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

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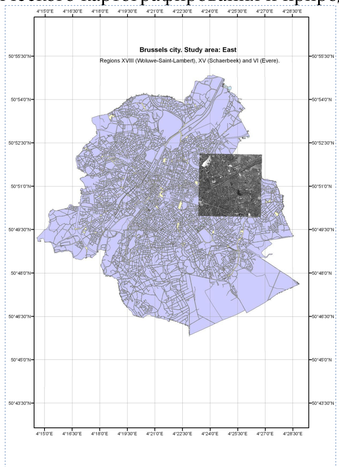
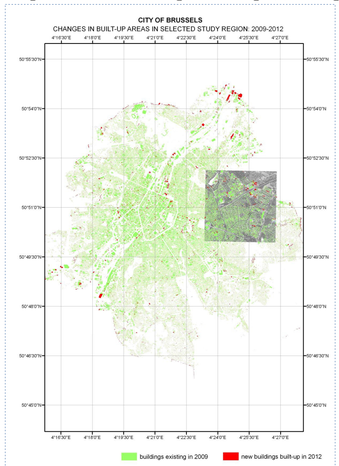
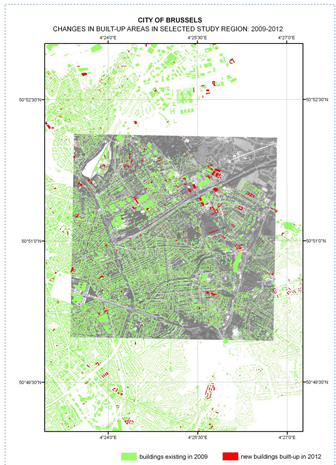
Views of the city of Brussels (Belgium). Photos: author (Lemenkova Polina)

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 программыеCognition 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. 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 urbanization and expansion of the city margins to the suburbia, the urban structure Brussels is 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.

Research objective - to evaluate, how to efficiently use 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 building. The vegetation areas were masked, to focus on the settlement growth. This method is based on the use of remote sensing and cadastral data, processed by model-based sub-pixel supervised classification and non-parametric machine learning method. The main software is *eCognition* focused on object oriented multi-resolution processing of raster images. The *eCognition* is the first object oriented image analysis commercial software on the geospatial market. It provides an appropriate link between remote sensing imagery and GIS. The *eCognition* processes images according to the principle that information contained in the image is not represented by the single pixels but by 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 The research data include vector and raster types of data. Raster data consists o f VHR Pléiades satellite imagery covering Brussels city. 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 include ground topographic map in shp format (ArcGIS), a part of the municipal project of Brussels URBIS.

Methods and Results

Step I. The panchromatic image was loaded into project and processed.

Step II. The image was segmented using the principle of *Multiresolution Segmentation.* This 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 “neighbour pixels have similar parameters” (spectral reflectance value, texture, form, shape).

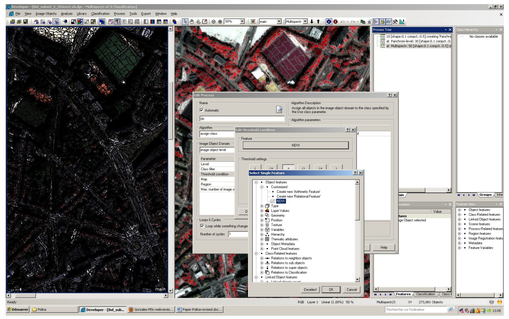


Fig.1. Creation of NDVI conditions, eCognition

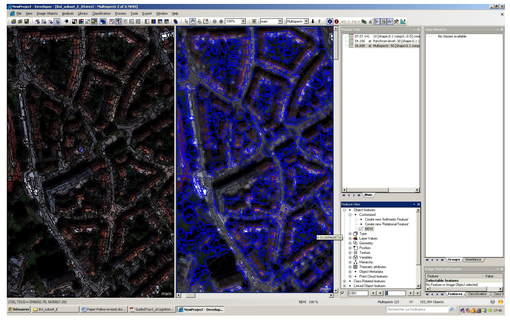


Fig.2. Objects classified as ‘vegetation’ class: outlines of the created polygons

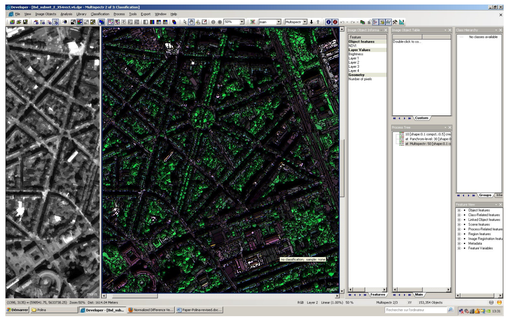


Fig.3. Objects classified as ‘vegetation’ class (green, right). Initial image: left.

Step III. All vegetation coverage has been detected and separated from 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 formula for spectral reflectance in visible (VIS) and near infrared (NIR) bands. This enables to detect pixels of vegetation: NDVI=(NIR-VIS)/(NIR+VIS). After this operation was created, it was added to the conditions of objects processing.

Step IV. After this, the operation of extraction of vegetation was performed. 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 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. The objects with NDVI values more than 0.3 were assigned to the “vegetation” class.

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

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