# Review On Medical Image Fusion Using Shearlet Transform

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**Abstract -** *Medical image fusion is the technique of registering and combining complementary information from two or more multimodality images into a single image to improve the imaging quality and reduce randomness and redundancy. The medical images can be particular organ focused by the different types of modalities which include X-ray, computed tomography (CT), magnetic resonance imaging (MRI), magnetic resonance angiography (MRA), and positron emission tomography (PET) images. The medical images fusion use in the diagnosing diseases, tumor tissues analysis and treatment plain strategies etc. Shearlets are a multiscale framework which allows to efficiently encoding anisotropic features in multivariate problem classes. One of the most significant properties of shearlets is the information that they provide optimally sparse approximations.*

***Key Words*: Image Fusion, Shearlet Transform, Multimodelity image, Image registration, CT/MRI images**

## 1.INTRODUCTION

Medical image fusion is the technique of registering and combining complementary information from two or more multimodality images into a single image to improve the imaging quality and reduce randomness and redundancy. The resulting image will be more informative than any of the input images. The medical images can be particular organ focused by the different types of modalities which include X-ray, computed tomography (CT), magnetic resonance imaging (MRI), magnetic resonance angiography (MRA), and positron emission tomography (PET) images. The medical images fusion use in the diagnosing diseases, tumor tissues analysis and treatment plain strategies etc. For example, fusing MR and CT images is a benefit for the operational results in computer assisted navigated neurosurgery of temporal bone tumors. PET/CT in lung cancer, MRI/PET in brain tumors, SPECT/CT in abdominal studies and ultrasound images/MRI for vascular blood flow. In recent years, multimodal medical image fusion algorithms have shown notable achievements in improving the accuracy of decisions based on medical images. This shows improvement in diagnosing and analysing diseases and its treatment. The popular fusion methods are based on multiresolution analysis, such as the discrete wavelet transform, stationary wavelet transform and contourlet transform.

The theory for multidimensional data has been developed recently to provide higher directional sensitivity than wavelets which is using in medical image analysis improvement.

Medical image fusion techniques generally involve the pixel level fusion techniques. The advantage of pixel fusion is that the images use to contain the original information. Shearlets are a multiscale framework which allows to efficiently encoding anisotropic features in multivariate problem classes. Originally, shearlets were introduced in 2006. The shearlet transform is unlike the traditional wavelet transform which does not possess the ability to detect directionality. One of the most significant properties of shearlets is the information that they provide optimally sparse approximations. An important advantage of the shearlet transform over the contourlet transform is that there are no restrictions on the direction numbers.

## 2. Shearlet Transform

Shearlets are a multiscale framework which allows to efficiently encode anisotropic features in multivariate problem classes. Originally, shearlets were introduced in 2006 for the analysis as well as sparse approximation of functions. They are a natural extension of wavelets to accommodate the fact that multivariate functions are typically governed by anisotropic features such as edges in images. However, wavelets as isotropic objects are not capable of capturing such phenomena.

Shearlets are constructed by parabolic scaling, shearing and translation applied to a few generating functions. At fine scales, they are essentially supported within skinny and directional ridges following the parabolic scaling law, which reads length$^2$ ≈ width. Similar to wavelets, shearlets arise from the affine group and allow a unified treatment of the continuum and digital situation leading to faithful implementations. They for a frame allowing stable expansions of arbitrary functions $f \in L^2(R^2)$.

The construction of continuous shearlet systems is based on parabolic scaling matrices $A_a = \begin{bmatrix} a & 0 \\ 0 & a^{\frac{1}{2}} \end{bmatrix}$ as a mean to change the resolution, on shear matrix $Ss = \begin{bmatrix} 1 & s \\ 0 & 1 \end{bmatrix}$.

Let $\psi 1 \in L^2(\mathbb{R})$ be a function satisfying the discrete Calderón condition, i.e., with

$$\sum_{j \epsilon Z} |\Psi_1 (2 - j\xi)|^2 = 1, \ \xi \epsilon \mathbb{R}$$

where $\psi_1$ denoted the Fourier transform of $\psi_1$.

With $\psi_1 \in C^\infty(\mathbb{R})$, supp $\psi_1 \subseteq [-1 / 2, -1/16] \cup [1/16, 1/2]$.

Furthermore, let $\psi_2 \epsilon\ L^2(\mathbb{R})$ be such that $\psi_2 \in C^\infty(\mathbb{R})$, supp $\psi_2 \subseteq [-1, 1]$ and

$$\sum_{k \epsilon \mathbb{Z}} \Psi_2(\xi + k)^2 = 1, \ \xi \in \mathbb{R}$$

One typically choose $\psi_2$ to be smooth function then

$$\psi(\xi) = \psi_1(\xi_1)\, \psi 2\, (\xi_2 / \xi_1)$$

where $\xi = \xi_1,\ \xi_2 \in \mathbb{R}^2$

The SH($\psi$) is called a classical shearlet constitutes a Parseval frame for $L^2(\mathbb{R})$ consisting of band-limited functions. It can be shown that the corresponding discrete shearlet system ( , $\psi$, $\psi$ ; $c$) , the frequency domain is divided into a low-frequency part and two conic regions

$$R = F^L = \{(\xi_1, \xi_2) \in \mathbb{R}^2 \mid |\xi_1| , |\xi_2| \le 1 \},$$

$$C^H = \{(\xi_1, \xi_2) \in \mathbb{R}^2 \mid \xi_2 / \xi_1| > 1 , |\xi_1| > 1\}$$

$$C^V = \{(\xi_1, \xi_2) \in \mathbb{R}^2 \mid \xi_1 / \xi_2| > 1 , |\xi_2| > 1\}$$

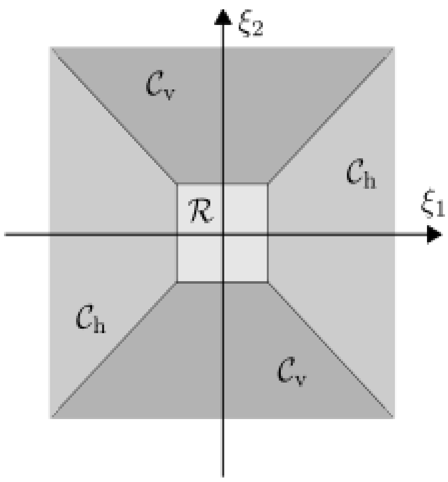


**Fig -1**: Decomposition of the frequency domain into cones.

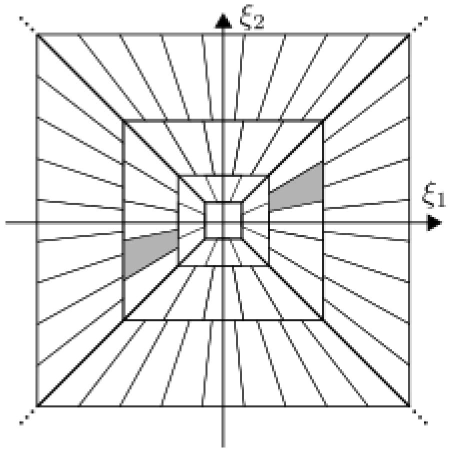


**Fig -2**: Frequency tiling of the cone-adapted shearlet system generated by the classical shearlet.

## 3. Algorithm of Proposed technique

The medical image fusion algorithm based on shearlet transform can be divided into three steps. These are decomposition, fusion rules and reconstruction of the registered images.

Image registration is the process of aligning two or more images of the same scene. This process involves designating one image as the reference (also called the reference image or the fixed image), and applying geometric transformations to the other images so that they align with the reference. It helps overcome issues such as image rotation, scale, and skew that are common when overlaying images. Image registration allows to compare common features in different images.

### 3.1 Decomposition

The registered image A (CT) and registered image B (MRI), respectively are decomposed with shearlet transform, and obtain the corresponding coefficients. Both horizontal and vertical cones are adopted in this method. Image decomposition is composed by two parts, decomposition of multi-direction (Kth directions) and J-level multi-scale wavelet packets.

### 3.2 Fusion Rule

The human feature visibility fusion scheme is used to perform the selection of shearlet low frequency coefficients. The concept of human feature visibility is introduced as a method to evaluate the quality of an image. The human visual feature is used to provide better details and conform to the human observer. Local mean intensity value of the image can be expressed as:

$$\mu^{(A\ or\ B)}(m, n) = \sum_{k,l \in W} W.\mathrm{Coff}_{sh}{}^{L,(A\ or\ B)}(m, n)$$

Where, W is a template of size k × l and satisfies the normalization rule.

After that the normalized weight $D^{L,A}$ and $D^{L,B}$ are calculated.

The fused image has the same energy distribution as the original input images. The coefficients of low frequency components for fused image F is shown below:

$$Coff_{sh}^{L,F} = Coff_{sh}^{L,A} .\ D^{L,A} + Coff_{sh}^{L,B} .\ D^{L,B}$$

Where, $Coff_{sh}^{L,A}$ and $Coff_{sh}^{L,B}$ represent low frequency coefficients of image A and B respectively.

Similarly, for the coefficients of the high-frequency, we calculate larger value of coefficients in shearlet domain means there is more high frequency information. Weights $^{H,A}$ and $D^{H,B}$ are calculated. Thus the coefficients of high frequency components in shearlet domain for fused image F is,

$$Coff_{sh}^{H,F} = Coff_{sh}^{H,A} .\ D^{H,A} + Coff_{sh}^{H,B} .\ D^{H,B}$$

### 3.3 Reconstruction

The modified fused coefficients are reconstructed by inverse shearlet transform to obtain fused image.

### 3.4 Block Diagram

The block diagram for Image Fusion based on Shearlet Transform is as shown below :

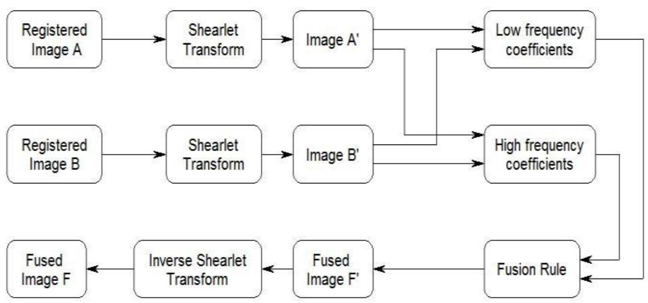


**Fig -3**: Block diagram for Image Fusion based on Shearlet Transform

The fusion of two source images as Image A (CT) and Image B (MRI) is as shown below

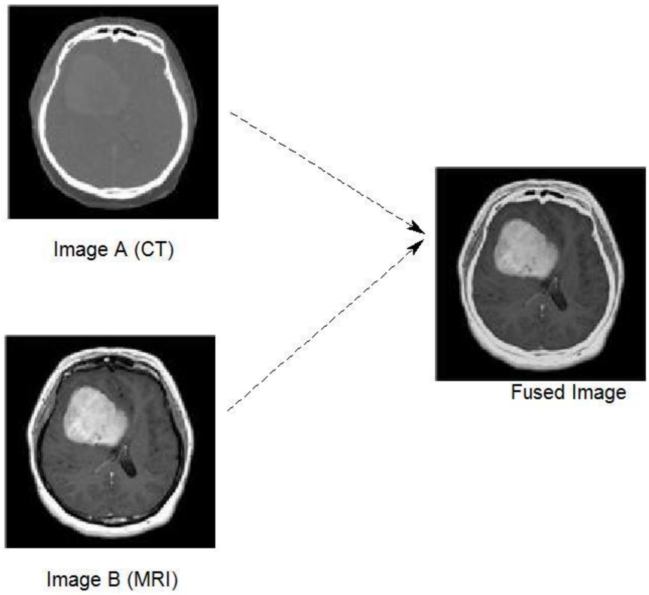


**Fig -4**: Medical image fusion

## 4. APPLICATIONS

The image fusion based on the shearlet transform has wide variety of applications in medical field as fusing MR and CT images is a useful for the operational results in computer assisted navigated neurosurgery of temporal bone tumors. PET/CT in lung cancer, MRI/PET in brain tumors, SPECT/CT in abdominal studies and ultrasound images/MRI for vascular blood flow. In addition to this image fusion based on shearlet transform has applications in remote sensing and in astronomy.

## 5. CONCLUSION

The medical image fusion algorithm using shearlet transform is an effective, efficient, and feasible algorithm. The image fusion based on the shearlet transform has wide variety of applications in medical. Shearlet transform possess the ability to detect directionality which is advantage over the traditional wavelet transform. One of the most significant properties of shearlets is the information that they provide optimally sparse approximations. An important advantage of the shearlet transform over the contourlet transform is that there are no restrictions on the direction numbers. Hence image fusion scheme based on shearlet transform will have wide applications in future like for 3D image fusion and in remote sensing.

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