International Journal of Signal Processing, Image Processing and Pattern Recognition
Vol. 7, No. 6 (2014), pp. 243-250
http://dx.doi.org/10.14257/ijsip.2014.7.6.20

Vein Image Processing based on Morphology for Medical Diagnosis

Jufang Hu

College of Mechanical and Electrical Engineering, Xinyu University, China
109816271@qq.com

Abstract

Medical diagnosis based on vein characteristics attracted large attentions. The change and some feature of vein will reflect the diseases which can be observed from the diagnosis from specialists. Thus, it is very important to process the vein image for medical diagnosis. In order to process the vein image efficiently and effectively, this paper introduces a vein image processing approach based on the morphology principle, which is suitable for examining the shape of veins. The vein images captured from human fingers are used for the experiments. It is observed that the vein shape could be examined clearly so that any diseases or potential risks could be diagnosed by the doctors, comparing with traditional image processing approaches.

Keywords: *Vein Image, Morphology, Shape, Weight Function*

1. Introduction

Currently, the medical diagnosis based on vein characteristics attracted large attentions since in the circulatory system, .veins are blood vessels which carry blood forward the heart so that it is very important to check the conditions that may reflect some diseases [1]. Most veins carry deoxygenated blood from the tissues back to the heart. Veins differ from arteries in structure and function [2]. For example, arteries are more muscular than veins, which are often closer to the skin and contain valves to help keep blood flowing toward the heart. Phlebology is the medical specialty devoted to the diagnosis and treatment of venous disorders.

The change and some feature of vein will reflect the diseases which can be observed from the diagnosis from specialists [3, 4]. Thus, it is very important to process the vein image for medical diagnosis. Getting the high quality of vein image is a basis for vein image processing. After that, image fusion is used for processing the image through integrating the information technology or image processing technology [5]. The vein image will be obtained from sensor devices [6]. Many vein images will be fused into one digital image, which may carry more information for the medical diagnosis [7]. The fused image could reflect the information carried from different separate images, aiming to describe the details and targeted objects.

This paper uses the vein images captured from human fingers which contain large number of veins and the skin is suitable for get the vein images easily. However, different fingers have different sizes and the thicknesses are various as well. The human physical organizations are diverse in individuals. Thus, this paper uses the morphology approach for analyzing the vein image. This approach adopts the constraints condition of smoothing mechanism to work out a response function from a set of static images, which are image orders from different exposure degree. After the optimal processing and movement of sampling in phases, the curves of inverse function of the response function.

The rest of this paper is organized as follows. Section 2 reports on the mathematical morphology principle that is based on the exposure degree of vein images. Section 3 illustrates the vein imaging processing approach using morphology principle. Section 4 demonstrates the experiments and results. Conclusions and future research directions are concluded in section 5.

2. Mathematical Morphology Principle

The mathematical morphology studies the shape of the images. Take the vein image for example, the shapes and characteristics of vein are easily analyzed and examined by the principle. According to the morphology, when the light radiation is stronger, the brightness value of image pixel is larger [8]. Thus, the monotone increasing response function has an inverse function. Generally, the morphology principle could be expressed as specific shape or application as follows (this paper focuses on exposure degree and fitting function):

Let X denotes the exposure degree of an image, exposure time is T, the Exposure radiation intensity E could be calculated: $E = X/T$. E has the direct proportion of radiation degree of light source L. Different images have different exposure time T_j, which is captured at time j. Let I_{ij} denotes the pixel value of no j image of location i. So we can get the response function:

$$I_{ij} = f(E_i T_j) \quad (1)$$

As the monotone increasing of response function, there is an inverse function which will reflect the shape of the response function:

$$f^{-1}(I_{ij}) = E_i T_j \quad (2)$$

The natural logarithm could be carried out on (2), then

$$\ln f^{-1}(I_{ij}) = \ln E_i + \ln T_j \quad (3)$$

So, the inverse function is g:

$$g = \ln f^{-1}(I_{ij}) \quad (4)$$

$$g(I_{ij}) = \ln E_i + \ln T_j \quad (5)$$

In formula (5), the parameters T_j and I_{ij} could be known in advanced. The unknown parameters are E_i and function g. In the morphology principle, the least square error is used for working out E_i and estimating function g given the vein image application scenarios [9]. The vein image has the pixel value I_{ij} which is the limited discrete value. Assume that the minimal value of brightness is $I_{\min}$, and the maximum value is $I_{\max}$. There are total P vein images from the captured image sets. Each image has N pixels.

Thus, it aims to solve total N values of $\ln E_i$ and total $(\mathrm{I}_{\max} - \mathrm{I}_{\min} + 1)$ values of $g(I_{ij})$, s.t. the objectives as follows:

$$\min O = \sum_{i=1}^{N}\sum_{j=1}^{P}[g(I_{ij}) - \ln E_i - \ln T_j]2 + \lambda \sum_{b=I_{\min}+1}^{I_{\max}-1} g_n(b)^2 \qquad (6)$$

The first part of (6) is the data fitting item, which is used for meeting the condition of least square error. The second part is smoothing condition, which describe the shape of image. The part comes from the square of the second derivative of g. The coefficient λ is used to adjust the relation between smoothing condition and data fitting. In the discrete situation, the second derivative could be calculated through:

$$g^n(b) = g(b-1) + g(b+1) - 2g(b) \qquad (7)$$

In this paper, in order to suit the vein image processing, we set a weight function w for enhancing the smoothing fitting weight in the image shape. The w is defined as:

$$w(b) = \begin{cases} b - \mathrm{I}_{\min} & b \le (I_{\max} + I_{\min})/2 \\ I_{\max} - b & b > (I_{\max} + I_{\min})/2 \end{cases} \qquad (8)$$

Thus, the objective function could be converted into:

$$\min O = \sum_{i=1}^{N}\sum_{j=1}^{P}\{w(I_{ij})[g(I_{ij}) - \ln E_i - \ln T_i]\}^2 + \lambda \sum_{b=I_{\min}+1}^{I_{\max}-1} [w(b) g_n(b)]^2 \qquad (9)$$

3. Vein Image Processing Approach

The vein image in this paper comes from infrared imagery which has several characteristics. The thickness of fingers from bottom to the top becomes light according to the images taken from infrared devices firstly. Secondly, the cross section of the fingers changes slightly. It is possible to get the image block from the vertical of the finger image [10]. Thus, the average gray value of each image block could be obtained. The average value from same location under different light intensity could be used for analyze the vein shape according to the mapping value from derivative curve h [11]. Then the minimal value could be got from $J_k = \min(t_{i,j=k}), (i = 1, 2, ..., N; k = 1, 2, ..., P)$.

Using the morphology approach, the vein image processing method could be briefly reported using the pixel blocks from the infrared images so that medical diagnosis could be carried out. Assume every image from the vein image series under multiple light intensities will be divided into P pixel blocks. Let E_i $(i = 1, 2, ..., P)$ is the best image which contains the information of the no i pixel block from total N images. The pixel adjusts function used for the vein shape study is defined as:

$$U(x, y) = \sum_{i \in Q(x,y)} w_i(x, y) E_i(x, y) \qquad (10)$$

Where $U(x, y)$ presents the final pixel value of the output image, $Q(x, y)$ is a set that includes the optimal image block and its neighbor blocks of (x, y). $w_i(x, y)$ is the weight value of no i image of (x, y). $E_i(x, y)$ is the pixel value of $Q(x, y)$ in the position of (x, y).

According to the morphology, the structural function of the processed image could be:

$$G_i(x, y) = \exp[-\frac{(y - y_i)}{2\sigma^2}] \quad (11)$$

Here, (x_i, y_i) is the center of no i image block. σ is the standard deviation. Using the information from light response function of derivative curve $t_i(x, y)$ which is a minus exponential distribution, then integrate (10) and (11), we can get:

$$S_i(x, y) = \exp[-\alpha t_i(x, y)] \quad (12)$$

Here, α is the smoothing index, which is used for adjusting the $t_i(x, y)$. The optimal value of output pixel could be calculated by the weight function with associated weights as follows:

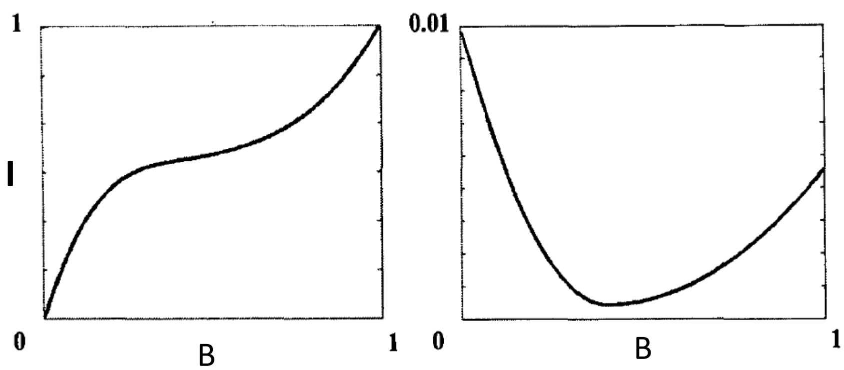
$$w_i(x, y) = S_i(x, y) G_i(x, y) \quad (13)$$

Finally, the output pixel value will be get using the normalized weight function:

$$\tilde{w}_i(x, y) = \frac{S_i(x, y) G_i(x, y)}{\sum_{i \in Q(x,y)} S_i(x, y) G_i(x, y)} \quad (14)$$

4. Experimental Results

Experiments are carried out from several aspects. First of all, the curves of response function and derivative function are examined. A set of images with the gray pixel values from [0 255] are converted into normalized range of [0 1]. Figure 1 shows the response function g and the derivative curves.



(a) Curve of g (b) Curve of $h = g'$

Figure 1. Examination Results of Associated Functions

From the Figure 1 (a), the curve of response function g is monotone increasing. From the curve, it can be seen that, in the phase of smaller tangent slop, the images may have more information of the light radiation intensity. While the larger tangent slop occurs in the both side (the beginning and the tail) which carry less information. The Figure 1 (b) from the derivative function of g indicates the movement of tangent slop. Thus, we can get the image blocks from a set of images so that the much more information could be obtained from the images at smaller tangent slop area.

The second is the integration of image blocks to generating the output images from optimal image blocks. Figure 2 shows the results, which comes from 200 captured images each of that is divided into 100 image blocks. Let I_{ij} denotes the no i image of j blocks. The left image is obtained from the average gray value $A_{i,r}(i=1,2,...,200)$, $A \in$ [0 255]. It can be seen that the information from the left figure is not rich enough so that the vein shape could be hardly observed. Using the morphology approach proposed in this paper, the right diagram shows more information hidden in the vein image. It is observed that the vein shape could be examined clearly so that any diseases or potential risks could be diagnosed by the doctors.

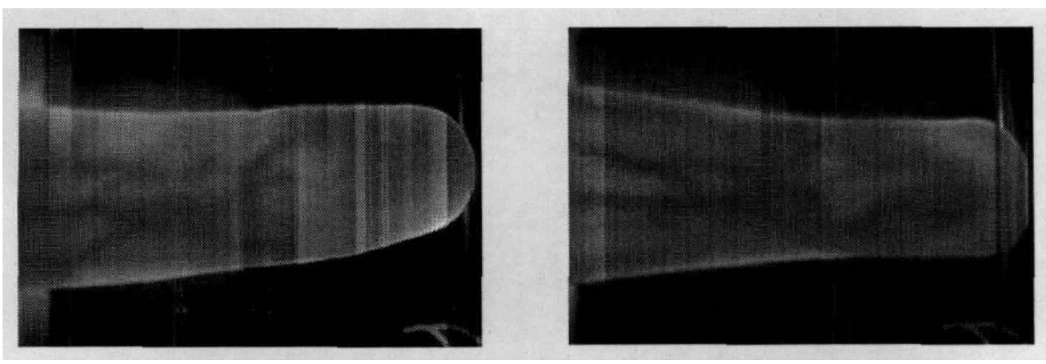
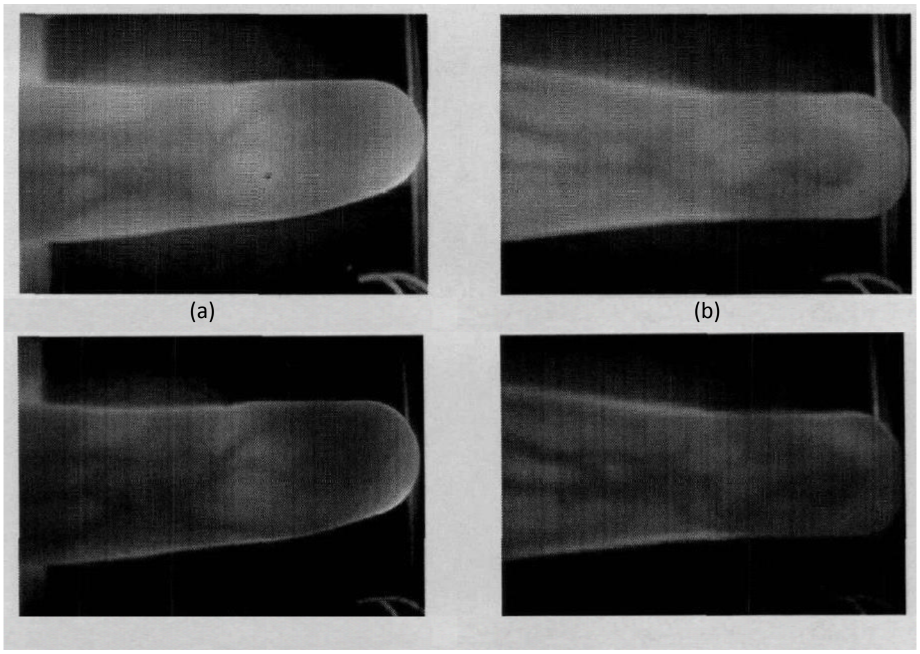


Figure 2. Integration of Image Blocks

The third experiments are carried out by comparing the proposed method with traditional image processing approaches using gray identification. Figure 3 shows the experimental results. Four images are obtained from this experiment. Figure 3 (a) and (b) are from the traditional approach using gray average pixel value to generate the output image from the set of image blocks. Figure 3 (c) and (d) are from the method in this paper. The block size the parameters are adjusted according to the maximum information standard. The neighbor range is 17 image blocks with the parameters: $\alpha = 12$ and $\sigma = 8$. Around 80% of the information blocks are from the weighted adjustment of the original image. The others are from the selected image blocks [12]. However, the mapping targets are with 8 bit gray image, thus, the images are not clear enough from eye-view.



(c) (d)

Figure 3. Experiments Results

5. Summary

This paper introduces a vein image processing approach based on the morphology principle, which is suitable for examining the shape of veins. This approach is tested with the finger images from three types of experiments. There are several significant aspects from this approach. In the first place, the weight function is defined to suite the smoothing fitting when carrying out the image processing. Thus, the objective function could be converted into weight associated minimization. Secondly, the response function and derivative curves are used for integrating the image blocks so that the final output image could be with optimal sequence given the pixel value at different positions. Thirdly, the experimental results show that the proposed method outperforms the traditional gray identification approach in the shape analysis. The veins shape could be clearly examined and checked from the output images after using the proposed processing approach.

Future research will be carried out from two aspects. In the first aspect, the proposed approach will be improved since the response function used in the morphology principle is monotone increasing. What is the impact of monotone deceasing or non-monotone function on the image output will be examined in the future. In the second aspect, this approach will be extended into other image processing like finger prints or artery of human beings so that the shape of similar organizations could be examined.

References

[1] R. C. Gonzalez, R. E. Woods, and S. L. Eddins, “Digital image processing using MATLAB”, vol. 2, Gatesmark Publishing Knoxville, (**2009**).
[2] J. Debayle and J.-C. Pinoli, “Spatially adaptive morphological image filtering using intrinsic structuring elements”, Image Analysis & Stereology, vol. 24, (**2011**), pp. 145-158.

[3] R. Y. Zhong, Q. Y. Dai, T. Qu, G. J. Hu, and G. Q. Huang, "RFID-enabled Real-time Manufacturing Execution System for Mass-customization Production", Robotics and Computer-Integrated Manufacturing, vol. 29, (**2013**), pp. 283-292.
[4] M. Zibulevsky and M. Elad, "L1-L2 optimization in signal and image processing," Signal Processing Magazine, IEEE, vol. 27, (**2010**), pp. 76-88.
[5] N. Olivier, M. A. Luengo-Oroz, L. Duloquin, E. Faure, T. Savy, I. Veilleux, X. Solinas, D. Débarre, P. Bourgine, and A. Santos, "Cell lineage reconstruction of early zebrafish embryos using label-free nonlinear microscopy", Science, vol. 329, (**2010**), pp. 967-971.
[6] R. Y. Zhong, Q. Y. Dai, K. Zhou, and X. B. Dai, "Design and Implementation of DMES Based on RFID", in 2nd International Conference on Anti-counterfeiting, Security and Identification, Guiyang, vol. 475-477, (**2008**), August 20-23, pp. 475-477.
[7] M.-M. Chen, S.-X. Guo and X.-H. Qian, "Finger vein image segmentation based on an improved LBF active contour model", Journal of Jilin University (Engineering and Technology Edition), vol. 41, (**2011**), pp. 1171-1176.
[8] M. G. Larese, R. Namías, R. M. Craviotto, M. R. Arango, C. Gallo, and P. M. Granitto, "Automatic classification of legumes using leaf vein image features", Pattern Recognition, vol. 47, (**2014**), pp. 158-168.
[9] S. R. Cho, Y. H. Park, G. P. Nam, K. Y. Shin, H. C. Lee, K. R. Park, S. M. Kim, and H. C. Kim, "Enhancement of Finger-Vein Image by Vein Line Tracking and Adaptive Gabor Filtering for Finger-Vein Recognition", Applied Mechanics and Materials, vol. 145, (**2012**), pp. 219-223.
[10] R. Y. Zhong, Z. Li, A. L. Y. Pang, Y. Pan, T. Qu, and G. Q. Huang, "RFID-enabled Real-time Advanced Planning and Scheduling Shell for Production Decision-making", International Journal of Computer Integrated Manufacturing, vol. 26, (**2013**), pp. 649-662.
[11] P. Prabhakar and T. Thomas, "Finger Vein Identification Based on Minutiae Feature Extraction with Spurious Minutiae Removal", in Advances in Computing and Communications (ICACC), 2013 Third International Conference on, (**2013**), pp. 196-199.
[12] S. Sharma, M. S. Bhushan, and M. J. Kaur, "Improved Human Identification using Finger Vein Images", (**2014**).

Author

Jufang Hu, she is an Associated Professor from Xinyu University. She graduated from Anhui University of Technology and Guangdong University of Technology with bachelor and master degrees respectively. Her research interests include embedded technology and image processing. She has published over 50 papers in international journals and conferences.