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Image Fusion to Enhance the Disease Diagnosis

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Abstract: *Medical image fusion is a technique in which useful information from two or more recorded medical images is integrated into a new image to offer as much details as possible for diagnosis. In medical field the fusion of different modality images is done by integrating the DWT & PCA method as it gives the more effective and reliable data without much loss. The decomposed coefficients of Discrete Wavelet Transformation (DWT) are applied with the Principal Component Analysis (PCA) to get fused image information. Choose decomposed coefficients by fusion rule and using inverse DWT to get the fussed image of two modalities images. The parameter analysis like RMSE, entropy, structural content, standard deviation and PSNR analysis shows better improvement on results.*
Keywords: *Image fusion, DWT, PCA, DSP Processor*

I. Introduction

Medical image fusion is the process of registering and combining multiple images from single or multiple imaging modalities to improve the imaging quality and reduce randomness and redundancy in order to increase the clinical applicability of medical images for diagnosis and assessment of medical problems. Multi-modal medical image fusion algorithms and devices have shown notable achievements in improving clinical accuracy of decisions based on medical images.

If we focus on cancer disease, because the cancer is considered to be the most dreadful and harmful disease amongst all. In today's world the easy detection of any dreadful disease can be difference between life and death. In radiology CT gives the information about hard tissues and MRI provides subjective information on soft tissues. These both provide characteristics of an organ to be diagnosed. So in order to enhance these characteristics of same organ fusion process of CT and MRI is adopted. Image fusion is the process to combine multimodality images through image processing technique.[1][3]

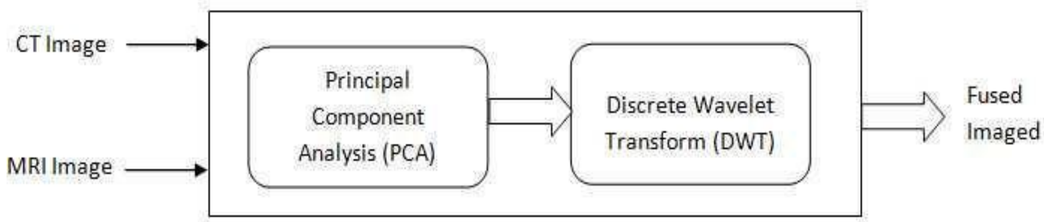

Figure1. Fusion process for cancer detection

II. Fusion Process

1. Image Fusion – The fusion process includes the two fusion algorithms namely PrincipalComponent Analysis and Discrete Wavelet Transform as explained below,

1.1 Discrete Wavelet Transform (DWT) -Discrete Wavelet Transform (DWT) is a mathematical tool forhierarchically decomposing an image. With strong spatial support, the DWT provides a compact representation of a signal's frequency component. DWT decomposes a image into frequency sub-band at different scale from which it can be perfectly reconstructed. The signal into high and low frequency parts is split by the DWT. The low frequency part contains coarse information of signal whereas high frequency part contains information about the edge components. Two dimensional Discrete Wavelet Transform implements image fusion. The resolution of an image, which is a evaluate amount of detail information in the image, is changed by filtering operations of wavelet transform. And the scale is changed by sampling. The DWT analyses the image at different frequency bands with different resolutions by decomposing the image into approximation and detail coefficient. Fusion of any image is implemented by two dimensional discrete wavelet transform. The resolution of an image, which is a measure of amount of detail information in the image, is changed by filtering operations of wavelet transform and the scale is changed by sampling of image. At different frequency bands the DWT analyses the image with different resolutions by decomposing the image into coarse approximation and detail coefficients. Following figure shows the fusion by discrete wavelet transform algorithm.[2][4]

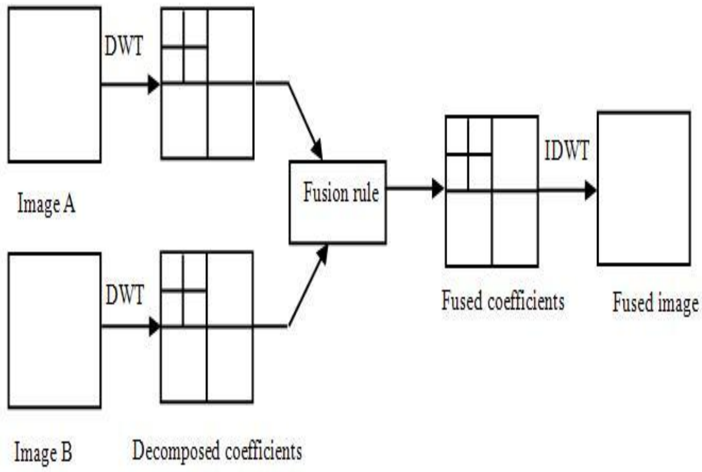

Fig.2. Flow diagram of the wavelet based image fusion.

a. **Principle Component Analysis**

The PCA involves a mathematical procedure that transforms a number of correlated variables into a number of uncorrelated variables. It computes a compact and optimal description of the data set. First principal component is taken to be along the direction with the maximum variance. The second principal component is constrained to lie in the subspace perpendicular of the first. This component points the direction of maximum variance within this subspace. The third principal component is taken in the maximum variance direction in the subspace perpendicular to the first two and so on. The PCA is also called as Karhunen-Loève transform or the Hotelling transform.

The PCA does not have a fixed set of basis vectors like FFT, DCT and wavelet etc. Its basis vectors depend on the data set. PCA is also a linear transformation that is easy to be implemented for applications in which huge amount of data is to be analyzed. PCA is widely used in data compression and pattern matching by expressing the data in a way to highlight the similarities and differences without much loss of information.

The information flow diagram of PCA-based image fusion algorithm is shown in Fig. 3. The input images (images to be fused) $I1(,)$ and $I\,2(,)$ are arranged in two column vectors and their empirical means are subtracted. The resulting vector has a dimension of nx2, where n is length of the each image vector. The eigenvector and eigenvalues for this resulting vector are computed and the eigenvectors corresponding to the larger eigenvalue achieved. The normalized components P1 and P2 (i.e., P1 + P2 = 1) are computed from the obtained eigenvector. The fused image is given by,[4]

$$I_f(\, , \,) = P1I1\,(\, , \,) + P2I2\,(\, , \,) \quad (1)$$

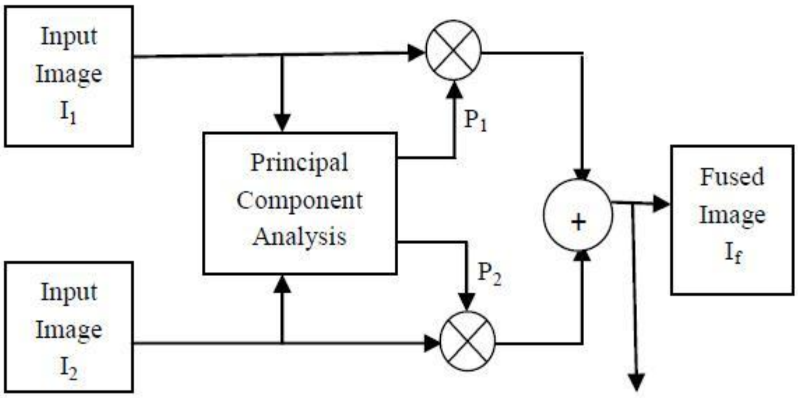

Figure 3: Image Fusion by PCA

III. Parameter Analysis

Parameter analysis is method of capturing visual content of images for indexing as well as retrieval. Parameter analysis is used to denote a piece of information that is relevant for solving the computational task related to certain application system. After segmentation, set of features are required for each image. In this stage every image is assigned a feature vector which is used to identify it & to distinguish the image. The extracted features act as the basis for classification process. These features are used to develop diagnostic rules to detect cancer nodule.

The parameters like mean squarer error, peak signal to noise ratio, structural content, standard deviation and entropy are useful to enhance the classification and to improve the diagnostic process for the physician,[7]

a. Root Mean Square Error

It is computed as the root mean square error (RMSE) of the corresponding pixels in the reference image *Ir* and the fused image *If* . It will be nearly zero when the reference and fused images are alike and it will increase when the dissimilarity increases.

√ —∑ ∑))) (2)

b. Peak Signal to Noise Ratio

For evaluating the performance of any fusion system peak signal to noise ratio is common measure parameter. Higher the value of PSNR indicates better the output. It is expressed in dB and can be given as bellow

PSNR = $20\log_{10}$ ∑ ∑))) (3)

Where, *L* in the number of gray levels in the image. This value will be high when the fused and reference images are alike and higher value implies better fusion.

c. Standard Deviation (SD)

Standard deviation is composed of the signal and noise parts. This metric is more efficient in the absence of noise. It measures the contrast in the fused image. Fused image with high contrast would have a high standard deviation.

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d. Structural Content (SC)

Structural content preserves the similar pixels in the image and shows that how much similar the new image from source image. This can be formulated as,

$$SC = \frac{\sum_{i=1}^{M}\sum_{j=1}^{N}(\,Y(i,j))^2}{\sum_{i=1}^{M}\sum_{j=1}^{N}(\,X(i,j))^2}$$

e. Entropy

The entropy of any image can be calculated as below,

∑

e.

IV. Experimental Results

The data to be analyzed consist of set of brain images where each data set contains one CT scanned image and one MR image. In this way five data sets will undergo PCA and DWT based image fusion process. In this paper we have five parameters to diagnose the disease. These parameters are shown below in table 1

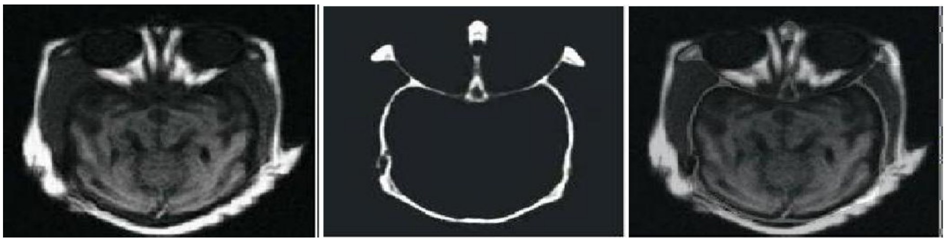

Figure 4: original MRI Image (a), original CT Image (b), Fused Image by PCA with DWT method (c).

Table 1: Parameter Analysis

	CT Image	MRI Image	Fused Image
MSE	682.54	531.73	797.83
PSNR	19.82	20.91	20.65
Structural Content	0.91	0.95	2.13
Standard Deviation	53.42	54.24	54.93
Entropy	1.11	1.10	1.42

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V. Conclusion

The experimental results show that the principle component analysis with discrete wavelet transform (PCA with DWT) is a powerful method for the fusion of medical images. Hence, to diagnose the human diseases such as brain cancer earlier & to provide appropriate treatments, the presented system is used. They help the physician as well as the radiologist to identify the suspicious nodules of disease hence the system mentioned above increases the sensitivity, specificity, accuracy & efficiency of the diagnosis.

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