IMAGE FUSION II IKONOS HIGH SPATIAL RESOLUTION BY THE METHOD OF REPLACEMENT RGB-I1I2I3

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Abstract: *Data fusion according Pine et. al (2005) consists of a formal framework in which are expressed concepts and tools for merging data from different sources in order to obtain higher quality information. The fusion method has gained wide recognition when Landsat imagery, multispectral, could be combined with SPOT panchromatic images, panchromatic, and proved to be useful for generating hybrid images that combine the properties of the original images into one new image that preserves the spectral information and provides input more spatial information. This document presents the I1I2I3 method, introduced by Ohta et al. (1980), as an option fusion by replacement with the method RGB-IHS.*

Keywords*: remote sensing, image processing, image fusion.*

1. INTRODUCTION

The fusion of images is a topic that aroused new interest due to the simultaneous collection of panchromatic and multispectral images with different resolutions. [9] exposes the following definition: "Data fusion is a formal framework in which are expressed in concepts and tools for merging data from different sources in order to obtain higher quality information."

The fusion method has gained wide recognition when Landsat imagery, multispectral, could be combined with SPOT panchromatic images, panchromatic, and proved to be useful for generating hybrid images that combine the properties of the original images into one new image that preserves the spectral information and provides input more spatial information.

The information content of a digital image is directly linked to its resolution in terms radiometric, spatial and spectral. An ideal image would have high spatial resolution, spectral, radiometric, offering all the advantages to the user or performer and facilitating information extraction. However, in practical terms, the remote sensing images show technical and operational limitations that restrict the acquisition of images with the resolution required for some purposes.

The apparent spatial resolution multispectral data, and its interpretation can be improved by combining these data with data of higher spatial resolution but low spectral resolution as the panchromatic images. There are different options for this, the replacement methods being the most common. According [6], method of efficiently fusing is characterized by preserving the spectral information of the original image and incorporating the spatial information of the panchromatic band for the hybrid product.

2. LITERATURE REVIEW

The objective of image fusion is to keep the spectral information and include, to the extent possible, the spatial information derived from the image pixel with lower (better spatial resolution). Different methods have been proposed for this purpose. The most traditional are described below, with emphasis on methods for replacement.

The image fusion technique using the IHS has been studied since the 80s. Authors such as [1], [2], [3], [10], and [12], demonstrate its application.

[9] divides the fusion techniques into three groups: those that use a model of the spatial domain, the spectral domain and working with algebraic operations. In the case of the model spectral domain, the multispectral image is transformed by processes that result in a new set of bands, one of which is correlated with the panchromatic image. Models such as Principal Components, IHS and Gram-Schmidt are part of this group.

For [11], RGB-IHS transformation can be used for image generation hybrid. The method was originally proposed to perform data fusion with panchromatic image of SPOT multispectral bands, or the fusion of SPOT panchromatic band with multispectral bands of Landsat, to improve image interpretation especially in urban areas. This kind of replacement is called melt and can be understood with the aid of Figure 1. Initially, the multispectral image, composed of three bands, the system is transformed to the RGB color system IHS. Then, the image associated with the intensity is replaced by the panchromatic band and then the inverse transformation is applied, returning to the RGB system with a multispectral image. The result is a color image with better spatial resolution.

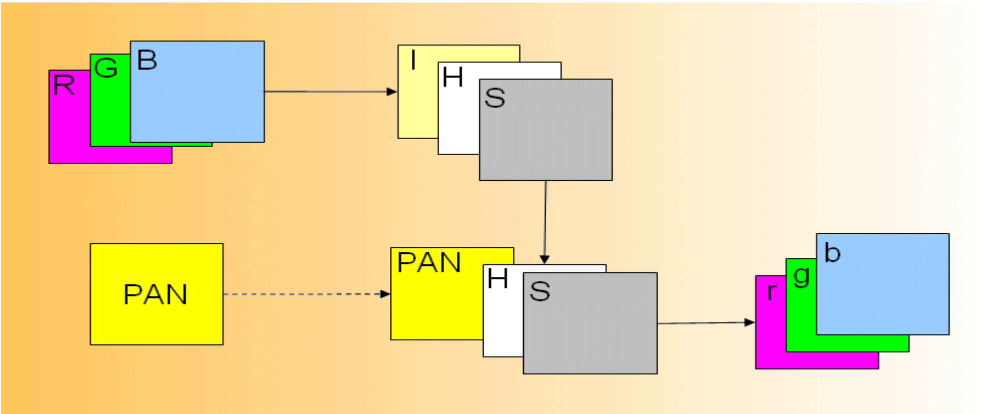


Figure 1 - Merger by substitution method with IHS.

Adapted to [5].

I1I2I3 The method, developed by [7], can be used for fusion, because the first band I1 processing upon rotation of the three axes of the space spectrum is also very similar to the component strength and can therefore be replaced by the image of better spatial resolution, the panchromatic. Also in [4] has been schematically the transformation of RGB for Hue-Saturation-Intensity (HSI) and vice versa.

The ideal case of IHS transformation applied to the merger should take into account the spectral range of the panchromatic image and multispectral images to allow for a proper spectral result [8].

3. MATERIALS

- IKONOS II with spatial resolution of 1.0 m with 4.0 m multispectral and dated date of June 2, 2003. The region of the Americas Garden neighborhood in Curitiba / PR.
- Programs are Matlab 6.1 - calculating the fusion method proposed by replacing the System I1, I2 and I3 [7].

4. METHODS

4.1 The RGB system

The way to display spectral data using a computer is to associate digital counter readings at different intensities of the bands in color monitor, associating the energy reflected from objects or levels of gray tones. The monitor represents colors through additive combination of basic colors: red (Red), Green (Green) and blue (Blue), which derives the name of RGB (Red, Green, Blue).

Any color to be represented on the screen should be the result of the combination of these three basic colors. This, according to [5], resulting in a limited number of colors, however, is too large relative to the capacity of perception of the human eye. The colors can be represented by a three-dimensional vector (RGB) and digital potential values depend on the radiometric resolution image. For an eight-bit image, the space takes the form of a cube of 256 digital values on each axis.

4.2 The I1I2I3 system

In search of an optimal system for the segmentation of photographs of natural scenes, evaluated the differences between various options for color representation which include, besides the IHS system and major components, systems such as YIQ, standardized RGB, XYZ, Lab or U * V * W *. Analyzing the results obtained in segmentation of eight color photographs, conclude that a simple transformation, consisting of three vectors originating rotation of the RGB system is efficient and can be used in segmentation without major losses in terms of color.

After computing the principal components of different images, [7] realized that there is a tendency of the principal components is similar, regardless of the nature of photography. The coefficients of the first component tends to be all equal and with the same sign. Therefore, this component is close to parallel to the main diagonal of the RGB system.

The other two are located in a plane perpendicular to the first. Therefore, they proposed the approach of components by a simple rotation. The components of this new system, called by him (I1, I2, I3) are described by the following rotation matrix:

$$MI = \begin{bmatrix} 1/3 & 1/3 & 1/3 \\ 0 & -1/2 & 1/2 \\ 1/2 & -1/4 & -1/4 \end{bmatrix} \quad (1)$$

The first component is the average of three bands in the RGB system. The second is the difference between red and green and blue. The third is the difference between blue and green. Eventually, the signs can be changed, depending on the direction vector. The last two stored color information and the first intensity, immediately following this will be investigated whether system can also be used to image fusion.

5. EXPERIMENTS

As a first step, a cut was extracted image, IKONOS II, containing the band PAN and multispectral bands. This cut was used to perform geometric transformation of multispectral scene and PAN, the multispectral bands still had its spatial resolution scaled to the same spatial resolution, thus pre-processed for fusion upon the method chosen.

Prior to the merger [7]. Transformation was performed by principal components to verify the possibility of replacing method I1I2I3 in place of HIS. The rotation matrix derived from the eigenvectors associated to the variance-covariance matrix when calculating the principal components of this part are shown in Table 1.

Table 1 – Matrix of rotation of the principal components derived from clipping.

	clipping 3		
CP1	0,50	0,55	0,67
CP2	0.43	0,51	-0,74
CP3	-0,75	0,66	0,02

For processing the merger called for I1I2 I3, developed by [7] just three multispectral bands were considered: the bands 2 (green - G: 0.52 - 0.60 mm), 3 (red - R: 0.63 - 0.69 mm) and 4 (near infrared - V: 0.76 - 0.90 mm). The same region was cropped the image panchromatic (Pan: 0.45 - 0.90 mm), Figure 2 shows the cutouts, image IKONOS II (b), the first being the panchromatic and multispectral Monday through false color composite color R4G3B2).

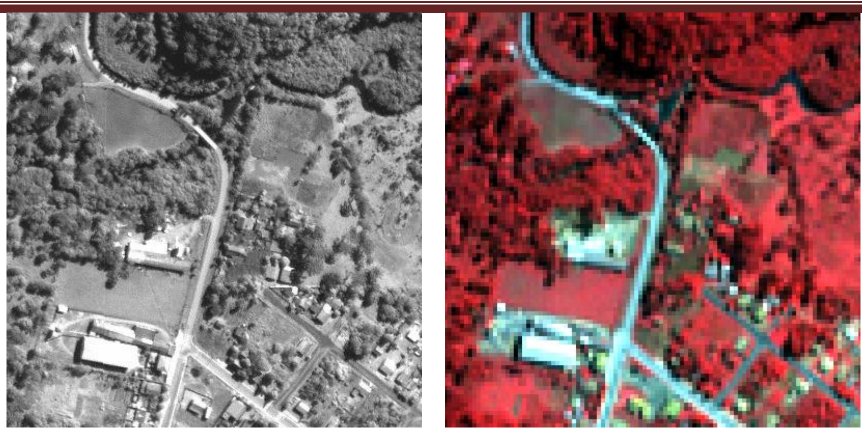


Figure 2 - Scene cropped image IKONOS II (a) Panchromatic and (b) multispectral.

It appears that the trend indicated also found in these indentations, as indicated in Table 1. One interpretation for the main components, in terms of spectral bands used, it is also possible:

(a) The first component tends to be the average of the three original components (Band 4, 3 and 2) because the coefficients tend to be equal, and all positive. This component corresponds to the intensity as calculated in transforming RGB - IHS.

(b) The second component shows a clear trend between the band-infrared and visible bands (0.5 Banda4 * - 0.25 * (+ Banda3 Banda2)). Therefore, it can be interpreted as a vegetation index, the contrast between infrared and visible.

(c) A terceira componente é caracterizada pela diferença entre as bandas do visível (Banda3 – Banda2).

(d) The second and third components are located in a plane perpendicular to the first eigenvector. Regardless of the direction of the second and third component, the plane defined by them is equal to the plane defined by the vectors V1 and V2 used in the IHS system.

Based on this finding, the rotation matrix proposed by [7], was adopted for the fused images by the substitution method. Accordingly, the following steps were implemented:

(a) The three bands were transformed using the rotation matrix [7], as shown in equation 1.

I1I2I3 = MI * (RGB)

(b) Corresponding to image I1 was replaced by the panchromatic image.

I1I2I3 $\rightarrow$ PAN I2I3

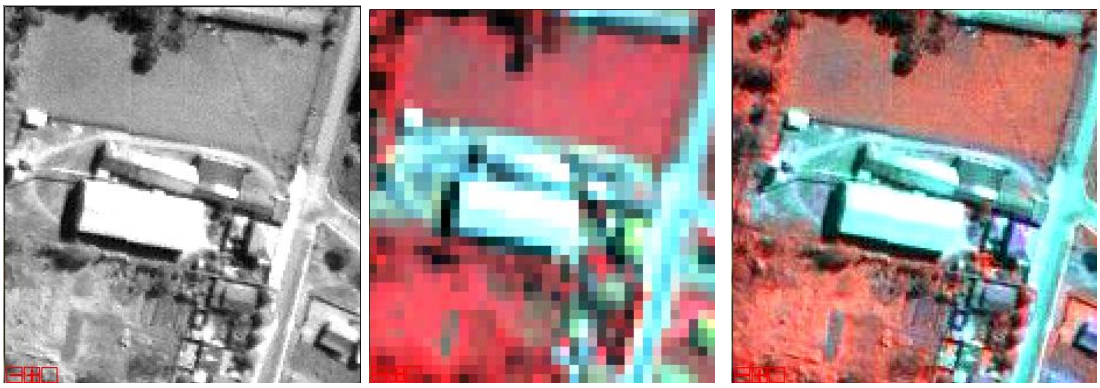
(c) The inverse transformation was applied to this new set:

RGB = inv (MI) * PAN-I2I3

The result of this process is a better spatial resolution image, the details of the panchromatic image derivatives, and the colors derived multispectral image. In Figure 3 are the hybrid image, i.e., the fusion already processed sensor IKONOSII.

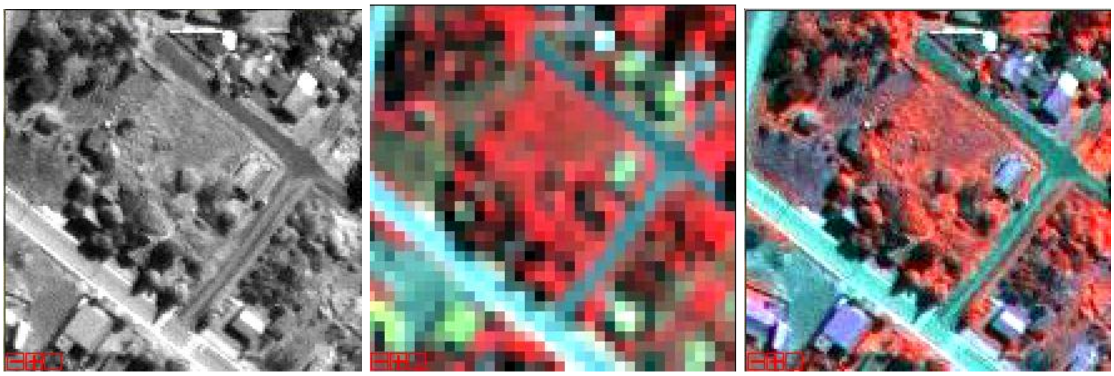
Figure 3 – Scene hybrid image - fusion between panchromatic and multispectral

Figure 4 shows the details of constructions, and Figure 4 (a) PAN scene with a spatial resolution of 1 meter, (b) with spatial resolution multispectral fourth and third spectral bands and, (c) the scene melting, that is, the image containing the hybrid spectral information (false color) and spatial resolution of 1 m from the panchromatic.



(a) (b) (c)

Figure 4 shows details of Figure vegetation being (a) the PAN scene, the (b) and multispectral (c) fusion with the scene, i.e. the hybrid image.



(a) (b) (c)

Figure 5 – PAN details of the original images, multispectral and hybrid.

6. CONCLUSIONS

In the present study we used the method I1I2I3 to perform the fusion between multispectral image with spatial resolution panchromatic and 4m IKONOS II of the same sensor with a spatial resolution of 1m.

The digital processing performed in the laboratory was fully mathematical program MATLAB 6.1, which is important since the separation of the spectral bands to a transformation by rotation by the method II1I2I3 replacement and also to achieve fusion. It was performed earlier and replacing rotation, a statistical analysis, the calculation of three major components for corroboration of the possibility of using the method I1I2I3 when the fusion, ie the possibility of replacing the panchromatic intensity upon rotation through equation 1 as described in the methodology.

The results shown in Figures 5 and 6 are satisfactory when the visual analysis and the importance of the method in I1I2I3 is easy to perform, because three steps are required: direct transformation (rotation), replacing the first component by the PAN image and inverse transformation, so there has the problems of transformation RGB-I1I2I3 therefore does not require angular transformations.

It is suggested comparing this method with other fusion methods. In addition, after conversion systems, the image associated with the intensity that is replaced by the panchromatic image and the subsequent realization of RGB-IHS transformation, returning to RGB with a multispectral image with better spatial resolution and we can note that depending on the type of information present in the image fusion can improve the picture or not, for example in the case where the texture points to better differentiation as can be seen in the example above (Figure 5 and 6) in the case of constructions highlighting and vegetation.

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