ISTANBUL UNIVERSITY –
JOURNAL OF ELECTRICAL & ELECTRONICS ENGINEERING

YEAR : 2006 (13 - 17)
VOLUME : 6
NUMBER : 1

TEXTURE ANALYSIS BASED IRIS RECOGNITION

Güray GÜRKAN [1] **Aydın AKAN[2]**

[1,2]Istanbul University, School of Engineering, Department of Electrical and Electronics Engineering, 34320, Avcılar, İstanbul,TURKEY

[1]E-mail: guray_gurkan@yahoo.co.uk [2]E-mail: akan@istanbul.edu.tr

ABSTRACT

In this paper, we present a new method for personal identification, based on iris patterns. The method composed of iris image acquisition, image preprocessing, feature extraction and finally decision stages. Normalized iris images are vertically log-sampled and filtered by circular symmetric Gabor filters. The output of filters are windowed and mean absolute deviation of pixels in the window are calculated as the feature vectors. The proposed method has the desired properties of an iris recognition system such as scale and rotation invariance. The system is realized in Windows platform using Delphi compiler.

Keywords: *Biometrics, Iris Recognition, Gabor Filters, Average Absolute Deviation, Log-Sampling.*

1. INTRODUCTION

In recent years, biometric personal identification become the most popular security demand with increasing network societies. Biometric measures are the physiological and behavioral that is unique to an individual, which have the ability the distinguish between an authorized person and an imposter. There are many biometric features such as [1,2,3]; facial features and thermal emissions, retina, iris, gait, voiceprint, gesture, finger-prints, palm-prints, face geometry and etc. The recent studies are motivated on fingerprint, speaker and face recognition and by being the most reliable one, iris recognition is a more recent method.

The methods for feature extraction in iris recognition can be divided into three major categories [10], the phase-based method, zero-crossing representation based method and the texture analysis based method. Daugmann used multi-scale quadrature wavelets to extract texture phase information of the iris to generate a 2048 bits of Iriscode® and determined the matching using the Hamming distances calculated using XOR operator [4]. Boles and Boashash [5] calculated zero-crossing representation of 1-D wavelet transform at various resolution levels of a virtual circle on an iris image to characterize the texture of the iris. Iris matching was based on two dissimilarity functions. Wildes et al. [6] represented the iris texture with a Laplacian pyramid constructed with four different resolution levels and used the normalized correlation in order to determine whether the input image and the model image are from the

[2] *This work was supported by The Research Fund of The University of Istanbul, Project numbers:*UDP-414/25012005, BYP-324/18122003 and T- 609/17032005

Received Date : 13.07.2005
Accepted Date: 13.12.2005

same class. T.Tan [7,8,9,10] , proposed many texture analysis based methods , in which Even (Real) and Circular Symmetric Gabor Filters are used, and iris features are represented by using global and local texture information. This paper also proposes a new texture analysis based iris recognition by using Circular Symmetric Gabor Filters.

Human iris has a rich pattern which is unique every individual and more stable than any biometric feauture [1, 4].

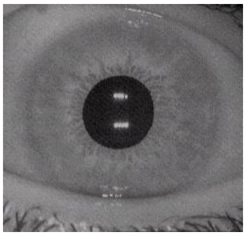


Figure 1. Iris Image Acquired From Our Device

2. PROPOSED METHOD

Designed system is generally composed of image acquisition, image preprocessing, feature extraction and decision (or enrollment) stages. First simulations are realized in MATLAB platform and to be used in further tests and fasten the processes, a Microsoft Windows executable is written using Delphi compiler. To ensure high reliability, CASIA Iris Image Database [11] samples are used. Each of these will be described in detail.

2.1. Image Acquisition

In our previous work [12], we first designed an iris image acquisition device, that uses near-infrared light for illumination and a CCD sensor for high-quality capture. The reason for infrared illumination is that dark pigmented iris reveals its rich texture detail comfortably under infrared. Each captured grayscale-frame has 8 bits per pixel and 320 to 240 pixels of resolution.

2.2. Image Preprocessing

The acquired image involves not only the iris itself but some unused parts (i.e. eyelids, eyelashes) as well. So iris must be purely extracted from captured images. Unfortunately, irises do not have a fixed size, any iris even from the same person can have a different size of radius and pupil radius. Besides, as the illumination is not purely homogenous over iris texture, the effect of this non-homogenity must be eliminated. For mentioned reasons, the next processes are achieved.

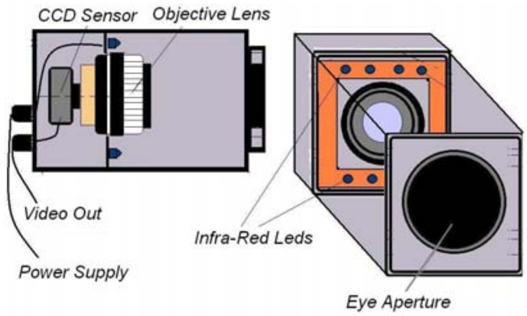


Figure 2. Iris Image Acquired From Our Device

2.2.1. Boundary Localization

The boundary localization stage includes the inner (pupil-iris) and outer (iris-sclera) boundary detections. In our previous work [12], we applied Sobel edge detection for inner boundary localization. In this work, we developed a new method that searches for the minimum point of iris images, which is always located somewhere in pupil area. After detection of minimum point and its amplitude V_{min}, the algorithm masks a region that has the values within this amplitude and a threshold ('$V_{min} + 30$' in our experiments). The origin of pupil -also the iris- is determined from vertical and horizontal projections. As a last step for inner boundary localization, the radius of pupil is exactly calculated from the mask area A_M , using inverse formula:

$$r = \sqrt{\frac{A_M}{\pi}} \quad \textbf{(1)}$$

For detection of outer boundary, a modified version of our previous method [12] is used. The pixels, located on a 45 degree arc that has an increasing radius from pupil to a predefined margin, to the left of each eye (for left eyed images) are involved for outer boundary detection. For each radius value r, the total number of pixels greater than a threshold value is calculated. The radius that has the maximum value yielded from the differentiation of this sequence is considered as the outer boundary radius r_o.

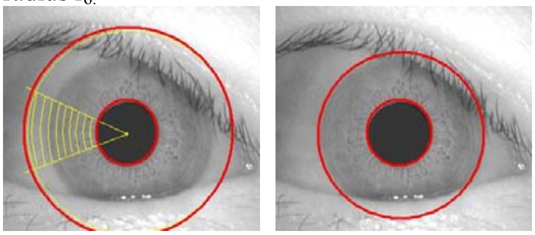


Figure 3. Arc Histogram Method Illustration for Outer Boundary Detection.

2.2.2. Iris Normalization

After localization of boundaries, iris normalization is required. As mentioned before, iris sizes can differ from person to person, even for the same person, the pupil size change time by time (different lighting and physiological conditions etc.). To this act, we applied polar to rectangular mapping as done in [8]. Iris ring is mapped to a fixed size - 64x512- rectangular frame in counter-clockwise direction. In this new frame, vertical axis represents increasing radius values, horizontal axis represents the whole 360 degree rotation.

2.2.3. Image Enhancement

The image enhancement is achieved by means of background-illumination estimation and local histogram equlization. The mean values, collected from 16x16 blocks, are resized to original image size (64x512), using linear interpolation. The estimation is substracted from original image which now has more homogeneus illumination. As a last step to image enhancement, the local histogram equalization is applied.

2.2.4. Vertical Log-Sampling

As we introduced in our previous work [12], the enhanced image is not directly used for feature extraction. In order to suppress errors due to eyelids, the enhanced image is resampled in a vertical logarithmic manner. The reason for vertical sampling is that local details of iris texture spread along the radial direction corresponding to vertical direction in enhanced image, so detail loss will be minimum in vertical sampling. The result of preprocessing can be seen in Figure 4.

3. FEATURE EXTRACTION

Feature extraction includes two main stages. In the first stage, log-sampled images are filtered by four channel circular symmetric Gabor filters. In the second stage, output of each filter is windowed by a sliding window and average absolute deviation of pixels within each window

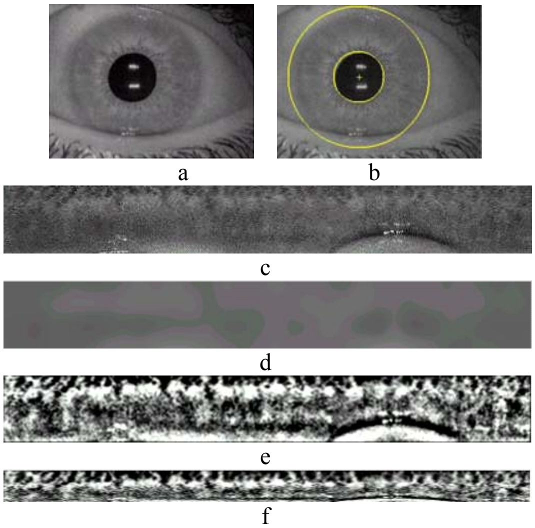


Figure 4. Image Preprocessing: (a) Original Image, (b) Boundary Localization, (c) Remapping, (d) Estimated Background, (e) Enhanced new image, (f) Vertical log-sampled image.

is calculated. The block diagram of feature extraction process can be seen in figure below. Operations will now be described in detail.

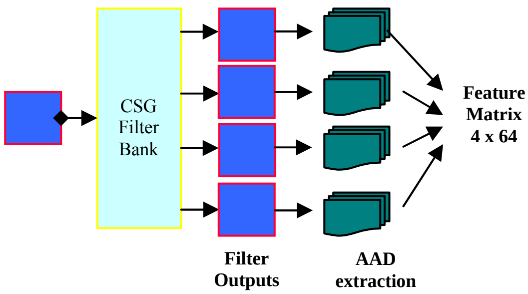


Figure 5. Feature Extraction Block Diagram

3.1. Circular Symmetric Gabor Filters

In recent years, Gabor Filters have been widely used in texture analysis. Being different from ordinary Gabor filters that have orientation and frequency selectivity, Circular Symmetric Gabor Filters have only frequency selectivity [9]. They are defined as:

$$G(x,y,f)=\frac{1}{2\pi\sigma_x\sigma_y}\exp\{-\frac{1}{2}(\frac{x^2}{\sigma_x^2}+\frac{y^2}{\sigma_y^2})\}M(x,y,f) \qquad (2)$$

$$\text{where } M(x,y,f)=\cos(2\pi f(\sqrt{x^2+y^2}))$$

In proposed method, four channeled CSG filter bank is used. Filter center frequencies are 0.1π, 0.2π, 0.4π and 0.8π., with space constants;

$$\sigma_x=\sigma_y=\frac{3\sqrt{2\ln(2)}}{\omega_m}, \qquad (3)$$

$$w_m \text{ center freq.}$$

Frequency domain responses of channels can be seen in figure below.

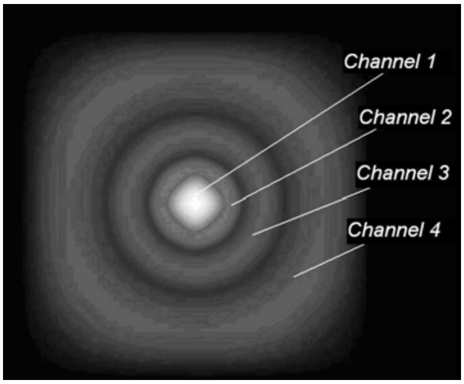


Figure 6 – Filter Frequency Responses

3.2. Feature Matrix Composition

Filter outputs, which have the size of 30 x 512 are separately used for construction of feature matrix. 30 x 64 sized sliding window is used to collect Average Absolute Deviation values in each window [8], which is defined as:

$$F_{i,j}=\frac{1}{N}\sum_x\sum_y\left|I_{i,j}(x,y)-m_{i,j}\right| \qquad (4)$$

where $I_i(x,y)$ is the i[th] windowed image matrix from j[th] filter output, m_i is the mean of this window, N is the total number of pixels within that window. Resulting feature matrix has the form,

$$M_X=\begin{bmatrix} F_{1,1} & F_{1,2} & .. & F_{1,64} \\ F_{2,1} & F_{2,2} & .. & F_{2,64} \\ F_{3,1} & .. & .. & F_{3,64} \\ F_{4,1} & F_{4,2} & .. & F_{4,64} \end{bmatrix} \qquad (5)$$

4. ENROLLMENT AND MATCHING

In enrollment stage, constructed feature matrices are used to construct database that will be reference to each enrolled individual. Database construction requires only one image per individual as our algorithm does not have any training stage. For an unknown iris that belongs to an enrolled individual, its feature matrix is extracted, and its Euclidian distances between database matrices are calculated. To ensure rotation invariance, calculations are done between circular shifted versions {-16 , -8, 0, +8, +16 pixels} of unknown matrix and minimum of these scores are taken as the net score.

5. SIMULATION RESULTS

For simulations, 60 images from 30 subjects are used. One of the image pairs is used for database enrollment, the other one is used for verification. As mentioned before, our algorithm does not include any training step. Under these conditions, our algorithm has a success rate of 28/30 (% 93.3). The studies showed that the net scores yield from a intensively-texturized iris verification is less sensitive to eyelash-pupil occlusion than a more smoothly-texturized iris.

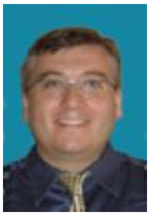
6. CONCLUSION

In this work, we present a new texture analysis based method for iris recognition. The contributions of our work are mainly in preprocessing of iris images and in the feature extraction stages. Our future work will concentrate on eyelash elimination and integration of a "Training" stage to current algorithm.

REFERENCES

[1] A.K. Jain, R.M. Bolle, and S. Pankanti, Eds., "Biometrics:Personal Identification in a networked Society", Norwell, MA:Kluwer, 1999.
[2] D. Zhang, "Biometrics Technologies and Applications",Proc. of International Conference on Image and Graphics,42-49, China, August 2000.
[3] G. Lawton, "Biometrics: A New Era in Security", IEEE Computer, pp.16-18, Aug. 1998.
[4] J.G. Daugman, "High Confidence Visual Recognition of Persons by a Test of Statistical Independence", IEEE Tans. Pattern Analysis and Machine Intelligence, vol.15, pp.1148-1161, Nov. 1993.
[5] W.Boles and B.Boashash, "A Human Identification Technique Using Images of the Iris and Wavelet Transform", IEEE Trans. on Signal Processing, Vol 46, No.4, 1185-1188, 1998.
[6] R. Wildes et al. "A Machine-vision System for Iris Recognition System," Machine Vision and Applications, Vol. 9, 1-8, 1996.
[7] Jainguo Zhang, Tieniu Tan, Li Ma, "Invariant Texture Segmentation Via Circular Gabor Filters", ICPR-2002, 901-904.
[8] L. Ma, Y. Wang, T. Tan, "Iris Recognition Based on Multichannel Gabor Filtering", Proc. of ACCV-2002, Vol. I, 279-283, 2002.
[9] L. Ma, Y. Wang, T. Tan, "Iris Recognition Using Circular Symmetric Filters", Proc. of the 16th International Conference on Pattern Recognition, Vol. II, 414-417, 2002.
[10] Li Ma, Tieniu Tan, Yunhong Wang, Dexin Zhang, "Local Intensity Variation Analysis for Iris Recognition", Pattern Recognition, 37 (6): 1287-1298 (2004).
[11] CASIA Iris Database: http://www.sinobiometrics.com
[12] G. Gürkan, A. Akan, "A New Iris Recognition Method Based On Texture Analysis", 13th IEEE Sinyal Işleme ve Iletişim Uygulamalari Kurultayi, SIU-2005, Kayseri, Turkey, 16-18 May 2005.

Güray GÜRKAN was born in Trabzon, Turkey in 1982. He received the B.Sc. degree in 2003 from Istanbul University, Istanbul, Turkey. He is currently an M.Sc. student at the same university. His research interests are digital signal and image processing and applications.



Aydın AKAN was born in Bursa, Turkey in 1967. He received the B.Sc. degree in 1988 from the University of Uludag, Bursa, Turkey in 1988, the M.Sc. degree from the Technical University of Istanbul, Istanbul, Turkey in 1991, and the Ph.D. degree from the University of Pittsburgh, Pittsburgh, PA, USA, in 1996 all in electrical engineering. He has been with the Department of Electrical and Electronics Engineering, University of Istanbul since 1996 where he currently holds an Associate Professor position. His current research interests are digital signal processing, statistical signal processing, time-frequency analysis methods and applications of time-frequency methods to communications and bioengineering. Dr. Akan is a member of the IEEE Signal Processing Society since 1994.