasing number of classified bands doesn't offer significantly better total accuracy, but eliminate the worst results. In case of 13 MNF bands sets the worst classification results achieved the range of 79-84%, and in this research 86-89% (Zagajewski, Olesiuk, 2009).

The percentage of classified pixels is relatively high 88.4%, because not all land cover patterns were created (e.g. small parcels, gardens or ecotones between forests, tree clumps and pastures or very heterogeneous polygons).

The best results are observed for: oat crops (99.7 %). stubbles (96.7 %). grasslands (93.9 %), coniferous (92.8%) and deciduous forest (91.9 %). and the worst for tree clumps (58.4 %). orchards (65.3 %) and side roads (73.2 %). Textural window (3x3 and 5x5) increases classification accuracy.

	40 bands				60 bands			
	1x1 [%]	3x3 [%]	5x5 [%]	7x7 [%]	1x1 [%]	3x3 [%]	5x5 [%]	7x7 [%]
Training	89,4	91,8	92,4	88,4	91,1	93,9	93,2	89,2
Test	86,9	89,1	89,3	86,5	89,7	92,1	92,0	88,6

Table 1. Overall accuracy of the Wiatrowki key polygon

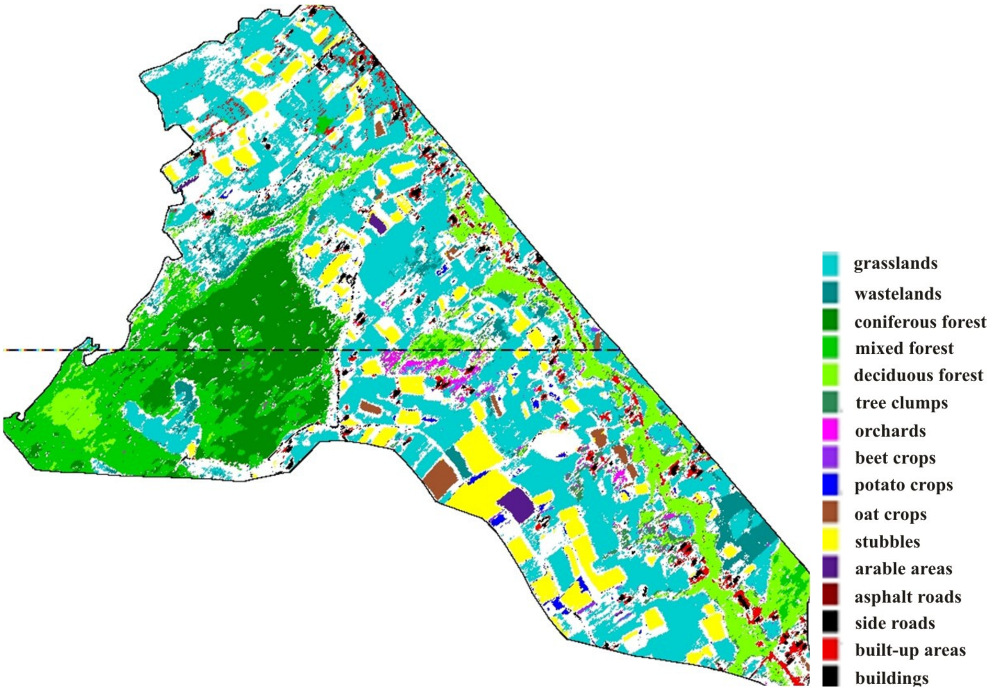

Figure 5. Classification results of the 40 bands (1x1 textural window) of the Wiatrowki key polygon

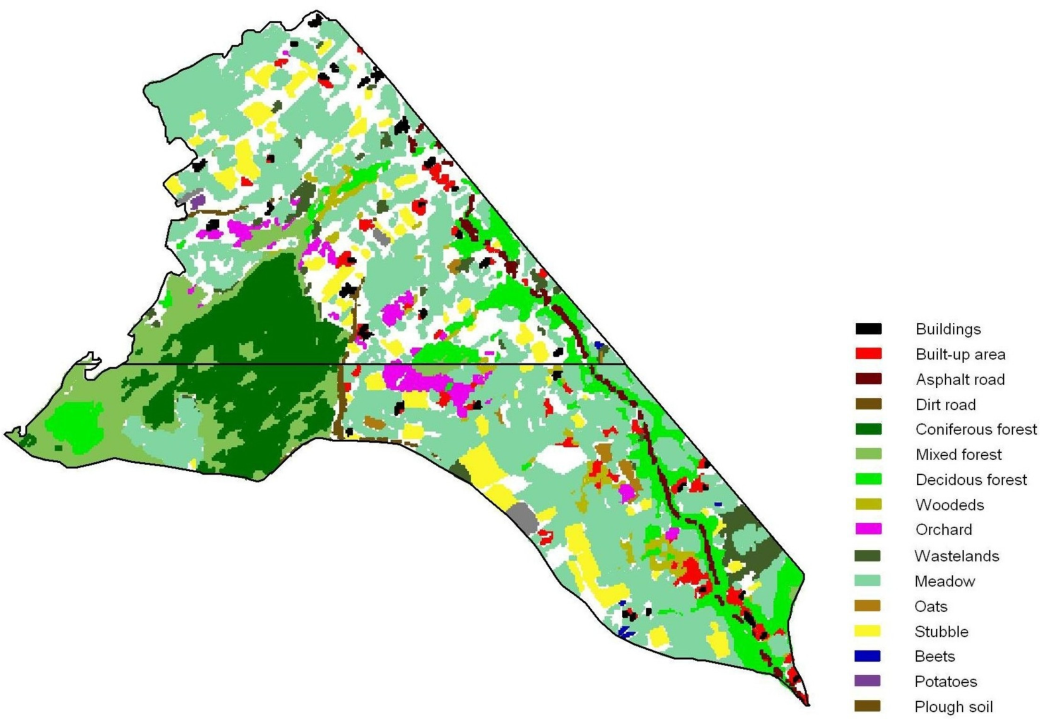

Figure 6. Classification results of the 60 bands (5x5 textural window) of the Wiatrowki key polygon

5. CONCLUSIONS

Artificial neural network is a proper method for land cover classification, and hyperspectral data showed significant potential for discriminating land cover types. Long training time is the most uncomfortable aspect of this kind of classification, but the trained nets could be applied for other areas, and it is very easy to apply.

Textural windows are useful for heterogeneous land cover units and eliminate single pixels in postclassification maps.

ACKNOWLEDGEMENTS

Interdisciplinary Centre for Mathematical and Computational Modelling – Warsaw Uniwerity (ICM UW). for open access to high power computers (Research Project No. G33-4).

This paper was prepared in the frame of the Hyper-i-net project activity (EU Marie Curie RTN-CT-2006-035927)

Special thanks for Andreas Mueller and his DLR team and Uta Heiden (GFZ Potsdam/DLR) for data and significant support.

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