Detection of vegetation coverage in urban agglomeration of Brussels by NDVI indicator using *eCognition* software and remote sensing measurements

Lemenkova Polina (Charles University in Prague, Department of Ecology)

Abstract:

The study focuses on the semi-automatic detection of the vegetation on the satellite panchromatic image covering area of Brussels, Belgium. Using functions of the Normalized Difference Vegetation Index (NDVI) and spectral reflectane parameters of the image, the vegetation was identified on the satellite scene. The research question was to assess, how NDVI measurements can be used for urban studies using remote sensing data. The aim is to distinguish and separate on the map built-up areas from the green spaces (parks, gardens, etc) within the urban landscape. The research is supported by the raster imageand the *eCognition* software for image analysis. The results show detected vegetation areas in eastern part of Brussels. The research demonstrated methodological applicability of eCognition software for GIS-based urban mapping and ecological assessment (areas and sizes of vegetation coverage).

Тезисы (абстракт):

Цель исследования - мониторинг растительного покрова г. Брюссель (Бельгия) с использованием спутникового панхроматического растрового снимка выского разрешения и программы *eCognition* для распознавания растровых изображений. Используя функцию NDVI (Нормализированный вегетационный индекс) и свойства спектральных характеристик пикселов на снимке, растительный покров (напр., парковые зоны, сады и зеленые участки) был идентифицирован на снимке. Конкретная цель исследования - установить, можно ли использовать измерения NDVI для задач градостроения и урбанистики с использованием программы *eCognition*. Результаты работы показали возможность различения разных типов земного покрова от застроенных кварталов (т.н. "спальные" районы) и зеленых зон (городские парки, сады, и т.д.) в пределах городского ландшафта. Результаты показывают позитивный опыт применения *eCognition* для картографирования городских территорий на примере восточной части Брюсселя. Также, исследование продемонстрировало методологическую применимость и совместимость технических функций *eCognition* для пространственного ГИС-анализа, тематического картографирования и природоохранного мониторинга городских районов.

Introduction

The study area encompasses selected regions of the Brussels municipality, Belgium (Fig.1). In the past years the city of Brussels is experiencing intensification of the density of building structures. Unlike in some other European cities, where the most evident problem is urbanisation and expansion of the city margins to the suburbia, the urban structure Brussels is not really urban sprawl which happens much further away from the city centre and outreach the urban limits, but the intensification of the buildings density in the city centre and the existing dwelling districts. Thus, the city structure tends to become more intense and dense, due to the process of filling the empty spaces in the urban patterns and high level housing. Another example of urban processes in Brussels is reorganisation of the industrial areas. At the same time, monitoring vegetation areas is essential for environmental sustainability of the capital city. The lack of the green spaces may cause ecological instability and increase atmospheric pollution. For studies of the specific problems of the Brussels city the remote sensing data (raster image) was used together with NDVI function, in order to detect areas covered by city parks. The satellite images are the best source of information for the GIS based urban studies, since they enable to detect selected land cover types, such as vegetation.

Research objective

The specific research question of this paper is to evaluate, how to efficiently use an a priori knowledge in object oriented image analysis approach for mapping land cover types from the raster images. Detecting vegetation and built-up areas using remote sensing data enables to assess the percentage of the coverage of the city by the newly created buildings (Esch *et al,* 2008). The non-built-up areas such as vegetation coverage are masked, in order to focus on the settlement growth. This method is based on the support vector machines, remote sensing and cadastral data, processed by model-based sub-pixel supervised classification and non-parametric machine learning method. The chosen software is *eCognition*, which is the first object oriented image analysis commercial software on the geospatial market. It provides an appropriate link between remote sensing imagery and GIS (Benz et al, 2004). The *eCognition* processes images according to the principle that information contained in the image is not represented by the single pixels but by the objects and their topology. Accordingly, using segmentation algorithm and extraction of image object primitives (e.g. parks, gardens, buildings), it classifies the whole segments of the homogeneous image, which are recognized as objects rather than pixels.

Data and methods

The research data used in this project include vector and raster types of data. Raster data consists of VHR Pléiades satellite imagery covering research study area (Brussels city area).

The image IMG_PHR1A_P has been provided by the Astrium, EADS company, projected in UTM (Universe Transverse Mercator projection system), 31°N, WGS84 reference ellipsoid. Vector data are presented by the ground topographic map covering Brussels area in shp format (ArcGIS), which is a part of the municipal project of Brussels URBIS. There are existing examples of application of the OBIA approach towards spatial studies (Baltsavias, 2004, Benz *et al,* 2004; Zhou *et al,* 2008; Petropoulos *et al.,* 2012; Lian and Chen, 2011). In the current work the proposed methodology from these previous works is considered. The main software used in the current work is eCognition, since it corresponds to the research task: it is focused on object oriented multi-resolution processing of the raster images. The panchromatic image was loaded into project and processed. The principle of Multiresolution Segmentation operation consists in the splitting of an image into segments in order to simplify complexity of the whole initial image. It is performed by the machine embedded logic based on mathematic algorithms and simplifying models. The general rule divides the area into regions according to the principle, for instance, "neighbour pixels have similar parameters", such as spectral reflectance value, texture, form and shape.

Results

During this procedure all vegetation coverage has been detected and separated other objects (impervious structures) using natural characteristics of the vegetation spectral reflectance. For this, first the arithmetic expression for Normalized Difference Vegetation Index (NDVI) was created in eCognition operators using well-known formula for spectral reflectance in visible (VIS) and near infrared (NIR) bands. This enables to clearly detect pixels that represent vegetation: NDVI=(NIR-VIS)/(NIR+VIS). In terms of corresponding image bands, this formula was used as NDVI=(NIR-VIS)/(NIR+VIS). After this operation was created, it was added to the conditions of objects processing (Fig.1). After this, the operation of extraction of vegetation was performed (Fig.2). The logical condition for vegetation detection is that we assign all objects which have values of NDVI more than 0.3 to vegetation. This is based on the properties of vegetation: dense tree canopy usually have positive values of NDVI (0.3 to 0.8). On the contrary, other objects, which do not belong to vegetation, have low NDVI values. For example, water bodies usually have low reflectance in both spectral bands (band 3 and band 4). Therefore, they have very low positive and sometimes slightly negative NDVI values (depending on local hydro-chemical conditions, depth, etc). Bare soils usually also have small positive NDVI values (0.1 to 0.2), since their spectral reflectance in near-infrared bands is larger than in red ones. So, using this knowledge, the NDVI formula was applied, and green areas within the city of Brussels were distinguished (Fig.3).

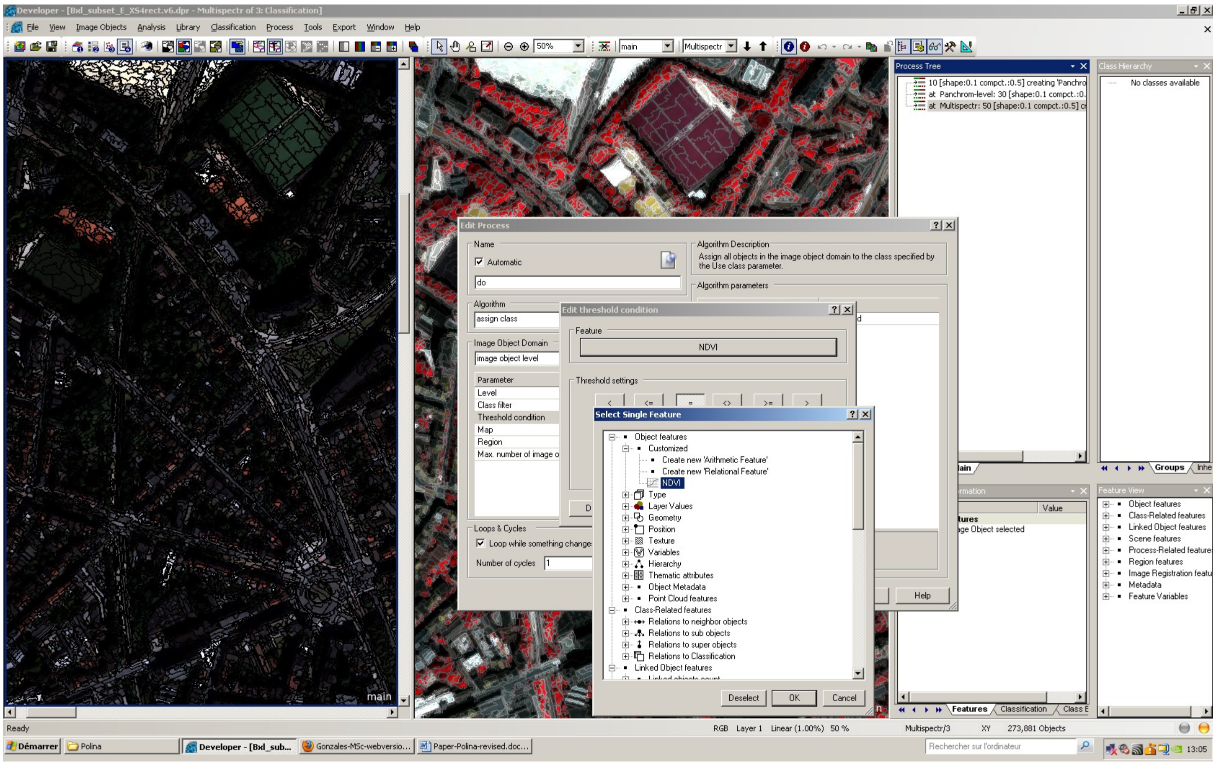
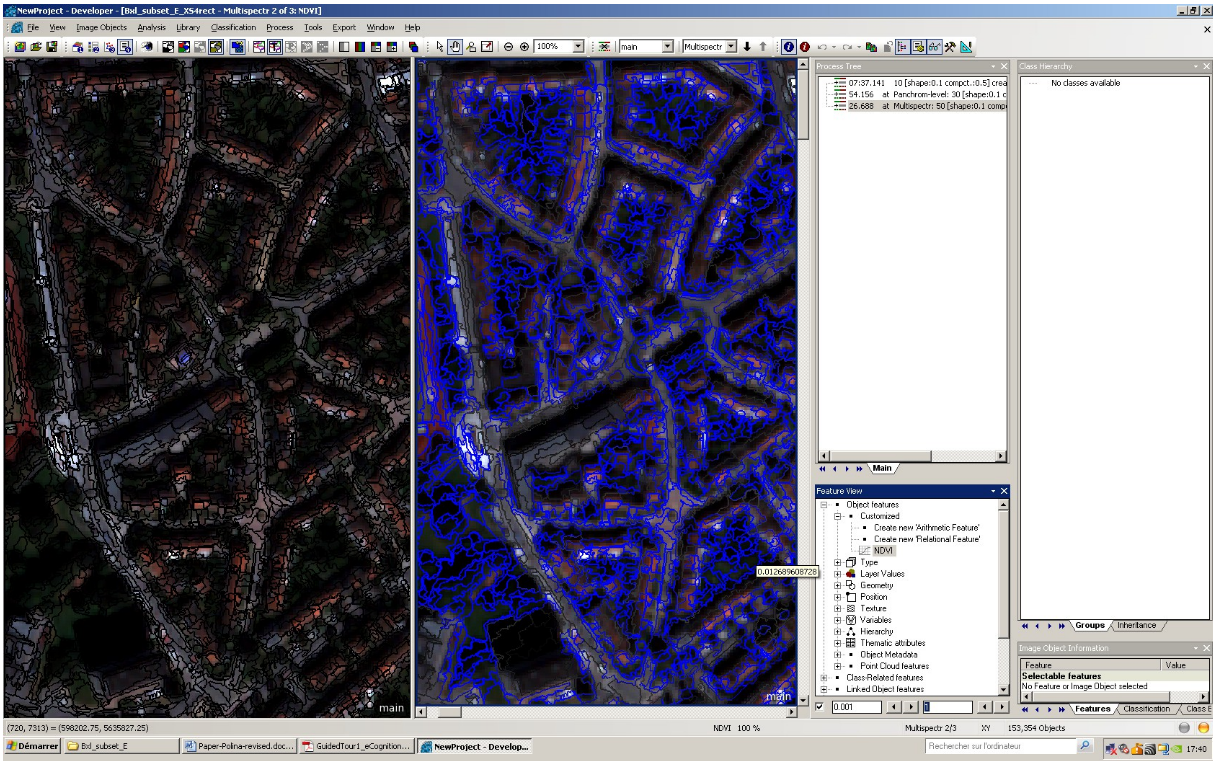


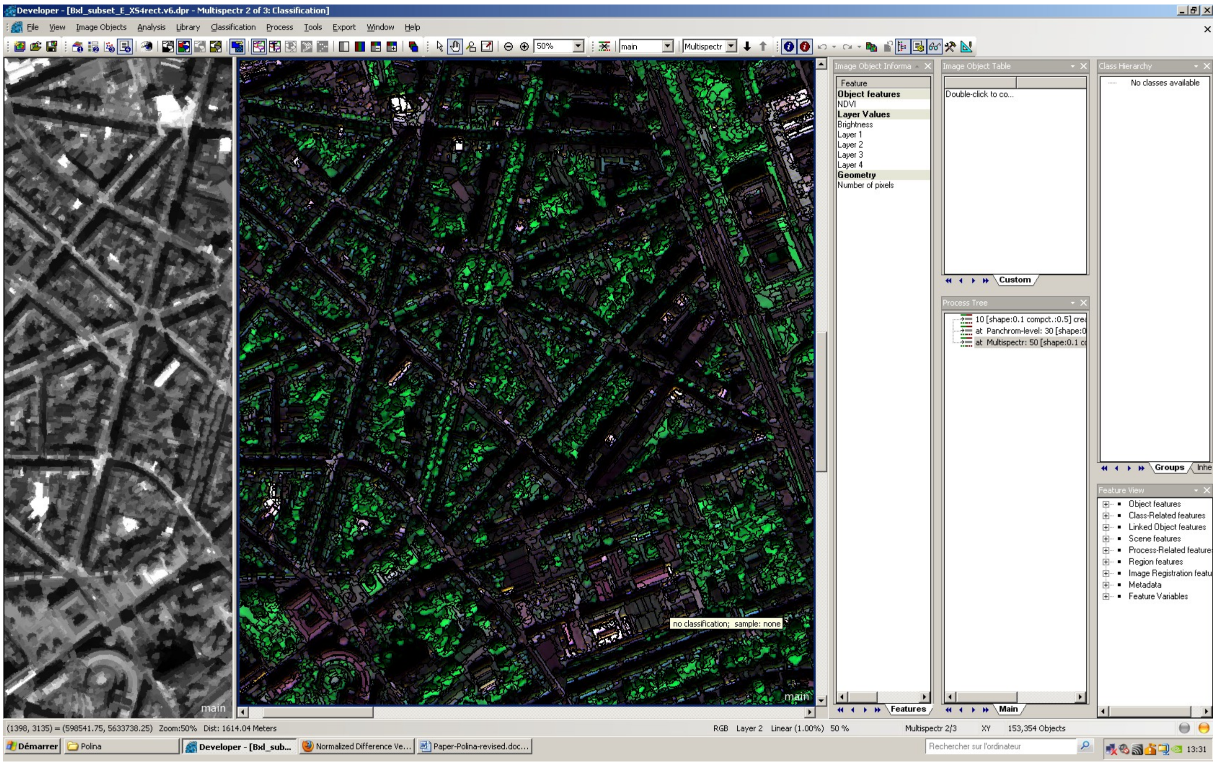
Fig.1. Creation of NDVI conditions, *eCognition*

The objects with NDVI values more than 0.3 were assigned to the “vegetation” class.



ig.2. Objects classified as ‘vegetation’ class: outlines of the created polygons.

The urban landscapes have complex environmental and socio-economic function and serve as habitat and agricultural surface in the surroundings. Land cover studies supported by satellite image contribute to the development of urban management system.



ig.3. Objects classified as 'vegetation' class (green coloured, right). Initial image: left.

Using object-oriented approach together with GIS techniques applied to remote sensing data enables to perform geospatial analysis with focus on urban landscapes.

Literature:

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