Optimum Block Size Detection for Image Quality Measure

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Abstract

This paper deals with the quality of the image itself as well as the algorithm used for evaluating the quality of the fingerprints to construct an effective algorithm for evaluating the quality of the fingerprints. The quality of the fingerprint is acquired by taking the regional quality of each fingerprint image. The amount of fingerprint varies according to the size of each block which makes the result unsteady. We concentrated on finding the right size for the block used to acquire the fingerprint image. Also, the quality distribution included in the fingerprint image was acquired when the optimal block size was adopted.

1. Introduction

In the age of information, the need for a personal authentication system has increased more than ever. The advantages of biometrics are that samples can be easily acquired from individuals and that they are hard to forge or modulate [1].

After various researches have been done on this area, the algorithm for fingerprint recognition has reached a certain level nowadays. However, such systems rely on the FAR and FRR, which makes the accuracy lower when the quality of the image itself is below a certain level [2]. If the acquired fingerprint is contaminated in any way such as by a cut or through an incomplete contact, a recognition error occurs and the fingerprint is misread [3]. A sample with poor quality becomes one of the main causes of a mismatch for the fingerprint recognition system. Therefore, measuring the quality of the fingerprint sample becomes an important factor in acquiring a high-quality fingerprint [4]. The quality evaluation system in most fingerprint recognition systems had been adopted to acquire a quality fingerprint by detecting the relative amount of area for the fingerprint compared to the location of the finger. This could only be used to notify the user whether the location of the finger was sufficient to acquire the fingerprint but not the quality of the fingerprint itself.

Current systems relied on human heuristic to evaluate the quality of the fingerprint image. Therefore, it relied too much on human decision which dropped its reliability. Some researched have recently begun in the area of evaluating the quality of the fingerprint images [2]. We will talk about the quality of the image itself as well as the algorithm used for evaluating the quality of the fingerprints to construct an effective algorithm for evaluating the quality of the fingerprints.

2. Necessity of quality measure

Measuring the quality of the fingerprints is required to measure the quality of the fingerprint image used for the AFIS. We can acquire a higher quality image by taking the quality of the image in the post-processing stage of the authentication and matching process. Also, by rejecting a low quality image and making user to input the fingerprint, we can guarantee better image quality. The bifurcation and the ridges become unclear if there is too much or less pressure on the finger in the input process. If the quality of fingerprints is poor (bad), we can find out three cases: false minutiae finding, omission of minutiae, and error occurrence in the position of minutiae. In order to solve these problems, the enrol stage must have a measure to select the good quality of fingerprint images. In this paper, we defined the area where the boundary is clear as a good quality region and the contaminated area and the area that cannot be recovered as a poor quality region. The region where the disconnection of the ridge occurs frequently is defined weak, and where the fingerprint is printed firmly is defined strong in a bad quality region.

3. Proposed Quality Measurement Method

3.1 Definition of the quality features

The standard for classifying the quality of the fingerprint image was set by experts in the field of

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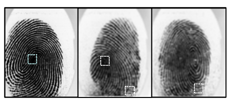
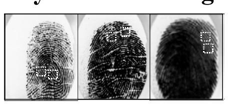
fingerprint classification. However, it still remains objective and is prone to differences made by different experts, and therefore it was necessary to set a generalized standard for classifying the images in this paper. We have classified the images as good quality and poor quality in our study.

Even images that have been classified as poor quality images contain both good quality and poor quality image blocks. [Figure 1] shows a good quality image. The ridge and the valley are clearly separated but the block indicated using dotted lines are of poor quality. [Figure 2] shows a poor quality image. The ridge and the valley are not clearly separated due to factors such as sweat and high pressure. However, locally there are some blocks which could be classified as good quality. The area shown with the dotted line in [Figure 2] shows such example.



(a) (b) (c)

[Figure 1] Poor quality block within good quality



(a) (b) (c)

[Figure 2] Good quality block within poor quality

3.2 Proposed classification method for fingerprint images

3.2.1 Choosing the optimal block size

The existing methods based on the grey-level change showed low performance because they did not take the structure of the ridge and the occurrence factor into account. A solution would be to divide the image into block sizes sufficient to take the local features of the fingerprint into account. Better quality can be obtained by including sufficient amount of ridge and valley in the block, when measuring the grey-level value for the pixels in each direction. Therefore, the size of the block is defined while changing the occurrence of the ridge to find the sufficient size for the block to measure the quality.

Definition by size of good and poor quality blocks The quality pattern shown on the fingerprint image can be defined as the following few patterns. The size of the block was decided based on the number of ridge. The fingerprints used in the experiment were acquired from adults in the age between 20 and 30. We were able to find out that there were 1 or 2 ridges in a 12*12 block. There were 2 or 3 ridges in a 16*16 block, 3 or 4 in a 24*24 block and 4 or 5 in a 36*36 block. In the example of a good quality image, the ridge and the valley are clearly shown within the block. However, in a poor quality image, they did not show up clearly. The ridge and valley were merged together or had many disconnected areas.

Applying the directional slot for each block size 8 directional slots out of the 16 chain codes were used for each block. Directions of the same index are defined for each 25° [5]. Each directional slot is formed to contain odd number of pixels to make it cross the centre of the block. Also, it is calculated for all direction to include specific information about the block. The slot applied for each block only differs in its size and not in its application and calculation method.

The directional slot is applied on the pixel block. The pixel for each direction in the figure has been indicated with numbers from 0 to 7. The pixels indicated with the alphabet are the pixels calculated more than once. The sum of the grey level for each direction is calculated. After adding all the grey level value for the pixels in each direction, the average is calculated. Each average value is defined as Dm (Direction mean).

$$Dm = Dd \,/\, \text{directional pixel number} \qquad \text{(Eq. 1)}$$

The average values are compared to get the Max and Min value in order to get their difference. They are each defined as DMax and DMin, and their difference is defined as QB(Quality Block).

The above equation is each applied on a good and poor quality block to acquire QB. A high value is obtained for a good quality block and vice versa. However, there are some cases where a poor quality block shows a high QB value, as well as good quality blocks with a low QB value. This is the disadvantage of using the change in the grey level for the quality classification, which occurs when the grey level is not properly taken into account due to the directional slot. This can be corrected using the following method. The QB value of both the good and poor quality block is compared to the quality block threshold value within the range from 0 to the maximum QB value. A block with a QB value larger than the threshold value is classified as a good quality block and that below the threshold as a poor quality block. The preciseness is calculated using (Eq. 2), by dividing the number of values under the QBT by the total number of QB values of the image. Redundant values are counted only once within the QB values that are under the QBT value. The optimal threshold value is set by comparing the classification rate of the good and poor quality images.

$$\text{Classification Rate} = \text{number of values under the QBT} \,/\, \text{total number of QB value} * 100 \qquad \text{(Eq. 2)}$$

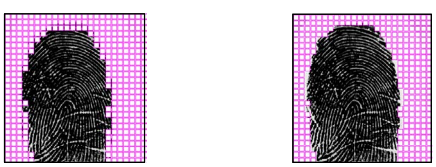
3.2.2 Measuring the QB for each region of the fingerprint image

Applying the QBT The quality of the image can be analysed by applying the QBT on each block size. There are more poor quality blocks than good quality blocks in a poor quality image and vice versa. The ratio for both a good quality image and a poor quality image can be obtained by analysing the ration of poor quality blocks in a poor quality image and good quality blocks in a good quality image. The image is divided into blocks to acquire the QB. The quality of the block is decided by comparing the QB value with the threshold value. The background region and the fingerprint region are separated to obtain the QB from only the fingerprint region to reduce the amount of calculation and increase the accuracy.

Segmentation of the fingerprint image A background region is formed around the actual fingerprint image when the fingerprint has been input. The analysis should be performed on only the fingerprint image itself. The blocks in the background image do not contain a ridge, which results in a higher grey level value. The QB value also shows up low due to the grey level value. The process for segmenting the fingerprint image is as follows:

1. Calculate the GM (Global Mean) of the whole image.
2. Divide the whole image into blocks to get the BM (Block Mean).
3. Calculate the QB (Quality Block) for each block.
4. If GM is greater than BM and QB is greater than QBT, it is defined as a background region. The region that does not fit into these categories is defined as the fingerprint region.

Blocks that include only parts of the fingerprint occur on the blocks that are on the border of the image. These blocks were not included in the quality measurement process because of the background region. Blocks that partially include the fingerprints were classified as background regions.



(a) before(bn: 278)   (b) after(bn: 332)

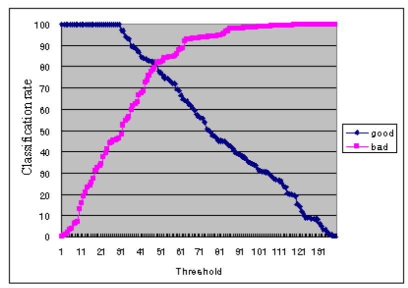
[Figure 3] Block segmentation of 12*12

The following figure shows an example of the image before and after the segmentation rules have been applied. [Figure 3] shows an example when segmentation has been applied for each block size (12*12 to 32*32). Only the blocks within the fingerprint area are marked as a fingerprint block when classification is applied. Therefore, the number of background blocks increases after the classification.

4. Results and Discussions

4.1 Block Size Optimisation

It is important to set the block to an appropriate size to apply the quality classification method. The ridge and valley would not be properly expressed if the block was too small, an unnecessary value would be acquired. Therefore, we have made the block size appropriate to take the ridge and valley information into account. Therefore, the block size should be larger than the ridge. The quality classification method has been applied on blocks with the size of 12*12 pixel, 16*16 pixel, 24*24 pixel, and 32*32 pixel each. We were able to find the appropriate block size that showed the highest accuracy in its threshold value.



[Figure 4] Result on 16*16 block size

As shown in the experiments above, any blocks larger than or smaller than the 16*16 block showed a lower classification rate. Therefore, it can be assumed that the classification would become most accurate when a 16*16 block was used.

4.2 Quality Distribution of Block Images

The quality distribution of the good and bad quality images is acquired by applying the threshold for each block size on the fingerprint area acquired through the segmentation. The ratio of the good quality block is higher in a good quality image. The optimal classification rate when the threshold has been applied is as follows.

A block whose QB is higher than the QBT is classified as a good quality block. If the QB is lower than the QBT, the conditions of a bad quality block are applied to figure out the number of blocks for both quality. Then the following equation is applied to calculate the ration of each quality blocks in every region.

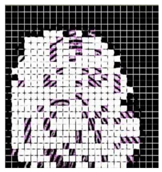
- Ratio of good quality blocks = 100 * Number of good quality block / Total number of blocks (Eq. 3)

- Ratio of poor quality block = 100 - Ratio of good quality block (Eq. 4)

(a) Original image

(b) After segmentation

(c) Good quality block (poor blocks: 296)

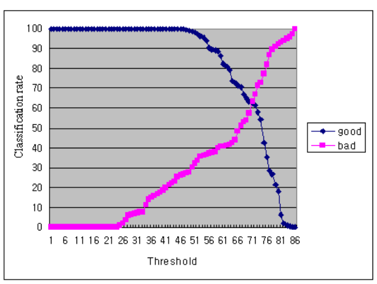


(d) Good quality block (poor blocks: 73)

[Figure 5] Block thresholding on 12*12

[Figure 5] shows a good quality image. [Figure 5]-(a) is the original image and (b) is the segmented image used for the experiment. In Figure (c), the good quality blocks are indicated using white-colored blocks. Therefore, the number of bad quality blocks in Figure (c) is the rest of the blocks not including the white-colored blocks. The same coloring is applied for Figure (d).

The following graph shows the ratio of good quality blocks in a good quality image. In our experiment using 12*12 blocks, the classification rate was 63% when the ratio of the bad quality blocks was 71%. Therefore, the optimal threshold value is 71.



[Figure 6] Block thresholding on 12*12

The 16*16 block showed a 92% classification rate. A good quality block contains clear ridge and valley information. A bad quality block has the following two problems. First of all is the effect of the ridge and valley being merged together into an unclear shape. The second problem is the disconnection of the ridge. A 16*16 block, shows the best performance, for the quality classification that defines a bad case only when the ridge and valley are mashed together. The threshold is nearly identical to the quality classification threshold from the previous section. Therefore, the method used in our experiment showed a high classification rate when the bad quality blocks were strong types.

5. Conclusions

This study aims at providing a subjective method for classification that is similar to the human expert. Therefore, we proposed a method that changes the block size to find the optimal threshold value for the classification. Through experiments, the optimal block size to be used for the classification has been measured, which is useful when the resolution changes by using a different sensor to acquire the fingerprint image. The method proposed in this paper estimates the real quality of the fingerprints to decide the quality distribution. The threshold value changes for different block sizes. The accuracy was the highest when the optimal threshold value acquired through this method was applied on the whole area. The grey-level value for each direction was measure for the regional characteristics which could not take the overall structure of the image into account. This could cause a problem when the valley and boundary were merged together and unclear. It also presented a problem when the ridge was disconnected in the image. Future works should provide a method to overcome such adversities that could affect the overall performance of the classification.

References

[1] L. C. Jain, U. Halici, I. Hayashi, S. B. Lee, S. Tsutsui, *Intelligent Biometric Techiques in Fingerprint and Face Recognition*, CRC Press LLC, pp. 3-21, 1999.

[2] M. Y. Yao, S. Pankanti, N. Haas, N. K. Ratha, R. M. Bolle, "Quantifying Quality: A Case Study in Fingerprints", http://www.research.ibm.com/ecvg/pubs/sharat-qqual.html, 2002.

[3] L. Hong, A. K. Jain, S. Pankanti, and R. M. Bolle, "Fingerprint Enhancement". Proc. 1st IEEE Workshop on the Application of Computer Vision, pp. 202-207, Sarasota, FL, 1996.

[4] L. L. Shen, A. Kot and W. M. Koo, "Quality Measures of Fingerprint Images", Proceedings of the Third International Conference on Audio and Video Based Biometric Person Authentication 2001, pp. 266-271, Halmstad, Sweden, 2001.

[5] Y. Hamamoto, S. Uchimura, M. Watanabe, "A Gabor filter-based method for recognizing handwritten numerals", Pattern Recognition, Vol. 21, no. 4, pp. 395-400, 1998.