Volume 2, Issue 5, May 2012 ISSN: 2277 128X

International Journal of Advanced Research in Computer Science and Software Engineering

Research Paper

Available online at: www.ijarcsse.com

Image Fusion Method Based On WPCA

[1]Mirajkar Pradnya P., [2]Sachin D. Ruikar

[1] *Researcher, Electronics & Telecommunication Dept. Sinhgad Acadmy of Engg. Pune*

[2]*Asst. Professor, Electronics & Telecommunication Dept. Sinhgad Acadmy of Engg. Pune*

[1]pradnya.mirajkar@yahoo.com

Abstract: **The standard data fusion methods may not be satisfactory to merge a high-resolution panchromatic image and a low-resolution multispectral image because they can distort the spectral characteristics of the multispectral data. Here we use our proposed integer wavelet transform and principal component analysis (*PCA*) to fuse low-resolution *Landsat TM* multispectral images and a *SPOT* panchromatic (*PAN*) image to generate spectrum-preserving high-resolution multispectral images; moreover, the fused multispectral images are simultaneously obtained via only one wavelet transform. Several other methods were implemented to compare with the proposed approach; based on the correlation criterion, the proposed approach was shown to be superior to the other methods.**

Keywords: **Image Fusion, Wavelet Transform, PCA, Panchromatic Images, Multispectral Images**

I. INTRODUCTION

The goal of image fusion is to integrate complementary information from multi-sensor data such that the fused images are more suitable for human visual perception and computer-processing tasks such as segmentation, feature extraction, and object recognition. The fusion of low-resolution multi-spectral images and high-resolution panchromatic images is a widely used procedure because the fused images possess complementary information from these different sources. Ideally, the method used for generating multi-resolution spatial high-resolution images should not distort the spectral characteristics in the multi resolution spectral resolution fused images

The fusion of low-resolution multispectral images and high-resolution panchromatic images is a widely used procedure. Many image fusion methods for the purpose have been proposed; however, most methods such as *IHS*, *PCA*, and *HPF*, distorted the spectral characteristics of the multispectral data. These methods don't satisfy the synthesizing specific infrared images from multispectral remote-sensing images. Only spectrum-preserving image fusion method can satisfy this synthesis.

Image fusion is an image processing technique that combines images from two or more sensors to form an enhanced final image. Here, we want to use wavelet transform and principal component analysis (*PCA*) to fuse low-resolution *Landsat* Thematic Mapper (*TM*) multi-spectral images and *SPOT* Panchromatic (*PAN*) single-band images to generate high-resolution multi-spectral images and then synthesize specified infrared images. The synthesized multi-spectral images and the infrared images will be mapped onto the corresponding terrain models for applications of tactical training and flight simulation. The traditional image fusion methods may not be satisfied for fusing a high-resolution *SPOT PAN* image and a low-resolution *Landsat TM* multi-spectral image because these methods may distort the spectral characteristics of the multi-spectral data. Thus a spectrum-preserving image fusion method technique is our pursuit for spectral classification.

II. WAVELET BASED IMAGE FUSION

The need for Image Fusion in current image processing systems is increasing mainly due to the increased number and variety of image acquisition techniques. The objective of image fusion is to combine information from multiple images of the same scene. The result of image of fusion is a new image which is more suitable for human and machine perception or further image-processing tasks such as segmentation, feature extraction and object recognition. Image fusion is the process by which two or more images are combined into a single image retaining the important features from each of the original images. Below figure shows the basic image fusion scheme.

In the first step the input images are decomposed into their multiscale edge representation, using either any image pyramid or any wavelet transform. The actual fusion process takes place in the difference resp. wavelet domain, where the fused multiscale representation is built by a pixel-by-pixel selection of the coefficients with maximum magnitude. Finally the fused image is computed by an application of the appropriate reconstruction scheme.

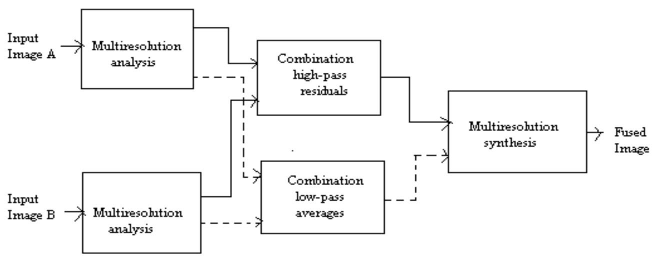

Fig.1- Block Diagram of Basic Image Fusion Process

In the first step the input images are decomposed into their multiscale edge representation, using either any image pyramid or any wavelet transform. The actual fusion process takes place in the difference resp. wavelet domain, where the fused multiscale representation is built by a pixel-by-pixel selection of the coefficients with maximum magnitude. Finally the fused image is computed by an application of the appropriate reconstruction scheme.

III. WAVELET BASED PCA METHOD

Traditional *PCA* image fusion consists of four steps:

(*i*) Geometric registration is formatting that size of low-resolution multi-spectral images is the same as the high resolution image.

(*ii*) Transforming low-resolution multi-spectral images to the principal component images by *PCA* transformation.

(*iii*) Replacing the first principal component image with the high-resolution image that is stretched to have approximately the similar variance and mean as the first principal component image.

(*iv*) The results of the stretched *PAN* data replace the first principal component image before the data are back transformed into the original space by *PCA* inverse transformation.

We replace the first principal component image with stretched *PAN* data because the first principle component image has the common information to all the bands. The traditional *PCA* fusion methods may not be satisfactory to fuse high-resolution images and low-resolution multi-spectral images because the methods may distort the spectral Characteristics of the multi-spectral data.

Here, we combine the standard *PCA* image fusion and the wavelet-based image fusion to propose an image fusion approach called wavelet-based *PCA* image fusion that improves the traditional *PCA* image fusion as shown in Fig. We use the wavelet-based *PCA* method to fuse the low-resolution *Landsat TM* images and the high-resolution *SPOT PAN* images. This method includes seven steps: geometric registration, *PCA* transformation, histogram matching, wavelet decomposition, fusion, wavelet reconstruction, and *PCA* inverse transformation.

A. *Geometric registration:*

We use a 3 by 3 weighted mask to enlarge the *Landsat TM* images such that the size is the same as the *SPOT PAN* images.

B. PCA transformation:

The *PCA* is a mathematical transformation that generates new images through the linear combinations of the components of the original images. The transformation generates a new set of orthogonal axes. The new images are represented by these axes and then the components are independent. In this study, we transform six original *Landsat TM* bands (1, 2, 3, 4, 5, and 7) to six principal component images by the equation:

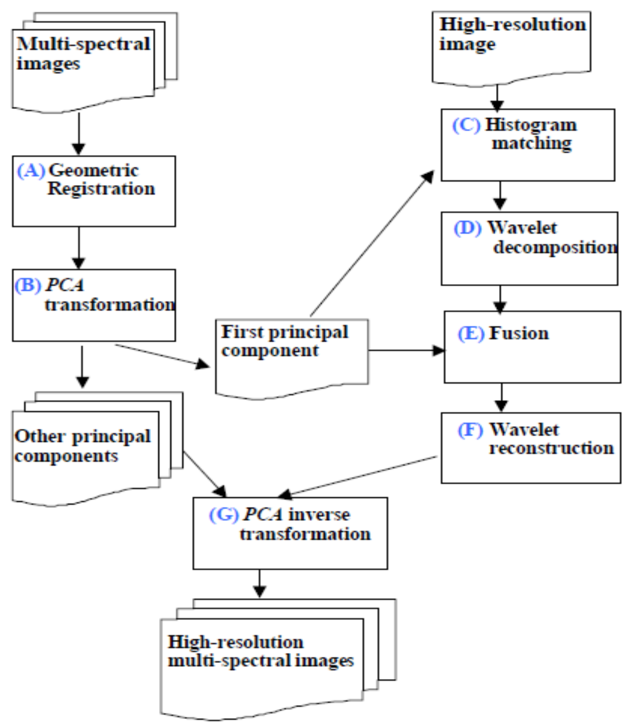

Fig.2- The flow chart of the wavelet-based *PCA* method

$$\begin{bmatrix} y_{1j} \\ . \\ . \\ y_{6j} \end{bmatrix} = A \left[\begin{bmatrix} x_{1j} \\ . \\ . \\ x_{6j} \end{bmatrix} - \begin{bmatrix} m_1 \\ . \\ . \\ m_6 \end{bmatrix} \right] \quad (1)$$

where ***A*** is a matrix whose row are formed by the eigenvectors of the covariance matrix of the six *Landsat TM* images. These eigenvectors in matrix ***A*** is ordered so that the first row of ***A*** is the eigenvector corresponding to the largest eigenvalue, and the last row is the eigenvector corresponding to the smallest eigenvalue. *mk*, *k* = 1, 2, . . ., 6, are the means of the *Landsat TM* six bands. *xk j* , *k* = 1, 2, . . ., 6, *j* = 1, . . ., *NL*, where *NL* is the size of the *Landsat TM* image, are the gray values of the six original *Landsat TM* images. $Y_k = \{y_{kj} | y_{kj} \in R, 1 \le j \le N_L\}$ is called the *k*-th principal component image.

C. Histogram matching:

Histogram match is used to specify the spectral distribution of the high-resolution image to the same as the low-resolution multi-spectral images. In this study, we perform conventional histogram matching between the *PAN image* and the first principal component image. This method includes four steps:

Step 1- Linearly stretch the range of the first principal component image to [0, 255].

Step 2- Calculate the cumulative distribution function (*cdf*) of the first principal component image and the *PAN* image.

Step 3- Adjust the *cdf* of the *PAN* image to approximate the *cdf* of the first principal component image.

Step 4- Recover range of the *PAN* and the first principal component image to the original range of the first principal component image.

D. Wavelet decomposition:

We use following equation to decompose the specified *PAN* image to *S* (content image) and *D* (details images) components.

$$S_n^{j+1} = \sum_k h_{(2n-k)} S_k^j \quad \text{And} \quad D_n^{j+1} = \sum_k g_{(2n-k)} S_k^j \quad (2)$$

The result of the *MWD* decomposition is represented by,

$$PAN = s + \sum_i^n D_i \quad (3)$$

where *n* is number of details image.

E. Fusion:

We replace *S* component, content image of the specified *PAN* image, by the first principal component image that has the same size as *S* image.

F. Wavelet reconstruction:

We use Eq. (4) to reconstruct *Y*1, the first principal component image of the multi-spectral images, and *D*, the details images of the specified *PAN* image, to the fused image *Fnew* by the equation

$$F_{new} = Y_1 + \sum_i^n D_i \quad (4)$$

where *n* is number of the details image. The process of integrating the wavelet decomposition, fusion, and wavelet reconstruction is called the wavelet based image fusion that replaces the content image of the high-resolution image with the low-resolution multi-spectral image.

G. PCA inverse transformation:

We use the equation

$$\begin{bmatrix} x_{1j} \\ . \\ . \\ x_{6j} \end{bmatrix} = A^{-1} \begin{bmatrix} F_{new_j} \\ y_{2j} \\ . \\ y_{6j} \end{bmatrix} + \begin{bmatrix} m_1 \\ . \\ . \\ m_6 \end{bmatrix}, \quad (5)$$

to back transform the fused image and the other component images into the original space. In the above eq. A^{-1} is an inverse matrix of the ***A*** that is in Eq. (1); *mk*, *k* = 1, 2, . , 6, are means of the six original *Landsat TM* images; *yrj*, *r* = 2, 3. . , 6, *j* = 1. . , N_p where N_p is size of the *SPOT PAN* image, are values of the other principal component images;

Fnew, j=1,..., N_p, is value of the fused image. The $X_k = \{x_{kj} | x_{kj} \in N, 0 \le x_{kj} \le 255, 1 \le j \le N_p\}$ is called the high-resolution multi-spectral image.

IV. EXPERIMENTS

Landsat TM images and *SPOT PAN* images were fused to generate high-resolution multispectral images by wavelet-based *PCA* approach. Objective performance evaluation is done by taking Mean Square Error (MSE) and Peak Signal-to-Noise Ratio (PSNR) with help of following equations.

$$MSE = \frac{\sum_{i=1}^{M}\sum_{j=1}^{N}[S(i,j) - F(i,j)]^2}{MXN}$$

$$PSNR = 10\log_{10}\left(\frac{255^2}{MSE}\right)$$

where S is the source image and F is the fused image

V. RESULTS

(a) *SPOT* PAN Image

(b) Landsat TM image

(c) High resolution MS image

Fig.3- (a) High resolution Source image i.e. SPOT PAN image, (b) Low resolution source image i.e., Landsat TM image, (c) Fused Image i.e., High resolution MS image

The PSNR value for this High resolution Multispectral image is 26.4371.

VI. CONCLUSION

In study, we proposed an image fusion approach to enhance the spatial quality of the multispectral images while preserving its spectral contents to a greater extent. By fusing low resolution multispectral image and high resolution PAN image, we have obtained High resolution Multispectral image with high PSNR ratio. However, we also found that though the wavelet-based *PCA* can preserve more spectral information, it is not stable for enhancing spatial resolution quality.

VII. REFERENCES

[1] Carper, W. J., T. M. Lillesand, and R. W. Kiefer, "The use of intensity-hue-saturation transformations for merging *SPOT panchromatic* and multi-spectral image data," *Photogrammetric Engineering & Remote Sensing*, Vol.56, No.4, pp.459-467, 1990.

[2] Chavez, P. S. Jr. and A. Y. Kwarteng, "Extracting spectral contrast in *Landsat thematic mapper* image data using selective principal component analysis," *Photogrammetric Engineering & Remote Sensing*, Vol.55, No.3, pp.339-348, 1989.

[3] Chavez, P. S. Jr., S. C. sides, and J. A. Anderson, "Comparison of three different methods to merge multiresolution and multispectral data: *Landsat TM* and *SPOT panchromatic*," *Photogrammetric Engineering & Remote Sensing*, Vol.57, No.3, pp.295-303, 1990.

[4] Civco, D. L., "Topographic normalization of *Landsat thematic mapper* digital imagery," *Photogrammetric Engineering & Remote Sensing*, Vol.55, No.9, pp.1303-1309, 1989.

[5] Garguet-Duport, B., J. Girel, J.-M. Chassery, and G. Pautou, "The use of multiresolution analysis and wavelets transform for merging *SPOT panchromatic* and multispectral image data," *Photogrammetric Engineering & Remote Sensing*, Vol.62, No.9, pp.1057-1066, 1996.

[6] Li, H., B. S. Manjunath, and S. K. Mitra, "Multisensor image fusion using the wavelet transform," *Graphical Models and Image Processing*, Vol.57, No.3, pp.235-245, 1995.

[7] Luo, R. and M. Kay, "Data fusion and sensor integration: state of art in 1990s," in *Data Fusion in Robotics and Machine Intelligence*, M. Abidi and R. Gonzalez, eds., Academic Press, San Diego, 1992, pp.7-136.

[8] Núñez, J., X. Otazu, O. Fors, A. Prades, V. Palà, and R. Arbiol, "Multiresolution-based image fusion with additive wavelet decomposition," *IEEE Trans. on Geoscience and Remote Sensing*, Vol.37, No.3, pp.1204-1211, 1999.

[9] Yocky, D. A., "Multiresolution wavelet decomposition image merger of *Landsat thematic mapper* and *SPOT panchromatic* data," *Photogrammetric Engineering & Remote Sensing*, Vol.62, No.9, pp.1067-1074, 1996.

