A Way of Image Fusion Based on Wavelet Transform

Huaxun Zhang
Electronic Engineering College
Changchun University
Changchun, China
ccdxzhx@163.com

Xu Cao
Center of Modern Education Technology
Changchun Chinese Medicine University
Changchun, China
zyxycx@163.com

***Abstract*—In this paper a way of medical image fusion based on wavelet theory is introduced. Medical image fusion have three steps, they are image processing, image registration and image fusion. In the paper, image processing get across multi resolution characteristics of wavelet to denoise, image registration pass the wavelet analysis to gain biggish change point and receive image edge to achieve quick and nice superposable, image fusion use disassumble image to different frequency subband to save all information to have a perfect fusion. Simulation experiment proved it has advantages of simply calculation, fast superposition and perfect fusion in medical image fusion. It is a direction of medical reacher and clinic iatrology.**

Keywords-Wavelet Transform Theory, Image Processing, Image Registration, Image Fusion

I. INTRODUCTION

The mainly proposal of medical image fusion is to improve the readability of the image by processing the redundant data in multiple images and increase image sharpness by disposing the complementary information among multi images. The precondition of image fusion is picture superimposition. It is significative to image fusion that only pixels of the two image in the same position are corresponding same anatomic structure. The fusion of multi modality medical image is provide more comprehensive and accurate data for clinical by consolidating the valuable physiological functions information and the precise anatomical information. The basal way are based on pixel based and characteristics of the image for the moment. The former is processing point by point and weighted sum, fetched size of gray value. It is a simple method but inefficient. The later extract the feathers of the image. It is a complicated mean but perfect impression is gained[2][3].

II. A MEASURE OF MEDICAL IMAGE FUSION

The research of medical image fusion is a investigation on multi discipline. It is an anlysis to multi images, but because of the orientation of sensor, the change of apparatus and all kinds of interfering, different degrees distortion and metamorphism lies in images. So pretreatment and image registration are integrant before image fusion.

A. Image Preprocessing

Image preprocessing is a course of noise reduction. There are sliding average filtering, weighted median filter , adaptive Wiener filtering, etc. These ways are effectual to wipe off Gaussian noise, impulse noise, multiplicative noise, and so on. But for all kinds of noises in image, this paper suggest a wavelet denoising method. The theory of wavelet denoising on image is:

The description of local characteristics of signal $x(t)$ is:

$$|x(t_0+\delta)-f_n(t_0+\delta)| \le A|\delta|^\beta, n<\beta\le n+1 \tag{1}$$

β is Lipschitz exponent of $x(t)$ at t_0 , $f_n(t)$ is polynomial of degree n throu-gh $x(t_0)$, δ is a sufficiently small amount.

If equation (2) is tenable on scale $a=2^j$, then τ_0 is the point of local modulus maxima of scale $a=2^j$.

$$|WT_x(a,\tau)| \le |WT_x(a,\tau_0)|, \tau\in(\tau_0-\sigma,\tau_0+\sigma) \tag{2}$$

$|WT_x(a,\tau_0)|$ is c. Lipschitz exponent β of signal $x(t)$ and $|WT_x(a,\tau_0)|$ are satisfied with equation (3),

$$Log_2|WT_x(a,\tau)| \le Log_2K+\beta j \tag{3}$$

K is a constant associated with the wavelet basis. For $\beta=-\frac{1}{2}-\varepsilon<0, \varepsilon>0,$ so modulus maxima of wavelet coefficient $d_k^{(j)}$ is decrease with the increase of scale a to noise. Moreover wavelet transform is a orthogonal transformation, therefor $d_k^{(j)}$ is still noise by wavelet transform. Viz. $d_k^{(j)}$ is accordant in the time domain and frequency domain[5][6].

When scale a is biggish, it fits general observation on account of wide field of vision and low frequency. When scale a is minor, it suit detail observation owing to narrow view and high frequency. Wavelet denoising signal is to analyze the wavelet signal, noise is usually contained in details of having high frequency, thereby threshold is used to processe the wavelet coefficient of the decomposition signals. Afterwards rebuild the wavelet signal, the aim of denoising achieve. The essence of signal denoise is suppressing the useless part and recovering the useful part. Image simulation results are as Figure 1. and Figure 2.

978-0-7695-5159-3/13 $31.00 © 2013 IEEE
DOI 10.1109/MSN.2013.103

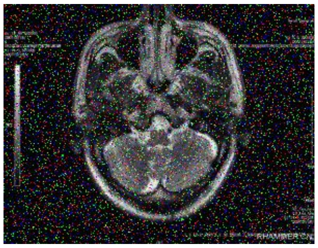


Figure 1. The noisy image

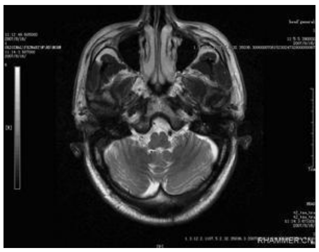


Figure 2. The denoising image

B. Image registration

Image registration is a premiss of multi image fusion and multi modality image analysis. If different images want to inosculate, they must have oppsite relation on position. There are many ways of image registration based on different imaging mode and different relation between objects. Because of limited length, only a mean of extract edge based on wavelet analysis is refered here.The first of edge detection based on multi-scale is polishing original signal, then inspect the change point of original signal from one or two derivative of polishing signal[1].

Suppose $\theta(x)$ is polishing function, is satisfied with

$$\int_{-\infty}^{\infty}\theta(x)dx = 1, \quad \lim_{x\to\infty}\theta(x) = 0 \tag{4}$$

If $\theta(x)$ can be derivate by two orders, define

$$\psi'(x) = \frac{d}{dx}\theta(x), \quad \psi''(x) = \frac{d^2}{dx^2}\theta(x) \tag{5}$$

Equation (6) is gained from equation (4):

$$\int_{-\infty}^{\infty}\psi'(x)dx = 0, \quad \int_{-\infty}^{\infty}\psi''(x)dx = 0 \tag{6}$$

So $\psi'(x)$ and $\psi''(x)$ is wavelet. The convolution of f, g is defined:

$$f * g(x) = (f * g)(x) = \int_{-\infty}^{\infty} f(u)g(x-u)du \tag{7}$$

The standard wavelet transform of $f(x)$ is defined equation (8) about $\psi'(x)$ and $\psi''(x)$:

$$W_s' f(x) = f * \psi_s'(x), \quad W_s'' f(x) = f * \psi_s''(x) \tag{8}$$

Integral wavelet transform is defined:

$$(W_h f)(a,b) = \langle f(t), h_{a,b}(t)\rangle = |a|^{-\frac{1}{2}}\int_{-\infty}^{\infty} f(t)\overline{h(\frac{t-b}{a})}dt \tag{9}$$

Thereinto $h_{a,b} = |a|^{-\frac{1}{2}} h(\frac{t-b}{a})$

Equation (10) and (11) is obtained from equation (8):

$$W_s' f(x) = f * (s\frac{d\theta_s}{dx})(x) = s\frac{d}{dx}(f * \theta_s)(x) \tag{10}$$

$$W_s'' f(x) = f * (s^2\frac{d^2\theta_s}{dx^2})(x) = s^2\frac{d^2}{dx^2}(f * \theta_s)(x) \tag{11}$$

Standard wavelet transform about $\psi'(x)$ and $\psi''(x)$ is become convolution of $f(x)$ and polishing function θ_s from equation (10) and (11).

Because of scale s is bigger, the convolution of $f(x)$ and $\theta_s(x)$ wipe off smaller change, only detect biggish change point, it's right of low frequence of wavelet decomposition. Therefore change points under different scale is obtainned to dissimilar value of s, it is edge detection of image. Edge inspect is solving the maximum of gradient vector modulus to two dimensional signal[4][8]. After that, image registration still need match corresponding point of two images through coordinate transformation. Image of edge detection simulation results is Figure 3 and Figure 4.

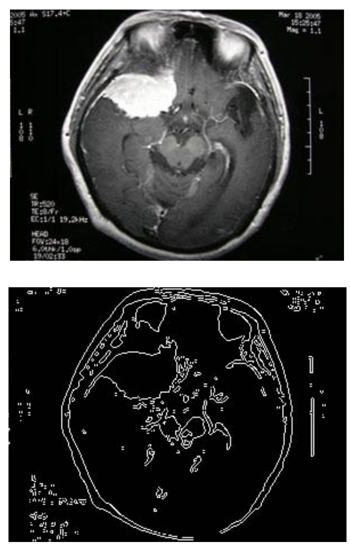


Figure 3. Edge detection of pathological change image

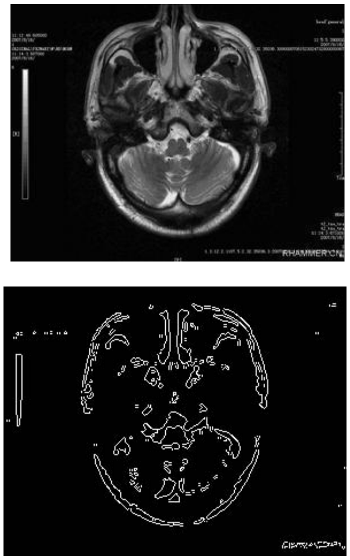


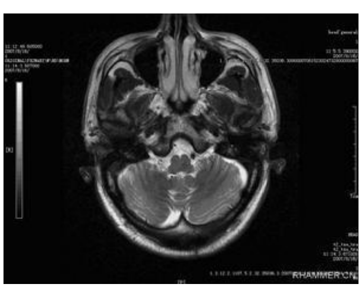
Figure 4. Edge detection of no lesion images

C. Image Fusion

The aim of image fusion is combination of different features of multi-images, reserve important message, stand out itself character. There are many means of Image fusion, here a way based on wavelet decomposition is introducted. Wavelet transformation fusion is orthogonal transformation, it analyze original image to form sub-image LL of low frequency, HL of high frequency in row and low frequency in arrange, HH of high frequency. Then decompose last sub-image and gain LL2, HL2, LH2 and HH2 in the multilayer decomposition. Suppose $g_1(x,y)$ and $g_2(x,y)$ is decomposed $G_1(x,y)$ and $G_2(x,y)$, then the coefficient of fusion image is:

$$F(i,j)=\begin{cases} G_1(i,j) & |G_1(i,j)|>|G_2(i,j)| \\ G_2(i,j) & others \end{cases} \tag{12}$$

Fusion image $f(x,y)$ is received through the inverse wavelet transform to $F(i,j)$ [7][9]. Image fusion simulation results is Figure 5.



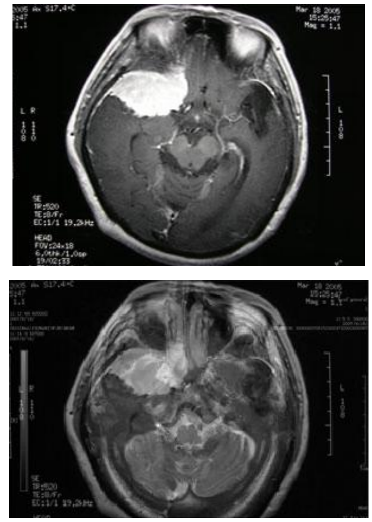


Figure 5. Fusion image of pathological change image and no lesion image

III. CONCLUSION

This paper introduce a way based on wavelet decomposition. It use different characters of wavelet theory. In image processing, it use enactment threshold to wipe off noise. In image registration, it use the convolution of $f(x)$ and $\theta_s(x)$ wipe off smaller change and receive image edge to achieve quick and nice image registration. In image fusion, it use disassumble image to different frequency subband to save all information to have a perfect fusion. Image simulation experiment proved that medical image processing on wavelet theory has advantages of simply calculation, fast superposition and perfect fusion

REFERENCES

[1] Wolfgang Wein, Shellby Brunke, Ali Khanmene. Automatic CT-ultrasound registration for diagnostic imaging and image-guided intervention[J]. Medical Image Analysis, 2008,12:577-585.

[2] Taylor RH, Stoianovici D. Medical robotics in computer_ intergrated surgery. IEEE Transactions on Robotics and Auto- mation 2003,19(5): 765-781.

[3] Vickers JP, Burnham KJ, Dil A.Knowledge-based organ segmen-hation in low constrast medical computed to mography images [A]. Proceedings of the International Comference on System Science[C], 2001(3): 381-388.

[4] Wyawahare M V, Patil P M, Abhyankar H K. Image Registration Techniques: An overview[J]. International Journal of Signal Processing, Image Processing and Pattern Recognition, 2009, 2(3)11-28.

[5] Mallat S G, Hwang W Lsingularity detection and processing with waelet[J]. IEEE Trans on Information Theory, 1992, 38(2): 617- 643.

[6] Polchlopek H M, Noonan J P. Wavelet, detection,destination and sparsity[J]. Digital Signal Processing, 1997(7): 2836-2847.

[7] VandenElsen P A, Pol E J D, Vierge M A. Medical Image matching: A review with classification[J]. IEEE Eng.Med. Biol.,2009,I2(3):12-39.

[8] Stefan Klein, Marius Staring. Evaluation of optimization methods for nonrigid medical image registration Using Mutual Information and B-Splinbes[J]. IEEE TRANSACTIONS ON IMAGE PROCESSING, 2007,16(12): 2879-2890.

[9] M. Brown, D.G.Lowe, Recongizing Panoramas. Procedings of IEEE International Conference on Computer Vision, 2003(2): 1218-1225.

[10] A.Rav-Acha,Y. Pritch, D.Lischinski, et,al. Dynamosaicing: Mosaicing of Dynamic Scenes, IEEE Trans.PAMI, Oct. 2007: 1789-1801.