An Effective Multi-Focus Medical Image Fusion Using Dual Tree Compactly Supported Shear-let Transform Based on Local Energy Means

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Abstract - This paper presents an algorithm for the fusion of multi-focus medical images which is based on Dual tree compactly supported Shearlet transform using the local energy approach. The purpose of choosing such transform is due to its optimal representation of the vital features in an image like anisotropic features. This approach efficiently measures the most prominent features in images such as edges. It will results high visual quality image and the resultant image was evaluated by considering various quality metrics like Entropy, Standard Deviation, Sharpness and PSNR.

Keywords: Shearlet transform, Local Energy, Entropy, Standard Deviation, PSNR.

1. INTRODUCTION

The importance of image fusion is to extract the high visual quality image from the available degraded images, and one thing we have to remember is that the originality in the actual images must be preserved. The name image fusion is creating a lot enthusiasm and encouraging particularly in the field of medical image processing, remote sensing applications. Enormous research is going on this area and number of researchers had shown their interests and proposed a wide variety of algorithms to make the fused image as accurate as possible. Z. Yun [1] *et.al* proposed a image fusion algorithm based on Discrete Wavelet transform since it preserves different frequency information in stable form and allows good localization both in time and spatial frequency domain and it results PSNR of 30.1192dB. But the problem with DWT is its poor spectral resolution and due to lack of shift invariance, to overcome this Wirat Rattanapitak [2] *et.al* proposed an image fusion algorithm based on Discrete Stationary Wavelet transform and it results PSNR of 32.8650dB. Here, the main limitation of this approach is that the fused image considers most of the redundant information available in the source images. B. Yang [3] *et.al.,* proposed new algorithm based on Curvelets which deals effectively with line singularities in 2-D and it results a PSNR of 38.0612dB. But the problem with curvelets is that it results poor directionality at the edges of the image. B. S. Wang [4] *et.al.* proposed an algorithm based on Non sub-sampled Contourlet transform and it results the PSNR of 40.8101dB. Shi Cheng [5] *et.al* proposed an algorithm based on Shearlets, the motive to move towards Shearlets is that there is no restriction in the direction numbers which limits the Contourlet transform. But the application of such Shearlets is limited to image de-noising and edge detection. The Shearlet transform results PSNR of 45.9108dB but the problem with Shearlets is its time complexity in decomposition. Compactly Supported Shearlet transform (CSST) is very suitable for image fusion, but the conventional CSST, which is shift-variant, causes distortions in fused images. By embedding structure of dual-tree (DT) in the Compactly Supported Shearlet transform (CSST), the shift-variant properties can be effectively reduced and also the originality in the fused image can be maintained effectively.

2. DUAL TREE COMPACTLY SUPPORTED SHEARLET TRANSFORM

A Shearlet transform is a special case of the composite dilation wavelet transform. The process of image fusion in the CSST domain was done in an efficient manner, which includes all the directions regarding to the input images. The CSST approach considers the horizontal and vertical directional cones individually.

reconstruction steps of the compactly supported Shearlet transform (CSST) are given in Figure 1. The input function I(x) is firstly processed by dilation operations in vertical and horizontal cones directly in the spatial domain. The process of dual tree compactly supported Shearlet transform involves the steps image decomposition and image reconstruction. In the case of image decomposition, initially the image to be decomposed is split into horizontal and vertical directions using their corresponding cone orientations.

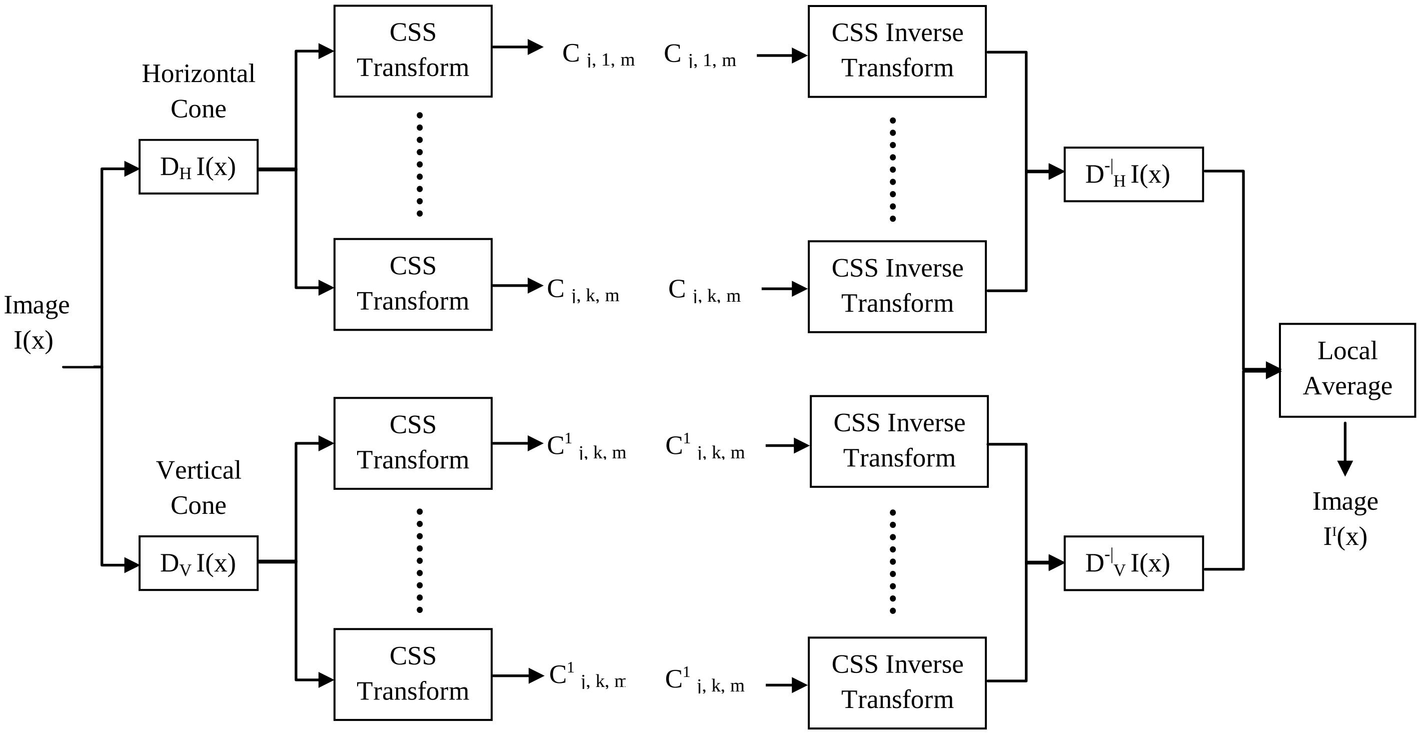


Figure 1. Image Decomposition and Reconstruction using Compactly Supported Shearlet Transform

A Shearlet transform is a special case of the composite dilation wavelet transform.

The dilation operation D_K is given as:

$$D_K\Psi(x) = \left|\det K\right|^{-1/2}\Psi(K^{-1}x) \ , \ M \in GD_d(\Re)$$

where M is the parameter of the dilation operation, $\Psi(x)$ is any function, and $GD_d(\Re)$ represents the group of d – dimensional invertible matrices defined on $\Re$.

The translation operation T_t is given as:

$$T_t\Psi(x) = \Psi(x-t) \ , \ t \in \Re$$

Cone-adapted Shearlets were introduced for the purpose of treating the different directions more equally, so the number of directions could be limited. The image decomposition and

Then the coefficients of the image in their corresponding directions are achieved by applying dual tree compactly supported Shearlet transform. The horizontally oriented cones will results real part coefficients of an image and the vertically oriented cones will results imaginary coefficients of an image.

On the other hand, that is in image reconstruction phase the real and imaginary coefficients we converted into spatial domain using the inverse transformation and finally all the reconstructed coefficients were accumulated as an image of more peculiar content.

3. PROPOSED METHOD

The image fusion process emphasizes the degree of accuracy in the fused image, and to meet this requirement certain procedure had to be followed.

The steps to be consider in the process of image fusion are,

i. Image Registration and Resizing
ii. Image Decomposition
iii. Local Energy (at the time of fusion)
iv. Image Reconstruction

The algorithm for image fusion using dual tree compactly supported Shearlet transform is as shown in Figure 2.

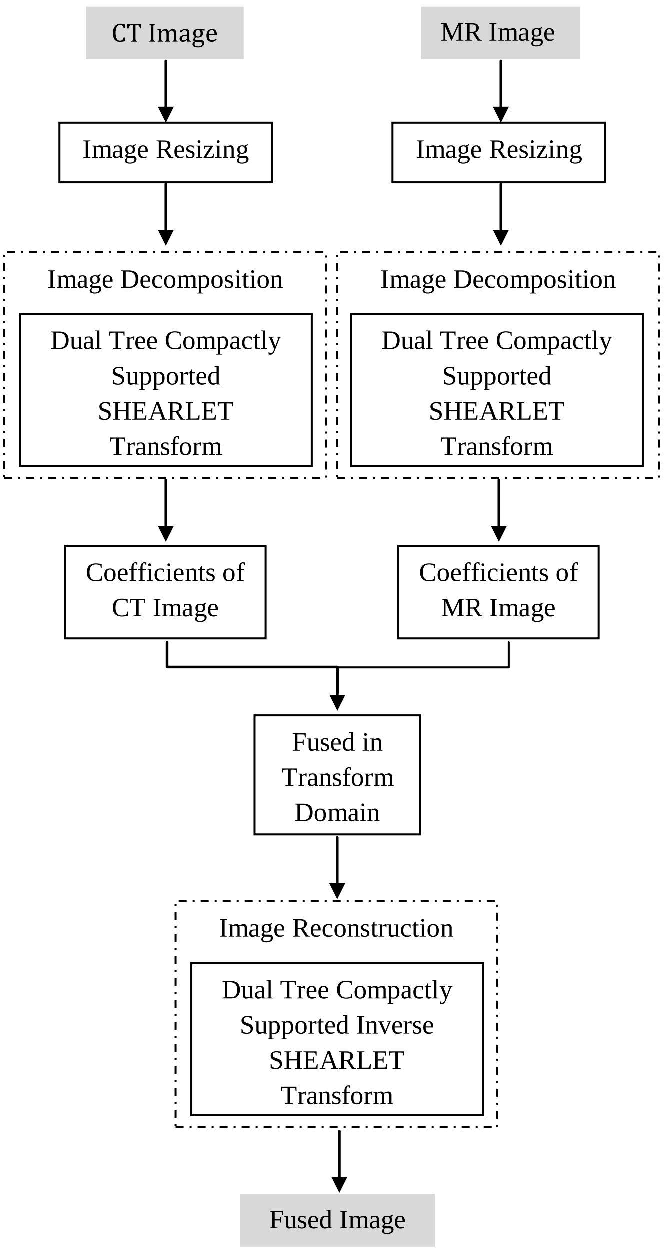


Figure 2. Process of Image Fusion

i. Image Registration and Resizing

Initially, the images which are going to be fused are must be registered and one more important point here is that registered images must be is of same size. The similarity in the sizes of the source image might give efficient results in terms of visual quality and it will be helpful in the decomposition and reconstruction steps.

ii. Image Decomposition

After resizing the source images, the image has to be decomposed. In the decomposition section by the application of dual tree compactly supported Shearlet transform coefficients of that particular images were extracted. These coefficients are the combination of both horizontal and vertical directional cones.

iii. PCA / Local Energy:

Principal component analysis (PCA) / Local Energy computation is a mathematical procedure which transforms a number of potentially correlated variables into a smaller number of uncorrelated variables called principal components. The objective of this approach is to reduce the dimensionality (the number of variables) of the dataset while retaining most of the original variability in the data. The first principal component accounts for the most of the variability in the data, and each succeeding component accounts for as much of the remaining variability as possible. Thus, PCA/Local Energy is concerned with explaining the variance and covariance structure of a high-dimensional random vector through a few linear combinations of the original component variables. A common way to find the principal components of a data set is by calculating the eigenvectors of the data covariance matrix. These eigenvectors give the directions in which the data distribution is stretched most. The projections of the data on the eigenvectors are the principal components. The corresponding eigen-values give an indication of the amount of information represented by the respective principal components.

iv. Image reconstruction

At the stage of image reconstruction the components which are selected by Local Energy Means or based on Principal Component Analysis approach, considers most desirable information content present in the source images. It is the most vital step in the process of image fusion, since in the image decomposition the source images are transformed from spatial domain to transform domain. Now, in order to convert this transformed domain images into spatial domain the process called image reconstruction should be applied. In the case of image reconstruction Dual tree compactly supported Inverse Shearlet transform was applied. This will be enabling the fused image to appear in terms of the enriched quality and also with much more information content.

4. COMPARISON OF DIFFERENT IMAGE FUSION TECHNIQUES

	ENTROPY	STANDARD DEVIATION	SHARPNESS	PSNR
PROPOSED METHOD	**6.7175**	**56.8997**	**21.9014**	**48.2838**
SHEARLETS	6.6303	44.4058	21.4188	45.1509
CONTOURLETS	6.1514	54.4706	20.8884	40.8101
CUVRVELETS	5.9189	52.1582	18.6654	38.0612
Discrete SWT	6.0528	45.0754	17.5806	32.8650
DT-CWT	5.8625	35.8754	17.0871	32.1753
DWT	5.9870	35.1490	16.9938	30.1192
PCA	5.8792	45.3889	17.2292	28.6018
AVERAGE	5.9868	34.9141	16.9935	28.0784

5.GRAPHICAL REPRESENTATION OF IMAGE FUSION TECHNIQUES

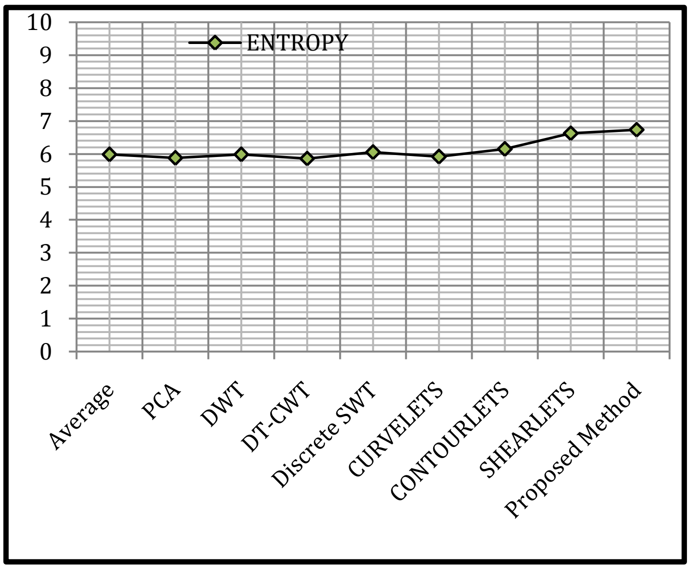


Figure 3. Graphical Representation of Entropy of various image fusion approaches

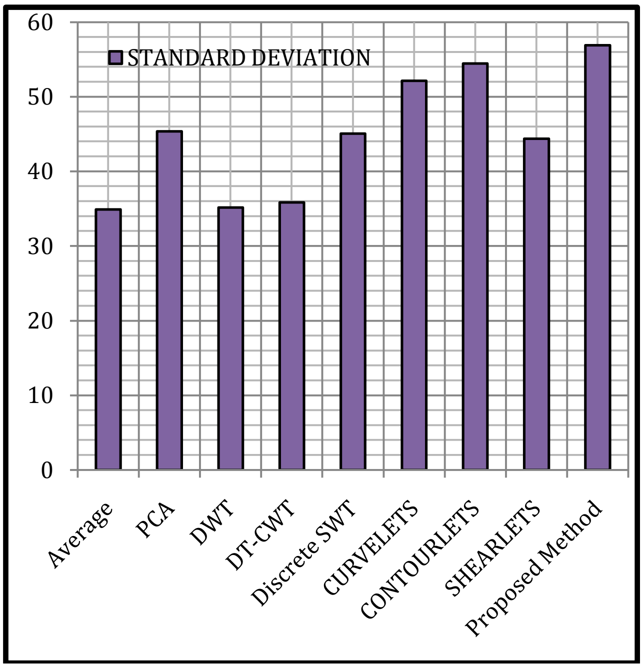


Figure 4. Graphical representation of Standard Deviation of various image fusion approaches

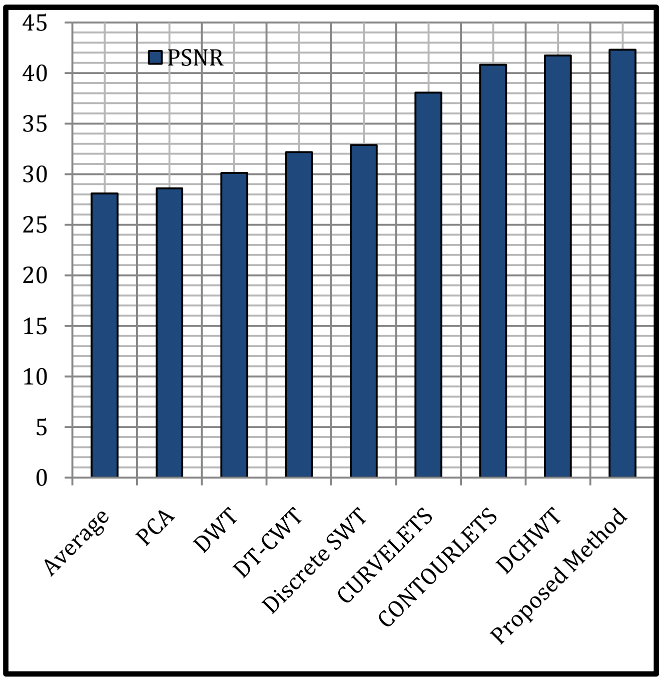


Figure 5. Graphical representation of PSNR of various image fusion approaches

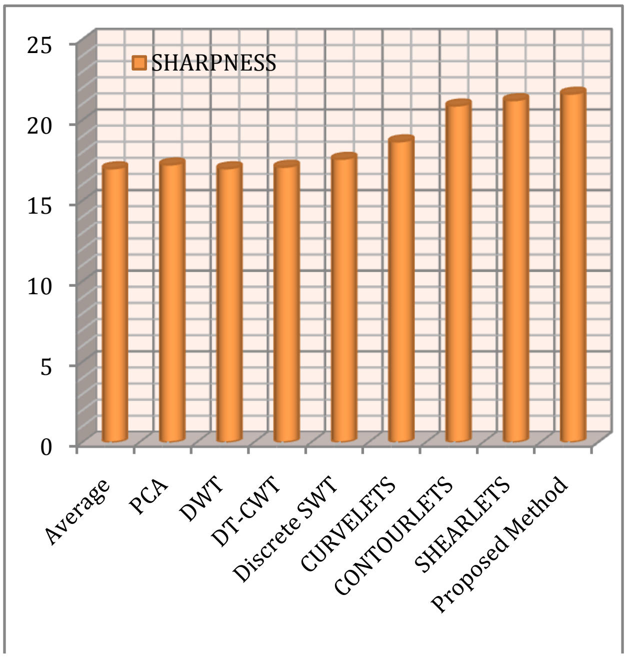
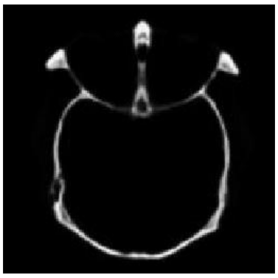


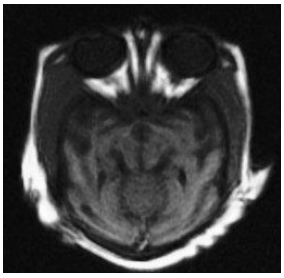
Figure 7. Graphical representation of Sharpness of various image fusion approaches

EXPERIMENTAL RESULTS

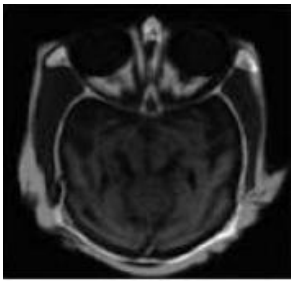
CT Image



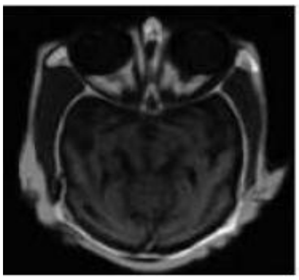
MR Image



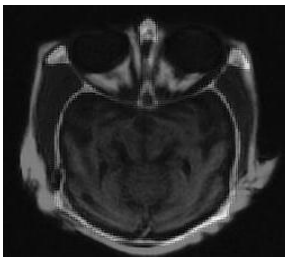
Simple Average



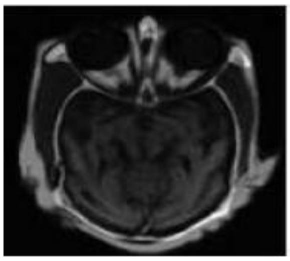
PCA



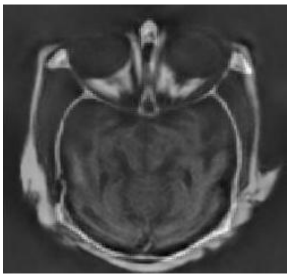
DWT



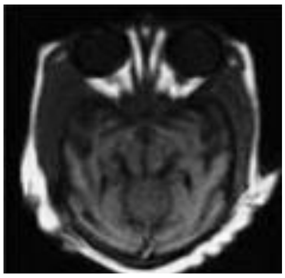
DT-CWT



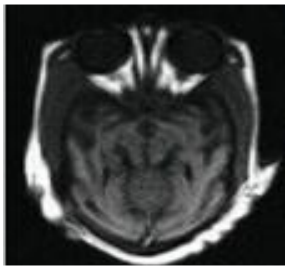
Discrete-SWT



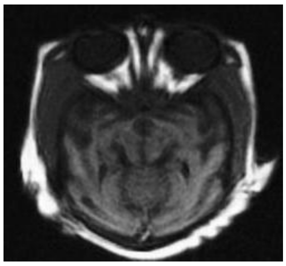
CURVELETS



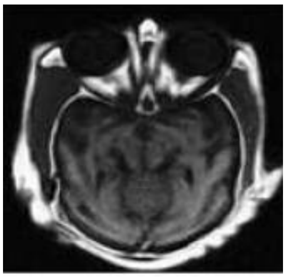
CONTOURLETS



SHEALETS



PROPOSED METHOD



CONCLUSION

In this paper, an image fusion technique is proposed based on the Dual Tree Compactly Supported Shearlet transform for multi-focus medical images like CT image and MR image. Through this approach we achieved much more acceptable results in terms of Entropy, Standard deviation, Sharpness and PSNR as compared to Simple Averaging method, PCA, DWT method, Un-decimated DWT method, DT-CWT method, Curvelet, Contourlet and Shearlet methods.

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BIOGRAPHIES

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