IMAGE FUSION USING HYBRID WAVELET TRANSFORM

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ABSTRACT

Image processing is a highly emerging field now-a-days. Image Fusion gains more concentration in this field .This paper explains the concept of image fusion. It explains how image fusion is advantageous. Basically there are two methods of image fusion spatial domain image fusion and frequency domain image fusion. Discrete Wavelet Transform(DWT), Stationary Wavelet Transform(SWT) and Principal Component Analysis are most widely used image fusion algorithms. A hybrid algorithm is developed using SWT, PCA and maximum selection method of image fusion. The results of proposed method are compared with previously implemented algorithms. The quality measure parameters are Peak Signal To Noise Ratio (PSNR), Mena Square Error (MSE) and Information Entropy.

Keyword: *-IMAGE FUSION, DWT, SWT, PCA, FREQUENCY DOMAIN, SPETIAL DOMAIN .*

1. INTRODUCTION

Image Fusion is one of the major research fields in image processing. Image Fusion is a process of combining the relevant information from a set of images, into a single image, wherein the resultant fused image will be more informative and complete than any of the input images[1]. Image fusion process can be defined as the integration of information from a number of registered images without the introduction of distortion. It is often not possible to get an image that contains all relevant objects in focus. One way to overcome this problem is image fusion, in which one can acquire a series of pictures with different focus settings and fuse them to produce an image with extended depth of field. Image fusion techniques can improve the quality and increase the application of these data. One of the important pre-processing steps for the fusion process is image registration, i.e., the coordinate transformation of one image with respect to other. Fusion algorithms are input dependent .Image fusion find application in the area of navigation guidance, object detection and recognition, medical diagnosis, satellite imaging for remote sensing, rob vision, military and civilian surveillance, etc.Image fusion systems are widely used in surveillance and navigation applications, for both military and domestic purposes. This is achieved by the use of multiple sensors to obtain the visual information and by utilizing the synergism of different imaging sensors for better situation assessment. Image fusion algorithms can be categorized into different levels: low, middle, and high; or pixel, feature, and decision levels.[2] The pixel-level method works either in the spatial domain or in the transform domain. Pixel level fusion works directly on the pixels obtained at imaging sensor outputs while feature level fusion algorithms operate on features extracted from the source images. 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 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[3].

Decision level fusion uses the outputs of initial object detection and classification as inputs to the fusion algorithm to perform the data integration. Both feature level and decision level image fusion may result in inaccurate and incomplete transfer of information. Several fusion algorithms starting from simple pixel based to sophisticated wavelets and PCA based are available. Image fusion system has several advantages over single image source and resultant fused image should have higher signal to noise ratio, increased robustness and reliability in the event of sensor failure, extended parameter coverage and rendering a more complete picture of the system. The actual fusion process can take place at different levels of information representation[6]. A common categorization is to distinguish between pixel, feature and decision level, although there may be crossings between them. Image fusion at pixel level amounts to integration of low-level information, in most cases physical measurements such as intensity. Generally, the pixel based image fusion methods average pixel intensity values of the source images pixel by pixel which leads to undesired side effects in the resultant image. Recently researchers have recognized that it is more meaningful to

combine objects or regions rather than pixels. The region based algorithm has many advantages over pixel based algorithm like it is less sensitive to noise, better contrast, less affected by miss-registration but at the cost of complexity.[6]

2. Fusion Algorithm

In this section a brief description on the methods like, Averaging, Maximum Selection, Even Degree, Entropy, Discrete Wavelet Transform (DWT), Principle Component Analysis (PCA).

2.1 Simple Average Method

Simple Averaging is the linear based method. This method is used for smoothing the image i.e. provides the better region in fused image than the input images. The value of fused image is defined as[5]

$$F(i,j) = (PA(i,j)+PB(i,j))/2$$

where F(i,j) is the fused image; PA(i,j)and PB(i,j)) are different medical input images

2.2 Maximum Selection Method

This method used to find out the maximum pixel values from the input images. It is defined as[5]

$$F(i,j) = Max((PA(i,j),PB(i,j))$$

where F(i,j) is the fused image; PA(i,j) and PB(i,j) are different medical input images.

TABLE-2 : Classification of image fusion techniques

2.3 Discrete Wavelet Transform

The registered input images are decomposed into two sub-bands like low sub-bands and high sub-bands using wavelet transform. The low sub-bands and high sub-bands are fused using various fusion methods. Finally, the output of the fused image is obtained by applying inverse wavelet transform on the fused coefficients of low sub bands and high sub-bands.[4]

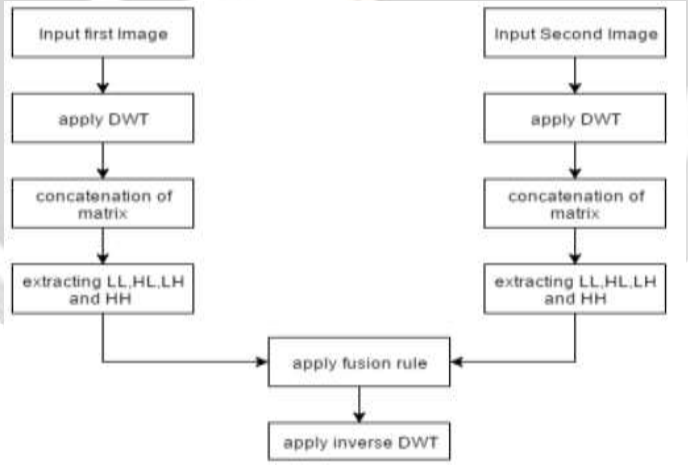


Fig-1 : DWT algorithm[5]

2.4 Principle Component Analysis

Principle Component Analysis is a statistical transformation method. This method is used to convert the multimodality medical input images correlated data variables into a new fused image uncorrelated data variables. The PCA method images are combined with weighted averaging and it's defined as [3]

$$f = (P1*A) + (P2*B)$$

whereP1and P2 are weights corresponds to the Eigen vector with greatest Eigen value from PCA.

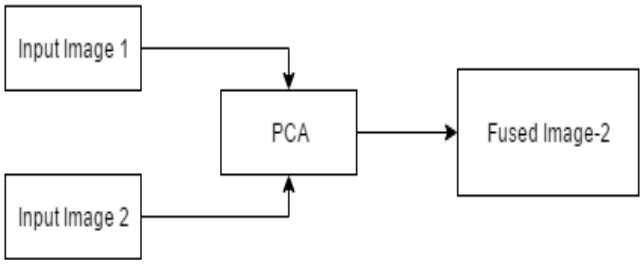


Fig-2 : PCA algorithm[4]

2.5 Stationary Wavelet Transform

The Discrete Wavelet Transform is not a time invariant transform. The way to restore the translation invariance is to average some slightly different DWT, called un-decimated DWT, to define the stationary wavelet transform (SWT). It does so by suppressing the down-sampling step of the decimatedalgorithm and instead up-sampling the filters by inserting zeros between the filter coefficients. Algorithms in which the filter is up-sampled are called "à trous", meaning "with holes". As with the decimated algorithm, the filters are applied first to the rows and then to the columns. In this case, however, although the four images produced (one approximation and three detail images) are at half the resolution of the original; they are the same size as the original image. The approximation images from the undecimated algorithm are therefore represented as levels in a parallelepiped, with the spatial resolution becoming coarser at each higher level and the size remaining the same. Stationary Wavelet Transform (SWT) is similar to Discrete Wavelet Transform (DWT) but the only process of down-sampling is suppressed that meansthe SWT is translation-invariant. The 2-D SWT decomposition scheme is illustrated in following figure.

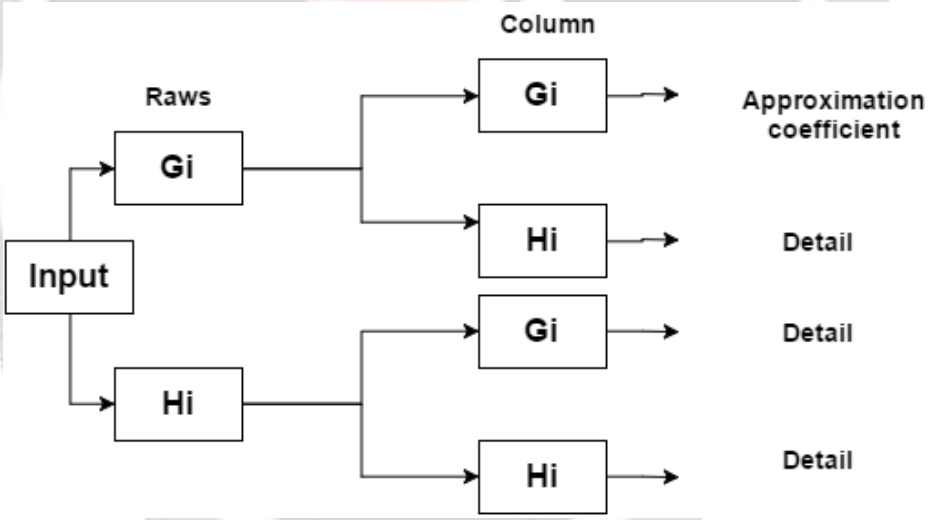


Fig 3 : SWT decomposition

3. Quality Measures.

In this section a brief description on the methods like, Averaging, Maximum Selection, Even Degree, Entropy, Discrete Wavelet Transform (DWT), Principle Component Analysis (PCA).

3.1 Mean-(μ) (of fused image):

We can find the mean of the data set by taking ratio of the aromatic sum of all sample of the dataset to the total number. The higher the mean the better the image quality. We can represent the mean as follows:

$$\mu = \frac{1}{MN} \sum_{i=0}^{A} \sum_{i=0}^{B} If(i,j) \ldots\ldots\ldots\ldots \quad (3.1)$$

Where If – is the output or fused images

A & B – numbers of raw and column in the image

3.2 Standard Deviation :

Standard deviation can be represented using symbol SD or σ .The square root of 'variance' is known as the 'standard' deviation. The value of the standard deviation is measure of spread in the data. Higher the value of variance means high contrast of the image and lower the value of the means lower the value of the contrast of the image. The closeness of fused image to the original image is represented by standard-deviation. Lower the value of SD better the fused image. Ideal value of standard deviation is zero.[5]

$$\sigma = \sqrt{\frac{\sum_{i=0}^{A}\sum_{i=0}^{B}(If(i,j)-\mu)\text{^}2}{AB}} \quad \ldots\ldots\ldots\ldots(3.2)$$

where , A & B – number of row and column

μ – variance

If – fused image or output image

3.3 Mean Square Error:

$$MSE = \frac{\sum_{A,B}[I1(a,b)-I2(a,b)]^2}{A*B} \quad \ldots\ldots\ldots\ldots(3.3)$$

Where , A & B – number of row and column

I1 – fused image

I2 – reference image

3.4 Peak Signal Noise Ratio:

The ration of maximum possible power to the noise is known as peak signal to noise ratio. The noise can affects the fidelity are taken into consideration. The PSNR represented as follows.[5]

$$PSNR = 10\log_{10}\frac{R^2}{MSE} \quad \ldots\ldots\ldots\ldots(3.4)$$

Where, MSE – mean square error

R = 255 for 8-bit image

we have to take calculate PSNR of Fused image with the use of MSE and R , MSE can be calculated using fused image and the reference image that is any image form two input images. Lower PSNR means lower quality of the image.

3.5 Information Entropy:

Entropy can be define as the measure of randomness or we can say the amount of information. Information entropy can represented as follows . As the value of information higher the more information contained by image.

$$H = -\sum_{l=0}^{J-1} P_l \log_2 P_l \quad \ldots\ldots\ldots\ldots(3.5)$$

where , J is number of gray level,

Pj equals the ratio between the number of pixels whose gray value is j($0 \leq l \leq J-1$)

and the total pixel number contained in the image[4].

4. Proposed Algorithm:

The image fusion algorithm is proposed with the novel approach for medical images like MRI, CT and PTE images. The dataset of CT, PTE and MRI images are prepared for testing purpose. Here the stationary wavelet transform is combined with principal component analysis and maximum selection algorithm of image fusion. Literature survey is done for fusion of medical images and on basis of that literature survey the algorithm with novel approach is proposed.

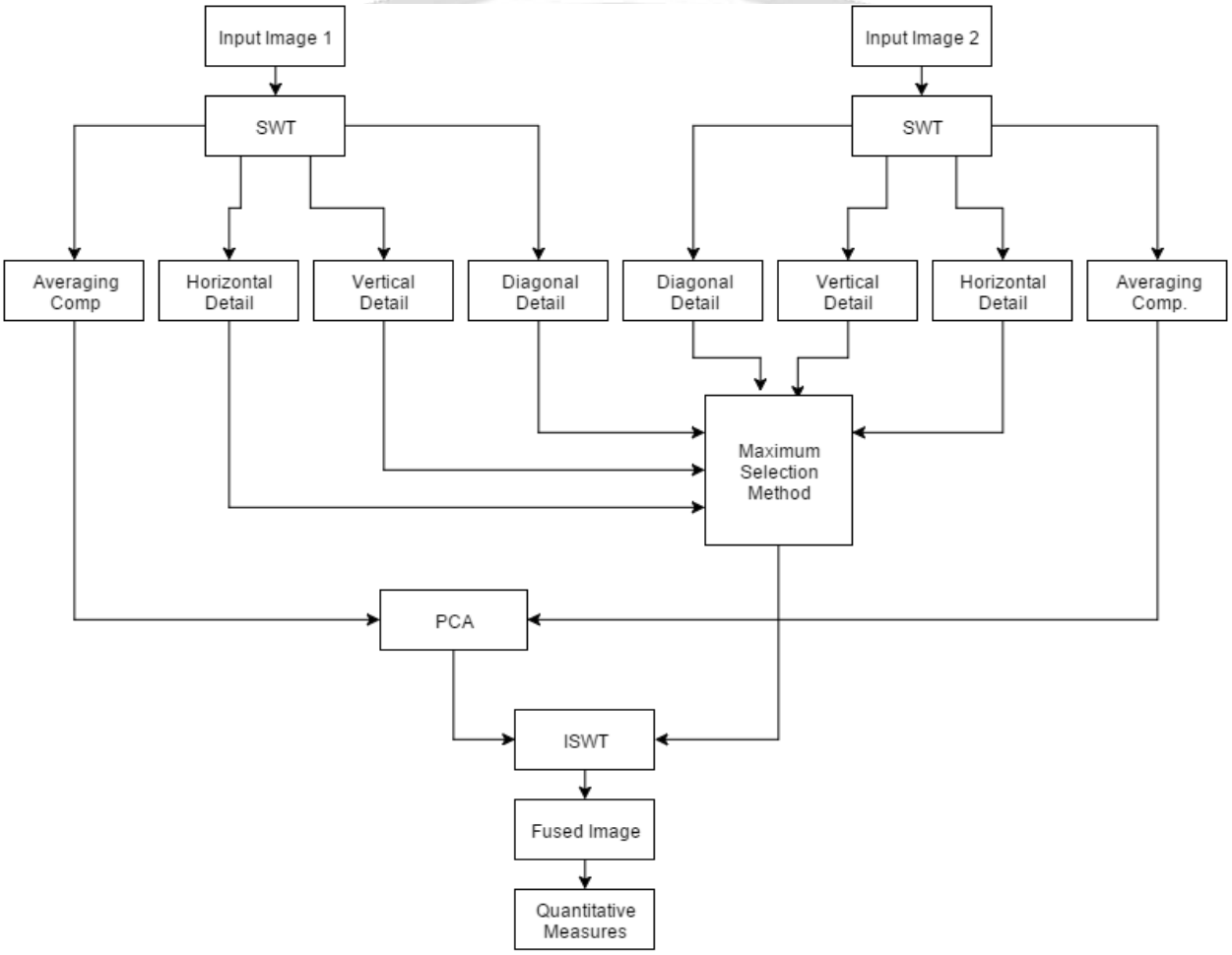


Fig 4 : Flow char of proposed Algorithm

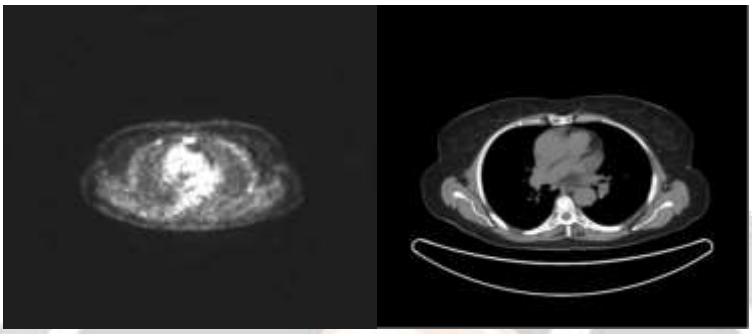
From literature we can infer that stationary wavelet transform result in lower error values and faster convergence compared to discrete wavelet transform[9]. Principal component analysis is also a batter algorithm for image fusion[4] so SWT is combined with PCA for fusion purpose.

Registered medical images are given as input. Using stationary wavelet transform the input medical images are decomposed. SWT will four component after second level decomposition that are averaging component, horizontal detail, vertical detail, and diagonal component. Averaging component contains very much amount of the information like shape details and texture details. So, averaging component is fused using principal component analysis method.

Other three components are fused using maximum selection method of image fusion. After fusion of all component inverse stationary wavelet transform is applied to all four fused components and fused image is obtained.
The quality of the fused will be decided on basis of quantitative measures. Various quality measuring parameters are peak signal to noise ratio, mean square error, information entropy and mutual information. All the quality measuring parameter calculated for fused and compared with the results of the standard papers.

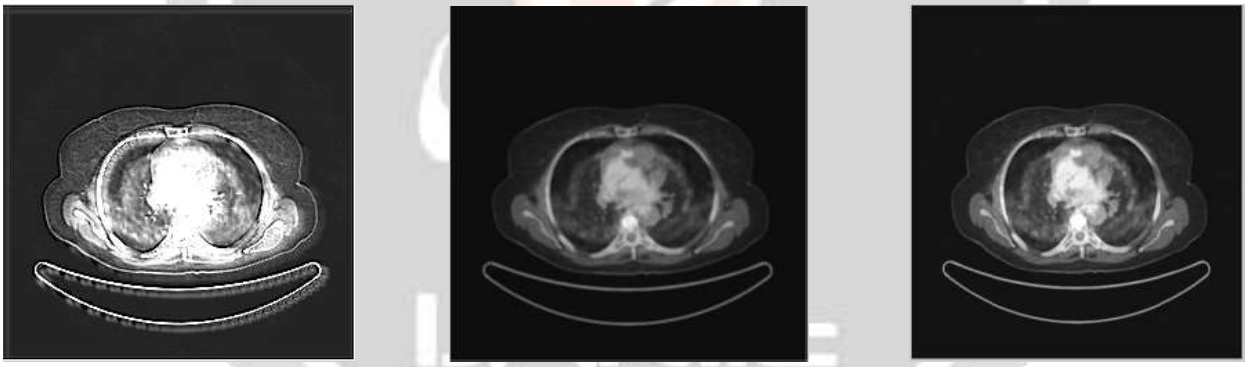
4. Experimental Results:

4.1 Image Dataset :



(a) (b)

Fig 5 (a)CT image (b) PTE image



(a) **(b)** **(c)**

Fig 6 : (a) Output of SWT algorithm, (b) Output of hybrid algorithm (a) Output of PCA algorithm

The input database is tested using hybrid algorithm. The quality measure parameters are compared with the previously implemented algorithm.

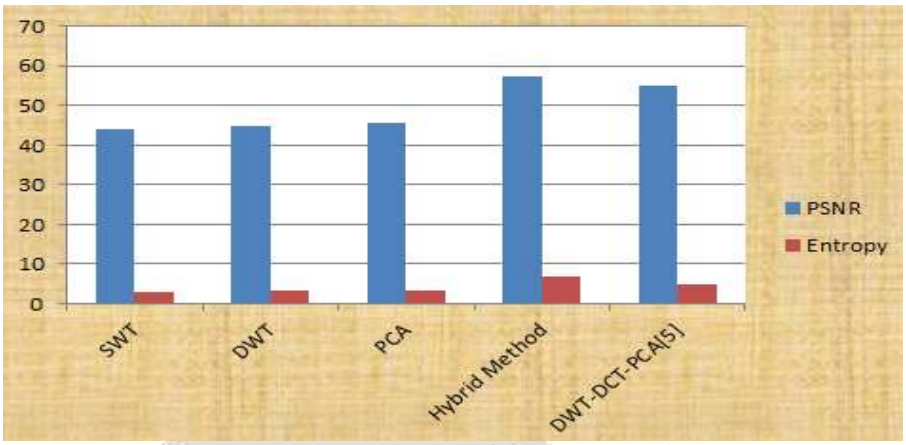


Fig 7 : Quantitative Analysis Chart Of PSNR and Information Entropy

4. CONCLUSIONS

- DWT is most widely used method for image fusion. But decomposition of image using DWT is bit slower compared to SWT decomposition. And restoration error of the STW is lower than DWT
- So an algorithm with a novel approach is proposed using PCA,SWT and maximum selection method of image fusion. The baseline system for this hybrid algorithm is developed. Medical images database is prepared (CT-PTE images and MRI-T1&MRI-T2).
- This image database is tested using the hybrid algorithm. Quality of the fused image measured using the Quantitative Measures (PSNR,MSE and Information Entropy). The PSNR and Information Entropy are compared with the previously proposed algorithms. Higher PSNR values and Information Entropy can be obtained using proposed algorithm.

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5. REFERENCES

[1]. Zhiming Cui, Guangming Zhang, Jian Wu , "Medical Image Fusion Based on Wavelet Transform and Independent Component Analysis.", IEEE-2009.
[2]. Mirajkar Pradnya P, Ruikar Sachin D, "Wavelet based Image Fusion Techniques", IEEE, 2013.
[3]. Richa Gupta, Deepak Awasthi, "Wave-packet image fusion technique based on Genetic Algorithms", IEEE-2014.
[4]. Ujwala Patil,Uma Mudengudi, "Image fusion using hierarchical PCA" , IEEE-2011.
[5]. Guruprasad S, M Z Kurian, H N Suma, "Fusion of CT and PET Medical Images using Hybrid Algorithm DWT-DCT-PCA" ,IEEE-2015.
[6]. Mohammad H. Kayvanrad , A. Jonathan McLeod, John S.H. Baxter,Charles A. McKenzie, Terry M. Peters, "Stationary wavelet transform for under-sampled MRI reconstruction"- school of Western university,Canada, Elsevier, (2014)
[7]. S. S.Bedi, Rati Khandelwal, "Comprehensive and Comparative Study of Image Fusion Techniques"- International Journal of Soft Computing and Engineering (IJSCE) ISSN: 2231- 2307, Volume-3, Issue-1, March 2013
[8]. A.Umaamaheshvari1, K.Thanushkodi ," IMAGE FUSION TECHNIQUES", IJRRAS-2010.
[9]. Sampath Kumar Dara, Kaparthi Uday, Harshavardhan Awari, "Fusion Of Multi Modality Images And Preserving Edge Features In Medical Applications Using Novel Wavelet Coefficient",IJRS-2012