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Image Fusion Based on DTCWT and PCA

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***Abstract*— the main objective of this paper is to improve the image quality by using image fusion techniques .Image fusion is a process of combining multiple images into a single composite image. A. single image with better description of the scene is generated from the collection of input images.. The output image generated should therefore be more useful for human visual perception or for machine perception .The main problem of image fusion is determining the efficient procedure for combining the multiple images. The fusion technique is very much useful in diagnosing and treating cancer in medical fields. This paper is based on fusion of input images using Dual Tree Complex Wavelet Transform and applying Principal Component Analysis(PCA) for fused image such that better image quality is obtained and estimated using various Image quality Metrics.**

Keywords*— *Image Fusion , Dual Tree complex Wavelet Transform (DT-CWT), Principal Component Analysis., Image Quality Metrics,

I. INTRODUCTION

The Image fusion is an integration of multiple images captured by different modality sensors into single image which is more suitable for computer processing or visual perception. The image quality metrics are useful to analyze the quality of fused image. This image fusion [2] found its application in various streams like military, medical, surveillance etc. The satellite images and remote sensing images are should be image with high spatial and spectral resolution which cannot be obtained directly by camera so the solution for this problem is Image fusion. Image fusion methods can be broadly categorized into spatial and spectral domain methods .The spatial domain fusion methods will produces spatial distortions in fused image; whereas these spatial distortion problems can be well handled by spectral domain methods.

The Dual Tree complex Wavelet Transform (DT-CWT) [1] is a wavelet transform based image fusion .It is a spectral domain method. In this fusion [2] are performed using masks to extract information from decomposed structure. The complex transform of a signal using two separate DWT decompositions [1] i.e. tree a and b is done. In this both real and complex coefficients are used, the fused pyramid is formed using DT-CWT [8, 9, 10, 11, 12,] coefficients which are generated from decomposed pyramid of source image. The reconstruction process is inverse DTCWT to obtain the fused image [5].

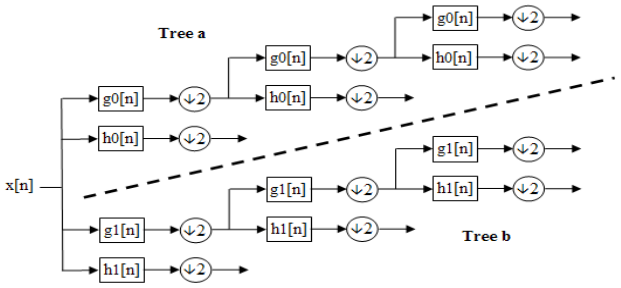


Fig. 1. DT-CWT Structure

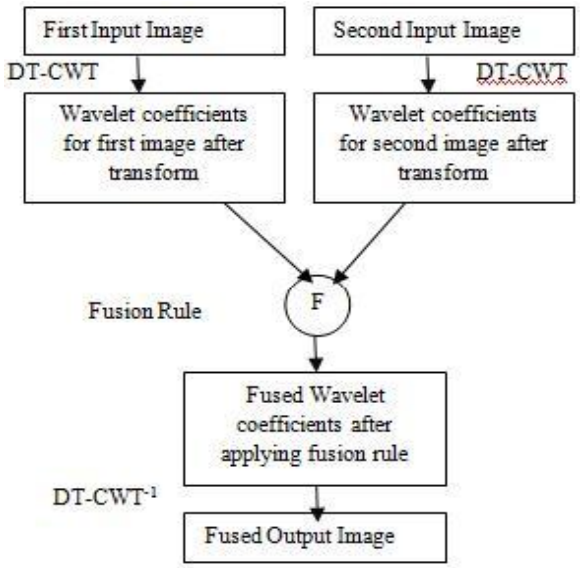


Fig. 2. DT-CWT based fusion

The fused image is analyzed using various Image quality Metrics like PSNR,MSE,AD,SC,NCC,NAE,LMSE etc. The Principal Component Analysis [4] is a image subspace technique used to reduce dimensionality .It is Eigen vector based multivariate analysis. In this the number of variables in data set are reduce without loss of information

.PCA operates by transforming a set of correlated variables into a set of uncorrelated variables that are called the principle components. PCA is a spatial method because it directly deals with pixels used with spectral domain method DTCWT. In this column vectors are extracted from respective input matrices then covariance matrix is calculated. The diagonal elements in the covariance vector will contain variance of each column vector. The vectors of covariance matrix and Eigen values are calculated and then Normalize column vector corresponding to lager Eigen value by dividing each element with mean of Eigen vector. The normalized Eigen vector value are weight vales which are multiplied with each pixel of input DTCWT fused image. The final image after application of PCA is further filtered i.e. better quality image is generated. The quality of image is analyzed using image quality metrics.

II. QUANTITATIVE IMAGE QUALITY METRICS

Quality is a characteristic that measures perceived image degradation i.e., in comparison with ideal or perfect image. Evaluation forms an essential part in the development of image fusion techniques. It involves Full Reference where quality is measured in comparison with ideal image and No Reference Methods, which have no reference image. Here we employ Full reference Methods. The metrics used are shown in Table1.

Assumptions made in the following equations are as A is the image which is perfect, B is the resultant image. i, j is the pixel row and column index

1) Mean Square Error (MSE)

$$MSE = \frac{1}{mn}\sum_{i=0}^{m}\sum_{j=0}^{n}(A_{ij} - B_{ij})^2 \quad (1)$$

2) Peak Signal to Noise Ratio (PSNR)

$$PSNR = 10\,x\,Log_{10}\left(\frac{peak^2}{MSE}\right) \quad (2)$$

3) Average Difference (AD)

$$AD = \frac{1}{mn}\sum_{i=0}^{m}\sum_{j=0}^{n}(A_{ij} - B_{ij}) \quad (3)$$

4) Structural Content (SC)

$$SC = \frac{\sum_{i=0}^{m}\sum_{j=0}^{n}(A_{ij})^2}{\sum_{i=0}^{m}\sum_{j=0}^{n}(B_{ij})^2} \quad (4)$$

5) Normalized Cross – Correlation (NCC)

$$NCC = \frac{\sum_{i=0}^{m}\sum_{j=0}^{n}(A_{ij} * B_{ij})}{\sum_{i=0}^{m}\sum_{j=0}^{n}(A_{ij})^2} \quad (5)$$

6) Maximum Difference (MD)

$$MD=\max(A_{ij}-B_{ij}) \quad i=1.2\ldots..m,j=1,2,\ldots.n \quad (6)$$

7) Normalized Absolute Error (NAE)

$$NAE = \frac{\sum_{i=0}^{m}\sum_{j=0}^{n}(A_{ij} - B_{ij})}{\sum_{i=0}^{m}\sum_{j=0}^{n}A_{ij}} \quad (7)$$

8) Laplacian Mean Squared Error (LMSE)

$$LMSE = \frac{\sum_{i=0}^{m}\sum_{j=0}^{n}(del2(A) - del2(B))^2}{\sum_{i=0}^{m}\sum_{j=0}^{n}(del2(A))^2} \quad (8)$$

III. PROCEDURE

1) Using DTCWT decompose input image to obtain LL bands and repeat for all input images
2) Sequence of resolution pyramids are created
3) Apply masks to corresponding bands and mark the filtered bands as and choose the coefficient value such that the value at spatial location is more.
4) Apply PCA for fused image for further filtering and better image quality
5) Analyze the fused and final image using different Image Quality Metrics

IV. EXPERIMENTAL RESULTS

5.1 EXAMPLE A:

fig.3. (a & b) satellite map images of same scene

Fig.4.Fused image

Fig.8.Fused image

5.2 EXAMPLE B:

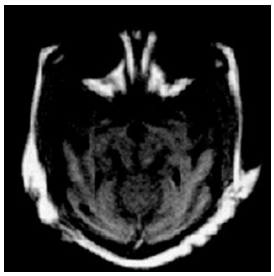


Fig.5. (a & b) CT scan and MRI scan

Fig.6.Fused image

5.3 EXAMPLE C:

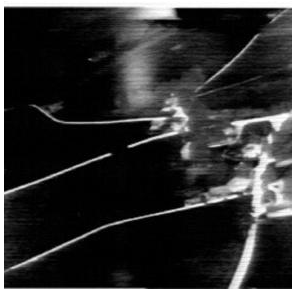
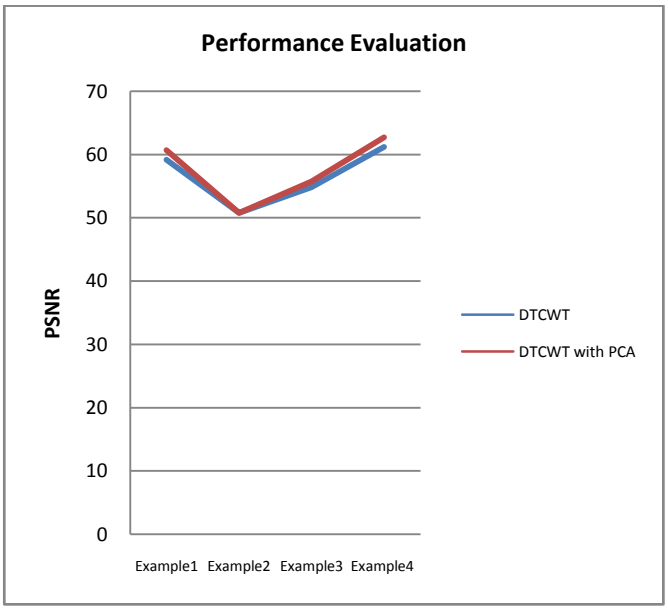


Fig.7. (a & b) images of visible camera and infrared camera

TABLE 1. TABLE OF IMAGE QUALITY METRICS FOR 3.1 EXAMPLE A

Image Quality Metrics Of Example A	Output of DTCWT	Output of DTCWT and PCA
Mean square error (MSE)	0.0000002	0.0000002
Peak signal to noise ratio (PSNR)	61.209269	62.7144192
Average Difference (AD)	0.0100292	0.1506952
Structural Content(SC)	1.0459692	2.0919382
Normalized Cross Correlation(NK)	0.9755082	0.6897892
Maximum Difference (MD)	0.0247072	0.0174712
Laplacian Mean square error(LMSE)	0.0702012	0.1171752
Normalized absolute error(NAE):	0.0622362	0.3082562

TABLE 2: PERFORMANCE EVALUATION



V. CONCLUSION

The fusion of different images taken from different modalities sensors is done and the following conclusions are drawn:

1. Quality of the fused image is improved after applying principal component Analysis.

2. Better quality, information can be achieved.

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