Image Fusion Using WPCA, Biorthogonal & FDCT

Dhiraj Agrawal
Department of Electronics and Communication Engineering, S.S.G.College of Engineering and Technology, Bhusawal 425203, North Maharashtra University, Jalgaon, Maharashtra, India.

Sanjeev B.Patil
Department of Electronics and Communication Engineering, S.S.G.College of Engineering and Technology, Bhusawal 425203, North Maharashtra University, Jalgaon, Maharashtra, India.

Abstract – The proposed method of image fusion uses the wavelet principal component analysis (WPCA),fast discrete curvelet transform(FDCT), Biorthgonal wavelet transform(BWT) for decomposing and reconstruction of the source images. The overall fusion scheme based on method of wavelet transform .Firstly, we decompose source images of same scene using any of one BWT,WPCA,FDCT wavelet transform and then coefficients obtained are merged using absolute maximum selection fusion rule. We have used wavelet and scaling functions used in wavelet transorm for decomposition of source images. The selection of proper wavelet for decomposition varies from application to application. Although vanishing moment and regularity (smoothness) of wavelet can be considered to decide wavelet function. For image fusion application, selection of wavelet with sufficient vanishing moment is desired. Therefore, we have used wavelet filters to get desired number of vanishing moments. The coefficients obtained by decomposition of source images are fused using absolute maximum fusion rule. Image fusion is to combine relevant information from two or more images of the same scene into a single composite image which is more informative and is more suitable for human and machine perception, medical and satellite applications. Experimental results are compare on basis of performance matric include mean square error(MSE),peak signal to noise ratio(PSNR),entropy(EN),processing time required for image fusion. WPCA and FDCT shows more efficient results.

Index Terms – Image Fusion, Biorthogonal Wavelet Transform, Fusion Rules. Fast discrete wavelet transform, WPCA.

1. INTRODUCTION

Sometimes Texture Identification is not done accurately when images are captured from no. of sensing devices. So, there is requirement of such a technique of identification which can identify texture correctly even when images captured from many sensing devices. Images of the same scene from sensors with different characteristics and different resolution at different time may provide complementary information about the scene. Image fusion is an advanced image processing technology, which could produce a new integrated image while retaining the important feature of these images. Image fusion is used to combine relevant information from two or more images of the same scene into a single composite image which is more informative and is more suitable for human and machine perception This paper makes the modest suggestion that WPCA and FDCT based Image Fusion is such a beneficial techniques of image fusion which produces a new integrated image and retaining the important feature of these images. Research into getting a new integrated composite image using image fusion with the help of various wavelet transform methods such as FDCT for different types of curves, WPCA shows high speed fusion method is required and hopes to have inspired others to use image fusion in for effective and accurate image identification.

2. PROPOSED SCHEME

Fig. 1 shows block diagram of the proposed system. Input images are resize (256x256)and convert colour image to Gray of 8 bit image. Low resolution image obtained is passed for wavelet transform like discrete wavelet transform and stationary wavelet transform which will give sub band coding .Different bands like LL, LH, HL, HH all bands are interpolated with bicubic and linear interpolation technique to increase resolution with pixel based improvement then estimated bands are passed to BWT, FDCT or WPCA transform then both images are fused and respective inverse by using BWT,FDCT or WPCA wavelet transform are calculated for reconstruction of high resolution of image. Discrete wavelet transform gives multi resolution analysis.

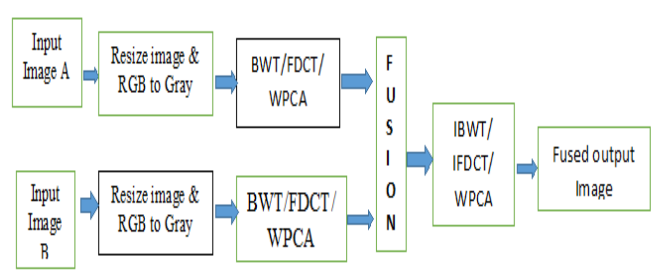


Fig.1: Block diagram of proposed system

Images are read. Resizing of the images into standard format is done. Applied functions to convert RGB to Gray Image. Padding zeros at the two dimensions of images is done. De-noised the images to remove the noise

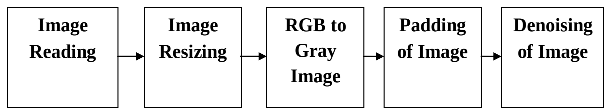


Fig.2 Image processing before passing to wavelet transform

BWT processing also happens with different levels and different transforms. Further processing is continue for fusion.

2.1 BWT (Biorthogonal Wavelet Transform)

For biorthogonal transform, perfect reconstruction is available. Orthogonal wavelets give orthogonal matrices and unitary transforms; biorthogonal wavelets give invertible matrices and perfect reconstruction. For biorthogonal wavelet filter, the Low pass and high pass filters do not the same length. The low pass and high pass filters do not have the same length. The low pass filter is always Symmetrical, while high pass filter could be either symmetric or anti symmetric. The method allows unusual flexibility in choosing a filter for any task involving the multiresolution analysis and synthesis. Using our method, one can choose any low pass filter for the multiresolution filtering. Firstly we decompose source images of same scene (can have different focusing and modality) using Biorthogonal wavelet transform (BWT) and then coefficients obtained are merged using absolute maximum selection fusion rule. We have used wavelet and scaling functions used in BWT for decomposition of source images. The selection of proper wavelet for decomposition varies from application to application. No general selection criteria for wavelet and scaling function is available in literature. Although vanishing moment and regularity (smoothness) of wavelet can be considered to decide wavelet function.

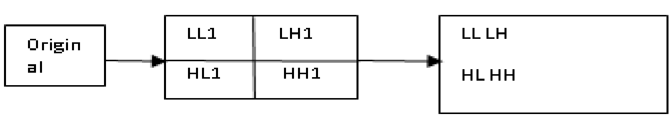


Fig.3 Process of decomposing using BWT of an image

The symbols L and H refer to low-pass and high-pass filter respectively. LL represents the approximation sub-band & LH, HL and HH are the detail sub-bands. LL is the low frequency sub-band gives global description of an image with directional features. Horizontal coefficients (LH) correspond to the low-frequency component in the horizontal direction and high-frequency component in the vertical direction.DWT based wavelet transform gives good multiresolution analysis compared to other wavelet transform. Wavelet Transform has good time frequency characteristics. It was applied successfully in image processing field. Nevertheless, its excellent characteristic in one dimension can't be extended to two dimensions or multi-dimension simply.Separable wavelet which was spanning by one dimensional wavelet has limited directivity. The most common form of transform type image fusion algorithms is the wavelet fusion algorithm due to its simplicity and its ability to preserve the time and frequency details of the images to be fused. Some generic requirements can be imposed on the fusion result. The fused image should preserve as closely as possible all relevant information contained in the input images. The fusion process should not introduce any artifacts or in consistencies which can distract or mislead the human observer or any subsequent image processing steps. In the fused image irrelevant features and noise should be suppressed to a maximum extent. When fusion is done at pixel level the input images are combined without any preprocessing. In the biorthogonal case, there are two scaling functions $\phi, \tilde{\phi}$, which may generate different multiresolution analyses, and accordingly two different wavelet functions $\psi, \tilde{\psi}$. So the numbers M and N of coefficients in the scaling sequences $a, \tilde{a}$ may differ. The scaling sequences must satisfy the following biorthogonality condition

$$\sum_{n \in \mathbb{Z}} a_n \tilde{a}_{n+2m} = 2 \cdot \delta_{m,0}$$

Then the wavelet sequences can be determined as

$$b_n = (-1)^n \tilde{a}_{M-1-n} \qquad (n = 0, \ldots, N-1)$$

$$\tilde{b}_n = (-1)^n a_{M-1-n} \qquad (n = 0, \ldots, N-1)$$

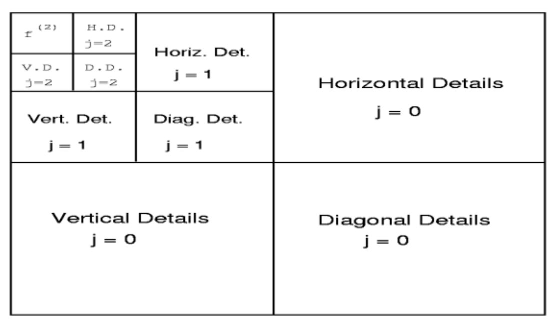


Fig.4 BWT processing

BWT is generalisation of the orthogonal wavelets. Two other spaces are introduced for the reconstruction.

2.2 Image Fusion & its Techniques

The proposed FDCT image fusion system consist two or more low resolution (LR) multispectral band images and high resolution (HR)Pan image. These two types of images after finding FDCT applied to calculate a directional sub-band, bigger curvelet coefficients of HR Pan Image and LR multispectral image represent sharp local feature. In method a Local Magnitude Ratio (LMR) to inject high frequency details of the local image feature into the fused image ,as shown in figure 5

LMR is defined as ratio of curvelet coefficients of sub bands of multispectral LR images to curvelet coefficients of sub bands of HR Pan Images.

$$\mathrm{LMR}\ [C_{j,1}(x,y)] = \frac{|C_{j,1}[M(x,y)]|}{|C_{j,1}(P(x,y))|}$$

Where, $\mathrm{LMR}\ [C_{j,1}(x,y)]$ is the sub-band curvelet coefficients at scale *j* in direction 1 at location (x,y).

The LMR is calculated as follows ,Let us suppose that $C_{j,1}(M)$ $C_{j,1}(P)$ are the sub-band curvelet coefficients at scale *j* in a direction *l* of the multispectral band *M* and panchromatic image P at higher frequencies respectively.

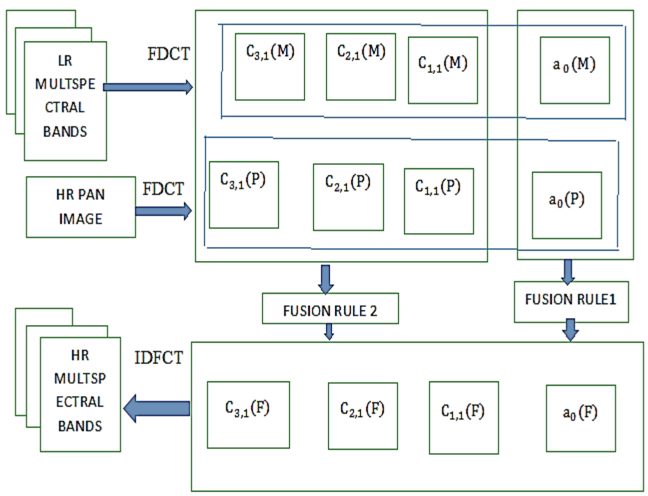


Fig. 5 Image fusion scheme using LR multispectral and HR Panchromatic images using FDCT.

After calculating the coefficients of M image and P image subband at each level are applied to fusion rule 1and fusion rule 2 .Then all curvlet coefficients are applied combining to Inverse Fast Discrete Curvelet Transform (IFDCT). In final stage the HR multi spectral band fused image is obtained.

This image fusion is a useful technique for merging similar sensor and multi-sensor images to enhance the information content present in the images. Image fusion has several applications in various areas such as Medical Imaging, Satellite Imaging, Remote sensing, Robotics, Military applications.

All the disadvantages of wavelet transform are overcome by curvlet transform . Image fusion is an advanced image processing technology, which could produce a new integrated image while retaining the important feature of these images. This paper makes the modest suggestion that WPCA and FDCT based Image Fusion is such a beneficial technique of image fusion which produces a new integrated image and retaining the important feature of these images. There are different techniques of Image Fusion are available such as: Spatial Domain Method Principal Component Analysis (PCA), Sharpness Criteria, Linear Fusion, and Wavelet Domain Method. Wavelet domain methods are generally used because it gives multiresolution analysis.

2.3 IBWT (Inverse Biorthogonal wavelet transform)

After BWT sub band coding different low and high bands are obtained after low pass filtering and high pass filtering. These sub bands from two images are obtained and fused with image fusion technology and then pass for inverse biorthogonal wavelet transform to obtain reconstructed original image.

FDCT(Fast Discrte curvelet Transform)

The Fast Wavelet Transform is a mathematical algorithm designed to turn a waveform or signal in the time domain into a sequence of coefficients based on an orthogonal basis of small finite waves, or wavelets. The transform can be easily extended to multidimensional signals, such as images, where the time domain is replaced with the space domain. The Discrete Cosine Transform (DCT) has been successfully applied to the coding of high resolution imagery .The conventional method of implementing the DCT utilized a double size Fast Fourier Transform (FFT) algorithm employing complex arithmetic throughout the computation Use of the DCT in a wide variety of applications has not been as extensive as its properties would imply due to the lack of an efficient algorithm. More efficient algorithm involving only real operations for computing the Fast Discrete Curvlet Transform (FDCT) of N points.

3. APPLICATIONS

The object of image fusion of MRI and CT images is to achieve a high spatial resolution image with functional and anatomical information [7].In the forensic labs, image fusion is used to identify and recognize theft from different fingerprints images ,image fusion done for medical diagnosis ,satellite communication. In optical remote sensing fields, the multispectral (MS) image which contains color information is produced by three sensors covering the red, green and blue spectral wavelengths.

4. EXPERIMENTAL RESULTS AND COMPARISON

Proposed system is used when different images captured from medical source of body parts using sensing devices and decomposed and fused using first some spatial domain methods and then by using fusion method BWT,FDCT,WPCA by fusion rule results are compared which Absolute Maximum Fusion Rule is we are going to use for fusion**.** In BWT different transform like Haar , Daubeshian (d4.4) are also tested. The performance of proposed system is compared on basis of MSE ,PSNR ,EN, Processing time are shown in table 1.

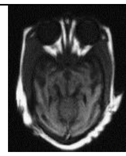
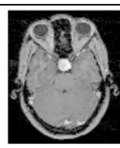
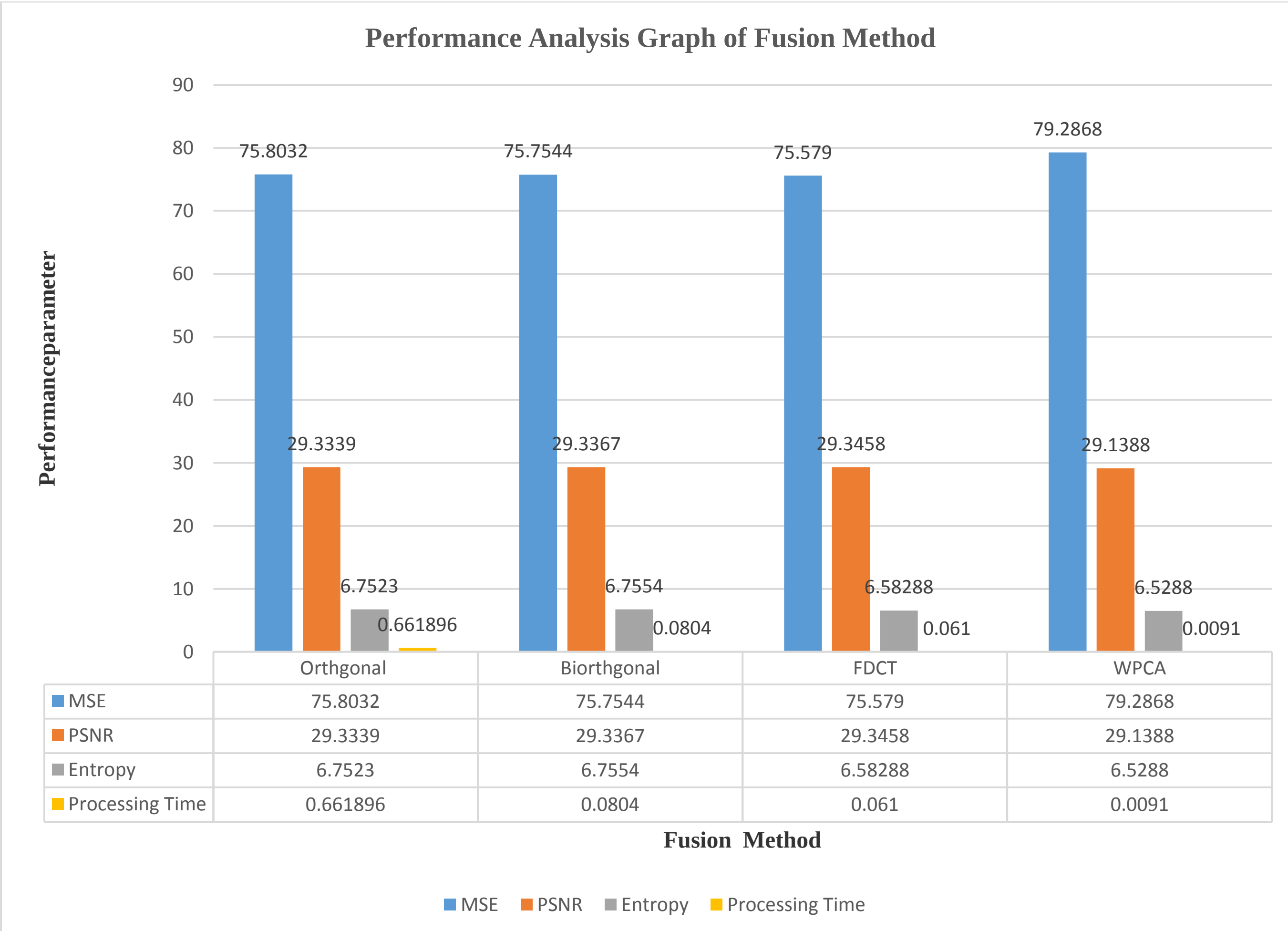
Sr. no	Image A	Image B	Parameters of fusion	Method of Image Fusion				
				Orthogonal	Biorthogonal	FDCT	WPCA	Expected result
1			**MSE**	**75.8032**	**75.7544**	**75.597**	**79.2868**	**Low**
			PSNR(dB)	**29.3339**	**29.3367**	**29.3458**	**29.1388**	**Low**
	CT scan	**MRI**	**Processing time**	**0.661896**	**0.0804**	**0.0610**	**0.0091**	**Low**
	Sample 1	**Sample1**	**Entropy**	**6.7523**	**6.7554**	**6.58288**	**6.58288**	**High**
2			**MSE**	**74.7832**	**74.3982**	**46.1023**	**48.3525**	**Low**
			PSNR	**29.3928**	**29.4152**	**31.4936**	**31.2886**	**Low**
			Processing time	**0.0395**	**0.0396**	**0.00822**	**0.004646**	**Low**
	Sample2	**sample 2**	**Entropy**	**6.67153**	**6.59903**	**6.59903**	**6.3659**	**High**
3			**MSE**	**45.7957**	**45.653**	**45.1835**	**47.388**	**Low**
			PSNR	**31.5226**	**31.536**	**31.581**	**31.374**	**Low**
	Sample 3	**Sample 3**	**Processing time**	**0.5848**	**0.4189**	**0.02067**	**0.0079**	**Low**
			Entropy	**5.9003**	**5.8419**	**6.0738**	**6.0738**	**High**
4			**MSE**	**38.177**	**38.1306**	**11.58**	**12.111**	**Low**
			PSNR	**32.3126**	**32.3181**	**37.5057**	**37.29**	**Low**
	Sample 4	**Sample 4**	**Processing time**	**0.03763**	**0.03609**	**0.0068**	**0.0044**	**Low**
			Entropy	**7.3139**	**7.3130**	**7.1247**	**7.1269**	**High**
5			**MSE**	**45.1933**	**45.1253**	**27.95**	**29.32**	**Low**
			**PSNR**	**31.5807**	**31.5866**	**33.666**	**33.45**	**Low**
			Processing time	**0.24420**	**0.06308**	**0.014**	**0.0071**	**Low**
	Sample 5	**Sample 5**	**Entropy**	**7.252**	**7.25174**	**6.981**	**6.9874**	**High**

Table 1



Graph 1

5. CONCLUSIONS

In this paper, we proposed image fusion schemes using multi resolution WPCA,FDCT, BWT shows comparable results. As MSE is take in account FDCT shows best results as theoretical exceptions. Important parameter PSNR of fusion method PCA shows low as compare to others. Another performance parameter is entropy of biorthgonal is good .Processing time required is new parameter add in performance metric .WPCA is fastest fusion method as per results and graph.

REFERENCES

[1] C.V.Rao, J.Malleswara Rao, A.Senthil Kumar, D.S.Jain, V.K.Dadhwal " Satellite Image Fusion using Fast Discrete Curvelet Transforms", 978-1-4799-2572-8/14/$31.00_c 2014 IEEE

[2] Om Prakash, Richa Shrivastva and Ashish Khare, "BIORTHOGONAL WAVELET TRANSFORM BASED IMAGE FUSION USING ABSOLUTE MAXIMUM FUSION RULE", Proceedings of 2013 IEEE Conference on Information and Communication Technologies (ICT 2013), Page No. 577-582.

[3] NK, "IMAGE FUSION ALGORITHM BASED ON BIORTHOGONAL WAVELET", International Journal of Enterprise Computing and Business Systems, ISSN (Online): 2230-8849, Vol. 1 Issue 2 July 2011.

[4] V.P.S. Naidu and J.R. Raol, "Pixel-level Image Fusion using Wavelets and Principal Component Analysis", Defence Science Journal, Vol. 58, No. 3, May 2008, Page No. 338-352.

[5] G Geetha, S.Raja Mohammad and Dr. Y.S.S.R. Murthy, "MULTIFOCUS IMAGE FUSION USING MULTIRESOLUTION APPROACH WITH BILATERAL GRADIENT BASED SHARPNESS CRITERION", Computer Science & Information Technology (CS & IT), Page No. 103-115.

[6] Lindsay I Smith, "A tutorial on Principal Components Analysis", February 26, 2002, Page No. 1-27.

[7] Deepak Kumar Sahu and M.P.Parsai, "Different Image Fusion Techniques – A Critical Review", International Journal of Modern Engineering Research (IJMER), Vol. 2, Issue. 5, Sep.-Oct. 2012, Page No. 4298-4301.

[8] Shih-Gu Huang, "Wavelet for Image Fusion".

[9] Mark Richardson, "Principal Component Analysis", May 2009, Page No. 1-23.