MULTI-MODALITY IMAGE FUSION OF PET/CT BY INTEGRATING METHODS, DWT-PCA

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Abstract It this paper given a views of the fusion of different modality images i.e. PET and CT (Positron Emission Tomography & Computed Tomography) by integrating the DWT & PCA methods. The decomposed coefficients of DWT(discrete wavelet transformation) are applied with the PCA(principal component analysis) to get fused image information. Before that ,choose a detailed part of decomposed coefficients by maximum selection and averaging the approximated part of DWT coefficients and applying the PCA after to reconstruct using inverse DWT to get the fussed image of two modalities CT & PET. So that add more information of both anatomic ,physiological and metabolic information in one image, helps in improvement of perception of physician in diagnosis of patients in medical field. The MSE, PSNR,ENTROPY analysis shows better improvement on results.

Key words: CT, DWT, ENTROPY, MSE, MODALITY , PCA, PET , PSNR.

I. INTRODUCTION

'Health is wealth', to the line every species wants healthy hence medical field become a hot spot in experiments research. From ancient to the modern medicine ,day by day the trends of medical procedures changing with trends with modern technology also according with human health. Now days there is a shift of human interest towards pre-clinical procedures than operations. Preclinical procedure by means of imaging the body through the some sensors and detectors using some physical phenomena and human friendly E-M spectrum ranges, these are called modalities. There are two types of modality 1. Anatomic, 2. Physiological and metabolic. Former gives the information about structures like bones(high density part), while other gives functional details of cell activity of organs. Some are like X-ray, MRI, CT, ECG, PET, SPECT, fMRI etc…

The main aim of Image fusion (IF) is gathering complementary, as well as silent redundant information from multiple images to create a fused image, to providing more complete and accurate description. In the area of medical imaging, integration of different modality images of same scene gives so many advantages it may be fusion of image taken at different resolution, intensity and by different techniques helps physician / Radiologists to easily extract or identify the features or abnormalities that may not be normally visible in single image. Another advantage of image fusion is that it reduces the storage cost by storing only the single fused image, instead of the different modality images.

Image registration [7] [9] [10] is a vital problem in medical imaging before a fusion, in clinical diagnosis using medical images; integration of useful data obtained from separate images is often desired. The images need to be aligned geometrically with respect to reference image for better observation .

The image fusion hierarchical levels are, [6] pixel, feature, and decision. There are some methods according to the data contains the fusion & according to purpose are multi-view, multi-modal ,multi-focus. And different techniques are used for image fusion through the evolution on this many approaches are used they are of Spatial-domain like IHS, PCA, averaging, brovey transformation etc... And other type is Transformation-domain are like pyramid, wavelet, curvelet transformation...etc

In this paper we presented method using pixel level and used a data set of two modalities CT/PET images to fuse to get a salient and redundant information of both in one image by integrating the DWT & PCA [1] [2] [3] [10] [11][12] techniques to form a new hybrid algorithm.

This paper is organized as section (2) explains the DWT. In section (3),PCA dealt. Section(4) involves the proposed algorithm steps. In section (5) , presents a experimental results. At last section (6), conclusion about the proposed method paper.

II. DISCRET WAVELET TRASFORM

The term 'wavelet' as it implies means a little wave, that has short period and fast decay to zero, in both positive and negative direction of its amplitude. The wavelet can be described by using two functions ,the scaling function ϕ(t), known as 'father wavelet' [1] [4]. The wavelet function Ψ(t) or 'mother wavelet'. Combining this obtains a daughter wavelet. The advantage is, it has time-frequency property, over DFT (Frequency transformation) where only get information of frequency at that time but, vise-versa is not true. So DWT gives time for that frequency . scaling ,frequency property and also it helps in dealing with multi-resolution images so to get different frequency coefficients after decomposing.

The filter bank (convolution) [2] [10] [11] [12] concept is used to explain DWT. There are two processing part initially, Analysis and second part is reconstruction. This is similar to modulation and demodulation in communication. In analysis process, the image f(x ,y) is decomposed into four different frequency coefficients i.e. approximated(LL), detailed (LH, HL, HH) as shown in figure 1., at every iteration the rows of input matrix f(x ,y) is high-passed and low-passed i.e. convolution

$$Z1(x,f) = f(x,y) \otimes H1(x,y)$$

$$Z2(x,f) = f(x,y) \otimes G1(x,y)$$

$$A4(X,Y) = Z1(x,y) \otimes H1(x,y)$$

$$A3(X,Y) = Z1(x,y) \otimes G1(x,y)$$

$$A2(X,Y) = Z2(x,y) \otimes H1(x,y)$$

$$A1(X,Y) = Z2(x,y) \otimes G1(x,y)$$

Where H1, G1, A1 ,A2, A3, A4 are HPF, LPF, LL, LH, HL, HH coefficients respectively. And these are decimated by 2 so that no. of samples is reduced to half at both end output. The outputs are again iterated taking columns and convolved with H1, G1 to obtain decomposed coefficients like detailed (HH^1, HL^1, LH^1) and approximated (LL^1) at every iteration.

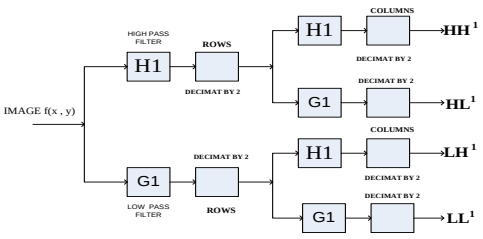


Figure 1. DWT analysis part.

Similarly, reconstruction process, using the reconstructing filters H2,G2 are reHPF, reLPF respectively. Initially detailed and approximated coefficients of columns are up-sampled by 2 and convolved with H2,G2. Then outputted of both end are summed and same method repeated once using rows are up sampled by 2 and convolved to get a reconstructed image f'(x y). As shown in figure 2.,

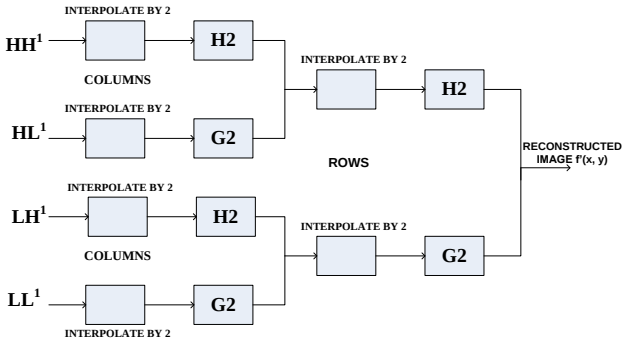


Figure 2. DWT reconstruction part.

III. PRINCIPAL COMPONENT ANAYSIS

Principal component analysis[2][3][10][11][12] is a statistical analysis for dimension reduction. It basically projects data from its original space to its eigen space to increase the variance and reduce the covariance by retaining the components corresponding to the largest eigen values and discarding other components. Principal components are guaranteed to be independent if only if the data set is jointly distributed. It is sensitive to the relative scaling of the original variables. It is also known as discrete Karhunen–loève transform (KLT), the Hotelling transform or proper orthogonal decomposition, depending on the field of application,. PCA helps to reduce redundant information and highlight the components with biggest influence so as to increase the signal-to-noise ratio.

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.

A. PCA image fusion algorithm

Let images f1(m,n), f2(m,n) be A and B of size m x n matrix, the steps for PCA are:

- The matrix A and B is arranged in column matrix of size 2 x n.
- Calculate mean of each column. Let assign as matrix M of 1 x 2.
- Subtract matrix vector M from each columns of matrix A i.e. variance ,Va is of 2 x n.
- Obtain the covariance matrix C of Va.
- Find the eigen vectors V and eigen values λ of C

- Sorting the values of V by decreasing order, according to λ values.
- Choosing first column of V which corresponding to larger eigen value to compute weighted values of image A and B are P1 and P2 as , $P1 = \frac{V1}{\sum V}$ and $P2 = \frac{V2}{\sum V}$
- Then fused image is obtained by

$$Ifus = P1 * f1 + P2 * f$$

The following diagram shows fusion of PCA method figure 3.,

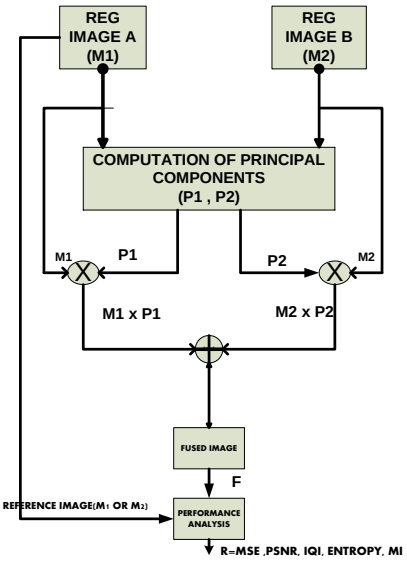


Figure 3. PCA image fusion Diagram.

IV. THE PROPOSED METHOD (DWT-PCA)

He proposed method of image fusion of two modality images i.e. CT and PET. Consider image A as CT and image B as PET ,the following steps are the proposed methods, as shown in figure 4.,

- ❑ The image A and Image B are resized and aligned together i.e. registered image A and B.
- ❑ The reg image A and B are decomposed by applying DWT i.e. $\{LL^1, LH^1, HL^1, HH^1\}$= DWT {reg image A} and $\{LL^2, LH^2, HL^2, HH^2\}$= DWT {reg image B}.
- ❑ Now , using each coefficients of reg image A and B and applying PCA by taking respective coefficients.
- ❑ The outputs of 3ed step LLp^1, LHp^1, HLp^1, HHp^1 and LLp^2, LHp^2, HLp^2, HHp^2 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.
- ❑ Applying IDWT to previous step output coefficients of approximated and detailes, to obtain the reconstructed image .
- ❑ Finally, the fused image F and reference image A is taken to obtain a performance analysis is done.

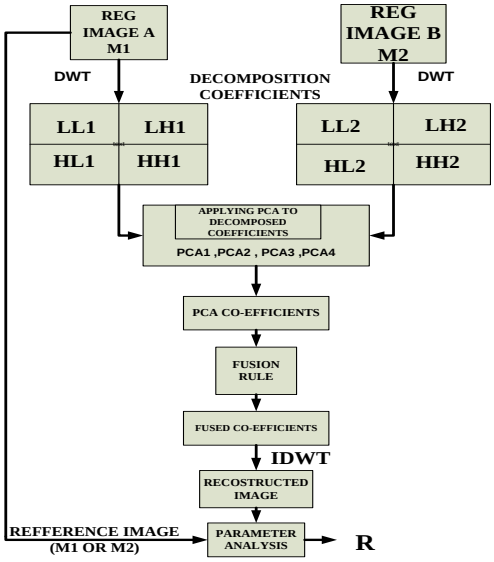


Figure 4. The proposed method block diagram.

V. RESULTS

The CT and PET images are fused by proposed method i.e. hybrid of DWT and PCA methods. The implementation of this project is done using platform of MatLab. The GUI model of this project implementation is shown below in figure 5. The fused image F is analyzed with MSE,PSNR, entropy, the values of these over proposed method gives better results. In figure 6, shows CT image, figure 7 is of PET image ,figure 8 is PCA method's fused image, similarly figure is of DWT and the proposed method's fused image is in figure 9. The results are compared and given in Tables of graphs in that and respective graphs of quantitative matrices are given.

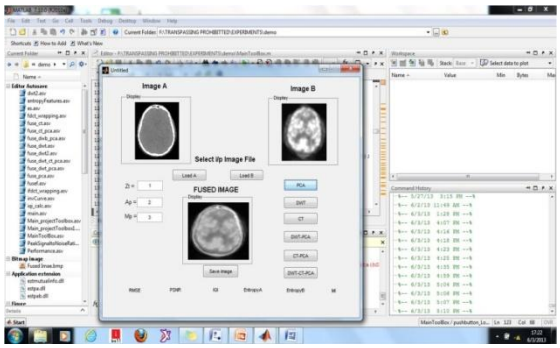


Figure. The GUI implementation of project.

Figure 7. CT image of brain

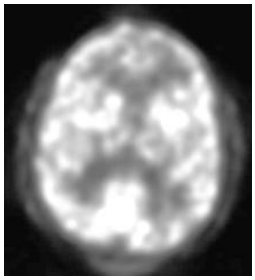


Figure 8.PET image of brain.

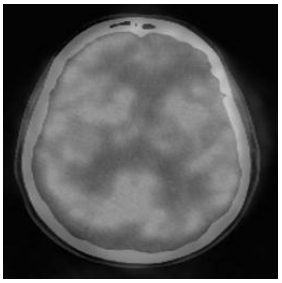


Figure 9 fused image ot PCA of DWT

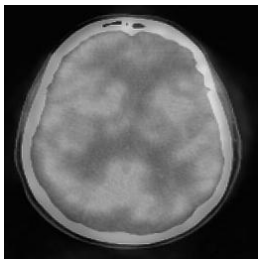


Figure 10. Fused image

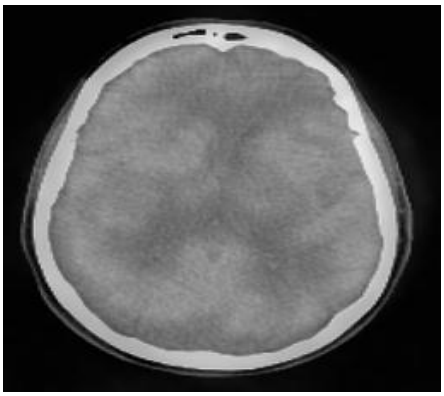
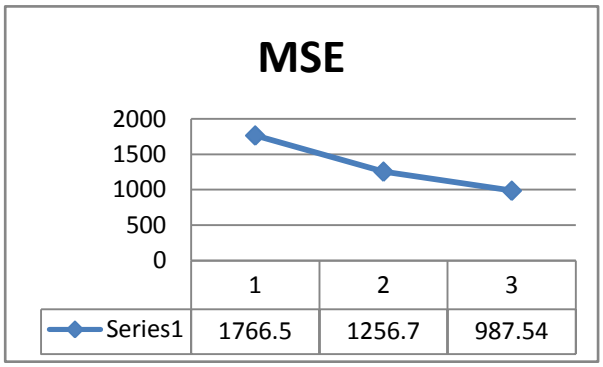
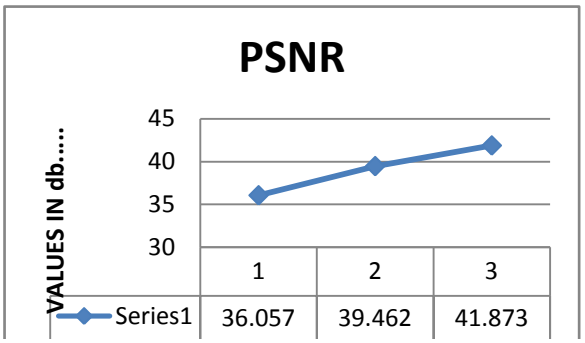
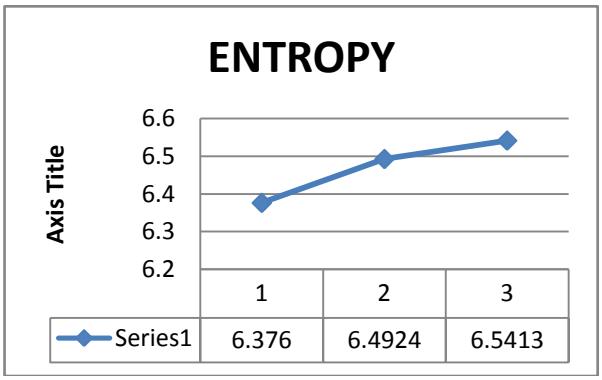


Figure 11. Fused image of proposed method







VI. CONCLUSION

The fusion of CT and PET of two modality images by proposed method DWT-PCA method , improves the perception of the images and adds information of both anatomical ,physiological information in one image . and also reduces the storage space less than of adding both images. By observing the numerical results and graphs of each methods and proposed method ,it is analyzed that there is better improvement of quantitative matrices like MSE, PSNR, and entropy. Hence the proposed method gives better results .

VII. REFFERENCES

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