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Land use mapping from CBERS-2 images with open source tools by applying different classification algorithms

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ABSTRACT

Land cover classification is often based on different characteristics between their classes, but with great homogeneity within each one of them. This cover is obtained through field work or by mean of processing satellite images. Field work involves high costs; therefore, digital image processing techniques have become an important alternative to perform this task. However, in some developing countries and particularly in Casacoima municipality in Venezuela, there is a lack of geographic information systems due to the lack of updated information and high costs in software license acquisition. This research proposes a low cost methodology to develop thematic mapping of local land use and types of coverage in areas with scarce resources. Thematic mapping was developed from CBERS-2 images and spatial information available on the network using open source tools. The supervised classification method per pixel and per region was applied using different classification algorithms and comparing them among themselves. Classification method per pixel was based on Maxver algorithms (maximum likelihood) and Euclidean distance (minimum distance), while per region classification was based on the Bhattacharya algorithm. Satisfactory results were obtained from per region classification, where overall reliability of 83.93% and kappa index of 0.81% were observed. Maxver algorithm showed a reliability value of 73.36% and kappa index 0.69%, while Euclidean distance obtained values of 67.17% and 0.61% for reliability and kappa index, respectively. It was demonstrated that the proposed methodology was very useful in cartographic processing and updating, which in turn serve as a support to develop management plans and land management. Hence, open source tools showed to be an economically viable alternative not only for forestry organizations, but for the general public, allowing them to develop projects in economically depressed and/or environmentally threatened areas.

1. Introduction

The planning and management of natural resources for the spatial planninig comprises among other aspects of a soil characterization study. This means, manage, analyze and handle large volumes of spatial information. For this reason, the use and management of geographic information systems (GIS), is essential for this task, thanks to its ability to store and process the data set. The information in these cases comes from primary or secondary sources. In the first case, they are collected in the field through direct measurements. In the second case, there are those which come from documentation, maps, aerial photographs, radar images, satellite images, handled through the digital image processing as can be supervised classification methods among others (Chuvieco, 2007).

The supervised methods are effective and accurate in classifying satellite images. Due to they are based on mathematical algorithms, these methods can be applied at the individual pixel level or to image objects (groups of adjacent, similar pixels). Some of the more common classification algorithms used for supervised classification include the Minimum-Distance to the Mean Classifier, Parallelepiped Classifier and Gaussian Maximum Likelihood Classifier

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(Kamaruzaman et al., 2009).

Remote sensing data are widely used for the identification and classification of land cover. Satellite images are useful in many applications related to the monitoring of the environment, such as forestry, agriculture, hydrology, geology, etc. (Bosque et al., 1988). These images are classified according to the values of each pixel, they are divided and grouped together forming the so-called thematic classes. Pixels with similar spectral properties form part of the same class. The image classification for the soil characterization is based on the response of the different spectral signatures present in the terrestrial coverage, influenced in turn by the set of bands and the ability of the application to distinguish clearly between one and another spectral signature within the same image (Kiptala et al., 2013).

There are several methods for classifying satellite images, the most common so far offers good results, being this one, the supervised classification method. This method involves some specific algorithmic functionalities that through the software they are being run on are open source or not, and they will present different classification mathematical algorithms, such as the Bhattacharya algorithm, Maxver or maximum likelihood and Euclidean distance or minimum distance. The method requires prior knowledge of the land coverage types to guide the algorithm in its classifying process (Kamaruzaman et al., 2009). The accuracy of the classification by the supervised method is measured by assessing the accuracy of the results obtained in order to achieve maximum reliability by the user and to ensure their maximum quality on the part of the mapping producer (Macedo, 2012).

The digital classification of images requires operational methodologies, interpretable, transparent and likely to have a high degree of automation. In the land cover cartography, starting from remote sensing data, many methodologies have been used, mainly of parametric type (maximum probability algorithm). However, due to the high availability of data and consequence of high technological development, the classification algorithms have emerged as exact and efficient alternatives to the conventional parametric techniques in the land cover mapping (Vorovencii and Muntean (2013).

A transparent and operational methodology to analyze the digital information can be addressed using GIS software applications based on free solutions (Bonet et al., 2014). These tools promise an improvement in the economy, with respect to proprietary solutions (exclusive). Major trading houses develop complex algorithms and processes, optimize the physical resources in the handling of large volumes of data. However, these processes are linked to high costs in the software license acquisition, limiting its use and affecting the scientific research (Guillen et al., 2006). On the other hand, the initiatives based on open-source solutions constitute a viable economic alternative and sustainable at a local, regional, and national level. These are significant advantages over exclusive trading houses, among them; greater interoperability, free competition, and allows working on mutual collaboration between users and developers around the world. These types of licenses are classified according to their access degree and use in; GPL (General Public License), AGPL (Affero General Public License), MPL (Mozilla Public License), among others (Andrew and Laurent, 2004). In this sense, the software licensed under this mode makes it necessary to give a series of basic freedoms to the user, the availability of source code being the most important, which can automate and industrialize processes (Stallman, 2005).

Open access GIS software use Geospatial Data Abstraction Library (GDAL/OGR) in order to achieve a greater interoperability. This library represents a common framework between privative and open source software and it is the prime database engine of many applications, including MapServer, GRASS, QGIS, and OpenEV. The use of this library guarantees a long term access to data stored by the system. This library is also used by OSSIM, Cadcorp SIS, FME, Google Earth, VTP, ILWIS, MapGuide and ArcGIS. GDAL/OGR multiplatform, based on open source X/MIT style, provides command line tools for converting and processing a wide range of geospatial data formats, both vector and raster. The most popular types of supported raster formats are GeoTIFF, Erdas Imagine, ESRI Grids, ECW, MrSID, while the supported vector formats are MapInfo (tab and mid/mif), ESRI Shapefile, ESRI Coverages, ESRI Personal Geodatabase, DGN, PostGIS, Oracle Spatial, and others (GDAL, 2015).

Currently studies have been developed aimed at environmental management and assessment using open source GIS tools such as Spring, Grass, GvSIG, Saga, Kosmo Quantum GIS, CNAE, (open source) MapServer, PostGIS, MySQL, OpenLayers (Altobelli et al., 2010; Ortiz, 2011). In many cases, the work carried out from these tools are usually published in the network through catalog services, according to the definition of the Open Geoespatial Consortium (OGC), through the spatial data infrastructure (SDI) services (Martínez de Antoñana, 2008; Bonet et al., 2014). These services provide useful products for the final user, and contribute among other things with the decision-making processes (Olaya, 2011, Kelly et al., 2013). These services include real-time download and analysis of information, such as the MODIS (Moderate Resolution Imaging Spectroradiometer) images, USGS (Science for a Changing World), CBERS (ChinaBrazil Earth Resources Satellite), in order to promote research and development (Valencia and Anaya, 2009, Argañaraz and Entraigas, 2011).

This study proposes a low cost innovative methodology that allows the generation of thematic cartography of land use and types of coverage from satellite images and GIS tools based on open source code, in order to have an information system for the land planning and management when there are not enough resources. The information analysis includes different classification algorithms, they are filed in a data storage array and subsequently integrating models are built on the land use and their types of coverage. By automatization, the qualitative and quantitative aspects of the determined classes are also identified, as well as the space-time level of detail required for its evaluation (Larocque et al., 2014).

2. Material and methods

2.1. Study area

The study was carried out in the Sotillo and Casacioma municipalities (Fig. 1) from the Monagas and Delta Amacuro states in Venezuela. These municipalities border to: Tucupita, (Delta Amacuro state), Uracoa and Libertador (Monagas state) on the north, Piar, Caroni, and Padre Pedro Chien (Bolivar state) on the south, Antonio Diaz (Delta Amacuro) on the east, and Libertador and Independencia (Anzoategui state) on the west.

Casacoima municipality, with an area of 2.929,69 km^2 and a population of 29.200 inhabitants (INE, 2014a), is geographically located in coordinates 07°46′ – 10°04′ N y 59°47′ - 62°36′ W, according to World Geodetic System 84 (WGS84) reference system. The main geological formations identified at the site, correspond to The Macizo Guayanès oriented to the south and Delta Del Orinoco located at the north (Lozada et al., 2011). The annual average temperature is 26,7 C^o and a high rainfall with more than 2.000 mm every year is registered. Vegetation present in the study area is semi-arid forest type, with savannah areas (Roa, 2010).

The Soltillo municipality has an area of 1.939 Km^2 and a population of 20.510 inhabitants (INE, 2014b). This municipality is

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