MAPPING WARSAW FROM SPACE
APPLICATION OF OBJECT ORIENTED APPROACH TO THE ANALYSIS OF URBAN STRUCTURE

Magdalena Wrzesien[1], Karol Zaremski[2]

Remote Sensing of Environment Laboratory
Faculty of Geography and Regional Studies, University of Warsaw
ul. Krakowskie Przedmiescie 30, 00-927 Poland
T: +48 22 5521507, e-mail: [1]septy@wp.pl, [2]karolz@uw.edu.pl

Abstrakt
In this study problems and solutions to remote, automated urban mapping are presented. On the example of Ikonos satellite data of Warsaw imaged in 2000, how to create land-use maps is demonstrated using e-Cognition software - object oriented approach. You do not classify single pixels but objects created in multi-resolution segmentation process, which allows use of, not only spectral responses but also texture, context and information from other object layers. The fuzzy logic rules are applied to the construction of class hierarchy. Such a way of classification is similar to human image understanding processes.

Introduction

Remotely sensed images proved to be an invaluable data source for many applications. However, only recently has remote sensing been introduced into urban applications. The accelerating urban sprawl, often characterised by a scattered growth, has rarely been well planned, thus provoking concerns over the degradation of our environmental and ecological health. Thematic assessments of urban sprawl involve procedures of monitoring and mapping, which require robust methods and techniques. Conventional survey and mapping methods cannot deliver the necessary information in a timely and cost-effective mode. Limited spatial information within the built-up zone hinders urban management and planning. As an example, a citation from the Strategy of Warsaw development until the year 2010" written by the Board of the City of Warsaw can be given: "In the nineties, the economic changes in Warsaw have led to changes in land use structure. Lack of detailed information about the spatial range and distribution of these changes impedes an in-depth analysis of the land use structure".
Given its technological robustness, remote sensing is increasingly affecting urban sprawl research. However, comparing remote sensing applications in other areas, automated classification and analysis of cities on satellite or aerial images is troublesome. The reason for this is a very specific structure of urban areas, characterized by varied land cover types responding to different land use types and functional zones. Those are not easily recognizable by automated algorithms and require either expert knowledge or development of new mapping techniques.
The objective of this study is to assess the potential of object oriented classification to create land use map using eCognition software. Problems and solutions to remote, automated analysis of urban areas are presented. Built-up areas are difficult to identify using solely spectral signatures due to high within-class variance.

Study area and data

The research was carried out for the agglomeration of Warsaw. The image acquired on 29th April 2000 by Ikonos satellite was analysed (Fig. 1.). IKONOS is a new generation satellite, delivering the first commercial image of a very high ground resolution (4 m in multispectral mode and one meter in panchromatic mode) and a high radiometric resolution of 11 bits. Spectral resolution is typical for many other satellite missions: four bands: three in the visible part of the electromagnetic spectrum (B, G, R) and one in near infrared (NIR). The area covered by Ikonos includes a transect extending south from the city centre through a compact built-up area (used mainly as a services area), through districts of multi-storey blocks of apartments districts of detached houses. Parks, allotments and a few agricultural areas have also been taken into consideration. Reference and training data for urban

structure analysis was derived from within a detailed, large-scale map of land use produced by the Board of the City of Warsaw.

Figure 1. The area covered by panchromatic band of the Ikonos Imagery

Methodology

Traditional elements of image interpretation include characteristics of first order (tone/colour), second order (spatial arrangement: size, shape and pattern) and third order (height, shadow). In digital remote sensing third order image characteristics are considered a nuisance, while potentially useful spatial information has been usually ignored, due to lack of methodology and computational limitations.

Parallel to advances in spectral image classification techniques, research has been undertaken, albeit by a limited number of researchers, contextual information in image classification. Positive results of these studies as well as a growing number of high ground resolution satellite sensors operating or scheduled for launch within the next few years will provide extra incentives for further research in this direction.

You do not classify single pixels but objects created in multiresolution segmentation process. One motivation for the object-oriented approach is the fact that the expected result of many image analysis tasks is the extraction of real world objects, proper in shape and proper in classification. Then you use not only spectral responses, but also texture, context and information from other object layers. The fuzzy logic rules are applied to the construction of class hierarchy. Such a way of classification is similar to human image understanding processes. This expectation can not be fulfilled by common, pixel-based approaches (Definiens, 2000).

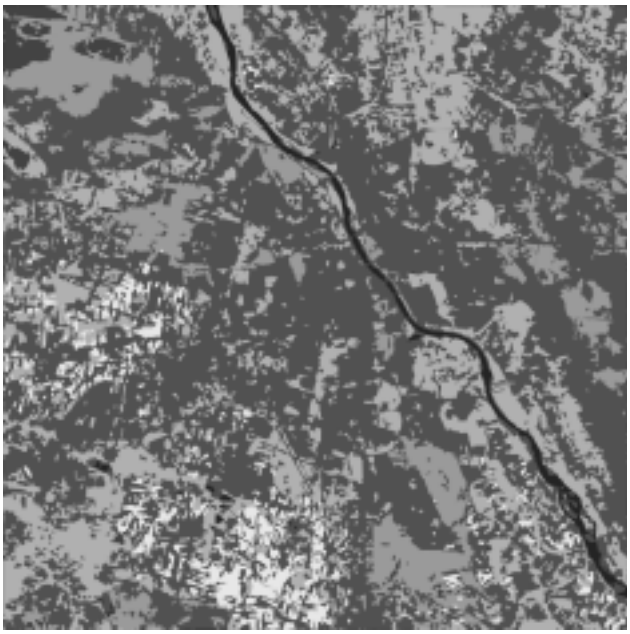
In eCognition software before classification you have to create objects. Thayer heterogeneity is determined by scale parameter. Scale parameter and data affects the size of acquired objects. Criterions of colour, shape, compactness and smoothness also affect the results of segmentation. To classify whole image class hierarchy is needed. The class hierarchy is constructed by dividing main classes for smaller ones (sub-classes). Each sub-class inherits features describing its super class and has its own features. There are about two hundred features. The user could choose the best suiting from these to distinguish classes. Every object has some value of every feature. Creating different levels of segmentation with different scale parameters allows classifying real objects of different scales like houses and quarters of the city.

In this study main scale parameter has value 30; color 0.8; shape 0.2; compactness 0.9 and smoothness 0.1. After using features: brightness, standard deviation of infrared band and self-constructed NDVI feature ((IR-R)/(IR+R))*100 where IR is infrared and R is red spectral bend of image 11 classes were distinguished.

Results

The results of the research are encouraging. New generation satellite data of high ground resolution aerial images particularly suited for the object oriented image classification and gives better classification than Landsat images classified by maximum likelihood method (Fig. 2.). Four strict

Figure 2. Landsat image of Warsaw classified by maximum likelihood



urban, four vegetation, river and shadows and water classes were distinguish on Ikonos image. Those classes need further researches.

Conclusions

Automated identification and mapping of urban areas is difficult due to high heterogeneity of structure and spectral responses of built-up areas. However, remotely sensed images can be applied in analysis of urban land use thanks to an object-oriented approach to classification. The method can also be used for change detection, particularly in areas of a dynamic urban sprawl. New generation satellite data of high ground resolution gives incentives for further, in-depth mapping urban areas. Classification of segments using new self-constructed features (parameters) should facilitate automated mapping of urban structure in larger scales. This hypothesis will be tested in future research.

Acknowledgements

Special thanks to staff of Limnology Station in Iffeldorf, in particular to Prof. Dr. Arnulf Melzer, Dr. Uta Raeder and Dr. Thomas Schneider for the support provided during the study.

The authors would also like to thank Dr. Roeland de Kok for teaching them the basics and more sophisticated functions of eCognition software.

References

(1) Bauer T., Steinnocher K., “Pre-parcel land use classification in urban areas applying a rule-based technique”, GeoBit/GIS 6, 12-17: 24-27, 2001

(2) Definiens Imaging, “User Guide 3”,2002

(3) Euro image, “Ikonos”, Products & Services, 2001

(4) Herold M., Scepan J., “Object-oriented mapping and analysis of urban land use/cover using IKONOS data”, Geoinformation for European-wide Integration, Ed. T. Benes, Millpress, Rotterdam, 2003

(5) Ivits E., Koch, B., “Object-oriented remote sensing tools for biodiversity assessment: A European approach”, Geoinformation for European-wide Integration, Ed. T. Benes, Millpress, Rotterdam, 2003

(6) Jakomulska A., 2001, “Warsaw from space application of geostatistics for analysis of urban areas”, Geographical Space at the Millennium. Theoretical and Methodological Challenges, Ed. A. Kowalczyk, Warsaw,2001