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Disease Edge Detection of Medical CT Image Using Digital Wavelet Filter

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***Abstract*—The aim of this study is detecting disease edge of the medical CT (Computed Tomography) image. This paper describes the method by using 3-Tap bandpass filter signal and two high frequency sub-band CT images in wavelet domain for detecting part of disease. Simulation result show that the proposed method has high accuracy in detecting the disease edge area as is compared to existing methods. It provide a useful and efficient solution for detecting disease of medical CT image, and this method should be applicable to various medical images.**

Keywords- medical images; edge detection; image processing; digital filter

I. INTRODUCTION

As the development of the Medical Science technology is gradually increased, it has brought a lot of changes in medical field. The big reason of change is the rapid computer processing development. By this development, it has become possible to perform the transferred and stored big medical images data instead of analog medical films that we have used.

In the medical field, medical imaging is one of the most application areas of digital image processing. Visualizing and extracting more details from the given image processing of medical images are much more supportive. Especially, the edge detection in the medical images is much more significant and important. Many techniques are available for detecting edge and it could be help to find disease. There are two methods that mainly used for the detecting edge. First is to utilize the first-order differential operator [1-2] and another is the quadratic differential operator [3]. But these two method has difficult to detecting disease of medical CT (Computed Tomography) image, because the edges and contour information of the medical CT image are not clear and obvious for various reasons. And it has the disadvantage that the first-order differential method could be sensitively depending on the orientation, while the quadratic differential method could be sensitive to the noise.

In order to overcome these dis-advantages and detecting the edge of disease, we used a 3-tap filter with discrete wavelet method. Discrete wavelet transform (DWT) could be faster than the existing signal processing algorithms based on Fourier transform [4]. And it is widely used in the field of the signal and the image processing to efficiently implement the localization of signals in the time and the frequency domain [4]. The proposed algorithm utilizes the discrete wavelet transform without the down-sampling, which divides the images of the same size into the low frequency band and high frequency band. After that, the image is divided by 4 images, such as LL (low-low), LH (low-high), HL (high-low), and HH (high-high) [5]. But In this work, we use only LH and HL image with add. It could be reduced noise and the edge is excellently detected rather than the existing method using conventional DWT.

II. PREPARE EXISTING METHOD OF EDGE DETECTION YOUR PAPER BEFORE STYLING

A. First-order Differential Operator

The basic edge detection method is to find the difference from the brightness of the surrounding. It means that the vector is large. For example, the slope values increase, when it has a change of the sudden brightness at the boundary of some objects. The method of first-order differential operator could be used as follows:

$$\nabla f = \begin{bmatrix} G_x \\ G_y \end{bmatrix} \quad (1)$$

If the $G_x = \partial f / \partial x$, $G_y = \partial f / \partial y$ has larger values of the slope than the particular threshold values, it could determined for the edge. The vector shows the value of the changing direction and the edge is present in the vertical direction of the vector. The magnitude (G) of a slope vector (Δf) and the angle direction (α) could be expressed as follows:

$$G = \sqrt{G_x^{\ 2} + G_y^{\ 2}} \quad (2)$$

$$\alpha(x, y) = \tan^{-1}\left(\frac{G_y}{G_x}\right) \quad (3)$$

It could be represented as the convolution of the filter and the image coordinates. Then, it is expressed as the G_x and G_y using convolution and referred to a mask of the filter as the h_x and h_y, as follows:

$$G_x = h_x(x, y) \times f(x, y)$$
$$G_y = h_y(x, y) \times f(x, y) \qquad (4)$$

The coefficient value of the mask, they have a sensitive to vertical, horizontal, and oblique edges. Thus, first-order differential operator system has the disadvantage to extinguish important information in the image.

B. Quadratic Differential Operator

The quadratic differential operator has expressed without breaking the edge by using the different rate of the brightness. One of the method using Quadratic differential operator is Laplacian method. It is the operator without a particular direction and it could be expressed by emphasizing all of the edge direction. Laplacian for the image, f can be expressed as follows:

$$\nabla^2 f = \frac{\partial^2 f}{\partial x^2} + \frac{\partial^2 f}{\partial y^2} \qquad (5)$$

Second method is LoG (Laplacian of Gaussian filter), which uses Gaussian function to reduce the noise and to emphasize the edge, is helped to reduce the disadvantage of Laplacian method. The output *g(x, y)* of the LoG operator could be obtained by the convolution operation. ∇^2 the equation below refers to the Laplacian operator and *h(x, y)* is a two-dimensional as follows:

$$g(x, y) = \left[\nabla^2 h(x, y)\right] \times f(x, y) \qquad (6)$$

$$\nabla^2 h(x, y) = \left(\frac{x^2 + y^2 - \sigma^2}{\sigma^4} \right) e^{\frac{-(x^2+y^2)}{2\sigma^2}} \qquad (7)$$

In the Equation (7), as the standard deviation (σ) is large, the wide edge could bel detected. On the other hand, as the standard deviation is small, it is possible to detect more accurate edge. But it is sensitive to the noise and responds strongly to an isolated point, and has the disadvantage of not seeking the direction of the edge.

III. PROPOSED METHOD USING DWT (DISCRETE WAVELET TRANSFORM)

Wavelet transform has favorable characteristics for analysis of non-stationary signals and could be applied to both continuous signals and discrete signals [6]. As shown in Figure 1, the proposed method use 3-tap filter and discrete wavelet transform on original medical CT image, which are separated into a low frequency band and high frequency band through 3-tap filter.

Then, the original image is typically divided into the size of a quarter of the image. In this case, the low frequency band (LL band image) has the key information of the original image, while the high frequency band (LH, HL, HH band images) has the edge information according to the characteristics such as horizontal edges, vertical edges, and diagonal edges [7]. However, the proposed method on the exclude down-sampling section could produce the same size of original images. The three images (LH, HL, HH) have the edge information and come out after DWT. But the HH band image has a lot of noise, so we suggest to use only LH and HL band images for the edge detection are composited.

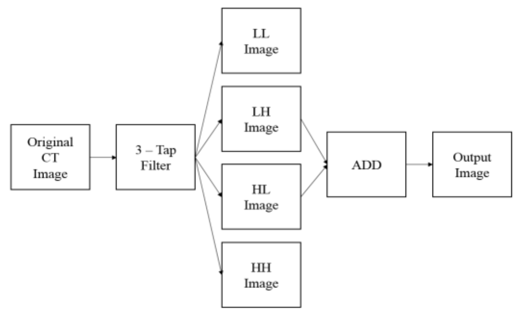

FIGURE Ⅰ. PROPOSED ALGORITHM

The 3-tap filter of low frequency $H(\omega)$ and high frequency $H^{-1}(\omega)$ filter as follows:

$$H(\omega) = \frac{1}{2}[(1) + (1)\cos\omega] \qquad (8)$$

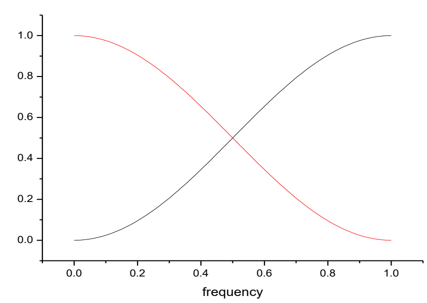

FIGURE Ⅱ. FREQUENCY RESPONSE OF H(ω) AND H^{-1}(ω)

And this high and low filter could be change to filter value, such as table 1.

TABLE I. 3-TAP FILTER VALUES OF LOW, HIGH BAND

k	3-tap filter values	
	Low-pass	*High-pass*
± 0	0.5	0.5
± 1	0.25	-0.25

With this 3-tap filter and DWT method, we could get the clear edge in the CT image. Furthermore, this method could help to find the disease.

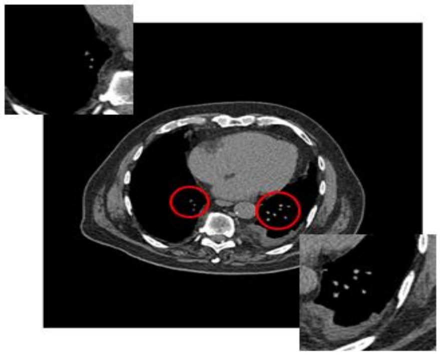

FIGURE Ⅲ. ORIGINAL CT IMAGE

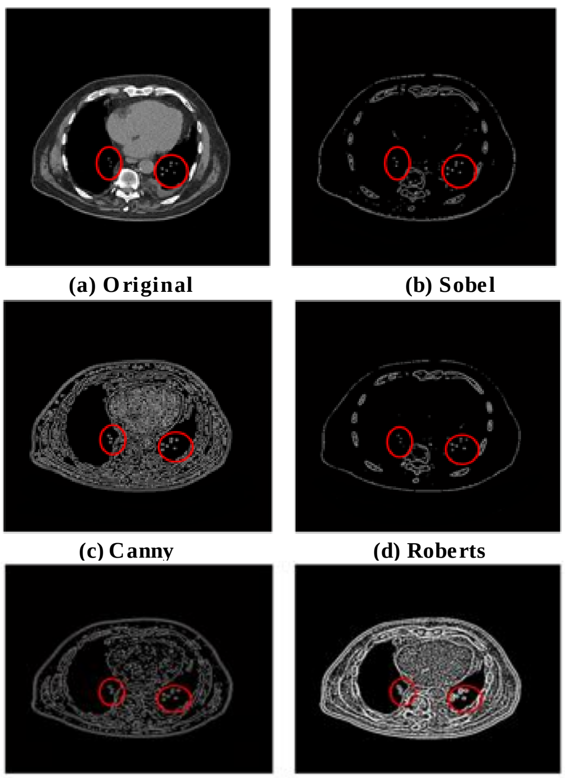

FIGURE IV. COMPARISON CT IMAGE WITH DIFFERENT ALGORITHM OF EDGE DETECTION

IV. CONCLUSION

Our method has a difference with the existent conventional edge detection method that performs directly the mask to the entire original image. Just using DWT method with 3- Tap filter.

The proposed method show that provides the clear edge and detected disease. Also, it desirable in the developed diagnosis medical CT image and it can be applicable to various medical CT images (i.e., brain, chest and abdomen, etc.). Consequently, this is shown to provide a useful and efficient solution for detected disease in medical CT image.

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