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Medical Image Fusion Using DWT, DRT and SVD Technique.

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***Abstract*—**Medical image fusion is the process of deriving important information from medical images like CT(Computed Tomography),MRI(Magnetic Resonance Imaging), PET(Positron Emission Tomography) and SPECT (Signal photon emission computed tomography).These derived information can be used for diagnosing diseases, detecting the tumor, surgery treatment and so on. The main objective of image fusion is to combine more useful information and remove redundant information from source images. This paper propose a hybrid image fusion method using the combine advantage of Multi-Scaling (DWT) and Multi-Resolution (DRT,SVD) Techniques on Medical images CT and MRI. The performance of the fused image is evaluated using different parameters like PSNR, MSE.
Keywords—Medical Image Fusion, Multi-Scaling, Multi-Resolution.

I. INTRODUCTION

Image Fusion is a process of combining relevant information from a set of images into a single image, hence the fused image will be more informative and better than input images. Image Fusion method is improve the quality of image.

In Medical imaging, CT (Computed Tomography), MRI (Magnetic Resonance Imaging) and other modes of medical images reflected human information from various angle. CT can clearly reflect the anatomical structure of bone tissues and MRI can clearly reflect the anatomical structure of soft tissues, organs and blood vessels. A CT image gives district contours of bones but it cannot show clear image of ligaments. MRI shows the shape of both ligaments and born but fails to produce distinct contours of the bones. Fusion of CT-MRI image is used to assist in planning surgical procedure. [1-4]

Several techniques for medical image fusion exits. Simple pixel domain method like average and choose maximum cause loss of details or contrast, making the image more difficult to interpret. [5-6]There are two types of techniques.1) Multi-Scale 2) Multi-Resolution. Combination of the techniques results is expected to improve accuracy.

The rest of this paper organized as follows. In Section II, Introduction of fusion Techniques. In Section III the proposed medical image fusion method. Section IV Discuss evolution of fusion method by different parameters. In Section V Experimental Results and analysis. The paper is concluded in Section VI.

II. FUSION TECHNIQUES

Image fusion techniques are classified in two Domains.

1. Spatial Domain (Pixel Level).
2. Transform Domain. [04]

A. Pixel level or Spatial Domain image fusion.

The pixel level image fusion combine the source images into a single image. This kind of methods is usually robust to noise and miss-registration. Spatial domain techniques are simple and fused image can be obtained by directly applying fusion rules on pixel values of source image. Simple averaging, PCA (Principal component analysis) and linear fusion are some example of spatial domain techniques. But major disadvantage are that they introduce spatial distortion in the fused image and do not provide any spectral information. [07]

B. Image fusion based on Transform Domain.

Pixel level image fusion is simple and easy to implement but with simplicity, it introduces loss of information and blurring of edges [04].This can be improved by using multi-scale decomposition. Medical image fusion using different transforms involves three phases: 1) Decomposing the input images into high and low frequency sub-band up to certain level. 2) Combining approximate (low frequency part) and detailed (high frequency part) coefficient using some fusion rules in order to obtain new fused coefficients. 3) Using the inverse transform a new image is constructed.DWT(Discrete Wavelet Transform), CVT (Curvelet Transform), DRT (Discrete Ripplet Transform) , CNT or CT (Countourlet Transform) are some example of transform domain techniques.Medical image fusion based on transform domains are classified into two techniques: 1) Multi-resolution 2) Multi Scale.

C. DWT (Discrete Wavelet Transform)

The original concept and theory of wavelet- based on multi-resolution analysis came from Mallat. DWT represent image variation at different scale. A wavelet is an oscillating and attenuated function and its integrals equal to zero. The wavelet transform is mathematical tool which detect local feature in a signal process. It can also be used to decompose two-dimension (2-D) signals or images into different resolution level for multi-resolution analysis. Wavelet transform is applied in many areas, such as texture analysis, data compression, feature detection and image fusion.The DWT is spatial-spectral decomposition that provides a flexible multi-resolution analysis of an image. In a 2-D DWT, a 1-D DWT is first perform on the rows and then columns of the data by separately filtering and down sampling. This results in one set of approximation coefficients LL and three sets of detail coefficient LH, HL, HH representing horizontal, vertical and diagonal direction of the image as shown in Fig. 1 (a). The 2-D structures of the wavelet transform with two decomposition levels is shown in Fig. 1(b)

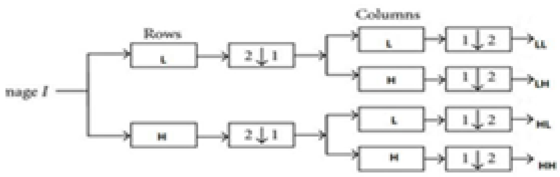

Fig. 1(a). A structure of DWT [5]

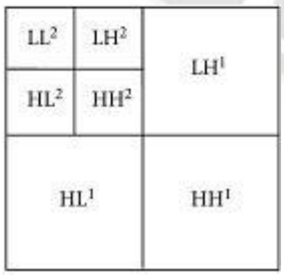

Fig. 1 (b). 2-D DWT Structure with labelled sub-band in two-level decomposition. [5]

By the recursively applying the same scheme to the LL sub-band a multi-resolution decomposition with a desired level can then achieved. Therefore, a DWT with K decomposition level will have M=3*K+1 such frequency band $(LL^{K)}$ as given in Fig. 1(b) and the rest of bands are high frequency bands in a given decomposition level.

D. CVT (Curvelet Transform)

The curvelet transform is a very young signal analyzing method with good potential. It is recognized as a milestone on image processing and other applications. Curvelet transform is more accurate to deal with the curve than wavelet transform the below Fig. 2 shows this.

Wavelet approach many wavelet coefficients are needed to account edges. i.e. singularities along lines or curves needed to account edges. Curvelet approach less coefficients are needed to account edges.

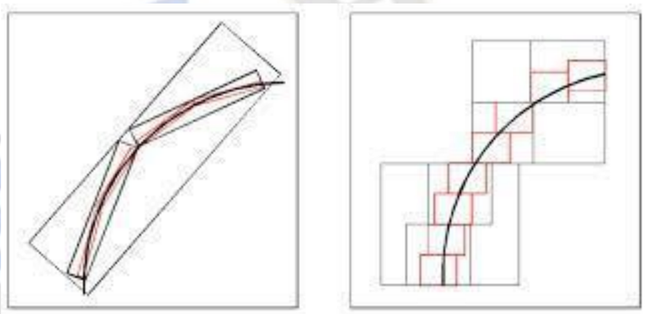

Fig. 2. Difference between Curvelet and Wavelet Transform[6]

E. DRT (Discrete Ripplet Transform)

The Conventional transforms like Fourier Transform and Wave Transform suffers from discontinuities such as edges and contours in images. A new MGA-tool called RT is used to solution of above problem. The RT is a higher dimensional generalization of the Curvelet Transform (CVT), capable of representing images or 2D signals at different scales and different directions.Visual and quantitative analysis shows, that the Ripplet Transform technique performs better compared to fusion scheme based on Contourlet Transform (CNT). RT generalizes CVT by adding two parameters, i.e., support c and degree d. CVT is just a special case of RT with c = 1 and d = 2. The anisotropy capability of representing singularities along arbitrarily shaped curves of RT is due to these new parameters c and d [5].

Ripplet Function: Discrete Ripplet function is defined in frequency domain:

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$$\hat{\rho}j(r,\omega) = \frac{1}{\sqrt{c}} a^{\frac{m+n}{2n}} W(2^{-j}.r) V(\frac{1}{c}.2^{-\left| j\frac{m-n}{n} \right|}.\omega - \quad (1)$$

$$\hat{\rho}a(r,\omega) = \frac{1}{\sqrt{c}} a^{\frac{d+1}{2d}} W \quad (2)$$

Where,

W(r) is "radial window" on [1/2,2].
V( ) is "angular window" on [-1,1]. c determines the support.

d denotes degree.

Here, the DRT is performed with support (c=1) and for degree d=3.

The DRT of MXN image

$$R_{j,\vec{k},l} = \sum_{n1=0}^{M-1} \sum_{n2=0}^{N-1} f(n1,n2)\overline{\rho_{j,\vec{k},l}} \quad (3)$$

Where , is Ripplet coefficients. The image can be reconstructed through Inverse Discrete Ripplet Transform (IDRT).

F. CT (Countourlet Transform)

CT can provide a multi-resolution, directional and local image expansion style. It includes multi-scale Laplacian Pyramid decomposition and the directional filter bank. Fig. 4 shows that CT has a double filter bank structure and the two steps are independent. The directional filter bank has a flexible number of directions and it can only capture the high frequency part of input image while the low frequency part of the input image are removed before applying it.

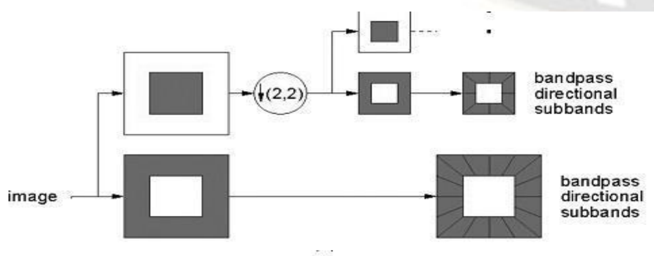

Fig. 4. The basic block diagram of contourlet transform[3]

The decomposition coefficients of CT are almost zero and only few of them have large magnitudes which are near the edge of the objects in the images. At the same time, the coefficients have strong dependences across different decomposition levels. That means the different directions in each decomposition level can describe different features for the same texture or edge. CT is a geometry transform for image processing. The directional decomposition and multi-scale decomposition are two independent stages which will effectively describe the textures and contours-rich of image. They have "long strip" structure which aspect ratios have changed with the scale in the elongated supported, it can effectively to track the characteristics of linear discontinuities and area discontinuities in the image.

III. Singular Value Decomposition (SVD):

Singular Value Decomposition (SVD) can be looked at following three mutually compatible points of view.

1. SVD is a technique for transforming correlated variable into a set of uncorrelated to better expose the various relationships among the original data items.
2. SVD is a technique for identify and ordering the dimension along which data points exhibit the most variation.
3.This binding into third way of viewing SVD, which gives most variation with the best approximation of the original data points using some dimensions.

Henceforth, SVD can be a technique of data reeducation.

"SVD takes a high Dimensional, highly variable set of data points and reducing it into lower dimensional space that exposes the substructure of the original data more clearly and orders it from most variation to the least."

"Based on linear algebra, SVD is a technique says that a rectangular matrix A can be broken down into the product of three matrices –first one an orthogonal matrix U, Second one a diagonal matrix S, and third one is the transpose of an orthogonal matrix V . The theorem is presented like this:"

Amn = Umm Smn VTnn

"where UTU = I, VT V=I; the columns of U are orthonormal eigenvectors of AAT , the columns of V are orthonormal eigenvectors of ATA and S is a diagonal matrix containing the square roots of eigenvalues from U or V in descending order."

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IV. PERFORMANCE MEASURES PARAMETER OF FUSION TECHNIQUES.

A. PSNR

The equation given below is used to find the PSNR between input image and fused image.

$$PSNR = 20\log_{10}(MAX_I) - 10\log_{10}(MSE)$$

These measures give only the global idea of the images. Also when assessing the performance of image fusion techniques using above measurements, we require the knowledge of both original image and fused image.

B. MSE (Mean Square Error)

The mean square error of an image can be finding out by using the following formulae.

MSE = 1 mn I (i, j)-K(i, j)[]2

C. Entropy

Entropy is a statistical measure of randomness. It can be used to characterize the texture of the input image. Entropy is defined as

-sum (p.*log2 (p))

Where p contains the histogram counts returned from histogram of the image.

V. EXPERIMENTAL RESULT AND ANALYSIS

The following sequence steps explain the fusion of image with the performance analysis.

Step 1- Input images of CT and MRI. Totally two groups of images are used in analysis.

Step 2- Apply DWT method, DWT-DRT and DWT-DRT-SVD method on Both Datasets 1 and Datasets 2.and get the results as shown in Fig.6 (a), (b) and Fig.7 (a), (b).

Step 3-As show in Table I, Performance and compression is done using the two fusion performance assessment metrics, 1.PSNR and 2.MSE

Fig. 6(a). DWT Fused Image

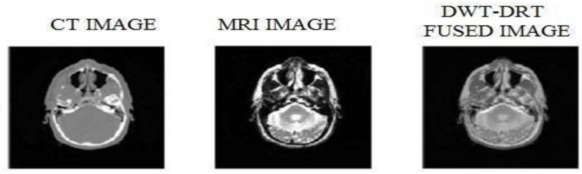


Fig. 6(b). DWT-DRT Fused Image

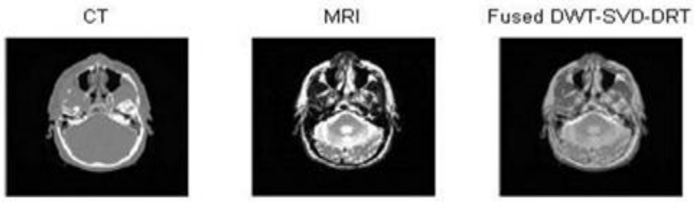


Fig. 6(c).DWT-SVD-DRT Fusion

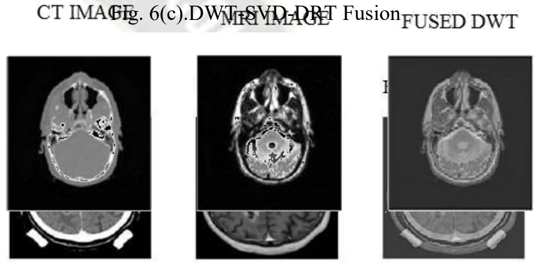
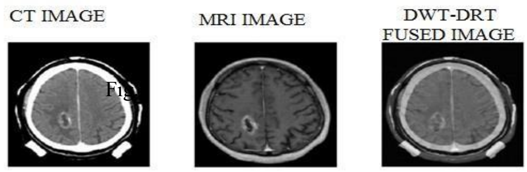


Fig. 7(a). DWT Fused Image



7(b). DWT-DRT Fused Image

Fig. 7(c).DWT-SVD-DRT Fusion

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TABLE I
PERFORMANCE

DATASETS	METHODS	CT IMAGES		MRI IMAGES	
		PSNR	MSE	PSNR	MSE
DATASET1	DWT	17.2698	1219.3	18.5227	913.7110
	DWT-DRT	20.5551	572.23	17.2508	1224.6
	DWT-SVD-DRT	20.4629	584.5067	17.4075	1181.2
DATASET2	DWT	15.7994	1710.6	14.6970	2204.9
	DWT-DRT	16.9966	1298.4	14.4097	2355.6
	DWT-SVD-DRT	17.3392	1199.9	14.2666	2434.5

By observing the data value of table, it is clear that the combination of DRT and DWT method give the better fused image.

VI.CONCLUSION

In this Paper, Medical Image Fusion has been performed using the combined effect of DWT, DRT and SVD. The quality of the fused images was evaluated using PSNR and MSE methods, each of which defines different criteria for image similarity. Experimental results show that the proposed Method successfully improves the fused image quality.

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