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A Pedagogical Proposal: Classification Of Pavement Types From An Othoimage Using Object-Oriented Analysis.

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ABSTRACT.

The traffic in Bogotá City, capital of Colombia, is very high due to convergences of all transport system and constitutes by itself the commercial, cultural and industrial center of the country. Withurban growthand economic development ofthe city,thenumberofvehiclescirculatinginitisincreasing yearafteryear, mainlyinthe metropolitan region. Due to this phenomena, it's been observed a deterioration in the road network of the city and it is necessary to search alternatives that can mitigate this problem.In this context, the central purpose of this research is to classify the types of pavements of urban roads in Bogotá, using orthoimages produced by the Geographic Institute "Agustín Codazzi", acquired by a high spatial resolution camera Vexcel UltracamD, in order to find an alteranative to map the roads that need to be restored. To evaluate the method, a study was developed in small downtown area using the OBIA (Object Based Image Analysis) approach implemented in Ecognition software. The results show that OBIA approach produces thematic map of the types of pavements of the study area with an accuracy of the 58,19% (Kappa).

Keywords: Fuzzy function, Obia, Geobia, Object Orientated, Orthoimage.

I. INTRODUCTION

The current remote sensing systems, orbital or airborne, are characterized by the ability to generate data with a potential to discriminate better and better the objects on the earth's surface, mainly due to the increase in their spatial and spectral resolution. The availability of high spatial resolution data is being extended to the possibility of urban studies using this technology, both for coverage mapping and for the definition and characterization of urban land use. Thus, the use of these data in urban areas is growing by leaps and bounds as the potential of remote sensing is demonstrated and confirmed in different applications.

The knowledge of the spatial, spectral and radiometric behavior of the objects to be analyzed from digital airborne images is becoming more and more suitable for intra-urban studies with the increasing resolutions of the sensors installed on board the new digital aerial cameras. The fragmentation of the area provided by the spatial resolution enables the analysis and mapping of the coverage with greater possibility for the characterization of intra-urban objects.

Currently, the use of automatic and semi-automatic techniques for the extraction of urban and intra-urban information from high spatial resolution images is the subject of several studies, with emphasis on object-based analysis techniques or OBIA (Object Based Image Analysis), [1][2].

In his work, Pinho (2005) identified the attributes that best describe intra-urban land cover classes using OBIA. Today, one of the main efforts of the remote sensing research community has been the conception and evaluation of automatic and/or semi-automatic urban land cover classification methodologies [3] - [4] [5] [6]. Thus, the use of a new concept such as GEOBIA (Geography Object Based Image Analysis), which integrates geographic information sciences, making an approach to automatic and semi-automatic classification methods for use in remote sensing image-objects, evaluating their characteristics by means of spatial, spectral and radiometric parameters, makes this concept more and more evaluated and applied by the research community.

Finally, the application of GEOBIA leads to the core objective of developing and applying theory, methods and tools to support and assist human interpretation of remotely sensed imagery, automated and/or semi-automated processes that result in increased throughput, reduced time, subjectivity and cost benefits[7].

STUDY AREA

The area selected for this study is located in the city of Bogotá, capital of the Department of Cundinamarca and Colombia (Figure 1). Within this area there is a sector of the city center, which has the characteristic roads containing the types of pavements to be evaluated in this study, such as: asphalt, concrete and earth.

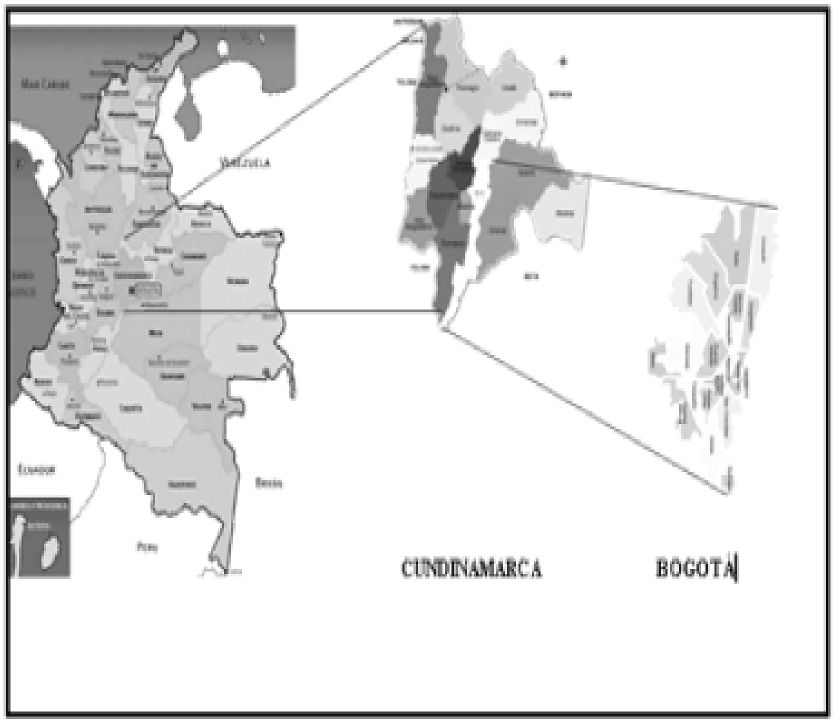


Figure1: General location of the project area.Source. AuthorsSource.

The area considered in this research covers an approximate surface of 72.26 hectares and a perimeter of 3490 m measured in the image which has been rectified and delimited by the yellow and black line, as shown in Figure 2.

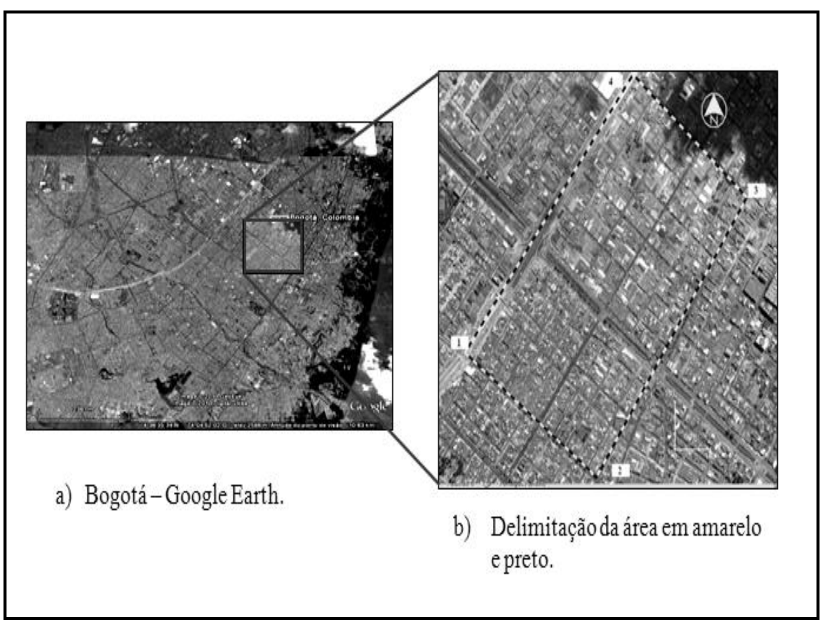


Figure 2: Specific location of the area**.**source. Orthoimaging VexCel UltraCam D

The area includes the neighborhoods of Paloquemao, Ricaurte, La Pepita, Santa Isabel and Industrial. The coordinates of the orthoimage are referenced to the Magna Sirgas Datum, which has its origin in the pillar of the Astronomical Observatory of Bogota, with the following coordinates: N 4 º 35' 56,57" y E 74 º 04' 51,30"; the maps of the Geographic Institute "Agustín Codazzi" in smaller scale than 1:500.000 use flat coordinates in meters and not geographic latitude/longitude coordinates. Planar coordinates are based on a cartographic projection system that represents the spherical surface of the earth projected on a plane; the system used in Colombia is the Gauss-Krugger system. Thus, Colombia has five origins for its plane coordinate system, separated by 3° of longitude. The main or central origin of the coordinates is defined by the pillar of the Astronomical Observatory of Bogota, attributing to the origin coordinates the values of 92,334.88 m. to the East and 109,320.97 m. to the North, (false East and false North) in order to georeference the orthoimage of study, its coordinates are presented in Table I.

Table 1. Plane coordinates of the ortho image - datum Bogota. Source. Authors

Plane coordinates of the ortho image - datum Bogota

CORNER	E(m)	N(m)	ADDRESS	
1	97.436,90	100.790,20	1-2	Calle 3ra
2	98.063,84	100.355,52	3-4	Calle 19
3	99.320,85	102.008,55	2-3	Carrera 24
4	98.794,22	102.450,54	1-4	Carrera 30

1. Material

The following data and programs were used to carry out this work:

a) Ortoimage of high spatial resolution aerial image, from 2009, in blue bands (390-470 nm), green (420-580 nm) and red (620-690 nm), provided by the Instituto Geográfico "Agustín Codazzi" (Geographic Institute "Agustín Codazzi") in Table II, some specifications of the orthoimage are presented.

Table2. Orthoimage specifications. Source. Hhtp:/web Gtbi.net/cms/GTBiWeb/products

Data	Feature
Sensor type	CCD
Pixel size	9µm
Spatial resolution on the	0.15m

ground	
Radiometric resolution	$> 12\ bit$
File type	TIFF
Image size	$4.008 * 2.672$ Pixel
Camera	VEXCEL- ULTRA CAMD

b)Vector file prepared at a scale of 1:2000 with the information of the blocks of the study area.

Software used:

a) Ecognition (v. 8.0): Software used in multiresolution segmentation, based on the evolution of fractal network techniques or FNEA. (Fractal Net Evolution Approach).

b) ENVI 4.4 (Free Demo): Applied in the generation of textures and Main Components.

c) ERDAS Imagine 9.1 (Demo free):Used in the digitization of the study area boundary, cutting of the evaluation area and de-termination of the coordinates.

d) ARC-VIEW 3.2 (Demo free): File generation *.shp (cuadras), for export to Ecognition software.

2. METHODOLOGICAL PROCEDURE

The methodology presented is based on the object-oriented approach, where a problem or application is represented by a collection of objects that have their own characteristics and interact with each other. [8].

The image must be segmented for the objects to be created, which then have attributes that allow the construction of a semantic structure, whose descriptors are passive association and the application of fuzzy logic rules, enabling context analysis. Thus, knowledge can be fixed through the geometric and thematic structures of the objects based on their spatial relationships. In compliance with the objective of the present work, the following procedure was proposed, illustrated in Figure 3.

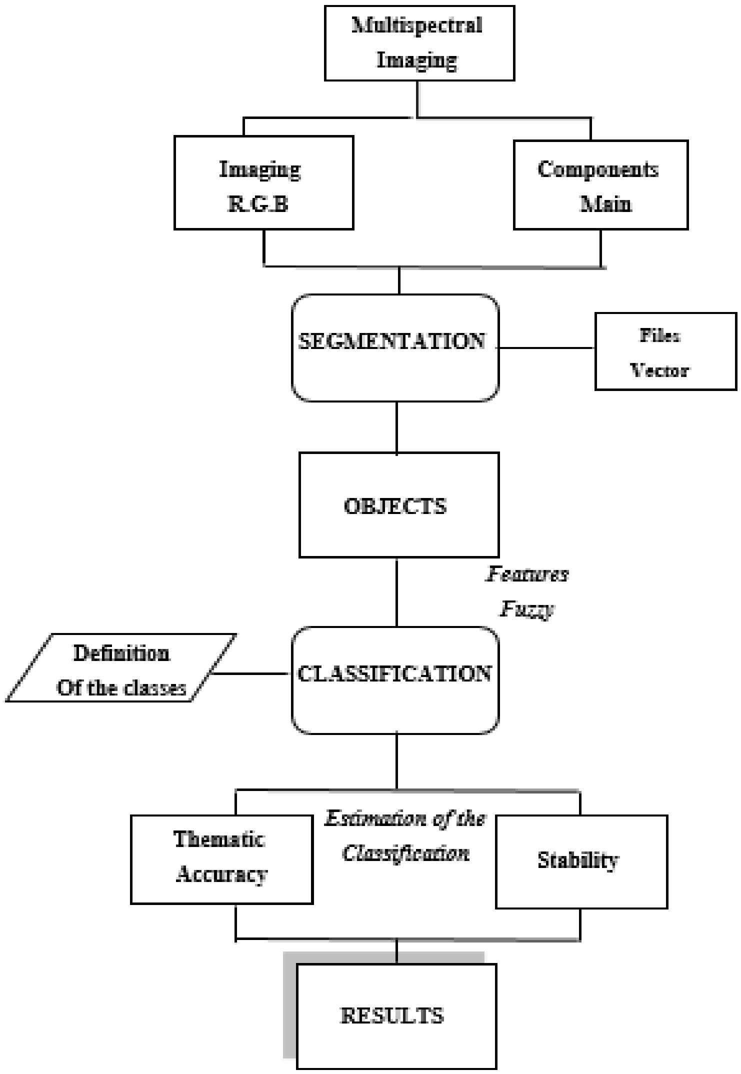
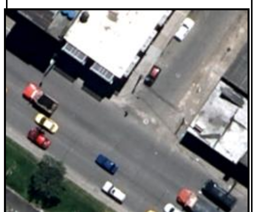
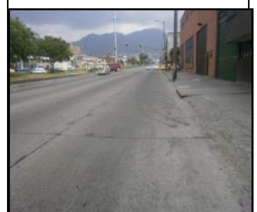
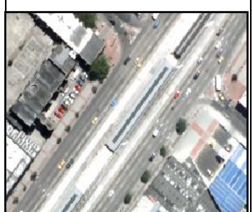
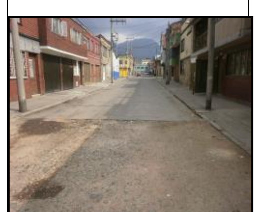


Figure 3. Methodological procedure.Source: Authors

3. DEFINITION AND CHARACTERIZATION OF THE CLASSES

The selection and characterization of the classes of interest (types of pavements of urban roads) were made based on the visual interpretation of the orthoimage, identifying the paveents of the roads as: concrete and asphalt; and in the unpaved roads as: gravel, asphalt, asphalt, asphalt, asphalt, asphalt, asphalt, asphalt, asphalt, asphalt, asphalt, asphalt, asphalt, asphalt and asphalt.

The characterization of the classes was aided by the elaboration of "interpretation keys" such as: size, shape, location and texture, in addition to field work. Figure 4 shows the "interpretation keys" relating the classes of interest and their respective characteristics.

Class	**Orthoimage sampleRGB (123)**	**Color**	**on-site photography**	**Shape, Size, Texture.**
Road with Concrete pavement_a		Light gray and dark colors in heavy traffic parts.		Rectangular shape, smooth texture, non-fixed size.
Concrete paved road_b		Light gray colors.		Rectangular shape, smooth texture, non-fixed size.
Road with asphalt pavement		Well-defined black colors, and light gray in the older parts		Rectangular shape, smooth texture, non-fixed size.
Land Road		Light and dark red color.		Rectangular shape, rough texture, non-fixed size.

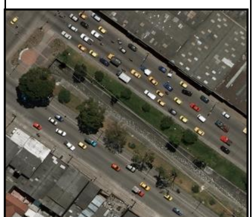
courts		Mix of green, red, light gray and dark blue colors.		Rectangular shapes with rough and smooth textures, large size not fixed.
Others		Mix of green, red, light gray and dark colors.		Rectangular and circular shapes, rough and smooth textures, non-fixed size.

Figure4: Interpretation Keys. Source. Authors

4. SEGMENTATION

From the beginning, two levels of segmentation had been defined in Figure 5; one for the extraction of the blocks and roads and another for the classification of the types of pavement of the same, but with the integration of the vector file of blocks it was not necessary to perform the second level of segmentation, leaving in practice only one level.

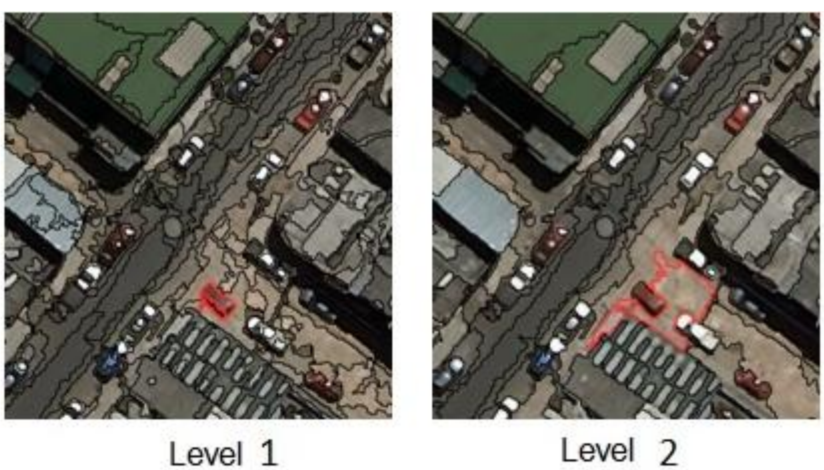
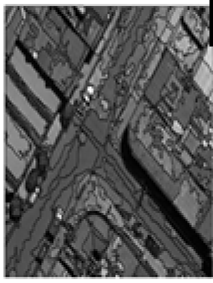


Figure 5: Segmentation levels. Source. Authors Ecognition Software

Once the segmentation level was defined, as well as the parameters of scale, shape and compactness which were evaluated, the segmentation level was chosen with scale 30, shape 0.1 and compactness 0.5 (Table III), the segmentation algorithm used for this evaluation was the multiresolution segmentation (mutiresolution segmentation).

Table 3.Parameters chosen for segmentation. Source. Authors, Ecognition software



Segmentation settings	
multispectral band weights	1.1.1
Scale parameter	30
Homogeneity criterion composition	
Form	0.1
Compactness	0.5

5. DEFINITION OF CLASSES

After the segmentation process, the classes used for orthoimage classification were structured. The elaboration of these structures followed the attributes of the interpretation keys. Thus, the orthoimage presents eight classes (Asphalt, Concrete_a, Concrete_a, Concrete_a, Cairns, Bridge structures, Background, Squares and Soil) Figure 6.

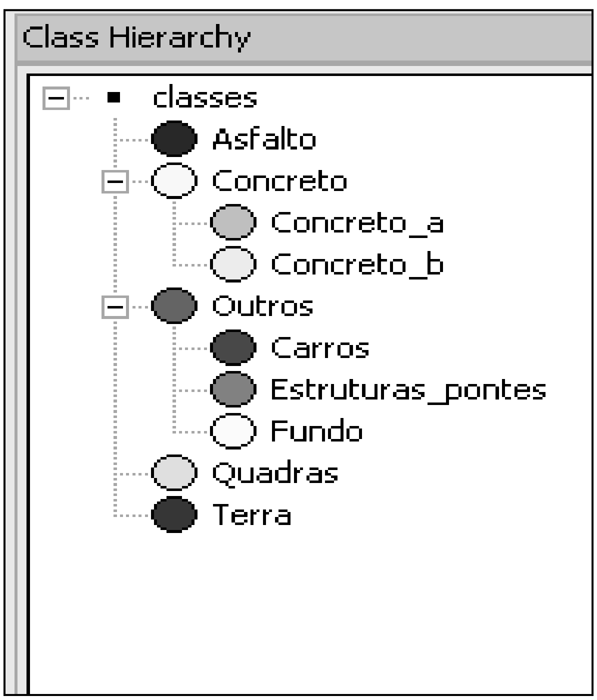


Figure 6: Classes. (Original image of the software in Portuguese). Source. Authors, Ecognition software

6. DEFINITION OF ATTRIBUTES AND RULES OF RELEVANCE

To perform the classification using the Ecognition software, it is necessary to have three well-defined preliminary phases: knowledge of the characteristics of the objects or attributes inherent to the objects, the application of Fuzzy or Boolean logic and the use of the logical operators, looking at comparing and analyzing one or all the objects to be classified. At this stage, attributes were used based on the spectral parameters for each of the classes generated from bands 1, 2, and 3 of the orthoimage; the brightness values of each of the bands, the shape functions and the Fuzzy and/or Boolean functions were used.

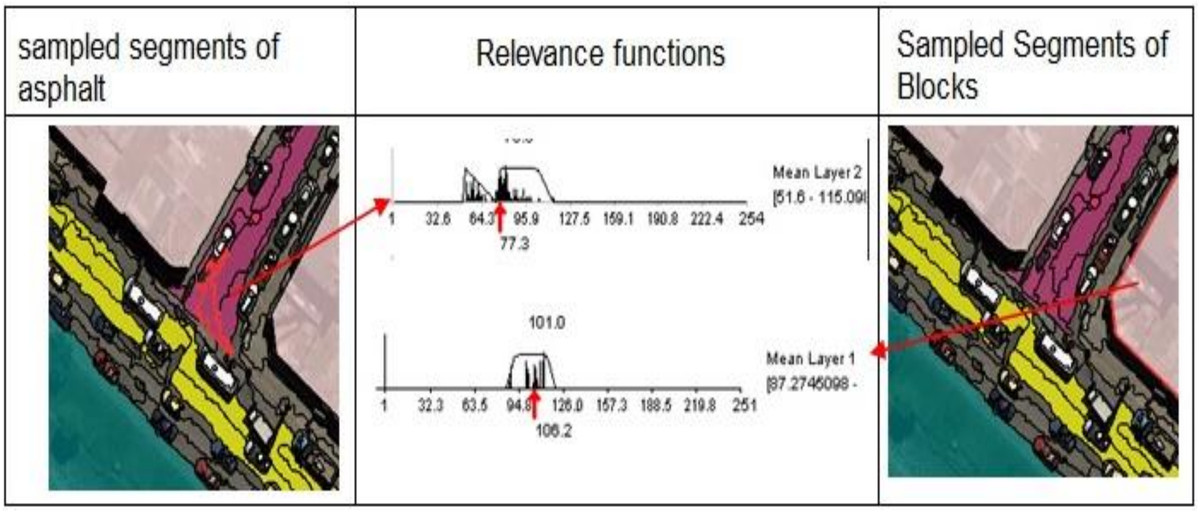


Figure7: Relevance functions for asphalt and squares**.**source. Authors, Ecognition software.

For the "Squares" class, in addition to the spectral attributes, the spatial attributes (area by number of pixels) were used for a better classification of the squares, because there was confusion in the spectral response with the concrete Figure 8.

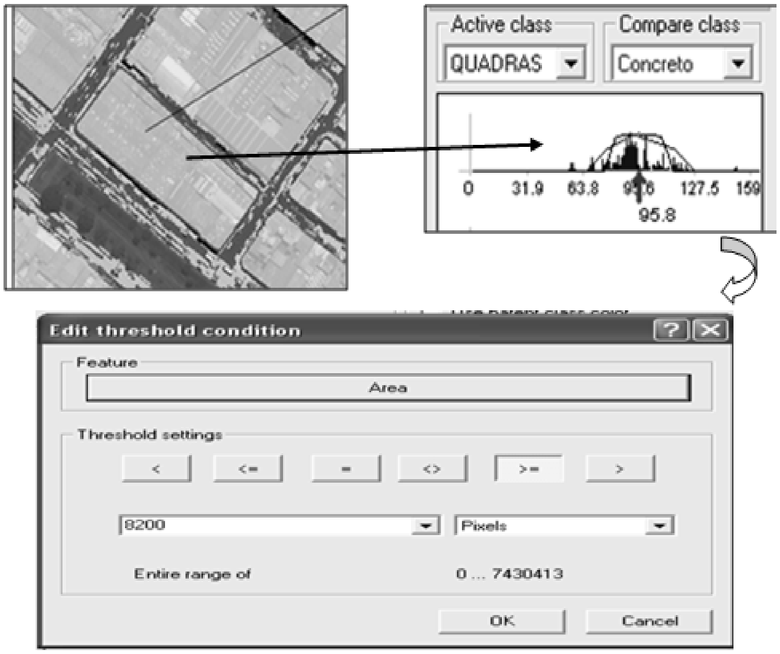


Figure 8: Confusion in the spectral response between QUADRAS and Concrete (The term "QUADRAS" is due to the original use of the software and the language in which the work was presented - Portuguese).Source. Authors, Ecognition software.

7. CLASSIFICATION

The classification was first performed in a smaller area of the study area Figure 9, executing all possible rules and considerations for subsequent application to the total area of the study area Figure 10.

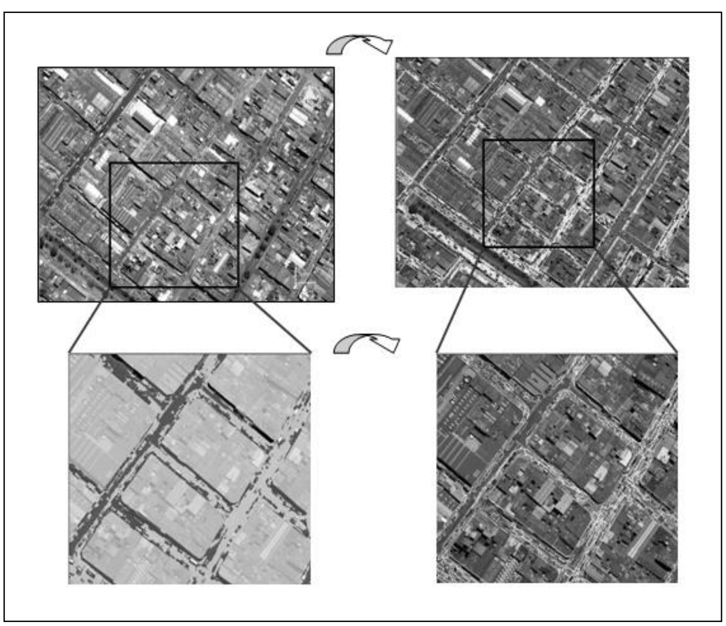


Figure 9: Classification in a smaller area. Source. Authors, Ecognition software.

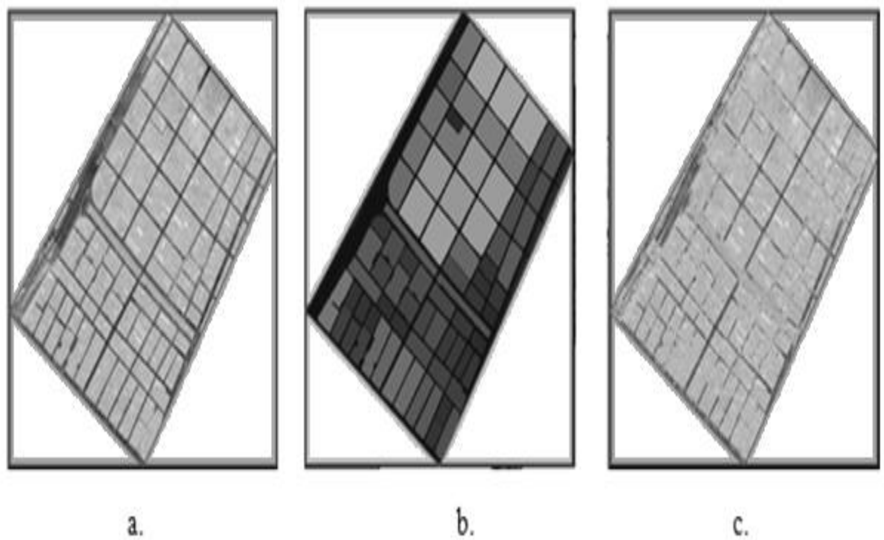


FIGURE 10: Original blocks and tracks (a), edited blocks and tracks (b), and classified tracks (c). Source. Authors, Ecognition software.

8. EVALUATION OF THE CLASSIFICATION

At this stage, two evaluation techniques were used: the confusion matrix through the calculation of statistical coefficients and the analysis of uncertainty measures based on the classification stability statistics. This analysis requires the definition of some parameters such as: sampling scheme; number of sampling elements; type of sampling unit; and reference data. For our study, we used the stratified random sampling scheme by class, which mixes the geographic distribution with the lowest potential for bias. This strategy is particularly useful because it ensures that all classes of study or interest are taken into account.

To estimate the number of sampling elements, equation 1 was considered. With a probability level of 95%, a maximum allowable error of ±5%, and an 85% success rate [9].

$$n = \frac{Z^2 pq}{L^2}$$

Where Z is the probability level that we want to give to the estimation; p, indicates the estimated percentage of hits; q, the percentage of errors (q=1-p), and L, the allowed level of error. This value indicates that at least 196 samples must be taken to obtain the levels of sampling accuracy. Considering that the total number of segments for the classes of interest (Asphalt, Concrete and Soil) was 15,572 segments or polygons, the number of sampling elements was approximated to 200 and the number of segments was calculated proportionally for each of the classes Figure 11.

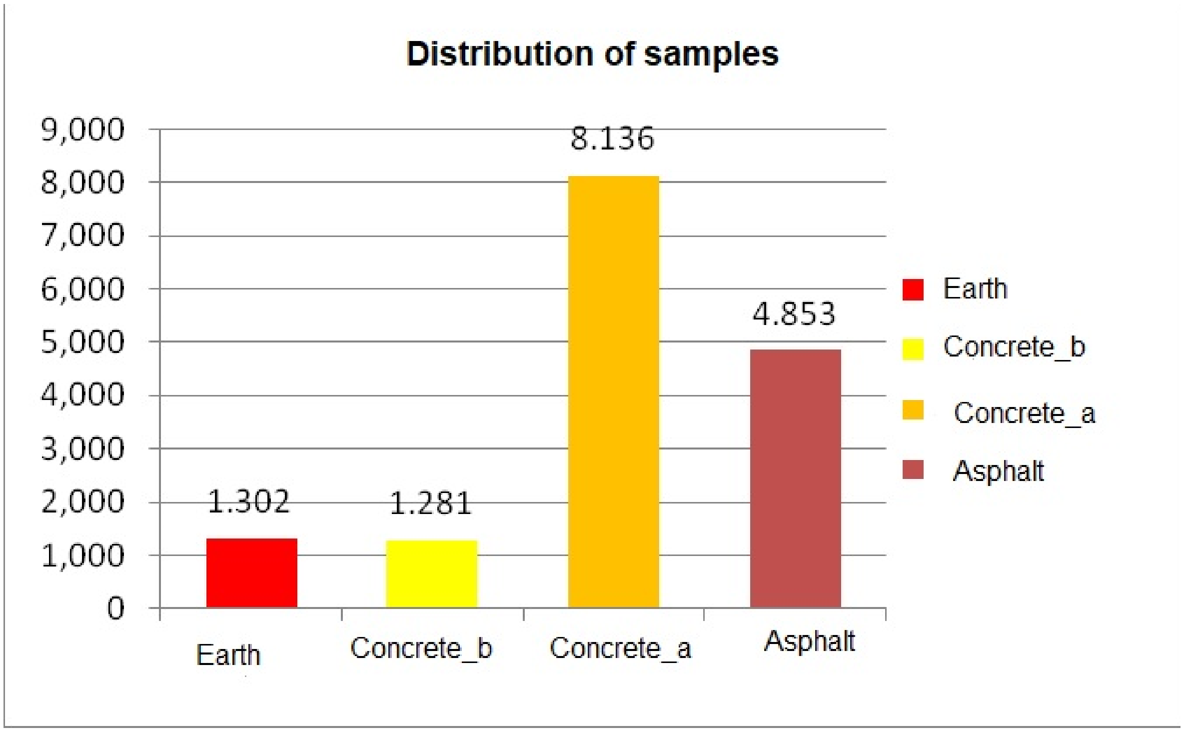


Figure 11: Graphical distribution of the number of samples. Source. Authors.

To generate the samples and their distribution over the study area with a stratified scheme, Ecognition software was used to generate a *.shp file for each of the classes and a table of random numbers for each of the classes was elaborated using Excel software. With the random numbers generated, the classification files and the polygons generated, the confusion matrix of the classes of interest Table IV was elaborated.

Table 4: Matrix of confusion of the classes of interest. Source. Authors.

		Earthly Truth					
		Asphalt	Concrete_a	Concrete_b	Others	Earth	Σ
Classification	Asphalt	42	3	0	17	0	**62**
	Concrete_a	1	75	1	27	1	**105**
	Concrete_b	0	0	10	6	0	**16**
	Earth	0	0	2	2	13	**17**
	Σ	**43**	**78**	**13**	**52**	**14**	**200**

The confusion matrix shows that, of the total number of segments or polygons analyzed, 60 polygons were misclassified, 30% of the total, which means a reliability of 70%. Based on this result, we could conclude that this index was good. However, Congalton and Green (1999) warn that, based only on this global accuracy index, inferences can be misleading and conclude that the calculation and analysis of the User (eu) and Producer (ep) indexes give greater meaning to the data, revealing whether there is any confusion between the categories.

The Kappa concordance coefficient (k), gave a value of 58.19%, presenting a good qualification [9]. For the analysis of accuracy by class, user accuracy (eu) and producer accuracy (e_p)were calculated, with their complementary values of errors of commission (e_c) and errors of omission (e_0) for each of the classes [9].

Table 5: Accuracy rates by class.Source. Authors.

Classes	eu (%)	e_c (%)	ep (%)	e_o (%)	$\hat{k}$ (%)
Asphalt	67,74	32,26	97,67	2,33	96,71
Concrete_a	71,42	28,58	96,15	3,85	92,37
Concrete_b	62,50	37,50	76,92	23,08	75,03
Earth	76,47	23,53	92,85	7,15	92,23

In the classification based on the fuzzy relevance functions approach, the analysis of the thematic quality can be performed through uncertainty measures, which are calculated from the a posteriori probability images provided by the classifier, Figure 12.

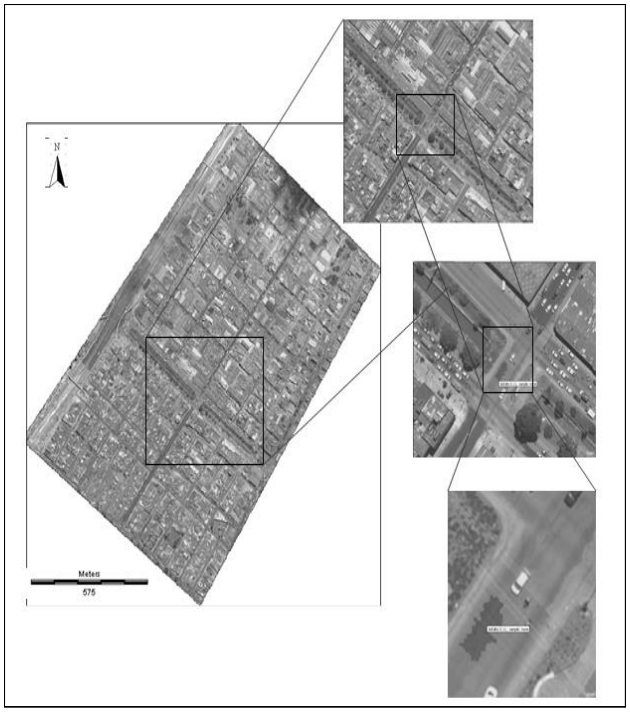


Figure 12. stability of the classification (in red less stable - for this case darker polygon). Source. Authors, Ecognition software

In the a posteriori image provided by the Ecognition software, the stability of the classification can be seen by placing the most stable polygons in green (almost the entire image is green) and the least stable polygons in each of the classes in red.

CONCLUSIONS AND RECOMMENDATIONS

Some of the objects (blocks) can be generated following the rules and processes established in the Object Oriented models, but if we have the possibility to use the existing thematic maps we bring a benefit in time and money to our work.

The kappa index alone has no significant value, it is closely related to the knowledge of the analyst who is responsible for providing the samples and pre-assessing the classification result.

The results obtained in this research motivate the continuity of studies in this field, as well as the mastery of techniques and the knowledge of new classification methods whose theoretical budget is approaching and breaking the barrier of studies of urban and intra-urban objects with airborne remote sensing images with spatial resolution or GSD (Ground Sample Distance) greater than 0.15 m.

Finally, the result of the classification of the types of pavements of urban roads does not intend to present the good or bad condition of urban roads, but to provide the means to meet the demand for accurate and rapid information on the existence of roads that are not suitable for the mobilization of communities in general.

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