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GEOBIA 2014 Advancements, trends and challenges, 5th Geographic Object-Based Image Analysis Conference, Thessaloniki, Greece, May 21-24, 2014

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Special Thematic Issue

Editorial

This special issue of South-Eastern European Journal of Earth Observation and Geomatics includes the extended illustrated abstracts presented at the Geographic Object-Based Image Analysis conference (GEOBIA 2014), held in Thessaloniki, Greece. Apart from these conference proceedings, short abstracts of all presentations can be also found in the abstract book compiled alongside.
The conference was hosted by the Laboratory of Forest Management and Remote Sensing, Aristotle University of Thessaloniki and the Interbalkan Environment Center. GEOBIA 2014 was the fifth conference on geographic object-based image analysis following the successful bi-annual GEOBIA conferences held in Salzburg (2006), Calgary (2008), Ghent (2010), and Rio de Janeiro (2012) that have provided the impetus for much progress in Geographic Object-Based Image Analysis.
GEOBIA 2014 eventually gathered over 200 participants from 41 countries, 5 keynote addresses, 2 industry led workshops, one special session on ontologies co-organized with IRD-ESPACE-DEV unit and a round table with renowned experts representing international associations, academic, industry, public sector and governmental organizations. Both oral and poster contributions presented the more recent evolutions on conceptual and methodological aspects of geographic object-based image analysis as well as innovative applications over a broad spectrum of domains. As a continuum of GEOBIA 2014, a special issue of Photogrammetric Engineering & Remote Sensing journal, has been also arranged for publication in 2015 where all conference participants are invited to submit a paper.
GEOBIA 2014 verified the progress and the growing interest in geographic object-based image analysis as demonstrated also by the increasing number of high-quality peer-review manuscripts appearing in the literature and the recent development of GEOBIA-related (open source/commercial) software packages. Since emerging early in the 21st century, GEOBIA has incorporated and developed established concepts, motivating an image processing shift from pixel to object-based approaches within the remote sensing community. The increased availability of the H-resolution scene model, analysis on meaningful objects rather than arbitrary defined spatial units, provision of a conceptual framework for representing the multi-scale structure of nature as well as development of powerful computing tools and commercial software were among the main reasons triggering the GEOBIA evolution at first place.
Within the last two decades and through various conceptual developments, GEOBIA has gained wide popularity and attracted the interest of both the scientific and professional communities, for its efficiency to provide enhanced and reliable geospatial intelligence.
The increased availability and the wide range of Earth Observation and geospatial data as well as the establishment of global initiatives such as the Global Earth Observation System of Systems (GEOSS), it is expected that it will further stimulate evolvement and spread of the GEOBIA paradigm not only among the Remote Sensing and GIScience communities but to a broad array of earth-related disciplines.

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Discrimination of tropical agroforestry systems in very high resolution satellite imagery using object-based hierarchical classification: A case-study in Cameroon

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Abstract: Tree crops and agroforestry systems are very representative of tropical agricultural landscape. Automatic recognition and mapping of this typical land cover type is thus a challenge for the use of remote sensing in driving issues in food sustainability. Therefore, this paper presents an attempt to use the potential of the object-based approach in image classification to produce a land-cover map of a complex agroforestry area. This case-study focuses on very high spatial resolution data acquired over the savannah/cocoa/forest transition region of Bokito in Cameroon, providing a large panel of various cropping systems. WorldView2 panchromatic and multispectral data are thus processed through textural indices derivation and principal component analysis, to select the more discriminant attributes for the different land-cover types, resulting in a stack of 32 image layers. The object-based approach is then run on eCognition Developer, combining several levels of multiresolution segmentation and consecutive classifications that involves different criteria at each step. At the end, a land-use map based on 13 classes was produced with 85% of global accuracy, evaluated based on ground-truth data and photointerpretation. Its typology is rather fine, especially for the agroforestry crops displaying complex structures, and that would not have been accurately delimitated nor discriminated with a pixel-based approach.
Keywords: Remote Sensing, Agriculture, Sustainable Development, Image processing and analysis.

1. Introduction

Tree crops, and moreover agroforestry systems that associate different kinds of trees in a complex structure, are still a challenging type of land cover for automatic recognition and mapping. Even though, it is very representative of a tropical agricultural landscape, and thus mapping these types of agricultural systems drives several issues in food sustainability. Coarse or medium resolution images do not provide with enough details to differentiate forests from tree plantations, bushes, savannah, or even dense herbaceous vegetation, while very high spatial resolution implies a high intra-plot spectral variability of woody lots that impede automatic mapping. We here propose an object-based approach, combining both textural and spectral information of a very high spatial resolution image into the mapping process, at segmentation as well as classification levels. It is tested over a WorldView2 image acquired over the region of Bokito in Cameroon, where the landscape is ruled by a matrix of savannah patches, live crops, palm/citrus/cocoa crops in more or less regular plantation, and cocoa-based agroforestry plots. This area is thus variable enough, with quite a complexity in structure and organization, to provide with a good sample of agroforestry situations, so that the method could be reusable in other regions.

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2. Satellite Data and derivate attributes

WorldView2 satellite data was acquired in 2011, February the 21st, in 8 spectral bands in visible and near-infrared, at 2m/pixel resolution, bundled with a panchromatic image acquired at 0.5m/pixel. The image frame covers about 110km2 directly East of Bokito village, in the Mbam and Inoubou Central Cameroon District. These data were orthorectified on the basis of SRTM digital terrain model. They were then calibrated to top of canopy reflectance using the sensor characteristics and the acquisition configuration data. Finally, the Soil Adjusted Vegetation Index (SAVI, Huete 1988) and the Brightness Index (BI) were calculated on the multispectral images.

A set of 73 texture indices based on the co-occurrence matrix statistics (Haralick et al., 1973) was also derived from the panchromatic image: variance, entropy, and correlation with various combinations of kernel size (3, 7, 9, 13, 15, 19, 25, 31, 35, 41, and 51 pixels) and orientation (0°, 45°, and 90°). The 21 most discriminating indices in regards with tree crops and other land cover classes were then selected by means of a principal component analysis. Finally, these 32 attributes including the panchromatic image, the 21 texture indices, the 8 spectral bands, the SAVI, and the BI, were stacked for the classification processing.

3. Image classification procedure

The object-based approach is run on eCognition Developer software. The process tree includes 7 levels of multiresolution segmentation, each of them followed by a dedicated hierarchical classification. At each level, different criteria are used for the segmentation and for the classification respectively (cf. table1). Basically, the two preliminary steps help creating a mask, respectively for clouds and cloud shadows on one hand, and buildings and roads on the other hand. Then, a third level consists in discriminating tree covers from low vegetation. Further process follows two directions depending on the presence or the absence of tree in the object, and leads finally to an identification of:

- palm tree plantations, modern cocoa plantations, traditional cocoa plantations in agroforestry system, and silk-cotton trees (kapok), in the first branch,
- taro crops, other food crops, annual crops, savannah, and burned areas, in the second branch.

Table 1. Description of the seven levels of segmentation and subsequent classifications (P=panchromatic, CB= costal blue, B=blue, Y=yellow, R=red, RE=red-edge, Entr19= entropy in 19 pixels neighborhood, Entr25=entropy in 25 pixels neighborhood).

Level	Scale	Attributes used for segmentation	Discriminated Classes
1	1850	CB + Y + R + RE	Clouds & Shadows
2	160	P + Y+ R + RE + BI	Roads , Buildings
3	400	P + R + RE + NIR2 + SAVI	Low vegetation, High vegetation
4	400	Y +R + RE + NIR1 + Entr19	Taro, Burnt areas
5	200	P + CB + B	Savannah, Annual crops, Food crops
6	400	R + RE + NIR1 + SAVI + BI	Kapok trees
7	425	P + R + RE + SAVI + Entr25 + BI	Traditional cocoa-based systems, Modern cocoa groves, Sunlit cocoa trees in traditional systems, Palm trees plantations

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4. Results

A land cover / land use map was finally produced, providing 13 classes: 1=clouds/shadows, 2=buildings, 3=roads, 4=burnt areas, 5=savannah, 6=annual crops, 7=taro, 8=other food crops, 9=cocoa in modern estate, 10=sunlit cocoa in traditional agroforest, 11=traditional agroforest, 12=kapok trees, 13=palm trees plantation. Figure 1 presents two examples of places mapped with this classification, displaying a very precise typology of the agroforestry systems. This classification was then validated on the basis of ground-truth data and photointerpretation at the plot object level (cf. Table 2). The global accuracy is of 85%, with a kappa index of 0.836.

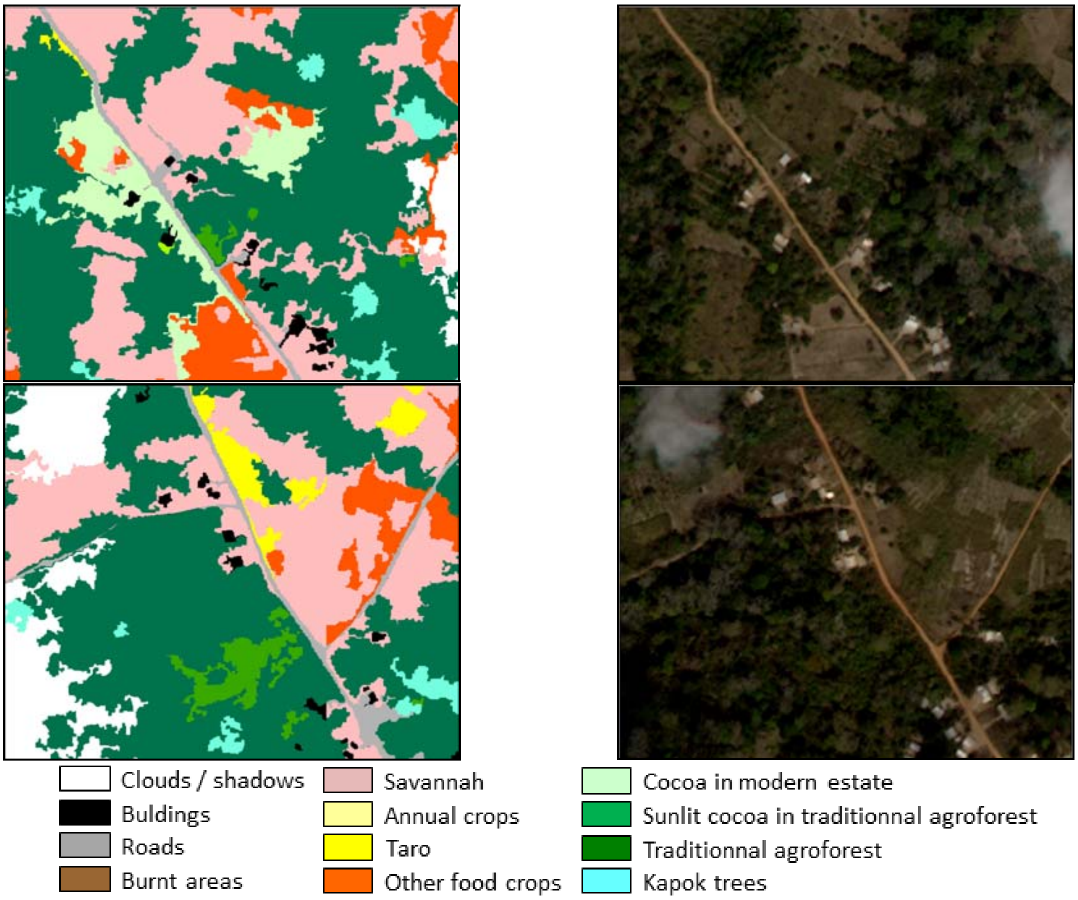

Figure 1. Two zoomed areas of the resulting land-cover map showing detailed accuracy of the classification and a detailed typology of the agroforestry systems.

Confusion mainly occurs between the classes 10-sunlit cocoa in cocoa agroforest and 11-traditional agroforest in one hand, and 11-traditional agroforest and 12-kapok trees on the other hand. The first one is thematically acceptable when considering that both classes belong to the same agrosystem. The second one is also of minor importance because kapok trees as only a component of the traditional agroforests, most of the time easily distinguishable but with little interest. The resulting classification is thus of high accuracy and gives a fine typology of different agroforestry systems.

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Table 2. Confusion matrix of the resulting classification

Classes	2	3	4	5	6	7	8	9	10	11	12	13	ObjectNb
2	*42*	0	0	0	0	0	0	0	0	2	0	0	44
3	2	*47*	0	4	1	1	0	0	0	0	1	0	56
4	0	0	*45*	4	0	0	0	0	0	0	0	0	49
5	0	2	6	*77*	3	4	2	0	0	0	0	1	95
6	0	0	0	2	*44*	1	0	0	0	0	0	0	47
7	0	0	0	0	0	*35*	0	0	0	0	0	0	35
8	0	0	1	5	0	3	*51*	0	0	0	0	0	60
9	0	0	0	0	0	0	0	*12*	0	0	0	0	12
10	0	0	0	0	0	0	0	0	*29*	1	1	0	31
11	0	1	0	6	0	5	0	1	18	*100*	11	0	142
12	0	0	0	0	0	0	0	0	0	0	*37*	0	37
13	0	0	0	0	1	0	0	0	2	0	0	*49*	52
ObjectNb	44	50	52	98	49	49	53	13	49	103	50	50	*660*

5. Conclusions

An accurate land-cover/land use map was produced on the basis of an object-based classification of WorldView2 images, with 13 classes including 5 classes of tree stands and agroforestry systems. The typology is rather fine, especially for the agroforestry crops displaying complex structures, and that would not have been accurately delimitated nor discriminated with a pixel-based approach. Even if some confusion still remains between very similar types of canopies, this study shows the potential of high level of process-tree in object-based approach to discriminate between different agroforestry systems.

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