An Approach for identifying Crops Types using UAV Images in the Ecuadorian Sierra

A. Sarmiento, G. Taboada and V. Morocho

Abstract. **Spectral signature analysis allows identification of the different types of terrestrial objects and characterizes behaviour of different kinds of vegetation. In Ecuador usually phenological analysis (state of vegetal growing) and crop type are based on acquired manually information. This does not allow taking agile decisions over crops management. The advantages for using UAV images propose a significant change to the current methodologies. This paper presented a correlation study of crop spectral signature using multispectral images from a UAV. Ecuadorian Sierra was the study zone to differentiate the types of crops in an agricultural field. The Inception algorithm of Tensorflow was chosen to generate a crop layer and to predict the crop type with the closest possible approximation from an image.**

***Index Terms*— UAV multispectral images, analysis images, phenological analysis, crop type.**

I. INTRODUCTION

SINCE ancient times, agriculture has become the main means of supplying human beings which has led to improving soil cultivation techniques for the benefit of humanity. In this way, the agricultural sector has become one of the main economic drivers of Latin American countries. In fact, Latin America will be the main food producing region not only for domestic consumption but also for export, and it is estimated that in 2020 it will represent 20% of the world food supply [1].

Latin American countries have abundant territory for agriculture; it can see in Table 1 majority of countries have more than 40% of its territory suitable for agricultural exploitation. Agriculture is one of its main income by exporting your products to various parts of the world.

Over the years new technologies have been introduced in the agricultural sector, and step by step the farming task has been eased by this. As to mention some examples to describe the importance of informatics in agriculture, we have software apps, programs computer for crofts, campaigns and crops management.

Those applications are very useful to keep track of crop rotations, plantings, harvests, post-harvest crops and the agricultural market [2].

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TABLE I
AGRICULTURAL AREA OF LATIN AMERICAN COUNTRIES.

Country	Area (Km2)	Agricultural area (Km2)	Percentage (%)
Argentina	2780400	1487910	53,51
Bolivia	1098580	375150	34,15
Brazil	8515770	2756050	32,36
Chile	756096	158089,8	20,91
Colombia	1141748	426176	37,33
Cuba	109880	64060	58,30
Dominican Republic	48670	24970	51,30
Ecuador	256370	75069	29,28
El Salvador	21040	15670	74,48
Guatemala	108890	44290	40,67
Haiti	27750	17700	63,78
Honduras	112490	32350	28,76
Jamaica	10990	4490	40,86
México	1964380	1067050	54,32
Nicaragua	130370	50710	38,90
Panamá	75420	22650	30,03
Paraguay	406752	215000	52,86
Peru	1285220	243260	18,93
Uruguay	176220	152590	86,59
Venezuela	912050	216000	23,68

Some advantages from the combination between informatics and agriculture are:

- Higher production
- Farmer has more planning time
- Plot Control and its crops during whole period
- Saving in Crop water, fertilizers and other products.
- Obtaining data from the plot in real time
- Automatic irrigation according to weather conditions

In last years the agricultural revolution is being experienced thanks to technology application in its processes such as crops monitoring from the air. It means that agronomists, agricultural engineers and farmers use drones and UAV to obtain another point of view for planning and administering of their operations with greater precision [3].

II. USING IMAGES FOR AGRICULTURE

Looking for the best and optimal technology to images gathering. Often, the question is which of the technology is to be used. Whether satellite images or images obtained from a drone. The drones and UAV are capable of carrying different measurement sensors (thermographic, multispectral, LIDAR, optical). On the other hand, sensors on satellite platforms can include optical and multispectral sensors and, although, there are also thermal and radar sensors, their resolution is not suitable for agricultural applications [4]. The images acquired by sensors on satellite platforms are calibrated by geometric and atmospheric corrections. The latter can cause distortions between images acquired at different times, due to a concentration of aerosols present in the atmosphere. However, these sensors have a high spectral resolution (number of bands), and their spatial resolution (number of pixels) is very large. Which causes the reflection of the ground or adjacent weeds to interfere with the accuracy of take measurements. A satellite image shows the differences by comparison very well, but radiometry from one satellite capture to another from a different date is usually not comparable. Radiometric calibration in cameras for UAV and drones is becoming an easier task. It does not require difficult atmospheric calibration. This feature allows a high precision, even allowing a perfect comparison of images. The latest sensors that can connected to UAVs have fewer bands (spectral resolution), but their high spatial resolution (pixel size) achieves a much more accurate vegetation analysis [4]. In the case of Sequoia® camera have real color and multispectral in the same equipment, then the comparison of bands can be done more accurate yet.

Within the field of agriculture, phenology is a solid indicator of the effects of climate change on natural systems. For example, the principles of sprouting and flowering of plants have been documented in response to recent warming trends. Improved monitoring of vegetation phenology is seen as an important, but simple, means of documenting biological responses to a changing world [3].

TABLE II
MAIN CHARACTERISTICS OF THE EQUIPMENT

Wingspan	Weight	Scope of the radio connection	Removable wings	Camera (supplied)	Optional cameras
96cm (37,8 in)	0,73 kg (1,61 lb)	3 km (1,86 mi)	Yes	WX RGB (18,2 MP)	S110 NIR/RE/RGB

Planner and control	Image processing
eMotion	Pix4Dmapper

Cruise speed	Wind resistance	Maximum flight autonomy	Maximum coverage (one flight)	Automatic landing	Oblique photograph
40-90 km/h (11-25 m/s o 25-56 mph)	Until 45 km/h (12 m/s o 28 mph)	40 minutes	8 km^2 (3 mi^2)	Linear landing with precision of ~ 5 m (16,4 ft)	0 - 50°

Earth sampling distance GSD[1]	Absolute accuracy horizontal / vertical
Until 1,5 cm (0,6 in)/pixel	Until 3 cm (1,2 in)/5 cm (2 in)

III. SPECTRAL PATTERNS DETERMINATION

A. UAV pothographs

In coordination with research group on SDI (Spatial Data Infrastructure) from University of Cuenca, was defined the study zone in an experimental farm, with controlled crops condition, for example documented application of fungicides and fertilizers. The planning and execution of flights with the eBee® RTK drone was carried out on May 23 (Canon® camera) and on May 12. September 2016 (Sequoia camera). Table 2 indicates the most important characteristics of the equipment used.

Within the planning phase of the flight several parameters were established within the application eMotion2® (automated controller of the UAV) as recommended by the manual of Pix4Dmapper® for land with agricultural fields. At least 75% of frontal overlap (with respect to the direction of the flight) and at least 60% of lateral overlap (between flight tracks). Fig. 1 shows an example of the planning configuration.

[1] Ground sample distance. Distance between the central pixels measured on the ground

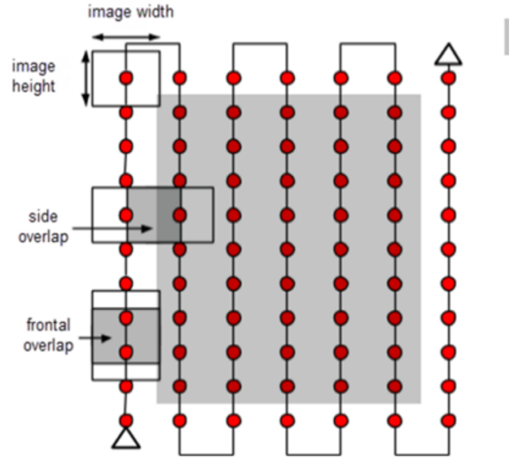


Fig. 1. Ideal acquisition plan for land with agricultural fields

The shots were made on the experimental farm, located1 about 42 km northwest of the city of Cuenca, between the towns of Paute and Guachapala (see illustration in Fig. 2). Whose climatic conditions are:

- Altitude: 2.945 m a.s.l
- Weather: 11-26° C
- Winds: 5-14 km/h

Fig. 2. Location of the Romeral of the University of Cuenca. VANT eBee RTK. Configuration of the flight through the software emotion. Drone's launching.

B. *Canon S110 NIR Camera*

The Canon S110 NIR camera (Fig. 3) provides data on the red green and NIR bands.

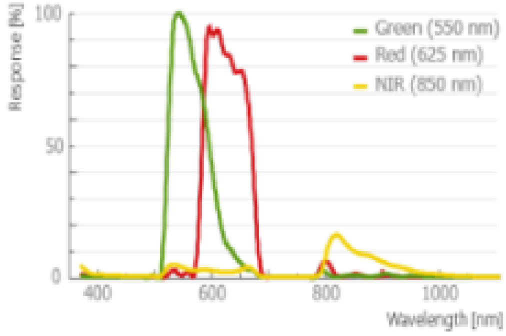


Fig. 3. Ideal acquisition plan for land with agricultural fields

TABLE III
CHARACTERISTICS OF CANON S110 NIR CAMERA.

Resolution	Resolution on the ground at 100 meters	Sensor size	Pixel size	Image format
12 MP	3.5 cm / px	7.44 x 5.58 mm	1.86 um	JPEG and/or RAW

C. *Sensor used - Sequoia Camera*

Sequoia (Fig. 4 (a)) is the smallest and lightest multispectral drones sensor released until 2016, capable of capturing crop images through four highly defined (visible and non-visible) spectral bands in addition to the RGB band as You can see in Fig. 4 (b). These four sensors: NIR, Red_Edge, Red and Green are 1.2 MP that are added to the 16 MP RGB sensor to give us a multispectral and RGB image in a single flight. It also has a solar sensor that is automatically calibrated to obtain accurate images whatever the lighting conditions.

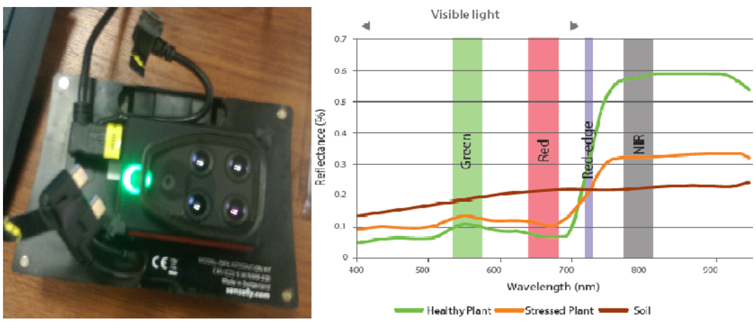


Fig. 4. a) Sequoia camera b) Bands that supports the Sequoia camera

Once the information is retrieved the project is generated and can be loaded into the Pix4D program. The result obtained from the flight performed in the experimental farm is shown in Fig. 5. The red points show the location where images where collected while the drone exploration experiment happened.

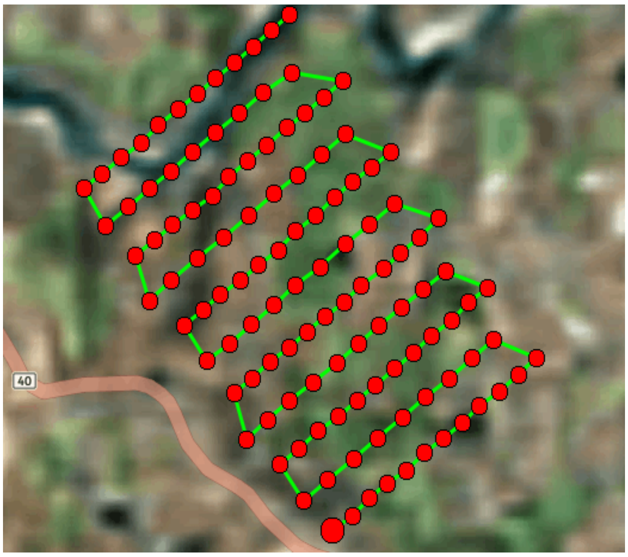


Fig. 5. Result of the flight performed on the romeral of the University of Cuenca

Likewise, Pix4D provides with a summary of the project to be processed, which indicates that the coordinate system used is the World Geodesic System 1984 (WGS84) and that 118 images were generated on the UTM 17 S area. In Fig. 6, it is expressed the complete summary of the project.

As mentioned in section 3.1, the first flight used a Canon camera that returned three types of bands: Green, Red and NIR. The processed image is the one shown in Fig. 6:

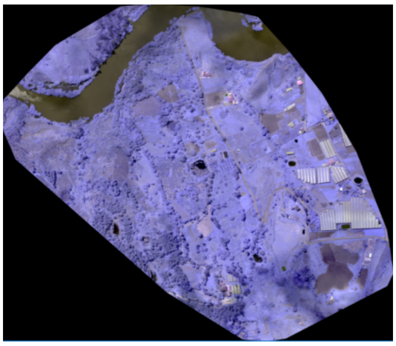


Fig. 6. Result of image processing with Canon S110 NIR camera

On the other hand, in Fig. 7 we have the result obtained when processing the images of the second flight made with the Sequoia camera.

It should be noted that this last image combines the Green, Red, Red Edge and NIR bands, allowing better analysis at a glance and later with specialized tools.

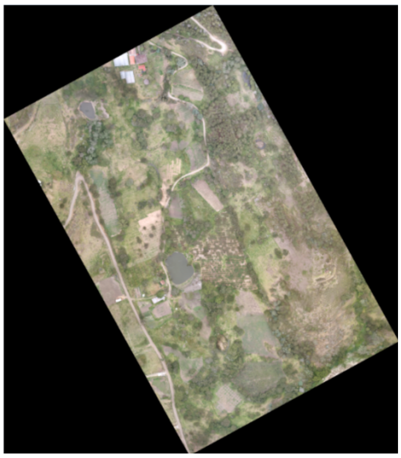


Fig. 7. Result of image processing with Sequoia camera

IV. CREATING THE PROJECT WITH ECOGNITION

Once the information is processed, the segmentation and classification of objects is performed using the application eCognition® 9 (Trimble, Sunnyvale, California, United States).

The first step is to import the processed information, which is in a TIF format file. In Fig. 8 we can see a selected selection, which with GPS survey was determined to belong to the apple plant. Also, it was decided to keep the RGB combination predetermined by the application, only changing the Equalization to Standard Deviation 3.0, which allowed having a differentiation between the apple plants and the shrubs that surrounded them.

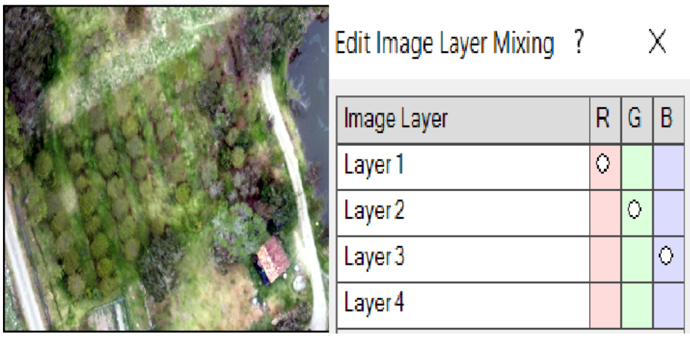


Fig. 8. Project creation eCognition

A. *Multi-resolution segmentation*

Among the different segmentation algorithms, it uses multi-resolution segmentation. The multi-resolution segmentation of eCognition (Fig. 9) achieves the best overall results compared to other software (Neubert and Meinel, 2003). Applying this segmentation technique allows to obtain good results for different types of data and images.

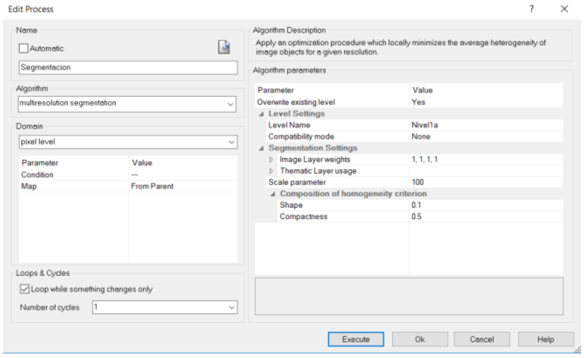


Fig. 9. Multi-resolution segmentation algorithm in the eCognition process tree

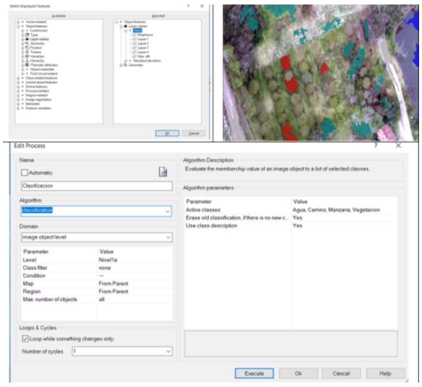


Fig. 11. OBIA Classification

After execute several tests (ten approximately), it was determined that the scale of 75 was ideal for the medium size of objects to be segmented. The rest of the parameters were kept with the default values, for example the values or composition of homogeneity criterion such as shape at 0.1 and compactness at 0.5. The result of the segmentation is shown in Fig. 10.

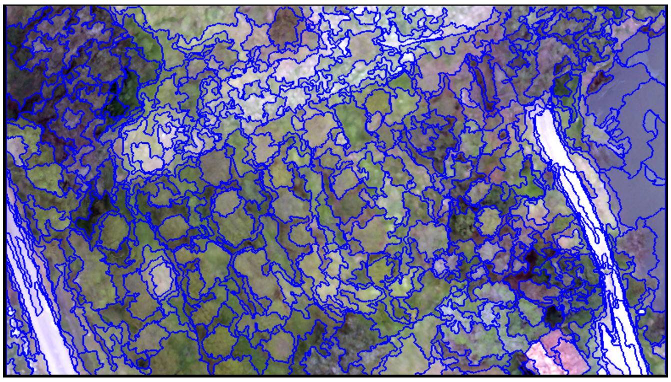


Fig. 10. Result of the segmentation process with 75 of scale, 0.1 of shape and 0.5 of compactness.

B. *OBIA Classification*

Once obtained the result of the segmentation process, we continue with the following OBIA procedure (Object Based Image Analysis), the classification of segmented objects. To obtain a Classification based on Objects, we start with the insertion of classes: Water, Path, Apple and Vegetation in general. Then we decided that the classification will be based on the average values of each of the 4 bands (Green, Red, Red Edge and NIR) and on the luminosity of the established segments. Now we proceed to the selection of samples for each class that will serve as the basis for the grouping. Finally we add the classification process (Fig. 11) activating the mentioned classes.

Fig. 12 shows image classification process, to grouping water segments at the upper right side which is a small lake, two roads that limit the plot of apples and covers the lower central side, the roof of a house (that was not part of the classes) in the lower right and the vegetation that grouped the rest of the green objects of the image.

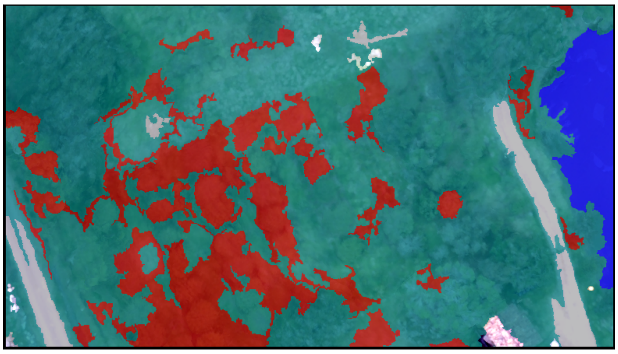
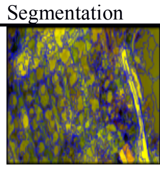
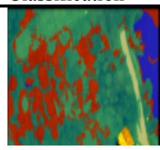


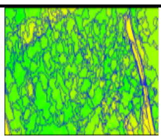
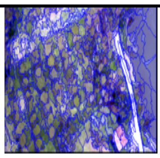
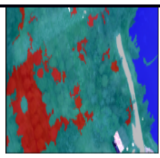
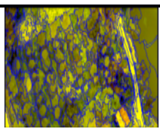
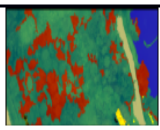
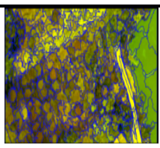
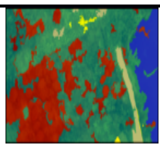
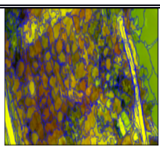
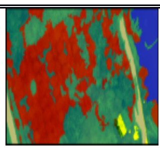
Fig. 12. Result of the Classification process

C. *Comparison of OBIA Classification with different bands*

In the previous section, the best result of an OBIA segmentation and classification process was shown, however to arrive at this result we made some tests and combinations on the different bands offered by the processes obtained from the two flights. Table 4 presents a comparison of said combinations.

TABLE IV
COMPARISON OF THE SEGMENTATION AND CLASSIFICATION PROCESSES OF THE DIFFERENT BANDS.

Bands	Segmentation	Classification	Description
Green / Red			Dispersed classification of the apple to such an extent that it enters the water, applies a yellow color to the house without being in the classes. The road is well differentiated.

Red_Edge / NIR			It does not allow classification because all nuances are lost to differentiate objects.
Green / Red / Red_Edge			It is quite close to the best version, since it presents very little dispersion of the apple plant, the water and path is correctly differentiated. Difference the roof of the house although this is not in the classes.
Green / Red / NIR			Results less real than the previous version, including water shows deviations, the apple very dispersed.
Green / Red_Edge / NIR			In the apple sector there is good coverage, but the vegetation is introduced into the water. It also detects yellow parts that did not enter the selection of images.
Red / Red_Edge / NIR			Parts of road are not determined to which class it belongs and introduces vegetation into the water. Discriminate on the roof of the house. Well pronounced sector of apples but also scattered by other areas.

D. *Methodology for the classification of crops*

After the research and tests carried out in the previous sections, the methodology proposed in this project (Fig. 13) consists of the following steps:

- Incorporate the five-band Sequoia camera into the eBee RTK drone.
- Flight configuration:
    - Frontal overlap: 75%
    - Lateral overlap: 60%
    - Radio: 800 meters
    - Fl1ight ceiling: 300 meters
    - K: 1 index
    - Number of satellites: 12
    - Pixel size: 8 cm / px
- Check weather conditions
    - Winds: normal to low
    - Weather: Sunny to cloudy
- Check the components and assembly of the drone
    - Foam on wings and body: Good condition
    - Pitot: Free obstacles
    - Earth sensor: Free obstacles
    - Helix with two bands: Fixed
    - Camera connected to Ebee: Correct
- Set an ideal time for flights in the mountainous sierra area: 11:00 - 15:00
- Generation of the project with Pix4Dmapper.
- Segmentation and classification with eCognition
    - Standard deviation: 3.0
    - Segmentation Algorithm: multiresolution with a scale of 75
    - Insertion of objects

Classification will be based on the objects average values.

Fig. 13. Methodology for crop classification

V. CONCLUSION

Using NIR camera with three bands implies size of the segments decreases; this is a disadvantage when making classification because it can generate mistakes about segregating classes. So, use five-band Sequoia camera allowed obtaining segmentation with a superior granularity that led to better defined and discerned classes.

There is a great difference between analyzing urban and nature images. Objects such as streets, houses, parks are more distinguishable than if it compares with field objects such as crops, plants or trees, because green color predominates in this type of elements. For this reason, eCognition segmentation algorithms were influenced by this similarity resulting in the diversification of classes over other areas.

Among the classes used in the segmentation phase, water and road had better defined and smaller quantity segments and compared with other segments. Water and road resulted in an almost perfect classification also influenced by the proximity of their polygons. On the other hand, vegetation and apple cultivation segments obtained less realistic results with overlapping in other areas.

Another aspect that affects the images classification is the number of classes used. For improving algorithm result in differentiation, it could be increasing the classes number. In field is more complicated to determine which group some vegetation belong.

A drone has become a practical device, easy to use and its price increasingly affordable for research, education and entertainment. The UAV used in this project was very useful since its characteristics allowed dozens shots in a prudential time. The disadvantage was presented when trying to analyze premature phenological stage crops because prevented the software used to determine their location or prediction.

From the results, it can be concluded that the agricultural field can take advantage from the use of drones and UAV. The image obtained from a drone and classify it among a number of categories of crops can be used in more research field. The farmer will have in his hands a useful tool capable of identifying with an almost exact approximation crops regardless of the type or characteristics of the same.

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