USE OF WORLDVIEW-II IMAGES AND THE KNOWLEDGE-BASED SOFTWARE INTERIMAGE FOR THE CLASSIFICATION OF LAND COVER IN AN URBAN AREA.

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ABSTRACT:

The objective of this study is to evaluate the potential of WorldView-2 satellite images and the free-access software InterIMAGE to map land cover in an urban coastal area. For the execution of this study, statistical data, information from public institutions and partner companies at this project, were used. Furthermore the following materials were utilized: 1. WorldView-2 satellite scenes obtained in June 10th 2010, with 16º off-nadir angle, and 11 bit radiometric resolution, delivered by Digitalglobe; 2. Vector files of city blocks from the databank, from the Project called "São Luis: reading the city"; 3. Ground Control Points (GCP) in vector format, with 1 m equidistance, for the area corresponding to the municipality of São Luis, collected during field survey in August 2011, with TOPCON Hiper Geodetic GPS equipments; 4. Level curves in vector format from the area of São Luis municipality. The thematic maps were generated from both test sites using InterIMAGE v 1.27 software. It allowed a supervised analysis of the different attributes and to define the best ones and respective thresholds for the classification. The results of these classifications were verified by a confusion matrix. It is concluded that WorldView-2 images ease the identification of urban targets due to its new spectral bands, emphasizing its use for the discrimination of different vegetation types. InterIMAGE allowed a fast classification of image attributes and to use the image texture tool to improve the discrimination of classes.

1. INTRODUCTION

In the last decades there was a strong increase of studies related to the dynamics of urban sprawl. In the city of São Luis (Maranhão State, Brazil) an intense population growth took place since the 60s, due to commercial and industrial activities concentrated in this region.

With the availability of high resolution data from the WorldView-2 satellite, launched in October 2009, new possibilites were opened for the study of mangroves in urban areas, because this is the first orbital sensor with 0.46m resolution at the panchromatic band and 1.84m at the multispectral bands (DIGITALGLOBE, 2010). The availabilty of four additional bands, if compared to previous spatial sensor systems, allowed to improve the discrimination of targets in the area under study.

In order to analyze these huge datasets, new methodologies and concepts were developed. OBIA (Object-based Image Analysis) is a paradigm indicated for the classification of land use/land cover in urban areas, using these very high resolution images (BLASCHKE & KUX, 2007). InterIMAGE, a free and open code image interpretation and knowledge-based system was jointly developed by INPE and the Pontificial Catholic University of Rio de Janeiro (PUC-Rio), Dept. of Electric Engineering (COSTA et al., 2010).

The objective of this study is to evaluate the potential of WorldView-2 satellite images and of the free-access software InterIMAGE to map land cover in an urban coastal area, with special interest to test the potential of these high resolution data, for the discrimination of targets located in very fragile environments.

1.1 Land cover classification

The improvement of the spatial and spectral quality of satellite images allowed to detail maps from urban areas, which typically present a large variety of targets (different types of roofs, vegetation cover, bare soil, shadow areas, among others) NOVACK (2009) developed a land cover/land use classification model for a large area of slums (Paraisópolis) within São Paulo city, using high spatial resolution images.

When using remote sensing data for land cover studies, one must consider "land cover" as the coating of land which presents typical biophysical, physical and chemical characteristics with different Energy-Matter reactions. (PRADO, 2009).

1.2 WorldView-II images

Souza et al., (2011) performed tests to improve the discrimination of vegetation types at coastal areas, such as mangroves and tidal flats (so-called "*apicuns*") using the new WorldView-2 bands. Applications of these bands as well as proposals of methodologies for its analysis, including spatial data analysis and OBIA, are found in Kerr (2011) and Vaduva (2011).

1.3 GEOBIA – Geographic Object-based Image Analysis

For the analysis of high resolution satellite images, the traditional pixel-by-pixel classification approach is quite limited because these data present a high level of heterogeneity as well as an internal class variation within the same scene. BLASCHKE (2010) presented the evolution of OBIA, presenting case studies in different applications. For classification purposes, OBIA considers information extracted from objects, as well as topological (neighborhood, context) and geometrical (form, size) data.

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Other attributes such as: size, texture, pattern and context are helpful for the classification when the spectral attributes are not sufficient and the knowledge from the specialist is inserted to improve this task. BENZ et al. (2004) report that this uncertainty must be modelled, which will help at the evaluation of the classification. HAY & CASTILLA (2008) define GEOBIA (Geographic Object Based Image Analysis) as a sub-discipline of Geoinformation Science, dedicated to the development of automated methods to partition remote sensing images in meaningful objects.

1.4 Image fusion

The fusion of panchromatic with multispectral images of WorldView-2 scenes was done using the Principal Components methods, resulting in an image with 0.50 m spatial resolution.

1.5 Orthorectification

The orthorectification was made using the 3D rational polynomial method (TOUTIN, 2004) and the software package PCI Geomatics v10.3.1, considering 55 GCPs for the entire area under study. The GCPs used for the geometric rectification were obtained during a field campaign in August 2011.

1.6 InterIMAGE

InterIMAGE is a knowledge-based free software for image interpretation. It was developed in the frame of a cooperation project between INPE, the Brazilian National Institute for Space Research, the Laboratory for Computer Vision of the Catholic University of Rio de Janeiro (PUC-RJ), and the Leibniz University of Hannover (Germany). According to COSTA (2009 and 2010), its knowledge structure, design and control mechanisms were inherited from the German system GeoAIDA (BÜCKNER et al., 2001), which consists of a further development from AIDA (Automatic Image Data Analyzer).

According to RIBEIRO (2010) the most important characteristics of InterIMAGE are its flexibility for the interpretation of multi-sensor images, the reduction of computer processing time and the load for the image analysis (Figure 01).

The most recent version of InterIMAGE can be downloaded at link http://www.lvc.ele.puc-rio.br/projects/interimage/. Among other operators for object extraction it contains: a segmenter from Baatz, the Checkerboard, a classifier by decision trees, an importer for vector files, topologic attributes which can be used at the decision rules of Top-Down and Bottom-Up operators (COSTA et al., 2010;).

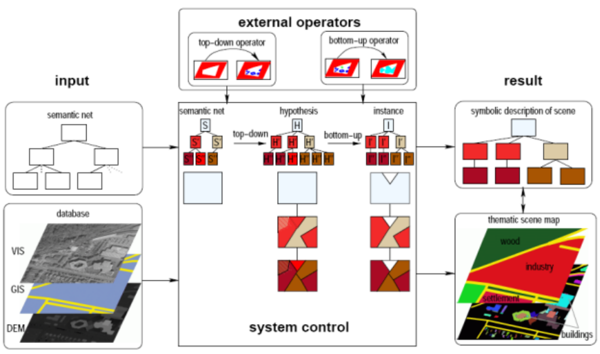

Figure 01- Components of the analysis process.
Source: Adapted from InterIMAGE (2009)

1.7 Semantic network

In order to compose the semantic network, the following land cover classes were defined for the test sites, based on the visual analysis of WorldView-2 images and on the previous knowledge of the area by the interpreter: swimming pools, grass and arboreal vegetation, different types of roofs (associated to different cover materials), buildings with different heights, industrial sheds, bare soil areas, etc.

2. AREA UNDER STUDY

The area under study is part of the Maranhão Island, NE Brazil, encompassing an area of 831.7 Km² (Figure 02).

At the northern section of São Luis municipality there are fragile geologic structures of Quaternary age, which eases landscape changes by relief modeling agents of climatic, hydrologic and oceanographic origin. A detailed description of this area is found in SOUZA & FEITOSA (2009) and GERCO (1998).

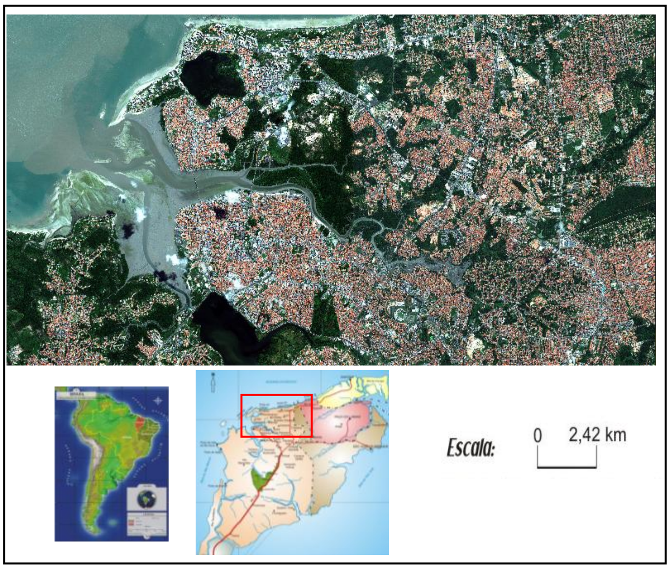

Figure 02 – Localization of test site
Source: Adapted from WorldView-2 image dated July 10th 2010. (DIGITALGLOBE, 2010).

Associated to this fragile underground structures, the mangroves are located mainly at the margins of bays, inlets, river mouths, lagoons and coastal indentions. Such vegetation systems are functionally complex, highly resilient, resistant and stable, occurring exclusively in tropical areas. They are characterized by typical vegetation types and sediments and are very important from an environmental and social-economic point of view (MOCHEL, 2006 p. 237).

The choice of test-sites was based on previous works from RIBEIRO (2010) and NOVACK (2009) which reported that, for the analysis of land cover, it is extremely important to choose test sites with a significant heterogeneity where all relevant objects could be identified. In our study site some targets are very important, such as: blockhouses, mangroves, beach and residential areas with differernt types of roofs, besides occupied or protected green areas. At Figure 03 there are typical environments of the area under study.

Figure 03 – Test site.
Source: adapted from WorldView-II image, dated July 10th 2010. (DIGITALGLOBE, 2010).

3. METHODOLOGY

The main methodological steps are presented in the flow diagram at Figure 04:

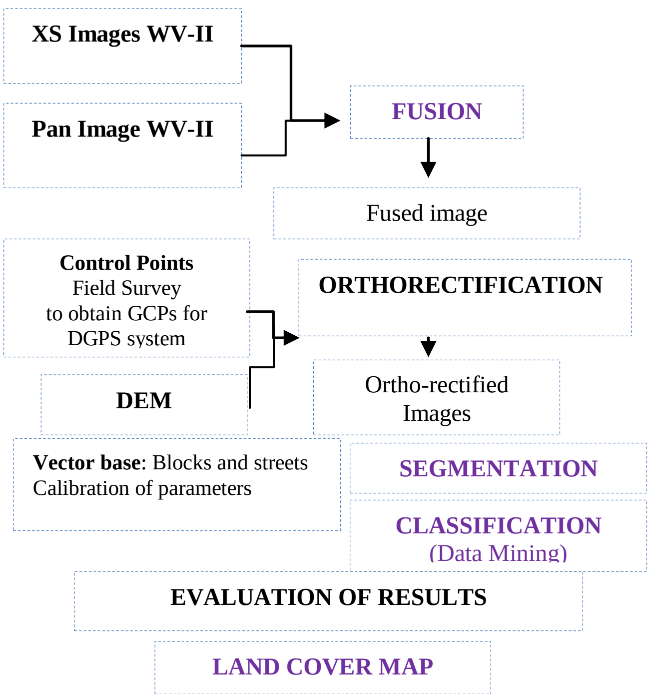

Figure 04 – Methodological steps

Materials used:

1) Scenes from *WorldView-II* sensor obtained in June 10th 2010, with off-nadir angle 16º and 11 bits radiometric resolution, delivered by DIGITALGLOBE.

2) Vector files of blocks in the databank of São Luis, from the city planning agency.

3) GCPs collected during Field survey in August 2011 with TOPCON Hiper L GPS geodetic equipment.

4) Contour lines in vector format, 1 m equidistance of contours, for the São Luis region.

5) Census data from 2010 encompassing the area under study, delivered by IBGE (Brazilian Institute for Geography and Statiscs).

The following software was used for image processing: ENVI 4.7 (ITT, 2009), for fusion and preparation of both test sites: PCI Geomatics V10.3.1 (PCI Geomatics, 2010) to work with the Digital Elevation Model and control points, followed by WorldView-2 image orthorectification, InterIMAGE v1.27 (InterIMAGE 2010) and GeoDMA for the exploratory analysis of image attributes and land cover classification.

Ortho-rectification was performed in order to correct image distortions. In order to accomplish this task, Ground Control Points were collected using a DGPS (Differential Global Positioning System) (Figure 05).

Figure 05 – Collection of control points during field survey.

The GCPs were collected on the entire scene (Figure 06) in order to generate an ortho-image (Figure 07).

Figure 06: Distribution of GCPs.

Figure 07: Ortho-image.

4. RESULTS

Based on the attributes chosen, a thematic land cover map was generated from the classification of WorldView-2 data, using InterIMAGE v1.27. This software allowed a supervised analysis of the different attributes and to define the best ones and the thresholds used for the classification.

During the implementation of the hierarchical network, the classification process implemented at InterIMAGE was considered, using the Top-Down and Bottom-Up approach (Figure 08). The option was a network with few levels and many leaf nodes allowing lower computer costs (RIBEIRO, 2010).

After the evaluation of the analysis from the most robust attributes at the exploratory analysis, including the texture attributes implemented at InterIMAGE vl. 27, the scene classification was performed. In comparison to other classifications the results were improved due to the availability of WorldView-2 new bands Yellow and Red Edge, eliminating frequent confusions such as e.g. among Ceramic Roofs and Bare soil.

Other important aspects to be emphasized is the classification of tidal channels, which was facilitated by decision rules modeled at InterIMAGE, using attributes of band Coastal, and the classification of the Beach area, based on attributes from band Yellow, which was also important to characterize those areas with paleo-dunes and dunes (Figure 10).

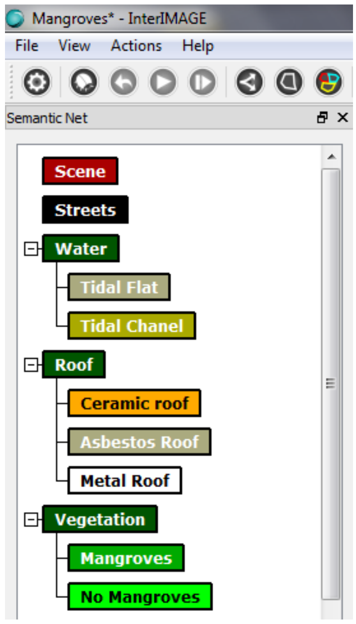

Figure 08: Semantic network elaborated at InterIMAGE.

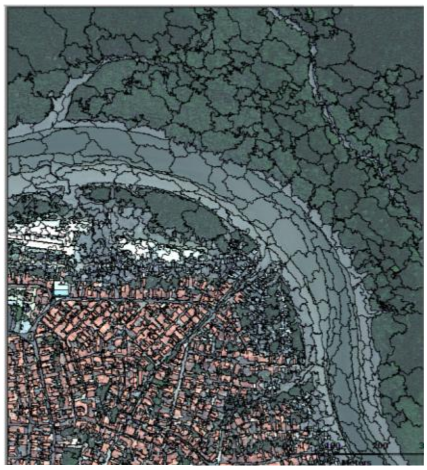

Figure 09: Segmented image.

Figure 10: Land Cover Map

CONCLUSION

The use of InterIMAGE software for image classification, and GeoDMA to elaborate the decision tree enabled a fast classification from improved image attributes, using the texture algorithm implemented at InterIMAGE allowing the separability of class mangrove. The very high spatial resolution of WorldView 2 images as well as the new spectral bands available also allowed the discrimination of different land cover classes.

The combination of spatial and spectral resolutions allows the improvement of separation among the physical characteristcs of targets to be mapped, resulting in higher detail and precision of land cover maps.

Mapping of coastal urban areas is imnproved by the use of these very high resolution images and considering OBIA. InterIMAGE allowed the knowledge modelling.

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