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Image Fusion using Principal Component Analysis and Discrete Wavelet Transform

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Abstract-- Image fusion is the process of combining two or more images to produce one single fused image. The Fusion process was worked on collecting all the relevant information from the input images and returns a single image. This single image has more informative and accurate than the other input images, and it is consist of all the necessary information. The final fused image is formed by combining many input images into one single image. This paper presents PCA and wavelet transform based Image Fusion.

Keywords— Image fusion, PCA, wavelet transform, Multi focuses Image.

I. INTRODUCTION

The Image fusion process is worked by which two images are fused together to obtain a single image. In image fusion process used on various images they are multi sensor and multi focus image.

The following requirements are most important for the image fusion process.

- The fused image should be preserve all relevant information from the input images
- The image fusion process should not helps to initiation introduce artifacts of wrong diagnosis

The fusion process using Images with different focused regions, images from different modalities or images taken in different times have been fused together to give enhanced results.

One of the most important pre-processing steps in the fusion process is image registration. Image registration is the process of transforming different data set into one coordinate system.

II. IMAGE FUSION ALGORITHMS

Image fusion algorithms can be listed into different levels. They are pixel, feature, and decision levels. Pixel level fusion directly works on the pixels of source images. The feature level fusion algorithms operate on features extracted from the source images.

Image fusion method can be divided into two types

1. Spatial domain fusion method
2. Transform domain fusion

Spatial domain fusion method is directly works on the pixels of input images.

The spatial domain fusion methods such as

- Simple Maximum
- Simple Minimum
- Averaging
- PCA(Principal Component Analysis)
- IHS

Transform domain fusion method is first transferred the image pixels in to frequency domain. The overall converted coefficient is helps to extracting relevant features from input images to form fused image.

The transform fusion method such as

- DWT (Discrete Wavelet Transform)
- SWT(Stationary Wavelet Transform)
- DCT(Discrete Cosine Transform)

Some of these pixel-level algorithms are described below:

A. Simple Maximum Method

In this algorithm is a simple way of obtaining an output image. That was considered by only the maximum intensity of corresponding pixels from both the input image.

B. Simple Minimum Method

In this method, considers only the lowest pixel intensity value and ignores other pixel values for the resultant fused image.

C. Simple Average Method

In this method considers only the average pixel intensity value and ignores other pixel values for the resultant fused image.

D. Principal component analysis (PCA)

Principal Component Analysis is a sub space method, which reduces the multidimensional data sets into lower dimensions for analysis. In this method determine the weight for each input images using the eigenvector corresponds to the highest Eigen value of the covariance matrix for each source image. The PCA is also called as Hotelling transform.

The PCA algorithm for the image fusion

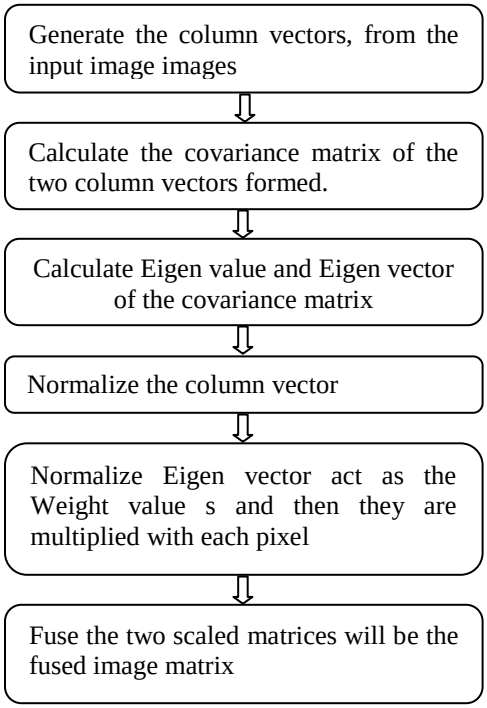


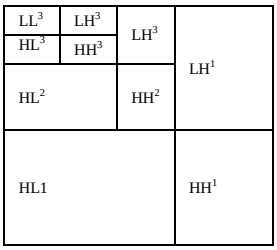
Fig. 1

The PCA algorithm for the image fusion process discussed as Follows.

Step 1: Generate the column vectors, from the input image matrices.
Step 2: Calculate the covariance matrix for the two column vectors formed.
Step 3: The diagonal elements of the 2x2 covariance matrix will consist of the variance of each column vector.
Step 4: Calculate the Eigen value sand the Eigen vectors of the covariance matrix.
Step 5: Normalize the column vector corresponding to the bigger Eigen value by dividing each element with mean of the Eigenvector.
Step 6: The values of the normalized Eigen vector act as the Weight value s and then they are multiplied with each pixel of the input images.
Step 7: Sum of these two scaled matrices that are calculated in the above step will be the fused image matrix.

E. Discrete Wavelet Transform (DWT)

Discrete Wavelet Transformation (DWT) converts the image pixels from the spatial domain to frequency domain. The wavelet transform decomposes the image into low- high, high-low, high-high and the low-low spatial frequency bands at different scales. In decomposing the image is divided by vertical and horizontal lines and represents the first-order of DWT, and the image can be divided on four parts those are LL1, LH1, HL1 and HH1. That shows Fig.1



1,2,3→ Decomposition levels

H→ High Frequency band
L→ Low Frequency band

Fig.1 DWT Decomposition

Steps in DWT are:

Step 1: Registered source image

Step 2: Implement Discrete Wavelet Transform on both the input image to create wavelet lower decomposition.

Step 3: Fuse each decomposition level by using various fusion rule.

Step 4:Carry Inverse Discrete Wavelet Transform on fused decomposed level, which means to reconstruct the image, while the image reconstructed is the fused image F.

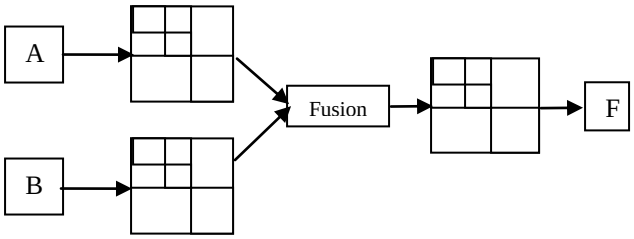


Fig.2 Wavelet Based image fusion

III. IMAGE QUALITY METRICS

A) Mean Square Error

Mean Square Error (MSE) is the cumulative squared error between the fused and original image. It shows average error of the pixels all through the image.

MSE=sum(D(:))/numel(image)

B) Peak signal to noise ratio

PSNR value is used to assess the refinement in the quality of the fused image.

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

Where MSE is the mean square error.

IV. RESULT ANALYSIS

Source images

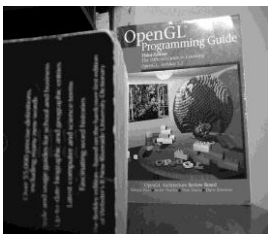


Fig.3

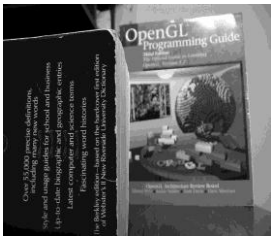


Fig.4

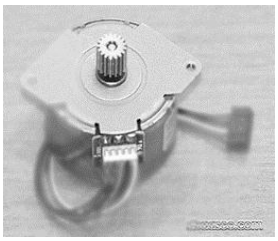


Fig.5

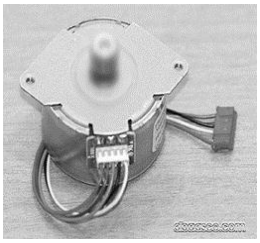


Fig.6

Fig.3 and Fig.4 are left and right side focus book images. Fig.5 and Fig.6 are inside and outside focus metal images.

Fused images

Fig.7

Fig.8

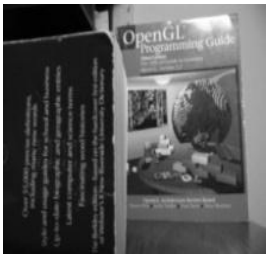


Fig.9

Fig.10

Fig.7 (Book Image) and Fig.8 (Metal Image) are fused images for PCA process. Fig.9 and Fig.10 are fused DWT process.

Table.1 Comparison of DWT and PCA

Fusion Techniques	Source Images		MSE	PSNR
PCA	Book Image	Image 1	1.515	46.327
		Image 2	1.509	46.344
		Fused Image	1.004	62.547
	Metal Image	Image 1	1.685	45.866
		Image 2	1.680	45.877
		Fused Image	1.005	62.541
DWT	Book Image	Image 1	1.021	48.042
		Image 2	1.020	48.043
		Fused Image	0.835	96.244
	Metal Image	Image 1	1.026	48.018
		Image 2	1.026	48.018
		Fused Image	0.836	96.239

Table.1 shows the comparison values for Mean Square Error and Peak Signal Noise Ratio For using Principal Component Analysis and Discrete Wavelet Transformation algorithms.

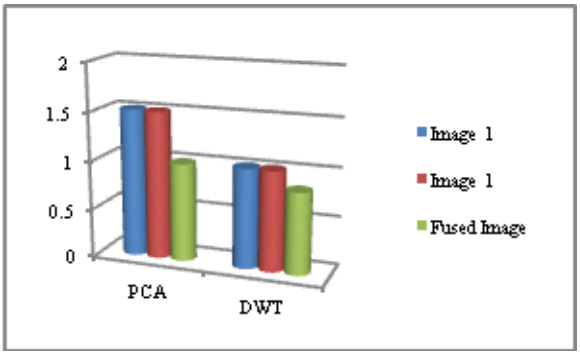


Fig: 11 MSE for Book Image

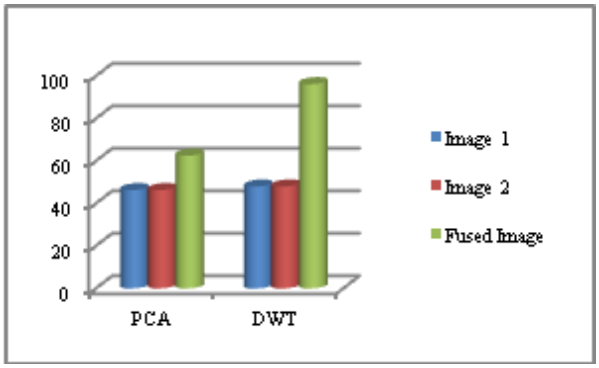


Fig: 12PSNR for Book Image

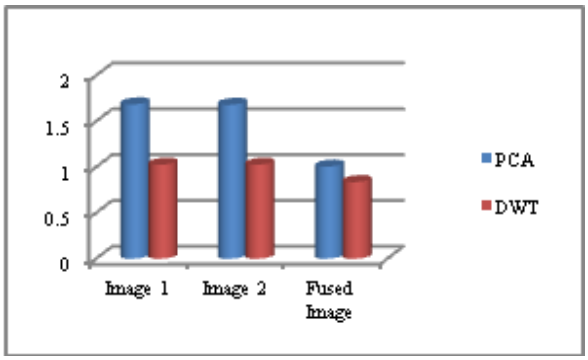


Fig: 13 MSE for Metal Image

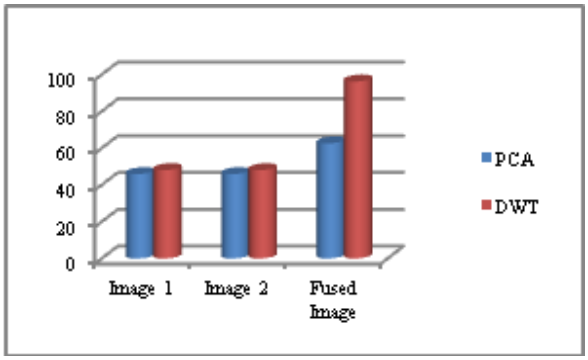


Fig: 14 PSNR for Metal Image

Fig: 11 and Fig: 13 Shows the MSE value for Book and Metal Images. Fig: 12 and Fig: 14 Shows the PSNR value for Book and Metal images.

V. CONCLUSION

In this paper, the algorithms Principal Component Analysis (PCA) and (DWT) are used for image fusion. From the results, it is observed that DWT algorithm provide better performance than PCA algorithm. The Image fusion using DWT algorithm provides higher Peak Signal Noise Ratio (PSNR) value than PCA algorithm. In the next few years, Experts expect the high-level fusion techniques combining different data sources.

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