Application of quadtree and multiresolution segmentation on rapideye images with and without histogram equalization for coffee crop classification in Machado municipality (MG) - Brazil

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Abstract. This paper evaluates the influence of segmentation by multiresolution and quadtree algorithm on automatic supervised classification of high spatial resolution satellite images with and without histogram equalization for crop coffee classification. The study area was the municipality of Machado (MG) and in this work were used rapideye images because of its high spatial and radiometric resolutions. The crop coffee plants because of its intrinsic characteristics is easily can be confused with savanna vegetation in automatic classification process because of their similar spectral response. The use of segmentation techniques allows the use of shape and texture features, yet the spectral ones. The study area had two images with two different angle looks at the same time, which implied in different responses for each sensor because of the non lambertianity of the objects. For each class training samples were collected and the thematic result image was got through the nearest neighbor classifier applied to its segments. The effects of the histogram equalization were measured by comparing the classification results with and without histogram equalization to the reference image classified manually by trained professional, getting the global and kappa indices. Also were done a comparison between the results of multiresolution segmentation and quadtree segmentation. Multiresolution have produced more adequate segments to the contours of the coffee plants objects, with homogeneous contents, while quadtree generated too many segments, not capturing border areas. Histogram equalization showed itself an important pre-processing step on image classification process, influencing in the accuracy.

key-words: remote sensing, image processing, segmentation, classification, sensoriamento remoto, processamento de imagem, segmentação e classificação.

1. Introdution

The Coffee crop is a tropical culture that can be found on nearly eighty countries, what makes it the agricultural product most negotiated in the world (RAMALHO et al., 2013). In Brazil, it is the second most exported agricultural product, one of the most important funds for its economy, constituting 33% of the world coffee production (CONAB, 2014).

Despite its importance, the coffee sector still lacks information, once planted area and production data differs among governmentally institutions and cooperatives surveys (SOUZA et al., 2012). Machado et al. (2010) and Vieira et al. (2007) stated that the application of remote sensing techniques on the coffee spectral variation, in its different phenological stages are good to analyze its characteristics.

Vieira et al. (2006) demonstrated that the spectral response of coffee crop is complex and can be similar to some types of savanna vegetation response, hindering the achievement of maps through automatic classification that uses only spectral features. Andrade et al. (2012) suggests the use of shape and texture features for coffee crop classification, to that they used artificial neural network to extract texture, resulting in a 0.602 kappa index valor for homogeneous regions and 0.558 for rugged terrain (Machado – MG).

The rapideye system consists of a constellation of five identical satellites placed in synchronous orbit with the sun and equally spaced. This approach allows smaller revisiting time a scene, increasing the temporal resolution of the system allowing new attempts to register the scene response in case of clouds (FELIX et al. 2009).

A histogram is a graphic representation of the frequencies in a sample set, in case of images this tool indicates the gray level pixel frequency (GONZALES e WOODS, 2008).

Histogram equalization is a technique that redistributes the gray level pixels on the image, such that the distribution of two images became uniform (MARQUES FILHO e VIEIRA NETO, 1999).

Gonzales and Woods (2008) define the segmentation is the process that allows subdividing an image in constituent parts. The segmentation allows the extraction of shape and texture features from regions (segments) of the image (important features used by human interpreters when doing visual interpretation of an image).

A quadtree structure consists of a collection of objects (in tree form) wherein each level the objects area a quarter of the father node (SAMET H., 1984). The quadtree segmentation algorithm is a uniformity detection method that initially splits the original image in four pieces and for each one it verifies its homogeneity. If the region is homogeneous it stays as it is, otherwise it is dismembered in four again, this process repeats until all the image has been processed (MARQUEZ et al., 2011). Baatz and Schape (2000) proposed the multiresolution algorithm, becoming one of the most used segmentation algorithms in satellite images. The multiresolution segmentation is a region growing approach algorithm that starts randomly placing points, called seeds, on the image. The selected points look at their neighbors and if they obey similarity criteria they are merged into one segment, otherwise not. The criteria of similarity are defined by the user and it shows the scale, shape, color, compacity and smoothness of the segments (BAATZ & SCHAPE, 2000).

2. Methodology

The study area was the municipality of Machado, located in Minas Gerais States. In this municipality there are rugged terrain, with high altitudes that varies from 780 to 1260 meters above the sea level, which agriculturally predominates is coffee crop. The Figure 1 diagram shows briefly the steps done in this work.

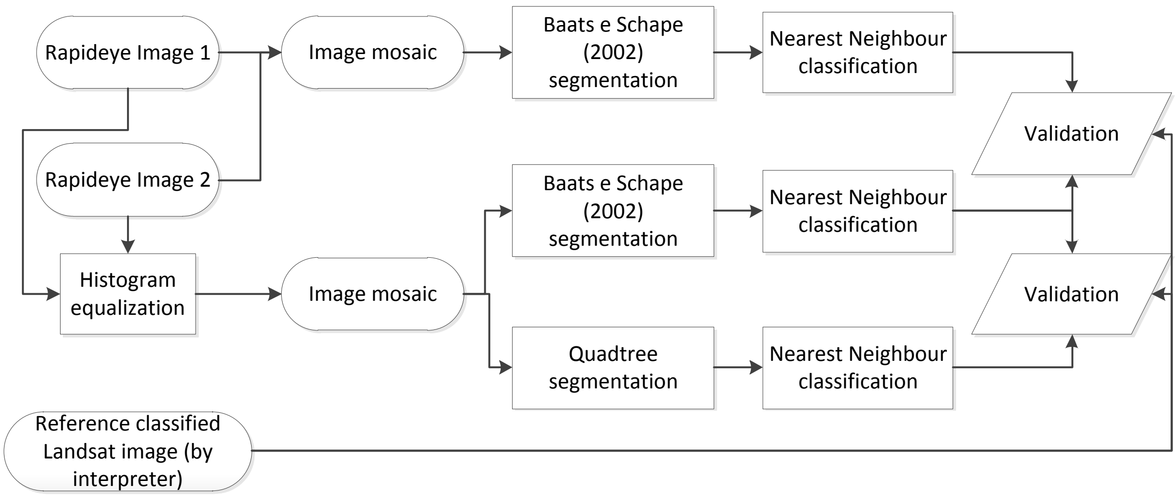

Figure 1. Metodology diagram, illustrating the steps of histogram equalization, segmentation, classification and validation.

The images were acquired through the INPE (Instituto Nacional de Pesquisas Espaciais) catalog, they were already registered and orthorectified and are from Year 2012. All spectral bands were used: Blue (440 – 510 µm), Green (520 – 590 µm), Red (630 – 685 µm), Rededge (690 – 730 µm), Near Infra-red (760 – 850 µm). The images have spatial resolution of 5 meters, and a radiometric resolution of 12 bits. For cloud removal were used a mask send with the images. To fit the Machado municipality were needed two scenes. The images were get at the same time with different angle views as can be seen in Figure 2. Even with corrections the image targets stills appears with different spectral responses, that occurs cause of the non lambertianity of the targets. To verify the influence of the non-equalized points in the classification, first it was segmented and classified with no corrections. Initially it was done a mosaic to merge the images (Figure 2 A), which was segmented through multiresolution algorithm and sampled for the class “coffee” and “non-coffee”, then it was classified using nearest neighbor. In a second plane was done an equalization of histogram (through ERDAS software) between image 1 and image 2 and again it was segmented by multiresolution and classified by nearest neighbor, using the same parameters and classes (Figura 2 B). Both classifications were validated by comparison with the thematic map obtained by a professional human trained image interpreter (donne through a landsat image), extracting global and kappa indexes.

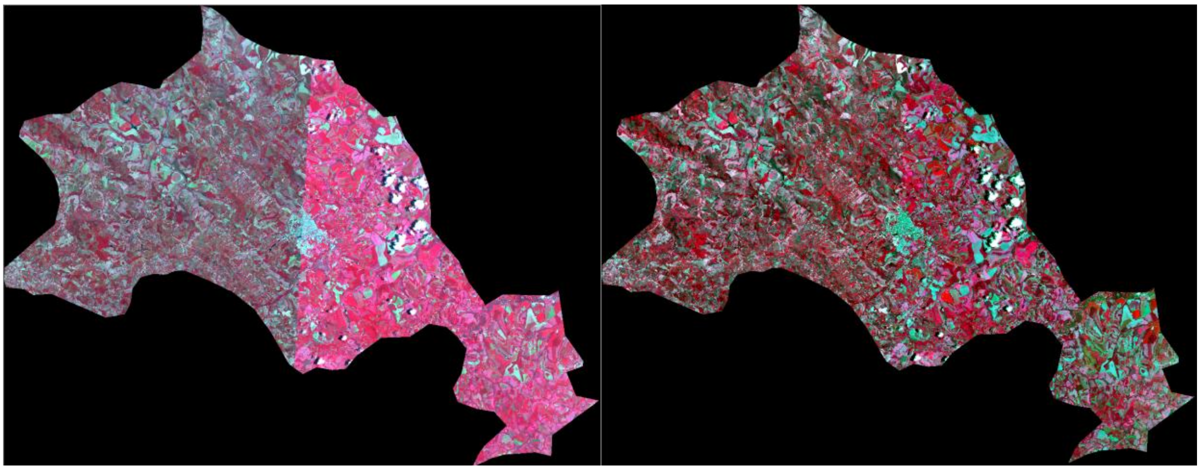

Figure 2. Rapideye images mosaic with no corrections Machado-MG (A) and Rapideye images mosaic with corrections Machado-MG (B).

The second experiment involves the comparison between two segmentation algorithms, the multiresolution used before and the quadtree. It was used the definiens ecognition software to apply the segmentation algorithms. The multiresolution segmentation was done using the following parameters: scale (pixel similarity): 50; smoothness 0.5; compacity 0.5. Samples were collected to the classes: “coffee”, “forest”, “water”, “urban”, “exposed soil” and “pasture”. In the classification process all classes except “coffee” were merged into “non-coffee”. The features used to separate the classes are: spectral mean and standard deviation of each band, brightness, compacity, width, shape, volume, density, and the textures homogeneity, entropy and dissimilarity. Using the quadtree segmentation the procedure was the same, changing only the scale parameter to 180 because they fit in different ways. For the quadtree segmentation was used only one fourth of the original scene, because this algorithm supersegments the heterogeneous parts of the image creating segments of one pixel size, which difficulties the image processing. The quadtree has generated almost two millions of segments, meanwhile the multiresolution almost three thousand.

The segments evaluation in images can be done by quantitative or qualitative ways. (ZANOTTA et al., 2012). The adjust of segmentation parameters was done according to Espindola and Camâra (2007), aiming homogeneous segments with distinct adjacent regions obeying the scale parameter. The evaluation of the segments was done visually, given that both segmentation methods generate distinct types of segments. For that it was verified how well the segments were adequate to the border regions of each type of element in the image, if its inner was homogeneous, if there was any confusion of different classes in the same segment, if the size and shape of it were adequate.

3. Results and discussions

Comparing the accuracies without histogram equalization (Table 1) and the accuracies with histogram equalization (Table 2) it is possible to note that histogram equalization process is important when doing automatic classification that involves two images with different capture angles, once the non-application of it affects the classification accuracy. That occurs because when not equalized there is more confusion areas, dificulting the detection of separable points. The classification without histogram equalization resulted in a global index of 60.82% and kappa index of 0.216, while with the equalization it resulted respectively in 65.65% and 0.313.

The Figure 3 (A) illustrates the process tree created to follow the methodology, and the Figure 3 (B) the classes used in it and their hierarchical distribution. The generated segmentations can be compared in Figure 4, where can be seen that the multiresolution has generated more adequate segments to the coffee crop, with borders with no class mixture, equally done to other classes like forest and soil, meanwhile the quadtree algorithm supersegmented the image, implying in worse feature extraction and more processing time. The images comparison to the reference (validation) are showed at Tables 2 and 3. The multiresolution as shown before resulted in a kappa of 0.313, meanwhile the quadtree resulted in 0.302 (Table 3). The results with better accuracy were inferior to Andrade et al. (2012) (which obtained 0.558) for the same region while using artificial neural networks. To obtain more precise indexes it is needed to do the validation map on the same reference image type. The results from this paper are not good enough to replace an interpreter, but are more accurate than pixel by pixel methods. The final classified image can be observed in Figure 5.

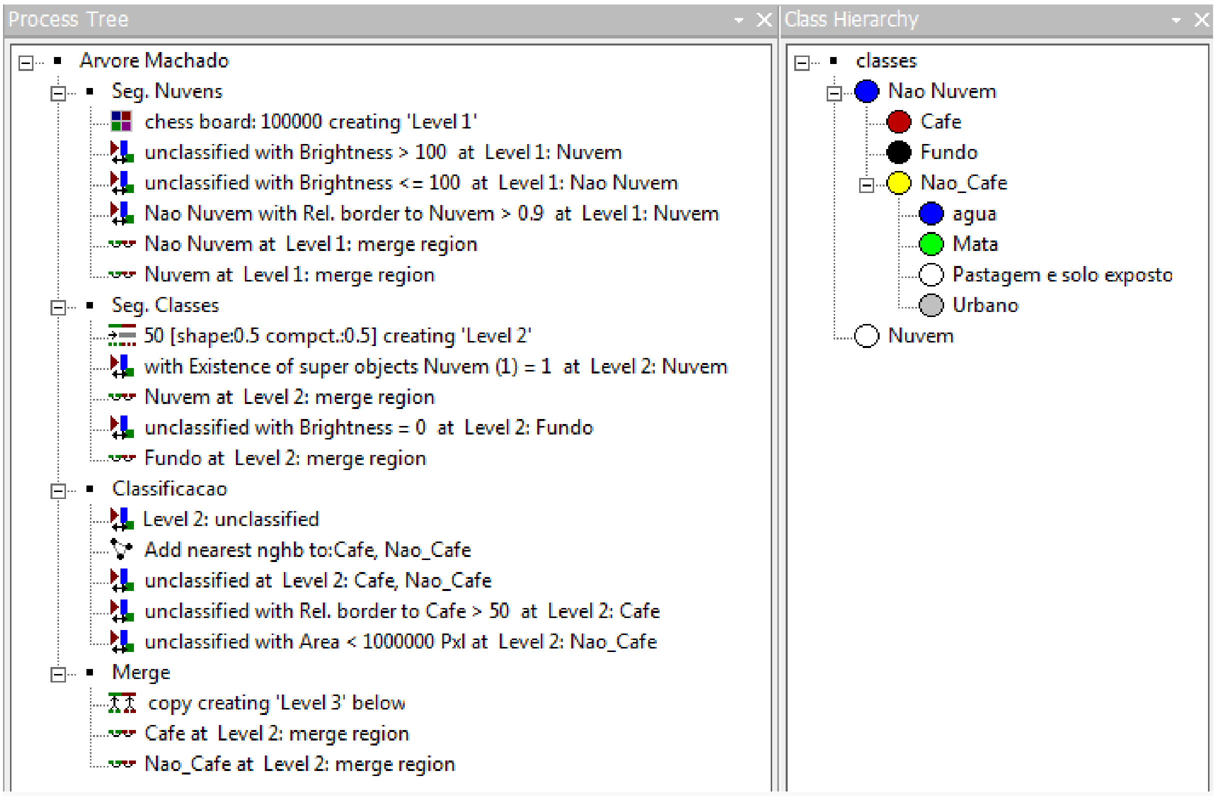

Figure 3. Process tree of the segmentation process and classification on the ecognition software (A). Class hierarchy of classes used for classification (B).

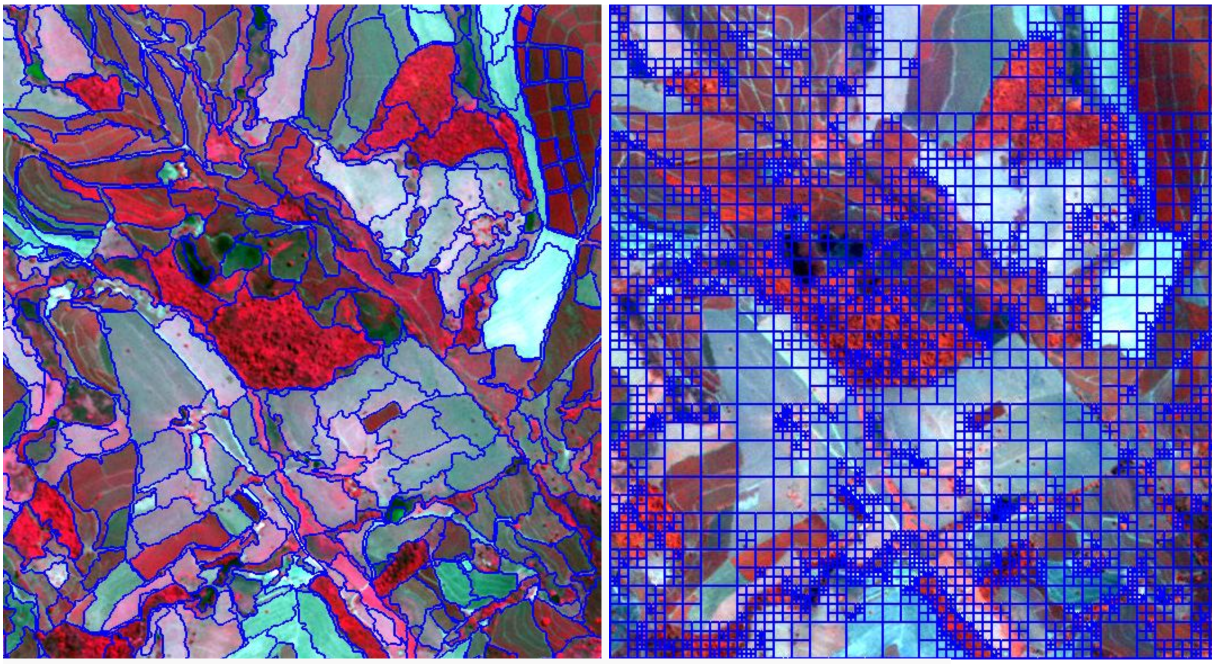

Figure 4. Segmentation comparisson between multiresolution (A) and quadtree (B).

Table 1. Confusion matrix of the classified image using multiresolution segmentation without histogram equalization with the reference image.

Class	*Coffee*	*Non-coffee*	*Total (%)*
Coffee	4499	2335	27,71
Non-coffee	5501	7665	72,29

Table 2. Confusion matrix of the classified image using multiresolution segmentation with histogram equalization with the reference image.

Class	*Coffee*	*Non-coffee*	*Total (%)*
Coffee	6156	3026	36,56
Non-coffee	3844	6974	63,44

Table 3. Confusion matrix of the classified image using quadtree segmentation and histogram equalization with the reference image.

Class	*Coffee*	*Non-coffee*	*Total (%)*
Coffee	7011	3987	47,13
Non-coffee	2989	6013	52,87

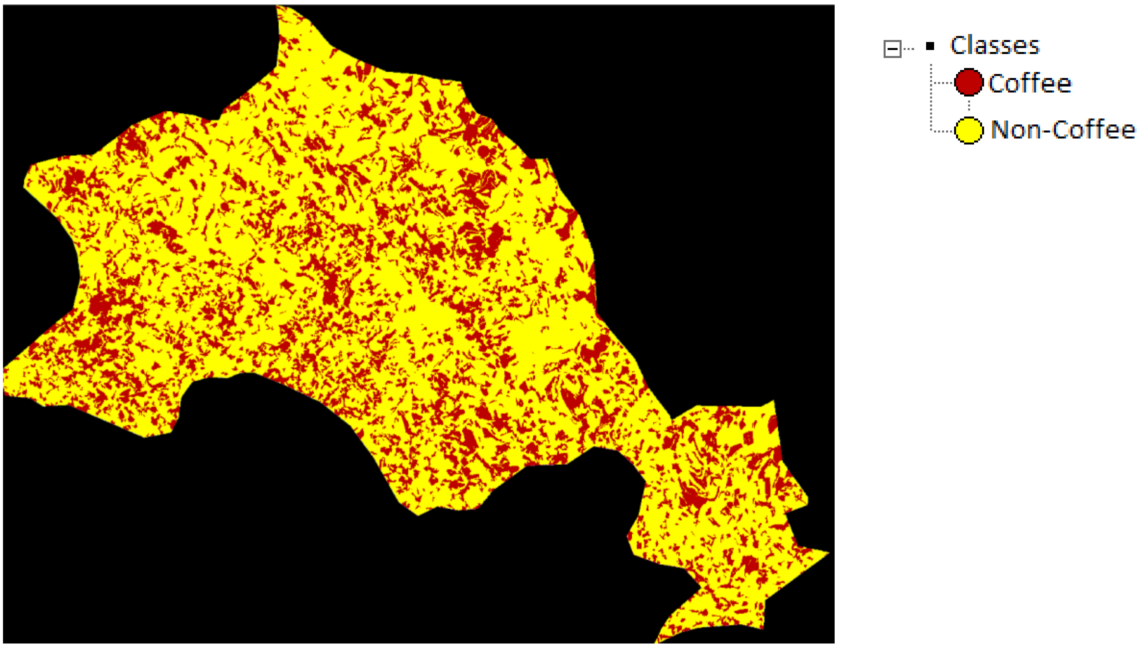

Figure 5. Classified image of the municipality of Machado (MG).

1. Conclusions

The results of this research allowed the following conclusions:

- The histogram equalization showed itself an important factor to decrease error.
- The non-fulfillment of it contributed inserting error in the feature space, decreasing the classification accuracies, once there was more confusion between different classes.
- The image segmentation occurred with low influence of the histogram equalization because it is a local operation looking only to neighbors to construct a region obeying the scale criteria, but in the image merge region it was evident that the spectral values were different in each image.
- The segments obtained by the multiresolution segmentation, enclosured very well the contours of the future classes, showing itself a good segmentor for coffee crop.
- The quadtree process took more processing time because of the greater quantity of segments generated.

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