Directive Contrast based Medical Image Fusion Using DWT

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Abstract: now a day, multimodality medical image fusion has drawn lots of attention with the increasing rate at which multimodality medical images are available in many clinic application fields. The main motivation is to capture most relevant information from sources into a single output, which plays an important role in medical diagnosis. CT scans and MRI scans contains details regarding soft and hard tissues. For medical diagnosis, CT provides the better information on denser tissue with less distortion, while MRI offers better information on soft tissue with more distortion. In this paper, a fusion method is proposed for multimodal medical images based on Discrete Wavelet Transform Directive contrast fusion rule is used in this method. The source medical images are first transformed by DWT followed by combining low- and high-frequency components. Now to reconstruct fused image Inverse Discrete wavelet transform is performed. Experimental results and comparative study show that the proposed fusion framework provides an effective way to enable more accurate analysis of multimodality images.

Keywords: Multimodal medical image fusion, Discrete Wavelet Transform, directive contrast, medical diagnosis**.**

1. Introduction

In the recent years, medical imaging has attracted increasing attention due to its critical role in health care. The main objective of image fusion is to get more useful information from the different image of different modality in to one single image as much as possible. For the image fusion numbers of algorithms have been proposed till date by many researchers. In medical image it is very important to preserve the edge information and directive contrast because fusion algorithm reduces the contrast of the fused image. There are many image fusion methods which obtained more information in fused image as much as possible, with keeping the error low as possible between the input image and fused image. In image fusion output image is always have more information than any source image Medical image contains more edge information and contrast also which need to preserve in fused image. Different type of imaging technique are there in medical field such as magnetic resonance imaging (MRI), computed tomography (CT), X-ray magnetic resonance angiography (MRA), etc., which provide limited information and some of the information is common in all of them. For example computed tomography (CT) and X-ray provide dense structure like bones having less distortion, but it cannot provide physiological changes [1]. Similarly, PET can be used to provide better information on flood activity and blood flow with low spatial resolution where as normal and pathological soft tissue can

be better visualized by MRI image. As a result of it to get compendious view anatomical and functional medical images are need to be combined. For this purpose, the multimodal medical image fusion has been identified which aims to integrating information from multiple modality images to obtain more complete and accurate description of the same object. Multimodal image fusion not only helps in diagnosing diseases but it also reduce the storage cost by reducing storage to a single fused image instead of multiple source images.

So far, lots of work is done on image fusion techniques [2] with various techniques dedicated to multimodal medical image fusion [3]. These techniques have been categorized into three categories .these include pixel level fusion, feature level fusion and decision level fusion where medical image fusion usually employs the pixel level fusion due to the advantage of containing the original measured quantities, easy implementation and computationally efficiency. Hence, in this methods we concentrate our effort on pixel level fusion, and the terms image fusion or fusion are intently used for pixel level fusion. The well- known pixel level fusion are based on principal component analysis (PCA), independent component analysis (ICA), contrast pyramid (CP), gradient pyramid (GP) filtering, etc. Since, human visual system is very sensitive to the image feature in different scale. Therefore image feature are highly suitable in medical image fusion [4]. Recently, with the development in image decomposition wavelet transform has been identified ideal method for image fusion. Many other application can also

used this image fusion method for preserving edge information and contrast of an image. In image processing many situations require high spectral resolution and high spatial resolution in a single image. Most of the equipment is not capable of providing such data convincingly.

The rest of the paper is organized as follows. Discrete wavelet transform and directive contrast are described in section II, simple averaging image fusion in section III, image fusion based on maximum pixel replacement fusion rule in section IV, fusion based on wavelet coefficient contrast is described in section V. experimental results that are obtained with MATLAB is section VI

2. Preliminaries

This section provides the description of concepts on which the proposed method is based. These concepts include DWT and directive contrast and are described as follows.

2.1 Discrete Wavelet Transform Method

Wavelet transforms are image decomposition tool that provide a variety of channels which represent the image feature by different frequency subbands. To separate detail component and the approximation decomposition is performed, 2-D Discrete Wavelet Transformation (DWT) converts the image from the spatial domain to frequency domain. After performing first order of DWT image is divide in vertical and horizontal lines and the image can be separated with four parts those are LL1, LH1, HL1 and HH1 [5].

Step 1. Apply Discrete Wavelet Transform on both the input image to implement wavelet lower decomposition

Step 2. Different fusion rule are used to fuse each decomposition level.

Step 3. Perform Inverse Discrete Wavelet Transform on fused decomposed level to reconstruct the image, while the image reconstructed is the fused image F.

2.1 Directive Contrast in DWT

The difference of the intensity value at some pixel from the neighboring pixels is known as contrast. The human visual system is highly sensitive to the intensity contrast rather than the intensity value itself. Generally, the same intensity value looks like a different intensity value depending on intensity values of neighboring pixels. Therefore, local contrast is developed and is defined as

$$c = \frac{L - L_B}{L_B} = \frac{L_H}{L_B} \qquad 1$$

Where L is the local luminance and L_B is the luminance of the local background. Generally, L_B regarded as local low frequency and hence L - L_B= L_H is treated as local high frequency. This definition of local contrast is further extended to as directive contrast for multimodal image fusion. To determine pixel is from clear part or not consideration of single pixel is insufficient. Therefore to get more accurate salient feature directive contrast is integrated with the sum-modified laplacian [6]. In general the larger absolute value of high-frequency coefficient lead to the salient features such as edges, lines, region boundaries, and correspond to the sharper brightness in the image. However, these are very to the noise and therefore, the noise will be taken as the useful information and misinterpret the actual information in the fused images. Hence to select high frequency coefficient is necessary to ensure better information interpretation.

3. Average Based Image Fusion

Discrete wavelet transform is performed on input to decomposed source image. Uniform averaging is most commonly used for fusing approximation coefficient. This is because approximation coefficients are interpreted as the mean intensity value of the source images. Source images that are encapsulated by the detail coefficient sub-band at their various scales. Therefore while fusing approximation coefficient by averaging maintains the appropriate mean intensity needed for the fusion result with minimal lose of salient features [7]. At the highest decomposition level N, the approximation coefficients for the fused image F at the highest level of decomposition is given by, [8]

$$F(i,j) = \frac{A(i,j) + B(i,j)}{2} \qquad 2$$

In the above equation given A(i,j) and B(i,j), the approximation coefficient sub-bands of images A and B, respectively Also the coefficient of the source images correspond to salient feature such as lines and edges detected at various scales. Therefore, a fusion rule for detail coefficient at is same as approximation coefficient fusion rule.

Figure 3 and Figure 4 are the source image (i.e. CT and MRI scans) while Figure 5 is the resultant fused image obtained by simple averaging using wavelet transform

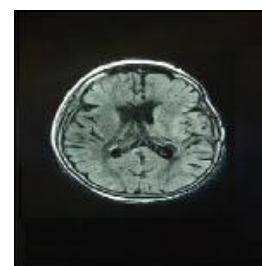Fig.3input image CT   Fig.4input image MRI

Fig.5 output image

4. Maximum Pixel Replacement Image Fusion

In maximum pixel replacement fusion coefficient with greatest magnitude is replace in fused image. The maximum pixel replacement fusion rule or absolute maximum (AM) detail coefficient fusion rule selects the detail coefficient in each sub-band. Discrete wavelet transform is used to decompose source image. This is because as said approximation coefficients are interpreted as the mean intensity value of source image with all features encapsulated by the detail coefficient sub-bands at their various scales. Therefore, fusing approximation coefficients by averaging maintains the appropriate mean intensity needed for the fusion result with minimal lose of salient feature [7]

The detail coefficient of the source images correspond to salient features such as edges and lines detected as various scales. Therefore, a fusion rule for detail coefficients is based upon maximum pixel replacement rule, which state that, given A(i,j) and B (i,j) the detail coefficient sub-bands of images A and B, respectively, at the highest decomposition level N, the detail coefficients for the fused image F(i,j) at the highest level of decomposition is given by maximum pixel of corresponding band in fused image[8]

In this method, from both the input images maximum intensity of corresponding pixels is selected and replace in the resultant fused image.

$$F(i,j) = \sum_{i=0}^{m} \sum_{j=0}^{n} Max\ A(i,j)B(i,j)$$

(3)

Figure 6 and Figure 7 are the source image (i.e. CT and MRI scans) while Figure 8 is the resultant fused image obtained by maximum pixel replacement fusion rule using wavelet transform

Fig.3input image CT   Fig.4input image MRI

Fig.output Image

5. Wavelet based Image Fusion

Input image can be maps to different level of pyramid structure of wavelet coefficient based on scale and direction by using wavelet multi-resolution expression. Wavelet transform decomposed the image in to four sub-bands. After decomposition contrast for the coefficient is calculated then after fusion rule inverse wavelet transform is applied to reconstruct the fused image.

The maximum coefficient detail components are respectively taken as the most salient feature with the corresponding local window along horizontal, vertical and diagonal directions. We took 3 by 3 local window. Now we supposed that the mean value of the local window of the approximate coefficient be the background of the central pixel of the corresponding local window of the detail component.

The contrast value for both the images is compared, and the image with higher contrast, its pixels is replaced in the fused image. This process is repeated for three sub-bands Therefore, in wavelet domain we obtain three new contrasts C_{jv} C_{jh} C_{jd}, which represent the most significant feature relative to the background of the local window along various directions respectively [8].For approximate component is to be average the low frequency component of the last decomposition level. Then in order to get the fused image inverse wavelet transform is applied.
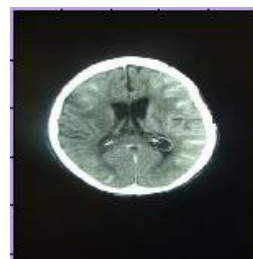

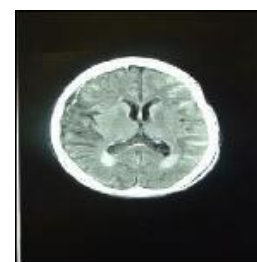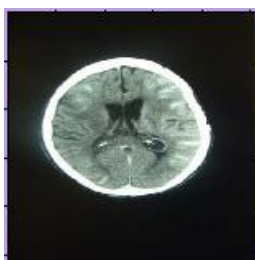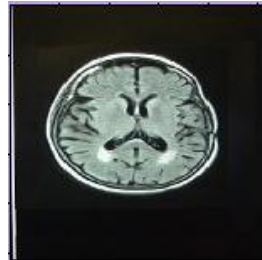Fig.3input image CT   Fig.4input image MRI

Fig.output image

6. Results and Discussion

In our image fusion method, first we establish an evolution index system. This system includes root mean square error (RMSE), peak signal to noise ratio (PSNR).

2.1 Evaluation indices of image fusion

Image evaluation indices are used to evaluate the quality of the fused image. Definition of these indices and their physical meaning are given as follows:
1. Entropy
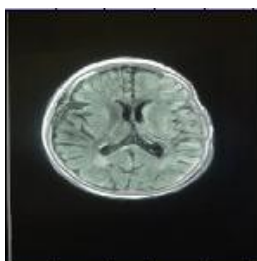
It is the measure of information quality contained in an image. Higher value of entropy in fused image indicate that information quality is increase

$$E = -\sum_{i=1}^{N} p(xi) \ln p(xi)$$

(4)

2. Peak Signal to Noise Ratio

The PSNR indicates the similarity between two images. The higher value of PSNR is the better the fused image [7]

$$PSNR = 10 \lg \frac{255^2}{RMSE^2}$$

(5)

Table 1: comparison of fusion method

Fusion methods	Image set II (CT and MRI scan)	
	Entropy	PSNR
Simple Average mechanism image fusion	1.98566	79.0125
Maximum pixel replacement image fusion	2.10596	79.2532
New wavelet coefficient contrast based image fusion	2.37528	82.9277
RGB method of image fusion	2.10596	79.1016

7. Conclusion

From the quantitative analysis and visual experiment it is observed that the proposed method of image fusion can preserve the edge information of organ, it can able to preserve contrast of fused image, outlines of tumors compared to other image fusion methods. These special characteristic makes this method an efficient in medical diagnosis. In future this method can be used for investigating different type of practical applications.

We can also conclude that image fusion leads to loss of contrast and edge information, which are very important feature from medical point of view and which can be preserve using directive contrast based method. It can be seen that DWT fusion rule is better to decomposed the image; it allows better frequency localization signals.

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