Multimodality Image Fusion of CT and MRI Images using Discrete Wavelet Transform (DWT)

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Abstract:- **The objective is fusion of the image can be combine multiple images of the same scene into a single image obtain the important and required features from each of the original image. Medical image fusion is used to derive useful information from multimodality medical images which provides more information to the doctor. Nowadays, with the rapid development in high technology and modern instrumentation, medical imaging has become a vital component of a large number of applications, including diagnosis, research and treatment. Medical image fusion is the idea to improve the image content by fusing images taken from different imaging tools like computed tomography(CT), magnetic resonance imaging(MRI) for medical diagnosis , computed tomography(CT) provides the best information on denser tissue with less distortion. MRI provides better information on soft tissue with more distortion. In this case, only one kind of image may not be sufficient to provide accurate clinical requirements for the physician. Therefore, the fusion of the multimodal medical images is necessary. This paper presents a method of image fusion based on discrete wavelet transform. Two dimensional DWT is used to decompose the image. The fusion performance is evaluated on the passage of the root mean square error (RMSE) and peak signal to noise ratio (PSNR) and mean square error (MSE).**

Keywords:- Medical image fusion, Computer tomography, magnetic resonance image, spatial filter, root mean square error(RMSE) and peak signal to noise ratio(PSNR), discrete wavelet transform (DWT), inverse discrete wavelet transform (IDWT)

I INTRODUCTION:

The term fusion means in general an approach to extraction of information acquired in several domains. The objective image fusion is to combine information from multiple images of the same scene into a single image retain the important and required feature from each of the original image. The main task of image fusion integrating complementary information from multiple images into single image. The resultant fused will be more informative and complete then any of input images and is more suitable for human visual and machine perception. Medical image fusion is the technology that good compound to mutual images into one according to certain rules to achieve clear visual effect. By observing medical fusion image, doctor good easily confirm the position of illness. Medical imaging provides a variety of modes of image information for clinical diagnosis such as CT, X-ray, MRI,PET and etc. different medical images have different characteristics , which can provides structural information of different organs. For example CT (computer tomography) and MRI (Magnetic resonance imaging) with high spatial filter resolution can provide anatomical structure information of organs. Thus, a variety of imaging for the same organ, they are contradictory complementary and interconnected

In this paper, a novel approach for the fusion of computer tomography (CT), magnetic resonance imaging (MRI) images faced on wavelet transform has been presented. Different fusion rules are then performed on the wavelet coefficients of low and high frequency portions. The registered computer tomography (CT) and magnetic resonance imaging (MRI) images of the same people and same spatial parts have been used for analysis. Registration is a fundamental task in image processing. It is the process of spatially aligning two or more images of a scene. The processing brings into correspondence individual pixels in the images. Therefore, given a point in one image, the registration processing will determine the positions of the same point in other image. In this paper, input images taken are registered images.

II.METHODOLOGY

Image fusions based on wavelet transform

Wavelet transform

Wavelet means “small waves” so wavelet analysis is about analyzing signal with short duration finite energy function.

They transform the signal under in investigation into another representation which presents the signal in a more useful form.mathematically,we donate the DWT,

$$\psi_{a,b}(t) = \frac{1}{\sqrt{|a|}}\psi((t-b)/a)$$

Where

b=is location parameter

a=is scaling parameter

It is performed with the two medical images are mathematically represented as,

$$I(x,y) = W - 1(\phi(W(I_1(x,y), W(I_2(x,y))$$

A. Pixel Averaging

This is one of the simplest image fusion methods. In this method, average of the two input images is taken. However, when this direct method is applied, contrast of the image is reduced.

B. Fusion with Discrete Wavelet Transform

The basic idea of image fusion based on wavelet transform is that the coefficients of both the low frequency band and high frequency bands are performed with a certain fusion rule as shown in Fig 1. The widely used fusion rule is maximum selection scheme. This simple scheme just picks the coefficients in each sub band with the largest magnitude. After that, the fused image is obtained by perform the inverse DWT (IDWT) for the corresponding combined wavelet coefficients. The general fusion procedure based on wavelet transform can be described as follows.

Step 1:

Read the set of multifocal in images. Two images are same size and registered images

Step 2:

Apply decomposition by wavelet on both the image with the fused spatial filter.

Step3:

Extracts from the wavelet decomposition structure of horizontal, vertical or diagonal in detail.

Step 4:

Perform the average of approximation coefficient of both the images

Step 5:

Compare horizontal, vertical and diagonal Coefficient of both the images. Apply maximum selection scheme to select the maximum coefficient value by comparing the coefficient of two images. Perform this for all the pixel values of images i.e.) m×n.

Step 6:

Apply inverse wavelet decomposition on both the images using different wavelet filters.

Step7;

Display the final fused images of averaging, maximum, minimum of the images.

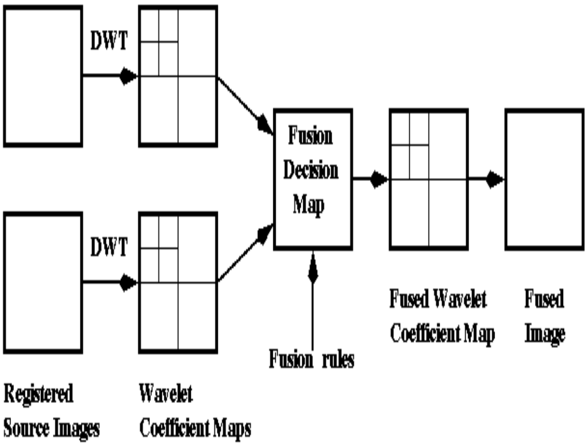
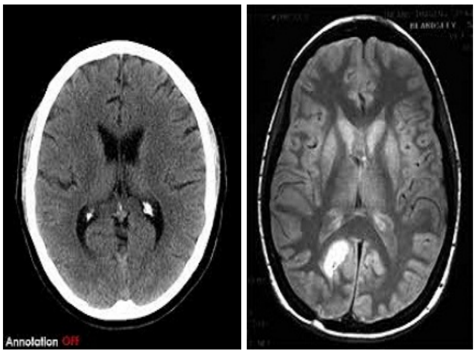


Fig 1: Image fusion procedure based on DWT

C. Proposed Fusion Method

As shown in the fusion block Fig 1, it is easy to find that the key step in image fusion based on wavelet is that of coefficient combination, namely, the fusion rules because it will decide how to merge the coefficients in an appropriate way so that a high-quality fused image can be obtained. Therefore, for this kind of image fusion method the key issue is its fusion rule design, and it should be paid more attention.



i) CT image ii) MRI image

Fig2: Two Pair of Multimodality input medical images.

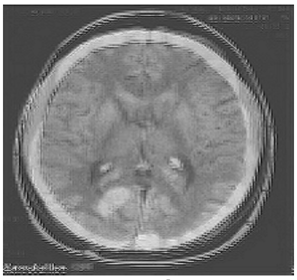


Fig 3: Fused image

1. *Average Method*

In this method the resultant fused image is obtained by taking the average intensity of corresponding pixels from both the input image.

$$F(x,y) = ((A(x,y) + B(x,y))/2$$

Where

A (x, y), B (x, y) are input image
F (x, y) is fused image.
Point (x, y) is the pixel value.
For weighted average method-

$$F(x,y) = \sum_{i=0}^{m}\sum_{j=0}^{n}(WA(x,y) + (1-W)B(x,y)$$

Where W is weight factor and point (x, y) is the pixel value

2. Select Maximum

In this method, the resultant fused image is obtained by selecting the maximum intensity of corresponding pixels from both the input image

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

Where
A (x, y), B (x, y) are input image
F (x, y) is fused image, and point

(x, y) is the pixel value.

3. Select Minimum

In this method the resultant fused image is obtained by selecting the minimum intensity of corresponding pixels from both the input images

$$F(i,j) = \sum_{i=0}^{m}\sum_{j=0}^{n} Min(A(x,y) + B(x,y))$$

Where

A (x, y), B (x, y) are input image

F (x, y) is fused image, and

Point (x, y) is the pixel value.

EXPERIMENTAL RESULTS:

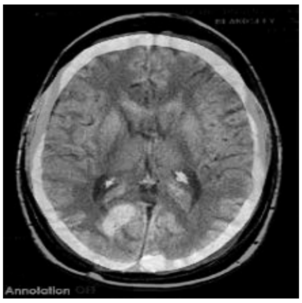


Fig: Averaging fusion image

Fig: Maximum fusion image

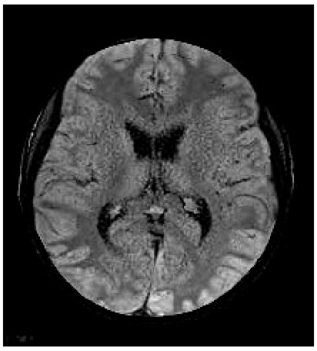


Fig: Minimum fusion image

III MEASUREMENT OF PERFORMANCE IN IMAGE FUSION

In this section, the result of the algorithm is displayed. The algorithm has been implemented using MATLAB 7.0.4.The proposed method has been applied to CT and MRI images and compared with pixel averaging and DWT with MS rule method.

Entropy

It is measure of information content in an image. The maximum value of entropy can be produced when each gray level of whole range has the same frequency. If entropy of fused of images is higher than parent image then it indicates that the fused images contain more in information.

$$H = -\sum_{I=1}^{L} P_I \log p_i$$

Mean

If measures the mean value of the pixel in the image.

$$\mu = \frac{1}{m \times n}\sum_{x=1}^{m}\sum_{y=1}^{n} f(x,y)$$

Where

f(x, y)= denotes the gray level of a pixel with coordinate.

(x, y)= The mean value represents the average intensity of an image.

Standard Deviation

The standard deviation of an image with size of m × n is defined as

$$\sigma = \frac{1}{m \times n}\sum_{x=1}^{m}\sum_{y=1}^{n} \sqrt{f(x,y) - \mu}$$

Where

μ is the mean value of the image.

The standard deviation is the most common measure of statistical dispersion, which can be used to evaluate how widely spread the gray values in an image. So, the larger the standard deviation, the better the result.

RMSE (Root mean square error):

This is evaluate the fused image. It presents the amount of deviation present in the fused image compared to reference image.

$$RMSE = \sum_{i=1}^{M}\sum_{j=1}^{N} \sqrt{\frac{[R(x,y) - F(x,y)]^2}{m \times n}}$$

R=input image

F=fused image

(x, y)=spatial position of pixels on m and n dimension of the image.

MSE (Mean square error)

It is one of the frequently measures the capture the deviation between the original and fused image. It is computed by finding the squared error divided by total number of pixels in the image. The spatial distortion introduced by the fusion process of are measured by MSE

$$MSE = \frac{1}{MN}\sum_{i=1}^{M}\sum_{j=1}^{N} [I(x,y) - F(x,y)]^2$$

Peak signal to noise ratio: It is ratio between the maximum the value of an image and then magnitude of backround noise. It is commonly measured the qualified of reconstruction in image fusion. The higher value PSNR the better is the fused image is

$$\text{PSNR} = \log_{10}\frac{(2n-1)^2}{MSE}$$

TABLE I: QUANTITATIVE RESULTS OF THREE DIFFERENT FUSION TECHNIQUES FOR CT & MRI IMAGES.

Fusion Methods	Mean Value	Standard Deviation	PSNR
Pixel Averaging	31.7994	32.9336	17.6900
DWT	32.0819	34.9640	30.5026
Proposed Method	59.7249	61.5909	41.4506

TABLE II: QUANTITATIVE RESULTS OF THREE DIFFERENT FUSION TECHNIQUES FOR MRI IMAGES

Fusion Methods	Mean Value	Standard Deviation	PSNR
Pixel Averaging	39.6132	47.7422	29.6285
DWT	45.4690	62.0304	58.0040
Proposed Method	49.8099	65.6692	59.0000

From Table I and II, the proposed method is better than the existing methods

CONCLUSION

This paper presents a new wavelet based approach for fusion of CT and MRI images. Firstly, the images to be fused are decomposed by wavelet transform. Then, by considering the characteristics of the two images, the coefficients of low frequency and coefficients of high frequency are selected by different fusion rule. Finally, the fused image is constructed with the inverse wavelet transform by the combined coefficients from the low frequency and high frequency bands. Experimental results on CT and MRI images indicate that the proposed method is better than existing methods.

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