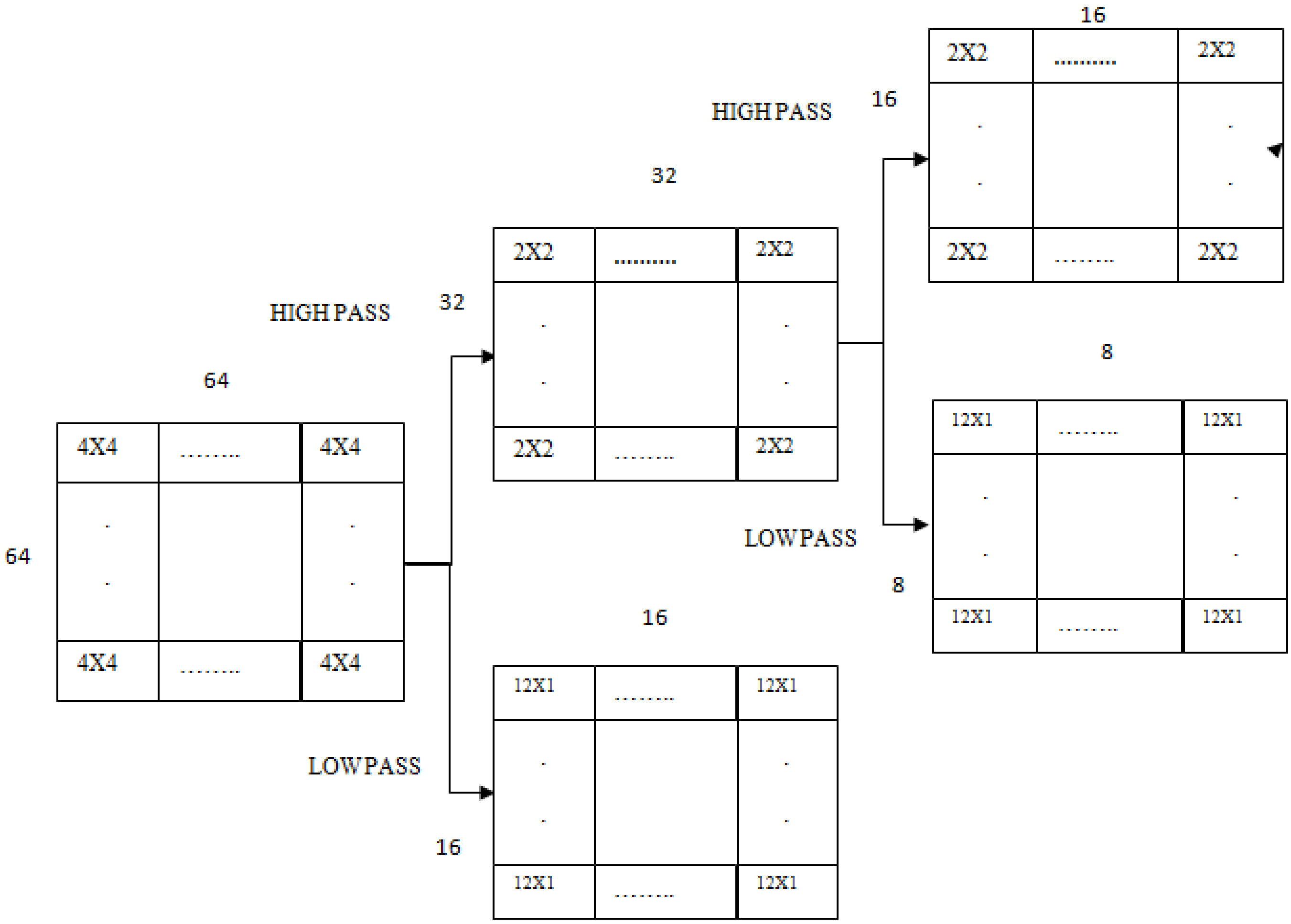


Figure 2: Diagram of Tetrolet decomposition algorithm

When we apply Tetrolet transform to an image $u=(u[i,j])_{i,j=0}^{N-1}$, where $N=2^J$ ($J \varepsilon$ N) so as to cover complete image by 4X4 tillings and apply the tetrolet transformation at J-1 levels. The algorithm is initialized by dividing the image into 4X4. The steps of the adaptive tetrolet transform algorithm are as follows:

a. The image is divided into 4 X 4 blocks.
b. Considering 117 solutions with tetrominoes segmentation, the Haar wavelet transform is applied to obtain 12 X 1 high-frequency coefficients and 2 X 2 low frequency coefficients in each block of every solution. The scheme with the lowest norm of the high-frequency coefficients is then selected as the optimal solution. If the lowest norm is not unique, the scheme whose index is lowest should be chosen as the optimal solution, resulting in a sparse representation in the tetrolet domain for each block.
c. The low-frequency coefficients of each block are rearranged into 2 X 2 blocks.
d. The high-frequency tetrolet coefficients are stored.
e. Steps a to e are repeated with the low-frequency tetrolet coefficients.

3. Proposed Image Fusion Algorithm

The proposed image fusion algorithm was implemented in the Tetrolet transform domain based on Global thresholding approach. The entire fusion algorithm was divided into four sub sections, those are

1) Image registration
2) Image Decomposition
3) Thresholding and Shrinkage
4) Image Reconstruction

The image fusion algorithm using Tetrolet transform based on Global threshing approach is as shown in figure 3.

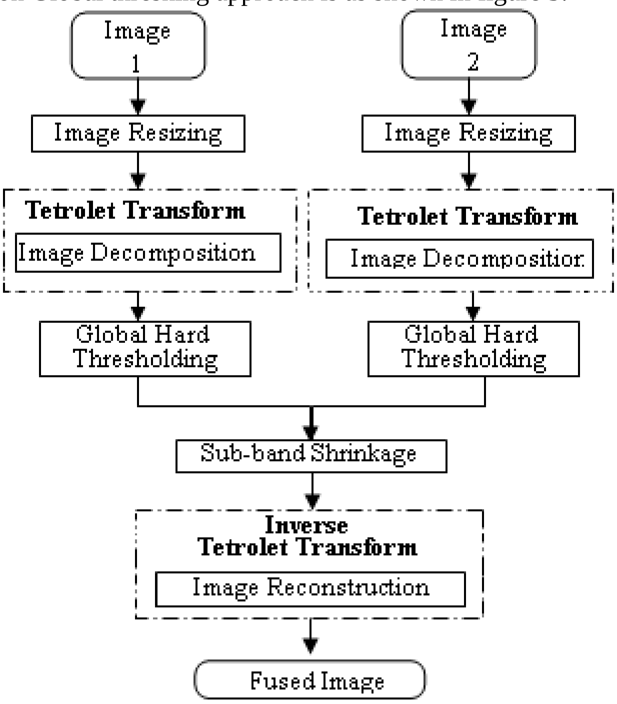


Figure 3: Image Fusion Algorithm in Tetrolet domain based on Global thresholding approach

i. Image Registration

The images which are to be fused must be registered first, for this purpose the source images are resized for effective and efficient measure of image fusion. Here, the noticeable point is that the image must be is same size.

ii. Image Decomposition

Now, the resized images are then decomposed by using Tetrolet transform. The purpose of decomposition is to extract the coefficients of source images those are low and high frequency components in the images. Here the thing is by simple averaging also we get fused image but it results less accuracy. In order to empower the accurate measurement we consider thresholding concept.

iii. Thresholding and Shrinkage rules

A major issue in the Tetrolet transform filtering process is to find an adequate threshold value. The commonly used threshold estimation criteria are Visu-Shrink (non-adaptive) Sure-Shrink (adaptive), Cross-Validation and Bayes-Shrink (adaptive). The shrinkage rule defines the applicability of a threshold. Some well-known shrinkage rules are hard and soft thresholding, hyperbola function, firm thresholding, garrote thresholding, SCAD thresholding. Most simple non-linear thresholding rules assume that the tetrolet coefficients are independent. However, it is observed that tetrolet coefficients of natural images have significant statistical dependencies.

iv. Image Reconstruction

In order to get back fused image Inverse Tetrolet transform was applied to the sub-band shrinkage coefficients. This process is termed as image reconstruction. The reconstructed image is free from the spectral degradations due to the facility provided by the soft thresholding.

4. Comparision of Medical Image Fusion

The proposed method performance was compared with the Tetrolet with Laplacian pyramid, Shearlets, Contourlets, Curvelets, Discrete Stationary wavelet transform [Discrete-SWT], Dual tree complex wavelet transform [DT-CWT], Discrete Wavelet transform [DWT], Principal Component Analysis [PCA] and Simple Average method. Comparison of different medical image fusion techniques is as shown in table1.

Table 1: Comparison of different medical image fusion techniques

Kind of Image Fusion Approach	*Entropy*	*Sharpness*	*PSNR*
Proposed Method	8.8615	20.9611	53.1663
TETROLETS with LP	8.2851	21.4188	48.0847
SHEARLETS	6.1851	20.5271	45.9108
CONTOURLETS	5.9189	18.9884	40.8101
CURVELETS	5.8625	18.6654	38.0612
Discrete SWT	6.0528	17.5806	32.8650
DT-CWT	6.1514	17.0871	32.7397
DWT	5.9870	16.9938	30.1192
PCA	5.8792	17.2292	28.6018
AVERAGE	5.9868	16.9935	28.0784

5. Graphical Representation of Various Image Fusion Approaches

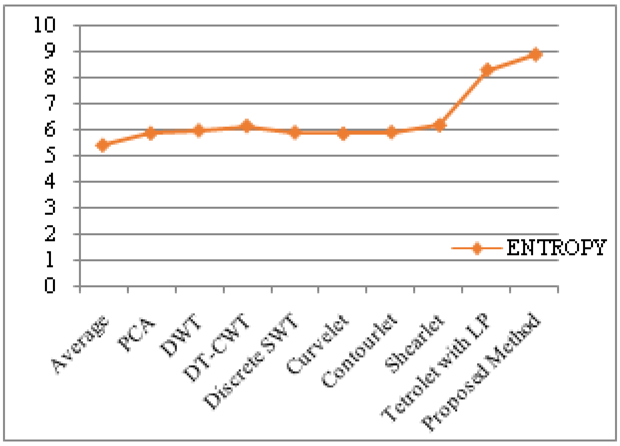


Figure 4: Graphical Representation of Entropy of various image fusion approaches

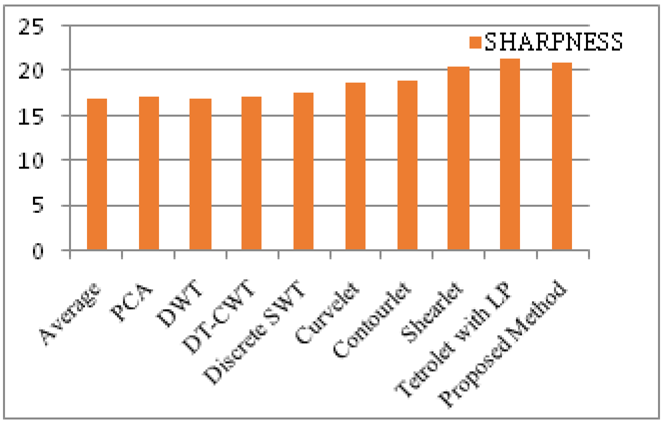


Figure 5: Graphical representation of Sharpness of various image fusion approaches

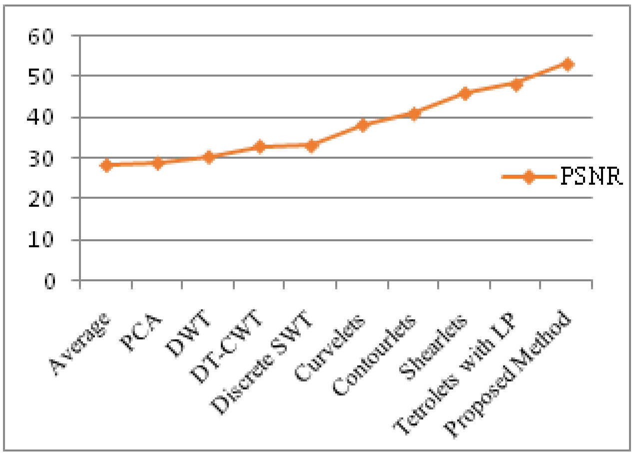
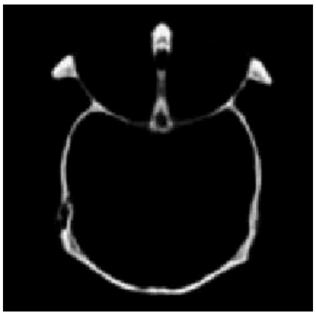


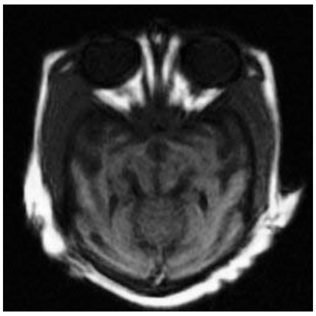
Figure 6: Graphical representation of PSNR of various image fusion approaches

6. Experimental Results

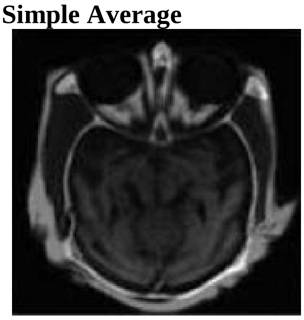
CT Image



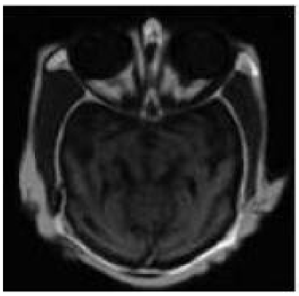
MRI Image



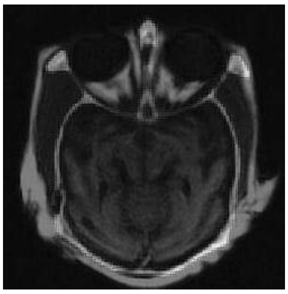
Simple Average



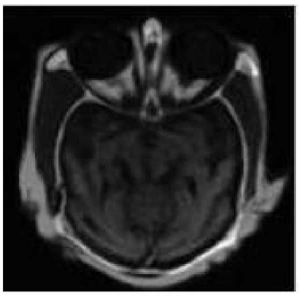
PCA



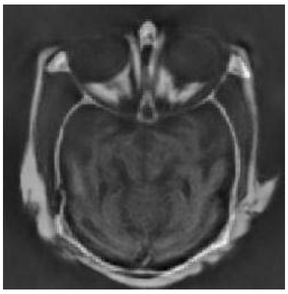
DWT



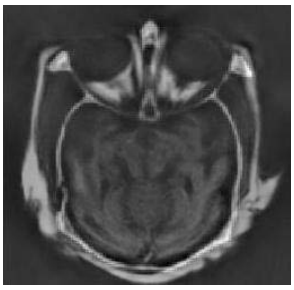
DT-CWT



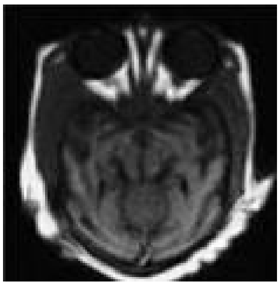
Discrete-SWT



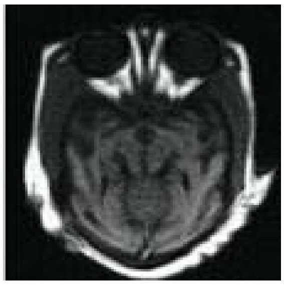
Curvelet Transform



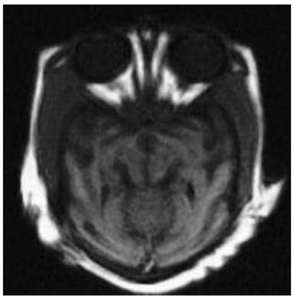
Contourlet Transform



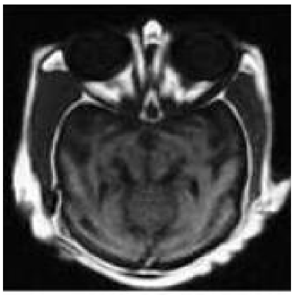
Shearlet Transform



Tetrolet with LP Method



PROPOSED METHOD



7. Conclusion

In this paper, an image fusion technique is proposed for multi-focused medical images of CT and MRI, which is based on Tetrolet transform with global thresholding approach. This paper compares the results with various image fusion algorithms like Simple Average method, PCA, DWT method, DT-CWT method, Discrete SWT method, Curvelet transform, Contourlet transform, Shearlet transform and Tetrolet with Laplacian pyramid. The resultant image had enriched quality in name of Entropy and PSNR.

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