A NOVEL FEATURE EXTRACTION FOR IRIS IDENTIFICATION USING MORPHOLOGICAL SKELETON

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ABSTRACT

In this paper we introduce a novel method to extract the features of space domain from iris image, which uses gray scale morphological filtering. It is well known that the skeleton which shows the features of images is extracted from binary images by morphological filtering. The skeleton of gray scale images can be also extracted by gray-scale morphological filtering. In order to extract the features of the iris, we apply the gray scale morphological filtering to the iris image and obtain the skeleton. The binary skeleton which is regarded as the iris code is obtained by thresholding. The Hamming distance was employed for classification of iris codes.

1. INTRODUCTION

A biometric system provides automatic recognition of an individual based on some sort of unique feature or characteristics processed by the individual. As well as others biometrics, the iris has been used in automated recognition systems, since it characteristics are unique to each individual, even between monocular twins and stable with age, the iris has great potential use in the biometric non-invasive evaluation.

The iris is located on the outside of eye; it is easier to take an image. However, the development of the identification system using the iris started relatively later. Since, the pattern of the iris is so highly detailed that it is very difficult to identify it. The iris identification system was first introduced by Daugman [1]. This identification system is based on 2D Gabor filer. Several other methods were developed using isotropic band-pass decomposition such as Laplacian pyramid [2] and multi-channel Gabor filtering [3]. Boles [4],[5] has detailed fine-to-coarse approximation at different resolution levels that are based on zero-crossing representation from wavelet transform decomposition. Hong *et al.*[6] extracted features from an iris image using multi scale-space filtering technique. Zero-crossing is also used for edge detection in this method.

In this paper, we introduce a novel method which is based on morphological filtering [7],[9] to extract the unique features from an iris image. It is well known that the skeleton is extracted from binary pattern images by using morphology filtering. The skeleton shows the characteristics of the binary pattern image and is used for coding of binary pattern images. In the gray scale image, the gray-scale skeleton is obtained by the gray-scale morphological filtering.

An iris image is separated from the whole image of eye and normalized into rectangular block with constant dimensions. Next, in order to make the contrast of iris images same, we adjust the average and standard deviation to the specified values. The feature (i.e., skeleton) is extracted from the normalized iris image by gray scale morphological filtering technique. From the skeleton image an iris code is given by thresholding.

The morphological filters which are consisted maximum and minimum operations, thus, the computational complexity of our method is very low. It is a merit of the proposed method.

2. SEGMENTATION

We introduce a modified version of Hong's method [6] to calculate the radius and center of pupil. From Fig.1, the border of the pupil and iris can be expressed

$$(r\cos\theta - x_0)^2 + (r\sin\theta - y_0)^2 = R^2 \qquad (1)$$

where (x_0, y_0) denotes the center of the pupil and (r, θ) denotes the corresponding polar coordinates and R is the radius of pupil to be found.

Let $f(r,\theta)$ be the iris image in the polar coordinates. Initially, the origin of the polar coordinates which is corresponded to the center of the pupil is chosen to be arbitrary point inside of the pupil. Next, we find the boundary, $e_{edge}(\theta)$ as

$$e_{edge}(\theta) = MAX_r\{|f(r+1) - f(r-1)|\} \qquad (2)$$

$MAX_r\{\}$ represents the value of r where {} is maximized at given θ. The radius and center of the pupil can be obtained by using $e_{edge}(\theta)$ .Let X1, X2, X3, X4 be the regions which are illustrated in Fig.2. Let X_i be the average value of $e_{edge}(\theta)$'s for the region labelled X*i*. Then, the radius R and center (x_0, y_0) of the pupil as

$$R = \tfrac{1}{4}(X_1 + X_2 + X_3 + X_4) \qquad (3)$$

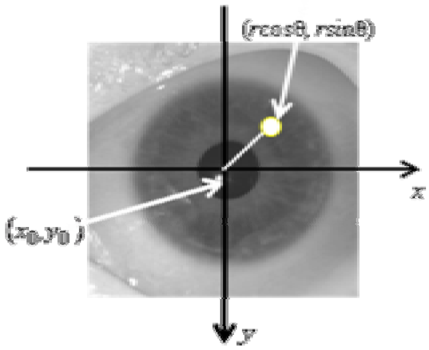


Figure 1 Iris image in the orthogonal coordinates

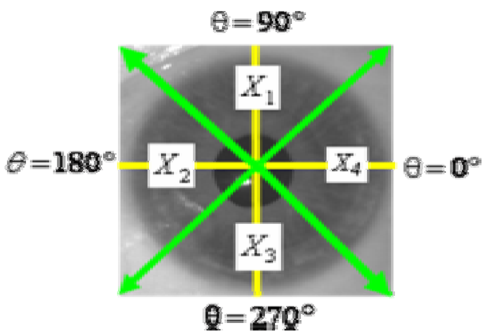
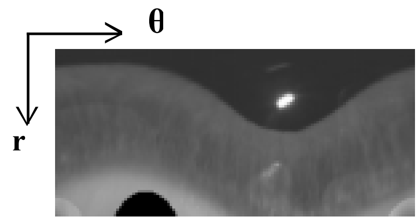
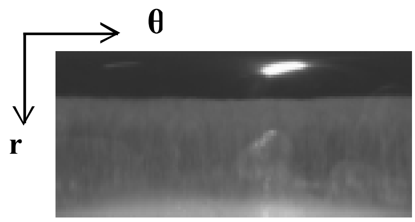


Figure 2 The region X*i*



(a) Transformed image with initial center point



(b) Correction of the center point

Figure 3 Calculation results of the center point

$$(x_0, y_0) = \left(\tfrac{1}{2}(X_1 + X_3), \tfrac{1}{2}(X_2 + X_4)\right) \qquad (4)$$

Figure 3(a) shows the $f(r,\theta)$ with arbitrary center point and Fig 3(b) shows the resulting image.

Deleting data that is inaccurate or unsure will cause fewer misidentifications. Even if the image is taken with highest precautions there are always noise caused by surroundings and light sources. Standard deviations are computed and used to discriminate areas that have a high possibility of being noise. An 8x8 window is applied by 4-pixel interval along the directions r and θ. Thus, one 4x4 area is overlapped four 8x8 areas. If all four 8x8 areas whose standard deviation are less than a half of the average, the 4x4 area is considered as noisy areas. Hence, we remove these regions for the further process.

3. FEATURE EXTRACTION

3.1 Adjusting the Average and Standard deviation

In order to attenuate the fluctuation of quality of iris images, it is necessary to uniform the contrast of iris images. Therefore a mean value and a standard deviation of the iris image $f(r,\theta)$ are adjusted to the specified values before feature is extracting. In this paper, $f(r,\theta)$ is an 8 bits image, therefore, the specified value of the mean and standard deviation are set to 128 and 20, respectively.

Let the mean and standard deviation of the original $f(r,\theta)$ be m and σ, respectively. Each point of the image is transformed as

$$\hat{f}(r,\theta) = \frac{20}{\sigma}\{f(r,\theta) - m\} + 128 \qquad (5)$$

By applying $f(r,\theta)$ to Eq.(5), the mean and standard deviation of $\hat{f}(r,\theta)$ become 128 and 20, respectively.

3.2 Morphological Skeleton

The skeleton of $\hat{f}(r,\theta)$ can be expressed in terms of *erosions* and *openings*. That is, it can be shown that

$$SK\{\hat{f}(r,\theta)\} = \sum_{n=0}^{N} S_n\{\hat{f}(r,\theta)\} \qquad (6)$$

with

$$S_n\{\hat{f}(r,\theta)\} = (\hat{f} \ominus ng) - (\hat{f} \ominus ng) \circ g \qquad (7)$$

where g is a structuring element, and $(\hat{f} \ominus ng)$ indicates n successive erosions of $\hat{f}(r,\theta)$:

$$(\hat{f} \ominus ng) = (\ldots((\hat{f} \ominus g) \ominus g) \ominus \ldots) \ominus g \qquad (8)$$

n times, and N is the last iterative step before $\hat{f}(r,\theta)$ erodes an empty set.

In this paper, we set structure element g as flat with 3x3 pixels, therefore, *erosion* is defined by

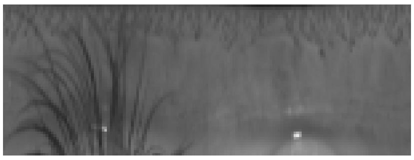
$$\hat{f} \ominus g = min\{\hat{f}(r+l, \theta+k) \,|\, -1 \le l, k \le 1\} \qquad (9)$$

The opening is given by

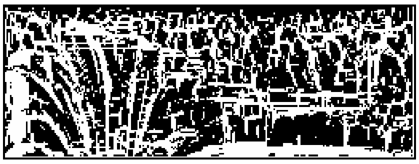
$$\hat{f} \circ g = (\hat{f} \ominus g) \oplus g) \qquad (10)$$

where

$$\hat{f} \oplus g = max\{\hat{f}(r+l, \theta+k) \,|\, -1 \le l, k \le 1\} \qquad (11)$$



(a) Original image $\hat{f}(r,\theta)$



(b) Iris code $I(r,\theta)$ (T=2)

(c) Iris code $I(r,\theta)$ (T=6)

Figure 4 Iris code

Finally, iris code $I(r,\theta)$ which is used for iris identification is defined as

$$I(r,\theta)=\begin{cases}1 \text{ if } SK\{\hat{f}(r,\theta)\}\geq T\\0 \text{ if } SK\{\hat{f}(r,\theta)\}<T\end{cases} \quad (12)$$

Figure 4 shows $\hat{f}(r,\theta)$ and the Iris code $I(r,\theta)$ with T=2 and 6. We can understand that the iris code can be expressed the feature of the iris image and it is important to set threshold parameter T adequately.

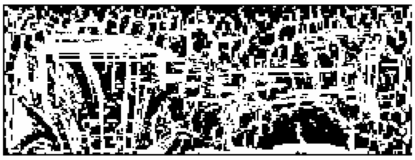
4. SIMULATION RESULTS

To create the experimental database, used for the simulations, ten samples of five persons' images were selected at random among fifty of images of both eyes. We make three resolutions (256x100, 128x50, and 64x25) of the iris code. We show a sample of the iris code (256x100, T=1) of each person in Figure 5.

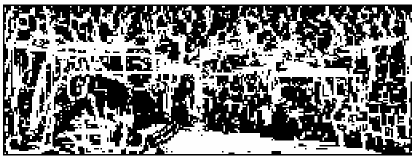
For matching, the Hamming distance (*HD*) was chosen as a metric for recognition. To prevent non-iris artefacts from influencing iris comparisons, AND operation is applied to the iris areas of two codes. *HD* is calculated using pixels in common area.

HD is similarity measure which is the fraction of bits that disagree between two codes. The performance of biometric identification scheme is characterized by the graph superimposing the two fundamental histograms of similarity that the test generates: one when comparing biometric measurements from the same, and the other when comparing measurements from different persons. Because this determines whether any two templates are deemed to be same or different, two fundamental distributions should ideally be well separated, as any overlap between them causes decision errors.

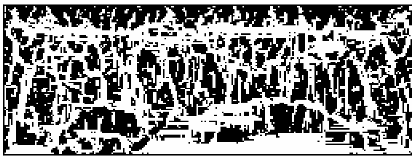
(a) Person #1



(b) Person #2



(c) Person #3



(d) Person #4

(e) Person #5

Figure 5 Iris code for each person

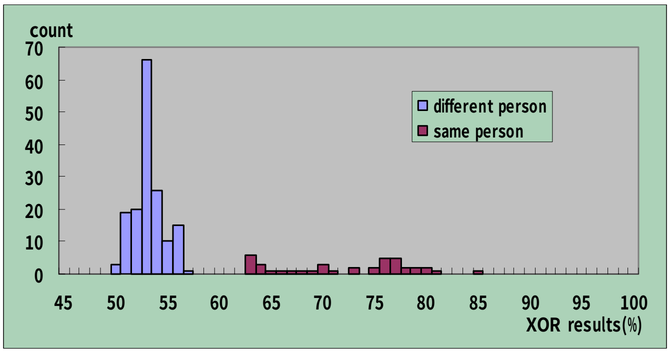
Table 1 Index value d for various cases

	256×100	128×50	64×25
T=1	3.61	3.76	3.51
2	3.34	3.95	4.06
3	2.95	3.70	5.07
4	2.36	3.15	4.45
5	1.96	2.55	3.77

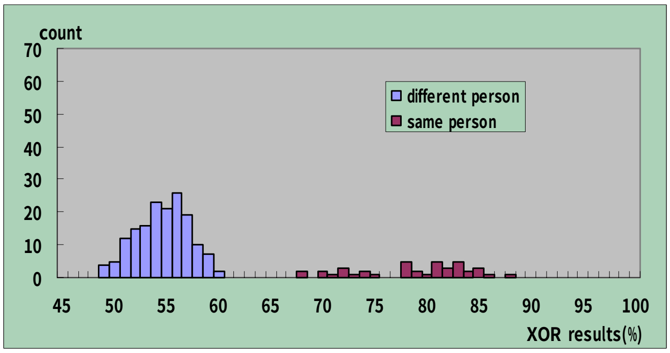
The index d which can measure how well separated the two distributions is defined in Ref. [8]. This is defined as the separation between the means of two distributions, divided by the square-root of their average variance:

$$d=\frac{|m_1-m_2|}{\sqrt{(\sigma_1^2+\sigma_2^2)/2}} \quad (13)$$

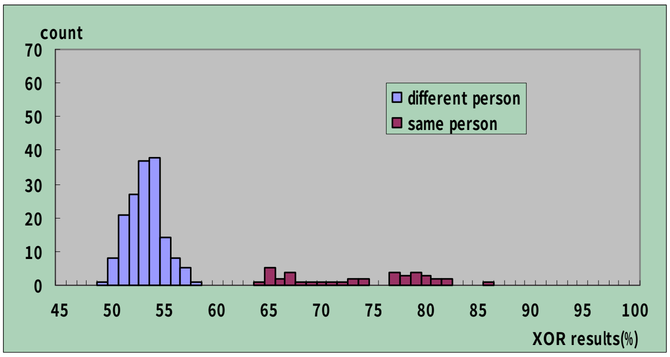
where m_i and σ_i^2 (i=1,2) represent the mean and variance of the distributions, respectively. We calculate the index d for various T in Eq.(12) and resolutions (i.e., 256x100, 128x50 and 64x25) and show them in Table 1. The value of percent was used to calculate.



(a) 256x100, *T*=1



(b) 128x50, *T*=2



(a) 64x25, *T*=3

Figure 6 % distribution of the Hamming distance

Figure 6 illustrates the distribution of the Hamming distance obtained from test group for each resolution. The two distributions on the graph show the results when different images of the same and different eyes are compared. Iris patterns belonging to same person can matched at an average about 75% for all resolutions. On the other hand, bit patterns extracted from different people matching with an average of only 52% for 256x100 and 64x25 resolutions and 55% for 128x50-resolution. Since the variance for same person is relative wide, the index *d* (Table 1) is relative small. However, two distributions are separated sufficiently. That is, persons can be clearly discriminated from others.

5. CONCLUSION

In this paper, we propose a new approach which use morphological skeleton to extract unique features from an iris image. The algorithm uses the pattern of space domain of image data. The morphological filters which are consisted maximum and minimum operations, thus, the computational complexity of our method is very low. Furthermore, it is well known that morphological filters have the ability of attenuation noise. Thus, the proposed method is low-sensitivity to noise.

Resulting iris code can be used to develop a system for rapid and automatic identification of person, with high reliability and confidence levels. Simulation results is very similar to Ref.[1],[8] which use Gabor filtering. It is also shown similar results to Ref.[6] which use scale-space filtering to extract feature from an iris image. The proposed approach provides one of the effective methods of iris pattern code extractions.

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