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PERFORMANCE ANALYSIS FOR COMPARISON OF IMAGE FUSION USING TRANSFORM BASED FUSION TECHNIQUES ON LOCALIZED BLURRED IMAGES

Amit Kumar Pathak*, M.P.Parsai

*PG student, Dept. of Electronics and Telecommunication Engg., Jabalpur Engg. College, Jabalpur, M.P., India

Asst. Prof., Electronics & Telecommunication Engg., Jabalpur Engg. College, Jabalpur, M.P., India

ABSTRACT

There are many image fusion methods that can be used to produce high-resolution mutli-spectral images from a high-resolution panchromatic image and low-resolution multispectral images. This paper presents a comparative study of various image fusion techniques. There are various methods of image fusion. They might be based on the various transforms i.e. discrete cosine transform, discrete wavelet transform, complex wavelet transform. Further the different strategies can be followed to combine the elements of two images. The different rules for the fusion of 2 elements of images are: averaging, maximum coefficient selection, maximum absolute coefficient selection, maximum energy coefficient selection etc. In this paper we have implemented all these methods and the results of different techniques are compared on the basis of visual perception and parameters named Mutual Information and PSNR, Quality index, RMSE etc.

KEYWORDS: DCT, DWT, Complex Wavelet Transform.

INTRODUCTION

Image fusion is used to combine multi-image information in one image which is more suitable to human vision or more adapt to further image processing analysis.

The term fusion means in general an approach to extraction of information acquired in several domains. The goal of image fusion (IF) is to integrate complementary multi sensor, multi temporal and/or multi view information into one new image containing information the quality of which cannot be achieved otherwise. Image fusion is a powerful tool used to increase the quality of image. Image fusion increases reliability, decreases uncertainty and storage cost by a single informative image than storing multiple images. The fast development of digital image processing leads to the growth of feature extraction of images which leads to the development of Image Fusion [1-2].

In the process of image fusion, two or more images are combined together into a single image retaining the important features from each of the original images. The images acquired from different instrument modalities or capture techniques of the same scene or objects often requires fusion of images. Important applications of the fusion of images include medical imaging, microscopic imaging, remote sensing, computer vision, and robotics [3-4]. For the image fusion the generalized approach follows the following steps: Transformation, Feature extraction or Component extraction, Selection or construction of the resultant component on the basis of the predefined technique. Here we have described the image fusion techniques based on the different transforms i.e. discrete cosine transform, discrete wavelet transform, complex wavelet transform.

IMAGE FUSION USING DCT

Discrete cosine transform (DCT) is an important transform extensively used in digital image processing. Large DCT coefficients are concentrated in the low frequency region; hence, it is known to have excellent energy compactness properties. DCT decomposes the image/block into a series of waveforms, each with a particular frequency. DCT coefficients are segregated into 2N-1 different frequency bands for image or block of size NxN. The m^{th} band is composed of the coefficients with m=k1+k2 [1,3,8].

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Image to be fused are divided into non-overlapping blocks of size NxN as shown in Fig1. DCT coefficients are computed for each block and fusion rules are applied to get fused DCT coefficients. IDCT is then applied on the fused coefficients to produce the fused image/block. The procedure is repeated for each block.

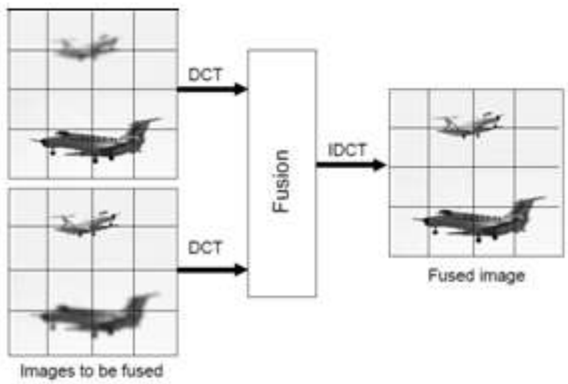

Fig. 1 : Framework of DCT based image fusion algorithm[8]

In [1,8] the following fusion rules are used for image fusion process.

Average Coefficients: In this fusion rule, all DCT coefficients from both image blocks are averaged to get fused DCT coefficients. It is very simple and basic image fusion technique in DCT domain.

Maximum value Coefficients: The DC components from both image blocks are averaged. The largest magnitude AC coefficients are chosen, since the detailed coefficients correspond to sharper brightness changes in the images such as edges and object boundaries etc. These coefficients are fluctuating around zero.

Maximum energy Coefficients: The DC components are averaged together. AC coefficients correspond to the frequency band having largest energy is chosen.

Maximum Variance Coefficients: In this technique , the variance is calculated for both the blocks and the block having the large variance is chosen [1,8,12].

IMAGE FUSION USING DWT

The discrete wavelet transform (DWT) of image signal produces image representations which provides better spatial and spectral localization of image formation compared with other multi scale representations such as Gaussian and Laplacian pyramid.

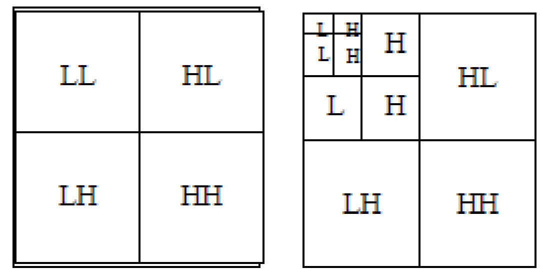

Fig.2 The pyramidal decomposition shown up to two levels

The Discrete Wavelet Transform (DWT) also converts the image from the spatial domain to frequency domain. The image is divided by vertical and horizontal lines and represents the first-order of DWT, and the image can be separated with four parts those are LL1, LH1, HL1 and HH1. In additional, those four parts are represented four frequency areas in the image. For the low- frequency domain LL1 is sensitively with human eyes. In the frequency domains LH1, HL1 and HH1 have more detail Information more than frequency domain LL1.

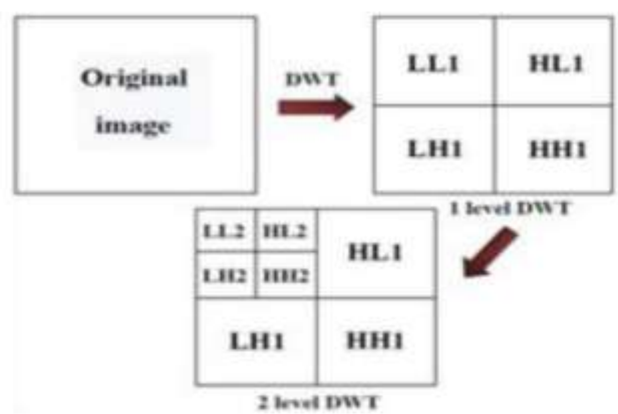

Fig 3. Frequency distribution of DWT [13]

In the case of wavelet transform fusion all respective wavelet coefficients from the input images are combined using the fusion rule. Since wavelet coefficients having large absolute values contain the information about the salient features of the images such as edges and lines, a good fusion rule is to take the maximum of the corresponding wavelet coefficients. The maximum absolute value within a window is used as an activity measure of the central pixel of the window. A binary decision map of the same size as the DWT is constructed to record the selection results based on a maximum selection rule. The discrete wavelet transform (DWT) uses filter banks to perform the wavelet analysis.[9]

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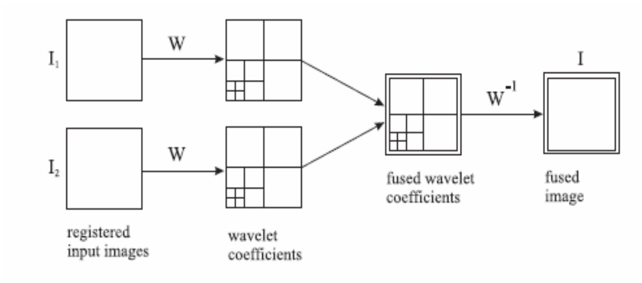

Fig. 4-Wavelet Based Image Fusion.[9]

There are following rules can be adopt for the DWT based image fusion:

Average coefficient: All the four sub bands of the fused image F is simply acquired by averaging the wavelet coefficients of source images A and B.

Maximum absolute values coefficient: Since larger absolute transform coefficients correspond to sharper brightness changes, the good integration rule is to select, at every point in the transform domain, the coefficients whose absolute values are higher.

Mixed approach: This method uses averaging to fuse low frequency sub-bands and selects the maximum value or absolute maximum value for high frequency bands.

IMAGE FUSION USING COMPLEX WAVELET TRANSFORM

Standard wavelet transform and its extensions mainly consist of the following limitations: shift variance, aliasing, lack of directionality, absence of phase information. Due to these limitations standard DWT may not be preferred to use in some applications of image and signal processing [4-6, 9-10].

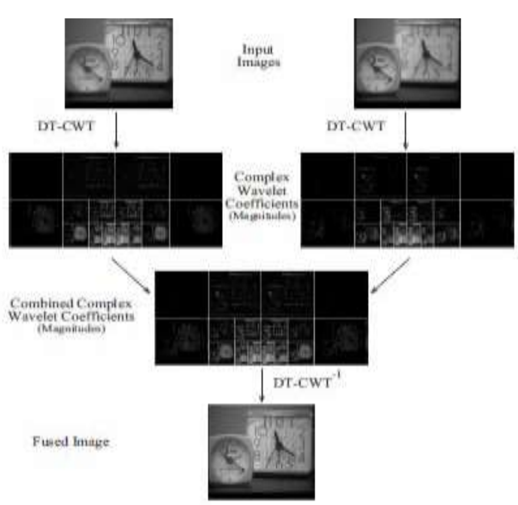

Fig. 5- Image fusion process using DT-CWT[9]

Fig 5. demonstrates the fusion of two images using the complex wavelet transform. The areas of the images more in focus give rise to larger magnitude coefficients within that region. A simple choose maximum scheme is used to produce the combined coefficient map (we may also use the other rules of image fusion that use for the image fusion using 2DDWT. CWT does not makes any difference we only changed the wavelet transform type). The resulting fused image is then produced by transforming the combined coefficient map using the inverse complex wavelet transform. The wavelet coefficient images show the orientated nature of the complex wavelet sub bands. Each of the clocks hands which are pointing in different directions are picked out by the differently orientated sub bands. All of the coefficient fusion rules implemented with the discrete wavelet transform can also be implemented with the complex wavelet transform. In this case, however, they must be applied to the magnitude of the DT-CWT coefficients as they are complex. [9]

PARAMETER

There are so many parameter have been prescribed for the quality assessment of the fussed image those are PSNR, SSIM, MSE. But on the basis of these parameter better assessment cannot be obtain because these parameters compare the fused image in respect to the first or the second image. So there is another parameter that can be used for the proper analysis of the fused image. It is called by Mutual- Information [7].

Mutual information (MI) essentially computes how much information from each of the original images is transferred to the fused image. The larger the MI value, the better the fused result is.

$$MI = MI_{FA} + MI_{FB} \qquad (8)$$

Where

$$MI_{FA} = H_A + H_F - H_{FA}$$
$$MI_{FB} = H_B + H_F - H_{FB}$$

And

H_A = entropy of first image;
H_B = entropy of second image;
H_f = entropy of fused image;
H_{FA}= crossed entropy of first image and fused image;
H_{FB}= crossed entropy of second image and fused image;

CONCLUSION

In this paper, we have seen the Significance and requirement of the image fusion. We have also seen the generalized methodology of the image fusion.

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Then we have studied the different techniques of image fusion. We have seen the four different rules for image fusion using DCT. The results obtained for the maximum variance coefficient technique are better as compare to the other techniques. The DCT based techniques applied on the blocks of image so these are slow enough so we can't use them in run time application. On the other hand, it's performance is good because the block approach can distinguish the small details also. Whereas the DWT based fusion is fast as compare to DCT. Its fusion performance becomes better then the DCT because of the sub band decomposition in DWT. We have also seen the different fusion rules for the DWT. The results are good for the mixed approach rule.

Further we have seen the results for the image fusion using Complex-DWT. Real and imaginary coefficients are developed in the transformed domain by the complex valued filters from the real/complex source signals. To provide the local phase information, complex-valued filtering is required. The Complex DWT based image fusion gives very good results. In the future we may try to get more advanced techniques of image fusion.

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APPENDIX

Table 1-Results for image fusion of the images: Saras91 Saras92

Method / Parameters	DCT Averaging	DCT Maximum value	DCT Maximum energy	DCT Maximum Variance	DWT Averaging	DWT Maximum absolute values	DWT Mixed approach	Complex DWT
Root mean square error (RMSE):	9.417	5.505	5.471	5.278	9.417	13.880	8.835	0.699
Percentage fit error (PFE):	4.039	2.361	2.346	2.264	4.039	5.954	3.789	0.299
Mean absolute error (MAE):	3.065	1.800	1.774	0.901	3.065	3.102	2.831	0.383
Correlation (CORR):	0.999	0.999	0.999	0.999	0.999	0.998	0.999	0.999
Signal to noise ratio (SNR):	27.873	32.536	32.590	32.902	27.873	24.503	28.427	50.460
Peak signal to noise ratio (PSNR):	38.425	40.757	40.784	40.940	38.425	36.740	38.702	49.719
Mutual information (MI):	1.401	1.492	1.505	1.750	1.356	1.543	1.444	1.592
Quality index (QI):	0.507	0.588	0.591	0.908	0.809	0.842	0.837	0.629
Structural similarity (SSIM):	0.968	0.975	0.975	0.975	0.968	0.962	0.973	0.998

Table 2- Result for Image fusion : Jabalpur Engg. College (JASHAN) image

Method / Parameters	DCT Averaging	DCT Maximum value	DCT Maximum energy	DCT Maximum Variance	DWT Averaging	DWT Maximum absolute values	DWT Mixed approach	Complex DWT
Root mean square error (RMSE):	5.2542	2.9701	2.7583	2.3596	5.2542	6.9085	4.9438	1.0355
Percentage fit error (PFE):	3.2783	1.8531	1.7210	1.4722	3.2783	4.3105	3.0846	0.6461
Mean absolute error (MAE):	2.8023	1.4087	1.2755	0.3924	2.8023	2.9415	2.6260	0.5848

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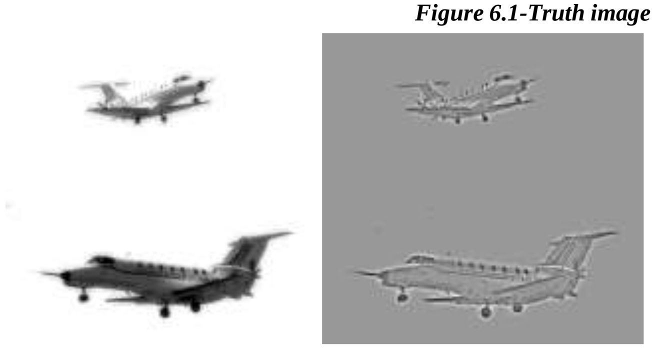
Correlation (CORR):	0.9994	0.9998	0.9998	0.9998	0.9994	0.9990	0.9995	0.9999
Signal to noise ratio (SNR):	29.6870	34.6416	35.2842	36.6402	29.6870	27.3.93	30.2158	43.7937
Peak signal to noise ratio (PSNR):	40.9597	43.4370	43.7583	44.4363	40.9597	39.7709	41.2241	48.0131
Mutual information (MI):	1.4096	1.5008	1.5173	1.8276	1.3941	1.4697	1.4145	1.6494
Quality index (QI):	0.8265	0.8908	0.8922	0.9320	0.8379	0.8223	0.8483	0.9285
Structural similarity (SSIM):	0.9495	0.9817	0.9842	0.9878	0.9495	0.9402	0.9567	0.9969

Figure (6) - Results for saras91

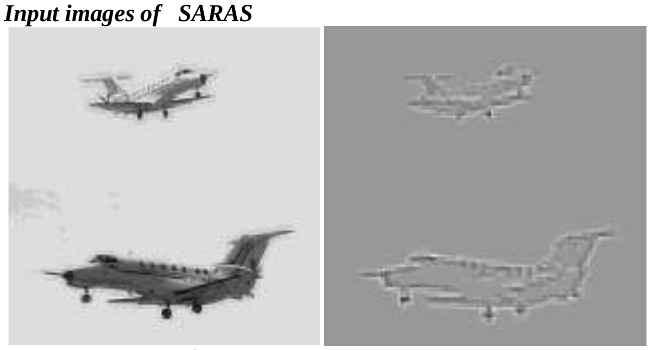
6.1(a) Truth Image **6.1(b) Input image (1)** **6.1(c) Input image (2)**

Figure 6.1-Truth image & Input images of SARAS



(i)fused Image **(ii) Error Image**

6.2 (a) DCT Averaging Method



(i)fused Image **(ii) Error Image**

6.2 (b) DCT Maximum value

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(i) fused Image (ii) Error Image

6.2(c) DCT Maximum energy

(i)fused Image (ii) Error Image

6.2 (d) DCT Maximum Variance

(i) fused Image (ii) Error Image

6.2 (e) DWT Averaging

(i)fused Image (ii) Error Image

6.2 (f) DWT Maximum absolute values

(i)fused Image (ii) Error Image

6.2(g) DWT Mixed Approach

(i)fused Image (ii) Error Image

6.2(h) Complex DWT

Figure 6.2 - Output fused images & its Error images.

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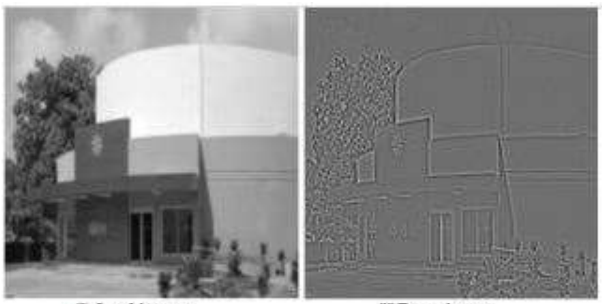
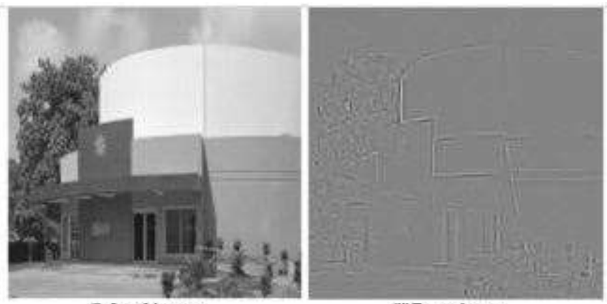
Figure (7) - Result for JEC image:

7.1(a) Truth Image 7.11(b) Input Image (1) 7.1(c) Input Image (2)

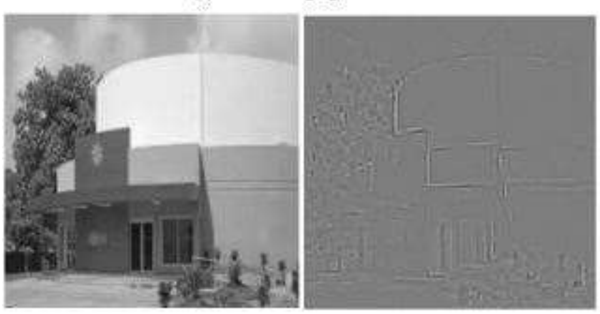
Figure 7.1-Truth image & Input images of JEC



(i) fused image (ii)Error image
7.1 (b) DCT Averaging Value

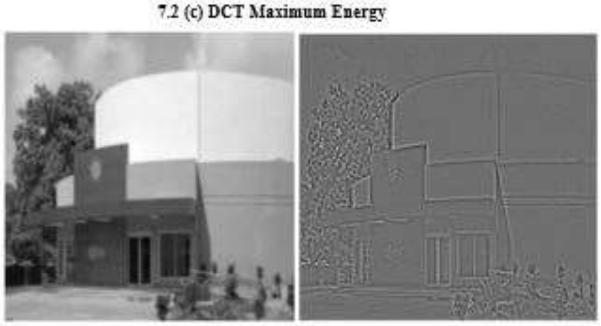


(i) fused image (ii)Error image
7.2 (b) DCT Maximum Value

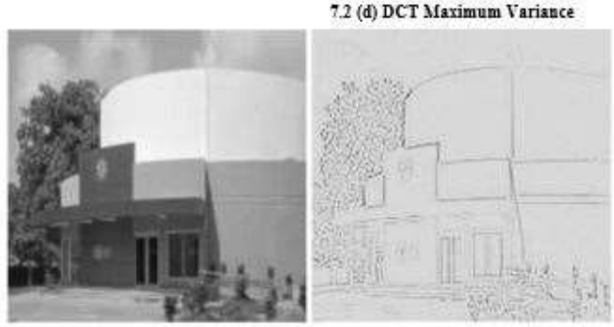


(i) fused image (ii)Error image
7.2 (c) DCT Maximum Energy

(i) fused image (ii)Error image
7.2 (d) DCT Maximum Variance



(i) fused image (ii) Error image
7.2(e)DWT Averaging



(i) fused image (ii)Error image
7.2 (f) DWT Maximum Absolute value

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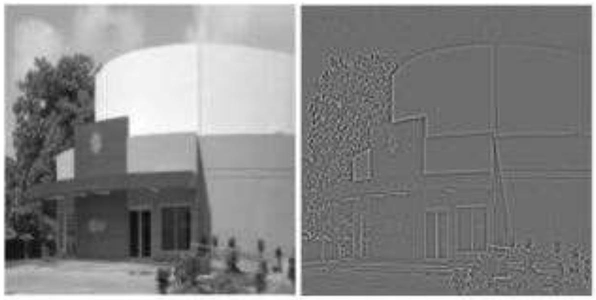
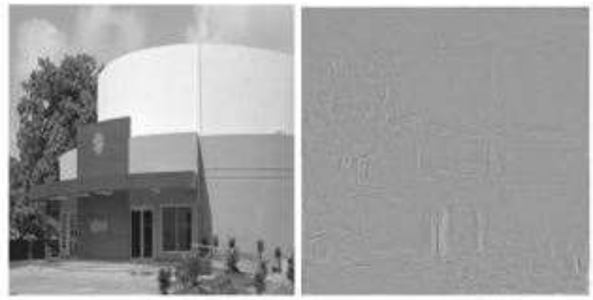


(i) fused image (ii)Error image

7.2 (g) DWT Mixed Approach



(i) fused image (ii)Error image

7.2 (h) Complex DWT

Figure 7.2 - Output fused image &its error images.