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Multimodal Medical Image Fusion and Segmentation using Non-Subsampled Contour let Transforms and Clustering

K. Sujeetha

Department of Applied Electronics, Arunai Engineering College, Thiruvannamalai, Tamil Nadu, India

Abstract: Multimodal image fusion is effectuated to minimize the redundancy while augmented the necessary information from the input images acquired using different medical imaging sensors. The sole aim is to yield a single fused image, which could be more informative for an efficient clinical analysis. This project presents multimodal fusion framework using the Non-Subsampled Contourlet Transform (NSCT) domains for images acquired using two distinct medical imaging sensor modalities (i.e., Magnetic Resonance Imaging and Computed Tomography scan). The major advantage of using NSCT is to improve upon the shift variance, directionality, and phase information in the finally fused image. The first stage employs a NSCT domain for fusion and then the second stage to enhance the contrast of the diagnostic features by using Guided filter. A quantitative analysis of fused images I carried out using dedicated fusion metrics. The fusion responses of the proposed approach are also compared with other state-of-the-art fusion approaches; depicting the superiority of the obtained fusion results. To final segment the tumor part by applying Fuzzy C-Means Clustering

KEYWORDS: Multimodal medical image fusion, non-subsampled contourlet transform, magnet resonance imaging, computed tomography

I. INTRODUCTION

To develop an image processing system to capture most relevant information from source input images into a single output image, which plays an important role in medical diagnosis. The continual development of medical imaging and information processing technologies provides many types of medical images for clinical diagnosis. Multimodal image fusion is one of the ways to yield a single fused image, which could be more informative for an efficient clinical analysis. Image fusion is the process of combining two or more images to form a single fused image. It is useful for human visual and machine perception or further analysis and image processing tasks. The image fusion plays an important part in medical imaging, machine vision, remote sensing, microscopic imaging and military applications. Particularly in Healthcare domain, medical imaging plays an important part in a large number of healthcare applications including diagnosis, treatment, etc. The main objective of multimodal medical image fusion is to capture the most interrelated information from input images into a single output image which is useful in clinical applications

Multimodal medical image fusion has been identified as a promising solution which purpose is to send information from multiple modal images to obtain a more complete and accurate description of the same object. The multimodality medical images cannot provide complete and accurate information. Hence, anatomical and functional medical images can be combined to obtain more useful information about the same object to help in diagnosing diseases exactly and reduces storage cost by storing the single fused image instead of multiple input images. The efficiency of this method is carried out by fusion experiments on different multimodality medical image pairs. Contourlet transform (CT) can provide a multiscale and directional decomposition for medical images which is more suitable for catching the features in medical images that are abundant in complex contours, textures and edges. It is a part of multi scale geometric

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analysis (MGA) tools. In this paper, the CT and MRI images of brain are fused together using NSCT. C.Nagarajan et al [15,16,17] then the features are extracted from the fused image. It is then classified, and the tumor part is segmented by means of fuzzy c-means clustering. Both qualitative and quantitative image analysis reveals that the proposed framework provides a better fusion result compared to the conventional image fusion techniques. In this paper the comparison of existing and proposed method by quantitative analysis are also done

II. METHODOLOGY

This part brings the depiction of concepts based on which the recommended framework is formed.

A. Non-Subsampled Contour let Transform

The multimodal images, MRI and CT images of brain are fused by using the NSCT transform is proposed and the tumor part of brain is detected at very early stage with the help of clustering process and segmentation. NSCT provides better edges and texture region than other transforms. It also provides better computational complexity and fast implementation. It also provides better sub band decomposition.

NSCT is one type of multiscale, multidirectional and multiresolution framework for the computation of discrete images. The NSCT is based on the theory of Contourlet Transform (CT) achieves better results in image processing in geometric transformations. The CT is a shift variant as it contains both down-samplers and up-samplers in the Laplacian Pyramid (LP) as well as Directional Filter Bank (DFB) stages. NSCT is a shift invariant, multi-scale and multi-directional transform as it has a very vibrant implementation. NSCT decomposition is to compute the multi scale and different direction components of the discrete images. It involves the two stages such as non-subsampled pyramid (NSP) and non-sub sample directional filter bank (NSDFB) to extract the texture, contours and detailed coefficients.

NSP decomposition with N = 3 levels is shown in Fig.1.

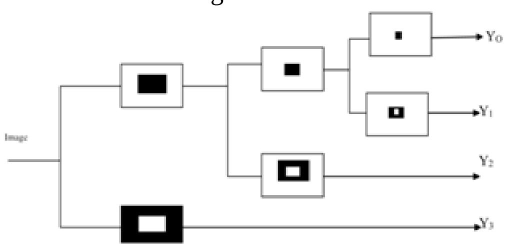

Fig.1. Three Stage NSP decomposition

For M levels, 2M directional sub images are produced by NSP at every scale. As a consequence, the NSDFB provides NSCT a multi-directional ability that gives extra decisive information about the directionality. These details are illustrated in Fig .2

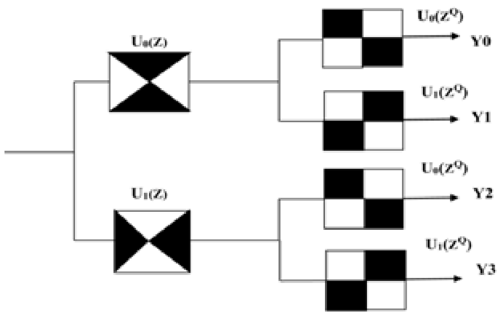

Fig.2. Four Channel NSDFB

Mathematically Energy of each sub band is calculated using the formula

$E1\ j,k = A(j,k)k+1k-1j+1j-1$ (1)

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$E2\ j,k = B(j,k)k+1k-1j+1j-1$ (2)

Where A and B are two source images.

B. Contourlet Transform

CT can provide a multiresolution, directional and local image expansion style. It includes multiscale Laplacian Pyramid decomposition and the directional filter bank. Figure 1 shows that CT has a double filter bank structure and the two steps are independent. The directional filter bank has a flexible number of directions and it can only capture the high frequency part of input image while the low frequency part of the input image are removed before applying it.

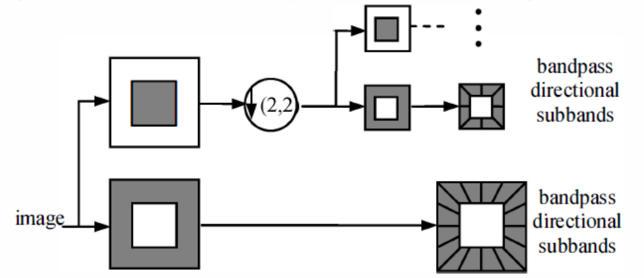

Fig 3. The basic block diagram of contourlet transform

CT is a geometry transform for image processing. The directional decomposition and multi-scale decomposition are two independent stages which will effectively to describe the textures and contours-rich of image. They have "long strip" structure which aspect ratios have changed with the scale in the elongated supported, it can effectively to track the characteristics of linear discontinuities and area discontinuities in the image.

III. FUSION RULES FOR MEDICAL IMAGES IN NSCT

Selection of fusion rule is a very important step, it will have an impact on the quality of image fusion. After Nonsubsampled Contourlet transform, the CT and MRI images are obtained high frequency sub band and low frequency sub band. High frequency components in the frequency domain refers to the details and features of the image, for example texture; the low-frequency part is image approximation and the average characteristic information, is the case for every image.

For fusion of multimodal medical images, the fusion algorithm used is the simple called as NSCT-simple, namely the low-frequency part selection fusion algorithm takes the average, high frequency part chooses maximum absolute value of the source images. The object of CT and MRI image fusion is the complementary part of their information integration. In order to achieve better fusion effect, we need the pixel fusion containing rich details as much as possible. So, in choosing the low frequency sub band coefficients if only select algorithm taking the average, it will make some useful visual information lost from source medical images, thereby reducing clarity of fused image to a certain extent. Therefore, in the selection of fusion algorithm, features which can characterize the image.

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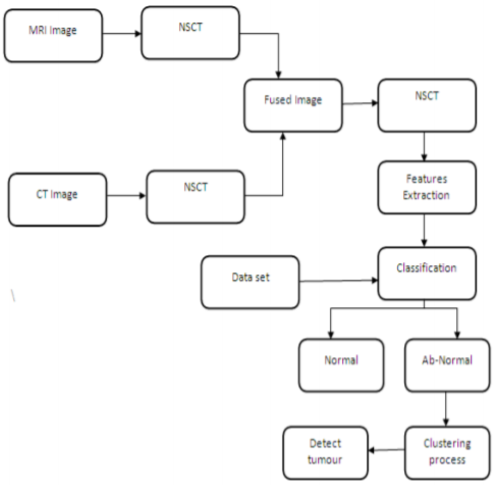

Fig 4. block diagram of fusion process

A new image fusion framework for multimodal medical images, which relies on the NSCT decomposes the images into sub bands. The sub band images of two source images obtained from NSCT are utilized for morphological process to get the enhanced information to diagnose the brain diseases. Here, the pixel level fusion method is implemented based on Gabor-filter bank and gradient detection for coefficient selection. The low frequency sub bands of two source images were fused by Gabor coefficients selection. It is helpful to discriminate and characterize the texture of an image through frequency and orientation representation. It uses the Gaussian kernel function modulated by sinusoidal wave to estimate the filter coefficients for convolving with an image. The high frequency coefficients always contain edge and texture features and the high frequency sub bands were fused by Gradient measurement to select desired coefficients. Finally, fused frequency sub bands are inverse transformed to reconstruct the fused image. This part shows the discussion of some of motivational factors in designing our idea for fusing medical images. The suggested work is taken into account, which requires two different images of the same source to get the compound image. The essential requirement of this framework is the source images must be registered for the alignment of pixels. To test the suggested fusion method, the image data typical of CT and MRI are taken and these are named A and B. The following steps are followed in our proposed algorithm.

Step 1: Take the images that will be merged from the database and the pre-processing treatment is done. As a rule, images of 256 x 256 sizes are selected for evaluation.

Step 2: First level merge: Apply NSCT on the input images, it results one LF and set of HF coefficients in every level and orientation. In this decomposition, number of levels(n) taken are [2, 2, 4]. With these levels no. of sub bands formed are 4,4,16. For the pyramidal filter and directional filters, maxflat filter and dmaxflat7 filters have been used respectively

Step 3: Energy of each co-efficient is calculated using the formula

$$E1(j,k) = \sum_{j-1}^{j+1} \sum_{k-1}^{k+1} A(j,k)$$

$$E2(j,k) = \sum_{j-1}^{j+1} \sum_{k-1}^{k+1} B(j,k)$$

Step 4: Low frequency fusion: The approximation of source images is represented by sub images of low frequency. Simple average methods are used for merging. However, because of low contrast, a high-quality merged image cannot be obtained. So, we use an Energy fusion rule

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$$F_l^F(j,k) = \begin{cases} F_l^A(j,k), & if\ E_l^A(j,k) > E_l^B(j,k) \\ F_l^B(j,k), & if\ E_l^A(j,k) < E_l^B(j,k) \\ \frac{\sum_{k\in A,B} F_l^K(j,k)}{2}, & if\ E_l^A(j,k) = E_l^B(j,k) \end{cases}$$

Step5: High-frequency fusion: The detailed components of source images correspond to sub images of high frequency. Energy of each sub band is calculated as

$$F(j,k) = \begin{cases} F_{l,\theta}^A(j,k), & if\ \ E_{l,\theta}^A(j,k) \geq E_{l,\theta}^B(j,k) \\ F_{l,\theta}^A(j,k), & if\ E_{l,\theta}^A(j,k) < E_{l,\theta}^B(j,k) \end{cases}$$

Step 6: Inverse operation of NSCT is done on all frequency sub bands to achieve the first level fused image F.

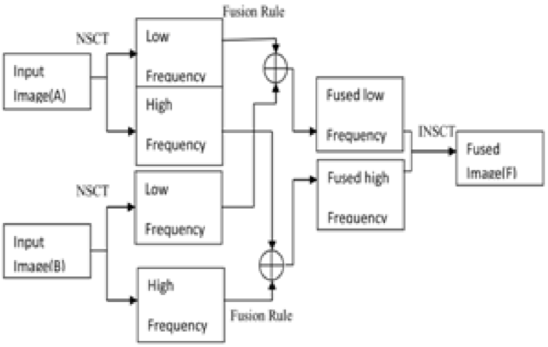

Fig.5. NSCT fusion

IV. EXPERIMENTAL RESULTS

The CT and MRI image of brain are fused by NSCT method. The fused images which are detected as abnormal are clustered and One of the images is chosen from the clustered image. Then, it is segmented to detect the tumor part of the brain.

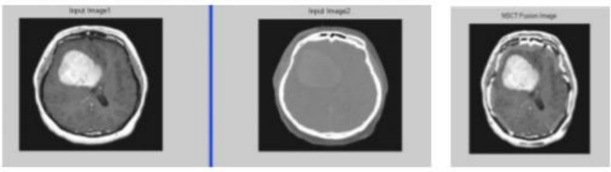

Fig 6. CT & MRI of human brain and fused image using NSCT

It is clear that the fused images for the existing methods is not clear and hence the NSCT method is better than the other methods. The resultant image for existing method is not at all informative and is not helpful for clinical analysis. The edge and contrast information are lost in the existing method. Spatial distortion is high hence the image is not clear in the existing methods. A better resolution and high contrast fused image are obtained by the proposed method. This image could be useful for clinical analysis and the stage of the disease could be detected easily. The fused image which does not have any tumor, or any affect are classified and displayed in the dialog box as normal. Hence, quantitative analysis is done for all the images. The various images of CT & MRI of brain are fused and the fused images are compared with the existing methods like Image Averaging Method and Principal Component Analysis. The fused image obtained contains information about bones and tissues, which cannot be seen in the separate CT & MRI image. From the fused image with NSCT domain and clustering method one can detect the tumor part affected in brain easily.

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V. CONCLUSION

Fusion of medical images from various modalities is examined as a topic of study for researchers due to its importance and usefulness for the health sector and a better diagnosis with merged images of quality information. Ideally, merged images should contain more comprehensive information than any input image, even if the redundant information is present.

Multimodal medical image fusion method is proposed based on Non-Subsampled Contourlet Transform (NSCT), which consists of three steps. In the first step, the medical images to be fused are decomposed into low and high frequency components by Non-Subsample Contourlet Transform. Next two different fusion rules are utilised for fusing the low frequency and high frequency bands which preserve more information in the fused image along with improved quality. The fused images obtained by the proposed method are more informative and have higher contrast than the existing method images which is helpful in visualization and interpretation. The fused image contains both soft tissue and bone information. The fused images obtained by the proposed method are more informative and have higher contrast than the input medical images which is helpful in visualization and interpretation. The fused images obtained by the proposed method have higher quantitative results than the methods of image averaging and principal component analysis.

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