Image Fusion On MR And CT Images

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Abstract　**Medical imaging has emerged as one of the most important tools to identify as well as diagnose various disorders. The main objective of medical imaging is to obtain high resolution image details as with as much details as possible for correct diagnosis. There are several medical imaging techniques such as MRI and CT imaging techniques. Both give special sophisticated characteristics of the organ to be imaged. So it is expected that fusion of MRI and CT images of same organ would result in an integrated image of much more details. Many algorithms and tools have been developed for fusing panchromatic and multispectral images. A image fusion algorithm based on wavelet transform to fuse two images is presented in this paper. When images are merged in wavelet space, different frequency ranges are processed differently. It can merge information from original images adequately and improve abilities of information analysis and feature extraction. Wavelet transform of two input images is taken together with fusion rule. Then, inverse wavelet transform is computed to reconstruct fused image.**

Key Words　**MRI, CT, Wavelet, Image Fusion,**

I. INTRODUCTION

Image fusion refers to the techniques that integrate complementary information from multiple image sensor data such that the new images are more suitable for the purpose of human visual perception and computation of processing tasks. Although an increasing number of high-resolution images are available along with sensor technology development, image fusion is still a popular and important method to interpret the image data for obtaining a more suitable image for a variety of applications, such as visual interpretation and digital classification.[4]The fused image should have more complete information which is more useful for human or machine perception. Image fusion is important in many different image processing fields such as satellite imaging, remote sensing and medical imaging.[3] In wavelet fusion method, decomposition of images is done and detail components of decomposition are added at different levels to obtain the new detail components in the different bands of the image which causes merging or fusion of 2 images. The inverse discrete wavelet transform is used to reconstruct the fused image. The fused image better preserves details and edge of the input or source images. The result of the fused image is excellent.

II. BRIEF REVIEW OF DWT

DWT or Discrete Wavelet Transform is the most common form of transform type image fusion algorithm due to its simplicity and ability to preserve time and frequency details of the image to be fused. Similar to Fourier analysis, where sinusoids are chosen as the basis functions, wavelet analysis is based on a decomposition of a signal using an orthonormal family of basis functions. Unlike a sine wave, a wavelet has its energy concentrated in time or space. Sinusoids are useful in analyzing periodic and time invariant phenomenon, while wavelets are well suited for the analysis of transient, time-varying signals. Accordingly, in spatial domain (eg. A 2-dimensional image) DWT analysis also gives the best performance in detecting discontinuities or subtle changes in gray level.

Suppose $f(x)$ $L^2(R)$ (where R is the set of real numbers and $L^2(R)$ denotes the set of measurable, square-integrable one-dimensional function) relative to the wavelet function (x) and scaling function (x). A wavelet series expansion is similar in form to the well-known Fourier series expansion, in which it maps a function of a continuous variable into sequence of coefficients.[5] If the function being expanded is sequence of number (e.g. samples of continuous function $f(x)$), the resulting coefficient are called the discrete wavelet transform (DWT) of $f(x)$. The DWT transform pair is defined as following:

$$W(j_0,k) \quad \frac{1}{\sqrt{M}} {}_{x} f(x) {}_{j_0,k}(x), \qquad (1)$$

$$W(j,k) \quad \frac{1}{\sqrt{M}} {}_{x} f(x) {}_{j,k}(x) \text{ for } j \quad j_0 \qquad (2)$$

And

$$f(x) \quad \frac{1}{\sqrt{M}} {}_{x} W(j_0,k) {}_{j_0 k}(x)$$

$$\frac{1}{\sqrt{M}} {}_{j 1} {}_{x} W(j,k)(x) \qquad (3)$$

Where $f(x)$, ${}_{j_0,k}(x)$, ${}_{j,k}(x)$ are functions of the discrete variable $x = 1,2,\&,M$ 1. Normally, let j_0 0, and M (the length of discrete samples of $f(x)$) is a power of 2 (i.e. M 2^j) so that the summations are

x $0,1,2...M$ 1 j $0,1,2...j$ 1,

k $0,1,2....,2^j$ 1.The transform itself is composed of M coefficients, the minimum scale is 0 and the maximum

scale is j 1 . The coefficients defined in equations (1) and (2) are usually called approximation and detail coefficients respectively. The process of computing the coefficients is referred to as DWT analysis. On the other hand, DWT synthesis (or inverse DWT) is defined by equation (3), to reconstruct $f(x)$ with these coefficients. Finally it should be noted that equations (1) through (3) are valid for orthonormal basis and type frames alone. The scaling function is given by

$$_{j,k}(x) \quad 2^{j/2} \quad (2^j x \quad k) \qquad (4)$$

for all j_0, k Z where Z is the set of integers and Here, k determines the position of along x-axis, j_0 determines width and controls its height or amplitude.

The wavelet function is defined as

$$_{j,k}(x) \quad 2^{j/2} \quad (2^j x \quad k). \qquad (5)$$

The same notations are used here as those in equation (4). (x) is also referred to as mother wavelet. Thus, wavelet basis functions are obtained from single mother wavelet by translation and scaling. However there is no single or universal mother wavelet function. The mother wavelet must simply satisfy a small set of conditions and is typically selected based on the domain of the signal or image processing problem. Almost all useful wavelet systems satisfy the multi-resolution condition. This means that given as approximation of signal $f(x)$ using translations of mother wavelet up to a selected scale, we can achieve better approximation by using expansions signals with half the width and half the translation steps. This is conceptually similar to improving frequency resolutions by doubling the number of harmonics in a Fourier series expansion. [4]

DWT is a spatial-frequency decomposition that provides a flexible multi-resolution analysis of an image. DWT decomposes an image into low frequency bands and high frequency bands and it can also be reconstructed at these levels when images are fused. In DWT, different frequencies are processed differently which improves the quality of new image.

I. THEORY OF FUSION ALGORITHM

First step in fusion using wavelet transformation consists in extracting the structures (also called details) present between the images of two different resolutions. These structures are isolated into three wavelet coefficients which correspond to detail images according to three directions (vertical, horizontal and diagonal). In wavelet decomposition four components are calculated from different possible combination of row and column filtering. Adding approximate components of image1 to approximate components of image2, similarly adding detail components of image1 to detail components of

image2, we will get approximate and detail components of target image. Inverse wavelet transform is applied to the fused components to create the fused image.
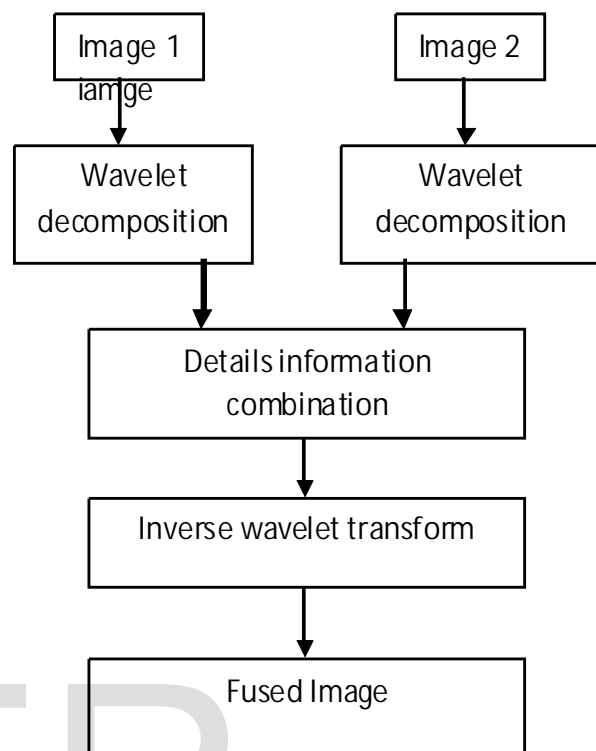

Figure (4) Algorithm For Image Fusion

There are hundreds of mother or base wavelets available for decomposition. In practice a mother wavelet is selected from ready-made wavelets for a particular problem and different wavelets (x) have different effects. For instance, Harr wavelets are suitable for the representing a piecewise signal and Daubechies wavelets are more suitable for compressing data. The Daubechies series is the most commonly used series for wavelet decomposition. Choice of mother wavelet has an important effect on the decomposition result. Although there are no base wavelets that can give best results, the Daubechies family, in general, has the most clear detection of changes in the energy of distorted signals over the most decomposition bands. Table below gives the percentage ratio of energy of signal A to energy of reference signal at different bands. As can be seen that db6 gives the maximum energy level and best suited for image fusion in medical imaging.

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Table I. The percentage ratio of energy of signal A to energy of reference signal at different bands.

Band	Mother Wavelet Type				
	db4	db6	db10	db40	Max
1	0.43	0.43	0.43	0.43	0.44
2	2.63	**8.49**	3.97	3.63	8.49
3	5.05	3.97	4.96	2.97	5.05
4	3.59	4.90	2.06	6.67	6.67
5	3.67	18.88	24.91	8.12	24.91

If we observe max column for band 2, we will find that db6 has the maximum energy level. So we will use db6 as base wavelet for decomposition of MRI and CT images. Both the source images, that is MRI and CT images are decomposed using wavelet transform. Wavelet transform computes four filters. The four output filters are: Lo_D, the decomposition low-pass filter, Hi_D, the decomposition high-pass filter, Lo_R, the reconstruction low-pass filter, Hi_R, the reconstruction high-pass filter.

I. EXPERIMENTAL RESULTS

Fig.(1) and Fig.(2) represents the MRI and CT images of brain of same person respectively. In MRI image the inner contour is missing but it provides better information on soft tissue. In CT image, it provides best information on denser tissue with less distortion but misses soft tissue information. Fig.(3) is the result of orthogonal wavelet fusion technique which is by combining of MRI and CT images. The orthogonal wavelet fused image have information of both images.

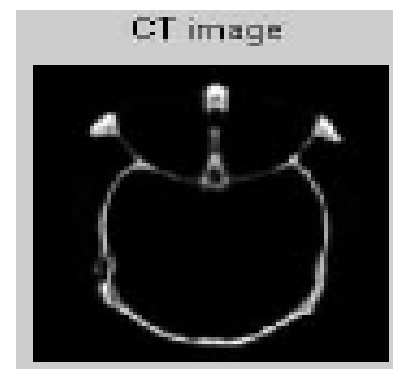Figure (1) MR Image Of Brain[9]

Figure (2) CT Image Of Brain[9]

Figure (3) Ortho Fused Image

II. DISCUSSION AND CONCLUSION

The aim of this paper has been to fuse MRI and CT images of same organ using wavelet transform. For an effective fusion of images a technique should aim to retain important features from all input images. These features often appear at different positions and scales. Multi-resolution analysis tools such as the wavelet transforms are therefore ideally suited to image fusion and thus provide a powerful set of tools for image enhancement and analysis together with a common framework for various fusion tasks. Wavelet fusion method used in this paper reduces the ringing and aliasing effects and makes the image smoother.

ACKNOWLEDGEMENT

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