

Multi-Focus Medical Image Fusion using Tetrolet Transform based on Global Thresholding Approach

K.L. Naga Kishore¹, G. Prathibha²

¹PG Student, Department of ECE, Acharya Nagarjuna University, College of Engineering & Technology, Guntur, AP, India

²Assistant Professor, Department of ECE, Acharya Nagarjuna University, College of Engineering & Technology, Guntur, AP, India

Abstract: In this paper Multi-focus medical image fusion algorithm based on the tetrolet transform with global thresholding approach was proposed. Tetrolet transform is successfully applied in the image de-noising, image sparse representation, and image restoration. In this paper, tetrolet transform was introduced into the field of medical image fusion since its sparse degree is high. Tetrolet can describe the geometric structural feature of the medical images very well. This paper compares the proposed image fusion algorithm to few similar image fusion algorithms based on the performance evaluation metrics like Entropy, Sharpness and PSNR.

Keywords: Tetrolet Transform, Global Thresholding, Entropy, Sharpness, PSNR

1. Introduction

The motto of image fusion is to obtain more detailed image from the several degraded images, particularly in the field of medical image processing systems where the details of an image must be understood visually. There is enormous research is going on particularly regarding to the enrichment of the clarity in the medical images, since such issue is becoming more important in area of diagnosis purpose. The fusion of images could be done in varieties of models but the thing is to get the fused image in an acceptable form. D.Peter [1] *et.al* proposed a image fusion algorithm based on Discrete Wavelet transform and it results PSNR of 30.1192dB. But the problem with DWT is its poor spectral resolution, to overcome this Somakait Udomhunsakul [2] *et.al* proposed an image fusion algorithm based on Discrete SWT 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. S.T. Li [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. Q.G. Mio [4] *et.al.* proposed an algorithm based on Non sub-sampled Contourlet transform and it results the PSNR of 40.8101dB. Li Weishing [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. Chang-Jiang Zhang *et.al.* [6] proposed a new algorithm based on Tetrolet transform with Laplacian pyramid approach and it results a PSNR of 48.0847dB. But the problem with Laplacian pyramid decomposition approach is that it results spectral degradations. In this paper, the problems with the available approaches can be cope up with the Tetrolet transform based on global thresholding approach.

2. Tetrolet Transform

In this paper, a new adaptive algorithm was introduced whose underlying idea is simple but enormously effective. The construction is similar to the idea of digital wedgelets where Haar functions on wedge partitions are considered. We divide the image into 4×4 blocks, and then determine in each block a tetromino partition which is adapted to the image geometry in this block. On these geometric shapes define Haar-type wavelets are defined, which form a local orthonormal basis. The corresponding filter bank algorithm decomposes an image into a compact representation. In order to obtain a compressed image suitable shrinkage procedure is applied to the Tetrolet coefficients of the image. Tetrominoes are shapes made by connecting four equal-sized squares, each joined together with at least one other square along an edge. Without considering rotation and mirroring, there are five basic tetrominoes which were shown below figure1.

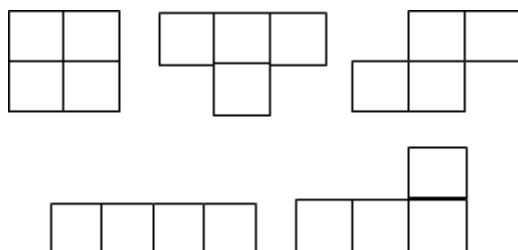


Figure 1: Basic Shapes of Tetrominoes

Every $N \times N$ image can be covered by the five basic tetrominoes. There are 117 solutions to cover a 4×4 image with tetrominoes [8]. Consequently, in order to handle the number of solutions, it is reasonable to divide an image into 4×4 blocks. Then using the classical Haar wavelet transform, which corresponds to a partition of the 4×4 block into squares, the optimal partition of the block into four tetrominoes, is computed by the geometry of the image. A Tetrolet decomposition diagram is as shown in figure 2.

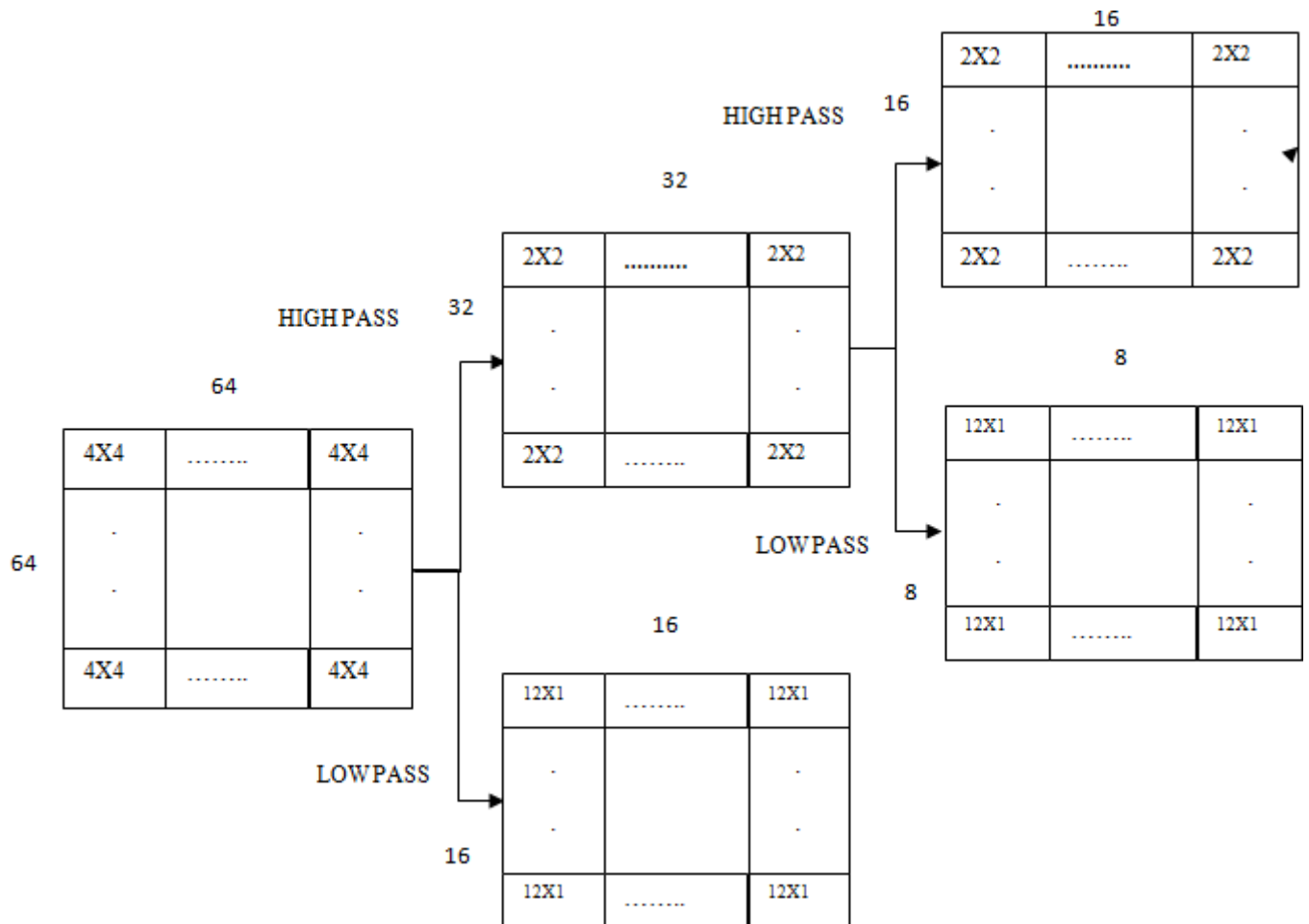


Figure 2: Diagram of Tetrolet decomposition algorithm

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

- The image is divided into 4×4 blocks.
- Considering 117 solutions with tetrominoes segmentation, the Haar wavelet transform is applied to obtain 12×1 high-frequency coefficients and 2×2 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.
- The low-frequency coefficients of each block are rearranged into 2×2 blocks.
- The high-frequency tetrolet coefficients are stored.
- 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 thresholding approach is as shown in figure 3.

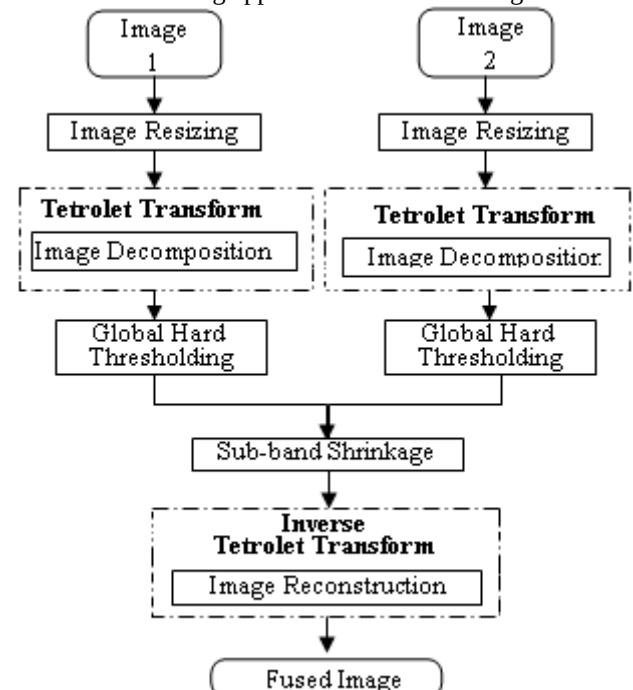


Figure 3: Image Fusion Algorithm in Tetrolet domain based on Global thresholding approach

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 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. Comparison 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

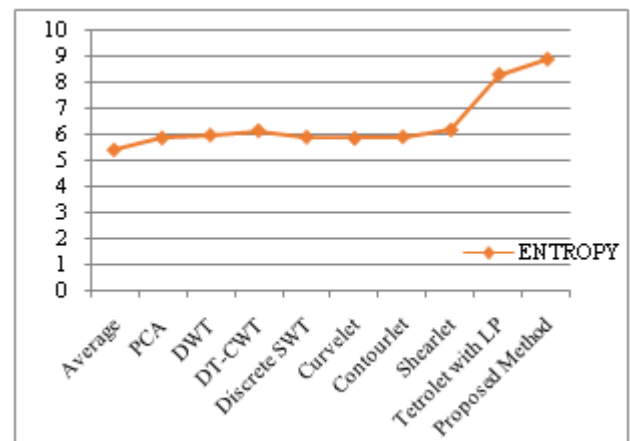


Figure 4: Graphical Representation of Entropy of various image fusion approaches

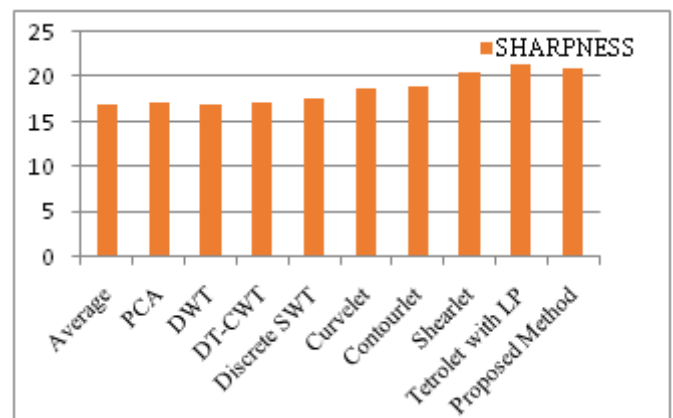


Figure 5: Graphical representation of Sharpness of various image fusion approaches

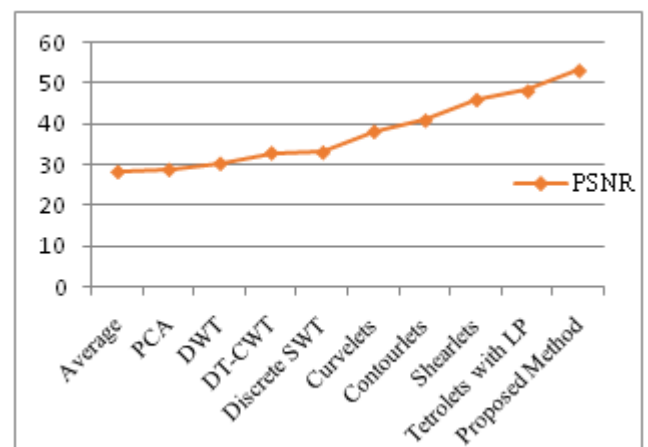
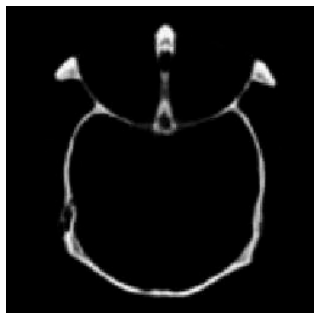


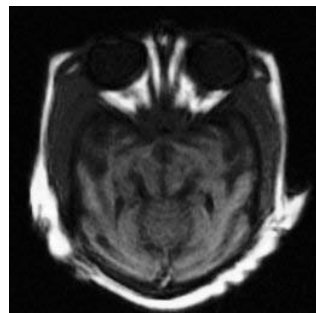
Figure 6: Graphical representation of PSNR of various image fusion approaches

6. Experimental Results

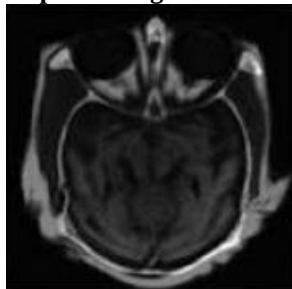
CT Image



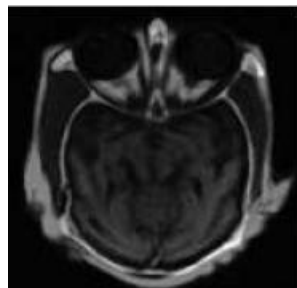
MRI Image



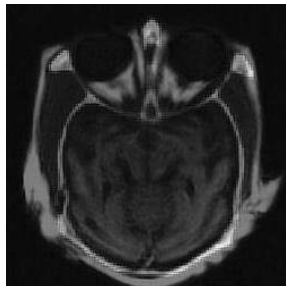
Simple Average



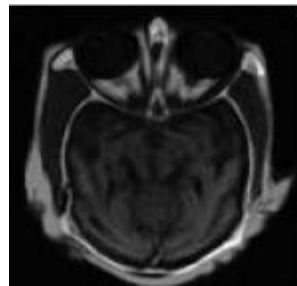
PCA



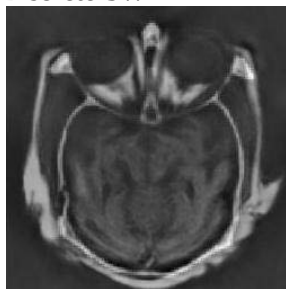
DWT



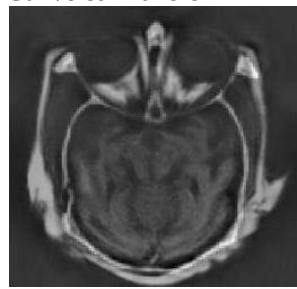
DT-CWT



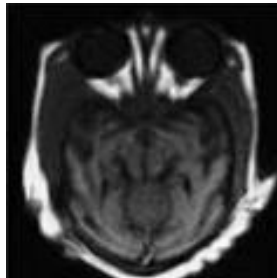
Discrete-SWT



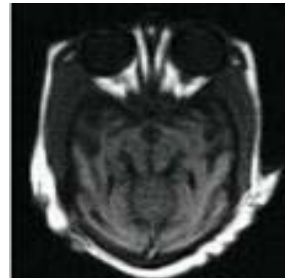
Curvelet Transform



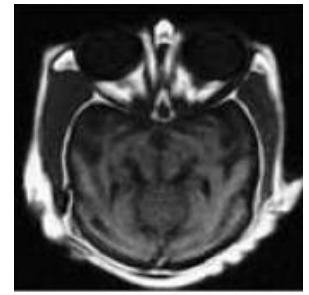
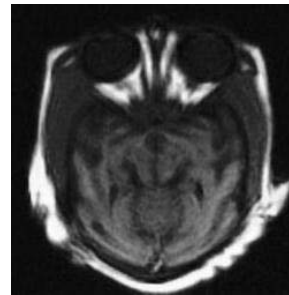
Contourlet Transform



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.

References

- [1] Krista, Z.Yun, D.Peter, Wavelet Based Image Fusion Techniques — An introduction, review and comparison, International Society for Photogrammetry and Sensing, 62(2007), pp: 249-263.
- [2] Pusit Borwonwatanadelok, Wirat Rattanapitak and Somkait Udomhunsakul, "Multi-Focus Image Fusion based on Stationary Wavelet Transform", 2009 International Conference on Electronic Computer Technology. 978-0-7695-3559-3/09 © 2009 IEEE
- [3] Li, S. T., and B. Yang. 2008a. "Multi-focus Image Fusion by Combining Curvelet and Wavelet Transform." Pattern Recognition Letters 29 (9): 1295–1301.
- [4] Miao, Q. G., and B. S. Wang. 2006. "Novel Image Fusion Method Using Contourlet Transform." In 4th International Conference on Communications, Circuits and Systems, Guilin, June 25–28, 548–552.
- [5] Miao Qiguang, Shi Cheng and Li Weisheng, "Image Fusion Based on Shearlets – New Advances in image Fusion: <http://dx.doi.org/10.5772/56945>
- [6] Chang-Jiang Zhang, Yuan Chen, Chunjiang Duanmu & Hua-Jun Feng - October 2014 " Multi-Channel Satellite Cloud Image Fusion in the Tetrolet transform domain" in International Journal of Remote Sensing-2014.
- [7] Peng, Z., L. B. Tang, B. J. Zhao, and G. Zhou. 2011. "Image Sparse Approximation Based on Tetrolet Transform." System Engineering and Electronics 33 (11): 2536–2539.
- [8] Krommweh, J. 2010. "Tetrolet Transform: A New Adaptive Haar Wavelet Algorithm for Sparse Image Representation." Journal of Visual Communication and Image Representation 21 (4): 364–374.
- [9] Ragheb, A.M., H. Osman, A. M. Abbas, S.M. Elkaffas, T. A. El-Tobely, S. Khamis, M. E. Elhalawany, M. E. Nasr, M. I. Dessouky, W. Al-Nuaimy, and F. E. Abd El-Samie. 2012. "Simultaneous Fusion and Denoising of

Panchromatic and Multispectral Satellite Images.”
Sensing and Imaging: An International Journal 13 (3–4):
119–141.

- [10] Peng, Z., L. B. Tang, B. J. Zhao, and G. Zhou. 2011.
“Image Sparse Approximation Based on Tetrolet
Transform.” System Engineering and Electronics 33
(11): 2536–2539.

Author Profile



Mr. K. L. NAGA KISHORE obtained **Diploma** in Electronics and Communication Engineering in Bapatla Polytechnic College, Bapatla in the year 2010. **B.Tech** degree in Electronics and Communication Engineering from VLITS, JNTU Kakinada in the year 2013. Presently he is pursuing **M.Tech** in Communication Engineering and Signal Processing from Acharya Nagarjuna University College of Engineering and Technology.. His interesting fields are Adaptive Signal Processing and Image Processing.



Mrs. G. PRATHIBHA obtained **B.Tech** degree from RVR&JC College of Engineering in the year 2005. **M.Tech** from JNTU Hyderabad in the year 2007. Currently she is working as Assistant Professor in Acharya Nagarjuna University College of Engineering And Technology, Guntur, A.P, INDIA. Her interesting fields are Pattern Recognition, Image Processing and Signal Processing