LAND COVER MAPPING USING KNOWLEDGE-MODEL WITH INTERIMAGE: THE CASE OF APA PETRÓPOLIS, RIO DE JANEIRO, BRAZIL

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KEY WORDS: Knowledge base, Classification, Alos, Open Systems, Landscape

ABSTRACT:

Established in 1982, with an approximate total of 60,000 ha, APA Petropolis, the first Environmental Preservation Area (APA) of Brazil, holds priceless historical and natural riches. The monitoring of this area with the help of thematic maps can be shown as an important resource for planning and decision making by their managers against the sprawl of urban occupation. With advances in remote sensing technologies and software capable of interpreting your images in an automated way, the production of these maps can become simplified. However, high costs attributed to these software license and the images generated by satellites provided by some distributors can restrict access to these technologies. Thus, this paper aims to show an alternative that allows the use of remote sensing through InterIMAGE open source software, developed by the Computer Vision Lab - LVC/PUC-Rio together with Image Processing Division - DPI/INPE, and AVNIR/ALOS images traded at accessible costs by the Brazilian Institute of Geography and Statistics - IBGE. From the construction of a semantic network modeled in an knowledge based system, proved the viability of producing thematic maps concerning the use and land cover, which enable the analysis of several components of the landscape as forest fragments. The methodology used as operators Baatz Segmenter, Shapefile Import, C4.5 Supervised Classification and NDVI Segmenter results showed that as the global accuracy and kappa index of 0.76 and 80% respectively in the identification of classes of forested areas (trees and grass fields) shadow area urban, rock outcrop and cloud.

1. INTRODUCTION

The Environmental Preservation Areas (APA) are categories of conservation (UC) created in Brazil in 1982 and are characterized by the presence of human occupation in areas with biotic, abiotic, aesthetic and cultural rights for the quality of life and well being of the population. In 2000, the National System of Conservation Units (SNUC) entered the APA's in the group of sustainable use, in order to still the council of the production processes and biodiversity protection (IBAMA, 2007), currently compromised due to the process of historical occupation of the country and intensified in the last 40 years with disorganized urbanization and the expansion of agricultural activities.

The establishment of this kind of territory requires a series of challenges governing bodies, since it overlaps existing territories and interests. Among the responsibilities applicable to managers, the regulations are working and monitoring the activities of the territory. In this sense, the adoption of the advances experienced in the field of remote sensing and image interpretation techniques can contribute to the monitoring of these conservation areas. However, the high costs of satellite imagery and software used for their interpretation can become restrictive because of the possibility of insufficient investment. The study aims to develop the knowledge necessary to map the land cover of APA Petropolis from AVNIR images acquired by the Brazilian Institute of Geography and Statistics - IBGE, using the free software InterIMAGE 1.27 (Costa *et al.*. 2008), developed by Image Processing Division - DPI/INPE and the Computer Vision Lab - LVC/PUC-Rio.

The results show that the classification developed with different operators of the software has achieved its objectives and the possibility of using an economically viable alternative to monitor these protected areas and support spatial analyzes that consider the various interactions between physical elements, biotic and anthropogenic in a given portion earth's surface.

2. METHODOLOGY

The modeling of knowledge performed in this study was initiated from the observation of results obtained by Cintra *et al.*. (2010) in their study monitoring of forest fragments outside the growth urban area in the Rio de Janeiro City.

The proposed classification for the work was based on a test area from the scene of the sensor AVNIR-2 (Advanced Visible and Near Infrared Radiometer type-2) which was carried by the Japanese satellite ALOS. This was released in 1996 and remained in operation until in early 2011. Among the reasons for its adoption, there is meant to generate products thematic land cover given the scale of 1:50,000 (EMBRAPA, 2011) and low cost, as distributed by the IBGE. Among its features stand out the presence of four spectral bands (three visible and infrared), 8-bit radiometric resolution and spatial resolution of 10 meters.

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The test area (Figure 1) set to the classification has approximately 25 km^2. The criteria adopted for selection was the presence of larger number of classes in order to use the software as well as expanding the classification to other areas within the APA Petropolis.

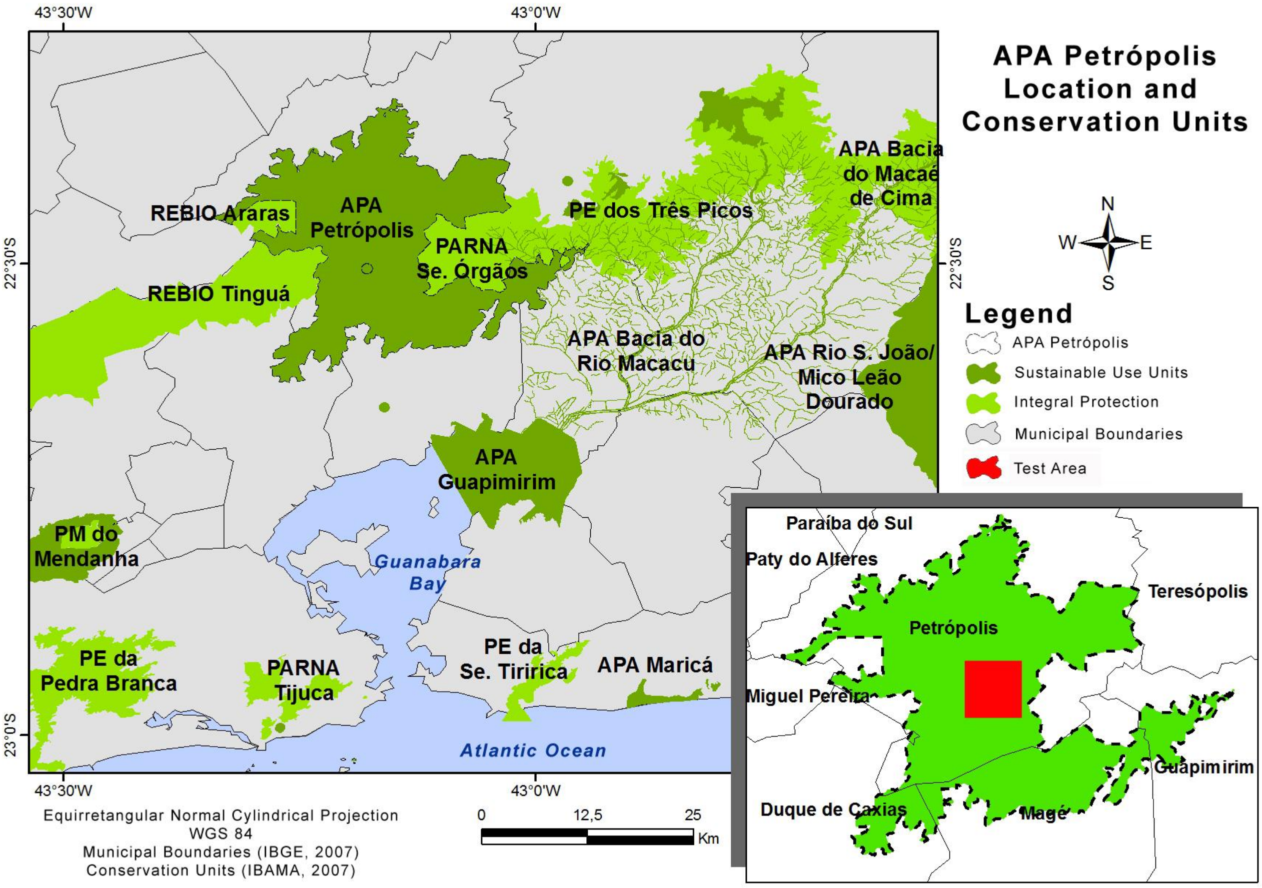

Figure 1. Location of the APA Petropolis and the test area

Due to the geomorphological characteristics of the area was also used Digital Elevation Model (DEM) from the TOPODATA Project (Valeriano, 2008). The choice of the DEM is given from the studies of Miceli *et al.*. (2011) showed that better quality to this data in relation to other models available such as SRTM, mostly to areas of mountainous relief very present in the study area.

Besides of raster data previously submitted data was obtained derived the vector basemap of the Management Plan APA Petropolis lying on a scale of 1:10,000. From this base used data from hydrography.

The methods applied to the cited materials are presented in Figure 2 and included the use of PCI Geomatics and InterIMAGE 1.27 softwares for the tasks of image orthorectification and elaboration of the classification key based on knowledge acquired with the materials and field trips.

The classification is performed in two steps by InterIMAGE software: top-down and bottom-up. The first is responsible for creating hypothesis and second for the resolving spatial conflicts from the first step to be validated or deleted.

The classes were defined forest tree and grass fields, shadow urban area, rocky outcrop, water and cloud (Figure 3). In accordance with the characteristics of the classes have been defined the data for extraction of classes and operators in the software InterIMAGE.

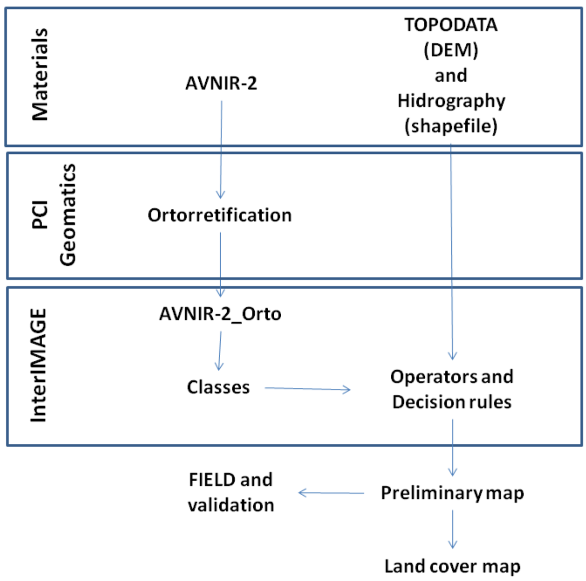

Figure 2. Methodology steps

Operators are inserted according to the knowledge of the characteristics of each class. The classes of vegetation (forest trees and grass fields) were selected using the segmentation based on NDVI (Vegetation Index Normalized Difference) called TA_NDVI_Segmenter (Rouse *et al.*., 1973), with different thresholds (0.23 and -0.01) with greater weight in areas classified as forest tree.

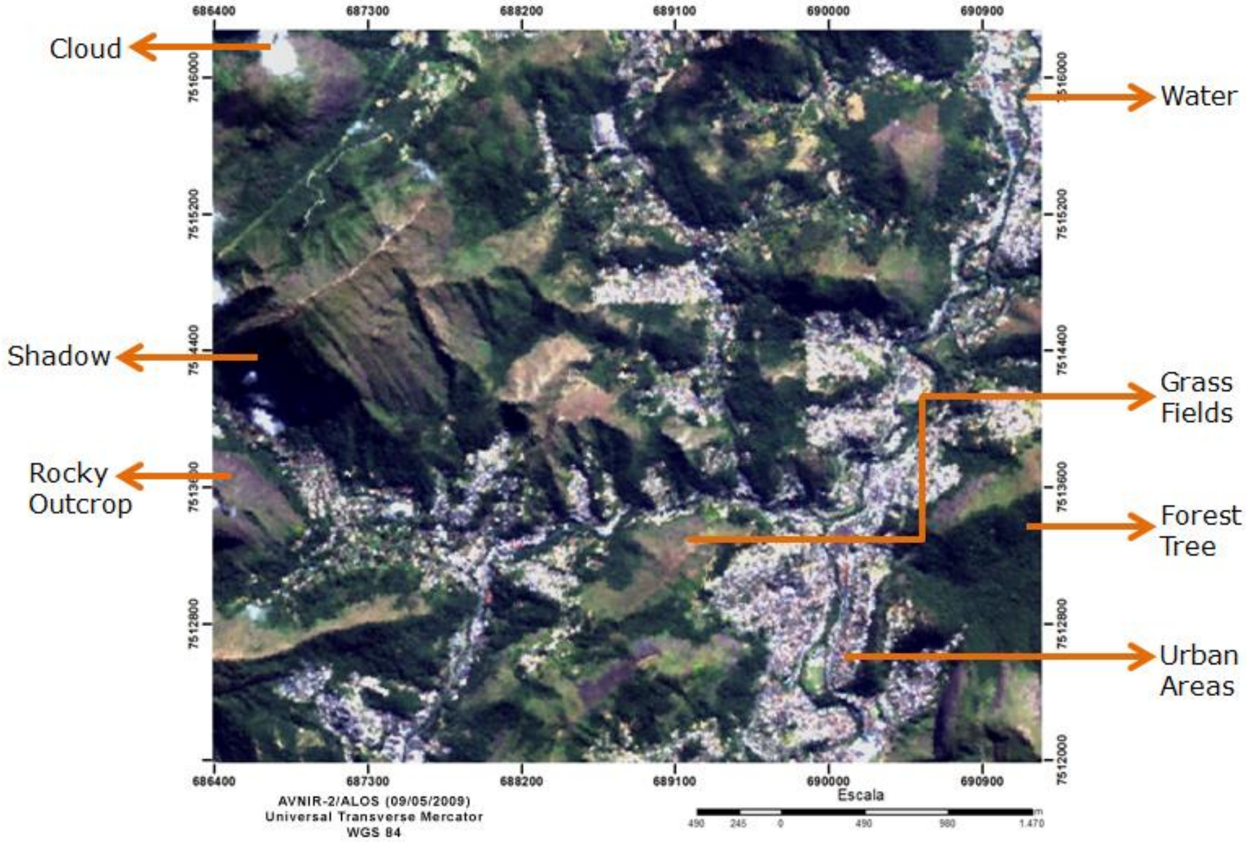

Figure 3. Examples of classes defined in the test area.

The shadow areas were extracted from the characteristics of brightness (arithmetic average of the four bands) using TA_Arithmetic operator (InterIMAGE, 2012) with a threshold between 0 and 38.

The urban areas and rock outcrops were classified from decision rule entered on the segments extracted by TA_Baatz_Segmenter (Baatz and Schape, 2000). The distinction of these classes was through the properties of entropy and slope obtained by the MDE TOPODATA.

The class cloud was identified in samples collected through the tool Samples Editor and supervised classification performed by TA_C4.5_Classifier (Körting *et al.*., 2011) which resulted in a shape file that was embedded classification as a whole through TA_Shapefile_Import operator (InterIMAGE , 2012). Similarly, a hydrography vector, produced by Estruturar (2005), was added to the project for the identification of water bodies.

Later processing of the data, the results were exported to a GIS allow checks in the field of possible questions in order to validate the mapping will be presented in the results and discussions section.

3. RESULTS AND DISCUSSIONS

The results obtained from the classification performed by the software InterIMAGE 1.27 are verified in Figure 4 and were validated in field and office for the testing performed and the mapping software performance.

The field observations made it possible to understand some of the existing conflicts in the classification of the transition between classes such as areas of forest tree and grass fields.
In addition classes of cloud and water were extracted from the data vector acquired by supervised classification and cartographic respectively making possible the insertion of other data of different spectral bands commonly adopted in classification procedures land cover.

The global accuracy results found achieved the 80% and was obtained from the confusion matrix (Table 2) obtained by classification performed visually by a photointerpreter compared with the results obtained from the classification of the data. Since the result from the kappa index (Congalton & Green, 1999) reached 0.76 which is considered very good (Landis & Koch, 1977).

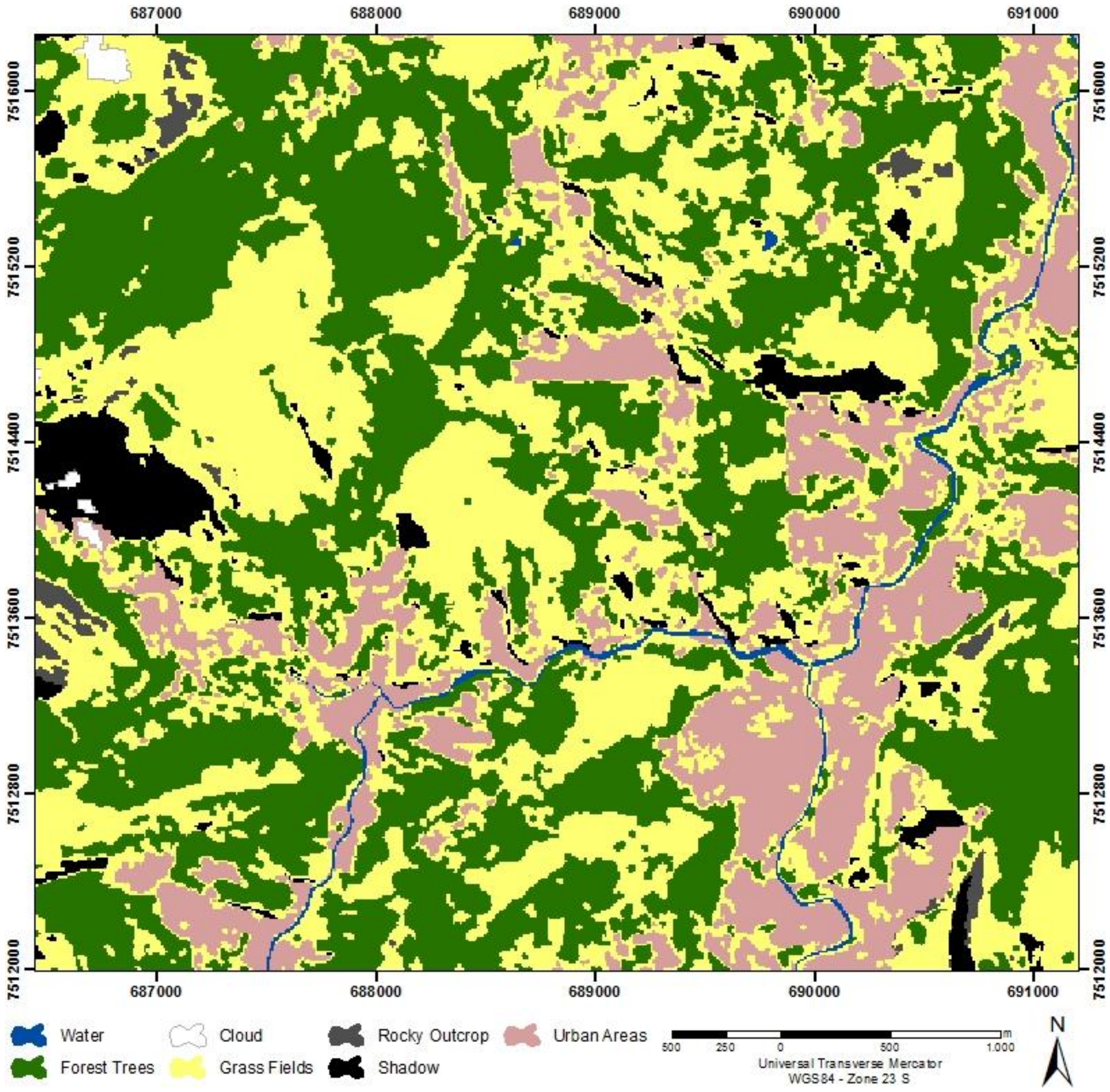

Figure 4. Classification result

	Water	Forest trees	Cloud	Grass fields	Rocky outcrop	Shadow	Urban areas	Total
Water	**19**	2	0	0	0	0	5	26
Forest Trees	0	**19**	0	10	0	0	0	29
Cloud	0	0	**30**	0	0	1	0	31
Grass fields	0	2	1	**18**	2	0	6	29
Rocky outcrop	0	0	0	8	**25**	0	1	34
Shadow	1	3	0	0	0	**25**	0	29
Urban areas	0	0	0	0	0	0	**28**	28
Total	20	26	31	36	27	26	40	**206**

Table 1. Confusion matrix

The results show that the knowledge model applied to the classification of land cover hit the target, but may have the increase of other data such as spectral bands from other sensors such as Landsat who may even allow a refinement of the results and the inclusion of new classes.

4. CONCLUSIONS

The methodology for generating the mapping of land cover of the APA Petropolis through software InterIMAGE presented good results who showed that replicable to other areas. The insertion of the slope from the digital elevation model and vector data enabled the refinement and distinction between classes of rock, urban and water.

The verification of results using the global accuracy and kappa index showed that the methodology is validated before statistical indexes and makes possible the expansion of the test area for all the APA Petropolis to provide knowledge of land cover throughout the Conservation Unit.

The knowledge obtained in this study can be expanded with the inclusion of other remote sensing data with higher spectral resolution and other data extracted from the landscape.

Furthermore, the InterIMAGE 1:27 has the possibility of inserting fuzzy rules which may also provide for the inclusion and refinement of other classes in this study.

The InterIMAGE software is in development and partnership between the Laboratory of Cartography (GEOCART) and Remote Sensing Group (ESPAÇO) at UFRJ and Computer Vision Lab at PUC-Rio is providing engagement between researchers and graduate students and post-graduate seeking other applications in remote sensing, geomorphology and geoecology.

5. ACKNOWLEDGEMENTS

Prof. Raul Feitosa, Dr. Gilson Costa and MSc. Rodrigo Ferreira of the Computer Vision Lab (LVC PUC-Rio) for all the support provided in development InterIMAGE Project and partnership.

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