Automatic mapping of the dynamics of forest succession on abandoned parcels in south Poland

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Abstract

Changing conditions in polish agriculture are leading to an increment of abandoned fields. This process can be observed indirectly by the monitoring of unmanaged forest succession. Due to EU regulations and modern EO systems it is necessary and possible to establish a rapid mapping of this phenomenon. In a case study, the initial strategy for a full automatic mapping procedure for VHR image data is presented.

1 Introduction

The Polish landscape is rapidly changing due to the socio-economical effects of the recent EU membership and it impact on agricultural incomes. An important indicator for this change is the increasing amount of abandoned fields. Imagery from satellite and airborne EO are showing the effect of forest succession on these abandoned parcels. This happens at such a large scale that it can not be regarded as incidental but moreover revealing the profound changes that are taking place in small scale farming. It is essential for landscape management to combine the interpretation of RS data with: social economical factors, EU agricultural policy as well as cadastral (GIS) information. Forest succession on abandoned agricultural fields might be the cause of one of the largest unmanaged afforestation processes in the EU.

2 Forest mapping in EU context

Poland by its late XVIII century borders had around 40% forest cover, but the post-War country from 1945, had only 20.8%. Huge deforestation has lead to a reduction in biodiversity and landscape impoverishment. Afforestation process after Word War II increased forest cover to recently 28,6% (8,942,000 ha) of Poland (PGL LP, 2003).

The basis for the afforestation in Poland is the Governmental National Programme for the Augmentation of Forest Cover dating from 1995. It anticipates an increment in forest cover up to 30% in 2020 and 33% in 2050. Publicly owned forests predominate in Poland, accounting for 82.6% of the total area. Within this, 78.4% of is under the management of the Polish State Forests National Holding. Other 16,1% of Polish forests belongs to natural persons (private 900,000 owners - 94% under small-scale ownership where the mean area of such a parcel is < 1 ha). In some south regions of Poland the private owner (farmers) holds an average parcel of only 0,2 – 0,3 ha. The rest is part of public (1,5%) and local authorities (0,9%). These statistics indicate the close connection of the agricultural and forestry domains in Poland.

2.1 IACS - LPIS

For agricultural information management, the IACS plays a crucial role (http://mars.jrc.it/marspac/PECO/; 1-2-2005, Oesterle, 2003). Cornerstone of IACS in Poland is LPIS (Land Parcel Identification System) which is now under development. LPIS should be build on the agricultural cadastre which is in a transition process from an analogue to a full digital database including a correct geometry. The polygons in the LPIS will also be attributed for areas which will be excluded from subsidential payments. This process is related to a Phare 2001 EU projects for new accessing countries involving VHR satellite imagery (IKONOS) as well as 1:13.000 and 1:26.000 aerial photos. For the revision on the existing cadastre, two standards of the orthophotomaps is applied, depending on image data (qualities and resolutions):

Standard I - based on the 1:26.000 scale B&W aerial photos covering 156.000 km2 (about 50% of Poland including) ground resolution 0,5-1,0 meter (RMSE = 1,5 - 2,5 m). Foreseen for areas with cadastre based on the map 1:5.000.

Standard II - based on 1:13.000 scale B&W aerial photos covering 85.000 km2, ground resolution 0.24 meter (RMSE = 0,75 m). Foreseen for areas with cadastre 1:2.880 or 1:2.000. Within the limits of Standard I an additional 25% coverage of Poland will be covered using IKONOS (50.000 km2 along frontiers) and old Phare 1997 RGB-Orthophoto (based on aerial photos 1:26.000). Important attributes from land use data are parcels divided in two categories: “active functional” and “non functional”. The latter includes those with “changes made by (forest) succession”. Here a decision must be taken to assign a parcel to be eligible or non eligible to subsidiary financing. Nevertheless, the EU funding will be available for afforestation from other sources. In Malopolska and Podkarpackie provinces, even historical information from the KK cadastre (1:2.880) is applied to support the process of LPIS construction. The constuction of LPIS with a directly access to up-to-date orthophotos is inevitable. The costs of LPIS are estimated to be 3-4 times higher then the orthophoto production. The generation of othophotomaps should have been finished by the end of 2004. but are as yet still incomplete. The latest GUGIK (Main Office of Geodesy and Cartography) tender is already focusing on VHR satellite data which has started since autumn of 2004. Satellite VHR date is expected to increase it’s dominance in information acquisition on the national level in accordance with EU trends.

3 Image Analysis tasks

3.1 Increasing automatic analysis

The visual interpretation of large amounts of data is at risk to be outdated by the time the analysis becomes available. This study tests automatic procedures for mapping of forest succession on agricultural parcels from VHR satellite data as well as from B&W orthophotomaps. The automatic procedures should enable a fast and low-cost RS data interpretation. Due to the large amounts of mosaic parts in VHR data, sampling of classes in each mosaic-tile will be too complex. Therefore classification methods without sampling are required to deal with large area mosaics. The case study introduces initial experiments on techniques which do not require sampling before image classification. Additionally, the RS data fusion with LPIS information will be an integral part of the analysis.

3.2 Preprocessing and image amplification

Texture analysis of imaging data can be separated in statistical textures analysis (Haralick features) as well as structural texture analysis (Musick, 1991). A hybrid textural analysis has been under development which involves a pre-processed edge detection to create the structural part of the texture analysis. The assignment of a weight function in a segmentation process is popular where a panchromatic band (PAN) has a higher ground resolution than other multispectral bands (MS). In this case an increased weight factor for the PAN allows a more detailed object reconstruction. The weight factor influences the complete band information. For a more detailed manipulation of the objects of interest and not the whole image domain, only specific details inside a single image can be given an 'increased weight' factor by using additional artificial image layer (s). The objects of interest will be backed-up by underlying 'pixel-artifacts'. Because the artificial layer contains near-zero values for the rest of the image, only preferential image objects will receive this influence. Contrasting edges are here expected to contain the prevailing information.

3.3 Image derivatives

Artificial bands are results of image pre-processing techniques such as edge detection filtering, spectral unmixing and textural derivatives. Based upon user preferences, the artificial bands can be used to amplify information on a selected type of objects of interest. The first function of the artifacts is the forcing of the preferential shape of segmented objects. In a second phase, a customized feature is created for which only extreme dark and bright values play a role in the classification. The artifacts must be reproducible. The absolute grey values of the image artifacts have little meaning. Their relative value and moreover their extreme brightness or darkness allows for the class selection. The central strategy of pre-processing leads to the canny positioning of the objects of interest in the extreme parts of the histogram of an artificial band. Sampling of the class inside the image becomes less relevant if objects of interest appear in general in the same extreme position in an (artificial) image histogram. The population of image objects located in the histogram-extreme represents the desired class.

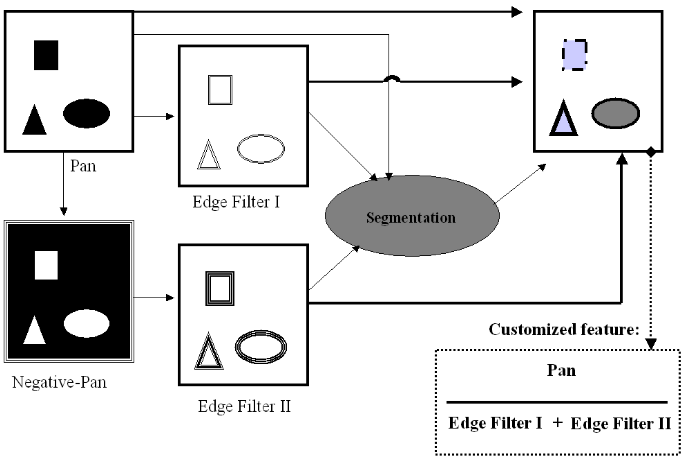

Fig. 1: Workflow; *The edge-detection images force a split of an object into core and frame. After segmentation the 3 images are combined in a map calculation for each segment. The customized feature visualization can also function as extra input layer for further classification.*

Isolated edges can be regarded as structural texture elements. They can incorporate a line of mixed pixels with high variance at the border between two adjacent image objects thus sharing the spectral characteristics of two different distributions. This situation is the most 'normal' one in satellite imagery and has been used frequently in Laplace analysis. Very typical for this type of edge detection is the fact that at least 3 pixels around the edge are influenced by the calculation. The resulting 'blurred' boundaries are here less useful.
Another type of edge detection is the isolation of edge pixels belonging to a homogeneous image object and are not considered as mixed pixels. They belong to the spectral distribution of the image object itself. A good example of this is the dark inside-edge pixels of shadow objects. This type of edge detection is only a single pixel width and more useful for sharp line reconstruction. Starting with the original panchromatic image (Input 1) the result of the Lee-Sigma filter (Input 2) is subtracted and an edge image (Output = difference image) will be produced. The Lee-Sigma filter (ERDAS, Help-menu) only replaces original pixel values with the moving-window (3*3) **mean**, if **2-sigma** values are exceeded; else there is no-change. In case of sharp boundaries, this condition exists and can therefore be extracted from the difference image. In case of 'no-change' for all pixels within **2-sigma** values, the difference image will return near-zero values for the largest part of a VHR satellite image under European environmental conditions.

The edges alone might be useful. The next step is to integrate edge-information in automatic vegetation detection. A customized feature (Fig.1) can be constructed involving the 'Lee-Sigma' edge-images to be applied to automatic detection of scattered shrub and trees on homogeneous agricultural parcels. The ratio of the original object and its self-derived edges (Fig 3B,C) incorporates information about size, homogeneity as well as intensity. The effect of such analysis can be applied to objects characterized by low homogeneity among neighborhoods with high homogeneity (Wezyk et all 2004). This is the typical condition of stages of forest succession on abandoned agricultural fields. Moreover the different response of this analysis in NIR versus Red band improves the performance.

4 The case study

According to the pre-processing workflow (Fig. 1), a customized feature is constructed for the PAN band of a QuickBird scene (20-09-2003, Fig. 2). This is done for the Red as well as the NIR band. This leads to an eCognition project containing 9 image layers e.g. three original bands: PAN, Red and NIR as well 3 pairs of 'Lee-Sigma' combinations (positive/negative, Fig. 1). The customized feature for the Red band has a typical result for complex artificial objects. Buildings and other constructions contain a lot of contrasting edges. Therefore in the visualization of this customized feature, all buildings appear dark (lowest part of the histogram). Vegetation with complex shadow casting and sharp edges in the Pan and NIR do not respond similar in the Red band. This is due to a reduction in the albedo of the Red light for both crowns and shadows. All vegetation areas which do not

cast/contain shadows have higher values in all of the three visualizations of this customized feature. The lowest part of the histogram of the customized feature **[Pan / (Edge I + Edge II**)] thus contains 3 classes: Build up areas, Shadows and High vegetation. Due to extreme low values in the customized feature of the Red band and very low panchromatic intensity values, the classes: 'Build up areas' and 'Shadows' can now be easily separated. The 'High vegetation' class remains. This class contains different forest types as well as 'forest succession' on agricultural fields. If the cadastral information predicts the existence of an agricultural parcel, the extraction of forest succession is simple. More complicated are the separations between two classes: 'forest regeneration' and 'forest succession' inside the forest area as well as the separation between 'forest succession' and 'fruit/berry orchards' outside the forest. The scattered nature of the succession can be separated from dense covered and closed canopy stands. However there is a transition from sparce to dense forest vegetation.
The same procedure was tested on a set of B&W orthophotomaps with similar results. However the 8 bit scanned images lack the spectral resolution of the 11-bit Quickbird image. The separation of vegetation and buildings/infrastructure as complex edge-containing objects in homogeneous environments become therefore less effective. Here the cadastral information, especially about settlements per plot becomes a necessity for further full automatisation.

5 Concluding remarks

Decisions must be made to assign the land use of parcels in two categories: "active functional" and "non functional". The latter includes those with "changes made by (forest) succession". The VHR classification immeadiatly creates the class where 'functional' is doubtfull when scattered forest vegetation is found. Also a decision must be taken to assign a parcel to be eligible or non eligible to subsidiary financing, knowing that EU funding will be available for afforestation from other sources. Detailed mapping of forest succession related to abandoned agricultural parcels using VHR –EO data is possible. The class of 'high-vegetation' has a fingerprint signature in a special customized image layer which makes automatic classification possible. The desired objects of interest (OOI) are located within the histogram-extreme of all mosaic parts of the mapping area. The possibility to predict the location in (artificial) feature space reduces considerably the need for locating the OOI inside the image domain and therefore the sampling procedure. An initial callibration of the 'Quantile' of the histogramms can rely on existing cadastral and GIS information, o.a. CORINE landcover and LSIP. The 11-bit Quickbird data is well suited for separating textured objects like buildings and high-vegetation. For 8-bit orthophoto's, cross-confirmation with existing cadastre is a necessity.

6 Literature

PGL.LP (2003). The State National Forest Holding, Annual Report 2003, Warsaw

Musick, H.B. & Grover, H.D. (1991) Image textural measures as indices of landscape pattern. Quantitative methods in landscape ecology (ed. by M.G. Turner and R.H. Gardner), pp. 77–103. Springer-Verlag, New York.

Oesterle M., Hahn M. (2003) A Case Study for Updating Land Parcel Identification Systems (iacs) by Means of Remote Sensing, Proceedings of the XXth ISPRS Congress, 12-23 July 2004 Istanbul, Turkey

Wezyk, P., R. de Kok, G. Zajaczkowski (2004): The role of statistical and structural texture analysis in VHR image analysis for forest applications - A case study on Quickbird data in Niepolomice Forest. In: Strobl, J., Blaschke T. & Griesebner, G. (Hrsg.): Angewandte Geoinformatik 2004. Beiträge zum 16. AGIT-Symposium Salzburg 2004, H. Wichmann Verlag, Heidelberg, S. 770-775.

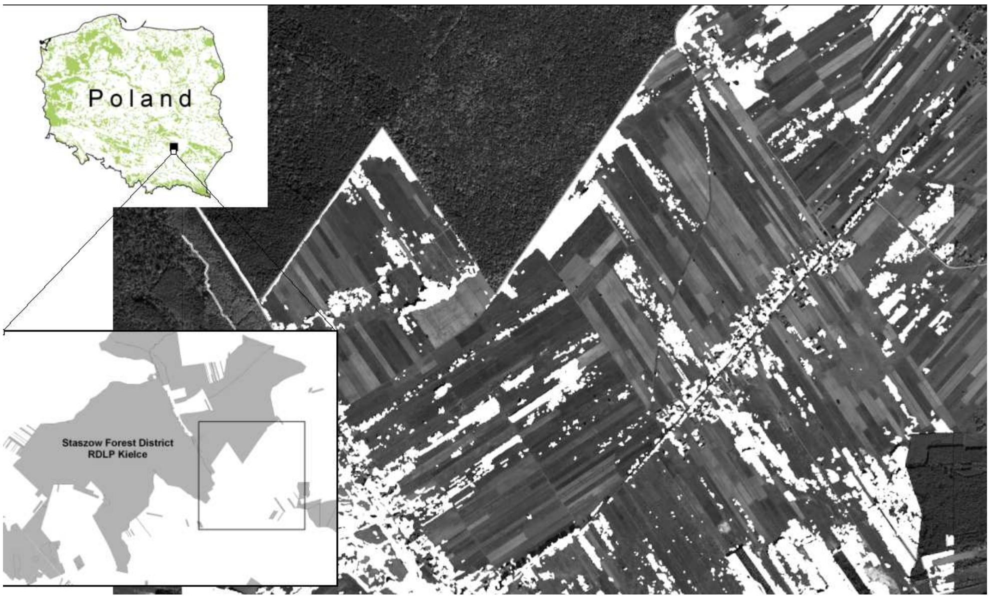

Fig 2, Quickbird classification on the test area of the Staszow District. High-vegetation outside the forest mask is classified in white. Small private forest plots, orchards as well as forest succession are included.

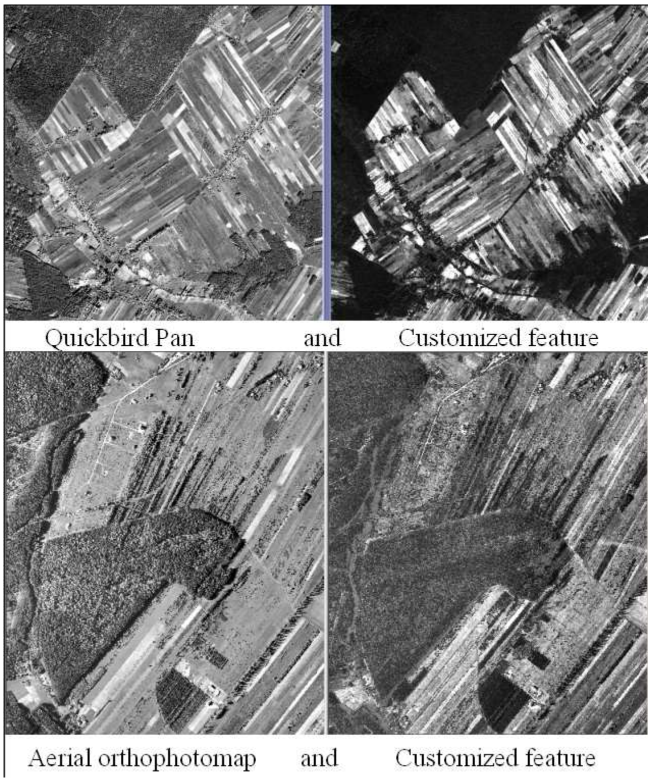

Fig 3, Two top images; a panchromatic Quickbird scene and the visualisation of the customized feature (Fig.1) . Below the same customized feature on a subset of the 8-bit orthophotomap from scanned aerial imagery.