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A MEDICAL MULTI-MODALITY IMAGE FUSION OF CT/PET WITH PCA, DWT METHODS

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Abstract

This paper gives a view on the fusion of different modality images like PET and CT (Positron Emission Tomography & Computed Tomography) by two domain methods PCA and DWT methods. The spatial domain is PCA method, and another transformation domain method (DWT). In dwt decomposed coefficients of DWT (discrete wavelet transformation) are applied with the IDWT 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. In applying the PCA using eigen values and eigen vector of larger values as principal components and after to reconstruct using addition to these to get the fussed image of two modalities CT & PET. So that adds complimentary features of both anatomic, physiological and metabolic information in one image, provides better visual information in single image of patients in medical field. The analytic parameters like, MSE, PSNR, ENTROPY results are better enough to prove the methods each other.

Key words:

Discrete Wavelet Transform (DWT), Mean Squared Error (MSE), Principal Component Analysis (PCA), Position Emission Tomography (PET), Peak Signal-to-Noise Ratio (PSNR)

1. INTRODUCTION

The preclinical imaging provides a set of powerful tools that hold the promise to facilitate this translation from basic science to improved patient diagnostics and therapeutics at a far greater pace and in vivo the concept of molecular imaging probes, their uses in preclinical and clinical imaging. To get full information regarding the body organs and tissues of human, there may be by invasive or non-invasive methods, in seconds there are different modalities of medical imaging techniques, and have their respective application ranges. For instance, structural images such as Magnetic Resonance Imaging (MRI), Computed Tomography (CT), Ultrasonography (USG) etc. Provide anatomical information with high-resolution images. On the other hand, functional images such as (PET), Single-Photon Emission Computed Tomography (SPECT), etc. Provide low-spatial resolution images with functional and metabolic activity information. Combining anatomical and functional medical images to provide much more useful information through image fusion has become the focus of imaging research and processing.

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 contain the fusion & according to purpose is 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 is 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 by using the DWT & PCA [1][2][3][10][11][12] techniques then comparing the two methods with analytical values and qualitative matrices like MSE, PSNR, entropy.

This paper is organized as section 2 explains the DWT. In section 3, PCA is dealt. Section 4 involves the proposed algorithm steps. Section 5 presents experimental results and section 6 gives conclusion.

2. DISCRET WAVELET TRANSFORM

Wavelet transformation has received considerable attention in the field of image processing due to its flexibility in representing non-stationary image signals and its ability in adapting to human visual characteristics. The term ‘wavelet’ as it implies means a little wave, which 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 *phi*(*t*), known as ‘father wavelet’ [1] [4] [14]. The wavelet function *psi*(*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, vice-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 Fig.1, at every iteration the rows of input matrix $f(x, y)$ is high-passed and low-passed i.e. convolution.

$$Z1(x, f) = f(x, y) \otimes H1(x, y) \quad (1)$$

$$Z2(x, f) = f(x, y) \otimes \mathrm{G}1(x, y) \quad (2)$$

$$A4(X, Y) = Z1(x, y) \otimes H1(x, y) \quad (3)$$

$$A3(X, Y) = Z1(x, y) \otimes G1(x, y) \quad (4)$$

$$A2(X, Y) = Z2(x, y) \otimes H1(x, y) \quad (5)$$

$$A1(X, Y) = Z2(x, y) \otimes G1(x, y) \quad (6)$$

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.

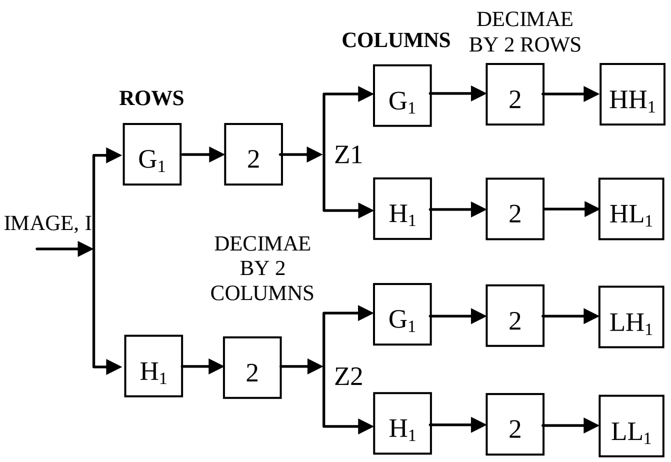


Fig.1. The DWT analysis part

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 Fig.2.

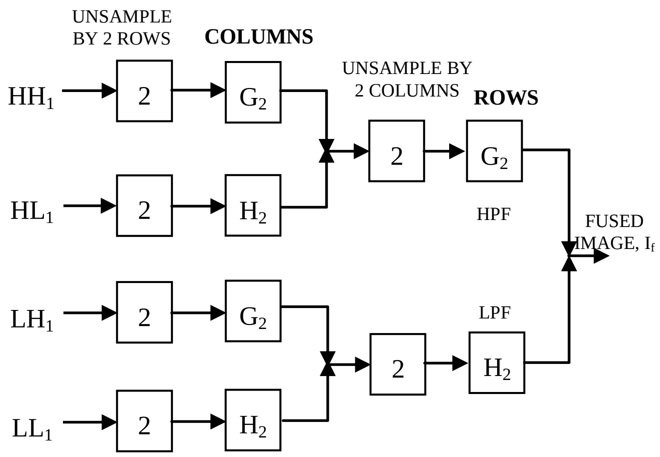


Fig.2. The DWT reconstruction part

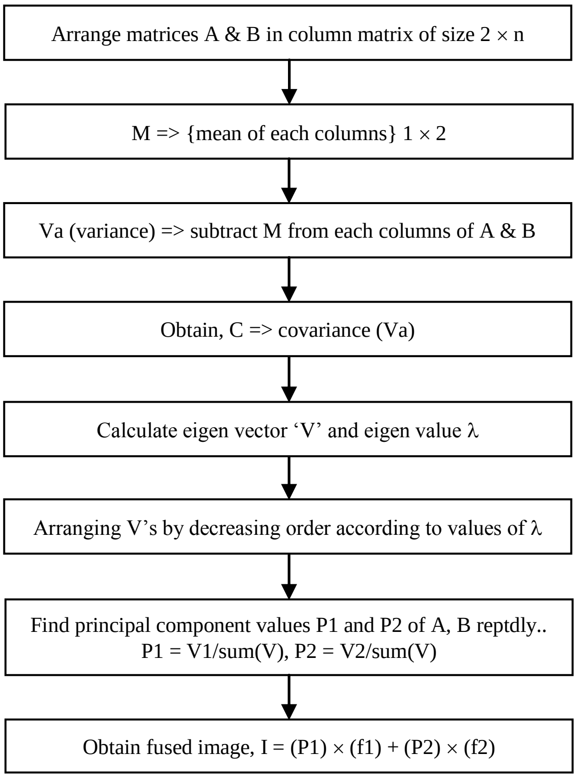
3. PRINCIPAL COMPONENT ANALYSIS

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 eigenspace to increase the variance and reduce the covariance by retaining the components corresponding to the largest eigenvalues and discarding other components. It is also known as discrete Karhunen–loeve 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.

3.1 PCA IMAGE FUSION ALGORITHM

Let images $f1(m, n)$, $f2(m, n)$ are A and B, of size $m \times n$ matrix, the steps for PCA is explained in flowchart–1:



Flowchart – 1

The following diagram shows fusion of PCA method Fig.3.

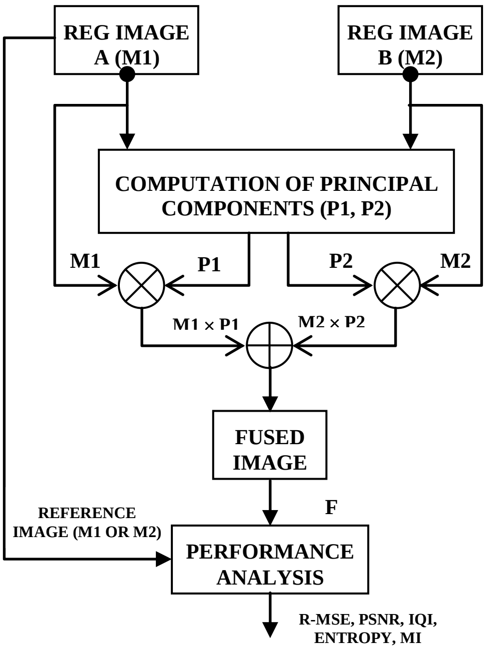


Fig.3. PCA Image fusion diagram

4. THE PROPOSED METHOD (DWT)

The 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 Fig.4.

1. The image A and Image B are resized and aligned together i.e. registered image A and B.
2. 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}.
3. The outputs of 2nd step LL^1, LH^1, HL^1, HH^1 and LL^2, LH^2, HL^2, HH^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.
4. Applying IDWT to previous step output coefficients of approximated and detailed, to obtain the reconstructed image.
5. Finally, the fused image F and reference image A is taken to obtain a performance analysis is done.

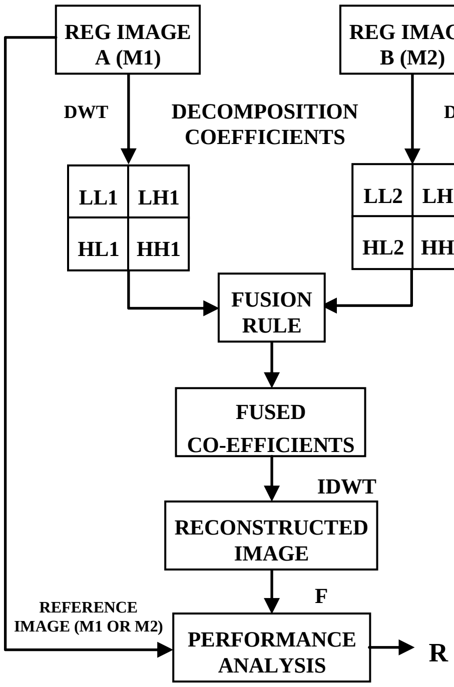


Fig.4. The proposed method block diagram

5. RESULTS

The CT and PET images are fused by proposed method i.e. DWT and compared with PCA method. The implementation of this project is done using platform of Mat Lab. Implementation of this work is done through the GUI model as shown below in Fig.5.

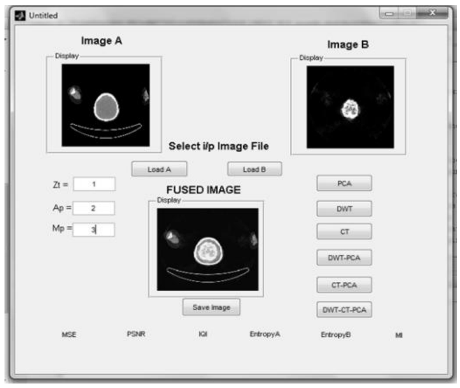


Fig.5. The GUI implementation of project

The performance of the proposed algorithm is evaluated with MSE, PSNR and Entropy values of resultant fused image ‘F’ and reference image ‘M1’ of these over proposed method gives better results. The Fig.6 shows CT image, Fig.7 of PET image, Fig.8 of PCA method’s fused image, similarly Fig.9 of DWT. The results are compared and given in Fig.10, Fig.11 & Fig.12, where 1, 2 represents PCA, DWT methods respectively and respective graphs of quantitative matrices are given.

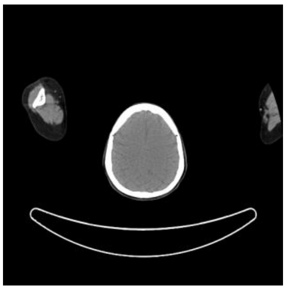


Fig.6. CT image of brain

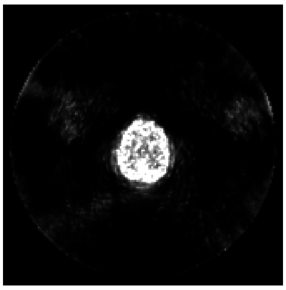


Fig.7. PET image of brain

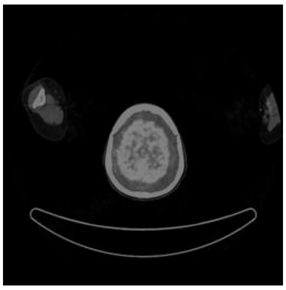


Fig.8. Fused image of PCA

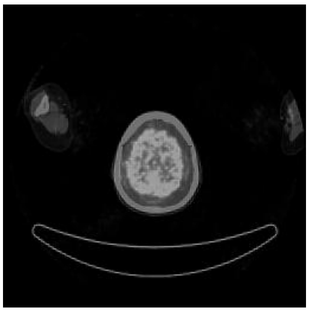


Fig.9. Fused image of DWT

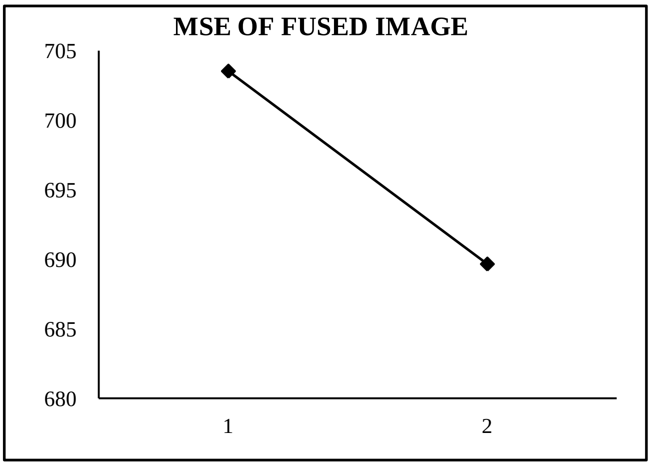


Fig.10. Mean square error

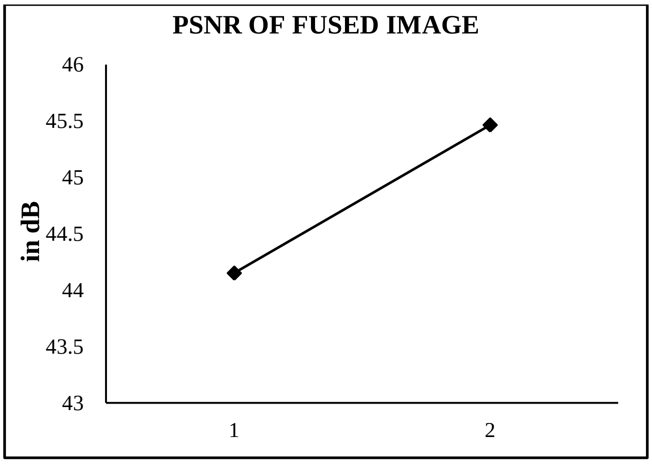


Fig.11. PSNR of fused image

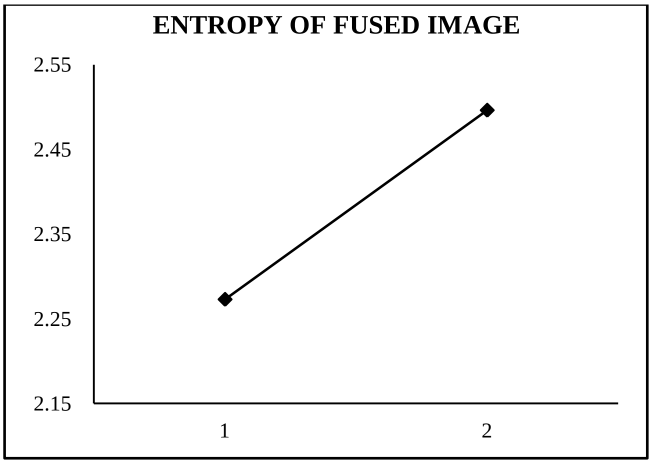


Fig.12. Entropy of fused image

6. CONCLUSION

The fusion of CT and PET of two modality images, 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 i.e. DWT with wavelet DBS2 has better results than spatial method: PCA, it is analyzed that there is better improvement of quantitative matrices like MSE, PSNR and entropy like (703.54, 689.67), (44.151dB, 45.463dB), (2.273, 2.4963) respectively. Hence the proposed method gives better results. As an extension of this project we can integrate these method to get a better result on both property multi resolution and appearance of fused image and one demerit the PCA is by its property of reduction of coefficients i.e. the no. of values of pixel may result reduced but can get a more important features it can be overcome by proposed method. Similar to PCA, DWT has disadvantage is that, as levels of decomposition increases the spatial value and resolution decreases. So we need to limit decomposition level as minimum as possible. At last line the DWT give better results than PCA with analytic values as shown in graphs and results.

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REFFERENCES

[1] Yuhui Liu, Jinzhu Yang and Jinshan Sun, "PET/CT Medical Image Fusion Algorithm Based on Multiwavelet Transform", *Proceedings of International Conference on Advanced Computer Control*, pp. 264-268, 2011.

[2] Amir Fareed Partu Al-Bakrei, "Brian Image Fusion of MRI-CT Multimodality Systems Using DWT and Hybrid Enhancement Fusion Algorithms", *Journal of Babylon University*, Vol. 20, No. 1, pp. 258-269, 2012.

[3] Lindsay I Smith, "*A tutorial on Principal Components Analysis*", 2002.

[4] Shih-Gu Huang, "Wavelet for image fusion" – Tutorial.

[5] Jan Flusser, Filip Sroubek and Barbara Zitova, "Image Fusion – Principles, Methods, and Applications", Lecture Notes, Tutorial EUSIPCO, 2007.

[6] Eduardo Fernández Canga, "Image Fusion", Project report.

[7] Derek L G Hill, Philipp G Batchelor, Mark Holden and David J Hawkes, "Medical image registration", *Physics in Medicine Biology*, Vol. 46, No. 3, pp. R1–45, 2001.

[8] M. Chandana, S. Amutha and Naveen Kumar, "A hybrid Multi-focus Medical Image Based on Wavelet Transform", *International Journal of Research and Reviews in Computer Science*, Vol. 2, No. 4, 2011.

[9] Hui Lin, Peijun Du, Weichang Zhao, Lianpeng Zhang and Huasheng Sun, "Image Registration Based on Corner Detection And Affine Transformation", *International Congress on Image and Signal Processing*, 2184-2188, 2010.

[10] Medha V. Wyawahare, Dr. Pradeep M. Patil and Hemant K. Abhyankar, "Image Registration Techniques: An overview", *International Journal of Signal Processing, Image Processing and Pattern Recognition*, Vol. 2, No. 3, pp. 11-28, 2009.

[11] V.P.S. Naidu and J.R. Raol, "Pixel-level Image Fusion using Wavelets and Principal Component Analysis", *Defence Science Journal*, Vol. 58, No. 3, pp. 338-352, 2008.

[12] S. Gandhimathi, S Nithyadevi, K. Sasikala and S Manicka Vinodhini, "PCA Based Fusion Algorithm for Medical Diagnosis", *International Journal of Communications and Engineering*, Vol. 4, No. 4, pp. 20-24, 2012.

[13] S. Jayaraman, S. Eskkirajan and T. Veerakumar, "Digital Image Processing", Tata McGraw Hill Education, 2001.