Combined multi- and hyperspectral analysis of spatial and temporal changes of the urban environment

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Abstract. With the appearance of very high spatial and spectral resolution data, and new methods, remote sensing analyses of urban changes have moved into a new direction. Our poster summarizes the first experiences with the new AISA Dual sensor and shows one of the first applications of hyperspectral analysis in urban environments in Hungary. The temporal changes of the natural and buildup areas in the city were analyzed using different spectral indices. The quantitative analysis of the 35 years of data indicates some important tendencies. Our analyses show that multi- and hyperspectral methods - combined with high spatial resolution – are suitable to identify different urban surfaces.

Keywords: hyperspectral, NDVI, AISA Dual, urban ecology

INTRODUCTION

Different datasets were used to define the urban land use changes in Szeged in the frame of urban ecological research (Mucsi, 2007). The city was rebuilt after the large flooding of the Tisza River in 1879 which destroyed 95 % of the buildings. The land use has dramatically changed during the last 120 years. Beside the extensive developments, in the inner parts of the city also functional changes occurred. The investigation of these last mentioned changes can be carried out only using high resolution satellite and hyperspectral aerial images.

METHODS AND RESULTS - HYPERSPECTRAL ANALYSES

A) AISA Dual

The AISA Dual flight campaign was executed by the University of Debrecen using their AISA instrument. AISA Dual combines an AISA EAGLE instrument for VNIR (400-965 nm) imaging and an AISA HAWK instrument for SWIR (965-2450 nm) imaging (See Table 1). For the NDVI analyses and the hyperspectral classifications one image covering the city center was used (see Figure 1)

FLIGHT CAMPAIGN	June 8, 2007 Szeged, Hungary
Number of Bands	359
Spectral resolution	4.0-4.5 nm, 6.29 nm
Flight height	1400 m
Spatial resolution	1.5 m

Table 1: Setup of the flight campaign

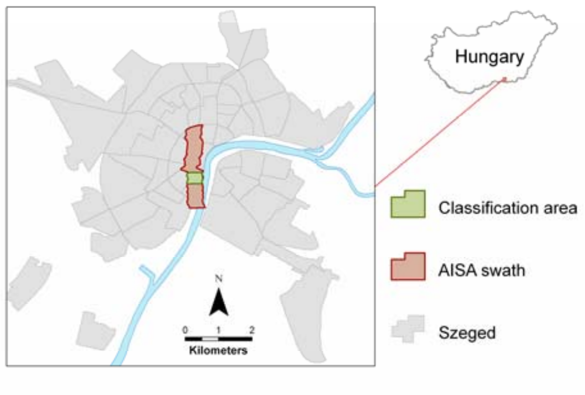

Figure 1: Szeged, Hungary, the swath of the hyperspectral image, the area of the NDVI images and the landcover survey area

B) Fieldwork data

In July 2007, a landcover survey was executed in the city of Szeged. Based on a simplified version of the classification developed by Herold (Herold, 2004) 5 km^2 was examined. For this research, an area in the city centre was selected with a variety of landcover, ranging from green (parks) to densely build up areas.

C) NDVI processing

In literature, numerous examples can be found of the use of single AISA red and NIR bands for the calculation of NDVI images. In this research 7 red – near infrared combination have been used of which 4 were described in literature. To simulate the earlier Landsat, SPOT and IKONOS broadband (BB) NDVI calculations, the narrow red and near infra red AISA bands were averaged in 3 different combinations (see Table 2). The highlighted combinations were used for comparison with the earlier NDVI data. Figure 2 shows the values from the 8 years of temporal NDVI data.

	Red [nm]	**NIR [nm]**	**AISA Red [#]**	**AISA NIR [#]**
Landsat TM (BB_Landsat)	630 – 690	760 – 900	52 – 65	80 – 110
SPOT (BB_Spot)	610 – 680	790 – 890	48 – 63	86 – 107
IKONOS (BB_Ikonos)	630 – 690	690 – 900	52 – 65	65 – 110
Runquist, 2002 (B_{672}-B_{776})	673	777	61	82
Matsusita, 2007 (B_{682}-B_{861})	681.32	862.73	63	101
Hunt Jr, 2001 (B_{682}-B_{804})	681	806	63	89
Campbell, 2005 (B_{672}-B_{780})	671	782	61	84

Table 2: Overview of the Red–NIR combinations

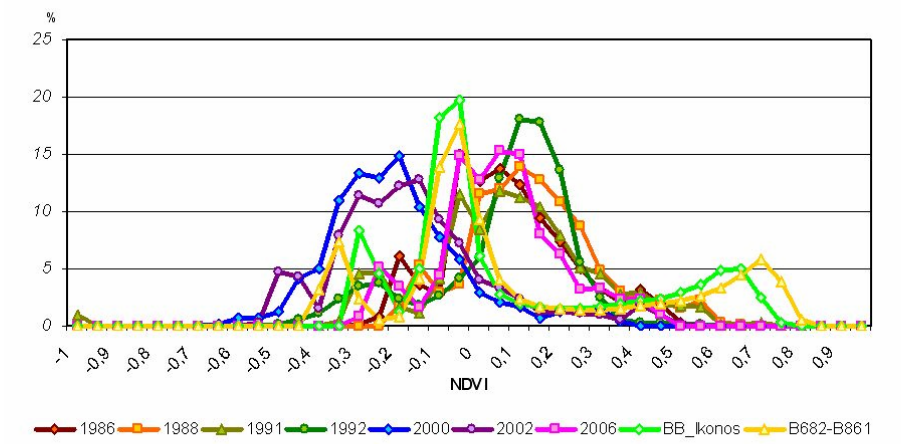

Figure 2: NDVI values from 8 years of temporal data

D) Classification

To evaluate the usefulness of AISA images for standard landcover classification in the urban environment, supervised and unsupervised classifications have been calculated on unprocessed and processed (Minimum Noise Fraction transformed, MNF) AISA data:

- Unsupervised classification on the original data
- Minimum distance classification on the original data using 11 landcover classes (see Table 3)
- Unsupervised classification on the forward MNF data
- Minimum distance classification on the forward MNF data
- Unsupervised classification on the reverse MNF data
- Minimum distance classification on the reverse MNF data

#	**Class names**	#	**Class names**
1	Dark red tile roof	7	Asphalt / Concrete
2	Red tile roof	8	Forest
3	Brown tile roof	9	Grass
4	Green roof	10	Water
5	Light gray asphalt roof	11	Other
6	Metal roof		

Table 3: Overview of the landcover classes

Table 4 describes classifications with the highest overall accuracy.

Classification	Overall Accuracy
Original Supervised	61.29%
Forward MNF Unsupervised	56.17%
Forward MNF Supervised	58.33%
Reverse MNF Supervised	60.68%

Table 4: Overall classification accuracy

CONCLUSIONS

Three supervised and three unsupervised classifications were calculated. From the unsupervised classifications only the forward MNF results were usable. The supervised classification on the original data (see Figure 3) resulted in the highest overall accuracy. In general the MNF transformation did not improve the results and the accuracies are lower than expected.

There are several reasons for this:

- The scale of the fieldwork and the hyperspectral images were different.
- The spectral differences between the different roof types classes were often very small.
- Flat roofs of apartment buildings were misclassified as asphalt because the material has very similar spectral features.

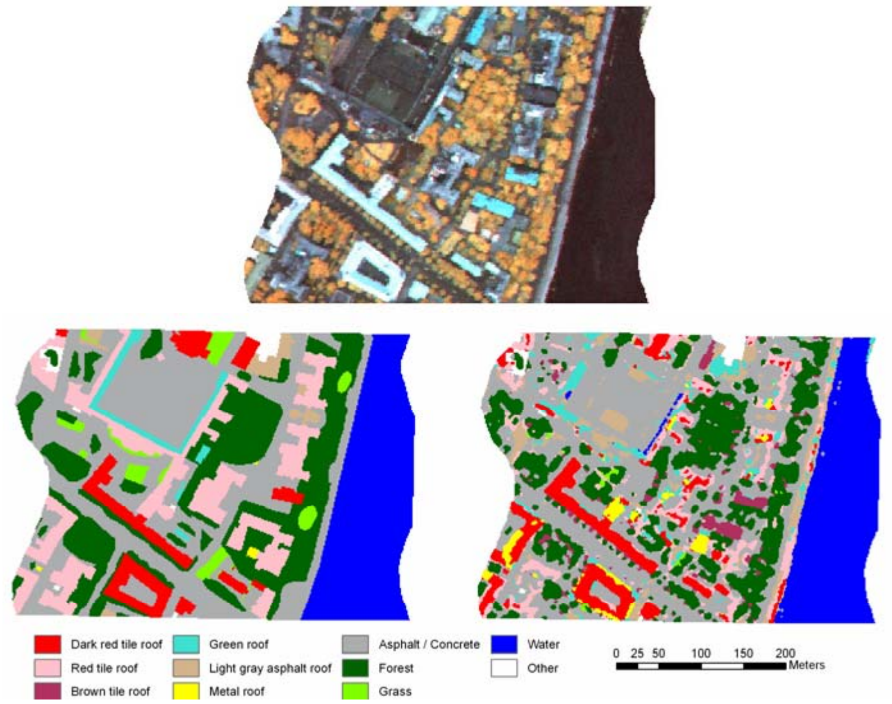

Figure 3: Original hyperspectral image (above) and the difference between the landcover survey (below left) and the supervised classification (below right) of the original dataset

The quality of the classification results is comparable to what could be expected when using multi-spectral imaging. There are several possibilities to improve the results of the hyperspectral classifications:

- Using a statistical method results in a better bad band selection.
- Using reflectance values instead of calibrated radiance at sensor values may give better results.
- Improvements of the fieldwork methods may result in lesser misclassifications.

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