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Iris Recognition using Cumulative SUM based Change Analysis

Jong-Gook Ko , Yeon-Hee Gil and Jang-Hee Yoo
Electronics and Telecommunications Research Institute (ETRI)
161 Gajeong-dong, Yuseong-gu, Daejeon, 305-700, Korea
Tel: +82-42-860-5940, Fax: +82-42-860-5611
E-mail: [jgko, jhy, yhgil]@etri.re.kr.

Abstract*—Iris recognition has received increasing attention recently. Compared with other biometric features such as fingerprint and face, Iris patterns are more reliable and stable. Iris recognition includes iris imaging, iris segmentation and iris recognition and so on. This paper focus on the iris feature extraction in iris recognition system. And this paper proposes novel and efficient iris recognition method that employs cumulative SUM based grey change analysis. Experimental results show that proposed method can be used for human identification in efficient manner.

Keywords—*Biometrics, Iris recognition*

I. Introduction

Among biometric identification technologies, iris recognition has attracted lots of attention because of uniqueness and long term stability [1]. And iris patterns remain stable from 6 month of age to death [2]. Many works for iris recognition have been presented [3][4][5][6]. In phased based approach by Daugman[3], Iris feature extraction is a process of phase demodulation. Iris image is encoded into a compact sequence of multi-scale quadrature 2-D(two-dimensional) Gabor wavelet coefficients, whose most-significant bits comprise a 256-byte iris code. Boles[4] calculated a zero-crossing representation of 1-D(one-dimensional) wavelet transform to characterize the texture of the iris. It made use of two dissimilarity functions to compare the new pattern with the reference patterns. Bole's methods have the advantage of processing 1-D iris signals rather than 2-D image. In texture analysis approach, Lima et al. [5] adopted a multi-channel Gabor filtering to capture both global and local details in an iris image. A bank of circular symmetric filters was designed to capture the discriminating information along the angular direction of the iris image. Lim [6] decomposed an iris image into four levels using 2-D Haar wavelet transform and quantized the fourth-level high frequency information to form an 87-bit code. And a modified competitive learning neural network was used for classification. Additionally, ICA(Independent Component Analysis)[7], wavelet packets[8], SVM(Support Vector Machine)[9], and histogram analysis[10] for Iris patterns analysis are used.

In this paper, we propose a novel and relatively simple and efficient approach for iris recognition. This approach is based on iris feature extraction which uses cumulative SUM based change analysis. This method could improve computational efficiency and simplicity of iris recognition, since this iris feature extraction method just needs cumulative SUM calculation. The remainder of this paper is organized as follows. Section II describes iris recognition using cumulative SUM based change analysis which includes iris imaging, iris segmentation and image enhancement. In section III, experimental results are presented and conclusions are given in section IV.

II. Iris recognition using cumulative SUM based change analysis

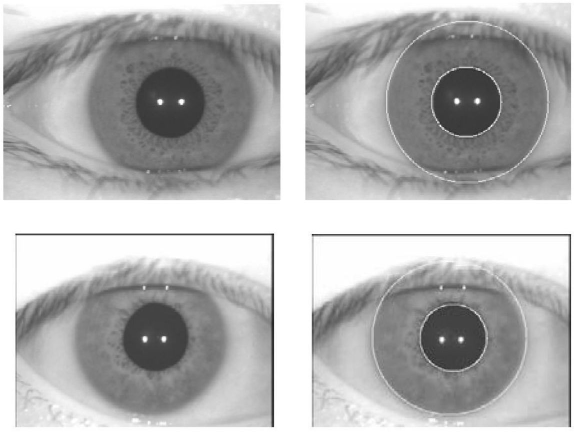
Iris recognition involves image acquisition, iris segmentation, iris image normalization and enhancement, iris features extraction and verification.

In iris image acquisition, an eye image of 320x240 size is obtained at a distance from a B/W CCD camera without any physical contact to the device. The eye is illuminated using near-infrared wavelengths and specular reflections are on the pupil area not to obscure iris regions. The eye image is shown in Fig. 1(a) and the iris diameter is above 170 pixels to provide good quality for iris recognition.

Iris region is isolated from eye image with the approximation that the shape of iris is circle. Like daugman method in equation (1), inner (pupil) boundary and outer (sclera) boundary of iris are located by using effective integrodifferential operator.

$$\max(x_0, y_0, r)\left| G_\sigma(r)\frac{\partial}{\partial r}\oint_{x_0,y_0,r}\frac{I(x,y)}{2\pi r}ds \right| \tag{1}$$

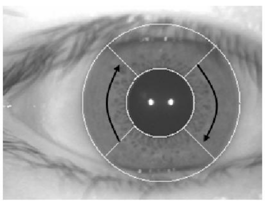
Where I(x,y) is original image and the complete operator behaves as a circular edge detector that searches over the candidate domain iteratively with respect to increasing radius r for maximum contour integral derivative. G_σ (r) is a smoothing function such as a Gaussian of scale σ. Before iris segmentation, image is downsized in order to increase the performance. And candidate regions for pupil center are obtained by using row/col profile methods that use information which pupil areas are darker than other areas. Fig.1(b) shows the results of iris segmentation.



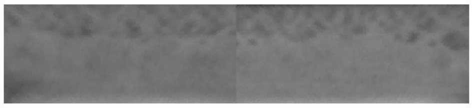
(a) (b)

Fig. 1. Iris segmentation. (a) Sample eye images. (b) Images after iris segmentation.

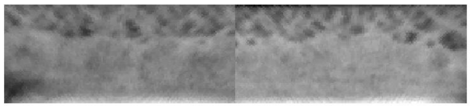
Iris image normalization and enhancement processing step is to normalize segmented iris image and enhance the normalized iris image. Irises from different people may be captured in different size. So, normalization of irises of different size to same size is need for achieving more accurate recognition. The result of iris normalization is shown in Fig. 2(b) and the size of normalized image is 64 x 300. Eyelash and eyelid rarely occlude iris region. That's why only iris image data in right side [45°~ 315°] and left side [135° ~ 225°] are transformed into polar coordinate system like Fig. 2(a).



(a)



(b)



(c)

Fig. 2. Iris image normalization and enhancement. (a) Iris regions to be transformed into polar coordinate system. (b) Normalized iris image. (c) Enhanced iris image.

It is necessary to improve the contrast of normalized iris image for iris feature extraction since it has low contrast like Fig. 2(b). Histogram stretching method is used to obtain well-distributed iris image and the result is shown in Fig. 2(c).

4. Iris feature extraction and verification

It is important to analyze the changes of grey values of iris patterns and extract features from iris image. Previous works used Gabor transform and wavelet transform and so on. In this paper, Cumulative sum based analysis method is used to extract features from iris images. Cumulative sums are calculated simply and do not need much processing burden.

A. Feature extraction using cumulative sums

Normalized iris image is used for features extraction. Overall feature extraction processing is as following:

Step1. Divide normalized iris image into basic cell regions for calculating cumulative sums. (One cell region is a m $\times$ n pixels size, and an average grey value is used as a representative value of a basic cell region to calculate the cumulative sum)

Step2. Basic cell regions are grouped in a horizontal direction and in a vertical direction as shown in Fig. 3. (Five basic regions are grouped into a group)

Step3. Calculate cumulative sums over the each group like equation (2).

Step4. Generate iris feature codes.

The cumulative sums are calculated as follows: Suppose that X1, X2, …, X5 mean five representative values of each cell regions within a group.

- First calculate the average $\bar{X}=\frac{X1+X2+...+X5}{5}$

- Calculate cumulative sum from 0: $S_0 = 0$
- Calculate the other cumulative sums by adding the difference between current value and the average to the previous sum,

$$i.e.,\ S_i = S_{i-1} + (X_i - \bar{X}) \text{ for } i = 1,2,\ldots, 5. \quad (2)$$

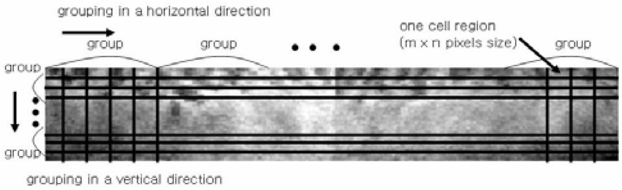


Fig. 3. Divide normalized iris image into cell regions and grouping of cell regions.

After calculation cumulative sums, iris codes are generated for each cells using following algorithm after obtaining MAX and MIN values among cumulative sums.

```
if Si located between MAX and MIN index
  if Si on upward slope
    set cell's iris_code to "1"
  if Si on downward slope
    set cell's iris_code to "2"
else
  set cell's iris_code to "0"
```

This algorithm generates iris codes by analyzing the changes of grey values of iris patterns. Upward slope of cumulative sums means that iris pattern may change from darkness to brightness. Downward slop of cumulative sums means the opposite change of upward slope.

B. Verification

In order to calculate the similarity of two iris codes, hamming distance method is used as equation (3) and the lower hamming distance means the higher similarity.

$$HD = \frac{1}{2N}\left[\left(\sum_{i=1}^{N} A_h(i) \oplus B_h(i)\right) + \left(\sum_{i=1}^{N} A_v(i) \oplus B_v(i)\right)\right] \quad (3)$$

Where $A_h(i)$ and $A_v(i)$ mean enrolled iris codes over the horizontal and vertical direction. And $B_h(i)$ and $B_v(i)$ mean new input iris codes over the horizontal and vertical direction. And N is total number of cell and $\oplus$ means the XOR operator defined as equation (4).

$$x \oplus y = \begin{cases} 0 & x = y \\ 1 & x \neq y \end{cases} \quad (4)$$

III. Experimental results

Eye images for the experiment were acquired through a B/W CCD camera with two LED lamps around the lens. The size of image is 320 × 240 with 8bit grey value. Experimental data are composed of 820 images acquired from 82 individuals and 10 eye images per person (left eye and right eye).

The performance evaluation of proposed method was measured by the two error rates such as FRR and FAR. The false acceptance rate (FAR) was computed as equation (5) and the false rejection rate was computed as equation (6).

$$FAR(\%) = \frac{\#\text{ of false acceptances}}{\#\text{ of total imposter attempts}} \quad (5)$$

$$FRR(\%) = \frac{\#\text{ of false rejections}}{\#\text{ of total authentic attempts}} \quad (6)$$

Figure 4. shows hamming distance distribution for the same persons. Hamming distance values are located between 0 and 30. Figure 5. shows hamming distance distribution for the different persons. Hamming distance values for the imposters are distributed from 25 to 52. x-axis and y-axis indicate the number of data and hamming distance respectively. Figure 6 shows the FAR/FRR curves according to the hamming distance. False rejection rate is decreased when the hamming distance value is increased and false acceptance rate is decreased when the hamming distance value is decreased respectively. So, two error curves have intersection point. By selecting the cross point of two error curves as a threshold, two error rates minimized at the same time can be found. By experimental results, the recognition performance of proposed method is 99.0% to 99.2% when the threshold is 26. The experimental results show that the proposed method is a promising and effective approach in iris recognition.

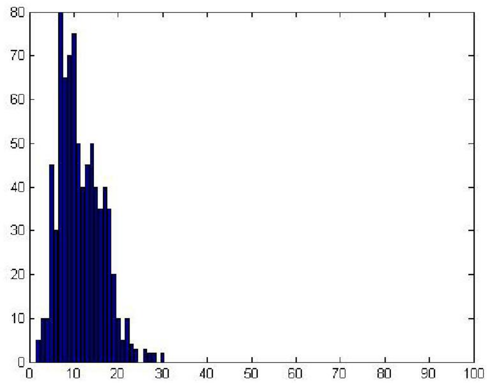


Fig. 4. Hamming distance for the same persons (Authentic)

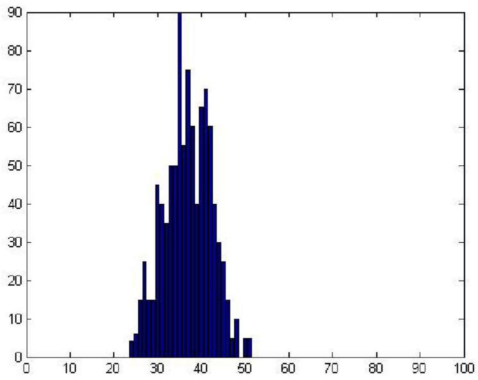


Fig. 5. Hamming distance for the different persons (Imposter)

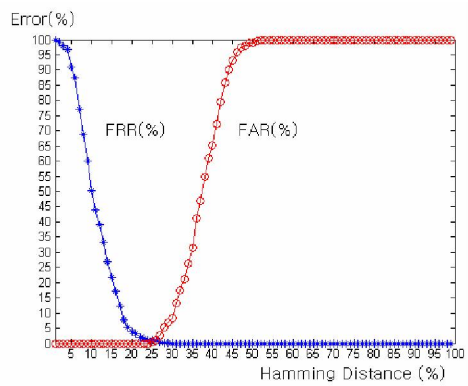


Fig. 6. FAR/FRR curves according to hamming distance

IV. Conclusion

In this paper, a novel iris recognition method was proposed. This method employed iris feature extraction that uses cumulative sum based change analysis. In order to extract iris features, normalized iris image is divided into basic cells. And iris codes of these cells are generated by proposed code generation algorithm which uses cumulative sums of each cell. Proposed iris recognition method is relatively simple and efficient against existing methods. And the experimental result show that the proposed approach has a good recognition performance. In future work, it is necessary to do experiments on many more iris image data in various environments for iris recognition system to be more reliable.

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