AN IMPLEMENTATION AND COMPARATIVE ANALYSIS OF FUSION TECHNIQUES ON MEDICAL IMAGES

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***ABSTRACT* - Image fusion is the technique of merging several images from multi-modal sources with respective complementary information to form a new image, which carries all the common as well as complementary features of individual images. With the recent rapid developments in the domain of imaging technologies, multisensory systems have become a reality in wide fields such as remote sensing, medical imaging, machine vision and the military applications. Image fusion provides an effective way of reducing this increasing volume of information by extracting all the useful information from the source images. Image fusion creates new images that are more suitable for the purposes of human/machine perception, and for further image-processing tasks such as segmentation, object detection or target recognition in applications such as remote sensing and medical imaging. The overall objective is to improve the results by combining DWT with PCA and non-linear enhancement. The proposed algorithm is designed and implemented in MATLAB using image processing toolbox. The comparison has shown that the proposed algorithm provides a significant improvement over the existing fusion techniques.**

Keywords* - *Image Fusion, MRI Image, CT Image, Discrete Wavelet Transform (DWT), Principal Component Analysis (PCA).

I. INTRODUCTION

Image fusion algorithms can be categorized into different levels: low, middle, and high; or pixel, feature, and symbolic levels. The pixel-level method works either in the spatial domain or in the transform domain. The prerequisite for such an operation is that the images have been acquired by homogeneous sensors, such that the images reproduce similar or comparable physical properties of the scene. The fusion methods, such as averaging, the Brovey method [11], principle component analysis (PCA) [7], and IHS [13]based methods fall under the spatial domain approaches. The feature-level algorithms typically segment the image into contiguous regions and fuse the regions together using their properties. The features used may be calculated separately from each image or they may be obtained by the simultaneous processing of all the images. Information is used in many forms to solve problems and monitor conditions. When multiple source information is combined, it is essentially used to derive or infer more reliable information. However, there is usually a point of diminishing returns after which more information provides little improvement in the final result. Which information and how to combine it is an area of research called data fusion. In many cases, the problem is ill defined when data is collected. More information is gathered in hopes of better understanding the problem, ultimately arriving at a solution. Large amounts of information are hard to organize, evaluate, and utilize. Less information giving the same or a better answer is desirable. Data fusion [8][10] attempts to combine data such that more information can be derived from the combined sources than from the separate sources. Data fusion techniques combine data and related information from associated databases, to achieve improved accuracies and more specific inferences.

In the recent years, the study of multimodality medical image fusion attracts much attention with the increasing of clinic application demanding. Radiotherapy plan, for instance, often benefits from the complementary information in images of different modalities. Dose calculation is based on the computed tomography (CT) data, while tumor outlining is often better performed in the corresponding magnetic resonance (MR) scan. For medical diagnosis, CT provides the best information on denser tissue with less distortion, MRI provides better information on soft tissue with more distortion the idea of combining images from different modalities becomes very important and medical image fusion has merged as a new and promising research field.

In this paper we presented method using pixel level and used a data set of two modalities CT/MRI images [11] to fuse to get salient and redundant information by using the DWT [3] & PCA techniques then comparing the two methods with analytical values and qualitative matrices. The fusion of multiple measurements can reduce noise and therefore eliminates their individual limitations. It is required that the fused image should preserve as closely as possible all relevant information obtained in the input images and the fusion process should not introduce any artifacts or inconsistencies, which can distract or mislead the medical professional, thereby a wrong diagnosis.

II. RELATED WORK

Image Fusion is used extensively in image processing systems. Various Image Fusion methods have been proposed in the literature to reduce blurring effects. Many of these methods are based on the post-processing idea. In other words, Image fusion enhances the quality of image by removing the noise and the blurriness of the image. Image fusion takes place at three different levels i.e. pixel, feature and decision. Its methods can be broadly classified into two that is special domain fusion and transform domain fusion. Averaging, Brovery method, Principal Component Analysis (PCA) [4] [7], based methods are special domain methods. But special domain methods produce special distortion in the fused image .This problem can be solved by transform domain approach. The multi-resolution analysis has become a very useful tool for analyzing images. A brief summary of the literature is given below:

Patil, U et al. (2011) [9] has focused on image fusion algorithm using hierarchical PCA. Authors described that the Image fusion is a process of combining two or more images (which are registered) of the same scene to get the more informative image. Hierarchical multiscale and multiresolution image processing techniques, pyramid decomposition are the basis for the majority of image fusion algorithms. Principal component analysis (PCA) is a well-known scheme for feature extraction and dimension reduction and is used for image fusion. We propose image fusion algorithm by combining pyramid and PCA techniques and carryout the quality analysis of proposed fusion algorithm without reference image.

We Qiang Wang et al. (2004) [14] has discussed that the Image fusion is becoming one of the hottest techniques in image processing. Many image fusion methods have been developed in a number of applications. They mainly discuss the structures of image fusion process, which is classified as hierarchical fusion structure, over-all fusion structure, and arbitrary fusion structure. And the effects of such image fusion structures on the performances of image fusion are analyzed. In the experiment, authors explained the typical hyper spectral image data set is fused using the same wavelet transform based image fusion technique, but applying different fusion structures. The differences among their fused images are analyzed. The experimental results testify the theoretical analysis that the performances of image fusion techniques are related not only to the fusion algorithm, but also to the fusion structures, and different image fusion structures that produces different fusion performance even using the same image fusion method.

Prakash, C et al. (2012) [11] explained that the Image fusion is basically a process where multiple images (more than one) are combined to form a single resultant fused image. This fused image is more productive as compared to its original input images. The fusion technique in medical images is useful for resourceful disease diagnosis purpose. This paper illustrates different multimodality medical image fusion techniques and their results assessed with various quantitative metrics. Firstly two registered images CT (anatomical information) and MRIT2 (functional information) are taken as input. Then the fusion techniques are applied onto the input images such as Mamdani type minimum-sum-mean of maximum (MIN-SUM-MOM) and Redundancy Discrete Wavelet Transform (RDWT) and the resultant fused image is analyzed with quantitative metrics namely Over all Cross Entropy(OCE),Peak Signal –to- Noise Ratio (PSNR), Signal to Noise Ratio(SNR), Structural Similarity Index(SSIM), Mutual Information(MI). From the derived results it is inferred that Mamdani type MIN-SUMMOM is more productive than RDWT and also the proposed fusion techniques provide more information compared to the input images as justified by all the metrics.

III. FUSION TECHNIQUES

A. Discrete Wavelet Transform (DWT)

A Discrete Wavelet Transform (DWT) [9] is any wavelet transform for which the wavelets are discretely sampled. The first DWT was invented by the Hungarian mathematician Alfréd Haar. For an input represented by a list of 2n numbers, the Haar wavelet transform may be considered to simply pair up input values, storing the difference and passing the sum. This process is repeated recursively, pairing up the sums to provide the next scale: finally resulting in 2n − 1 differences and one final sum.

The Steps of DWT Algorithm [6] [3]are shown below:

Step 1: The image A and Image B are resized and aligned together i.e. registered image A and B.

Step 2: The reg image A and B are decomposed by applying DWT i.e. {LL1,LH1,HL1,HH1} = DWT{reg image A}and {LL2,LH2,HL2,HH2}= DWT{reg image B}.

Step 3: The outputs of 2nd step LL1, LH1, HL1, HH1 and LL2, LH2, HL2, HH2 of reg-image A and B respectively. These output coefficients are combined by choosing maximum selection of detailed coefficients and averaging ,the approximated coefficients of both images.

Step 4: Applying IDWT [4] to previous step output coefficients of approximated and detailed, to obtain the reconstructed image.

Step 5: Finally, the fused image F and reference image A is taken to obtain a performance analysis is done.

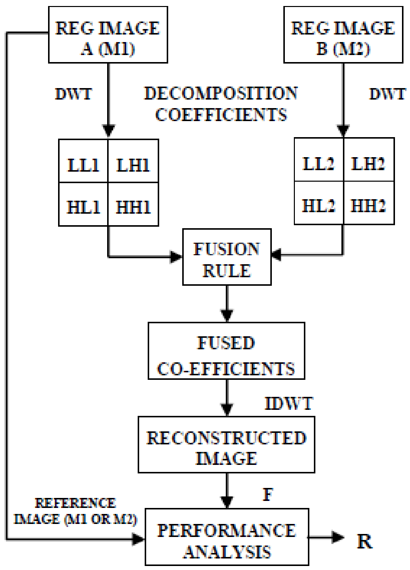

Fig 1: Flowchart of DWT Algorithm

B. Principal Component Analysis (PCA)

Principal component analysis (PCA) is a vector space transform often used to reduce multidimensional data sets to lower dimensions for analysis. PCA is the simplest and most useful of the true eigenvector-based multivariate analyses, because its operation is to reveal the internal structure of data in an unbiased way. If a multivariate dataset is visualized as a set of coordinates in a high-dimensional data space (1 axis per variable), PCA [12][5][14]supplies the user with a 2D picture, a shadow of this object when viewed from its most informative viewpoint. This dimensionally-reduced image of the data is the ordination diagram of the 1st two principal axes of the data, which when combined with metadata (such as gender, location etc) can rapidly reveal the main factors underlying the structure of data. PCA is especially useful for taming collinear data; where multiple variables are co-correlated (which is routine in multivariate data) regression based techniques are unreliable and can give misleading outputs, whereas PCA will combine all collinear data into a small number of independent (orthogonal) axes, which can then safely be used for further analyses.

Let images f1(m, n), f2(m, n) are A and B, of size m * n matrix, the steps for PCA is explained

Step 1: Arrange matrices A & B in column matrix of size 2 * n

Step 2: M => {mean of each columns} 1 * 2

Step 3: Va (variance) => subtract M from each columns of A & B

Step 4: Obtain, C => covariance (Va)

Step 5: Calculate eigen vector "V" and eigen value Lambda.

Step 6: Arranging V"s by decreasing order according to values of Lambda.

Step 7: Find principal component values P1 and P2 of A, B reptdly.. P1 = V1/sum(V), P2 = V2/sum(V)

Step 8: Find principal component values P1 and P2 of A, B reptdly.. P1 = V1/sum(V), P2 = V2/sum(V)

Step 9: Obtain fused image, I = (P1) * (f1) + (P2) * (f2)

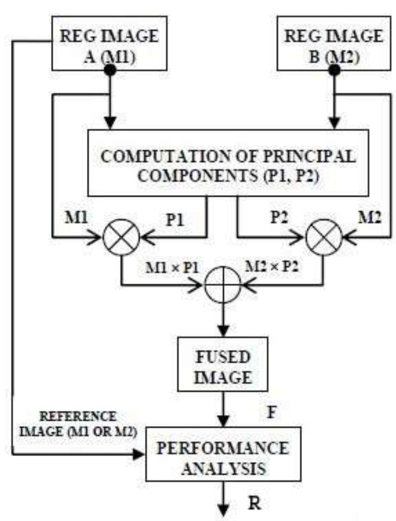

Fig 2: Flowchart of PCA Algorithm

IV. PROPOSED IMAGE FUSION METHOD

A. Combined PCA and DWT

The image fusion methods using discrete Wavelet transform (DWT) are considered to be more appropriate and time-saving in real-time systems. An efficient method for multi-focus images fusion is proposed. The proposed algorithm will integrate PCA [1][9][13]and DWT to achieve the fusion process. In order to enhance the results histogram equalization on the output image is used. The overall objective is to improve the visibility of fused images. The following figure shows the flowchart of proposed algorithm.

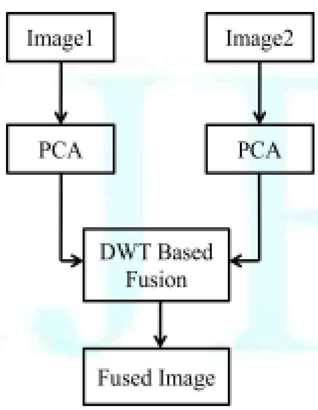

Fig 3: Flowchart of Proposed Algorithm

The proposed algorithm includes the following steps:

Step 1: First of all two images which are passed to the system.

Step 2: Apply RGB2PCA to convert given image in PCA plane.

Step 3: Now differentiate PCA of image1 and image2 into their 3 planes as image is assumed to be in RGB.

Step 4: For PCA (1) of image 1 and image 2 will be passed for fusion using DWT and PCA (2) & PCA (3) of image 1 and image 2 will determine new components by taking their averages respectively.

Step 5: Now concatenation of each output of step 4 will be done.

Step 6: Now PCA2RGB will be applied to get original fused image.

V. RESULTS AND DISCUSSION

Results using all algorithms are displayed below. From the experimental results as shown in Table 1 it can be observed that the values of Peak signal to noise Ratio, of the fused image generated by our algorithm are greater than values for the fused image generated by the other fusion algorithm.

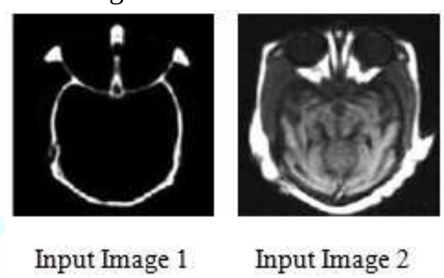

Fig 4: Input Image1 and input Image2 represents the CT and MRI images of Brain of same person respectively.

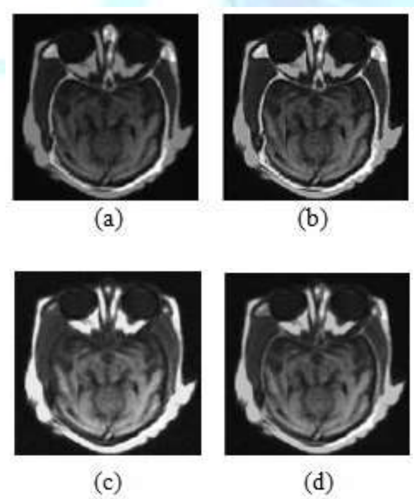

Fig 5: Fused Image Using Various Image Fusion Methods (a) Discrete 1st Level (b) Discrete 2nd Level (c) PCA (d) PCA+DWT

Table 1: The Fusion Methods Performance Measures

Parameters	PSNR	MSE	AD	MD	NAE	NCC	SC
Discrete 1st Level	18.4361	6994.59	46.9574	254	0.999684	0.0064	7090.01
Discrete 2nd Level	17.7983	6995.41	46.9743	254	0.999899	0.00633727	7212.93
PCA	23.5883	6994.59	46.9573	254	0.999684	0.00640004	7089.5
PCA + DWT	28.9649	6995.79	48.1573	254	0.999684	0.00640004	7090.7

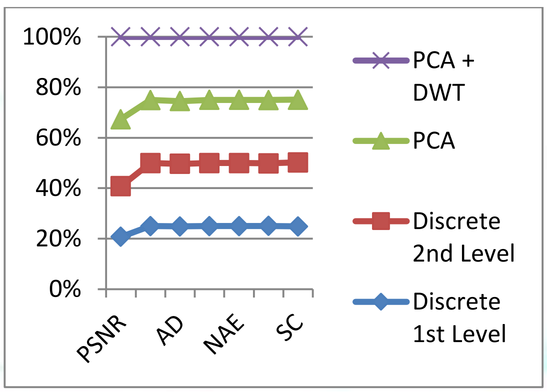

Fig 6: Graphical Representation of various Evaluation Parameters

VI. CONCLUSION

The fusion methods based on large decomposition levels are sensitive to noise, also it consumes more time as well as it requires more memory. And the spatial details cannot be captured well if the number of decomposition level is too small. The Wavelet transforms is the very good technique for the image fusion provide a high quality spectral content. But a good fused image have both quality so the combination of DWT & spatial domain fusion method (like PCA) fusion algorithm improves the performance as compared to use of individual DWT and PCA algorithm. In this paper, a method of image fusion is proposed. It is based on the use of Discrete Wavelet Transform and Principal Component Analysis. By surveying all the techniques with its parameters it is concluded that proposed method appears as an improvement over the respective existing methods.

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