International Journal of Information and Computation Technology.
ISSN 0974-2239 Volume 4, Number 1 (2014), pp. 47-52

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MRI and CT Image Fusion Based on Wavelet Transform

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Abstract

The objective of Image fusion is to combine information from multiple images of the same scene in to a single image retaining the important and required features from each of the original image. Nowadays, with the rapid development in high-technology and modern instrumentations, 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), Positron Emission Tomography (PET) and single photon emission computed tomography (SPECT). For medical diagnosis, Computed Tomography (CT) provides the best information on denser tissue with less distortion. Magnetic Resonance Image (MRI) provides better information on soft tissue with more distortion [1]. In this case, only one kind of image may not be sufficient to provide accurate clinical requirements for the physicians. Therefore, the fusion of the multimodal medical images is necessary [3]. This paper presents a method of image fusion based on discrete wavelet transform. 2-dimmensional DWT is used to decompose the image. The fusion performance is evaluated on the basis of the root mean square error (RMSE) and peak signal to noise ratio (PSNR).

Keywords: Medical Image Fusion, Computed Tomography(CT), Magnetic Resonance Image(MRI), Root mean square error (RMSE), Peak signal to noise ratio (PSNR) , Discrete wavelet Transform(DWT).

1. Introduction

The term fusion means in general an approach to extraction of information acquired in several domains. The objective of Image fusion is to combine information from multiple images of the same scene in to a single image retaining the important and required features from each of the original image. The main task of image fusion is integrating complementary information from multiple images in to single image [6]. The resultant fused image will be more informative and complete than any of the input image and is more suitable for human visual and machine perception. Image fusion is the process that combines information from multiple images of the same scene. Medical image fusion is the technology that could compound two mutual images in to one according to certain rules to achieve clear visual effect. By observing medical fusion image, doctor could easily confirm the position of illness. Medical imaging provides a variety of modes of image information for clinical diagnosis, such as CT, X-ray, DSA, MRI, PET, SPECT etc. Different medical images have different characteristics, which can provide structural information of different organs. For example, CT (Computed tomography) and MRI (Magnetic resonance image) with high spatial resolution can provide anatomical structure information of organs. And PET (Positive electron tomography) and SPECT (Emission computed tomography) with relatively poor spatial resolution, but provides information on organ metabolism [3] [6]. Thus, a variety of imaging for the same organ, they are contradictory, but complementary and interconnected. Therefore the appropriate image fusion of different features becomes urgent requirement for clinical diagnosis.

In this paper, a novel approach for the fusion of computed tomography (CT) and magnetic resonance images (MR) images based on wavelet transform has been presented. Different fusion rules are then performed on the wavelet coefficients of low and high frequency portions [12]. The registered computer tomography (CT) and magnetic resonance imaging (MRI) images of the same people and same spatial parts have been used for the analysis.

2. Image Fusion Based on Wavelet Transform

2.1 Wavelet Transform

"Wavelet transforms allow time – frequency localization"

Wavelet means "small wave" so wavelet analysis is about analyzing signal with short duration finite energy functions.

They transform the signal under investigation in to another representation which presents the signal in a more useful form. Mathematically, we denote a wavelet as;

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

Where b=is location parameter
a=is scaling parameter

for a given scaling parameter a, we translate the wavelet by varying the parameter b. we define the wavelet transform as

$$w(a,b) = \int_t f(t) \frac{1}{\sqrt{|a|}} \psi((t-b)/a) \tag{2}$$

According equation (4), for every (a, b), we have a wavelet transform co-efficient, representing how much the scaled wavelet is similar to the function at location, t = b/a.

"If scale and position is varied very smoothly, then transform is called continuous wavelet transform."

"If scale and position are changed in discrete steps, the transform is called discrete wavelet transform."

3. Image Fusion Method

Image fusion method can be generally grouped in to three categories-
(i) Pixel level (ii) feature level (iii) decision level
Pixel level fusion has the advantage that the images used contain the original measured quantities, and the algorithms are computationally efficient and easy to implement, the most image fusion applications employ pixel level based methods. Therefore, in this paper, we are still concerned about pixel level fusion [14].

Fusion methods are

3.1 Average Method

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

$$F(x,y) = (A(x,y) + B(x,y))/2 \tag{3}$$

Where A (x, y), B (x, y) are input image and F (x, y) is fused image. And point (x, y) is the pixel value.

For weighted average method-

$$F(x,y) = \sum_{x=0}^{m}\sum_{y=0}^{n}(WA(x,y) + (1-W)B(x,y)) \tag{4}$$

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

3.2 Select Maximum

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

$$F(x,y) = \sum_{x=0}^{m}\sum_{y=0}^{n} Max(A(x,y) + B(x,y)) \tag{5}$$

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

3.3 Select Minimum

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

$$F(x,y)=\sum_{x=0}^{m}\sum_{y=0}^{n} Min\left(\left(A(x,y)\right)+B(x,y)\right) \tag{6}$$

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

4. Image Fusion by Wavelet

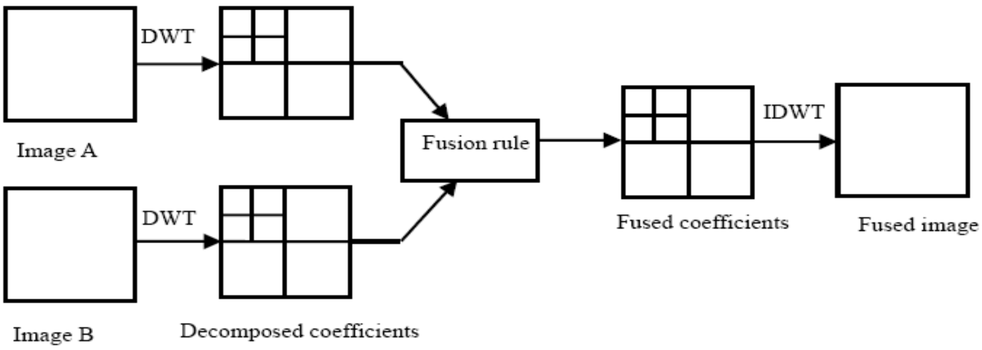

Fig. 1: The image fusion scheme using the wavelet transforms.

5. Experimental Results

Fig. 2 (a) CT image (Brain) **(b)** MRI image (Brain)

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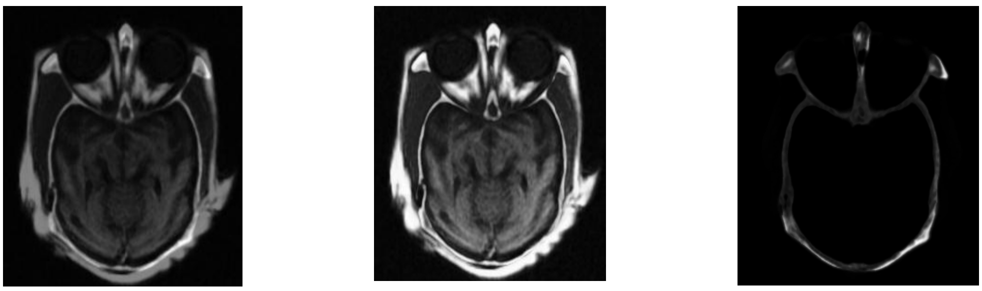

Fig. 3 (a) by average method **(b)** by maximum Method **(c)** by Select minimum Method

6. Conclusions

We have combined the wavelet transform and various fusion rules to fuse CT and MRI images. This method gives encouraging results in terms of smaller RMSE and higher PSNR values. Among all the fusion rules, the maximum fusion rule performs better as it achieved least MSE and highest PSNR values. Using this method we have fused other head and abdomen images. The images used here are grayscale CT and MRI images. However, the images of other modalities (like PET, SPECT, X-ray etc) with their true color nature may also be fused using the same method.

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