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A Novel NSCT Based Medical Image Fusion Technique

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ABSTRACT: *Image Fusion is a promising process in the field of medical imaging, the idea behind is to improve the content of medical image by combining two or more multimodal images. The resulting image will be more informative than any of the input images. The proposed fusion technique is based on non- subsampled pyramid and non-subsampled directional filterbanks which decompose the given image into LF & HF components. The core of the technique has two different fusion rules based on phase congruency and directive contrast which fuses the LF & HF components. Finally the fused image was obtained by applying inverse NSCT. Experimental results show that the fusion scheme is effective on multimodality images.*

KEYWORDS : *Image fusion, LF & HF components, multimodal images, non-subsampled pyramid, non-subsampled directional filter-bank.*

I. INTRODUCTION

Fusion (Also called synthesis) is the process of combining two or more distinct entities into a new whole. Image fusion is the process of combining relevant information from two or more images into a single image. The resulting image will be more informative than any of the input images. With rapid advancements in technology, it is now possible to obtain information from multi source images to produce a high quality fused image with spatial and spectral information. Image fusion is a mechanism to improve the quality of information from a set of images. Important applications of the fusion of images include medical imaging, microscopic imaging, remote sensing, computer vision, and robotics. use of the simple primitive technique will not recover good fused image in terms of performance parameter like peak signal to noise ratio (psnr), normalized correlation (nc), and mean square error (mse). Recently discrete wavelet transform (dwt) and principal component analysis (pca) techniques have been popular fusion techniques in image processing. These methods are shown to perform much better than simple averaging max and min. the purpose of this paper is to demonstrate an image enhancement technique for easy, rapid & effective mapping of investigating areas, separating the needed spectral information into one new component. Resultant image quality is superior to any of the input images.

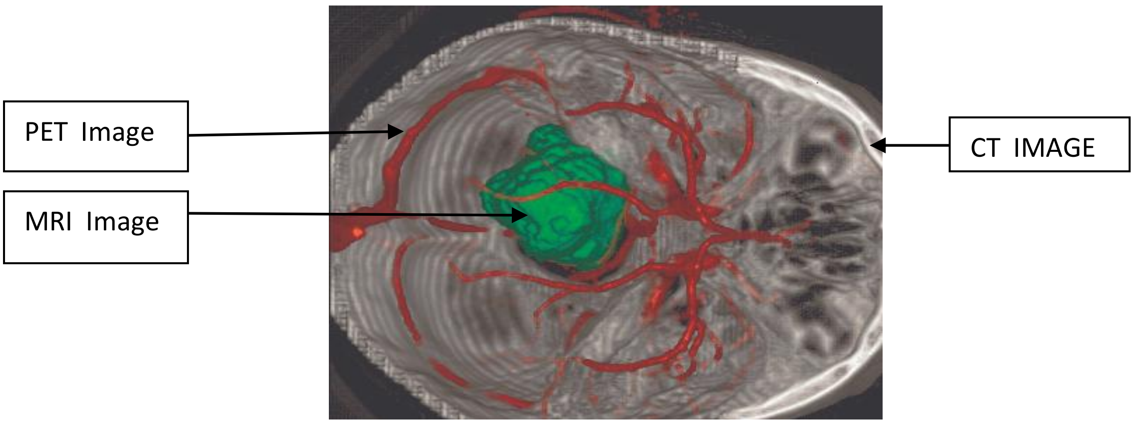


Fig. 1. Image Fuison For Skull Based Surgery Planning

The above figure illustrate the importance of image fusion in medical field. The above figure is the combination of three multimodal images CT, MRI & PET.

II. PROPOSED IMAGE FUSION TECHNIQUE BASED ON NSCT

Proposed image fusion technique is based on Non Sub-sampled Contourlet Transform method (NSCT), which is a shift-invariant version of the contourlet transform. The NSCT is built upon iterated non-subsampled filter banks to obtain a shift-invariant directional multiresolution image representation. The contourlet transform employs Laplacian pyramids for multiscale decomposition, and directional filter banks (DFB) for directional decomposition. To achieve the shift-invariance, the non-subsampled contourlet transform is built upon non-subsampled pyramids and non-subsampled DFB.

Non-subsampled Pyramids

The non-subsampled pyramid is completely different from the counterpart of the contourlet transform, the Laplacian pyramid. The building block of the non-subsampled pyramid is a two-channel non-subsampled filter bank as shown in Fig. 1. A non-subsampled filter bank has no down-sampling or up-sampling, and hence it is shift-invariant. The perfect reconstruction condition is given as

$$H0(z)G0(z) + H1(z)G1(z) = 1 \qquad (1)$$

This condition is much easier to satisfy than the perfect reconstruction condition for critically sampled filter banks, and thus allows better filters to be designed.

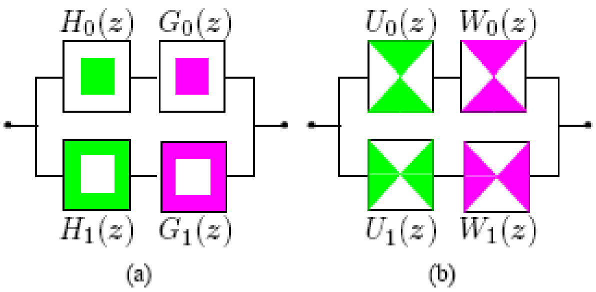


Fig. 2. Ideal Frequency Response Of The Building Block Of:

(A) Non-subsampled Pyramid (B) Non-subsampled DFB.

The ideal frequency response of the building block of the non-subsampled pyramid is given in Fig. 2. To achieve the multiscale decomposition, we construct non-subsampled pyramids by iterated non-subsampled filter banks. For the next level, we up-sample all filters by 2 in both dimensions. Therefore, they also satisfy the perfect reconstruction condition. Note that filtering with the up-sampled filter H(zM) has the same complexity as filtering with H(z). The cascading of the analysis part is shown in Fig. 2. The equivalent filters of a k-th level cascading non-subsampled pyramid are given by

$$H_n^{eq}(z) = \begin{cases} H_1(z^{2^{n-1}}) \prod_{j=0}^{n-2} H_0(z^{2^j}) & 1 \leq n < 2^k \\ \prod_{j=0}^{n-1} H_0(z^{2^j}) & n = 2^k \end{cases}, \qquad (2)$$

where z^j stands for $[z_1^j, z_2^j]$. These filters achieve multiresolution analysis as shown in Fig. 2.

Non-subsampled Directional Filter Banks

The non-subsampled DFB is a shift-invariant version of the critically sampled DFB in the contourlet transform. The building block of a non-subsampled DFB is also a two-channel non-subsampled filter bank. However, the ideal frequency response for a non-subsampled DFB is different, as shown in Fig. 1(b). To obtain finer directional decomposition, we iterate non-subsampled DFB’s. For the next level, we up-sample all filters by a quincunx matrix given by

$$\mathbf{Q} = \begin{pmatrix} 1 & 1 \\ 1 & -1 \end{pmatrix}. \qquad (3)$$

The frequency responses of two up-sampled filters are given

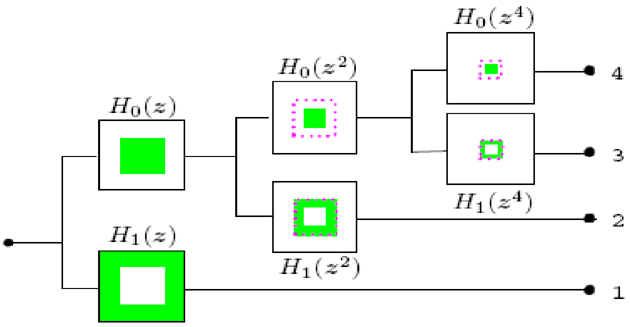


Fig. 3. Iteration of Two-Channel Non-subsampled Filter Banks in the Analysis Part of a Non-subsampled Pyramid.

Non-subsampled Contourlet Transform

The non-subsampled contourlet transform combines non-subsampled pyramids and non-subsampled DFB's as shown in Fig. 6. Non-subsampled pyramids provide multiscale decomposition and non-subsampled DFB's provide directional decomposition.

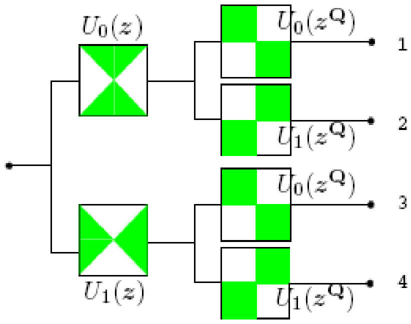


Fig. 4. The Analysis Part Of An Iterated Non-subsampled Directional Filter Bank.

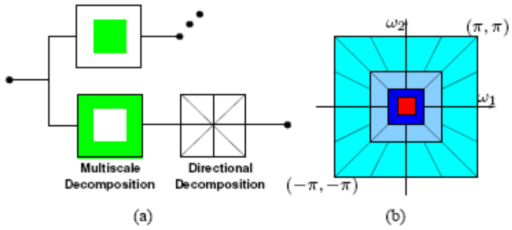


Fig. 5. The Non-subsampled Contourlet Transform Block Diagram.

(a) Non-subsampled Pyramid Split the Input into a Low pass Sub-band and a High pass Sub-band.

A Non-subsampled DFB Decomposes the High pass Sub-band into several directional sub-bands. The scheme is iterated repeatedly on the low pass sub-band.

(b) Resulting frequency division, where the number of directions is increased with frequency.

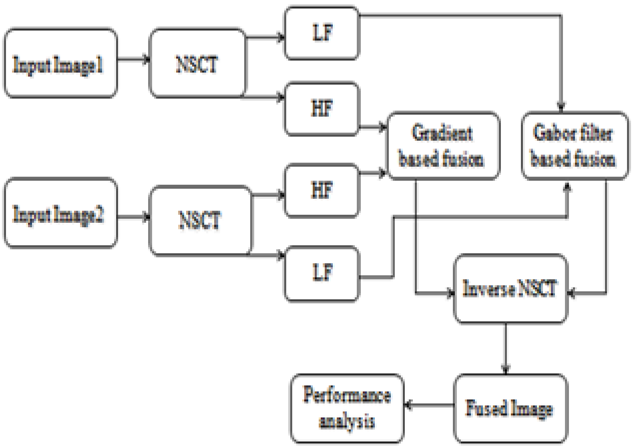


Fig. 6. Block diagram of multimodal medical image fusion

III. PROPOSED IMAGE FUSION ALGORITHM

The proposed Image fusion method using NSCT is summarized in the following steps.

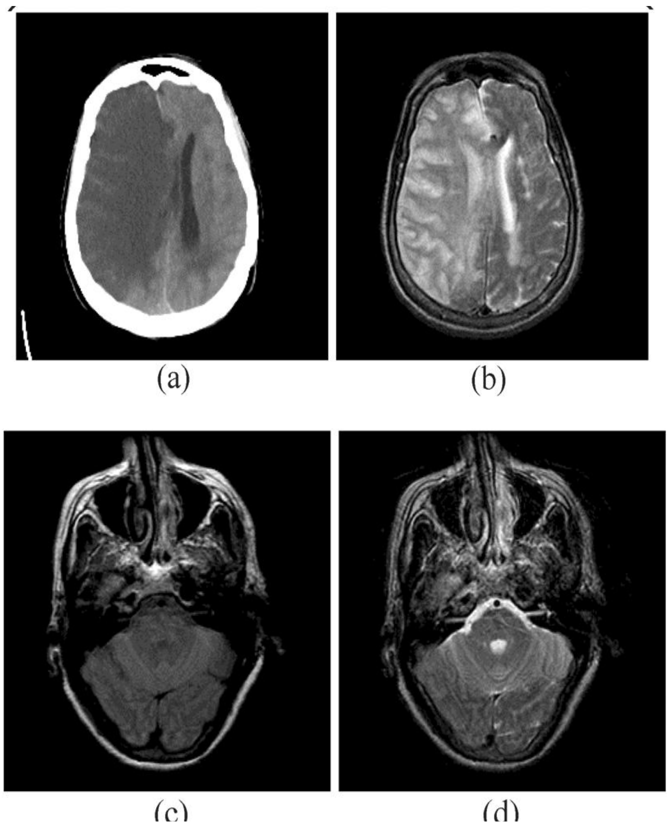
Step 1: Compute the NSCT of input image for N levels based on Non-subsampled pyramid & Non-subsampled directional filterbanks.

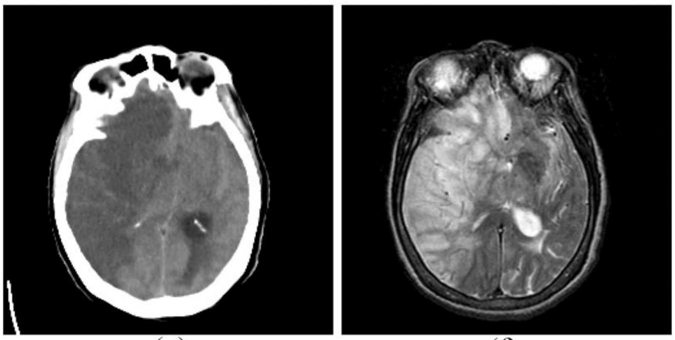
Step 2: Now the image is decomposed into LF & HF components.

Step 3: Two different fusion rules based on phase congruency & Directive contrast are used to fuse low frequency & High frequency components.

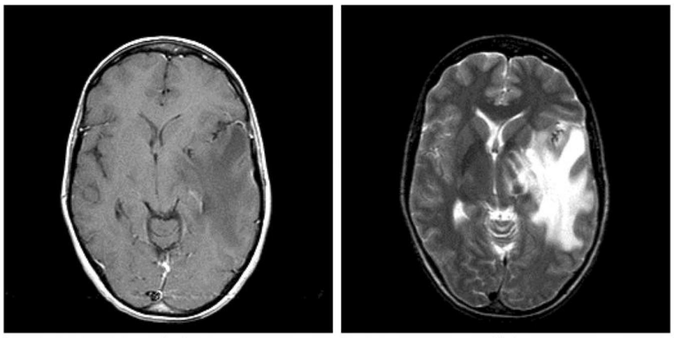
Step 4: Finally the fused image is obtained by inverse NSCT.

IV. RESULTS & VERIFICATIONS





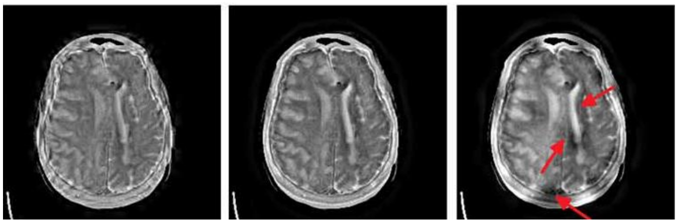
(e) (f)



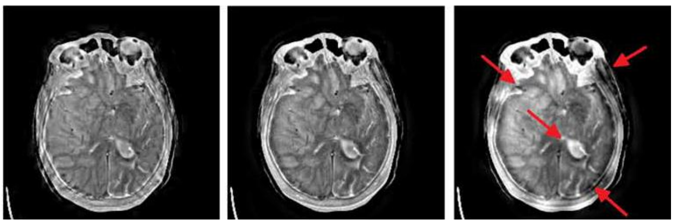
(g) (h)

FIG. 7. MULTIMODAL MEDICAL IMAGE DATA SETS: (A), (E) CT IMAGE (B), (F) MRI IMAGE (C), (G) MR-T1 IMAGE (D), (H) MR-T2 IMAGE

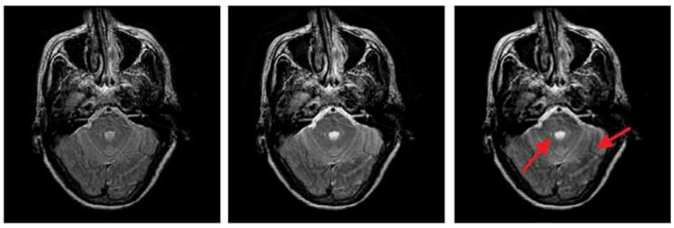
PCA WAVELET NSCT



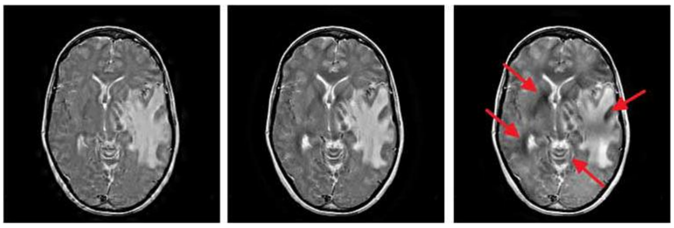
(I) FUSED OUTPUT IMAGE OF (A) & (B)



FUSED OUTPUT IMAGE OF (E) & (F)



FUSED OUTPUT IMAGE OF (C) & (D)



FUSED OUTPUT IMAGE OF (G) & (H)

Performance measures are essential to measure the possible benefits of fusion and also used to compare results obtained with different algorithms.

a. Peak Signal to Noise Ratio

The PSNR is use to calculate the similarity between two images. The PSNR between the reference image R and the fused image F is defined as

$$PSNR = 10 \times log_{10} \left(\frac{255}{RMSE}\right) \tag{4}$$

For better fused image PSNR value should high.

b. Normalized Cross Correlation

The Normalized Cross Content between the reference image and the fused image F is defined as

$$NCC = \sum_{i=1}^{m} \sum_{j=1}^{n} R_{ij} * F_{ij} \quad / \sum_{i=1}^{m} \sum_{j=1}^{n} R^2 \tag{5}$$

c. Entropy (EN)

Entropy is used to calculate the amount of information. Higher value of entropy indicates

$$E = \sum_{i=0}^{l-1} p_i \, log_2 \; p_i \tag{6}$$

TABLE I

Comparison of Different Image Fusion Techniques

S.NO	FUSION TECHNIQUE	DOMAIN	MEASURING PARAMETER	ADVANTAGE	DISADVANTAGE
1	Simple Average	Spatial	PSNR= 46.66 NCC= 0.95 EN=7.4122	Simple to implement	High information loss
2	PCA	Spatial	PSNR= 66.66 NCC= 0.96 EN=7.4128	Simple algorithm	Presence of spectral degradation
3	DWT	Transform	PSNR= 66.66 NCC= 0.97 EN=7.4244	Better Signal to noise ratio	Less spatial Resolution
4	SVD	Transform	PSNR= 70.44 NCC= 0.98 EN=7.4216	Robust, simple, fast to implement, efficiency is more even in the presence of noise	Efficiency is still improved if noise is reduced

V. CONCLUSION

A novel NSCT-based image fusion algorithm has been proposed. It constructed multiple input images as low frequency and high frequency components and can evaluate the quality of image patches using phase congruency and directional filter bank. Then, it employs LF fusion rule, HF fusion rule & inverse NSCT to obtain the fused result. Finally, experimental results show that the proposed transform domain algorithm is an alternative image fusion approach.

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