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MULTIMODAL MEDICAL IMAGE FUSION IN NSCT BASED ON PHASE CONGRUENCY AND REGIONAL ENERGY

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ABSTRACT

Image fusion is a technique that integrate complimentary details from multiple input images such that the new image give more information and more suitable for the purpose of human visual perception.Multimodal medical image fusion has developed with the advent of various imaging modalities in medical imaging. The main motivation is to capture most relevant information from sources into a single output, which plays an important role in medical diagnosis. In multimodal medical images based on non-subsampled contourlet transform (NSCT) the source medical images are first transformed by NSCT followed by combining low- and high-frequency components. Two different fusion rules based on phase congruency and regional energy are proposed and used to fuse low- and high-frequency coefficients. Finally, the fused image is constructed by the inverse NSCT with all composite coefficients.

***Keywords*: Non- Subsampled Contourlet Transform, Magnetic Resonance Angiography , Computed Tomography.**

I INTRODUCTION

Image fusion provides an efficient way to merge the visual information from different images in to a single output image. The fused image contains complete information for better human or machine perception and computer-processing tasks, such as segmentation, feature extraction, and object recognition. Image fusion can be done in pixel level, signal level and feature based. The traditional image fusion schemes performed the fusion right on the source images, which often have serious side effects such as reducing the contrast. Later researchers realized the necessity to perform the fusion in the transform domain as mathematical transformations provides further information from the signal that is not readily available in the raw signal.

With the advent of wavelet theory, the concept of wavelet multi-scale decomposition is used in image fusion. The wavelet transform has been used in many image processing applications such as restoration, noise removal, image edge enhancement and feature extraction; wavelets are not very efficient in capturing the two-dimensional data found in image. Several transform have been proposed for image signals that have incorporated directionality and multiresolution and hence, those methods could not efficiently capture edges in natural images.

The contourlet transform achieves better results than discrete wavelet transform in image processing in geometric transformations. The contourlet transform is shift-variant. However, shift invariance is a necessary condition in image processing applications.

The NSCT is a fully shift-invariant, multi-scale and multi-direction expansion that has a fast implementation. It achieves a similar sub band decomposition as that of contourlets, but without downsamplers and upsamplers in it, thus overcoming the problem of shift variance.

In the recent years, medical imaging has attracted increasing attention due to its critical role in health care. However, different types of imaging techniques such as X-ray, computed tomography (CT), magnetic resonance imaging (MRI), magnetic resonance angiography (MRA), etc., provide limited information where some information is common, and some are unique. For example, X-ray and computed tomography (CT) can provide dense structures like bones and implants with less distortion, but it cannot detect physiological changes. For this, purpose, the multimodal medical image fusion has been identified as a promising solution which aims to integrating information from multiple modality images to obtain a more complete and accurate description of the same object. Multimodal medical image fusion not only helps in diagnosing diseases, but it also reduces the storage cost by reducing storage to a single fused image instead of multiple-source image.

A novel fusion framework is proposed for multimodal medical images based on non-subsampled contourlet transform. The core idea is to perform NSCT on the source images followed by the fusion of low- and high-frequency coefficients. The phase congruency and regional energy feature are unified as the fusion rules for low- and high-frequency coefficients. The phase congruency provides a contrast and brightness-invariant representation of low-frequency coefficients whereas regional energy efficiently determines the frequency coefficients from the clear parts in the high-frequency. The combinations of these two can preserve more details in source images and further improve the quality of fused image.

II RELATED WORKS

In [2], Guihong *et al.* proposed a novel medical image fusion method based on wavelet transform modulus maxima. The advantage of this technique is, better preservation of both edge features and component information of the objects from different modalities in new fused image. wavelets are not very efficient in capturing the two-dimensional data found in images[3].

Several transform have been proposed for image signals that have incorporated directionality and multiresolution and hence, those methods could not efficiently capture edges in natural images. Do and Vetterli proposed contourlet transform[4], an efficient directional multi resolution image representation. The contourlet transform achieves better results than discrete wavelet transform in image processing in geometric transformations. The contourlet transform is shift-variant based on sampling. However, shift invariance is a necessary condition in image processing applications.

L.Yang *et al*.[5] proposed a multimodality medical image fusion based on contourlet transform. As a multiscale geometric analysis tool, contourlet has shown many advantages over the conventional image representation methods. All fusion operations are performed in contourlet domain. A novel contourlet contrast measurement is developed, which is proved to be more suitable for human vision system. Other fusion rules like local energy, weighted average and selection are combined with ‘‘region’’ idea for coefficient selection in the lowpass and highpass subbands, which can preserve more details in source images and further improve the quality of fused image. The final fusion image is obtained by directly applying inverse contourlet transform to the fused lowpass and highpass subbands.

Aili Wang *et al*[6] proposed a multimodal medical image fusion based on nonsubsampled contourlet transform(NSCT).At first the source images are decomposed in to low and high frequency subband by NSCT. The low frequency subbands are fused by local entropy and the fusion criterion for the coefficients of high frequency subband is regional energy. The NSCT is a fully shift-invariant, multiscale and multidirection expansion that has a fast implementation

2.1 Non Subsampled Contourlet Transform

The Non Subsampled Contourlet Transform (NSCT) is constructed by combining the Non Subsampled Pyramids (NSP) and the Non Subsampled Directional Filter Banks (NSDFB). The former provide multiscale decomposition and the later provide directional decomposition. A Non Subsampled Pyramid split the input into a low-pass subband and a high-pass subbands. Then a Non Subsampled Directional Filter Banks decomposes the high-pass subband in to several directional subbands.

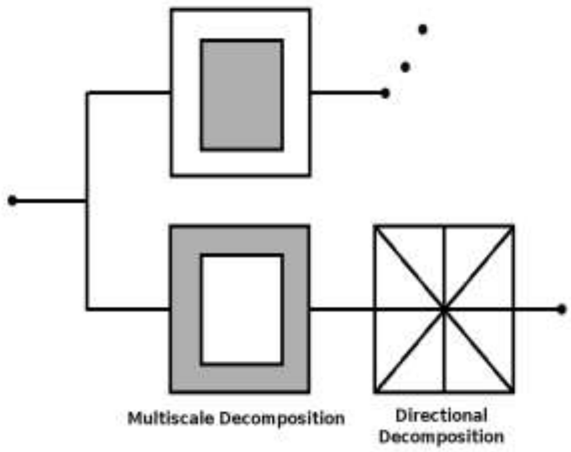

Fig 1: Block Diagram of NSCT

III. PROPOSED METHOD

Although image fusion based on NSCT is very efficient, the quality of the fused image mainly depends on the fusion rules which are used for low frequency and high frequency subband coefficients. The combination of regional energy and local entropy fusion rules can preserve more details in source images and can further improve the quality of fused image. But there are some disadvantages in using local entropy as fusion rule for low frequency subband coefficients. Local entropy method is not invariant to pixel intensity mappings and illumination and contrast changes. So another method called phase congruency can be used for fusion of low frequency subband coefficients. It is more efficient than local entropy method.

The input medical images A and B are decomposed in to low frequency subband coefficients and high frequency subband coefficients by NSCT. Low frequency subbands corresponds to the coarse part of the image. High frequency subbands corresponds to the region of boundaries and edges. The Non Subsampled Contourlet Transform (NSCT) is constructed by combining the Non subsampled Pyramids (NSP) and the Non subsampled Directional Filter Banks (NSDFB). The former provide multiscale decomposition and the later provide directional decomposition. A Non subsampled Pyramid split the input into a low-pass subband and a high-pass subbands. Then a Non subsampled Directional Filter Banks decomposes the high-pass subband into several directional subbands.

Two different fusion rules are proposed for low frequency subband coefficients and high frequency subband coefficients. The coefficients of low frequency subbands are fused by phase congruency and the high frequency coefficients are fused by regional energy. Finally the fused output image is obtained by the inverse NSCT with all composite coefficients.

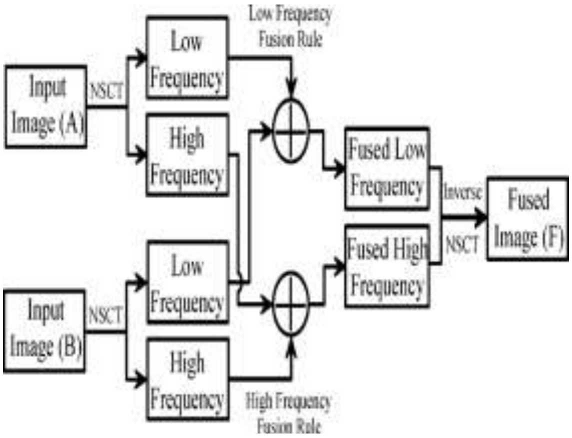

Fig 2: Block Diagram of proposed framework

3.1 Phase Congruency

Phase congruency is a measure of feature perception in the images which provides a illumination and contrast invariant feature extraction method. This approach is based on the Local Energy Model, which postulates that significant features can be found at points in an image where the Fourier components are maximally in phase. Furthermore, the angle at which phase congruency occurs signifies the feature type. The phase congruency approach to feature perception has been used for feature detection. First, logarithmic Gabor filter banks at different discrete orientations are applied to the image and the local amplitude and phase at a point *(x,y)* are obtained. The phase congruency,$P^0_{x,y}$, is then calculated for each orientation *o* , where $W^0_{x,y}$ is the weight factor based on the frequency spread, $A^{0,n}_{x,y}$ and $\emptyset^{0,n}_{x,y}$ are the respective amplitude and phase for the scale *n*, $\emptyset^0_{x,y}$ is the weighted mean phase, *T* is a noise threshold constant and ε is a small constant to avoid divisions by zero. The symbol $[]_+$ denotes that the enclosed quantity is equal to itself when the value is positive, and zero otherwise. Only energy values that exceed T , the estimated noise influence and are counted in the result. The appropriate noise threshold *T*, is readily determined from the statistics of the filter responses to the image.

$$P_{x,y}^{0} = \frac{\sum_n W_{x,y}^{0} \left[A_{x,y}^{0,n}(\cos\left(\varphi_{x,y}^{0,n} - \overline{\varphi_{x,y}^{0}}\right) - \left|\sin(\varphi_{x,y}^{0,n} - \overline{\varphi_{x,y}^{0}})\right|) - T\right] +}{\sum_n A_{x,y}^{0,n} + \varepsilon}$$

3.2 Regional energy method

Through the Non-subsampled Contourlet decomposition is calculated, high frequency coefficient can reflect detail information of the image. Texture of the image details are more obvious, the regional energy of these places is bigger. Energy is defined as follows:

$$E_{j,1}(m,n) = \frac{1}{M \times N} \sum_{m=1}^{M} \sum_{n=1}^{N} [f(m,n)]^2$$

Where $E_{j,1}(m,n)$ is local energy in direction of *l* and decomposition scale of *j* centered of pixel *(m, n)*. The coefficients of high frequency subband for the fused image are obtained according to the following rule:

$$C_{j,1}^{F}(m,n) = \begin{cases} C_{j,1}^{A}(m,n), E_{j,1}^{A}(m,n) \geq E_{j,1}^{B}(m,n) \\ C_{j,1}^{B}(m,n), E_{j,1}^{A}(m,n) < E_{j,1}^{B}(m,n) \end{cases}$$

IV. CONCLUSIONS

A novel image fusion technique for multimodal medical images based on NSCT is proposed. Two different fusion rules are proposed for low frequency subband coefficient fusion and high frequency subband coefficient fusion. Phase congruency and regional energy are used as fusion rules for low frequency and high frequency subband coefficients respectively.

Fusion of multimodality medical images provides a promising diagnostic tool with numerous clinical applications. It is anticipated that fusion of multimodal medical images will help the physician towards a more realistic and quantitative , assessment of diseases.

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