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Review on Wavelet Based Image Fusion Techniques

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Abstract—: Image fusion is a kind of tool that serves to merge multi sensors images by using advanced image processing techniques. Particularly it serves best in medical diagnosis like, computed tomography (CT), magnetic resonance image (MRI), scan provides different types of information, by fusing them we can get exact information for better clinical diagnosis. This paper gives introduction of image fusion method based on wavelet transform. Recently, almost all the area of medical diagnosis is influenced by Image Processing. For medical diagnosis, MRI and CT images are of main concern, both gives Special intellectual characteristic of the organ to be imaged. MRI provides better information on soft tissues whereas Computed Tomography (CT) provides the best information on denser tissue. A though of merging image for different modalities becomes very important and medical image fusion has developed as new encouraging research field that help surgeons in the diagnosis process. This paper postulates an overview of different image fusion methods for medical applications and to enhance the fusion results proposed method is described shortly.

Keywords— Image fusion, wavelet transform, discrete wavelets transform (DWT), CT, and MRI.

I. INTRODUCTION

Image fusion is a technology which holds images as main contents. It refers to the techniques that merge multi-images of the same scene from multiple image sensor data or combine multi images of the same scene at different times from one image sensor. Wavelet Transform has decent time-frequency characteristics. It was applied effectively in image processing field. This paper gives details about the Second Generation Curvelet Transform and uses it to fuse images. The experiments show that the method could extract useful information from input images to fused images so that clear images are obtained. This paper gives the characteristics of the Second Generation Wavelet Transform and the Second Generation Curvelet Transform. From high and low frequency we choosing the low-frequency coefficients, the purpose of local area variance were chosen to measuring criteria. In choosing the high frequency coefficients, the window property and local characteristics of pixels were identified. The main goal of medical imaging is to obtain a high resolution image with as much details as possible for the sake of diagnosis. MRI and the CT scan techniques are medical imaging techniques. Both techniques give special characteristics of the tissue to be imaged. So, it is expected that the fusion of the MRI and the CT scan images of the same tissue would result in a combined image of much more details. Due to the limited capability of the wavelet transform to deal with images having curved shapes, the application of the curvelet transform for MRI and CT scan image fusion is represented.

II. WAVELET THEORY USED IN IMAGE FUSION

Wavelets are finite duration oscillatory functions with zero average value. The variability and best localization proper-ties make them better basis for analysis of signals with discontinuities. Wavelets can be described by using two functions. 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 similar wavelet families as in (1).

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

Where, as is the scale parameter and b the translation parameter. Practical implementation of wavelet transforms requires discretization of its translation and scale parameters by taking,

$$a = a_0^j, b = ma_0^j b_0 \qquad j, m\varepsilon Z \qquad (2)$$

Thus, the wavelet family can be defined as:

$$\varphi_{j,m}(t) = a_0^{-\frac{j}{2}}\varphi\left(a_0^{-j}t - mb_0\right)\ j, m\varepsilon Z \quad (3)$$

.

Different Types of Wavelets

Different types of wavelets used in image fusion can be categorized into Orthogonal, Bi-orthogonal and A'trous wavelet. Although these wavelets share some general kind of properties, each wavelet has a unique image decomposition and reconstruction characteristics that lead to different fusion results [2].

A. *Orthogonal Wavelet*

The dilations and translation of the scaling functionφ_j, k(x) constitute a basis forV_j, and same asΨ_j, k(x) for W_j, if the φ_j, k(x) and Ψj, k(x) are orthonormal, they include the following property.

$$\boldsymbol{V_j} \perp \boldsymbol{W_j} \qquad (4)$$

These results give a representation of a single image, containing multi-scale detail information from all component images involved.

B. *Bi-orthogonal Wavelet*

For bi-orthogonal transform, perfect reconstruction is available. Orthogonal wavelets give orthogonal matrices and unitary transforms; bi-orthogonal wavelet gives exact reconstruction. For bi-orthogonal wavelet filter, the Low-pass and high-pass filters do not have the same length. The low-pass filter is always Symmetric, while high pass filter could be either symmetric or non-symmetric. The method allows unusual flexibility in choosing a filter for any task involving the multi-resolution analysis.

C. *A'trous (Non-orthogonal) Wavelet*

A'trous is a kind of non–orthogonal wavelet that is different from orthogonal and bi-orthogonal. It is a stationary or redundant transform, i.e. decimation is not implemented during the process of wavelet transform, while the orthogonal or bi-orthogonal wavelet can be carried out using either decimation or undecimation mode. The enhancement of the spatial information frequently leads to the distortion of the information in the spectral domain.

III. EXISTING METHODS

Wavelet Transform

The most common types of transform type image fusion algorithms is the wavelet fusion algorithm due to its easiness and its ability to preserve the time and frequency details of the images to be fused.

Wavelet transform fusion is more properly defined by considering the wavelet transforms of the two registered input images together with the fusion rule .Then, the inverse wavelet transform is computed, and the fused image is reconstructed [2]. 2-D DWT is very useful for image processing because the image data are discrete and the spatial and spectral resolution is dependent on the frequency. The DWT has the property that the spatial resolution is small in low-frequency bands but it is large in high frequency bands.[4]

There are several wavelet fusion rules that can be used for the selection of wavelet coefficients from the wavelet transforms of the images to be fused. The most commonly used rule is the maximum frequency rule which selects the coefficients that have the maximum absolute values. The wavelet transform concentrates on representing the image in multi-scale and it is suitable to represent linear edges. For curved edges, the accuracy of edge localization in the wavelet transform is low. So, there is a need for an alternative approach which has a high accuracy of curve localization such as the curvelet transform.

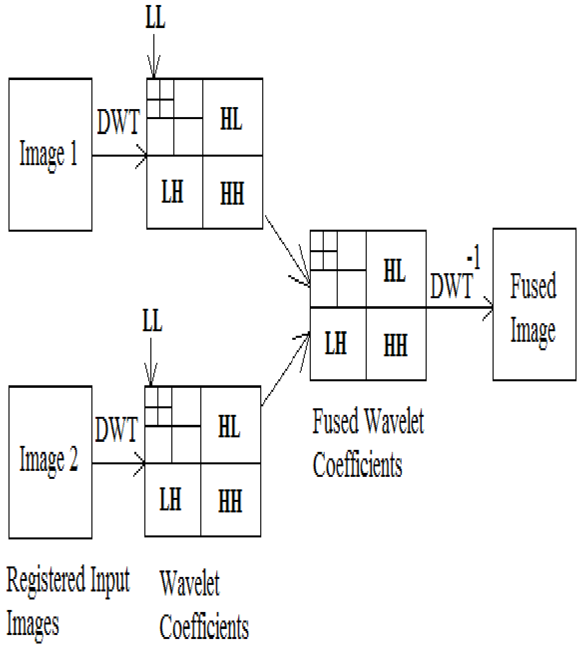

Fig.1 Block diagram of Discrete Wavelet transform

Discrete Wavelet Transform (DWT)

The discrete wavelet transform (DWT) is an implementation of the wavelet transform using a discrete set of the wavelet scales and translations obeying some defined rules. In other words, this transform decomposes the signal into mutually orthogonal set of wavelets, which is the main difference from the continuous wavelet transform (CWT), or its implementation for the discrete time series sometimes called discrete-time continuous wavelet transform (DT-CWT).

The wavelet can be constructed from a scaling function which describes its scaling properties. The restriction that the scaling functions must be orthogonal to its discrete translations implies some mathematical conditions on them which are mentioned everywhere e. g. the dilation equation

$$\phi(x) = \sum_{k=-\infty}^{\infty} a_k \phi(Sx - k).$$

Where S is a scaling factor. Moreover, the area between the function must be normalized and scaling function must be orthogonal to its integer translates e. g.

$$\int_{-\infty}^{\infty} \phi(x)\phi(x+l)dx = \delta_{0,l}$$

After introducing some more conditions we can obtain results of all this equations, e. g. finite set of coefficients a_k which define the scaling function and also the wavelet. The wavelet is obtained from the scaling function as

$$\psi(x) = \sum_{k=-\infty}^{\infty} (-1)^k a_{N-1-k}\psi(2x-k)$$

Where N is an even integer. The set of wavelets than forms an orthonormal basis which we use to decompose signal. Note that usually only few of the coefficients a_k are nonzero which simplifies the calculations[12].

Wavelet Decomposition of Images

Wavelet decomposition is first performing row by row and then column by column. Here is the procedure for an N x M image. You can filter each row and then down-sample to obtain two N x (M/2) images. Then after filter each column and subsample the filter output to obtain four (N/2) x (M/2) images. [3] The one obtained by low-pass filtering the rows and columns is referred to as the LL image. The one obtained by low-pass filtering the rows and high-pass filtering the columns is referred to as the LH images. The one obtained by high-pass filtering the rows and low-pass filtering the columns is called the HL image. The sub image obtained by high-pass filtering the rows and columns is referred to as the HH image. Each of the sub images obtained can then be filtered and sub sampled to obtain four more sub images. This process can be continued until the desired sub band structure is obtained (Fig-3).

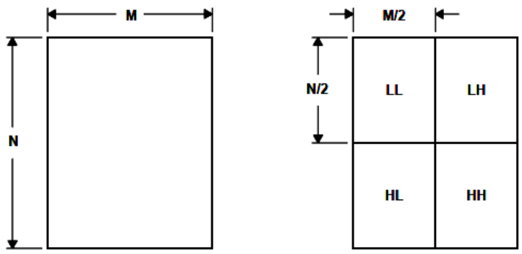

Fig.2. Original Image One-Level 2-D Decomposition

Three of the most popular ways to decompose an image are: pyramid, and wavelet packet, as shown in Fig.2.

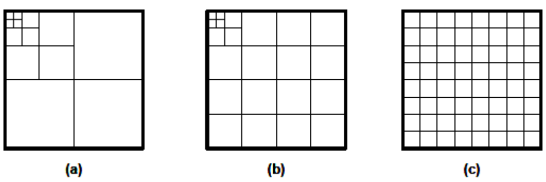

Fig.3. Three Popular Wavelet Decomposition Structure On Image: (a) pyramid, (b) spacl, (c) wavelet packet

In the structure of pyramid decomposition, only the LL sub image is decomposed after each decomposition into four more sub images.[3]

- In the structure of wavelet packet decomposition, each sub image (LL, LH,, HL, HH) is decomposed after each decomposition.
- In the structure of spacl, after the first level of decomposition, each sub image is decomposed into smaller sub images, and then only the LL sub image is decomposed.

CURVELET TRANSFORM

The curvelet transform has evolved as a tool for the representation of curved shapes in graphical applications like medical image processing [6]. Then, it was extended to the fields of edge detection and image Denoising, Image Fusion.. The algorithm of the curvelet transform of an image P can be summarized in the following steps as given below: [6]:

1. The image P is split up into three sub bands 1, 2 and P3 by using the additive wavelet transform.
2. Tiling is performed on the sub bands 1 and 2.
3. The discrete transform is performed on each tile of the sub bands 1 and 2.

Curvelet transform is a tool for representation curved shapes of images. The concept of curvelet transform in image fusion is based on the quality of image after fusing two source images. It is most suitable to work with medical images[14].
Sub band filtering decomposes image into additive components which are the sub ands of the image. In order to decompose image A'trous algorithm is given by where represents the low pass content of the image and represents the high pass content. This is done by applying 1D discrete wavelet transform to the slices of the radon transform. Curvelet transform helps in shape detection. The first generation curvelet transform is more complex involves a series of steps. Due to its complexity, the second generation curvelet is much preferred. Thus Second generation does not use the Curvelet transform, and hence reduces the redundancy.[6]

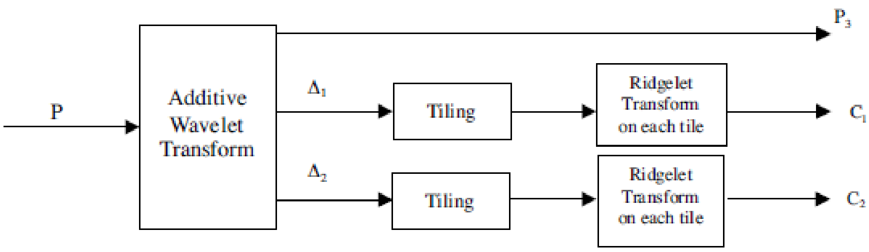

Fig.4. Discrete Curvelet Transform of Image P

IV. PROPOSED WORK

The most important issue concerning image fusion is to determine how to combine the sensor images. There are several image fusion techniques have been proposed. The primitive fusion schemes perform the fusion on the source images. Pixel-by-pixel gray level average of the source images is the very simple fusion technique. This simplistic approach often has serious side effects such as reducing the contrast. With the introduction of pyramid transform in mid-80, some more sophisticated approaches began to emerge. We get the good results if the fusion was performed in the transform domain. This transform appears to be very useful for this purpose. Multi resolution decomposition is performing on each source image. Integration of all decompositions done to form a composite representation. Reconstruct the fused image by performing an inverse Multiresolution transforms. More recently, with the development of wavelet theory, the multi-scale wavelet decomposition has begun to take the place of decomposition for image fusion [15]. Actually, the wavelet transform can be considered to be one special type of decompositions. Proposed Algorithm has following steps:

1. Take the CT and PET images from user.
2. Check for the size.
3. If size is not same, resize the input images.
4. Enter the level of decomposition.
5. Enter the type of wavelet (haar, Daubechies, symlet).
6. Decompose both the images by using discrete wavelet transform.
7. Separate out the approximate and details from decomposed image.
8. Apply appropriate selection criterion to select the wavelet
   Coefficients from both the images and concatenate them to form a single decomposed image.
9. Take the absolute values of approximate and details.
10. Reconstruct the image by using inverse discrete wavelet transform.
11. Evaluate the different parameters.
12. Display the input and output images.

It retains most of the advantages for image fusion but has much more complete theoretical support. In medical, CT and MRI image both are tomographic scanning images [8]. Both images have different features. Fig.10. shows CT image, in which image brightness related to tissue density, brightness of bones is higher, and some soft tissue can't be seen in CT images [7].

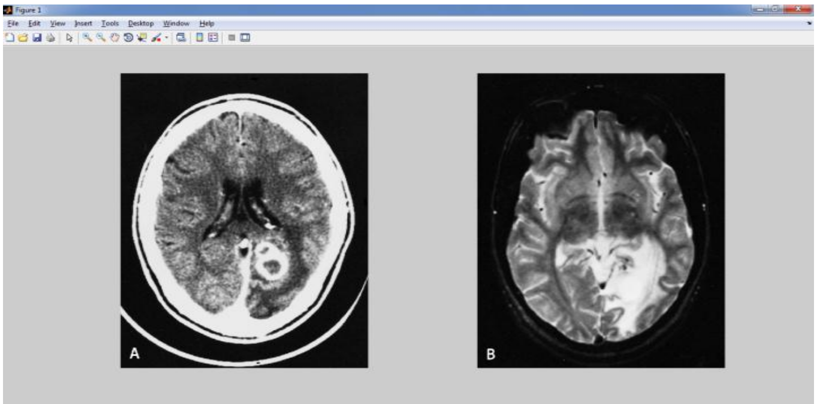

Fig.5. CT Image **Fig.6. MRI Image**

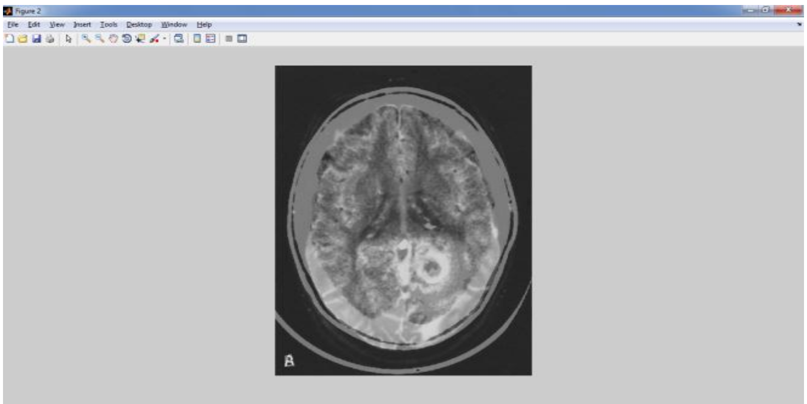

Fig.7. Fused image

Fig.5. 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 be seen. There is complementary information in these images. We use Curvelet Transform and fused medical images.Fig.7 shows the fused image.

V. CONCLUSION

This paper puts forward an image fusion algorithm based on Wavelet Transform and Curvelet Transform. It includes multi resolution analysis ability in Wavelet Transform, also has better edge feature of awaiting describing images in the Curvelet Transform. This method could better describe the edge direction of images, and gives feature of images better. MRI image provides much greater contrast between different soft tissues of body than CT scan image. Brightness of bones is higher in CT scan images but soft tissues can't be seen. Fusion image provides both characteristics of CT scan and MRI in the single image.

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