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A Novel Approach For Medical Image Fusion Based On NSCT Theory

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Abstract

In medical application the multimodal image fusion is an important tool. It has developed with the advent of various imaging modalities in medical imaging. It is mostly used for the medical diagnosis. In this proposal a novel fusion technique is proposed for the multi modal medical image based on the NSCT (non-sub sampled Contourlet transform). In this algorithm high frequency and low frequency components are fused by using fusion rules. In this project the two different fusion rules based on phase congruency and 'averaging' method is proposed. Finally the fused image is reconstructed by using the inverse NSCT with all coefficients. Simulation results show the proposed frame work provides the better and effective analysis of multimodal fusion. Simulation is done using MATLAB.

KEYWORDS: NSCT, Image fusion, Phase congruency

I. INTRODUCTION

In the recent years, medical imaging has attracted increasing attention because of its essential role in health care. However, differing kinds of imaging techniques like X-ray, X-raying (CT), magnetic resonance imaging (MRI), magnetic resonance angiography (MRA), etc., give restricted details wherever some is common, For instance, X-ray and X-raying (CT) will give dense structures like bones and implants with less distortion, however it cannot observe physiological variations [1]. Similarly, traditional and pathological soft tissue is highly pictured by tomography image whereas PET is to give higher information on blood flow and flood activity. As a result, the anatomical and useful medical pictures are to be combined for a compact reading. For this purpose, the multimodal medical image fusion has been known as a promising answer that aims to desegregation data from multiple modality pictures to get a additional complete and correct description of a similar object.

Multimodal medical image fusion not solely helps in identification diseases, however it additionally reduces the storage price by reducing storage to one consolidated image rather than multiple-source pictures. So far, intensive work has been created on image fusion technique [2]-[9] with varied techniques dedicated to multimodal medical image fusion [10]-[13]. These

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techniques are classified into 3 classes consistent with merging stage. These embody decision level, pixel level and feature level fusion wherever medical image fusion sometimes employs the pixel level fusion thanks to the advantage of containing the first measured quantities, simple implementation and computational potency .Hence, during this paper; we tend to concentrate our efforts to pixel level fusion.

In this paper, a completely unique fusion framework is planned for multimodal medical pictures supported non-sub sampled contourlet remodel. The core plan is to perform NSCT on the supply pictures followed by the fusion of low- and high-frequency coefficients. The phase congruency and 'averaging' measure are the fusion rules for low- and high-frequency coefficients. The phase congruency (PC) provides a brightness-invariant and contrast-invariant illustration of low-frequency coefficients whereas 'averaging', with efficiency determines the frequency coefficients from the clear components within the high-frequency. The unification of those 2 will preserve additional details in supply pictures and improve the standard of consolidated image. Further, visual and mensuration show that the planned framework provides a much better fusion outcome in comparison to traditional image fusion techniques.

The paper continued as II NSCT description, III Rules employed in fusing frequencies and IV proposed fusion framework, in V Results, and in VI conclusion.

II. NSCT

NSCT [13] is advancement in the CT(Contourlet Transforms), with an added quality of Shift-invariance. This is deployed eliminating down samplers used in the filter banks of NSCT framework

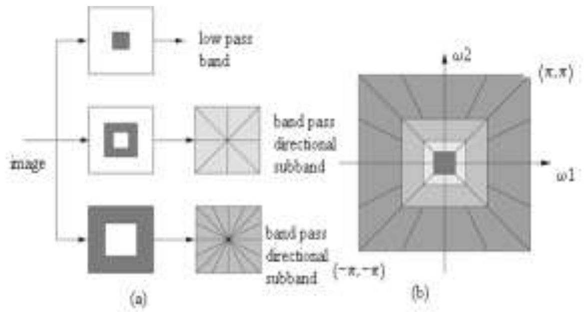


Fig.1. NSCT (a) NSCT implemented using NSFB structure (b) Frequency divisions attained with NSCT.

NSCT is sequence of steps,

Step1, NSP, ensuring 'multi scalability', pyramid that is non-sub sampled.

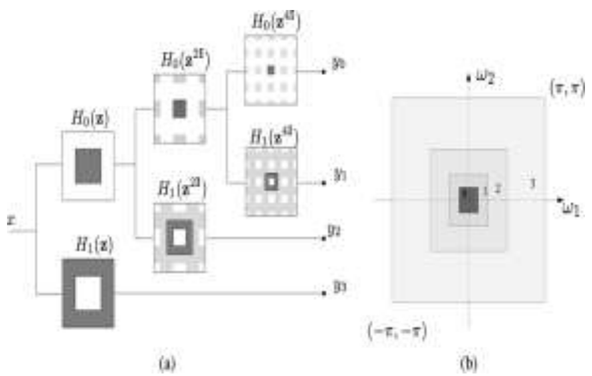


Fig.2 NSP decomposition with three-stages

At each decomposition level of NSP, a HF(High frequency) image and a LF(low frequency) image is produced using a non-sub-sampled bank of filters with two channels. The image singularities are captured applying NSP steps iteratively on subsequent LF components. As shown in fig.2, NSP gives m+1 sub images with 1 LF image and 'm' HF images.

Step2, Directional Filter Bank, assess directionality.

The non-sub-sampled DFB (NSDFBs), as sin Fig.3, is made up of directional fan bank of filters.

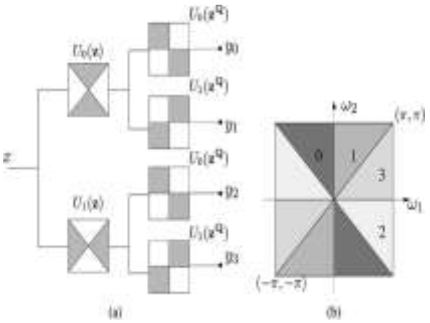


Fig.3 A 4-channeled DFB that is non sub sampled

This NSDFBs permits directional decomposition with 'n' stages in HF images and sequentially reproduce 2 to the power 'n' directional sub images. Ultimately from this filter bank step, accurate directional details are extracted.

III. Rules employed in fusing frequencies

After applying NSCT on individual images, both the images yield set of low and high frequencies. The low frequencies of both images are combined based on some criteria

A. Fusion of low frequencies

Phase Congruency (PC)

A feature which is invariant to the illumination level and contrast level, the *Phase Congruency (PC)* [14] is used for low frequency fusion. The method is approached by 'local energy' model. By this, critical features are assumed in the image where the coefficients are in phase with maximum level. Type of the feature is determined by the orientation of phase congruency occurrence. PC approach enables feature detection so far. Initially, for a point say (x, y), in an image, phase and amplitude are extracted using log Gabor bank of filters at various angles. Then PC ($P^{o}_{x,y}$) is found at each angle 'o' using the formula stated below

$$\boldsymbol{P^{o}_{x,y}} = \frac{\sum_n W^{o}_{x,y}\left[A^{o,n}_{x,y}\left(\cos(\emptyset^{o,n}_{x,y}-\widetilde{\emptyset}^{o}_{x,y})-\left|\sin(\emptyset^{o,n}_{x,y}-\widetilde{\emptyset}^{o}_{x,y})\right|\right)-T\right]}{\sum_n A^{o,n}_{x,y}+\varepsilon} \qquad (\mathbf{1})$$

For scale n, at (x,y)

$A^{o,n}_{x,y}$: Amplitude

$\emptyset^{o,n}_{x,y}$: Orientation

$W^{o}_{x,y}$: Weight factor

T: a constant, noise threshold

ε: Constant to overcome ambiguity like division with zero.

Following are the attractive qualities of PC that ensures its prominence in the fusion of multimodal images.

- PC ensures invariance to various intensity matching's. Different images caught from different modes have varied pixel matching's. i.e., the feature which is not affected by pixel matching's to be considered that is obviously PC.
- As PC is invariant to changes in the contrast level and illumination level of individual images, fusion has added benefits.
- The efficient localization can be attained through PC, which identifies edges and corners of images through coefficients at maximum phase.

B. Fusion of high frequencies:

To fuse the high frequencies of individual images A and B, here the 'average' method is employed. Here the HFs (high frequencies) of image A and HF (high frequencies) of image B, at are added up and the average is taken as the high frequency component in the fused image F.

As 'average' metric can ensure an appropriate measure in mathematical analysis in the situation of opting the best among two or more unknown quantities, this concept is implemented.

IV Proposed Fusion Methodology

In this segment, the planned fusion frameworks are going to be mentioned in detail. Considering, 2 registered supply images, the planned approach consists of the subsequent steps:

1. First on two individual images X and Y, the transform NSCT is performed to yield set of LF(low frequencies) and HF(high frequencies) for A and B at 'l' level and θdirection i.e.,

$$A : \{C_l^A, C_{l,\theta}^A\} \ \& \ \text{B}: \{C_l^A, C_{l,\theta}^B\} \quad (2)$$

C_l^* Denote LF images

$C_{l,\theta}^*$ Denotes HF images

Fusing LF Sub-images: Conventional simplest way is to use the averaging ways to reproduce the composite bands. Unfortunately as it cannot offer the united low-frequency component of top quality for medical image as a result of it ends up in the reduced contrast within the united pictures. Therefore, a new phase congruency replacement criterion is planned here.

First, using (1), features from the Low Frequency sub-images are extracted respect to inputs as $P_{C_l^A}$ & $P_{C_l^B}$.

The fused coefficients are formed as,

$$C_l^F(x,y) = \begin{cases} C_l^A(x,y), & \text{if } P_{C_l^A}(x,y) > P_{C_l^B}(x,y) \\ C_l^B(x,y), & \text{if } P_{C_l^A}(x,y) < P_{C_l^B}(x,y) \\ \frac{\sum_{k\in A,B} C_l^k(x,y)}{2} & \text{if } P_{C_l^A}(x,y) = P_{C_l^B}(x,y) \end{cases}$$

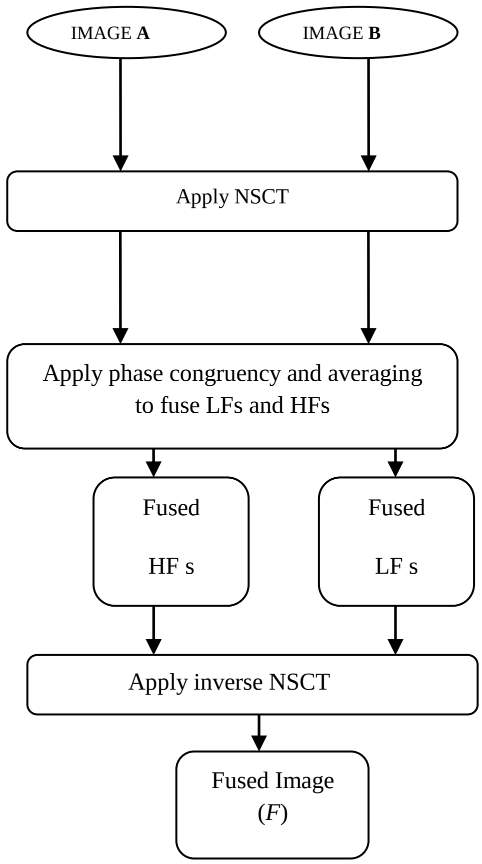


Fig.3. Figure of proposed scheme

Fusing HF Sub-images: In contrast to Low Frequencies, High Frequencies are the detailed components. By default HFs are relates noise and hence leads miscalculating sharpness resulting its effect on the entire process of fusion.

Here taking the averaging concept, we can assume that we can achieve a neutral result and hence proceed as follows.

We have result of NSCT on first image A as

A : $\{C_l^A, C_{l,\theta}^A\}$ i.e., corresponding HF coefficients as $C_{l,\theta}^A$; similarly those of B as

$C_{l,\theta}^B$. Then we formulate the consolidated High frequencies as, $C_{l,\theta}^F(x,y)$ as,

$$C_{l,\theta}^F(x,y) = \frac{C_{l,\theta}^A(x,y)+C_{l,\theta}^B(x,y)}{2}$$

4. As a final step to acquire a composite of of two individual images,apply at each level, l, the inverse form of NSCT .

Further for a better visualization of fused mechanism as well as for improved image accessing, color space conversion RGB to L*a*b is added up with proposed scheme here. L takes value '0' for black & for white it takes '1' . 'a' & 'b' has value range of -100 to 100, where 'a' has red at positive and green at negative; and 'b' takes yellow at +ve values and blue at –ve values.

First rgb2lab is applied on individual images and the proposed method is followed; then at the end, lab2rgb is applied to the fused image. This helps in colored ouput.

V Observed Results

For the Quantative analysis, two metrics are defined and used.

1. **SNR (signal to noise ratio) based metric (SF):**

It helps in detecting signal to noise ratio of two variables.

First SNR between fused and first input A is determined and then the same is calculated for F,B; finally both are concatenated as

SF= $[SNR(A,F) + SNR(B,F)]$/2;

SNR(X, Y) represents signal to noise ratio of X, Y

SNR(X, Y) =

10*log10 (255*255*height*width/enorm)

Error = abs (original - noisy)

Enorm = sum (sum (error.^2))

2. **Edge based similarity metric (Q_e)**

It's a measure of similarities between the transferred edges. Mathematically given as,

$$Q_e = \frac{\sum_{j=1}^{N}\sum_{i=1}^{M}\left[w_{i,j}^{y}Q_{i,j}^{FB}+w_{i,j}^{x}Q_{i,j}^{FA}\right]}{\sum_{j=1}^{N}\sum_{i=1}^{M}\left[w_{i,j}^{y}+w_{i,j}^{x}\right]}$$

'*'Can be A or B accordingly

$$Q_{i,j}^{F*} = Q_g^{*F} * Q_\alpha^{*F}$$

Q_α^{*F} , Q_g^{*F}, are the orientation & edge strength respectively found using Sobel's operators.

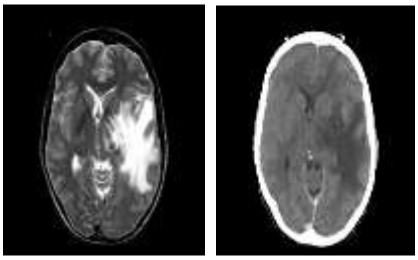
Numerical values

Below table holds the parameter values seen on running the MATLAB code for the proposed NSCT and wavelet-based fusion schemes. Results include the proposed in colour, the last column.

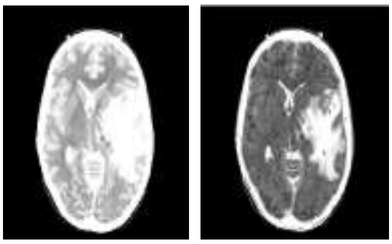
Image set. Parameter	Wavelet-based fusion technique	Proposed(NSCT based) fusion technique	Proposed with 'lab' Color space transformation
1.SF	**58.7570**	**62.3705**	**66.2665**
Qe	**0.3576**	**0.5078**	**0.7103**
2. SF	**59.2914**	**62.7439**	**66.7128**
Qe	**0.4051**	**0.5015**	**0.7066**

SIMULATION RESULTS

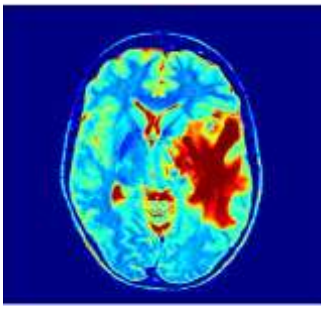
Following are the visually observed results on running MATLAB code for the Proposed and Wavelet based fusion methods



(a) (b)

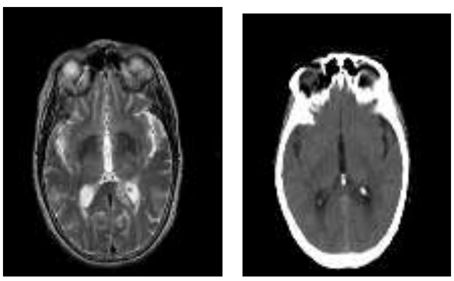


(c) (d)

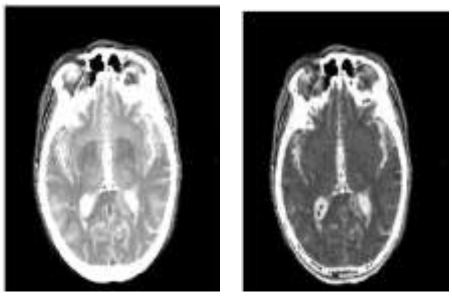


(e)

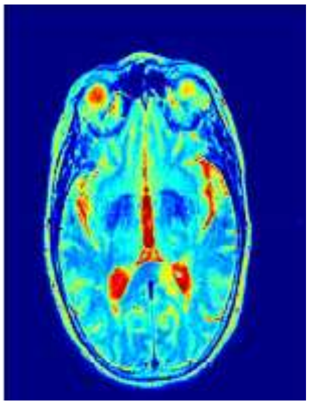
Fig.4 Simulation results for first set of images (a)MRI, (b)CT, (c) Wavelet-based fusion ,(d)Proposed fusion, (e) Proposed method in color.



(a) (b)



(c) (d)



(e)

Fig.5 Simulation results for second set of images (a)MRI, (b)CT, (c) Wavelet-based fusion ,(d)Proposed fusion, (e) Proposed method in color.

VI CONCLUSION

In this proposal new images fusion algorithm is proposed for the multimodal medical images. This proposal is based on the NSCT theory (non sub sampled counter let transform). In this, different rules are used for the fusion of the image. More information can be preserved in the fused image with improved quality. The low frequency band is fused by the 'phase congruency' and high frequency sub band is fused by using 'average' scheme. In our simulation results we fuse the CT/MRI images and we demonstrate that the NSCT method can enhance the detail of the fused image and visual effect with the low distortion than its competitors say here wavelet-based fusion method.

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