HSV Based Satellite Image Fusion

Rohan Ashok Mandhare and Prof. Sudha Gupta

Abstract:

Remote sensing images fusion can not only improve the spatial resolution for the original multispectral image, but also preserve the spectral information to a certain degree HSV sharpening technique is one of the most commonly used technique for image fusion. A transformation is developed to transfer a RGB image into HSV space. In this paper, two different HSV based methods are studied and examine in order find better fusion algorithm for LANDSAT satellite images. Numerical statistical methods such as RMSE, PSNR are used to quantitatively assess fused images produces using above algorithm. The analysis indicates HSV method based on NDVI is best method for fusion as far as vegetation area is concerned.

***Keywords*: HSV, NDVI, PSNR,RMSE.**

INTRODUCTION

Remote sensing offers a wide variety of image data with different characteristics in terms of temporal, spatial, radiometric and Spectral resolutions. For optical sensor systems, imaging systems somehow offer a trade off between high spatial and high spectral resolution, and no single system offers both. Hence, in the remote sensing community, an image with 'greater quality' often means higher spatial or higher spectral resolution, which can only be obtained by more advanced sensors [1]. The designing of a sensor to provide both high spatial and spectral resolutions is limited by the trade off between spectral resolution, spatial resolution, and signal-to-noise ratio of sensor. It is, therefore, necessary and very useful to be able to merge images with higher spectral information and higher spatial information [2].

Image fusion techniques can be classified into three categories depending on the stage at which fusion takes place; it is often divided into three levels, namely: pixel level, feature level and decision level of representation [3; 4]. The pixel image fusion techniques can be grouped into several techniques depending on the tools or the processing methods for image fusion procedure. By [5; 6] it is grouped into three classes: Color related techniques, statistical, arithmetic/numerical, and combined approaches.

The acronym IHS is sometimes permutated to HSV in the literature. HSV fusion methods are selected for comparison because they are the most widely used in commercial image processing systems. Many other papers describe different formula of IHS transformations, which have some important differences in the values of the matrix, are used such as IHS transformation.

Rohan Ashok Mandhare is a ME student, K. J. Somaiya College Of Engineering and Prof. Sudha Gupta is working as a Assistant Professor, K. J. Somaiya College Of Engineering

The rest of the paper is organized as follows: in section 1, we will discuss basics of HIS techniques, in section 2, we will introduce two different HSV based fusion techniques followed by a quality assessment in section 3. Before concluding in section 5 we present some experimental results in section 4.

1. IHS Technique Basic

The IHS technique is one of the most commonly used fusion techniques for image fusion. In the IHS space, spectral information is mostly reflected on the hue and the saturation. From the visual system, one can conclude that the intensity change has little effect on the spectral information and is easy to deal with. For the fusion of the high-resolution and multispectral remote sensing images, the goal is ensuring the spectral information and adding the detail information of high spatial resolution, therefore, the fusion is even more adequate for treatment in IHS space.

The complexity of the models varies, they produce similar values for hue and saturation. However, the algorithms differ in the method used in calculating the intensity component of the transformation. The most common intensity definitions are:-

V = max(R,G,B)

L= max(rgb)+min(R,G,B)/2

The first system (based on V), also known as the Smith's hexcone and the second system (based on L), known as Smith's triangle model. The hexcone transformation of IHS is referred to as HSV model which drives its name from the parameters, hue, saturation, and value, the term "value" instead of "intensity" in this system.

2. HSV(Hue,Sturation,Value)

HSV method consists on transforming the R, G and B bands of the multispectral image into HSV components, replacing the value component by the panchromatic image, and performing the inverse transformation to obtain a high spatial resolution multispectral image.

This one of the most widely applied fusion procedure for merging panchromatic imagery with three-color multispectral imagery [6].

Corresponding matrix expression of HSV method is follows :

To convert RGB to HSV:

$$\begin{bmatrix} V \\ V_1 \\ V_2 \end{bmatrix} = \begin{bmatrix} 0.577 & 0.577 & 0.577 \\ -0.408 & -0.408 & 0.816 \\ -0.707 & 0.707 & 1.703 \end{bmatrix} \begin{bmatrix} R \\ G \\ B \end{bmatrix}$$

$$H = tan^{-1}\left(\frac{V_2}{V_1}\right)$$

$$S = \sqrt{V_2^2 + V_1^2}$$

The gray value Pan image of a pixel is used as the value in the related color image, i.e. in the above equation (2) V=I

To convert HSV to RGB:

$$\begin{bmatrix} R \\ G \\ B \end{bmatrix} = \begin{bmatrix} 0.577 & -0.408 & -0.707 \\ 0.577 & -0.408 & 0.816 \\ 0.577 & 0.816 & 0 \end{bmatrix} \begin{bmatrix} V \\ V_1 \\ V_2 \end{bmatrix}$$

The simplest, most wide-spread and probably most intuitive technique works as follows:

1. Take three spectral bands from the multispectral imagery;
2. register the low resolution color image to the high resolution panchromatic image (i.e. essentially to magnify the color image to the same pixel size as the panchromatic image);
3. Transform the magnified color image from an RGB color system into the HSV color system (Hue, Saturation, and Value).
4. replace the ``Value'' image by the high resolution panchromatic image;
5. Transform back into the RGB color system.

This technique is known to work well for moderate resolution ratios (such as 1:3 for SPOT + LANDSAT TM). The results are still helpful but less reliable for resolution ratios such as 1:20, e.g. for fusion of SPOT color images with panchromatic aerial photography.

It has to be noted, however, that fusion by HSV transformation can be applied only to multispectral imagery consisting of three bands, since the image has to be coded as an RGB image before fusion can take place. Another problem with this approach is that it introduces color distortion result of the mismatches; that is, the Pan and I are spectrally dissimilar. In particular, the grey values of Pan in the green vegetated regions are far larger than the grey values of I because the areas covered by vegetation are characterized by a relatively high. reflectance of NIR and Pan bands as well as a low reflectance in the RGB bands

When IHS-like fusion methods are used with wide band PAN imagery, there is a significant color distortion, due primarily to the range of wavelengths of Pan image. Pan images have an extensive range of wavelengths from visible to near-infrared (NIR). This difference obviously induces the color distortion problem in the traditional IHS fusion.
As mentioned in the latter section, the IHS fusion introduces color distortion when dealing with wide band PAN images. To solve this problem, we adopt new technique: this approach makes use of the Normalised Difference Vegetation Index (NDVI) to identify the vegetation area and then enhances it in the green (G) band by using the red (R) and the NIR bands[5].

In this work, we adopt a new approach in order to minimize color distortion in fuse image. We know that color distortion is seen in fuse image due to fact that gray values in PAN image are far larger than that of V. Hence we will enhance green band of MS image in order to have gray values of MS and PAN at same range.

2.1 NDVI

Vegetation indices (VI) are combinations of spectral measurements in different wavelengths as recorded by a radiometric sensor. They aid in the analysis of multispectral image information by shrinking multidimensional data into a single value. They serve as indicators of relative growth and/or vigour of green vegetation, and are diagnostic of various biophysical vegetation parameters.

The Normalized Difference Vegetation Index (NDVI) is an index calculated from reflectance's measured in the visible and the near infrared channels.

$$NDVI = \frac{NIR - R}{NIR + R}$$

Where NIR and R stand for the spectral reflectance measurements acquired in the near-infrared and red regions, respectively. NDVI has the advantage of varying between -1 and 1, where vegetated areas typically have values greater than zero. It is related to the fraction of photo-synthetically active radiation.

2.2 Current Approach for Vegetation area

In this a method is used to enhance the vegetation area in the green band using a proportion of the difference between the NIR and Red bands. After finding NDVI basic HSV method is used to fuse MS and PAN image. When we are calculating NDVI we can get two kind of NDVI positive or negative. Positive NDVI indicates high vegetation area. The enhancement is accomplished only for the region where the NDVI is positive. In our experiments, a 40 percent of the (NIR-R) difference gave best results in terms of fused image quality1. Given the NIR and the R bands, calculate the NDVI index using equation 1. following are the steps used for fusion[7]:

1. For region where NDVI is positive apply enhance green band.

2.The HSV transform is then applied on the R, B and engG

3. The enhanced H and S are used with the Pan to get the enhanced RGB image, by use of the inverse IHS transform. We then subtract the amount added in step 2 from the green band[7].

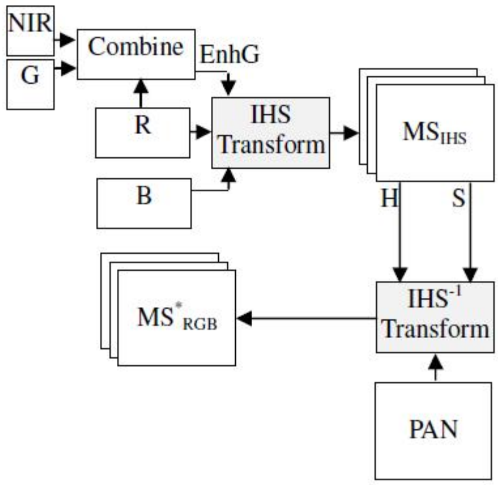


Fig. 1 Steps for image fusion using Enhanced NDVI method

3. Assessment parameters

.Simple image metrics were considered to measure the various features of the fused image to getter a better picture of the quality measurement. We have selected Root Mean Square Error(RMSE) and Peak Signal to Noise Ratio (PSNR)for this purpose.

a. Root Mean Square Error (RMSE):

A commonly used reference-based assessment metric is the root mean square error (RMSE). This ratio is used as a quality measurement between the original and a reconstructed image. The higher the value of RMSE, the better is the quality of reconstructed image. It is defined as follows:

$$RMSE = \sqrt{\frac{1}{MN}\sum_{m=1}^{M}\sum_{n=1}^{N}(R(m,n) - F(m,n))^2}$$

where R(m,n) and F(m,n) are reference and fused images, respectively, and M and N are image dimensions.

b. Peak Signal to Noise Ratio (PSNR):

PSNR computes the peak signal-to-noise ratio, in decibels, between two images. This ratio is used as a quality measurement between the original and a reconstructed image. The higher the PSNR, the better is the quality of the reconstructed image. To compute the PSNR, first we have to compute the mean squared error (MSE) using the following equation:

$$MSE = \frac{1}{mn}\sum_{i=1}^{m}\sum_{j=1}^{n}\left(A_{ij} - B_{ij}\right)^2$$

$$PSNR = 10 \times \log_{10}\left(\frac{peak^2}{MSE}\right)$$

Peak depends on the input image maximum fluctuation.

4. Input Data

To work on image fusion techniques data from LANDSAT+ETM sensor is taken. These two images are in .LAN format. These images are first read using “multibandread’ command in matlab in order to convert in JPEG format. These images are of ITHAC, New York.

Fig. 2a Using Band 321

Fig. 2b Using Bands 432

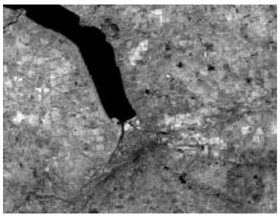


Fig. 2b Panchromatic Image

Fig. 2 Input Images

5. Results

In order to fully utilize spectral information of former and geometric information of latter, image fusion algorithm is applied to the set of input images. All the methods explained above were implemented using Matlab software.

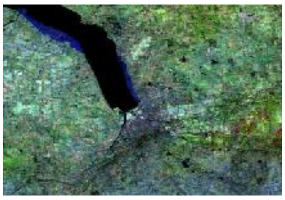


Fig.3a Bands 321 and Pan image

Fig.3a Bands 432 and Pan image

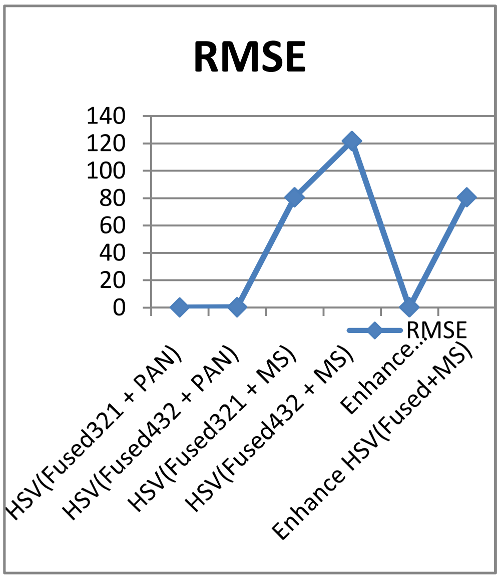
Fig. 3 Results of Fusion using HSV method

Fig. 3 Results of Fusion using enhanced HSV method

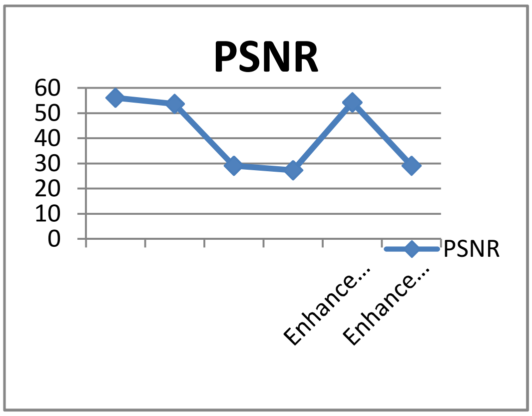
Visual analysis: If we observe the above images, we can say that enhanced HSV method gives better results than normal HSV method.

In addition to visual analysis, we conducted a quantitative analysis. In order to assess the quality of the fused images in terms of RMSE and PSNR.

METHOD	RMSE
HSV(Fused321 + PAN)	0.1585
HSV(Fused432 + PAN)	0.2787
HSV(Fused321 + MS)	80.7003
HSV(Fused432 + MS)	121.867
Enhance HSV(Fused+PAN)	0.2427
Enhance HSV(Fused+MS)	80.7284



METHOD	PSNR
HSV(Fused321 + PAN)	56.1311
HSV(Fused432 + PAN)	53.6802
HSV(Fused321 + MS)	29.0621
HSV(Fused432 + MS)	27.272
Enhance HSV(Fused+PAN)	54.2805
Enhance HSV(Fused+MS)	29.0605



Above table and graph gives values of RMSE and PSNR for different methods. For quality image RMSE value between PAN image and fused image should be less. At a same time it should be more between fused and MS image.

6. Conclusion

This paper analyze and compare two different methods of satellite image fusion with the help of visual and quantitative methods. Out of these two methods applied here second method which is based on enhancing green band of MS image and then applying HSV algorithm is providing good result in terms of visual analysis. Quantitatively both the methods are providing same results. So we can conclude that enhance HSV method is better than basic HSV method.

References

[1]. Firouz Abdullah Al-Wassai1, N.V. Kalyankar2, Ali A. Al-Zuky, "IHS based Image Fusion Method",

[2]. C Pohl, J van Genderen, "Multisensor Image Fusion of remotely sensed data: concepts, methods and applications", *International Journal Remote Sensing vol19(5)* march 2009.

[3]. R McDaniel, D Scribener, W Krebs, P Warren, N Ockman, and J McCarley, " Image Fusion for tactical applications" ", *International Journal Remote Sensing*, Vol. 3436.

[4]. Dou W., Chen Y., Li W., and Daniel Z. Sui, 2007. "A General Framework for Component Substitution Image Fusion: An Implementation Using the Fast Image Fusion Method". *Computers & Geosciences 33 (2007), pp. 219–228* july 2007.

[5]. Zhang Y."Understanding Image Fusion". *Photogrammetric Engineering & Remote Sensing,* pp. 657-661., September 2004.

[6]. Zhang J.,. "Multi-Source Remote Sensing Data Fusion: Status and Trends". *International Journal of Image and Data Fusion, Vol. 1, No. 1, , pp.5–24,* March 2010.

[7]. Heng Chu, Welie Zhu " Fusion Of IKONOS Satellite Imagery Using HIS Transform & Local Variation", IEEE Geoscience & Remote Senescing,653-657, Oct 2008.

[8]. Ehlers M., Klonus S., Johan P., and strand Å and Rosso P., "Multi-Sensor Image Fusion For Pan Sharpening In Remote Sensing". *International Journal of Image and Data Fusion,Vol. 1, No. 1,* , pp.25–45. March 2010.

[9]. Gangkofner U. G., P. S. Pradhan, and D. W. Holcomb, "Optimizing the High-Pass Filter Addition Technique for Image Fusion". *Photogrammetric Engineering & Remote Sensing, Vol. 74, No. 9, pp. 1107–1118*, January 2008.

[10]. Ms. Poorvi H. Patel, Prof. Vandip J. Patel and Prof. Ashish M. Kothari, "Fusion of Reconstructed Magnitude and Phase part of MRI", *International Journal of Emerging Trends in Electrical and Electronics (IJETEE),* Vol. 3, Issue. 2, pp. 49-55, May-2013.