IMAGE FUSION ALGORITHMS USING DIFFERENT WAVELET METHODS AND IMPROVEMENT TECHNIQUES

B. Ragavendra Reddy[1]   ,Dr T. Ramashri[2]

PG student, Department Of ECE, Sri Venkateswara University College of Engineering, Tirupati-AP; India[1]

Professor, Department Of ECE, Sri Venkateswara University College of Engineering, Tirupati-AP; India[2]

ABSTRACT -- Image fusion is the process of combining the relevant information from two or more images into a single highly informative image. The resulting fused image contains more information than the input images. In this paper, different methods for fusing different modality of images [e.g., MRI, CT; MULTI-SPECTRAL, PANCHROMATIC etc.] and comparison of all these methods are presented. In addition to this, image fusion improvement technique also presented. The methods presented here are Simple Averaging Method, Principal Component Analysis [PCA] method, different wavelet transform methods and integrating these wavelet methods with PCA method. The wavelet Transform methods used here are Symlet Wavelets, Bi-Orthogonal wavelet, discrete Meyer wavelet, Reverse Bi-Orthogonal wavelet methods etc. The Fusion results obtained from above methods are evaluated and compared according to the measures Mean, Standard Deviation, Entropy (H) , Correlation Coefficient(CC), Co-Variance, Root Mean Square Error(RMSE), Peak Signal To Noise Ratio(PSNR).

Keywords—Image Fusion, Panchromatic, Multispectral, Root Mean Square Error (RMSE), Peak Signal To Noise Ratio (PSNR)

I. INTRODUCTION

In some cases high spectral and spatial Resolutions both are needed together, but the instruments available now can't produce such data because of several limitations In addition, several external effects blur images: atmospheric turbulence, camera lens, relative camera-scene motion, etc. yet we can model them as clear image fusion. Image fusion is a useful technique for inclusion of similar sensor and multi-sensor images to improve the information content present in the images. Image fusion techniques have been developed for fusing the complementary information of Multi - source input images in order to create a new image that is more sui-table for human visual or machine perception. Image fusion has several applications in various areas such as Medical Imaging, Robotics, manufacturing, Military and law enforcement, remote sensing, applications and so on. Computer Tomography (CT) and Magnetic Resonance (MR) are the most important modalities in Medical Imaging, used for clinical diagnosis and computer-aided surgery. CT provides more information about Bone structures and less information about soft tissues. Magnetic Resonance (MR) imaging provides more information about the Soft tissues and less information about the bone structures. A single modality of medical image cannot provide comprehensive and accurate information. As a result, combining anatomical and functional medical images to provide much more useful information through image fusion. In Robotics, they require motion control, based on feedback from the environment from visual, tactile, force/torque, and other types of sensors.So, in this case image fusion is useful. In manufacturing it is useful for Electronic circuit and component inspection, Product surface measurement and inspection, non-

destructive material inspection, Manufacture process monitoring. In Military and law enforcement it is useful for Detection, tracking, identification of ocean (air, ground)target/event Concealed weapon detection, Battle-field monitoring ,Night pilot guidance etc.There are different methods available to implement image fusion such as Principle Component Analysis (PCA)[1],average method Wavelet transform method. To improve the performance we can integrate any two methods. First two methods change the spectral characteristics very much. The wavelet transform, due its multi-resolution Decomposition property, is more suitable to merge the panchromatic band and multispectral bands of the same sensor.

II LITERATURE SURVEY

Many Image fusion methods have been proposed for combining any two images. The methods are Hue Saturation (IHS) [12], Principle Component Analysis (PCA) [1][12], Brovey Transform (BT) [12], High Pass Filtering (HPF)[8], High Pass modulation (HPM) [8], Multiresolution Analysis Based Intensity Modulation (MRAIM) [8], Pixel Block Intensity Modulation (PBIM) [12], Smoothing Filter Based Intensity Modulation (SFIM) [12], Wavelet Transform (WT) [2] etc., All these are the already proposed fusion methods. In this paper proposes simple averaging of all the pixels of the input images is taken to produce averaged pixel so that from these averaged pixels we can get fused image of the input images. Two types of PCA methods in image fusion are proposed. 1) In PCA multichannel image, replacement of first principle component by different images. And 2) PCA of all multi image data channels. The basic idea of all wavelet-based fusions schemes is to combine all respective wavelet coefficients from the input images. The combination is performed according to a specific fusion rule. The wavelet decomposition of each source image is performed leading to a multiresolution representation. The actual fusion process is performed as a combination of the corresponding wavelet decomposition coefficients of all input images, to build a single wavelet decomposition image. This combination takes place on all decomposition levels k (k = 1, 2…L) where L is the maximum wavelet decomposition level. Two different fusion rules are applied to combine the most important features of the input images. A basic fusion rule is applied to the Lth level approximation sub bands. The three detail sub bands (horizontal, vertical, and diagonal) are combined using a more sophisticated fusion algorithm [10].Principal Component Analysis [PCA] is a vector space transform used for reducing the multidimensional data sets to lower dimensions. In this we calculate Eigen values and Eigen vectors and then these Eigen vectors are sorted in decreasing order of Eigen values and then choose the best Eigen vector to perform Fusion. To improve Fusion we can integrate any two methods.

III WEIGHED AVERAGE METHOD

Basically it is a Pixel based image fusion; the work presented in this paper assumes that the input images meet a number of requirements. Firstly, input images must be of the same scene, i.e. the fields of view of the sensors must contain a spatial overlap. Furthermore, inputs are assumed to be spatially registered and of equal size and spatial resolution. This paper addresses the topic of pixel-level fusion with two monochrome input images and a monochrome fused output image. However, all the work can be easily extended to accommodate a higher number of inputs and explanations of this are provided where appropriate. [11] Steps of our proposed method of the pixel based image fusion are explained below:

Step 1: Read the set of multifocus images i.e. here in our proposed algorithm we have consider two images which are of same size (registered images).
Step 2: Alpha Factor can be varied to vary the proportion of mixing of each image.
 With Alpha Factor = 0.5, the two images are mixed equally.
 With Alpha Factor < 0.5, the contribution of background image will be more.
 With Alpha Factor > 0.5, the contribution of foreground image will be more.
    So, in our proposed algorithm we have consider alpha factor= 0.5

Step 3: Perform element by element multiplication of image array with alpha factor for foreground image and multiply complement of alpha factor with image array of background image.
Step 4: Now perform pixel by pixel intensity value comparison and find the maximum intensity value.
Step 5: This value is consider for the final output image.
Step 6: Finally display the fused image contains all the huge intensity value of the pixel.

IV WAVELET TRANSFORM METHODS

The DWT can be interpreted as signal decomposition in a set of independent, spatially oriented frequency channels. The signal is passed through two complementary filters and emerges as two signals, approximation and Details. This is called decomposition or analysis. The components can be assembled back into the original signal without loss of information. This process is called reconstruction or Synthesis. The mathematical manipulation, which implies analysis and synthesis, is called discrete wavelet transform and inverse discrete wavelet transform.
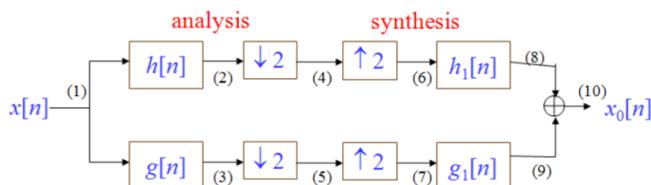

Fig.4.1.Process of Wavelet Transform

In all wavelet based image fusion techniques the wavelet transforms W of the two registered input images $I1(x, y)$ and $I2(x, y)$ are computed and these transforms are combined using some kind of fusion rule $\emptyset$ as show in below equation

$$I(x,y) = W\text{-}1 (\emptyset (W(I1(x,y)), W(I2(x,y))))$$

Steps of our proposed method of the wavelet based image fusion are explained below:

Step 1: Read the set of multifocus images i.e. here in our proposed algorithm we have consider two images which are of same size (registered images).
Step 2: Apply wavelet decomposition on both the Images with the use of Daubechies filter.
Step 3: Extracts from the wavelet decomposition structure [C, S] the horizontal, vertical, or diagonal detail.
Step 4: Perform average of approximation coefficients of both decomposed images
.**Step 5:** Compare horizontal, vertical and diagonal coefficient of both the images and apply maximum selection Scheme to select the maximum coefficient value by comparing the coefficient of the two images. Perform this for all the pixel values of image i.e. m x n.
Step 6: Now Apply wavelet decomposition on both the Images with the use of different wavelet filters (namely Bi-Orthogonal wavelet, discrete Meyer wavelet ,Reverse Bi-Orthogonal wavelet etc.)
Step 7: Display the final fused image.

V. PRINCIPAL COMPONENT ANALYSIS (PCA) METHOD

PCA is a vector space transform used for reducing the Multidimensional data sets to lower dimensions. The PCA algorithm for the fusion of images is discussed as Follows.
Step1: Generate the column vectors, respectively, from the input image matrices.
Step2; Calculate the covariance matrix of the two column vectors formed.

Step 3: The diagonal elements of the 2x2 covariance matrix would contain the variance of each column vector with itself, respectively.

Step 4: Calculate the Eigen values and the Eigen vectors of the covariance matrix.

Step5: Normalize the column vector corresponding to the larger Eigen value by dividing each element with mean of the Eigen vector.

Step 6: The values of the normalized Eigen vector act as the Weight values which are respectively multiplied with each pixel of the input images.

Step 7: Sum of the two scaled matrices calculated in the previous step will be the fused image matrix .

VI. PROPOSED WORK

The main condition for successful fusion is that "all" visible information in the input images should also appear visible in the fused image. The simplest form is a weighted averaging of the registered input to give the fused image. One of the simplest of these image fusion methods just takes the pixel-by-pixel gray level average of the source images. This simplistic approach often has serious side effects. Pixel level image fusion methods are affected by blurring effect which directly affect on the contrast of the image.

PCA technique place much more emphasis on the spatial information than spectral information. They can achieve higher spatial results but preserve less spectral fidelity.

In wavelet transform method the input images are decomposed using respective wavelets. And, compared to above two methods, wavelet transform methods produces better results. Many of these image fusion techniques proposed aim at improving the fusion rate and not concentrating on enhancing the information content on the images.So,,to improve the information content much more here, proposing integration of wavelet method with PCA method.

The whole process consists of following steps.

Step1: Transform the multispectral image into the IHS or PCA components.

Step2: Apply histogram match between panchromatic image and intensity component and obtain new panchromatic image.

Step3: Decompose the histogram matched panchromatic image and intensity component to wavelet planes respectively.

Step4: Replace the LL^P in the panchromatic decomposition with the LL^1 of the intensity decomposition, add the detail images in the panchromatic decomposition to the corresponding detail image of the intensity and obtain LL^1, LH^P, HH^P and HL^P. Perform an inverse wavelet transform and generate a new intensity.

Step5: Transform the new intensity together with hue, saturation components or PC1, PC2, PC3 back into RGB space [4].

VII. PERFORMANCE MEASURES FOR IMAGE FUSION

Assessment of image fusion performance can be divided into two categories: one with and one without reference images. In reference-based assessment, a fused image is evaluated against the reference image which serves as a ground truth. In second case only fused image is taken. In the present work, we have used some Performance measures to evaluate the performance of the Image fusion algorithms.

A. Entropy (H)

The Entropy (H) is the measure of information content in an image. The maximum value of entropy can be produced when each gray level of the whole range has the same frequency. If entropy of fused image is higher than parent image then it indicates that the fused image contains more information.

B.MEAN (M)

M = mean (A) returns the mean values of the elements along different dimensions of an array.

If A is a vector, mean (A) returns the mean value of A.

If A is a matrix, mean (A) treats the columns of A as vectors, returning a row vector of mean values.

If A is a multidimensional array, mean (A) treats the values along the first non-singleton dimension as vectors, returning an array of mean values.

C. STANDARD DEVIATION
A measure of how the data values are spread out around the mean. It can also define as the square root of the variance.

D.CO-VARIANCE
Co-Variance is a measure of how much two random variables change together. If the greater values of one variable mainly correspond with the greater values of the other variable, and the same holds for the smaller values, i.e., the variables tend to show similar behavior, the covariance is positive. In the opposite case, when the greater values of one variable mainly correspond to the smaller values of the other, i.e., the variables tend to show opposite behavior, the covariance is negative. The sign of the covariance therefore shows the tendency in the linear relationship between the variables.

E.CORRELATION CO-EFFICIENT (CC)
The correlation coefficient is the measure of the closeness or similarity in small size structures between the original and the fused images. It can vary between -1 and +l Values closer to + 1 indicate that the reference and fused images are highly similar while the values closer to -1 indicate that the images are highly dissimilar.

F. Root Mean Square Error (RMSE)
A commonly used reference based assessment metric is the Root Mean Square Error (RMSE). The RMSE between a reference image, R, and a fused image, F, is given by the following equation:

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

Where R (I, j) and F (i, j) are the reference and fused images, respectively, and M and N are image dimensions. Smaller the value of the RMSE, better the performance of the fusion algorithm.

G. PEAK SIGNAL TO NOISE RATIO (PSNR)
PSNR is the ratio between the maximum possible power of a signal and the power of corrupting noise that affects the fidelity of its representation. The PSNR of the fusion result is defined as follows:

$$PSNR = 10 \log[\frac{(f_{max})^2}{RMSE^2}]$$

Where f_{max} is the maximum gray scale value of the pixels in the fused image. Higher the value of the PSNR, better the Performance of the fusion algorithm.
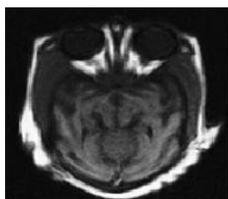
VIII. EXPERIMENTAL RESULTS AND COMPARISONS

Different images are taken as the source images. Different Fusion methods are applied to fuse the input images. The corresponding outputs of the source images are shown in the below Figs.

(A)Experimental Results
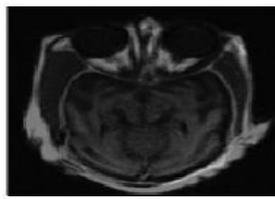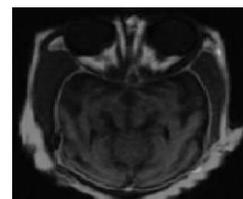(I)Take MRI, CT scanned images as input images

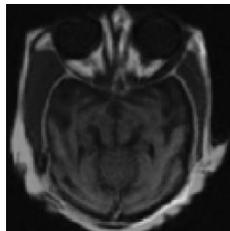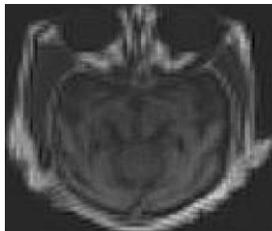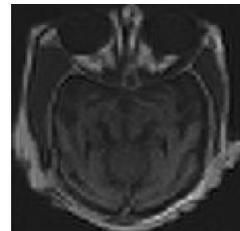| (A)MRI image | (B) CT Image | (C) weighted average method | (D) PCA Method |
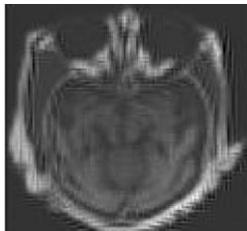
(E)reverse bi-orthogonal   (F) descrete meyer   (G)Symlets   (H) Biorthogonal
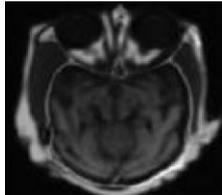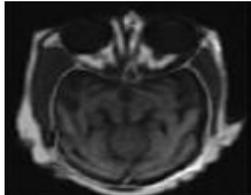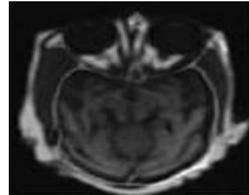
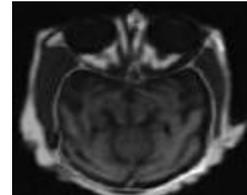(I)reverse bi-orthogonalt with PCA   (J)descrete meyer wavelet with PCA   (K)Symlets with PCA   (L)Bi-Orthogonal Wavelets With PCA

IV) Results for Hoed Images
(A)Middle side blurred image   (B) Corner side blurred image   (C) weighted average method   (D) PCA Method

(E)reverseBi-orthogonal wavelet   (F) Descrete Meyer   (G) Symlets   (H) Bi-Orthogonal Wavelets

(I) reverseBi-orthogonal with PCA   (J) Descrete Meyerwith PCA   (K) Symlets with PCA   (L) Bi-Orthogonal with PCA

(B)Comparison   (i)Statistical Results For CT, MRI Images

Metrics	Weighted Average Method	PCA	Reverse Bi-Orthogonal Wavelets	Symlet Wavelet	Descrete Meyer wavelet	Bi-Orthogonal Wavelet	Reverse Bi-Orthogonal wavelet with pca	Descrete Meyer Wavelet with pca	Symlet With PCA	Bi-Orthogonal With Pca
					FUSION METHODS					
Entropy	5.9562	6.4647	6.2154	6.7668	6.5980	6.5974	6.0508	5.9961	6.0438	6.0293
Mean	32.844	50.087	32.666	29.607	29.7369	29.84	29.7369	32.723	32.723	32.7234
Standard Deviation	36.403	52.598	26.637	24.272	24.083	24.55	24.0835	26.449	26.686	26.6613
Co-Variance	1.192	3.4727	5.236	5.236	5.301	5.236	5.313	5.313	5.313	5.313
Correlation Coefficient	0.157	0.157	0.3778	0.375	0.375	0.376	0.6046	0.6196	0.6056	0.608
RMSE	3.2996	3.5362	0.2925	0.2941	0.2963	0.2964	0.1558	0.1579	0.1559	0.1562
PSNR	16.265	11.398	58.842	58.795	58.723	58.726	69.8557	69.855	69.855	69.8557

(ii)Statistical Results for Hued Images

Metrics	FUSION METHODS									
	Weighted Average Method	PCA	Reverse Bi-Orthogonal Wavelet	Symlet	Descrete Meyer wavelet	Bi-Orthogonal	Reverse Bi-Orthogonal Wavelet With PCA	Descrete Meyer with PCA	Symlet With PCA	Bi-Orthogonal With PCA
Entropy	7.6156	7.6171	7.596	7.596	7.5896	7.596	7.6503	7.6515	7.65	7.6401
Mean	98.5008	98.161	98.5866	98.586	98.567	98.5866	98.1003	98.1020	98.1003	98.5866
Standard Deviation	57.4893	57.552	44.6777	44.677	44.567	44.6777	45.5108	45.664	45.5108	44.3415
Covariance	3.5358	3.6575	5.4994	5.4994	5.459	5.4994	5.6241	5.6241	5.6241	5.5001
Correlation Coefficient	0.8379	0.9509	0.9618	0.9634	0.9564	0.9634	0.9639	0.968	0.9639	0.9647
RMSE	6.6755	6.976	0.4468	0.6291	0.6103	0.6103	0.0754	0.0788	0.0754	0.0762
PSNR	23.801	22.827	55.1845	54.184	55.1843	55.1845	95.3054	95.305	95.3054	95.3053

REFERENCES

[1] T.S.Anand ; K.Narasimhan P.Saravanan"Performance Evaluation of Image Fusion Using the Multi-Wavelet and Curve let Transforms" IEEE - International Conference On Advances In Engineering, Science And Management(ICAESM-20 12) March 30,31,2012.

[2] Kulkami,J.S,"Wavelet transform applications",3rd International Conference on Electronics Computer Technology ,voLI, pp 11-17,2011.

[3] Gaurav Bhatnagar and Balasubramanian Raman," A New Image Fusion Technique Based on Directive Contrast ",Electronic Letters on Computer Vision and Image Analysis,vol.8(2),pp.18-38, 2009.

[4] Stavri N., Paul H., David B., Nishan C., "Wavelet for Image Fusion," Image communication group, U.K.

[5] R. Maruthi, Dr. K. Sankarasubramanian," Multifocus Image based on the information level in the region of the images," JATIT, 2005-2007.

[6] Hongzhi Wang; Liying Qian; Jingtao Zhao, "An image denoising method based on fast discrete Curve let transform and Total Variation", International Conference on Signal Processing, pp 1040-1043, 2010.

[7] HAI-HUI WANG, JUN WANG, WEI WANG, "Multispectral Image Fusion Approach based on GHM Multi Wavelet Transform", Fourth International Conference on Machine Learning and Cybernetics, Guangzho,VoL8, pp 5043-5049, 2005.

[8] Zhijun Wang, Djemel Ziou, Costas Armenakis, Deren Li, and Qingquan Li, "A Comparative Analysis of Image Fusion Methods", IEEE Transactions on Geosciences and Remote Sensing,Vol.43,No.6, pp.1391-1402, June 2005.

[9] Yuanning Liu and Fei He, Yonghua Zhao and Ning Wang, "An Iris Recognition based on GHM multiwavelet transform", 2nd International Conference on Advanced Computer Control, VoL2, pp 264-268, 2010.

[10] Lahouari Ghouti, Ahmed Bouridane and Mohammad K. Ibrahim, " Improved Image Fusion Using Balanced Multiwavelets ", Proceedings of the 12th European Signal Processing Conference,2004, pp. 57-60, Sep 2004.

[11] Ramesh, K.P., Gupta, S., Blasch, E.P., "Image Fusion Experiment for Information Content," Proc, Information Fusion, 2007 10th International Conference: 1 - 8, 2007.

[12] Wenquan Zhu, Xinhua Pang, Yaozhong Pan, Bin Jia & Xiaoqiong Yang , "A spectral preservation fusion method based on band ratio and weighted combination", Multispectral Image Processing,vol. 6787,2007,doi. 10.1117/12.749474