Decomposition & Reconstruction of Medical Images in MATLAB using different Wavelet Parameters

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Abstract- **Fusion ofMedical images derives useful information from medical images containing the data which has important clinical significance for doctors during their analysis. The idea behind the concept of image fusion is to improve the image content by fusing two images like MRI (Magnetic resonance imaging) & CT (Computer tomography) images to provide useful &precise information for doctor for their clinical treatment. In this paper Discrete Wavelet Transforms (DWT)method has been used to fuse two medical images to decompose the functional & anatomical images.The fused image contains both functional information and more spatial characteristics with no color distortion. In the proposed work different fusion experiments are performed on Medical images by using seven wavelet transform methods - Bior, coif, db, dmey, haar, rbio and sym. Further explores the comparision between all fused image using the measuring parametersEntropy & standard deviation. Experimental results show the best fusion performance is given by the Symlets (sym) wavelet transform.**

Keywords- **Image fusion,Frequency,CT,MRI,Entropy, 2-D Discrete wavelet transform Fusion metrics,Phase information.**

I.INTRODUCTION

In Image fusion process a fused better visualized image is formed by combining two or more images to retrieve the vital information from these images [1]. Image fusion techniques, merge& integratethe complementary information from multiple image sensor data & makes the image more suitable for the visual perception and processing. Image fusion process extracts all the useful information to minimize redundancy & reduce uncertainty from the source images [2]. Image fusion can combine information from two or more images into a single composite image which become more informative and more suitable for computer processing & visual perception for further analysis and diagnosis. But it is necessary to align two images accurately before they fused [3].Before fusing images, all features should be preserve in the images and should not introduce any inconsistency or artifacts,so that it could not distract the observer. The advantages of image fusion are improved capability and reliability. The fused image should not have any undesired feature. The idea behind the image fusion concept is that the fused image after image fusion method should posses all relevant information [4].

The fusion of multi-modality imaging increasingly plays an important role in medical imaging field as the extension of clinical use of various medical imaging systems [5-8]. Different medical imaging techniques may provide scans withcomplementary and occasionally redundant information. The fusion of medical images can lead to additional clinical information not apparent in the single images. However, it is difficult to simulate the surgical ability of image fusion when algorithms of image processing are piled up merely. So many solutions to medical diagnostic image fusion have been proposed today. Registered medical MRI and CT images of the same people and same spatial part are used for fusion [9-11].

The fusion of medical images acquired from different instrument modalities such as MRI (magnetic resonance imaging), CT(computed tomography), X-rays andPET (positron emission tomography) of the same objects is often needed . A number of fusion techniques have been reported in the literature [12-13]. The Fusion techniques include different methods for pixel averaging or complicated methods like wavelet transform fusion and principal component analysis. Pixel level image method is comparatively easy to implement & the resultant image contain huge & original information.Many simple image fusion algorithm based on wavelet transform is proposed in reference [14-17]. The image is decomposed into spatial frequency bands at different scales in wavelet transform method, such as low-low, high-high, high- low and low-highband. The average image information is given by the low-low band [18, 19]. Other bands High-high, High-low contain directional information due to spatial orientation. In high bands higher absolute values of wavelet coefficients correspond to salient features such as edges or lines. The common element idea in almost all of them is the use of wavelet transforms to decompose images into a multi resolution scheme [20]. MRIimages provide greater contrast of soft tissues of brain than CT images, but the brightness of hard tissues such as bones is higher in CT images. CT &MRI images individually have some shortcomings such as MRI images not concentrate on hard tissues & in CT image soft tissues can't be clearly visible. In this paper image fusion of CT & MRI images has been carried out so that the fused image which is the

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combination of soft & hard tissues proven as the focused image for doctors & their clinical treatment.

This paper further quantitatively evaluates the fused images quality through two performance measures Standard Deviation (SD) and Entropy (EN).

This research paper is organized as follows;section -IIelaborates theimage fusion using different wavelet transforms. Section-III details the image fusion performance evaluation criterion. In section-IVpresentation and discussion of experimental result has been carried out. Further conclusion is mentioned in Section -V.

II. IMAGE FUSION BASED ON DIFFERENT WAVELET TRANSFORMS

The original concept and theory of wavelet-based multiresolution analysis gave by mallat. Wave let transform has increasingly important in image fusion since wavelet allows both time & frequency analysis simultaneously. The wavelet transform is nothing but a mathematical tool. It can detect local features in a signal process and also can be used for multiresolution analysis to decompose two-dimension (2-D) signal such as 2-D gray-scale image signals into different resolution levels. Wavelet transform widely used for many fields, such as data compression, feature detection, texture analysis, image fusion, and many more. In image fusion method, the formation of fusion pyramid is the most important step. The basic idea of image fusion based on wavelet transform which perform a multiresolution decomposition of each source image and the coefficients of both the low frequency band and high frequency bands are then performed with certain fusion rule. At first compute the wavelet transforms of images, then decompose the image into various sub images based on local frequency content and by choosing the salient wavelet coefficients; a composite multi-scale representation is built [21].The common integration rule is that the coefficients whose absolute values are higher being selected at every point in the transform domain. The larger absolute wavelet transform coefficients correspond to sharper brightness changes. In this way the fusion takes place in all the resolution levels and the more dominant features at each scale are preserved in the new multiresolution representation. Anew image has been constructedwith the help of specific rules of decision or weightingby performing an inverse wavelet transformation.In wavelet transformation, at each level of decomposition process, theimage size is halved which lead to a multi-resolution signal representation, in both spatial directions.

Different types of wavelet methods has been used in image fusion process such as Biorsplines (bior), coiflets (coif), daubechies (db), dmeyer (dmey), Haar (haar), reverse bior (rbio) and symlets (sym). Daubechies wavelets are the most popular wavelets among all of them.Daubechies wavelet used in many applications &are supposedto be the foundations of wavelet signalprocessing. Coiflets,Haar, Symlets and Daubechies, are capable of perfect reconstruction &compactly supported orthogonal wavelets.The Mexican Hat,Morlet and Meyer, waveletsare symmetric in shape. Biorthogonal wavelet exhibits the property oflinear phase &needed for image reconstruction and signal processing. These wavelets are chosen in a particular applicationbased on their ability and their shape to analyse the signal the wavelets.

Wavelet transforms has two groups i.e. DWT (discrete wavelet transforms) & CWT (continuous wavelet transforms).DWT has the features of fast operational speed and occupies less memory & also maintains the characteristics of wavelet. The continuous function transforms into a highly redundant function of two continuous variables; translation & scale in CWT. In this paper, image fusion process is carried out in MATLAB using DWT method. The concept and procedure of the wavelet based fusion technique has been presented in fig 1.

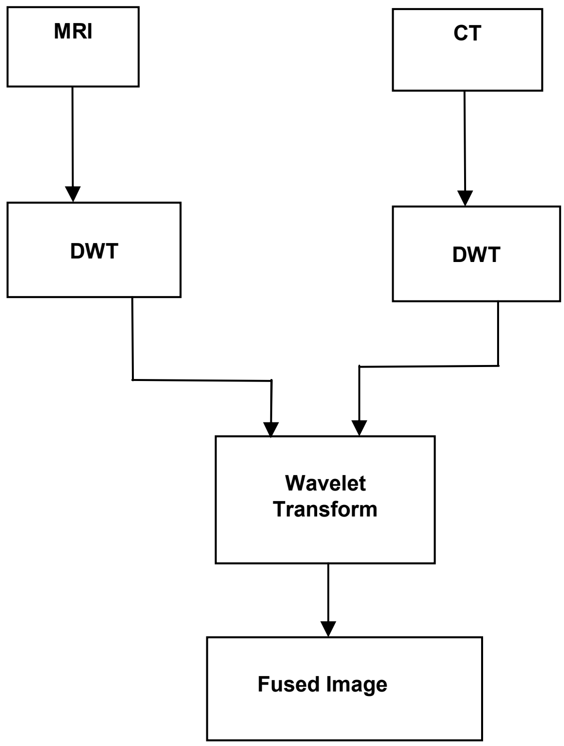


Fig. 1 Fusion Method using DWT with different wavelet transform

Discrete Wavelet Transform (DWT)

The discrete wavelet transform (DWT) is the one of themost commonly used and simplest wavelet transform for image fusion.Wavelet theory improves spatial resolution and spectral characteristics. A signal is decomposed, with each level corresponding to a coarser resolution or lower frequency band, and higher frequency bands by Wavelet transform.

Using the Matlab Image Fusion tool (Fig. 2), the fusion has been carried out to give a fused & detailed image.

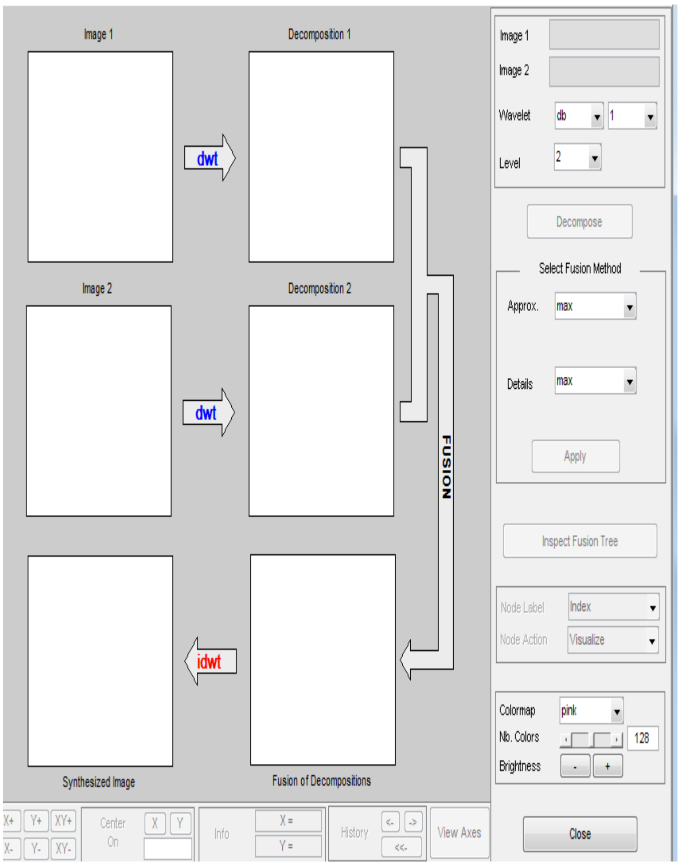


Fig. 2 Matlab Image Fusion tool for fusion of medical images

The wavelet series expansion maps the function of a continuous variable into a sequence of coefficients [22]. If the function being expanded is a sequence of numbers, such as samples of a continuous function $f(x)$ the resulting coefficients are called thediscrete wavelet transform (DWT) of $f(x)$.The series expansion becomes the DWT transform pair

$$W_\varphi(j_0,K) = \frac{1}{\sqrt{N}}\sum_x f(x)\varphi_{j0,k}(x)$$

$$W\psi(j,k) = \frac{1}{\sqrt{N}}\sum_x f(x)\psi_{j,k}(x)$$

For $j \geq j_o$ and

$$f(x) = \frac{1}{\sqrt{N}}\sum_K W_\varphi(j_0,k)\varphi_{j_0,K}(x) + \frac{1}{\sqrt{N}}\sum_{j=j_0}^{\infty}\sum_K W_\psi(j,K)\psi_{j,K}(x)$$

Here $f(x)$, $\varphi_{j_0}k_{(x)}$ and $\varnothing_{jk}(x)$are functions of the discrete variables x = 0, 1, 2……., N-1. The$W_\varphi(j_0,k)$'s and $W_\psi(j,k)$'s in equation (1, 2, 3) correspond to the c_{j0} (k)'s and d_j(k)'s of the wavelet series expansion . The integrations in the series expansion have been replaced by summations, and a $\frac{1}{\sqrt{N}}$normalizing factor. This factor could alternatively be incorporated into the forward or inverse alone as 1/N.

DWT, applies a two-channel filter bank (with down sampling) iteratively to the low-pass band (initially the original signal).In wavelet representation.The high-pass bands and at the lowest resolution low-pass band has been obtained at each step.This transform is invertibleand non-redundant. Because DWT has a spatial domain decomposition property, it provides a flexible multiresolution analysis (MRA) of an image.

III. Performance Assessment

Although wavelets share some common properties,yet fusion results varies because of their unique image reconstructionanddecompression characteristics.The general requirement is to preserve all valid and useful pattern information from the source imagesand also it should introduce artifacts that could interfere with subsequent analyses simultaneously. The performance measures used in this paper are SD (Standard Deviation) & EN (entropy). It provides quantitative comparison among different fusion schemes. It focuses mainly at measuring the definition of an image [23].

A. Standard Deviation (SD)

The standard deviation (SD) is the among the most commonly used assessment measure of statistical dispersion, SDevaluate how widely spread the gray values in an image and measures the fused imagecontrast. SD denotes the deviation degree of the estimation and the average of the random variable. SD produces best results in the absence of noise. An image with highcontrast would have a high standard deviation.For better results SD should be at the higher end.Larger the standard deviation, better the result.The unbiased estimate of the standard deviation, S_a, of the brightness within a region (Ř) with pixels is called the sample standard deviation and itis given by:

$$S_a = \sqrt{\frac{1}{-1}\sum_{mn \in Ř}(a[m,n] - m_a)^2}$$

$$= \sqrt{\frac{\sum_{mn \in Ř}(a^2[m,n] - ma^2)}{-1}}$$

By using the histogram formulation, we have:

$$S_a = \sqrt{\frac{(\sum_a a2h[a1]) - m^2 a}{-1}}$$

An image with high standard deviation having the high contrast for an image.

$$\sigma = \sum_{i=0}^{L} (i-1)^2 h_{if}(i), \dots = \sum_{i=0}^{L} i h_{if}$$

Where $h_{if}(i)$ is the normalized histogram of the fused image and L is number of frequency bins in histogram.

B. Entropy (EN)

Shannon was the first person to introduce entropy to quantify the information. Entropy is a quantitative measure. Entropy defined as the amount of information contained in a signal.The concept of EN has been employed in many scientific fields as well as in image processing methods and it contains the information content of an image. Entropy is an parameter to evaluate the information quantity contained in an image. Entropy defines the information in the digital numbersin images as a frequency of change. Entropy reflects an average information content of an image.When each gray level has the same frequency, then the Entropy has the maximum value.

If entropy of fused image is higher than thesource imagethen it indicates that the fused image contains more information than source image and the fusion performances are improved.

The entropy of the image can be evaluated as

$$\sum_{i=1}^{G} P(i) \log_2 (P(d_I))$$

Where G is the number of possible gray levels, P (*di*) is probability of occurrence of a particular *gray level di.*

The fused image contains abundant information if the entropy value is large. Information entropy is used for comparing the difference of image details. Entropy is defined as

$$E = -\sum_{i=0}^{L-1} p_i \log_2 p_i$$

Where L is the total of grey levels, $p = \{p_0, p_1 \dots p_{L-1}\}$ is the probability distribution of each level.

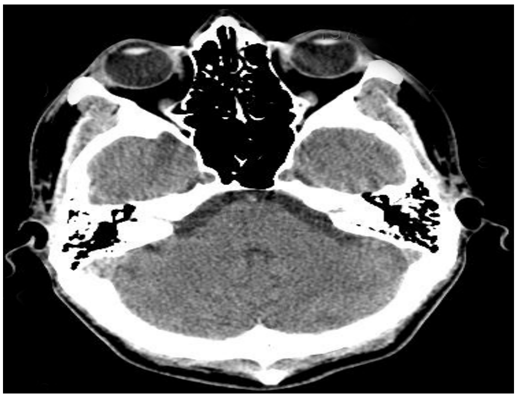
IV.EXPERIMENTAL RESULTS

The MRI& CT medical images (Fig. 3) are used in this fusion experiment.

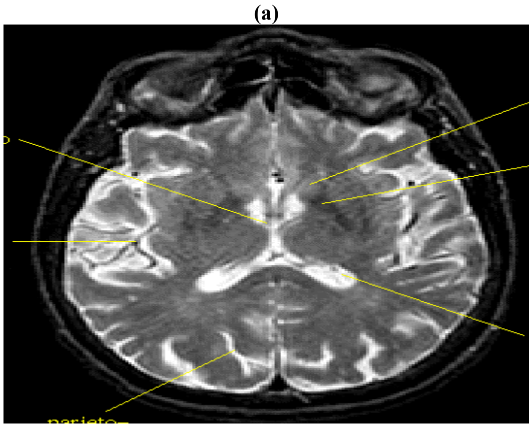
The simulations are performed on these CT scan and MRI Medical images for 7 different wavelet transform methods (Bior, coif, db, dmey, haar, rbio and sym) AS SHOWN IN Fig. 4.In the whole work the *LR Fusion – Max* wavelet coefficient is used.

The fusion performance for each combination is evaluated by using the standard deviation (SD) and Entropy (EN) as quantitative measures.

The comparison of all fusion results (TABLE 1) clearly show that fused images have minimum /maximum Entropy 2.5719/2.5969 for Dmeyer (dmey) and Symlets (sym) Wavelet Transforms respectively.The minimum/maximum SD varies from 21.8027 to 25.5604 for Coiflets (coif) and Symlets (sym) Wavelet Transforms respectively.

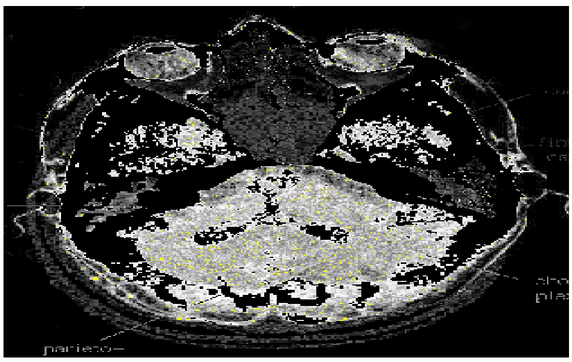


(a)

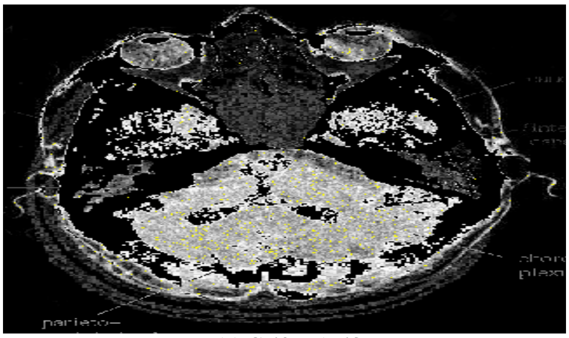


(b)

Fig. 3 Original medical images to be fused (a) CT image (b) MRI image

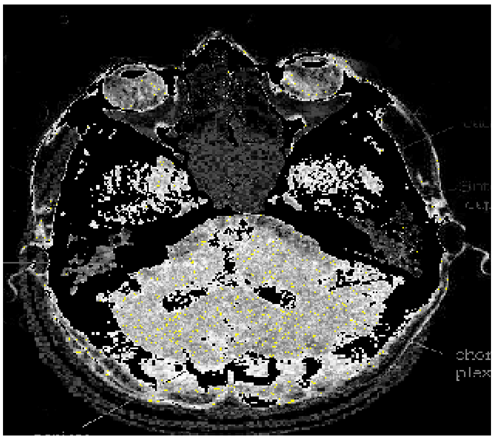


(a) Biorsplines(bior)

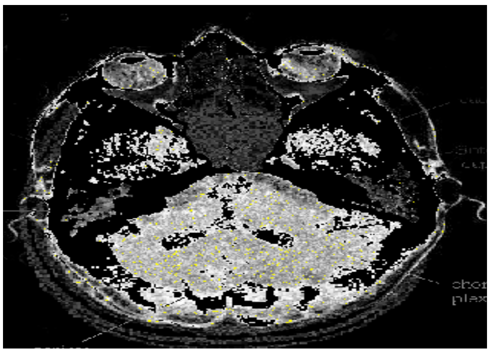


(b) Coiflets(coif)

(c) Daubechies(db)



(d) Dmeyer(dmey)



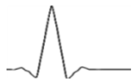
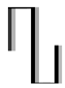
(e) **Haar (haar)**

(f) Reversebior (rbio)

(g) Symlets (sym) (BEST IMAGE)

Fig 4(a-g) Image fusion results for medical images with different Wavelet Transforms

TABLE 1. QUANTITATIVE EVALUATION RESULTS WITH DIFFERENT WAVELET TRANSFORMS

SN	Discrete Wavelet Transform(dwt)		Entropy (EN)	Stand. Dev. (SD)
	Name	Symbol		
1	Biorsplines(bior)		2.5949	22.5067
2	Coiflets(coif)		2.5969	21.8027 (Lowest)
3	Daubechies(db)		2.5949	24.5906
4	Dmeyer(dmey)		2.5719 (Lowest)	23.0651
5	Haar(haar)		2.5949	21.9931
6	Reverse bior(rbio)		2.5958	22.5067
7	**Symlets(sym) (Best Image)**		**2.5969 (Max.)**	**25.5604 (Max.)**

V.CONCLUSIONS

In this paper, the image fusion of MRI &CT medical images is done using fully automated wavelet transforms in MATLAB environment. The synthesized image has the qualities of both MRI &CT fused images. The different fusion methods used are - Bior, coif, db, dmey, haar, rbio and sym. Further the comparative analysis of a number of image fusion techniques helps in selecting the best fusion method and therefore one can obtain better visualization of the fused image. The worst entropy & Standard Deviation are obtained for Dmeyer (dmey) & Coiflets (coif) wavelet transforms respectively. The Symlets (sym) wavelet transform gives best Entropy & Standard Deviation .Thus the Symlets (sym) fusion method with LR Fusion – Max wavelet coefficients outperforms other fusion methods.

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