ISSN: 0974-2115
www.jchps.com Journal of Chemical and Pharmaceutical Sciences

Pansharpening using Adaptive Fusion

Tessy Zacharia*, Geetha P
Remote Sensing and Wireless Sensor Networks, Center for Excellence in Computational Engineering and Networking, Amrita Vishwa Vidhyapeetham, Coimbatore, India
***Corresponding author: E-Mail: tessyzacharia43@gmail.com**

ABSTRACT

Pansharpening refers to fusion of a multispectral (MS) image with a panchromatic (PAN) image to obtain an image with both high spatial and spectral resolution. Among the many existing pansharpening methods the most widely used is the component substitution method. In this paper an improved model of this existing method is proposed which is based on the matting model and an adaptive fusion technique known as the harmony search algorithm. In this model the MS image which can be decomposed to three components via, the alpha channel, spectral foreground and background is used to reconstruct a high resolution MS image by substituting the PAN image instead of the alpha channel. The fusion is done using an adaptive technique, the harmony search which finds the optimal weight value for effective fusion and it is observed that this method gives a better value for many quantitative indices.

KEY WORDS: Pansharpening, Matting model, Adaptive fusion, Harmony search.

1. INTRODUCTION

Remote sensing refers to the activities of obtaining information about an object by recording, observing and perceiving without coming in direct association with it. It has a lot of applications in military, urbanism and surveillance. It uses sensor technology to identify and classify objects on the surface of the earth or in its atmosphere through means of propagated signals. The radiation which are emitted or reflected by the objects at different wavelengths are detected and measured by the sensors. The applications of remote sensing imagery is vast but the common applications include mapping land-use and cover, precision farming, forestry, surface temperature, object detection, military observation etc.

Usually the sensors, can acquire images in different spectral bands at various frequency bands or resolutions. Therefore, a broad spectrum of data can be acquired from the same observed object or scene. Considering many of the applications, the data collected by one sensor may be insufficient, inconsistent, and imprecise. Many of the satellites use dual sensors to capture images. For example satellites like IKONOS, Quick bird, Geo Eye etc. uses dual sensors to capture both panchromatic and multispectral images. These sensors are of different spectral and spatial resolutions. The panchromatic (PAN) images are generally obtained with high spatial resolution and multispectral (MS) images obtained in high spectral resolution.

Panchromatic sharpening otherwise known as Pansharpening is a method of sharpening multispectral image using a panchromatic image. Pan sharpened images results in a fusion of both panchromatic and multispectral images which gives the best of both the image types. The image will have both high spectral resolution and spatial resolution. There are many methods of pansharpening. One of the methods is injection-based method. Another one is based on image formation method and yet another type of pansharpening is based on component substitution. Injection-based methods focus on proposing effective image representation methods such as wavelet transform, Laplacian pyramid, nonsub sampled contourlets, bilateral decomposition, and support value transform to extract image details. The image formation method aims at solving the inverse problem through utilizing different regularization or optimization methods such as the sparsity regularization, autoregressive model, Markov random fields, or maximum a posterior. The third method is mostly based on the principal component analysis (PCA) or intensity hue saturation (IHS) transform.

The first method effectively sharpens the MS image and also retains the spectral information contained in the MS image. Hence this shows a good pan sharpening performance. But the spatial details for PAN images and MS images may look very different from one another for the images captured by remote sensing satellite. Hence this method may produce serious spectral and spatial distortions. Formation model-based methods usually work well in retaining both spectral and spatial information. However, estimating a appreciable solution of the ill-posed inverse problem consumes more time and is rather difficult. Among these methods, the last method i.e. the PCA or IHS can be efficiently implemented and generally performs well in preserving spatial information, even though it may cause serious spectral distortion. Also there are many commercially available software packages for pansharpening. Some of them are ERDAS, ENVI, ERSI and PCI. Each of these use different types of pan sharpening techniques for merging the PAN image and MS image. ERDAS uses techniques like HPF (high pass filter) Resolution Merge, Modified IHS Resolution Merge, Resolution Merge, Subtractive Resolution Merge, and Wavelet Resolution Merge. ENVI techniques include Color normalization (Brovey algorithm), Gram Schmidt Spectral Sharpening, and PC (principle component) Spectral Sharpening. The PCI software uses a technique called Pan Sharp and ERSI uses ESRI Pansharpening technique.

All these techniques may have unstable performance when processing images from different satellite which may contain various different objects. So here the proposed model is based on matting model and adaptive fusion using harmony search algorithm for pansharpening which is efficient and simple. Experimental results show that this method gives a better performance than many of the existing methods.

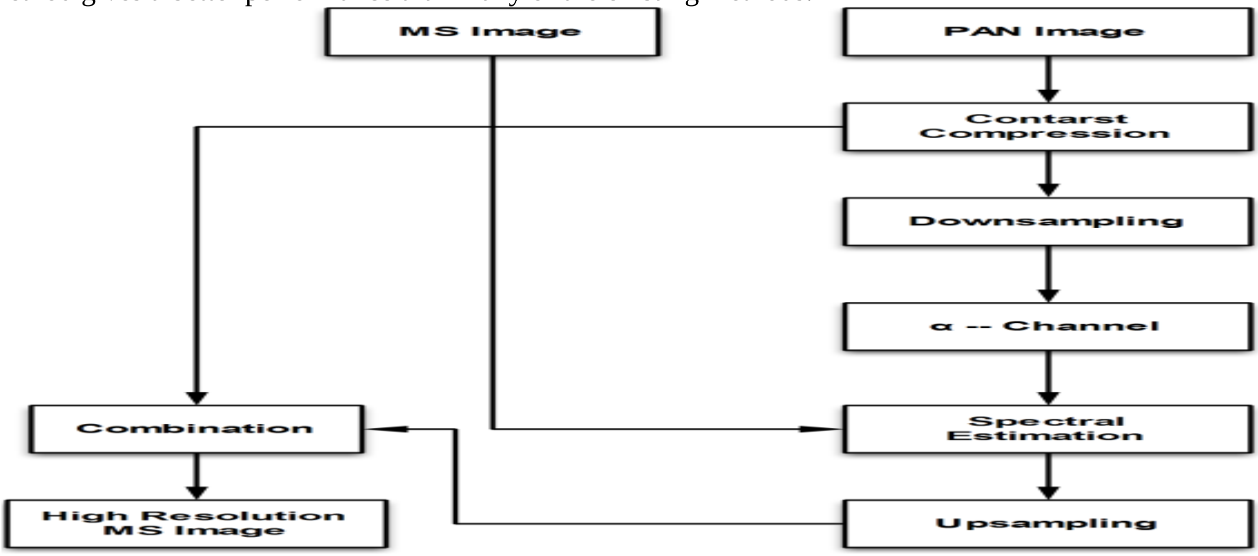


Fig.1.Schematic diagam of the proposed method


a


b

Fig. 2. (a) Input PAN image (b) Input MS image

ENVI, ERSI and PCI. Each of these use different types of pan sharpening techniques for merging the PAN image and MS image. ERDAS uses techniques like HPF (high pass filter) Resolution Merge, Modified IHS Resolution Merge, Resolution Merge, Subtractive Resolution Merge, and Wavelet Resolution Merge. ENVI techniques include Color normalization (Brovey algorithm), Gram Schmidt Spectral Sharpening, and PC (principle component) Spectral Sharpening. The PCI software uses a technique called Pan Sharp and ERSI uses ESRI Pansharpening technique.

All these techniques may have unstable performance when processing images from different satellite which may contain various different objects. So here the proposed model is based on matting model and adaptive fusion using harmony search algorithm for pansharpening which is efficient and simple. Experimental results show that this method gives a better performance than many of the existing methods.

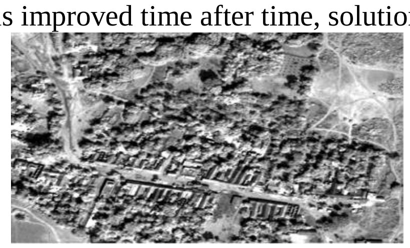
Theory of proposed model: Mathematically the matting model, models the observed image as a convex combination of the foreground image and the background image.

$$I_m = \alpha_m F_m + (1-\alpha_m) B_m \qquad (1)$$

Where *m* refers to the *m*th pixel value and refers to the opacity of the foreground image.

In this method a high resolution MS image is expected to be reconstructed by substituting the alpha channel, foreground and background into (1). As the PAN image contains most of the edge information, it can be replaced instead of the alpha channel to efficiently reconstruct a high resolution MS image. Then fusion of the images is done using an optimal fusion algorithm, harmony search which finds the optimal weight value for an efficient fusion.

The HS algorithm was created from inspiration by the spontaneity of Jazz musicians. Just like musical harmony is improved time after time, solution vector is improved each time iteration by iteration.


a


b

Fig.3. (a) Compressed PAN image and (b) Downsampled PAN image

Steps of the HS algorithm include problem formulation, algorithm parameter setting, random tuning for memory initialization, harmony improvisation (random selection, memory consideration, and pitch adjustment), memory update, performing termination, and cadenza.

Pansharpening based on adaptive fusion: Fig.1. Shows the schematic diagram of the proposed method. The proposed method basically consists of five steps. In the first step the high resolution PAN image (HP) is compressed to relatively smaller pixel values. This is done so that the edge features of the PAN image is equally processed at the next step. This can be mathematically represented as follows:

$$\tilde{HP}_m = \frac{(1-2\rho)HP_m}{v} + \rho \qquad (2)$$

Where *m* is the m th pixel value, is a contrast that determines bounds of the pixel value in compressed image and is the maximum pixel values in *HP*.

The second step involves down sampling of the compressed PAN image to reduce its resolution to the resolution of the MS image. The down sampled image is called the alpha channel of the MS image.

$$\tilde{LP}_m = \downarrow \tilde{HP}_m \qquad (3)$$

The third step is the spectral estimation in which the alpha channel and the MS image which is of lower resolution is used to estimate the spectral foreground and background. This is based on the assumptions that the spectral foreground and background are spatially smooth and also that the alpha channel, the spectral foreground and background should be able to reconstruct the original low resolution MS image.

$$\begin{aligned} \min \sum_{m \in LM} \sum_{c} & (\tilde{LP}_m LF_m^c + (1-\tilde{LP}_m) LB_m^c)^2 \\ & + \left|\tilde{LP}_{mx}\right| ((LF_{mx}^c)^2 + (LB_M x^c)^2) \\ & + \left|\tilde{LP}_{my}\right| ((LF_{my}^c)^2 + (LB_M y^c)^2) \end{aligned} \qquad (4)$$

Where c and m means the c th color channel and m th pixel. LF_{mx}^c, LF_{my}^c, LB_{mx}^c, LB_{my}^c, $\tilde{LP}_{mx}$ and $\tilde{LP}_{my}$ are horizontal and vertical derivatives of spectral foreground LF^c, spectral background LB^C and low resolution alpha channel $\tilde{LP}$.

Fig.4. (a) Spectral foreground and (b) Spectral background

The fourth step involves the up sampling in which the high resolution spectral foreground and background is approximately estimated from the low resolution spectral foreground and background from (4).

$$HF^c = \uparrow LF^C \qquad (5)$$

$$HB^c = \uparrow LB^C \qquad (6)$$

In the final step the high resolution spectral foreground, background and the high resolution alpha channel is fused to give the pansharpened image.

$$HM_m^c = \tilde{HP}_m HF_m^c + (1-\tilde{HP}_m) HB_m^c \qquad (7)$$

Where $\tilde{HP}_m = \tilde{HP}_m \times weight$. The weight is predicted from the harmony search algorithm to fuse the image optimally.

2. EXPERIMENTS AND RESULTS

In the experiment A PAN image and a MS image is taken where the PAN image has a size of 512×512 pixels and the MS image of size 216×216 pixels. First contrast compression is done on the PAN image to compress the pixel values to smaller size which is shown in Fig. 3. (a). Then the PAN image is down sampled to get the alpha channel for the MS image as shown in Fig. 3.(b). Then spectral estimation is done to get the spectral foreground and background as in Fig. 4. (a) and (b). Then up sampling is done to get the high resolution spectral foreground and background which is shown in Fig.5. (a) and (b). Finally using harmony search algorithm we find the optimal weight value for effective fusion of the image as seen in Fig. 6. The performance of the system is evaluated using some quality assessment indexes such as PSNR, mean square error (MSE) root mean square error (RMSE), universal image quality indexes (UIQIs), enhancement measurement error (EME), and pearson correlation coefficient. The values of these indexes are given in Table I.

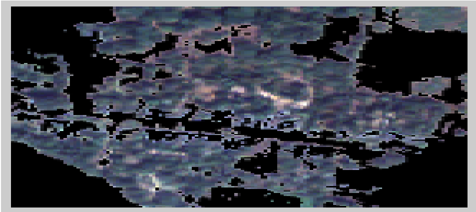
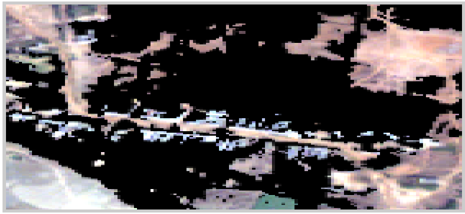

a

b

Fig. 5. (a) Upsampling foreground and (b) Upsampling back ground

3. CONCLUSION AND FUTURE WORK

In this paper, a new model for pansharpening based on matting model and harmony search algorithm has been proposed. The alpha channel of the MS image is substituted with the PAN image which contains most of the edge information. Then using the harmony search algorithm the optimal weight value is estimated for effective fusion. It is observed that the proposed method produces favorable values for several quantitative indices and is able to approximately reconstruct the high resolution MS image. In future, the proposed method can be improved further using advanced method for spectral estimation.

Fig. 6. Enhanced Image

Table.1.Values of quality assessment indexes

Quality assessment index	PSNR	MSE	RMSE	UIUQ	EME (Original image)	EME (Enhanced image)	PCC (Original vs enhanced)
Values	+12.18886 dB	0.24579	0.49577	0.02519	14.86720	0.59728	63390.82285

4. ACKNOWLEDGMENT

The authors would like to thank the department of center of excellence in computational engineering and networking (CEN) for their immense support and insightful comments and also the satellite imaging corporation for providing the data.

REFERENCES

Clerk Maxwell J, A Treatise on Electricity and Magnetism, 3rd ed., 2, Oxford: Clarendon, 1892, 68-73.

Daneshvar S, Elyasi M, and Danishvar M, Multispectral and panchromatic images fusion based on integrating feedback retina and IHS model, Proc. World Congress on Engineering, II. 2011.

Geem, Zong Woo, State-of-the-art in the structure of harmony search algorithm, Recent Advances In Harmony Search Algorithm, Springer Berlin Heidelberg, 2010, 1-10.

Kang, Xudong, Shutao Li, and Jon Atli Benediktsson, Pansharpening with Matting model, Geoscience and Remote Sensing, IEEE Transactions, 52 (8), 2014, 5088-5099.

Mahdavi M, Mohammad Fesanghary, and Damangir E, An improved harmony search algorithm for solving optimization problems, Applied mathematics and computation, 188 (2), 2007, 1567-1579.

Rahmani, Sheida, An adaptive IHS pan-sharpening method, Geoscience and Remote Sensing Letters, IEEE, 7 (4), 2010, 746-750.

Zhang, Yun, and Rakesh K Mishra, A review and comparison of commercially available pan-sharpening techniques for high resolution satellite image fusion, Geoscience and Remote Sensing Symposium (IGARSS), IEEE International, 2012.