An Edge Extraction Algorithm of Thenar Palmprint Image Based on Wavelet Multi-Scale

Xijun Zhu,Qiulin Zhang
College of information science and technology
Qingdao university of science and technology
Qingdao,Shandong,China
E-mail:zhuxj990@163.com

,Dazhuan Liu,Wenying Lv
College of information science and technology
Qingdao university of science and technology
Qingdao,Shandong,China
E-mail:ll-pyf@163.com

***Abstract*—This paper mainly introduces the edge extraction algorithm of thenar palmprint image based on wavelet modulus maxima multi-scale. First, some classical edge detection operators and the Hough transform are introduced. And then the paper focuses on the wavelet modulus maxima multi-scale edge detection algorithm. In this algorithm,a multi-scale Gaussian edge detector is constructed. According to cross-scale transfer characteristic of wavelet transform modules of the image edge and the noise, we combine the wavelet modulus maxima multi-scale algorithm to extract the edge of the thenar palmprint image. The results of experiments show that this algorithm can detect rich edge details and reduce the affect of noise. The edges fused have precise position. The shortcoming of the algorithm is the poor continuity of the edges.**

Keywords-component; thenar palmprint; edge detection; modulus maxima; wavelet multi-scale analysis

I. INTRODUCTION

In many years of clinical observation and medical research, medical experts found that asthmatics and the patients of allergic disease generally have the phenomenon that their thenar palmprint is rough and is shown as lattice-like distribution. The phenomenon can be used as a outward manifestation significant physical. This is closely related with kidney deficiency constitution. The significant physical can be used as the objective indicator for the differential diagnosis of asthma and allergic disease. Medical specialists can carry out the diagnosis and treatment through observing the thenar palmprint. Medical experts divide thenar palmprint into four levels by observing the direction of stria, the distance of stria, the depth of stria grooves and the pattern features constituted by stria[1,2].

I level: The surface skin of thenar palmprint is moist and gloss and the texture is exquisite. The distance between two strias is short. The depth of stria groove is very shallow. There are no characteristic patterns and are soft when palpation.

II level: The surface skin of thenar palmprint is moist and gloss. The texture is clear and is shown as lattice-like distribution. But the distance of the stria is short and are soft when palpation.

III level: The surface skin of thenar palmprint is lack of moist and gloss. The texture is clear and is evident visible. The texture is also shown as lattice-like distribution and the distance of the stria is wide and is lack of soft when palpation.

IV level: The surface skin of thenar palmprint is dry and rough, the texture is clear and evidently visible. It is palpable that the texture is an obstruction of hands, even as the leather when touch it. The texture is shown as big lattice-like distribution and the distance between two strias obviously wider than the III level.

Recently, the classification of the thenar palmprint main by the naked eye and palpation. There must be some subjectivity. In order to determine the level of thenar palmprint more objectively and more exactly, we do the operation of preprocessing, feature extraction and classification on thenar palmprint using the image processing technology. The purpose is the quantitative identification of thenar palmprint. The thenar region is the lateral muscle groups where the muscle uplifts from the root of the thumb to the wrist joint. The parrerns of every thenar palmprint are different. And the characteristic of the thenar region may change following age growth. The edge of the thenar palmprint image main contains the texture characteristics such as the direction of stria the pattern features constituted by stria. This is the main basis for judging the classification. So an effective edge detection can play an important role in the feature extraction and quantitative recognition.

For thenar palmprint, the method of edge detection requires not only to detect the exact location of the edge, but also to suppress irrelevant details and noise. The classic and conventional edge detection methods are still in used. These methods are generally sensitive to noises and often enhance the noise when detecting the edge[3].Wavelet transform is a powerful tool for detecting mutant signal[7,8]. Wavelet transform has the good time-frequency localization characteristics and the capability of multi-scale analysis. And it also has "zooming" function at different scales. So the edge detection algorithms based on wavelet transform gradually become a hot spot in image processing area. Because its positioning accuracy and noise rejection capability, the method of image edge detection based on multi-scale wavelet analysis have been widely used. The edge information which can reflect the target location and the shape characteristic in thenar palmprint image, determines the accuracy and speed of target identification to a large extent and plays an active role in the whole recognition process. We are only interested in those feature edges that expressing the essential content of thenar palmprint.

978-0-7695-4261-4/10 $26.00 © 2010 IEEE
DOI

II. THE CLASSICAL METHODS OF EDGE DETECTION

The early methods of edge detection estimate the gradient direction of image intensity change and enhance the transformation regions in image by the detector based on gradient operator or the first derivative, and than do the threshold operation of this gradient. This is the edge if this gradient value is greater than a given threshold.

First-order differential is the basic method of image edge and line detection. The gradient of image function $f(x,y)$ at the point (x,y) is vector with size and direction, that:

$$\nabla f(x,y) = \frac{\partial f}{\partial x} i + \frac{\partial f}{\partial y} j \tag{1}$$

The amplitude of $\nabla f(x,y)$ is:

$$mag(\nabla f) = g(x,y) = \sqrt{\frac{\partial^2 f}{\partial x^2} + \frac{\partial^2 f}{\partial y^2}} \tag{2}$$

The direction angle is:

$$\phi(x,y) = \arctan\left|\frac{\partial f}{\partial y} \Big/ \frac{\partial f}{\partial x}\right| \tag{3}$$

Based on these theories, many scholars have put forward a number of traditional and classical edge detection operators. The common edge detection operators include: Roberts edge detection operator, Sobel edge detection operator, Prewitt edge detection operator, Laplace edge detection operator, LOG edge detection operator, Canny edge detection operator, Zero Cross edge detection operator, Differential edge detection operator[4] and so on.

III. THE EDGE EXTRACTION OF HOUGH TRANSFORM

Hough transform[5] is one of the basic methods to detect geometric shapes from a image in image processing. The basic principle of Hough transform is that using the duality of points and lines to turn a given curve in the original image space into a point of the parameter space through the curve expression. So the detection of a given curve in the original image is transformed into finding a peak in the parameter space. That is the detection of the local characteristics instead of the overall.

The ideas of Hough transform: A point in the original coordinates corresponds to a line in the parameter coordinates. Similarly, a line in the parameter coordinates corresponds to a point in the original coordinates. All points of the lines in the original coordinates have the same slope and intercept so they correspond to the same point in the parameter coordinates. When each point in the original coordinates projected to the parameter coordinates, we check that if there is any aggregation point. The aggregation point corresponds to the line in the original coordinates.

Algorithm realization of Hough transform:

- The form of polar coordinates: $x\cos\theta + y\sin\theta = \rho$, parameter plane ρ、θ, corresponding to sine curve;
- Set up a discrete parameter space between the right maximum and minimum of ρ 、 θ;
- Set up a accumulator A（ ρ,θ) , set each element to zero;
- Do Hough transform on each point which gradient is greater than the threshold, that means calculate the corresponding curve of the point in $\rho - \theta$ grid, while the corresponding accumulator plus one. $A(\rho,\theta) = A(\rho,\theta) + 1$;

Find the the accumulator's local maximum of collinear points in image plane. The local maximum would provide the parameter for collinear points in a line on the image plane.

IV. WAVELET MODULUS MAXIMA MULTI-SCALE EDGE DETECTION

A. *Multi-scale Wavelet Operator*

2D image $f(x,y) \in L^2(R^2)$, 2D gaussian function $G(x,y)$, $\Psi^x(x,y) = \frac{\partial G}{\partial x}(x,y)$ and $\Psi^y(x,y) = \frac{\partial G}{\partial y}(x,y)$ as the wavelet functions[6], that:

$$G(x,y) = \frac{1}{2\pi\sigma^2}\exp\left(-\frac{x^2+y^2}{2\sigma^2}\right) \tag{4}$$

$$\begin{cases} \psi^x(x,y) = \dfrac{\partial G}{\partial x}(x,y) = -\dfrac{x}{2\pi\sigma^4}\exp\left(-\dfrac{x^2+y^2}{2\sigma^2}\right) \\ \psi^y(x,y) = \dfrac{\partial G}{\partial y}(x,y) = -\dfrac{y}{2\pi\sigma^4}\exp\left(-\dfrac{x^2+y^2}{2\sigma^2}\right) \end{cases} \tag{5}$$

Scale factor $s = 2^j$, 2D multi-scale wavelet functions:

$$\begin{cases} \psi_s^x(x,y) = \dfrac{1}{2^s}\psi^x\left(\dfrac{x}{s},\dfrac{y}{s}\right) \\ \psi_s^y(x,y) = \dfrac{1}{2^s}\psi^y\left(\dfrac{x}{s},\dfrac{y}{s}\right) \end{cases} \tag{6}$$

The 2D multi-scale wavelet transform[9] of the image $f(x,y)$:

$$\begin{pmatrix} W_s^x f(x,y) \\ W_s^y f(x,y) \end{pmatrix} = s\begin{pmatrix} \dfrac{\partial}{\partial x}(f*G_s)(x,y) \\ \dfrac{\partial}{\partial y}(f*G_s)(x,y) \end{pmatrix} = s(f*\nabla G_s)(x,y) \tag{7}$$

$$G_s(x,y)=\frac{1}{2\cdot 2^s\pi\sigma^2}\exp\left(-\frac{x^2+y^2}{2\cdot 2^s\sigma^2}\right) \tag{8}$$

Modulus and argument of wavelet transform of the image $f(x,y)$:

$$\begin{cases} M_s f(x,y)=\sqrt{\left|W_s^x f(x,y)\right|^2+\left|W_s^y f(x,y)\right|^2} \\ A_s f(x,y)=\arctan\left[\dfrac{W_s^y f(x,y)}{W_s^x f(x,y)}\right] \end{cases} \tag{9}$$

B. Algorithm Realization

Wavelet transform is used in the edge processing of the image, and the basic ideas of multi-scale edge detection are: Along the gradient direction, detect the modulus maxima of wavelet transform by the constraint of the threshold. In the small scale, the image edge details are rich and edges fused have precise position but the edge is susceptible to noise. In the large scale, the image edge is stable and the noise suppression is good but the edge has poor positioning accuracy. Combine the advantages of the small and large scale, the more desirable edge will be received. We may get the final image edge through the synthesis of different scales.

A thenar palmprint image $f(x,y)$, the size is 128*128. The wavelet functions are partial derivative of 2D gaussian function. Algorithm realization:

- Structure partial derivative of gaussian function under the formula (5). The length of filter is 40 and the scale factor is $s=2^j$;
- Do wavelet transform on each row of $f(x,y)$, we will get $W_s^x f(x,y)$. Do wavelet transform on each column of $f(x,y)$, we will get $W_s^y f(x,y)$;
- Get the modulus $M_s f(x,y)$ and argument $A_s f(x,y)$ of wavelet transform under the formula (9). Choose the threshold E of the modulus and set the modulus who is little than E to zero;
- First light the pixel P_0. If the argument direction of pixel P_0 points to the pixel P_1, then compare the modulus of the two points. Light the pixel P_1 if its modulus is bigger than pixel P_0. Do the same treatment to pixel P_1 until the modulus of the next point equal to this one. After ergodic all the pixels, local maxima image is constituted by the lit points.

V. THE SIMULATION RESULTS AND NANLYSIS

A. The Simulation Results

These experiments are implemented using MATLAB. The palmprint image is obtained with a digital camera. There are four conditions in order to get appropriate palmprint image: black background, adequate light, the hand of collected relaxed naturally and the camera shot is perpendicular to thenar area. First we segregate and locate the thenar palmprint area and get the area through the method based on the anchor. Then we detect the edge of the thenar palmprint using the edge detection algorithms described in this paper. The thenar palmprints used in the paper are the level IV.Fig1, Fig2 ,Fig3 and Fig4 are the results.

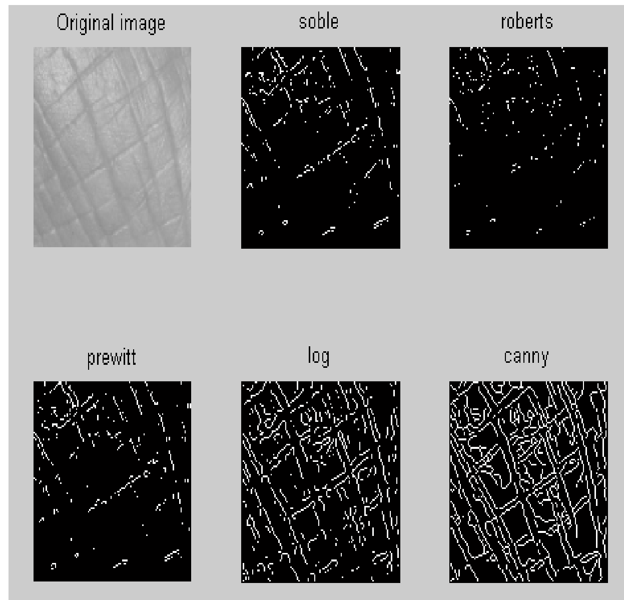

Figure 1. The edge images of some classical operators

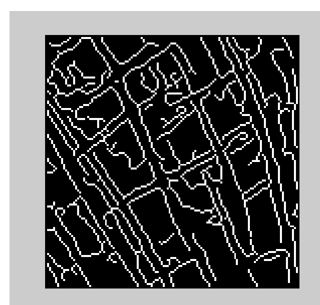

Figure 2. The edge images of Hough transform

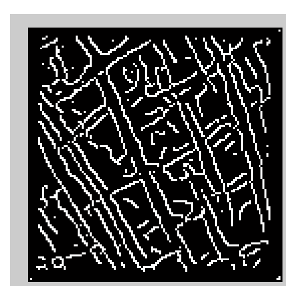

Figure 3. The edge image of wavelet modulus maxima multi-scale

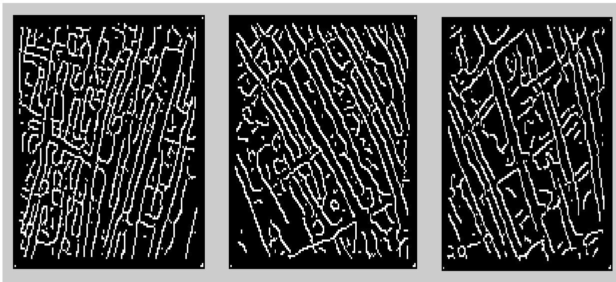

Figure 4. Some edge images of wavelet modulus maxima multi-scale

B. The Analysis of Simulation Results

From the Fig1 we see that different templates bring different degrees of edge strength. For the classical operators, the edges detected by Log and Canny are more strong and rich of edge details. The edges detected by Canny have some continuity. In practice, we can select the operator according to the need .

See the Fig2, the edges image detected by Hough transform have better continuity than the Fig1 and the noise suppression is good. The edge details are not rich enough.

We can get the conclusions from the Fig3 and Fig4: the wavelet modulus maxima multi-scale edge detection algorithm can reduce the affect of noise and detect rich of edge details. And the edges have precise position. The algorithm extracts the edges of thenar palmprint effectively. The edges provide a reliable information for target identification. The shortcoming is the poor continuity and a lot of discrete edge points. To solve the problem we can amend the edge by using the edge tracking compensation technology[10].

VI. SUMMARY

We detect the edges of thenar palmprint using classical operators, Hough transform and wavelet modulus maxima multi-scale edge detection algorithm in the paper. Different classical operators bring different degrees of edge strength. The edges detected by Soble, Roberts and Prewitt have poor details and poor continuity. Log and Canny are better than them. Hough transform have better continuity than the classical operators and the noise suppression is good. But the edge details are not rich enough. For the compromise between the edges and noises, the wavelet modulus maxima multi-scale edge detection algorithm take advantage of the characteristics of the wavelet transform fully. In the large scale, the noise suppression of edge is good and in the small scale, the edges fused have precise position. The result of experiments shows that this algorithm can reduce the affect of noise, detect rich of edge details and the edges fused have precise position. But the shortcoming is the poor continuity of the edges.

ACKNOWLEDGMENT

Our research is supported by Natural Science Fund of Shandong (2009ZRB019PP) and the National Natural Science Foundation project (30873315);This work was partially supported by the Science and Technology Project of Shandong Province (grant no. J09LG12).We would like to thank Z.S.Zhou at the Qingdao Hiser Medical Group for sharing their datasets.

REFERENCES

[1] Zhaoshan zhou, Yanqing wang. The Corelation Research of Morphological Characteristics of Thenar Palmprint and Asthma. The School Paper of Shandong University of Traditional Chinese Medicine, 2004, 28(2), 114-116.

[2] Zhaoshan zhou, Yanqing wang. Investigation of Correlation between the Form Stigmata of Maximus Thenar Dermatoglyphic Patterns of Palm and Allergic Dermatitis. The Information Magazine of Traditional Chinese, 2006,6,1 3(6), 19-21.

[3] Jun gao,Xuewei li,Jian zhang. The Research of Image Preprocessing Algorithm in Color Print Quality Inspection System[J]. Packaging Engineering, 2007, 28 (1): 64 – 66.

[4] R.A.Kirsch.Computer Determination of the Constituent Structure of Biological Images.Computers in Biomedical research,1971,4:315-328.

[5] Xinghua he, Yuanyuan zhou, Jiyang wang. MATLAB7.X Image Processing[M].Beijing: Posts & Telecom Press, 2006 : 144-150.

[6] Jiyou xu, Rong xiang zhu. The Application of Wavelet Transform in Image Edge Extraction[J]. Optical Engineering, 1998, 25(4) : 28—34.

[7] Zhu Xijun, Guo Jinyun. Wavelet solution of multi-path effect on GPS precise positioning. The 7th World Congress on Intelligent Control and Automation, Chongqing, June 25-27, 2008.doi:10.1109/WCICA.2008.4593179.

[8] Zhu Xijun, Guo Jinyun, Wei Chongyu. Prediction and diagnosis of mine hoist fault based on wavelet neural network. Chinese Control and Decision Conference (CCDC 2008), 2-4 July, 2008, Yantai, China. Doi: 10.1109/CCDC.2008.4597383.

[9] Zhongxin le. The Information Processing of Digital image[M].Beijing: National Defence Industry Press. 2003 : 206-263 .

[10] Haiyan shu. The Research and Application of Image Recognition Technology. Master's degree Paper of Northwestern industry University. 2002.3.