FEATURE EXTRACTION OF FINGERPRINT IMAGES

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ABSTRACT

As the demand of information security increase, the application of fingerprint has been widely used. The application of fingerprint included entrance monitoring system, identification of user status before entering the computer system and so on. In fingerprint verification system of police department, the fingerprint of crime that is hard to recognize by naked eyes can also be verified, but, it will spend a large time to analyze. Fast and exact recognition is important in on-line fingerprint verification system. If the quality of image is poor after examination, we will enhance it in order to have a better one. The main purpose of image enhancement is to improve low quality images, so that it can avoid the users to re-provide their fingerprint just because it is no good impressed. Therefore, if the image is hard to recognize after image enhancement, i.e. the quality of image is poor, thus, it will be rejected to recognize. We have defined a simple criterion area to examine the captured fingerprint images. Moreover, in order to reduce the computational flow and time, we do preprocessing in the criterion area instead of the whole fingerprint image. In image preprocessing, generally, Gray-Level is used to reduce computational flow. However, we suggest another approach as follow. After we examine the captured fingerprint images, we can calculate the value of the minimum red-value subtract the maximum blue-value. It can almost help us to capture the “ridge” of the fingerprint image. In pruning, we propose a simple concept — slope to trim the image.

Keyword: entrance monitoring system, fingerprint, criterion area, feature extraction, slope.

1. INTRODUCTION

The research of fingerprint recognition has been established since the end of the 16th century [3]. In fact, the captured fingerprint without preprocessing is difficult to recognize. Generally, they are suffered from several types of noise: (1) sebum of skin, (2) hydrosphere in the air, and (3) inequality of finger printed in ink. To accurately extract the features of fingerprint images, useful and precise image preprocessing is very important.

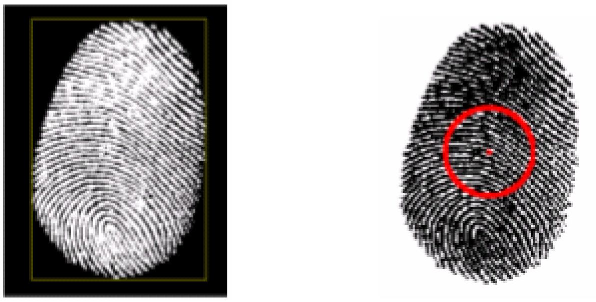
Not all of the captured fingerprint image should be employed to recognize after preprocessing because they would not be identified efficiently by pattern recognition or naked eyes in short time. Therefore, we offer a simple criterion area to examine the fingerprint images and know whether if they could be recognized immediately or not. We will discuss it in section 2.

We take the value of the minimum red-value subtract the maximum blue-value instead of the Gray-Level in the preprocessing stage. Then we will introduce the image preprocessing in section 3. Finally, the last section is conclusion.

2. SIMPLE CRITERION AREA

Some of poor quality fingerprint images that were stamped with too more or too less ink by user might be hard to obtain. In order to avoid it, we suggest simple criterion area to analyze the captured fingerprint images.

There are 70~80 minutiae in a fingerprint image and only 10~13 ones are enough to recognize the identification of user. Therefore, we purpose a criterion area to inspect the quality of fingerprint and extract enough minutiae. We use centroid to find the center of fingerprint out. Then, we compare the wide of fingerprint image with its height (as shown in figure 1) and take one-fourth of the shorter one as the radius of criterion area (as shown in figure 1).



(a) (b)

Figure 1: (a) projective wide and height of fingerprint image (b) criterion area.

In this study, we compute the proportional part of red pixel in the criterion area and calculate the value of red-value subtract blue-value of 30 good quality fingerprint images (as shown in Table 1). According to Central limit theorem, the distribution of the sample can be considered as normal when its size is more than 30. Thus, take the value (red-value subtract blue-value) which is higher than 78 as a foreground (fingerprint).

Table 1: red-value and blue-value in the spatial resolution

FPR	red-value	blue-value	FPR	red-value	blue-value
1	255	167	18	255	138
2	255	166	19	255	166
3	255	163	20	254	167
4	255	162	21	255	177
5	255	166	22	255	154
6	255	176	23	255	132
7	255	152	24	255	154
8	255	166	25	254	164
9	255	164	26	255	175
10	255	165	27	255	155
11	255	167	28	254	145
12	255	131	29	255	168
13	255	155	30	255	166
14	255	165			
15	255	165	Max	255	176
16	255	177	Min	254	131
17	255	141	R_Min-B_Max		78

Note:
FPR is Fingerprint.
R_Min is the minimum of red-value and B_Max is the maximum of blue-value.

Then, we calculate the proportion of red pixel in the criterion area from the sample of 20 good quality fingerprint images in statistics. The conclusion of examination is that these data present a normal distribution. Based on its 95% confidence interval, the good quality of fingerprint image is determined by the upper and lower limits which are located between 0.641 and 0.695. Therefore, we can determine the good quality fingerprint image of which the proportion of red pixel in the criterion area that is 0.641 to 0.695(as shown in Table 2).

Table 2: upper limit and lower limit

input		output	
0.88	0.929	mean	0.8235
0.87	0.861	confidence interval	95%
0.92	0.308	upper-limit	0.695
0.73	0.993	lower-limit	0.641
0.65	0.802		
0.96	0.994		
0.83	0.655		
0.83	0.994		
0.76	0.799		
0.8	0.919		

3. IMAGE PREPROCESSING

In the RGB model, each color is consisted of red, green, and blue. Gray-Level (in 256 gray-level) is a general processing procedure of image preprocessing. This approach is to replace the pixel of the image into the average of its red, green and blue values. The reason of this processing is to reduce the computational flow. But now, by using the methodology we introduced in the previous section, we can fast find the foreground, thus, the Gray-Level can be excluded in this study.

3.1. Noise Reduction

We implement Median filter to reduce noises because it is a better methodology to lessen the disturbance in random noise.

3.2. Image Enhancement

Next, the following formulation (1) is utilized to enhance the fingerprint image [5].

$$
\begin{aligned}
&\sigma = 255/(H*W) \\
&C_0 = \sigma * h(0) \\
&C_i = (C_i - 1) + \sigma * h(i) \quad i = 1,2..,255
\end{aligned}
\tag{1}
$$

H is the height of fingerprint image, W is the wide of fingerprint image, h(i) is the frequency of gray value of i, and C(i) is the new gray value of i after image enhancement.

40 fingerprint images which are out of control limit boundary are tested. From these samples, 20 images of them are upper than the limited control (as shown in Table 3, 4) and the others 20 are lower than it (as shown in Table 5, 6).We can observe that the enhancement is more useful in the images which have lower value than the limited control.

Table 3: upper than the limited control before enhancement

input		output	
0.701	0.812	mean	0.8313
0.971	0.786	confidence interval	95%
0.841	0.714	upper-limit	0.8656
0.922	0.848	low-limit	0.7969
0.813	0.733		
0.779	0.915		
0.855	0.774		
0.871	0.936		
0.777	0.726		
0.783	0.721		

Table 4: upper than the limited control after enhancement.

input		output	
0.685	0.989	mean	0.8409
0.954	0.75	confidence interval	95%
0.822	0.832	upper-limit	0.8783
0.986	0.786	low-limit	0.8035
0.876	0.712		
0.825	0.729		
0.848	0.836		
0.804	0.761		
0.777	0.737		
0.832	0.802		

Table 5: lower than the limited control before enhancement.

input		output	
0.586	0.357	mean	0.4579
0.463	0.6	confidence interval	95%
0.571	0.615	upper-limit	0.5018
0.459	0.353	low-limit	0.4139
0.507	0.353		
0.568	0.427		
0.397	0.441		
0.4	0.541		
0.341	0.578		
0.305	0.54		

Table 6: lower than the limited control after enhancement.

input		output	
0.685	0.554	mean	0.6591
0.522	0.951	confidence interval	95%
0.557	0.624	upper-limit	0.7015
0.647	0.658	low-limit	0.6166
0.781	0.654		
0.833	0.568		
0.657	0.691		
0.675	0.772		
0.669	0.761		
0.565	0.732		

3.3. Thresholding

A special characteristic of fingerprint is that it has flow orientation. Otsu [4] provides an auto threshold selection method of binarization. But in this case, it is not suitable to implement.

We apply the method in [7] to achieve binarization. They first find out the dominant ridge directions in each 9*9 window shown in Figure 2.

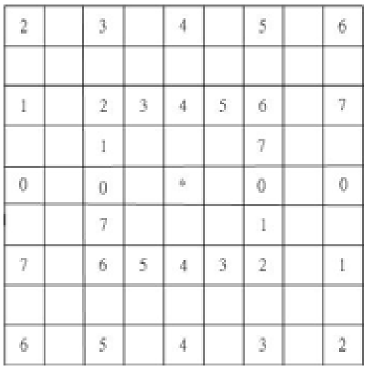


Figure 2: eight dominant ridge directions

They compute the average gray value of the direction i (i=0,1,...,7 which represent one of the eight directions) and obtain the mean of gray values, G[i]. The mean of gray values are divided into four groups. G[j] and G[j+4] are perpendicular to each other (j=0,1,2,3). The calculation of the absolute difference in each group is shown in (2).

$$G_d = |G[j] - G[j+4]| \quad (j = 0,1,2,3) \tag{2}$$

Next, the possibility of the largest difference ridge direction if

$$i_{Max} = \arg\left\{ \underset{i\in\{0,1,2,3\}}{Max} \left(G_d(i)\right) \right\} \tag{3}$$

Here, i_{Max} and i_{Max} +4 are possible ridge directions. The ridge direction in the pixel is supposed to:

$$D_i = \begin{cases} i_{Max} & if \begin{pmatrix} |Grey - G[i_{Max}]| \\ < |Grey - G[i_{Max}+4]| \end{pmatrix} \\ i_{Max}+4 & otherwise \end{cases} \tag{4}$$

where Grey is the grey value of the pixel.

Noises would affect the result of dominant direction. After computing the dominant direction of each pixel, the fingerprint image is divided into 16*16 block. Then, the number of each direction of the block is calculated and the most number (N_i) of the direction is set to be the mean of direction in this block:

$$B = \arg\left\{ \underset{i=\{0,1,2,\ldots,7\}}{Max} \left(N_i\right) \right\} \tag{5}$$

If the direction of the pixel is i, i_{ver} will be the perpendicular direction i+4 (i=0,1,2,…,7). And i_{val} is the new grey value of the pixel. The binarization image is shown in figure 3.

$$i_{Val} = \begin{cases} 255 & if G[i] \geq G[i_{ver} + 4] \\ 0 & otherwise \end{cases} \tag{6}$$

Figure 3: The binarization image

3.4. Thinning

In this subsection, thinning is employed to find out the skeleton of fingerprint. Figure 4 describes its block and the following algorithm is its mathematic equations. The algorithm will be executed until one of the two steps does not match the condition. The thinning image is shown in figure5.

P9	P2	P3
P8	P1	P4
P7	P6	P5

Figure 4: thinning block

Step1:

(a) $2 \leq N(P1) \leq 6$

(b) $S(P1) = 1$ (7)

(c1) $P2 * P6 * P8 = 0$

(d1) $P2 * P4 * P6 = 0$

Step 2:

(a) $2 \leq N(P1) \leq 6$

(b) $S(P1) = 1$ (8)

(c2) $P4 * P6 * P8 = 0$

(d2) $P2 * P4 * P8 = 0$

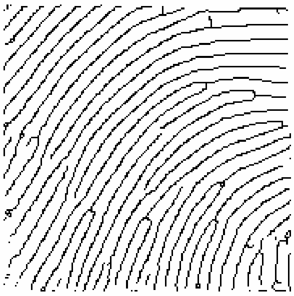
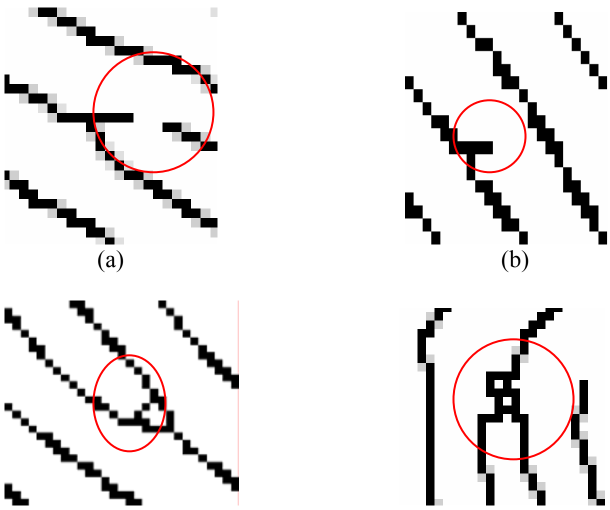


Figure 5: The thinning image.

3.5. Pruning

After thinning, the features of the image has not completely extracted yet. A lot of false features will influence the recognition. Thus, pruning is the next stage which is needed to be executed.

The angle of pixel and average bridge is employed to prune [1]. In this subsection, we execute average bridge and slopes to prune three types of false features: ending connection, spur, and false bridge. Then we use a filter to remove the “bubble” (as shown in figure 6).



(a) (b) (c) (d)

Figure 6: (a)ending connection (b) spur (c) false bridge (d)”bubble”.

Further, we compute the average wide of bridge, the average beeline between the bridge and its next bridge, to be the criterion of pruning (as shown in figure 7).

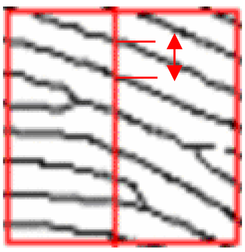


Figure 7: the wide of the bridge.

According to the average bridge, we set a criterion range to extract the candidate of ending. If there is another one, they will be conjoined.

A bifurcation is consisted of three different directions bridge. Obviously, spur and false bridge are occurred in bifurcation.

To prune the false bridge, we first extract the candidate of bifurcation. Respectively, the coordinate and pixels' number of the three directions of bifurcation are being searched and recorded. If in this process we found out others bifurcation in one of the directions or the accumulated number of pixels has reached the average bridge, the searching processing in these directions will be stopped. Then, the searching process will be continued on two others direction. Next step, we calculate the slopes of three directions by using regression. If the pixels' number of one direction is less or equal than the average bridge and its slope is significantly differed with the others, the direction of bifurcation will be taken as false bridge

The center of 9_block of "bubble" is "white" and its eight neighborhoods are "black". To avoid any "breaking point" in the bubble type, we keep two of "black" pixels according to the position of the red points (figure 8), the center of the bubble is changed to "black" and the others are changed to "white" pixels. Thus, it can generate a connective bridge. The pruning image is expressed in figure 9.

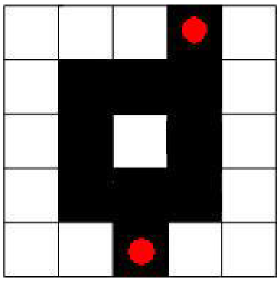


Figure 8: "Bubble" and its two connective bridges.

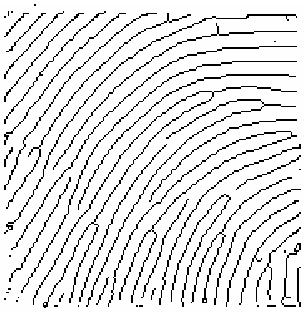


Figure 9: The pruning image.

4. EXTRACT FEATURE OF FINGERPRINT

To increase the accuracy of recognition, the algorithm fingerprint classifier by using singular points were proposed [7]. However, this approach needs much time to classify. Therefore, we only select two types of the features to be extracted [1,6]. One is ending and the other is bifurcation. We extract the features in criterion area to reduce computational flow (as shown in figure 10).

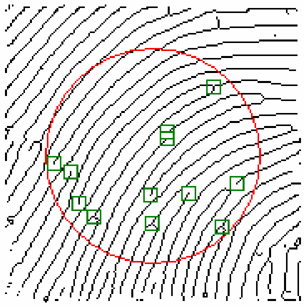


Figure 10: extract two types of feature, ending and bifurcation, in criterion area.

5. CONCLUSION

We have replaced Grey-Level in preprocessing stage with the value of the minimum red-value subtract the maximum blue-value in order to reduce the processing time. For on-line fingerprint verification system, we propose a simple criterion area to examine the quality of fingerprint image. And we utilized the concept of slope to prune instead of the concept of angle.

6. ACKNOWLEDGE

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7. REFERENCES

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