Blocking based Medical Image Fusion using Multi-Resolution and Multi-Scaling Transform

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***Abstract*— Image Fusion is a process of combining the relevant information from a set of images into a single image, where the resultant fused image will be more informative and complete than any of the input images. Image fusion techniques can improve the quality. This paper uses MRI (Magnetic Resonance Imaging) and CT (Computed Tomography) images for fusion which contains complementary information helpful for diagnosis of disease. Proposed approach, medical image fusion based on the combined effect of Discrete Wavelet Transform (DWT) and Discrete Ripplet Transform (DRT). The images are initially transformed into multi-resolution image using DWT. The approximation images are further transformed using DRT. Then after ripplet coefficients are applied to Image Blocking method. The proposed method can be helpful for better medical diagnosis.**

***Index Terms* – Image Fusion, MRI Image, CT Image, Discrete Wavelet Transform (DWT), Discrete Ripplet Transform (DRT), Image Blocking.**

I. INTRODUCTION

Image Fusion is the process of generating better quality image from two or more input images. The resultant image should retain all important features of all input images [8].

The medical imaging field demands more complementary information for disease diagnosis purpose. However, this is not possible using single modality medical images as X-ray computed tomography (CT) is suited only for recognizing bones structure, MRI giving clear information about the soft tissues and so on. In this regard, medical image fusion is the only emerging technique which has attracted researchers to assist the doctors in fusing images and retrieving relevant information from multiple modalities such as CT, MRI, FMRI, SPECT, PET [8]. Here, two input images from different image modalities are shown Fig 1 and Fig 2 .First image is a Computed Tomography (CT) image and the second image is a Magnetic Resonance Imaging (MRI). Each image has its own limitation, which can be solved by creating the fused image from two different image modalities as shown Fig 3. This would lead to improved diagnosis, better surgical planning, more accurate radiation therapy and countless other medical benefits [9]. The main advantage of Image fusion (IF) is integrating complementary, as well as redundant information from multiple images to create a fused image for providing more complete and accurate information. Another advantage of image fusion is that it reduces the storage cost by storing only the single fused image, instead of the multisource images.

Fig 2. CT Image [9]

Fig 2. MRI Image[9]

Fig 2. MRI Image[9]

Image fusion method can be broadly classified into two groups – 1.Spatial domain fusion 2.Transform domain fusion.

Spatial image fusion methods work by combining the pixel values of the two or more images to be fused in a linear or nonlinear way [10]. This simplistic approach often has serious side effects. Pixel level image fusion methods are affected by

blurring effect which directly affect on the contrast of the image [10]. The limitations of Spatial Domain are resolved by Transform Domain.

In Transform Domain, Wavelet Transform is faster developed multi-resolution analysis image fusion method. The problem with Wavelet Transform (WT) is that, it can preserve spectral information efficiently but cannot express spatial characteristics well [4]. So Recently, a theory called Multi-scale Geometric Analysis has been developed. Many MGA tools were proposed, such as Curvelet, Contourlet, Ripplet etc. Which have higher directional sensitivity [1].

In this paper, Medical Image fusion is based on combining multi-resolution transform (DWT) and multi-scaling transform (DRT). It uses Image Blocking method.

II. Related Works

Review of literature survey has been conducted on evaluating the performance of Medical Image Fusion Using Combined Multi-Resolution and Multi-Scaling Transform. In this section describes the previous work which had been done for Image Fusion.

C.T.Kavitha ,C. Chellamuthu, R. Rajesh[1] proposed method using the combined effect of DWT and DRT. The DWT could detect local features of images. DRT had provide better advantage of directionality and localization, then PCCN was applied to low pass coefficients and maximum fusion rule was applied to fuse the approximation image. Proposed method had better clarity compared to DWT and PCNN methods.

Arathy Menon N.P, Arunvinodh C, Amritha Mary Davis[2] compared three transform based fusion rules,The Wavelet transform(WT), Contourlet transform(CT) and Non-subsampled contourlet transform(NSCT). Each technique having its own Pros and Cons depends on the application. All providing the good quality fused images. To evaluate the performance of the proposed image fusion approach, four different datasets of human brain are considered. The fusion technique is applied to image sets. Based on entropy experiments were carried out on four different groups of medical images and got comparable result. The fusion rules for low and high frequency coefficients give better performance. The low and high frequency fusions performed separately will provide more natural output with good visual quality. The wavelet and contourlet method suffer from less contrast and less visibility than NSCT.

Wang Xin , Li Yingfang[3] Proposed method has advantage of Contourlet transform and images blocking fusion algorithms, First in this the new image fusion method combined Contourlet transform and fusion-blocking. Contourlet transform fusion algorithm with a new designed fusion rule was used for the border part between the clear area and blurring one. The source image blocks, which were more similar to the corresponding initial fused image blocks, were chosen as the final fused image blocks. Used of new algorithm effectively overcome the translation invariance of Contourlet Transform and obtains a better visual effect.

Sudeb Das and Malay Kumar Kundu Senior Member[4] proposed multimodality MIF method based on ripplet transform using modified spatial frequency motivated PCNN. The DRT makes the fused images clearer and more informative. In the fused images the low frequency source sub-bands are fused using max selection rule, and PCNN is used to select the better coefficients from the decomposed source high frequency sub-bands. To improve the result, Modified spatial frequency is used as the image feature to motivate the PCNN. Results show that the more useful information in the fused image with higher spatial resolution and less difference to the source images.

K.Rajarshi, Ch.Himabindu[5] proposed a Wavelet transform algorithm to improve the quality and quantity of an image using DWT. DWT preserve more detail in source images and further improves the quality of fused image. Paper sows the comparison of the Proposed algorithm uses approximation and detailed layer fusion rules and the performance, with the multi-level local extrema(MLE) method .Several sets of medical images ware taken for analysis of method. Comparison was done using SSIM (structural similarity index), MI (mutual index), and PSNR (peak signal noise ratio) for quality evaluation with the existed method The results shows that the proposed method is efficient for fusion process. Reliability of fusion is achieved by this proposed algorithm, and also effective for multimodal medical image.

Morteza Ghahremani, Hassan Ghassemian[6] proposed a novel remote sensing image fusion method based on the ripplet transform and the compressed sensing (CS) theory. The ripplet transform generalizes the curvelet transform. The ripplet transform provide efficient representation of the HRP images. In the proposed method, the spatial details are first extracted from the PAN image by means of ripplets, and then, they are injected into the MS bands by CS-based injection. The quality measurements of the fused results carried out on two data sets IKONOS and QuickBird demonstrate that the proposed method provides better fused images in terms of the visual and quantitative evaluations. Ripplets with two adjustable parameters in the scaling law provide efficient representation of the HRP images.

Bhavana. V, Krishnappa. H.K[7] proposed a new fusion method for fusing PET and MRI brain images based on discrete wavelet transform with less color distortion and without losing any anatomical information. This method performs wavelet decomposition with four levels for low and high activity regions, respectively, in the PET and MRI brain images. Various inputs

and the results are taken to analyze its performance and accuracy. Metrics such as PSNR, MSE, SD and AG are the various measures which facilitate the qualification of some particular characteristics. Result shows that images have less color distortion and richer anatomical structural information than those obtained from the other existing fusion techniques. Visually and quantitatively brain images have less color distortion and richer anatomical structural information and high contrast is also achieved by this method. This method of image fusion gives promising results.

III. Discrete Wavelet Transform (DWT)

Discrete Wavelet Transform provide directional information in decomposition levels and contain unique information at different resolutions [1]. The fusion procedure can be described as follows.

Step 1: Input two source images, image I and image II to be apply as input for fusion.
Step 2: Perform separate wavelet decomposition of the two images
Step 3: Apply pixel based algorithm for approximations which involves fusion based on taking the maximum valued pixels from approximations of source images I and II.
Step 4: Based on the maximum valued pixels between the approximations from a binary decision map is formulated.
Step 5: The final fused image corresponding to approximations through maximum selection pixel rule is obtained.
Step 6: Combining fused approximations and details gives the new coefficient matrix.
Step 7: Applying inverse wavelet transform, we get the resultant fused image [2].

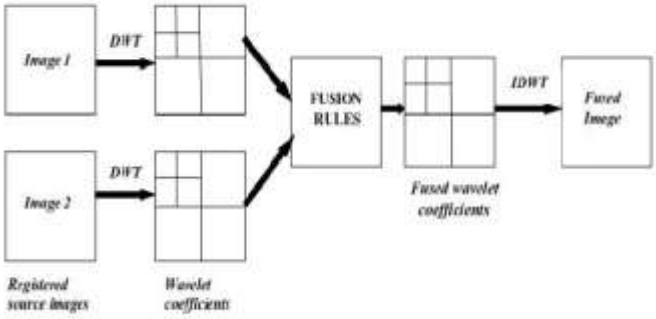

Fig.4 Block Diagram Of DWT based Image Fusion[2].

IV. Discrete Ripplet Transform (DRT)

The Conventional transforms like Fourier Transform and Wave Transform suffer from discontinuities such as edges and contours in images. To solve this problem, Jun Xu etal proposed a new MGA-tool called RT. 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 [11]. Visual and quantitative analysis shows, that the Ripplet Transform technique performs better compared to fusion scheme based on Contourlet Transform (CNT) [11]. 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 [11].

In DRT, a is sampled at dyadic intervals. $\vec{b}$ and θ are sampled at equal-spaced intervals. a_j, b_k and θ_l substitute a, $\vec{b}$ and θ respectively, and satisfy that $a_j = 2^{-j}$, $\vec{b}_k = [c \cdot 2^{-j} \cdot k_1 , 2^{-j/d} \cdot k_2]^T$ and $\theta_l = 2\Pi/c \cdot 2^{-[j(l-1/d)]} \cdot l$, where $k = [k_1,k_2]^T$, and j, k_1, k_2, l ∈ Z. $(\cdot)^T$ denotes the transpose of a vector. d ∈ R, since any real number can be approximated by rational numbers, so d can represent as d = n/m, n,m≠0 ∈ Z. Usually, n,m ∈ N and n,m are both primes. In the frequency domain, the corresponding frequency response of ripplet function is in the form

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

Where W and V satisfy the following admissibility conditions:

$$\sum_{l=-\infty}^{+\infty} \left|w(2^{-j}.r)\right|^2 = 1 \quad (2)$$

$$\sum_{l=-\infty}^{+\infty} \left|V\left(\frac{1}{c}\cdot 2^{-[j(1-1/d)]}\cdot\omega - l\right)\right|^2 = 1, \quad (3)$$

function in the frequency domain is

$$H_{j,l}(r,\theta) = \left\{2^j \le |r| \le 2^{2j}, \left|\theta - \frac{\pi}{c}.2^{-\left|j(1-\frac{1}{d})\right|}.l\right| \le \frac{\pi}{2}2^{-j}\right\} \quad (4)$$

$$R_{\vec{j},\vec{k},l} = \sum_{n_1=0}^{M-1}\sum_{n_2=0}^{N-1} f(n_1,n_2)\overline{\rho_{\vec{j},\vec{k},l}(n_1,n_2)} \quad (5)$$

$$\hat{f}(n1,n2) = \sum_{j}\sum_{\vec{k}}\sum_{l} R_{\vec{j},\vec{k},l}\rho_{\vec{j},\vec{k},l}(n1,n2) \quad (6)$$

where $R_{\vec{j},\vec{k},l}$ are the ripplet coefficients.
The image can be reconstructed through Inverse Discrete Ripplet Transform (IDRT)[11].

V. Proposed Medical Image Fusion Method

The step can be summarized as follows:
1. Take input images Like CT and MRI and register both these images so that the corresponding pixels are aligned means stay in the same magnitude.
2. Now apply DWT to input images, so that images are decomposed into four sub-bands. These sub-bands are one low frequency sub-band and three high frequency sub-band (LL,LH,HL,HH).
3. Then get wavelet coefficients from both input images (CT, MRI) which give high resolution and high spectral quality contents from input images.
4. After getting wavelet coefficients apply DRT transform to obtain ripplet coefficients and get initial Fused image F1.
5. Then apply Image Blocking method. In this method, divide CT, MRI and initial fused image into equi-sized square blocks.

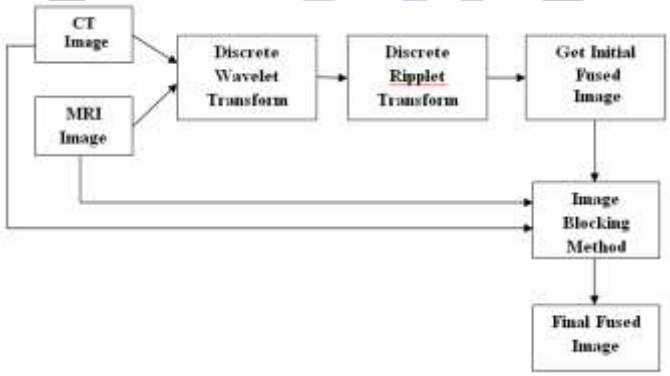

Fig.5 Block Diagram of proposed Image Fusion Method

whose size are same (m×n). Calculate the similarity measure values(SM) of the corresponding sub-blocks of CT, MRI and F1 respectively.

$$SM_{F_1MRI} = \frac{2\times\sum_{i=1}^{m}\sum_{i=1}^{n}F_1(i,j)\times MRI(i,j)}{\sum_{i=1}^{m}\sum_{i=1}^{n}[F_1(i,j)^2 + MRI(i,j)^2]} \quad (7)$$

$$SM_{F_1CT} = \frac{2\times\sum_{i=1}^{m}\sum_{i=1}^{n}F_1(i,j)\times CT(i,j)}{\sum_{i=1}^{m}\sum_{i=1}^{n}[F_1(i,j)^2 + CT(i,j)^2]} \quad (8)$$

The higher the value of SM indicates the high similarity of two images. If the similarity between the source image block and the initial fused image block is greater, the greater the probability is that the ultimate fused image blocks comes from the source image block[3].
6. Create Matrix S(r,c):

$$S(r,c)=\begin{cases}1 & SM_{F_1CT}(r,c) \ge SM_{F_1MRI}(r,c)\\ 0 & otherwise\end{cases} \quad (9)$$

Where M,N is the length and width of the source image. r=1,2,..,M/ m and c = 1,2,.., N/ n. r and c are actually the image block position coordinates in the image.
Check consistency on the S matrix, then get the final fused image F by the following calculation:
If S (r,c) =1 and the sum of each element in the S matrix entered at (r,c) of 3 × 3 area is equal to 9, then:

$$F(i,j)= F_{CT}(i,j) \quad (10)$$

Else if: S(r,c) =0 and the sum of each element in the S matrix centered at (r,c) of 3 × 3 area is equal to 0, then:

$$F(i,j)= F_{MRI}(i,j) \quad (11)$$

Else,

$$F(i,j)= F_1(i,j) \qquad (12)$$

And finally get fused Image[3].

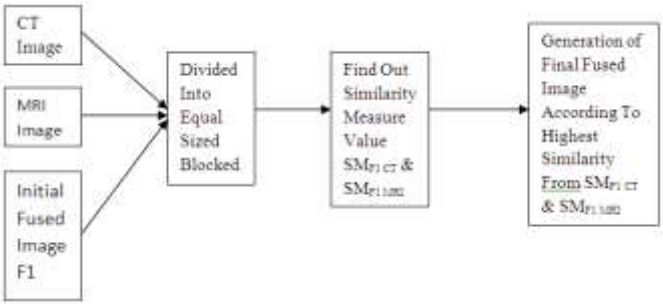

Fig.6 Block Diagram of Image Blocking Method

VI. CONCULSION

The proposed image fusion method based on combination of Discrete Wavelet Transform and Discrete Ripplet Transform can works efficiently for fusion of medical imaging applications. The Quality and Quantity of Fused Image can be measured based on the performance measure parameter like PSNR value, Entropy, NCC, etc. Performance measure parameters value must be increase, higher the value of the parameter means the better fusion result.

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