Image Fusion based on Wavelet Transform for Medical Application

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Abstract
Image Fusion is a technique that integrates complementary information from multiple images such that the fused image is more suitable for processing tasks. The paper starts with the study of initial concepts for image fusion. In this paper, the fusion of images from different sources using multiresolution wavelet transform with preprocessing of Image Fusion is proposed. The fused image has more complete information which is useful for human or machine perception. The fused image with such rich information will improve the performance of image analysis algorithms for medical applications.

Keywords **–** CT, DWT, fusion, MR.

I. INTRODUCTION
Information is used in many forms to solve problems and monitor conditions. When multiple source information is combined, it is essentially used to derive or infer more reliable information. However, there is usually a point of diminishing returns after which more information provides little improvement in the final result. Which information and how to combine it is an area of research called data fusion. In many cases, the problem is ill defined when data is collected. More information is gathered in hopes of better understanding the problem, ultimately arriving at a solution. Large amounts of information are hard to organize, evaluate, and utilize. Less information giving the same or a better answer is desirable. Data fusion attempts to combine data such that more information can be derived from the combined sources than from the separate sources. Data fusion techniques combine data and related information from associated databases, to achieve improved accuracies and more specific inferences.

The image fusion system processing flow is shown in Fig.1.The image fusion is the synthesis of multi source image information which is retrieved from the different sensors. These images are then registered to assure the corresponding pixels are aligned properly. Afterwards they are fused using any of the transforms discussed below. It then generates fused image which is more accurate, all-around and reliable. It can result in less data size, more efficient Target detection, and target identification and situation estimation for observers. Also it can make the images more suitable for the task of the computer vision and the follow-up image processing [1].

With the many new sensor types blooming up, the image acquisition capability is rapidly increasing, and the images generated by the sensors with the different physical characteristics. As the image data retrieved by different sensors has the obvious limit and difference in the geometry, spectrum, time and space resolutions, it's hard to satisfy the practical acquirement to use just one type of image data. In order to have the more complete and accurate comprehension and acknowledge to the target, people always hope to find a technical method to make use of the different types of image data. It's very important and practical to combine the advantages of the different types of image data. For medical image fusion, the fusion of images can often lead to additional clinical information not apparent in the separate images. Another advantage is that it can reduce the storage cost by storing just the single fused image instead of multi-source images. So far, many techniques for image fusion have been proposed in this paper and a thorough overview of these methods can be viewed in reference [3].

The fusion of multiple measurements can reduce noise and therefore eliminates their individual limitations. It is required that the fused image should preserve as closely as possible all relevant information obtained in the input images and the fusion process should not introduce any artifacts or inconsistencies, which can distract or mislead the medical professional, thereby a wrong diagnosis.

Ii. Preprocessing Of Image Fusion
Two images taken in different angles of scene sometimes cause distortion. Most of objects are the same but the shapes change a little. At the beginning of fusing images, we have to make sure that each pixel at correlated images has the connection between images in order to fix the problem of distortion; image registration can do this. Two images having same scene can register together using software to connect several control points. After registration, resampling is done to adjust each image that about to fuse to the same dimension. After resampling, each image will be of the same size. Several interpolation approaches can be used,

to resample the image; the reason is that most approaches we use are all pixel-by-pixel fused.

Images with the same size will be easy for fusing process. After the re-sampling, fusion algorithm is applied. Sometimes we have to transfer the image into different domain, sometimes haven't depending on the algorithm. Inverse transfer is necessary if image has been transferred into another domain. Fig.1 summarizes these steps called, preprocessing of image fusion.

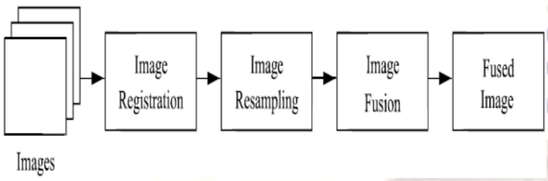

Fig.1. Preprocessing of image fusion.

Iii. Wavelet Based Image Fusion

A. *Wavelet Theory*

Wavelets are finite duration oscillatory functions with zero average value. The irregularity and good localization properties make them better basis for analysis of signals with discontinuities. Wavelets can be described by using two functions viz. the scaling function f (t), also known as 'father wavelet' and the wavelet function or 'mother wavelet'. 'Mother' wavelet ψ (t) undergoes translation and scaling operations to give self similar wavelet families as in (1).

$$\psi_{a,b}(t) = \frac{1}{\sqrt{a}}\psi\left(\frac{t-b}{a}\right),(a,b\varepsilon R), a>0 \quad (1)$$

where a is the scale parameter and b the translation parameter. Practical implementation of wavelet transforms requires discretisation of its translation and scale parameters by taking,

$$a = a_0^j, b = m a_0^j b_0 \quad j,m\varepsilon Z \quad (2)$$

Thus, the wavelet family can be defined as:

$$\psi_{j,m}(t) = a_0^{-j/2}\psi(a_0^{-j}t - mb_0) \; j,m\varepsilon Z \quad (3)$$

If discretisation is on a dyadic grid with a0 = 2 and b0 = 1 it is called standard DWT [13]. Wavelet transformation involves constant Q filtering and subsequent Nyquist sampling as given by Fig. 1 [9]. Orthogonal, regular filter bank when iterated infinitely gives orthogonal wavelet bases [14]. The scaling function is treated as a low pass filter and the mother wavelet as high pass filter in DWT implementation.

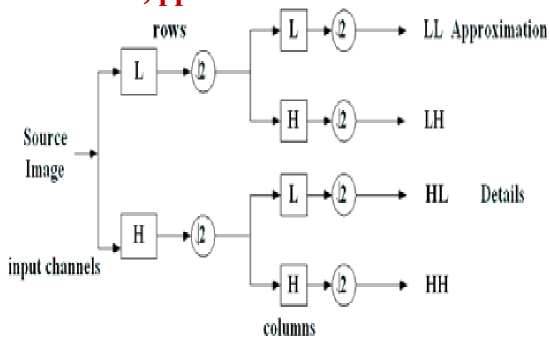

Fig. 1 Two-dimensional subband coding algorithm for DWT: The source image is decomposed in rows and columns by low-pass (L) and high-pass (H) filtering and subsequent downsampling at each level to get approximation (LL) and detail (LH, HL and HH) coefficients. Scaling function is associated with smooth filters or low pass filters and wavelet function with high-pass filtering

B. *Fusion Algorithms*

The advent of multiresolution wavelet transforms gave rise to wide developments in image fusion research. Several methods were proposed for various applications utilizing the directionality, orthogonality and compactness of wavelets [4],[5],[6]. Fusion process should conserve all important analysis information in the image and should not introduce any artefacts or inconsistencies while suppressing the undesirable characteristics like noise and other irrelevant details [1], [5].

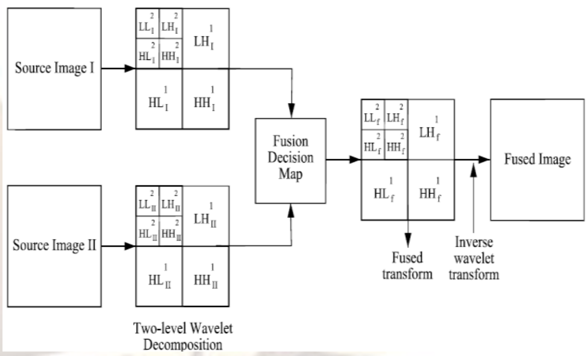

Fig.2. Wavelet based image fusion

The source images such as CT and MR are decomposed in rows and columns by low-pass (L) and high-pass (H) filtering and subsequent down sampling at each level to get approximation (LL) and detail (LH, HL and HH) coefficients. Scaling function is associated with smooth filters or low pass filters and wavelet function with high-pass filtering. Wavelet transforms provide a framework in which an image is decomposed, with each level corresponding to a coarser resolution band.

IV. PROPOSED ALGORITHM

The steps involved in this algorithm are as below:

Step 1: Read the two source images, image I and image II to be fused and apply as input for fusion.

Step 2: Perform independent wavelet decomposition of the two images until level L to get approximation (LL^L) and detail (LH^l, HL^l, HH^l) coefficients for l=1, 2... L

Step 3: Apply pixel based algorithm for approximations which involves fusion based on taking the maximum valued pixels from approximations of source images I and II.

$$LL_f^L = maximum(LL_I^L(i,j), LL_{II}^L(i,j)) \quad (2)$$

Here, LL^L_f is the fused and LL^L_I and LL^L_{II} are the input approximations, i and j represent the pixel positions of the sub images. LH^l_f, LH^l_I, LH^l_{II} are vertical high frequencies, HL^l_f, HL^l_I, HL^l_{II} are horizontal high frequencies, HH^l_f, HH^l_I, HH^l_{II} are diagonal high frequencies of the fused and input detail sub bands respectively.

Step 4: Based on the maximum valued pixels between the approximations from Eq. (2), a binary decision map is formulated. Eq. (3) gives the decision rule D_f for fusion of approximation coefficients in the two source images I and II as

$$D_f(i,j) = 1, d_I(i,j) > d_{II}(i,j) \\ = 0, \text{otherwise} \quad (3)$$

Step 5: Thus, the final fused transform corresponding to approximations through maximum selection pixel rule is obtained.

Step 6: Concatenation of fused approximations and details gives the new coefficient matrix.

Step 7: Apply inverse wavelet transform to reconstruct the resultant fused image and display the result.

V. EXPERIMENTAL RESULTS

In medicine, CT and MRI image both are tomographic scanning images. They have different features. Fig.4(a) shows CT image, in which image brightness related to tissue density, brightness of bones is higher, and some soft tissue can't been seen in CT images. Fig.4(b) shows MRI image, here image brightness related to amount of hydrogen atom in tissue, thus brightness of soft tissue is higher, and bones can't been seen. There is complementary information in these images. We use three methods of fusion forenamed in medical images, and adopt the same fusion standards

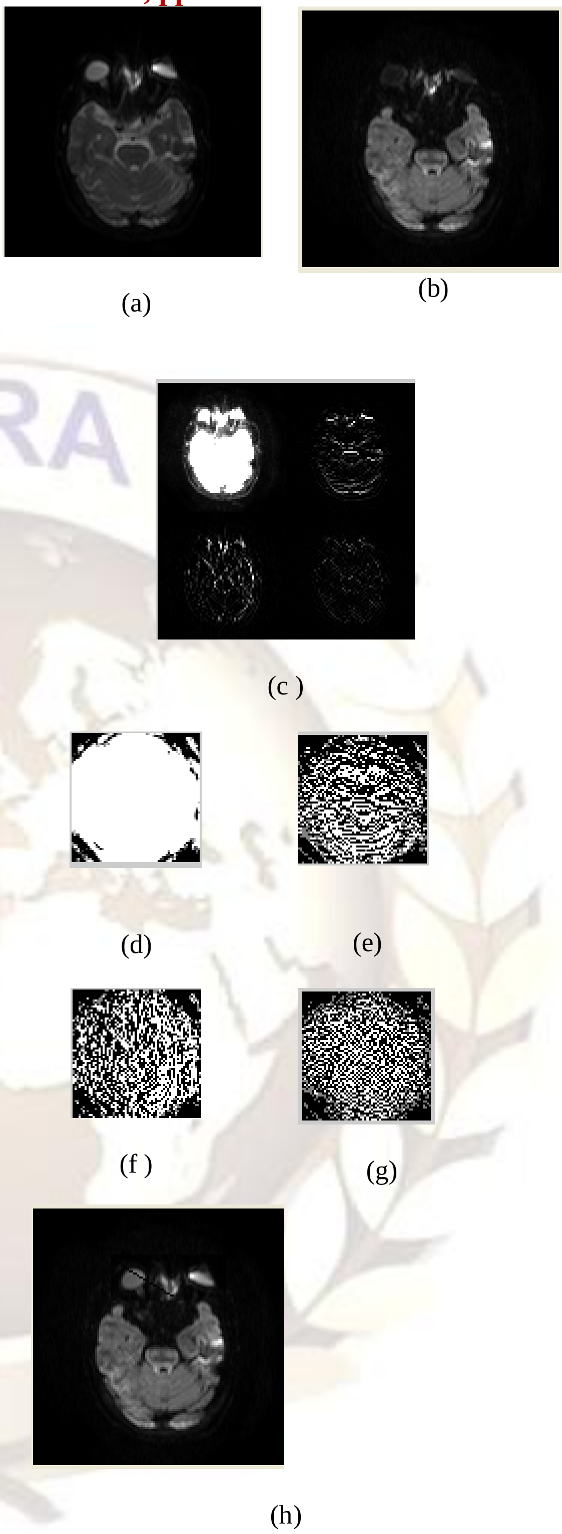

Fig.4 Images and their image fusion. (a): CT Image; (b): MRI Image; (c):Decomposed image; (d):approximations; (e):Horizontal details; (f):Vertical Details; (g):Diagonal Details; (h): Fused Image;

VI. CONCLUSION

This paper puts forward an image fusion algorithm based on Wavelet Transform. It includes multiresolution analysis ability in Wavelet Transform. Image fusion seeks to combine information from different images. It integrates complementary information to give a better visual picture of a scenario, suitable for processing. Image Fusion produces a single image from a set of input images. It is widely recognized as an efficient tool for improving overall performance in image based application. Wavelet transforms provide a framework in which an image is decomposed, with each level corresponding to a coarser resolution band. The wavelet sharpened images have a very good spectral quality. The wavelet transform suffers from noise and artifacts and has low accuracy for curved edges. In imaging applications, images exhibit edges & discontinuities across curves. In image fusion the edge preservation is important in obtaining complementary details of input images. So furure work include Curvelet based image fusion which is best suited for medical images.

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