Jurnal Sistem Informasi (JSI), VOL. 2, NO. 2,Oktober 2010, *Halaman 238-245*
ISSN Print : 2085-1588
ISSN Online : 2355-4614
http://ejournal.unsri.ac.id/index.php/jsi/index

Segmentation Of Fingerprint Image Using Block-Wise Coherence Algorithm

Saparudin
Faculty of Computer Science, Sriwijaya University
e-mail: saparudin@unsri.ac.id

Abstract

The Segmentation of fingerprint image is an important step in the fingerprint identification. The objective of the fingerprint image segmentation is to separating the foreground regions from the background regions. Accurate segmentation of fingerprint images influences directly the performance of minutiae extraction like minutiae and singular points. In this paper, an algorithm for the segmentation of fingerprint image is presented. The method uses block-wise coherence. Fingerprint data has been taken from NIST databases 14. The segmentation algorithm has been trained on fingerprints of this database, but not on these particular fingerprints. Human inspection shows that the block-wise coherence algorithm provides satisfactory result.

Keyword: fingerprint image segmentation, block-wise, coherence, minutiae, singular point.

1. Introduction

The Segmentation of fingerprint image is an important step in the fingerprint identification. Segmentation is a process to isolate features from a fingerprint image and is often a key step in interpreting the fingerprint image. It is a process in which regions or features sharing similar characteristics are identified and grouped together. A captured fingerprint image usually consists of two components, which are called the foreground and the background.

The objective of the fingerprint image segmentation is to separating the foreground regions from the background regions. The foreground regions correspond to the clear fingerprint area containing the ridges and valleys, which is the Region of Interest (ROI). The background corresponds to the regions outside the borders of the fingerprint area, which do not contain any valid fingerprint information.

If the image background were always uniform and lighter than the fingerprint area, a simple approach based on local intensity could be effective for discriminating foreground and background; in practice, the low quality of fingerprint image requires more robust segmentation techniques. The problem of segmentation features is being sensitive to the quality of image. The first problem is the presence of noise that results from dust and grease on the surface of live-scan fingerprint scanners. The second problem is false traces which remain in the previous image acquisition. The third problem is low contrast fingerprint ridges

ISSN Print : 2085-1588
ISSN Online : 2355-4614
http://ejournal.unsri.ac.id/index.php/jsi/index

generated through inconsistent contact, dry/wet finger surface. The fourth problem is the presence of an indistinct boundary if the features in the fixed size of window are used.

Accurate segmentation of fingerprint images influences directly the performance of minutiae extraction like *minutiae* and *singular points*. Most feature extraction algorithms extract a lot of false features when applied to the noisy background area [1].

2. Literature Review

The current segmentation of fingerprint about foreground and background of the main methods can be summed up in the following two types: one is based on the pixel-wise of segmentation, and the other is based on the block-wise of segmentation. Both are based on fingerprint image of the demographic characteristics to design algorithm.

Pixel-wise features of the gray-scale image form the basis of segmentation. The feature vector of each pixel is classified, the class determining the region. Selected pixel features include local mean, local variance, standard deviation, and Gabor response of the fingerprint image. Because pixel-wise features segmentation method is time consuming and computational complexity, block-based features are usually used in the commercial automatic fingerprint recognition systems [16]. Block mean, block standard deviation, block gradient histogram, block average magnitude of the gradient are some common features used for fingerprint segmentation.

Several approaches to pixel-wise fingerprint image segmentation are known from literature. In [1] proposed a pixel-wise segmentation technique, where three pixel features; the coherence, the mean, and the variance are computed for each pixel. An optimal linear classifier is trained for classification per pixel, while morphology is applied as post processing to obtain compact clusters and to reduce the number of classification error. In [6], fingerprint images are segmented based on pixel-wise coherence, combine with some morphological operations is capable of accurately segmenting fingerprint of very bad quality that cannot be processed by the variance-based methods. In [7] trains a quadric surface model based on pixel-wise CMV (Coherence, Mean and Varian) features. In [18] proposes a multiscale Gabor wavelet filter bank using the Phase of Multiscale Gabor wavelets for robust and efficient fingerprint segmentation. In [9] apply convex hull algorithm to fingerprint segmentation. In [10] propose a personalized fingerprint segmentation method: Automatic Labeling based Linear Neighborhood Propagation (ALLNP), which learns a segmentation model special for each input fingerprint image based on the input image only. In [11] proposes to segment fingerprint based on Gaussian-Hermite moments.

Several approaches to block-wise fingerprint image segmentation are known from literature. In [2], the fingerprint as an original image is partitioned in blocks of 16 x 16 pixels and segmented using the statistics derived from the directional image. The directional image can be thought of as an image transform, where each pixel of an image represents direction of the local grey level uniformity. This method is suited for simple images like fingerprint and other images that consist of only background and foreground, but whose histogram may not necessarily be bimodal. In [3] proposed a composite method that, besides histograms of orientations, computes the gray-scale variance of each block and, in the absence of reliable information from the histograms, assigns the low-variance blocks to the background. In [4] computes the variance of the projection signal on different directions with the prior knowledge that the foreground block is of large variance along the direction orthogonal to the orientation of the ridges is used to classify each 16 × 16 block and is of small variance along the direction parallel to the ridges, and background is usually of small variance along all directions. In [5], the output of a set of Gabor filters is used as input to a clustering algorithm that constructs spatially compact clusters. In[12] discriminated foreground and background by using the average magnitude of the gradient in each image block; in fact, because the fingerprint area is rich in edges due to the ridge/valley alternation, the gradient response is high in the fingerprint area and small in the background. In [13] proposes a segmentation method consisting of two steps: in the primary segmentation, non-ridge regions and unrecoverable low quality ridge regions are removed as background by a well trained neural network, and the secondary segmentation, the remaining ridges are identified and removed according to the two typical differences between the remaining ridges and the true ridges. In [14] uses a hidden Markov model (HMM) to solve the problem of fragmented segmentation. In [15] segmentation of fingerprint uses three block features: the block clusters degree, the block mean information, and the block variance. In [17] uses the gradient vector field. Fingerprint image is divided into 15 × 15 block. For each block is obtained gradient vectors using Sobel Operator. Compute the average gradient magnitude and direction variance. Calculate the block quality score to determine block is foreground or background.

3. Methodology

3.1 Variance Dynamic Threshold

ISSN Print : 2085-1588
ISSN Online : 2355-4614
http://ejournal.unsri.ac.id/index.php/jsi/index

In a fingerprint image, the background regions have a very low variance value, whereas the foreground regions have a very high variance. Hence, a method based on variance dynamic threshold [8] can be used to perform the segmentation. The following is a segmentation algorithm using variance dynamic threshold in [8];

1. choosed a desire threshold (T) value;
2. grouped of both G_1 and G_2 class grayscale image based on the threshold value;
3. average grayscale group: $m_1 = \mu(G_1)$ and $m_2 = \mu(G_2)$ Defined a new threshold base on m_1 and m_2, $T' = \frac{m_1 + m_2}{2}$
4. compared old T (threshold) with new T', if $T \neq T'$ then $T' = T$ repeat step 1 to 4 until both thresholds have same value;
5. compute image mean and variant used block $W \, x \, W$

$$M(k) = \frac{1}{w^2} \sum_{i=0}^{w-1} \sum_{j=0}^{w-1} (I(i,j))$$

$$V(k) = \frac{1}{W^2} \sum_{i=0}^{W-1} \sum_{j=0}^{W-1} (I(i,j) - M(k))^2$$

where, $V(k)$ is variant of k-block, W is size of block, $M(k)$ is grayscale mean of k block (i,j) is image coordinates;

6. if $V(k) > T$ then set pixels as a background colour (black) else set as a foreground (stay colour).

3.2 Proposed Segmentation Algorithm

a. Gradients

The first steps for calculating the gradient at pixel (i,j) are as follows:

1. Firstly, a block of size $W \times W$ is centred at pixel (i,j) in the fingerprint image.
2. For each pixel in the block, compute the gradients $G_x(i,j)$ and $G_y(i,j)$ which are the gradient magnitudes in the x and y directions, respectively. The horizontal Sobel operator is used to compute $G_x(i,j)$:

ISSN Print : 2085-1588
ISSN Online : 2355-4614
http://ejournal.unsri.ac.id/index.php/jsi/index

$$\begin{bmatrix} 1 & 0 & -1 \\ 2 & 0 & -2 \\ 1 & 0 & -1 \end{bmatrix}$$

The vertical Sobel operator is used to compute $G_y(i,j)$:

$$\begin{bmatrix} 1 & 2 & 1 \\ 0 & 0 & 0 \\ -1 & -2 & -1 \end{bmatrix}$$

b. Coherence

Using some trigonometric identities, an expression for average squared gradient vectors to estimated the local orientation at pixel (i,j) in block $W\,x\,W$ can using the following equation:

$$V_x(i,j) = \sum_{u=i-\frac{W}{2}}^{i+\frac{W}{2}} \sum_{v=j-\frac{W}{2}}^{j+\frac{W}{2}} G_x^2(u,v) - G_y^2(u,v)$$

$$V_y(i,j) = \sum_{u=i-\frac{W}{2}}^{i+\frac{W}{2}} \sum_{v=j-\frac{W}{2}}^{j+\frac{W}{2}} 2G_x(u,v)G_y(u,v)$$

$$V_z(i,j) = \sum_{u=i-\frac{W}{2}}^{i+\frac{W}{2}} \sum_{v=j-\frac{W}{2}}^{j+\frac{W}{2}} G_x^2(u,v) + G_y^2(u,v)$$

$$\theta(i,j) = \frac{1}{2}\tan^{-1}\frac{V_y(i,j)}{V_x(i,j)}$$

Where $\theta(i,j)$ is the least square estimate of the local orientation at pixel (i,j).

The gradient coherence could be used to reflect the orientation coherence of the texture. The gradient coherence value is usually larger in foreground of the fingerprint image, where the gray values are much smoother along the direction of the ridge than that at the perpendicular direction of the ridge. Gradient coherence in each block can be calculated by following formulas:

$$Coh(i,j) = \frac{\sqrt{V_x(i,j)^2 + V_y(i,j)^2}}{V_z(i,j)}$$

4. Experimental Results and Conclusions

This section presents some experimental result of the segmentation algorithm. First, in figure 1, segmentation results are shown for two methods using NIST Database 14.

ISSN Print : 2085-1588
ISSN Online : 2355-4614
http://ejournal.unsri.ac.id/index.php/jsi/index

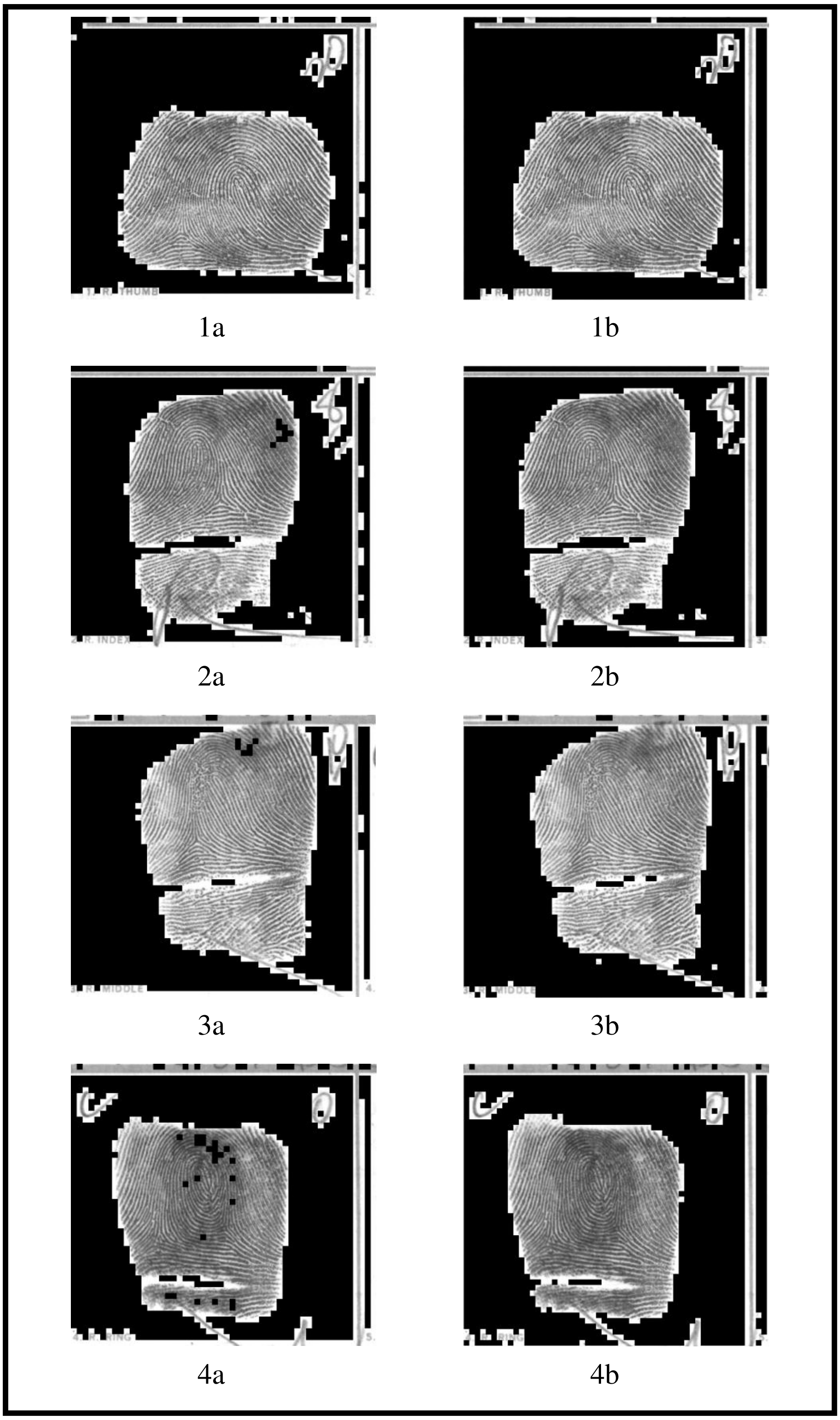

Figure 1. 1a, 2a, 3a, 4a are segmentation using variance dynamic threshold and 1b, 2b, 3b, 4b are segmentation using block-wise coherence.

The segmentation algorithm has been trained on fingerprints of this database, but not on these particular fingerprints. Figure 2a, 3a, 4a shows a segmented fingerprint image can be observed that is contain valid fingerprint information at foreground area is lost or covering by black color pixel block. It is can decrease accuracy to processing of fingerprint identification, that is orientation field estimation, detection of singular point or detection of minutiae. Whereas according to Figure 1a not contain pixel block covering ridges and valleys because fingerprint have a very good quality. In figure 1b, 2b, 3b, 4b foreground area of fingerprint not covering pixel block fingerprint area containing the ridges and valleys. Human inspection shows that the block-wise coherence algorithm provides satisfactory result.

5. References

[1] A.M. Bazen and S.H. Gerez (2001). Segmentation of _fingerprint images. In *Proc. ProRISC2001, 12th Annual Workshop on Circuits, Systems and Signal Processing*, Veldhoven, The Netherlands.

[2] B.M. Mehtre, N.N. Murthy, S. Kapoor, and B. Chatterjee (1987). Segmentation of Fingerprint Images Using the Directional Images, *Pattern Recognition*, Vol.20, No. 4, pp. 429-435, Printed in Great Britain.

[3] B.M. Mehtre and B. Chatterjee (1989). Segmentation of Fingerprint Images a Composite Method, *Pattern Recognition*, Vol. 22, No. 4, pp. 381-385.

[4] N. Ratha, S. Chen, and A.K. Jain (1995). Adaptive flow orientation based feature extraction in fingerprint images, *Pattern Recognition,* 28(11), pp. 1657-1672.

[5] A.K. Jain and N.K. Ratha (1997). Object Detection Using Gabor Filters, *Pattern Recognition*, Vol. 30, No. 2, pp. 295-309.

[6] A.M. Bazen and S.H. Gerez (2000). Directional Field Computation for Fingerprints Base on the Principal Component Analysis of Local Gradients, in *Proceedings of ProRISC2000, 11th Annual Workshop on Circuits, Systems and Signal Processing*, Veldhoven, The Netherlands.

[7] Yin, Y.L., Wang, Y.R., Yang, X.K (2005). Fingerprint image segmentation based on quadric surface model. In: Kanade, T., Jain, A., Ratha, N.K. (eds.) AVBPA 2005. LNCS, vol. 3546, pp. 647–655. Springer, Heidelberg.

[8] Saparudin, Abdiansyah (2010). Fingerprint Classification Using Region Partition. International Conference on Informatics Cybernetics, and Computer Applications (ICICCA2010). Bangalore, India.

[9] Ross, A.(2003). Information Fusion in Fingerprint Authentication, Ph.D. Thesis, Michigan State University.

ISSN Print : 2085-1588
ISSN Online : 2355-4614
http://ejournal.unsri.ac.id/index.php/jsi/index

[10] Xinjian Guo, Yilong Yin, and Zhichen Shi (2009). Personalized Fingerprint Segmentation. ICONIP 2009, Part I, LNCS 5863, pp. 798–809 © Springer-Verlag Berlin Heidelberg.

[11] Wang, L., Dai, M., Geng, G.H. (2004). Fingerprint image segmentation by energy of Gaussian-Hermite moments. In: Li, S.Z., Lai, J.-H., Tan, T., Feng, G.-C., Wang, Y. (eds.) SINOBIOMETRICS 2004. LNCS, vol. 3338, pp. 414–423. Springer, Heidelberg.

[12] Maio D. and Maltoni D. (1997). Direct Gray-Scale Minutiae Detection in Fingerprints, IEEE Transactions on Pattern Analysis and Machine Intelligence, vol. 19, no. 1.

[13] Yin, J.P., Zhu, E., Yang, X.J., Zhang, G.M., Hu, C.F. (2007). Two steps for fingerprint segmentation. J. Image and Vision Computing 25(9), 1391–1403.

[14] Klein, S., Bazen, A., Veldhuis, R.(2002). Fingerprint image segmentation based on hidden Markov models. In: Proceedings of 13th Annual Workshop on Circuits, Systems, and Signal Processing, vol. 2002, pp. 310–318.

[15] Chen, X., Tian, J., Cheng, J., Yang, X. (2004). Segmentation of Fingerprint Images Using Linear Classifier. In: EURASIP Journal on Applied Signal Processing 2004:4, 480-494. Hindawi Publishing Corporation.

[16] Chaohong Wu (2007). Advanced Feature Extraction Algorithms for Automatic Fingerprint Recognition Systems. Ph.D. Thesis. University of New York. United State of America.

[17] Jin Qi, Mei Xie (2008). Segmentation of Fingerprint Images Using The Gradient Vector Field. IEEE, 978-1-4244-1674-5, pp. 543-545.

[18] Bernard, S., Boujemaa, N., Vitale, D., Bricot, C. (2002). Fingerprint Segmentation Using the Phase of Multiscale Gabor Wavelets. In: The 5th Asian Conference on Computer Vision, Melbourne, Australia.