

# COMPARATIVE ANALYSIS OF AUTOMATIC DIGITAL IMAGE BALANCING AND STANDARD HISTOGRAM ENHANCEMENT TECHNIQUES IN REMOTE SENSING IMAGERY

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## ABSTRACT

Recently, radiometric image homogenization techniques have been thoroughly studied among the digital mapping techniques. The main characteristics of digital image balancing methods — vignetting and hot spot minimization, as well as color homogenization — were inherited from photo laboratory techniques. However, the current digital image balancing processing uses mathematical modeling of matrices which evaluates the most suitable histogram templates and applies customized corrections to each image region, with or without user intervention. In this paper, we review the main phenomena involved in aerial image quality and outline image correction. Image balancing problems and solutions will focus on digital processing techniques and their applications. The study will also apply an automatic recursive block method and a standard histogram technique to satellite imagery. The balancing and color adjustment performances are compared.

**Keywords:** Photogrammetry, digital image processing, image balancing, radiometry, image enhancement, mosaic.

## 1. INTRODUCTION

The extensive use of digital image products, such as orthophotos and mosaics, by GIS users, demands quality analysis as well as a production flow of digital images. This paper describes some techniques of image balancing. Also, some methodological analyses of digital balancing in Remote Sensing are investigated.

Image balancing is a procedure that minimizes radiometric discrepancies between adjacent images and between different regions of the same image. It improves the visual aspect of images, especially for mosaic compositions. It reduces the difference of brightness, contrast and color tones between one or more images (NÓBREGA, 2002).

The focus of this paper is not to describe the standard image balancing techniques that have been historically used by the Photogrammetry community, but to report the main radiometric effects resulting from aerial and orbital imagery. Furthermore, this concept is extended to the digital environment.

The use of image balancing procedures is not restricted to aerial photography. Balancing techniques based on histogram enhancement are also used in orbital images, especially for mosaic composition.

The correction procedures of atmospheric effects in Remote Sensing images are based on solar illumination geometry, absorption modeling and atmospheric scattering. These processes require complex solutions that are usually not adopted for visual application purposes. In place of rigorous models, an ordinary solution for mosaic application can be implemented by histogram-stretching techniques. However, it may cause radiometric changes in images, disabling applications like image interpretation and classification.

This paper analyzes problems in aerial and orbital images, their effects in mosaic composition, and the solutions suggested for digital image balancing. The analysis of local image balancing and the standard histogram enhancement technique are related. It uses two pairs of adjacent and time different Remote Sensing images. The processed images are mosaiced, enhancing their radiometric discrepancies. This enhancement allows the comparison of both procedures.

## 2. IMAGE HETEROGENEITY

Since Photogrammetry and Remote Sensing applications are based on image-flow processing, the existence of rules for image quality standardization

according to specific parameters would be desirable. It must be performed before the subsequent processing.

Although there are special equipments and procedures for radiometry standardization, the image quality always depends on extra factors. One of the most important factors is the change of atmospheric conditions.

The main aspects unfavorable for radiometric image quality are hot spots, vignetting, different acquisition times and scanner settings. These aspects are described in the following sub-sections.

## 2.1 Hot spots

Hot spots correspond to highlighted image regions caused by solar reflectance on features like rivers, lakes, pools and metallic roofs. They can also modify the image homogeneity, introducing difficulties in measurement processes.

For practical applications, surrounding features are affected by excessive light exposure, due to hot spot closeness. Areas near to hot spot regions can be prejudiced in other processes like image correlation and interpretation, fundamental for manual and automatic feature extraction. Figure 1 shows the damage in the left window compared to the right window, caused by a hot spot on the river.

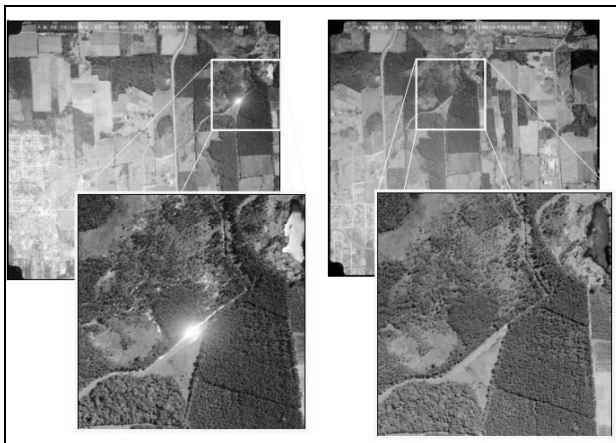


Fig. 1 - Hot spot effect detailed in the left aerial image in relation to a next one. NÓBREGA (2002).

## 2.2 Vignetting

Vignetting is the progressive fading effect that occurs on photographic image borders. The image appears brighter in the central region than on the edges. According to MOIK (1980), a light bundle that traverses the lens-system axis in the normal direction is less attenuated than an oblique one. It is an optical effect caused by the interaction between the camera lens system and the incident light bundle. Thus, the quality of the image normally is better at the center than on the borders.

Photogrammetry is based on mapping scale, aircraft altitude and focal lens distance ratio. These parameters can be changed according to a specific

application. However, a change in the lens focal distance results in a different view angle and image area. The wider the view angle, the higher the vignetting effect will be. The figure 2 shows a typical vignetting image. The uniform luminous intensity in the image at right was obtained by altering the configurations of the system of lenses and the scene.

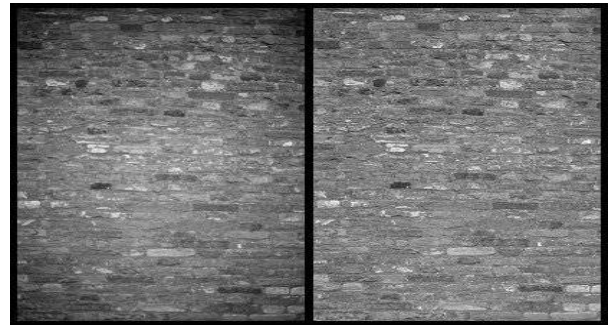


Fig. 2 - Vignetting effect on the left image in contrast to a light uniform image. NÓBREGA (2002).

## 2.3 Scanner

Since the advent of digital photogrammetric workstation, the scanning process has often been used to produce digital aerial images. However, even the simple insertion of a scanner can cause some problems in image quality. Consequently, this process must follow some quality control rules. Radiometric and geometric calibrations of the CCD (Charge Coupled Device) often need to be performed, as well as radiometric homogeneity supervising. On the other hand, the homogeneity can be obtained by control tools through brightness, contrast and color saturation in each used channel. However, hot spot and vignetting elimination require local procedures with adaptive correction enhancements.

## 2.4 Images Acquired at Different Times

Aerial or satellite images acquired at different times can cause differences in the radiometric pattern. Usually, a new image acquisition is always necessary whenever there is a cloud or shadow. Then, the new complementary imagery will have different histogram structures from the original ones. These discrepancies are due to atmospheric deviations of the different acquisition dates of image.

For Remote Sensing, the contiguous image acquisition under similar atmospheric conditions normally occurs during the same satellite orbit. Adjacent side images (parallel orbits) have different acquisition times and the probability of occurrence of different atmospheric conditions is high.

In Photogrammetry, this problem is aggravated by a limited flight schedule. The angular position of the sun (solar elevation), the minimization of the projected shadow and the maximization of the ground illumination impose this restriction. Thus, the photogrammetric flight partition into several sections is

frequent and sometimes unavoidable. Large photogrammetric projects spend much time in flight coverage, usually demanding several days for a conclusion.

### 3. IMAGE BALANCING

According to NÓBREGA & QUINTANILHA (2001), the demand for higher quality of image improved the traditional photographic balancing. In the beginning, they basically depended on photographic resources, controlled light, filters and chemical agents, to correct the differences, especially the vignetting. Color tone discrepancies were minimized by using color filters. During World War II, the need for faster and more precise maps forced the balancing process to operate with large image productions. A few decades later, electronic resources were adopted and the balancing process became semi-automatic, speeding up the processing.

The need of image balancing became apparent with massive use of digital photogrammetric workstations. Placing an aerial film onto a photogrammetric scanner, in order to generate an image, can underscore many imperfections occurred during the flight image acquisition that can be minimized later by using digital image processing techniques.

The most of digital image balancing procedures consist basically in histogram manipulation. The color balance can be reached by changing the original digital number of the pixels by the stretched one, or fitting the histogram shape, until the image aspect become similar to other one.

#### 3.1 Standard Histogram Adjustment

There are two main reasons for radiometric correction at aerial and remotely sensed imagery: basic visual improvement and hard atmospheric effects normalization. The second one is based on spectral analysis of the images. It compensates the atmospheric effect through mathematic models and spectral control data. Unlike these complex methods, image balancing uses a simpler method to compensate radiometric discrepancies in the images. Usually, it uses known methods of image enhancement, since the algorithm efficiency and the quality processing analysis are based solely on visual inspection.

Thus, some traditional methods of histogram manipulation, such as linear and non-linear stretching, have been used for color tone homogenization of orbital images, based on a reference image (SCHOWENGERDT, 1997). These methods allow a global change in the image radiometry, and they have the same effect in all pixels. This characteristic hinders the minimization of local effects.

Histogram stretching has been successfully applied to Remote Sensing of color image balancing. Local effects for remote sensing occur at a lower

intensity than the effects for aerial photography. The significant reduction of vignetting effect in remote sensing images can be explained by the orbit geometry (which depends on the satellite altitude) and the lens system. The elevation angle of the sun and the use of infrared spectral band - responsible for low radiometry intensity of water features - can explain the reduction of hot spots. Usually, aerial or orbital images acquired at different times have their differences uniformly distributed throughout the whole image extension, allowing the use of global procedures for balancing.

The concept of histogram manipulation to increase the image homogeneity is based on the mean, the standard deviation and the available limit values for the histogram stretching. For practical reasons, we can interpret the statistical parameters like image ones. Average means brightness and standard deviation means contrast. A complete description can be found in MOIK (1980), NOVO (1992) AND GONZALES & WOODS (1993).

Figure 3 shows the difference between two QuickBird images acquired in different times. The first histogram shows a standard deviation greater than the other one, which can be viewed by contrasted top image.

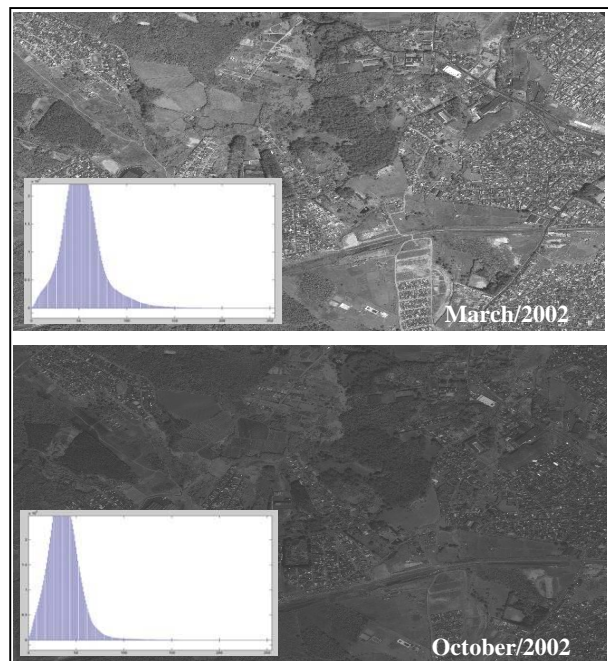


Fig. 3 - Quickbird Pan Images taken at different dates.

#### 3.2 Adaptive Histogram Adjustment

Similar to human operation, based on visual investigation of the image regions, the automatic analysis used in digital balancing is developed through local histogram pattern detection. It allows the detection of bright and dark regions as well as the computation of the values to be used in each local adaptive histogram adjustment. Vignetting regions, for example, can be automatically detected since the local histogram has smaller mean values than the

global ones. In other words, these regions are darker than the rest of the image and they can be detected by statistical values, as shown in the Figure 4. It shows three different patterns of histogram on similar vegetation coverages. In a perfect situation, these histograms must be similar.

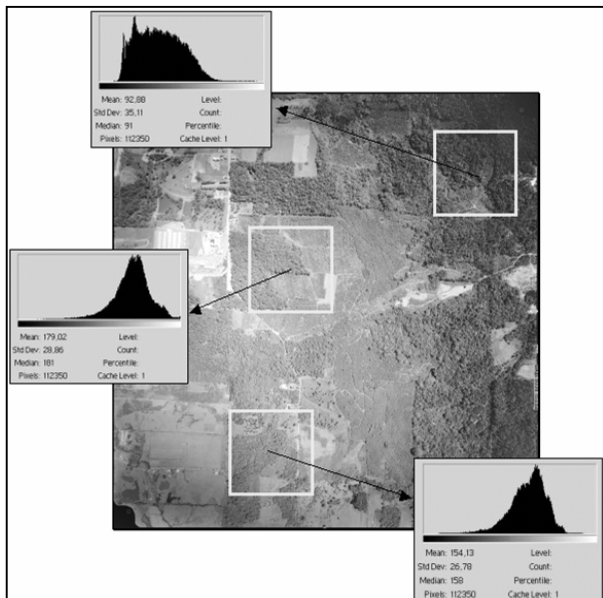


Fig. 4 - Histogram pattern differences for similar ground coverage feature regions. NÓBREGA (2002).

SCHOWENGERDT (1997) introduced the Local Range Modification (LRM), which is a method for brightness and contrast homogenization based on image partition into adjacent blocks. It requires the detection of maximum and minimum brightness pixel values in each block. These values are used as weights in the parameters of a bilinear interpolation, using Euclidian distance and digital number difference to fit the digital number associated to each pixel and to its neighboring blocks.

The partition of the original image into a few adjacent blocks harms the quality of the processed image. The large size of these blocks causes discrepancies between of maximum and minimum brightness values, introducing difficulties for their smoothing. However, the use of a small block size results in similar limit values of brightness and promotes better smoothing results for detection and minimization of hot spots and shadows, but has a high computational cost.

The use of adaptive methods for image balancing through adjacent blocks can be based not only on LRM, but also on other types of radiometry homogeneity analysis. Actually, some of the main photogrammetric systems, such as BAE Systems Dodger®, Intergraph Autododging® and Leica Image Equalizer®, use block partition methodology, described in NÓBREGA (2002).

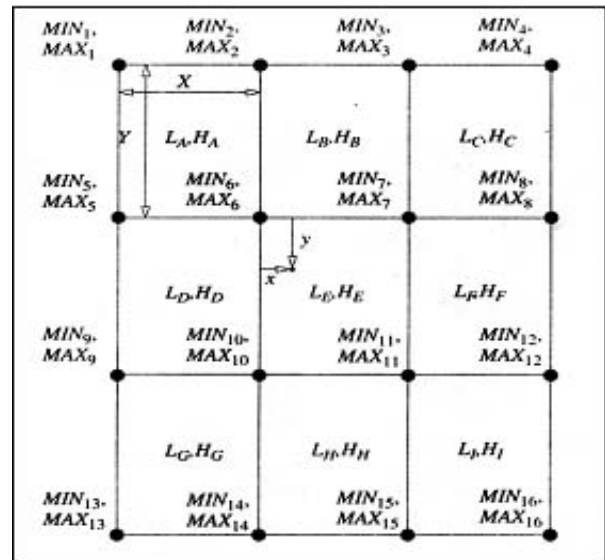


Fig. 5: Model of adjacent block partition of digital image for the adaptive histogram adjustment process used in the LRM algorithm. SCHOWENGERDT (1997).

While LRM method calculates the maximum and minimum brightness values in each block, the method adopted in commercial systems uses statistical parameters of brightness and contrast. In other words, the primary concept involved in these software is the statistical analysis of mean and standard deviation values of the histogram, in each image region, as well as the comparison with the histograms of the adjacent images.

The results with this procedure and LRM method are very. They allow easy detection of vignetting and hot spot through a global comparison of statistical values between blocks. Local mean and contrast values are compared to global image values in order to detect dark and bright regions. The main advantage of LRM over the second one is the guarantee of non-saturated image, by using known limit values. Otherwise, LRM method implies a high computational cost for most of current commercial applications.

NÓBREGA & QUINTANILHA (2001) analyzed the results obtained with block sizing tests for adaptive balancing method. Even though the focus was in the smoothing improvement, the results of interpolation methods were analyzed. These methods are based on pixel-by-pixel scanning and block size tests. The weight assigned to each pixel depends on the pixel's relative position inside the block. The results show that the larger the size of the blocks, greater the difficulty in homogenizing their differences.

In aerial images, the reduction of the size of the block can confuse the outcome. The use of small blocks - less than 100 pixels - will act in the areas of shadow of buildings. However, big blocks - more than 100,000 pixels - can generate a difficult process to promote the softness among the blocks, depending on the degree of variation of the land use class shown in the image. The ideal dimension of the blocks should

take into account the range of the vignetting effect. It should not exceed the dimension of the vignetting, as well as taking into account the softness among the blocks. Figure 6 illustrates how the use of balanced images can benefit the mosaic quality.

One of the most important advantages of digital image balancing over the traditional photographic process is the ability to adjust color tones in distinct images as well as the operational easiness obtained by the process automation. Regularly, this process needs to run independently for each channel to promote the best balancing of color tones. First, the images must be processed for color decomposition purposes. Then, each channel should be balanced independently to prevent interference. After that, the channels should be merged again, to create the final balanced color images.

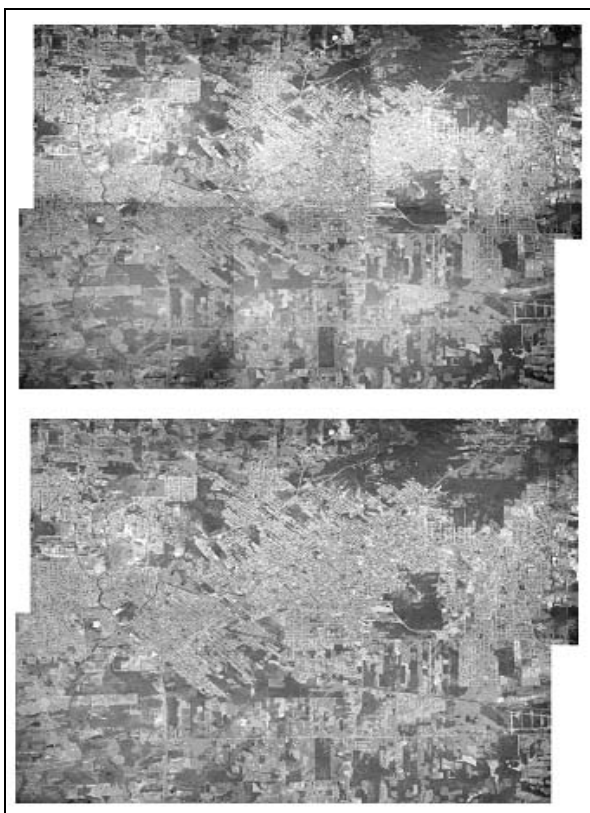


Fig. 6 - Mosaic of non-balanced images (above) and balanced images (below). NÓBREGA (2002).

#### 4. ORBITAL IMAGE BALANCING

Some types of Remote Sensing imagery need specific processing whenever the amount of visual information is excessive. However, traditional images used in thematic mapping, as well as, high-resolution images can be processed by visual methods, according to the application. Currently, automated and simple visual image balancing techniques are already consolidated in Photogrammetry, but they have not been used in Remote Sensing yet. The shortage of literature emphasizing simple methods of radiometric

homogenization of images for mosaic improvement has motivated the elaboration of this paper.

#### 4.1 Materials

Two adjacent LANDSAT ETM+ and two adjacent CBERS CCD images were processed. Their characteristics are listed in Table 1.

TABLE 1: IMAGE DESCRIPTION.

<i>Satellite</i>	<i>Path/Row</i>	<i>Date</i>	<i>Band</i>
LANDSAT	221/075	23/01/2000	1,2,3,4,5,7,8
LANDSAT	222/075	25/08/2000	1,2,3,4,5,7,8
CBERS	153/126	28/10/2000	CCD 1,2,3,4
CBERS	154/126	27/04/2001	CCD 1,2,3,4

The two regions are neither adjacent nor geographically close to each other. LANDSAT images correspond to the Tietê River neighborhood whereas CBERS images correspond to the Presidente Dutra Highway neighborhood. Both regions are located in the State of São Paulo, Brazil.

In the first step, images were processed and analyzed interactively, by using Spring<sup>®</sup> 3.2 tools, to manually enhance the histogram of each independent band. In the second step, the automatic processing was performed by the LH-System Dodger<sup>®</sup> v. 4.3.

#### 4.2 Methods

The methodology was developed for visual applications, especially brightness, contrast and color tone differences for mosaic composition, since the images were acquired without any kind of histogram pre-processing. Thus, all images were processed and analyzed by two different methods. A comparison of the histogram stretching technique and the automatic technique of local adaptative histogram enhancing was performed to evaluate the feasibility of orbital image balancing application. CBERS CCD images were processed before LANDSAT ETM+ images.

At first, experiments involving the global histogram stretching were done to find the best values to be applied for each image. The determination of the values to be applied in the local processing was done in a similar way. It is worth to emphasize that the two processes were accomplished independently.

##### 4.2.1 Global Image Enhancement

After the two scenes were loaded and their brightness enhanced, the differences of color tones could be observed and analyzed. The Spring<sup>®</sup>'s histogram manipulation tools were used to produce the statistical information for each channel. (See tables 3 and 5).

The great variation of mean and standard deviation values of two scenes shows the actual brightness and contrast heterogeneity. The lower and

upper histogram limits are the range for future histogram adjustment.

Brightness and contrast adjustments were performed interactively in the Spring<sup>®</sup> environment, in order to place the lower limits near to zero and the upper limits near to 255, until the color tone of the image channels became visually similar. (See figures 7-c and 8-c).

#### 4.2.2 Local Adaptive Image Enhancement

Local Adaptive Image Enhancement does not require user intervention, except the definition of block size, maximum and minimum bright intensity and eventual parameters of the histogram for each channel. The adaptive processing used the LH-Systems Dodger<sup>®</sup> software, which was developed for aerial image balancing. Table 2 shows the main parameters.

TABLE 2: ILLUSTRATION OF THE DODGER<sup>®</sup> INPUT PARAMETERS.

BAND INDEPENDENT:	<i>TRUE</i>	NUM TILES: <i>10</i>		
BAL. ACROSS IMAGES:	<i>FALSE</i>	PERCENT SKIP: <i>0.0</i>		
<b>PARAMETER</b>	<b>BAND 0</b>	<b>BAND 1</b>	<b>BAND 2</b>	
DESIRED MEAN:	<i>AUTO SET</i>	<i>AUTO SET</i>	<i>AUTO SET</i>	
MIN / MAX CONTRAST:	<i>0.9 / 1.5</i>	<i>0.9 / 1.5</i>	<i>0.9 / 1.5</i>	
MIN / MAX GREY:	<i>0 / 255</i>	<i>0 / 255</i>	<i>0 / 255</i>	
PERCENT ADJUST:	<i>100.0</i>	<i>100.0</i>	<i>100.0</i>	
MAX GREY SHIFT:	<i>100</i>	<i>100</i>	<i>100</i>	
COMPRESSION LIMIT:	<i>2.5</i>	<i>2.5</i>	<i>2.5</i>	

The BAND INDEPENDENT parameter should only be used for colored images. It will allow each color channel to be processed separately. The BALANCE ACROSS IMAGES placement as false allows the program to calculate a global value of a histogram using all the images together. The NUMBER OF TILES means the number of divisions that will be done in the image in line and in column. In other words, it describes the size of the blocks to be used. The size of the blocks used for LANDSAT images was about 600X600 pixels and for CBERS was about 550X550 pixels. The PERCENT SKIP is the percentage of the image that should be discarded in the borders, relative to the black borders of the aerial images.

The remaining parameters can be adjusted independently for each channel. The DESIRED MEAN selected as being AUTO SET allows the program to calculate the global medium value of the mean and of the standard deviation. The other parameters are the limits imposed to the system to control the processing result. Their complete description can be found in LH SYSTEMS (1998).

All scenes used in this study are north-oriented and include some additional borders (normally black filled). The use of these black borders can compromise the quality of automatic balancing since the adjustment is locally adaptive and any discrepant pixel value can be interpreted as an invalid data. Then,

the images were rotated according to orbit orientation before their use.

During the processing, some experiments were performed, varying the input parameters, in order to obtain the best visual quality. The final input parameters were obtained through the average values of each channel between two scenes.

At the end of the processing, images were rotated back to north-orientation, returning to original configuration for a new mosaic composition.

#### 4.3 First Experiment: CBERS Images

This experiment employed two scenes acquired by the first China-Brazil Remote Sensing satellite. The images are false-color composition of bands 4, 3 and 2 of a CCD sensor. Even though CBERS CCD sensor produces four bands distributed in the electromagnetic spectrum, the blue band was not used due to noise and other image-generation problems.

Both experiment steps were developed independently. The aim of the first step, responsible for the traditional enhancement procedure, was to create balanced images in an interactive way, through user interventions for color tones that decrease among different images. The second step included local adaptive algorithms for automatic processing. Figure 7 shows the original CBERS CCD images, as well as the final mosaics of both processings. Tables 3 and 4 show the input values used in global and local processing.

TABLE 3: CBERS CCD GLOBAL STATISTICAL INFORMATION AND CORRESPONDING VALUES FOR HISTOGRAM MANIPULATION.

Scene	Band	Statistic Mean / SD	Histogram Limits
154-126	4	94.8 / 9.9	43 – 139
154-126	3	55.2 / 7.3	41 – 97
154-126	2	47.7 / 4.7	34 – 68
153-126	4	124.1 / 13.1	83 – 164
153-126	3	69.0 / 9.2	49 – 109
153-126	2	56.1 / 5.6	34 – 81

TABLE 4: DODGER OUTPUT VALUES FOR THE CBERS CCD COMPUTED IMAGES.

Band 4	Mean	Standard Deviation
154-126	169.5	35.5
153-126	155.3	38.2
Band 3		
154-126	73.2	44.8
153-126	84.7	49.2
Band 2		
154-126	91.8	45.7
153-126	105.1	48.7
Calculated Values		
Band 4	162.4	36.8
Band 3	79.0	47.0
Band 2	98.4	47.2



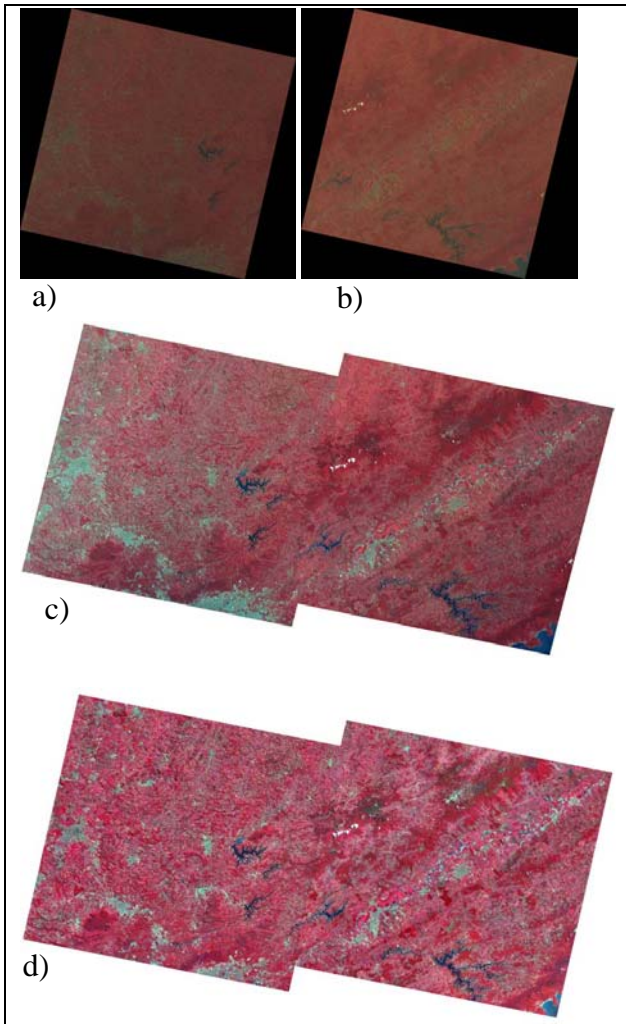


Fig. 7 - Original CBERS CCD images a) 154-126 and b) 153-126; c) manually enhanced images mosaic; d) automatic adaptive enhanced images mosaic.

#### 4.4 Second Experiment: LANDSAT ETM+ Images

The methodology applied to this step was similar to the previous one. Even though LANDSAT ETM+ has seven spectral bands and one panchromatic plus, bands 5, 4 and 3 only was used, because this composition is frequently mentioned in the literature. However, any other band composition could be used for visual inspection.

As well as in the previous experiment, the figures were illustrated in grayscale, only for print purpose, what can hinder the visualization of the effects. Figure 8 shows the original LANDSAT ETM+ images and the final mosaics of both processings. The input values used in global and local processing are in Tables 5 and 6.

Table 5 allows the user to analyze some interesting aspects in the images. For example, the red portion of the electromagnetic spectrum is equivalent to band 3. Thus, the mean value of band 3 of scene 222-075 is brighter than the adjacent image. This effect can be explained by the increase of vegetation

coverage in the period of 221-075 (rain season) scene acquisition and by its decrease during the dry season. The higher contrast indicates that the definition of the ruddy features in the 222-075 scene is greater than in the 221-075 scene.

TABLE 5: GLOBAL STATISTICAL INFORMATION OF LANDSAT ETM+ IMAGES AND THEIR RESPECTIVE HISTOGRAM LIMITS.

Scene	Band	Statistic Mean / SD	Limit Histogram adjust
222-075	3	108.6 / 22.8	44 – 157
222-075	4	83.5 / 14.6	47 – 125
222-075	5	108.9 / 23.0	40 – 157
221-075	3	62.4 / 18.7	25 – 134
221-075	4	94.1 / 21.9	49 – 146
221-075	5	101.1 / 29.5	43 – 184

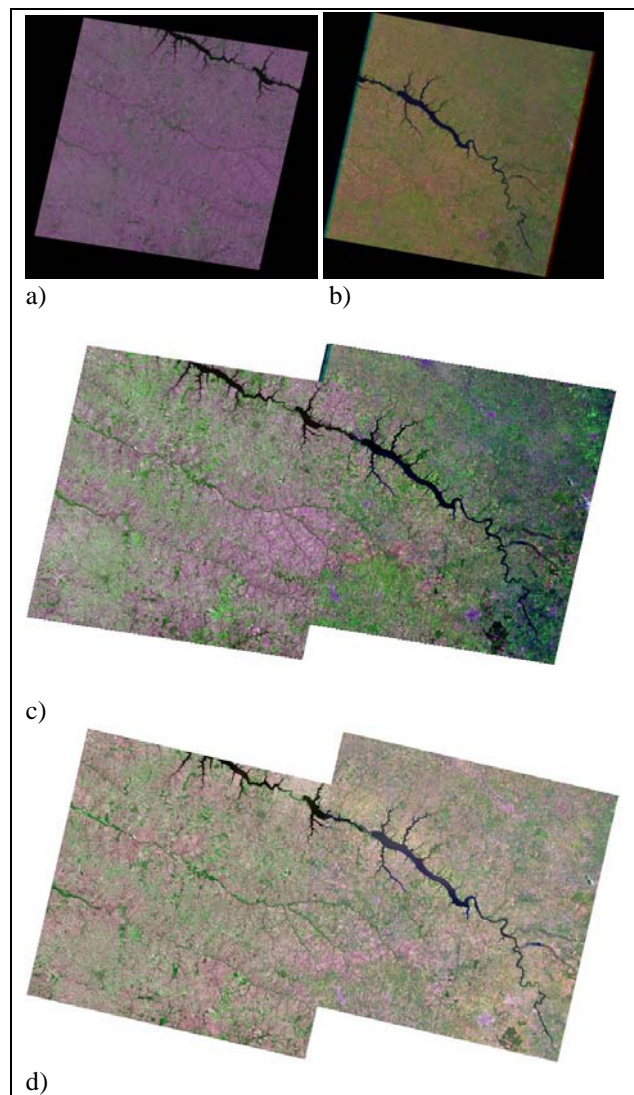


Fig. 8 - LANDSAT ETM+ Color composition of bands 5, 4 and 3. a) Original 222-075 image; b) original 221-075 image; c) global interactive images enhanced mosaic; d) automatic adaptive images enhanced mosaic.

TABLE 6: DODGER OUTPUT VALUES FOR THE LANDSAT ETM+ COMPUTED IMAGES.

	Mean	Standard Deviation
<b>Band 5</b>		
222-075	146.7	32.5
221-075	102.7	34.9
<b>Band 4</b>		
222-075	135.7	27.3
221-075	129.9	34.0
<b>Band 3</b>		
222-075	156.3	33.4
221-075	71.0	40.9
<b>Processed Values</b>		
Band 5	124.7	33.7
Band 4	132.8	30.6
Band 3	97.4	42.5

## 5. RESULT ANALYSIS

The traditional radiometric balancing for mosaic composition of Remote Sensing imagery was performed by global image histogram enhancement and enabled a good approximation between adjacent ones. Progressively, one of the images was used as a radiometric reference to adjust the other.

Since images included in the mosaic composition were acquired under different atmospheric conditions, especially the images from different reference orbits, the time difference between acquisitions should not be significant.

The main aspect of the first experiment was the time difference between the acquisitions of CBERS CCD imagery. Despite of the large time difference of almost six months, there were not large radiometric differences, since the atmosphere characteristics are similar in spring and fall seasons, in tropical regions. Another important aspect is the land coverage, composed of tropical forest, minimizing the temporal change effects. Therefore, the global result obtained by manual processing was adequate.

The automatic adaptative processing caused a reduction of discontinuities in the merging region. However, after automatic balancing, the images presented accentuated colorations than the processed manually ones, especially in clear and dark areas (see Figure 9). Probably, it can be caused by inadequacy of the parameters MIN/MAX CONTRAST and MAX GRAY SHIFT of the Dodger®. These accentuated colorations can cause feature interpretation errors.

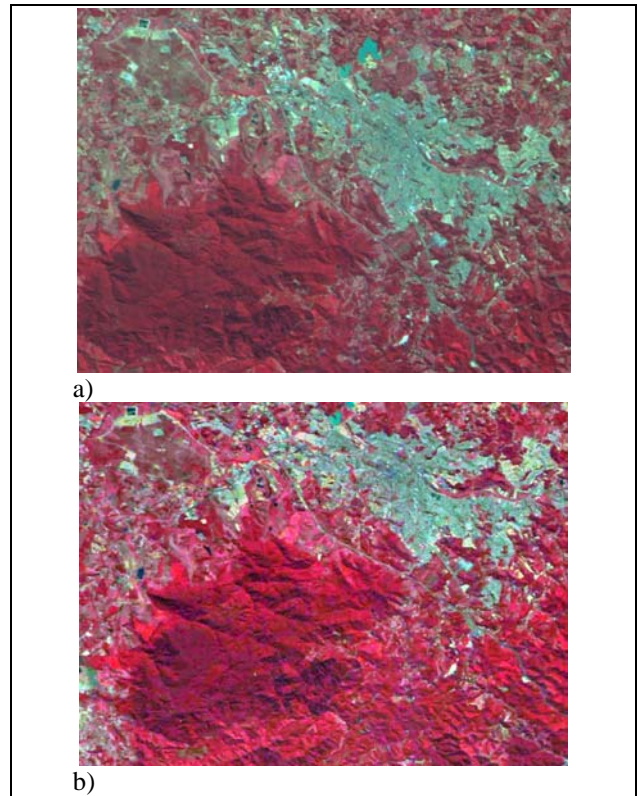


Fig. 9 - Effect of the process for CBERS image feature.  
a) Manual histogram enhancement;  
b) Automatic adaptative histogram enhancement.

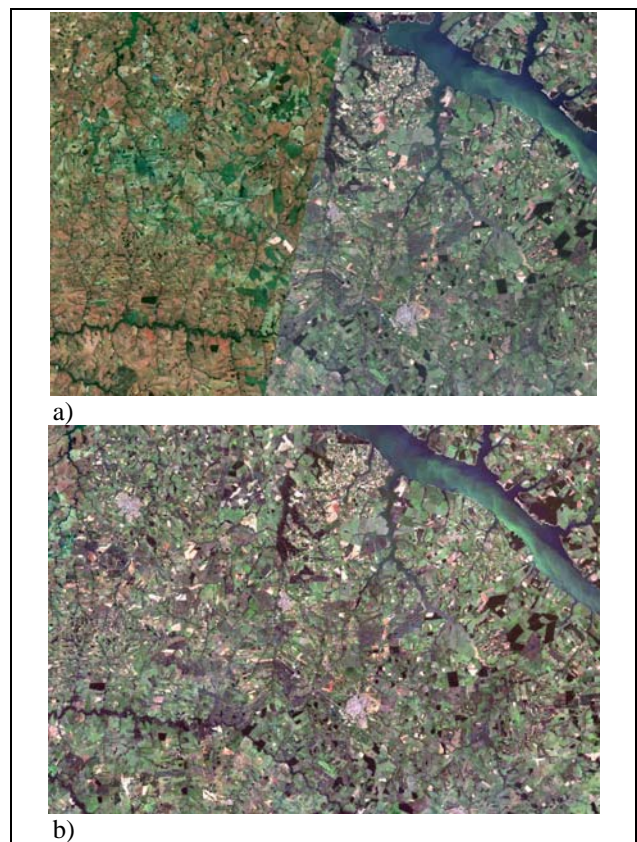


Fig. 10 - Detail of the merging region of LANDSAT ETM+ images: a) after global enhancement; b) after adaptative local enhancement.



Even though there was also a six-month interval between the CBERS CCD images used in the first experiment, they were acquired under similar atmospheric conditions. However, the LANDSAT ETM+ images used on the second experiment were acquired during summer and winter seasons, which present a tremendous climatic variation. Thus, in a rigorous analysis, all possible effects should be considered due to weather variation differences in temperature, humidity, soil and vegetation. Remembering that, the proposal of this paper is to analyze, in a visual way, if the balancing of images used in Photogrammetry can also be significant in satellite images, particularly for mosaics elaboration. Thus, any detailed analysis was disregarded here.

An important characteristic of the LANDSAT images is related to the soil coverage pattern, which is generally composed by temporary crops of sugar cane. Then, the high variation of spectral pattern can be interpreted as the presence or absence of sugar cane crops, which is seen in the ruddy aspect of the image 222-075 (Figure 8.a and 8.b).

In a general visualization, both processings can be considered good as the radiometric homogenization of the images. However, an approach of the mosaic in a transition area among the two images shows the softness promoted by the process adaptive, according to Figure 10.

## 6. CONCLUSION

Standard image enhancement techniques based on histogram stretching can be used for radiometric balance, as well as, automatic and adaptive techniques.

Based on visual analysis, two sets of Remote Sensing images acquired at different times were processed by manual and automatic procedures. The visual analysis showed the main differences between the two methods and revealed the advantages of the automatic method. However, time processing as well as computer resources was not evaluated.

The automatic process, based on the local histogram adaptation of global image balancing, has been used by Photogrammetry community, for one or more images. Then, based on the characteristics of the set of images, automatic image balancing procedures of global adaptive histogram enhancement were applied to Remote Sensing images. A detailed analysis of merging regions showed some improvements, such as local color tone minimization for both images after adaptive processing. The main advantages of this process are the reduction of computation time, the reduction of human intervention, the minimization of vigneting and hot spots; and the applicability to more than two images. Nevertheless, as the automatic is also based on histogram parameters, the introduction of a wrong parameter can worsen the quality of the result drastically.

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