IOSR Journal of Electronics and Communication Engineering (IOSR-JECE)
ISSN: 2278-2834, ISBN: 2278-8735, PP: 14-18
www.iosrjournals.org

Fusion of PET and CT images using wavelet transform

Supriya Arote [1], Vaishali Upadhaye [2]
[1](Biomedical Engg/Yadavrao Tagaonkar college of Engg/Mumbai,India)
[2](Instrumentation & control / Cummins College of Engg/Pune,India)

ABSTRACT: *PET/CT medical image fusion has important clinical significance. As the wavelet transform has several particular advantages in comparison with scalar wavelets on image processing, this paper proposes a medical image fusion algorithm based wavelet transform after in-depth study of wavelet theory. The algorithm achieves PET/CTfusion with wavelet coefficients fusion method. Experimental results show that fusion image combines information of the source images, adds more details and texture information, and a good fusion result. Based on the proposed algorithm, we can obtain the best result when using gradient fusion in the low-frequency part and classification fusion in the high frequency part.*

Keywords *- PET/CT; image fusion; wavelet transform*

I. INTRODUCTION

Depending on the principle of imaging equipment, medical images can be divided into anatomical images and functional images . Because of the different imaging principle, they have different advantages. If these two kinds of image information integrate together as a basis for medical diagnosis, clinicians will make more rapid and more accurate medical result. PET and CT fusion on the same machine is a typical representative of the multimodal medical image fusion technology. One image can get PET and the corresponding parts of CT. It combines the advantages of both and provides a reliable basis for diagnosis. PET/CT image fusion has become a research hotspot at present .There are many multimodal medical image fusion methods. Because of the good sub-frequency features in the transform domain, the wavelet transform has been widely used. Multiwavelet is an extension from wavelet theory, and has several particular advantages in comparison with scalar wavelets on image processing. It can simultaneously posses many desired properties such as short support, orthogonality, symmetry and smoothness. These properties are very important for the image analysis and processing. This paper studies the basic principles of multiwavelet transform and characteristics of multiwavelet coefficients, and designs a medical image fusion algorithm based on multiwavelet transform for the PET/CT image fusion. Experimental results show that fusion image. Combines information of the source images, adds more details and texture information, and achieves a good fusion result.[1]

II. MULTIWAVELET INTRODUCTION

Wavelet analysis is a new development field of applied mathematics and engineering sciences. Because of the good time-frequency localization characteristics, scale variation characteristics and direction characteristics, wavelet has been widely used in many fields. In 1994, Goodman and others established the multiwavelet basic theoretical framework based on the multi-resolution analysis In recent years, multiwavelet research has become a hot research topic in the wavelet field.Multiwavelet is an extension from scalar wavelet. It not only maintains the good time-domain and frequency domain localization properties which scalar wavelet possess, but also overcomes the shortcomings of the scalar wavelet. Compared with the scalar wavelet transform, multi-wavelet transform has the following advantages .Multiwavelet posses many desired properties such as short support, orthogonality, symmetry and smoothness which are very important for the image analysis and processing. Multiwavelet filter banks have no strict division of low-pass and high-pass. Through the multi-wavelet profiteering, it can transfer high-frequency energy to the low-frequency[2]. This is very beneficial to improve the compression ratio. There is increasing concern about the multiwavelet for the theoretical advantages and potential applications. The commonly used multiwavelets involve orthogonal multiwavelet such as GHM,CL,SA4 and biorthogonal multiwavelet such as BIGHM. In this paper, we use GHM and CL multiwavelet to process the image.[1]

2.1 Algorithm Design

According to the Mallat tower wavelet decomposition theory, the original image is decomposed using 2-dimensional wavelet transform, which can get a low frequency sub band and three high frequency sub-bands (Figure 1). The low frequency sub-band reflects the image's approximate components and presents basic information, while the high frequency sub-bands reflect the details of the components of the image horizontally, vertically, and diagonally, along with the corresponding edge, line, area, boundary and other information.[3] Figure 1

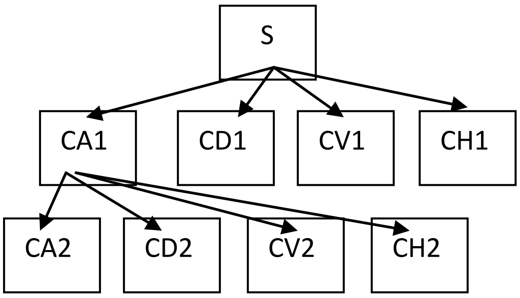

Fig 1. The tower shape structure of image wavelet decomposition

Here, *S* represents the coefficient matrix of the original image. *CA* represents the low frequency coefficient matrix; *CD,CV AND CH* respectively represent the diagonal, vertical and horizontal direction of the high frequency coefficient matrix; 1 and 2, respectively, represent level one and level two decomposition. Therefore, if the image performs *n* level wavelet decomposition, we will eventually get (3n + 1) different frequency bands, which contain a low frequency band and 3*n* high frequency bands. The higher the decomposition level, the smaller the size of the corresponding layer. The process of image fusion is shown in Figure 2. A and B are registered images[5]. F is the fusion image. First of all, we make the decomposition and filtering for the source images. Then, the image is decomposed into decomposition transform coefficients of different frequency bands in frequency domain, which constitute a series of matrices to represent the various features of the source image components. Fusion process can use different ways to achieve the best fusion results according to different characteristics component. Next, we make the consistency check and post filtering, and at last, the final fusion image will be generated. Next, we will explain the crucial steps in the wavelet fusion process.[4]

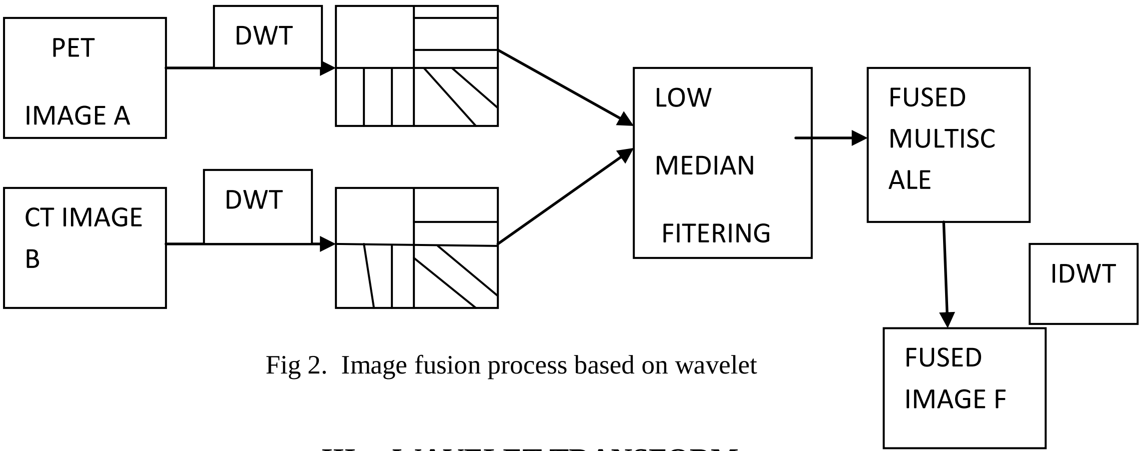

Fig 2. Image fusion process based on wavelet

III. WAVELET TRANSFORM

3.1 Wavelet decomposition in the row direction

First, convert each row of *C* into a row vector signal in accordance with the following way shown in(1)

$$C\ iR\ (n) = \begin{bmatrix} ci, n \\ c\ i, \frac{N}{2} + n \end{bmatrix} \qquad (1)$$

Where, i _ 0,1,...,N -1,n = 0,1,...,(N -1) / 2 , then, make wavelet transform to each row of *C iR* in accordance with the following way shown in (2) and (3)

$$Di,m\text{^}L\ (n) = \sum Gr*r\ (n-2m)\ C\ iR\ (n) = \begin{bmatrix} d\ i, m\text{^}L \\ d\ i, m+, \frac{N}{4}\text{^}L \end{bmatrix} \qquad (2)$$

$$Di,m\ \hat{}H\ (n) = \sum Gr^*r\ (n-2m)\ C\ iR\ (n) = \begin{bmatrix} d\ i, m\hat{}H \\ d\ i, m+, \frac{N}{4}\hat{}H \end{bmatrix} \qquad (3)$$

Where, $i = 0,1,...,N - 1, m = 0,1,...,(N -1) / 4$,$Gr^*\ r$ is a 2_2 matrix, means the low-frequency filter corresponding with the used wavelet. $r\ r\ H$ _ is a 2_2 matrix, means the high-frequency filter corresponding with the used wavelet Let D^L =[Di,j^L],D^H[Di,j^H] = [D^L,D^H].

3.2 Wavelet decomposition in the column direction

Convert each column of D into a column vector signal in the same way with treatment of row direction.

$$D\ ic\ \hat{}L(n) = \begin{bmatrix} Dn\ i\hat{}L \\ Dn + \frac{N}{2}, i \end{bmatrix} \quad D\ ic\ \hat{}L(n) = \begin{bmatrix} Dn\ i\hat{}H \\ Dn\hat{}H + \frac{N}{2}, i \end{bmatrix} \qquad (4)$$

Where, $i= 0,1,...,N -1, n = 0,1,...,(N -1) / 2$,then, we make wavelet transform in the column direction. The wavelet transform *Dic ^L* is shown in equation (5)

$$Ei,m\hat{}LL(n) = \sum_{N} G\ r^*r\ (n- 2m)\ Dir\hat{}L(n) = \begin{bmatrix} Em, i\hat{}LL \\ E^{LL}\, m + \frac{N}{2}, i \end{bmatrix} \qquad (5)$$

$$Ei,m\hat{}LH(n) = \sum G\ r^*r\ (n- 2m)\ Dir\hat{}L(n) = \begin{bmatrix} Em, i\hat{}LH \\ E^{LH}\, m + \frac{N}{2}, i \end{bmatrix}$$

Where, $i = 0,1,...,(N -1) / 2, m = 0,1,...,(N -1) / 4$.

$$Ei,m\hat{}HL(n) = Gr^*r(n-2m)DiR\hat{}H(n) = \begin{bmatrix} E\ m, i^{HL} \\ E^{HL} m + \frac{N}{4}, i \end{bmatrix} \qquad (6)$$

$$Ei,m\hat{}HH(n) = Gr^*r(n-2m)DiR\hat{}H(n) = \begin{bmatrix} E\ i, m\ HH \\ E^{HH} m + \frac{N}{4} \quad , i \end{bmatrix}$$

Where, $i =0,1,...,(N -1) / 2, m =0,1,...,(N -1) / 4$.At last, the wavelet transform of matrix *A* is shown in equation (7)

LL = [Ei,j^LL],LH = [Ei,j^LH], HL = [Ei,j^HL], HH = [Ei,j^HH], (7)

Compose a matrix with LL,LH,HL and HH expressed as E.

$$E= \begin{bmatrix} LL & LH \\ HL & HL \end{bmatrix} = \begin{matrix} L1L1 & L1L2 & L1H1 & L1H2 \\ L2L1 & L2L2 & L2H1 & L2H2 \\ H1L1 & H1L2 & H1H1 & H1H2 \\ H2L1 & H2L2 & H2L1 & H2H2 \end{matrix}$$

So far, the first level of two –dimensional wavelet decomposition is finished.[6]

3.3 Fusion rules

In the fusion process, the selection of fusion rules is very important, which directly affects the image quality. The advantage of multiwavelet transform applied in the image fusion is that it can decompose the image into different frequency domains. In different frequency domain, it can use different fusion rules to obtain multiresolution decomposition image of the synthetic image, thereby to retain outstanding features in different frequency domain of the source image in composite image. In this paper, the low frequency part of the fusion rule uses weighted average and, high-frequency part uses the maximum fusion method, fusion method based on direction contrast and classification strategy fusion method. In addition, in order to maintain consistency of data in various frequency bands after fusion, probabilistic methods should be used to make consistency check and adjustment. The last two steps are inverse transformation and post filtering, we will no longer discuss them in detail.[7]

IV. EXPERIMENTAL RESULTS AND EVALUATION

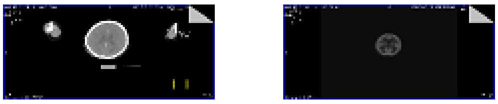

Fig 3. Original Image Of Pet And Ct

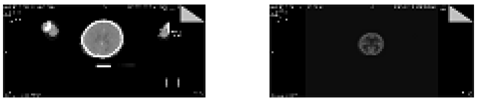

Fig 4.Covert Original Image Into Grey Scale

Fig 5.Crop Image

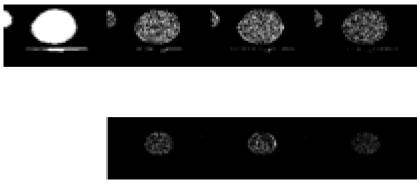

Fig 6. Decompose Image

Fig 7.After Idwt

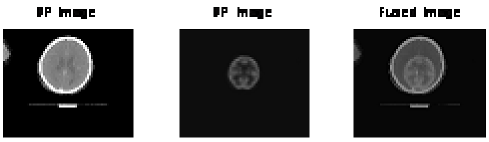

Fig. 8.Fused Image

Table 1:Evaluation of the fusion image of brain related to the source image

sr no	image no	peak signal to noise ratio	mean square error
1	IMAGE NO 40	31.12	5.3
2	IMAGE NO 50	33.68	7.8
3	IMAGE NO 126	28.28	4.5

V. CONCLUSION

We can obtain fusion images with more details and more comprehensive information using medical image fusion technology. This kind of image is able to provide reliable basis for the doctor's diagnosis and treatment. Based on the advantages of multiwavelet transform in image processing, we designed a medical image fusion algorithm based on wavelet transform, implemented the fusion of PET and

CT images using wavelet coefficients fusion method. We also made the algorithm implementation in this paper. From the experimental results, we can see that the fusion image has more details and the texture is more clearly. So the algorithm proposed in this paper is an effective method for the fusion of medical images.

VI. ACKNOWLEDGMENT

I take this opportunity to express my deep sense of gratitude to my guide, Prof. Vaishali Upadhaye for his continuous guidance and encouragement throughout the course of my study and implementation. It is because of her experience and wonderful knowledge; I can fulfill the requirement of completing the Project I would like to thank Prof. A.K.Gaikwad, Head of the department of Instrumentation and Control and Dr. M B. Khambete, Principal of Cummins College of Engineering for Women. Last but not least, thanks to my family for moral support and I thank to all my colleagues for their valuable cooperation and coordination, which was available time to time.

REFERENCES

[1] Gonzalo Pajares *,Jesus Manuel de la cruz,A wavelet based image fusion tutorial- Pattern recognition 37(2004) 1855-1872

[2] Yuhui Liu The research of Northeastern university ,china,PET/CT Medical Image Fusion Algorithm Based On Multiwavelet Trasform ,2010,264-268

[3] Zhi-hai Xu^1,Ling-Xiang Liu^2,Lei Tong^3,Wavelet medical image fusion algorithm based on local area feature,2012,25-31

[4] Wavelet transform introduction to theory and application, RM Rao,Ajit Bopardikar

[5] Ivan W.Selesnick polytechnic University Brroklyn,NY,Wavelet Transform-A Quick Study,Sep 2007,1-11

[6] Jan Flusser,Filip Sroubek and Barobara,Image Fusion;Principles,Methods and application,2007 [7] Nicholos Triel,Stephane Mallat-Iamge Wavelet Decomposition and application,1989