Implementation of Image Fusion Scheme for 2D Images Using DWT and PCA Techniques

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***Abstract*— Image fusion is the process of extracting meaningful visual information from two or more images and combining them to form one fused image. Image fusion is important within many different image processing fields from remote sensing to medical applications. In various real life applications, such as medical image diagnosis, image fusion plays important role. Because of undefined nature of practical imaging systems the capture images or acquired images are corrupted from different types of noises hence fusion of image is an integrated approach where reduction of noise and retaining the original features of image is essential. Here the input to fusion involves set of images taken from different modalities of the same scene; Output is a better quality image. Image fusion is important within many different image processing fields from remote sensing to medical applications. Combining of two different modality images using wavelet transform and various fusion rules to fuse CT and MRI images. This method gives encouraging results in terms of greater entropy. The DWT (Discrete wavelet Transform) technique uses three methods of fusion i.e Maximum Selection Method, Average Selection Method and Minimum Selection Method. Of these three methods the Maximum Selection Method gives greater entropy. PCA(Principal Component Analysis) technique is one of the most widely used techniques for dimension reduction, image fusion, feature identification, pattern recognition.The PCA technique gives the greater entropy value when compared to DWT and is one of more efficient technique.**

***IndexTerms*— Image fusion, DT-CWT, Fused images, PCA, Multi-resolution, Image reconstruction, Gradient Criterion, Relative Smoothness Criterion.**

I. INTRODUCTION

Image fusion is the process by which two or more images are combined into a single image retaining the important features from each of the original images. The fusion of images is often required for images acquired from different instrument modalities or capture techniques of the same scene or objects(like multi-sensor, multi-focus and multi-modal images). For example, in multi-focus imaging one or more objects may be in-focus in a particular image, while other objects in the scene may be in focus in other images. For remotely sensed images, some have good spectral information whereas others have high geometric resolution. In the arena of biomedical imaging,

two widely used modalities, namely the magnetic resonance imaging (MRI) and the computed tomography (CT) scan do not reveal identically every detail of brain structure. While CT scan is especially suitable for imaging bone structure and hard tissues, the MR images are much superior in depicting the soft tissues in the brain that play very important roles in detecting diseases affecting the skull base. These images are thuscomplementary in many ways and no single image is totally sufficient in terms of their respective information content. The advantages these images may be fully exploited by integrating the complementary features seen in different images through

the process of image fusion that generates an image composed of features that are best detected or represented in the

individual images. Important applications of the fusion of images include medical imaging, microscopic imaging, remote sensing, computer vision, and robotics. The first step toward fusion, which may be interpreted as a preprocessing step is the registration which brings down the constituting images to a common coordinate system as fusion of images is meaningful only when common objects in images have identical geometric configuration with respect to size, location and orientation in all the images. In the next step, the images are combined to form a single fused image through a judicious selection of proportions of different features from different images. Fusion techniques include the simplest method of pixel averaging to more complicated methods such as principal component analysis and wavelet transform fusion. Several approaches to image fusion can be distinguished, depending on whether the images are fused in the spatial domain or they are transformed into another domain, and their transforms fused. Li et al. [1] have suggested a multisensory image fusion using wavelet transform in which a cascaded sequence of forward and reverse wavelet transform on multimodal images produces a fused image. Other common wavelet transform based fusion schemes include maximum selection (MS) just picks the wavelet transform coefficient in each sub-band with the largest magnitude. Burt and Kolczynski [2] used a normalized correlation between the two images sub-bands over a small local-area and the resultant coefficient for reconstruction is calculated from this measure via a weighted average of the two images coefficients. Zu Shu-long

[3] proposed wavelet based fusion approach using gradient criteria, while Hill et al. [4] achieved fusion throughthe application of the shift invariant and directionally selective Dual Tree Complex Wavelet Transform (DT-CWT). In this proposed work, an image fusion algorithm based on wavelet transform is proposed. In the proposed scheme, the images to be processed are decomposed into sub-images with the same resolution at same levels and different resolution at different levels and then the information fusion is performed using high-frequency sub-images under the combined gradient‘ and relative smoothness‘ criterion and finally these sub-images are reconstructed into a resultant image having plentiful information. The developed scheme is applied to fuse multi-focus, multi-modal and remotely sensed multisensory images.

II. LITERATURE SURVEY

Wavelet transform is apowerful mathematical tool used in the fields of signalprocessing. It is used to divide the given function or signalinto different scale components such that each scalecomponent can be studied with a resolution that it matches.Mallat [10] used the wavelets to be the foundation of newpowerful approach to signal processing and analysis called theMulti-resolution Theory. The same approach has beenextended to multi-dimensional signal decomposition. Themost common form of transform image fusion is wavelettransform fusion [1], [2], [3], [4]. In common with alltransform domain fusion techniques the transformed imagesare combined in the transform domain using a defined fusionrule then transformed back to the spatial domain to give the resulting fused image. Wavelet transform fusion is moreformally defined by considering the wavelet transforms *w* of the n registered input images *Ij(x,y), j=1,2…n* together withthe fusion rule *'f'*. Then, the inverse wavelet transform *w-1* iscomputed, and the fused resulting image *I(x, y)* isreconstructed as depicted in figure 1.

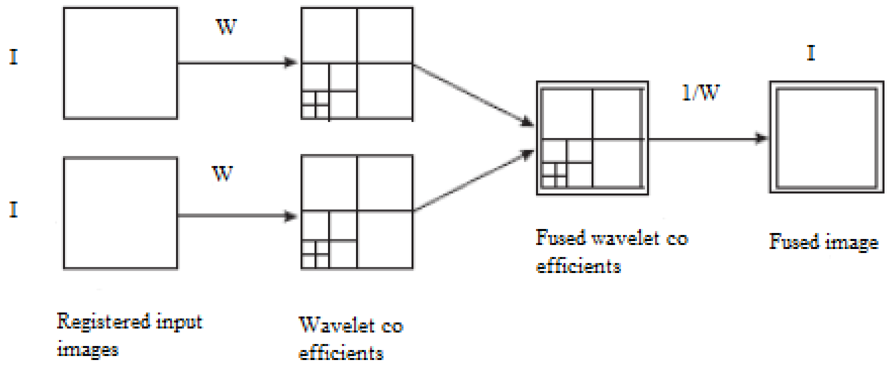


Figure 1: Fusion of wavelet transforms of images

III. WORKING PRINCIPLE

We use a scheme for fusion of different registered set of images of same scene obtained through different modalities. The basic idea is to decompose each registered image into sub-images using forward wavelet transform which have same resolution at same level and different resolution at different levels. Information fusion is performed based on the high frequency (detailed coefficients) sub-images and resulting image is obtained using inverse wavelet transform. The proposed scheme uses two criterions namely the gradient and smoothness measure which we discuss first.

The Gradient Criterion

Given a gray image *I(x, y)*, the gradient at any pixellocation (x, y) is obtained by applying twodimensional direction derivative.

$$\nabla I(x,y) = \begin{bmatrix} Gx \\ Gy \end{bmatrix} = \begin{bmatrix} \frac{\partial I(x,y)}{\partial x} \\ \frac{\partial I(x,y)}{\partial y} \end{bmatrix} \quad (1)$$

The gradient magnitude and two fast decreasing approximations can be obtained by using equation,

$$G = |\nabla I(x,y)| = \sqrt{Gx^2 + Gy^2} = |Gx| + |Gy| \quad (2)$$

The Relative Smoothness Criterion

The second criterion of relative smoothness uses the statistical moments of gray-level histogram of the region in the neighborhood of the pixel (x, y). Let z be the random variable denoting gray levels and p (zi), i=1, 2…L-1, be thecorresponding histogram of the region in the neighborhood ofpixel (x, y), where L is the number of distinct gray levels. Thesecond moment or variance of z about mean is given by,where m is the mean gray level of z given by below term,

$$\sigma^2(z) = \sum_{i=0}^{L-1}(z_i - m)^2\, p(Z_i) \qquad (3)$$

$$m = \sum_{i=0}^{L-1} Z_i\, p(Z_i)$$

The measure for relative smoothness in the neighborhood ofpixel (x, y) [11] can be thus established as,

$$R(x,y) = 1 - \frac{1}{1+\sigma^2(z)} \qquad (4)$$

The measure R(x, y) nears zero in neighborhoods of constant intensity and approaches one for large variances.

Image Fusion

Image fusion involves two or more images to attain the most useful features for some specific applications. For Instance, doctors can annually combine the CT and MRI medical images of a patient with a tumor to make a more accurate diagnosis. Medical fusion image is to combine functional image and anatomical image together into one image. The resultant image can provide abundance information to doctor to diagnose clinical disease. The information obtained will influence the treatment a patient will receive. Perhaps the most widely used clinical diagnostic and research technique is MRI.

Image Reconstruction

Using the inverse wavelet transform, and fused high and low frequency components we reconstruct the image. This reconstructed image has information integrated from all the different images sources. This scheme shows thehigh frequency image fusion between *n* images under thecombined gradient and relative smoothness criterion.
Performance parameters areof two types: with reference image and without reference image.

IV. IMAGE FUSION ALGORITHMS

Simple Average method

The value of the pixel of each image is taken and added. This sum is then divided by 2 to obtain the average. The average value is assigned to the corresponding pixel of the output image. The pixels in the resultant fused image are obtained by taking average of the every corresponding pixel in the input images.

Maximum selection method

For every corresponding pixel in the input images, the pixel with the Maximum intensity is selected. The resultant pixel is used to obtain a fused image. Resulting in highly focused image output obtained from the input image as compared to average method.

Minimum selection method

For every corresponding pixel in the input images, the pixel with the Minimum intensity is selected. The resultant pixel is used to obtain a fused image. Images with dark shades would generate a good fusion image with this method.

Principal Component Analysis

Principal component analysis (PCA) is a vector space transform often used to reduce multidimensional data sets to lower dimensions for analysis. PCA algorithm involves the following steps for fusion.

1. Generate the column vectors, from the input image matrices.
2. Calculate the covariance matrix of the two column vectors formed in 1
3. The diagonal elements of the 2x2 covariance vector should contain the variance of each column vector with itself.
4. Calculate the Eigen values and the Eigen vectors of the covariance matrix
5. Normalize the column vector corresponding to the larger Eigen value by dividing each element with mean of the Eigen vector.
6. The values of the normalized Eigen vector act as the weight values which are respectively multiplied with each pixel of the input images.
7. Sum of the two scaled matrices calculated in step 6 will be the fused image matrix.

V. PERFORMANCEMETRICS

Image fusion performance can be divided into two categories one with and one without reference images. In the present work, the performance measures are used to evaluate the performance of various fusion methods such as Simple average Method , Maximum Selection Method , Minimum Selection Method. MR and CT images are taken as the reference image in the calculation of performance metric values.

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.

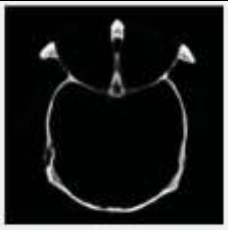
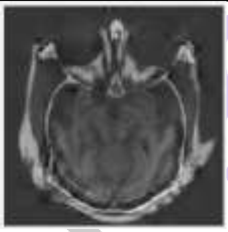
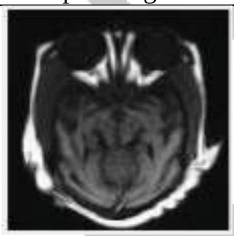
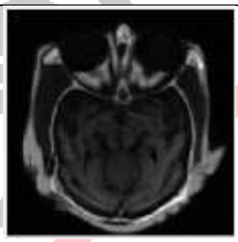
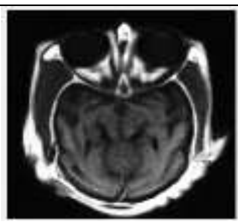
$$H = -\sum_{g=0}^{l-1} p(g) log_2 p(g) \qquad (5)$$

where p(g) parent image.

VI. EXPERIMENTAL RESULTS

Various multi-focus and multi-modal images have been considered for display of various results.

Table 1: Output for various fusion methods

INPUT IMAGES	COMPARATIVE STUDY OF HAAR WAVELET & PCA	VALUE OF ENTROPY
 Input image 1	 Maximum selection method	0.3143
 Input image 2	 Average selection method	0.011
	 Minimum selection method	1.9090
	 Principal Component Analysis	6.1422

 Input image 1	 Maximum selection method	0.5820
 Input image 2	 Average selection method	0.0402
	 Minimum selection method	0.1906
	 Principal Component Analysis	5.9565

VII. CONCLUSION

Image fusion seeks to combine information from different images. It integrates complementary information to give a bettervisual picture of a scenario, suitable for processing. Wavelet transform provide a framework in which an image is decomposed, with each level corresponding to a coarser resolution band. The wavelet sharpened images have a very good spectral quality. Thus the two different modality images are fused using the various fusion rules based on the Discrete Wavelet Transform. Moreover the difference in performance of the various fusion methods is clearly exhibited using three performance measures.

VIII. FUTURE WORK

Image registration has significant contribution towards the enhancement of image fusion quality. Image registration has not been incorporated in this research work. By the implementation of the suitable image registration techniques, the competitiveness of the proposed image fusion methods can be properly justified with some more set of sample test/perfect images. This proposed work fusion is done during the construction of modified coefficients and can be extended for fusion of ‘n’ images. The hardware implementation of this project can be done using Spartan 6 FPGA kit, DBR4, Nexus Hetric board etc.

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