EFFECTIVENESS OF FEATURE DETECTION OPERATORS ON THE PERFORMANCE OF IRIS BIOMETRIC RECOGNITION SYSTEM

Binsu C. Kovoor[1], Supriya M.H.[2] and K. Poulose Jacob[3]

[1,3]Department of Computer Science, Cochin University of Science and Technology, Cochin, Kerala, India
[2]Department of Electronics, Cochin University of Science and Technology, Cochin, Kerala, India

ABSTRACT

Iris Recognition is a highly efficient biometric identification system with great possibilities for future in the security systems area.Its robustness and unobtrusiveness, as opposed tomost of the currently deployed systems, make it a good candidate to replace most of thesecurity systems around. By making use of the distinctiveness of iris patterns, iris recognition systems obtain a unique mapping for each person. Identification of this person is possible by applying appropriate matching algorithm.In this paper, Daugman's Rubber Sheet model is employed for irisnormalization and unwrapping, descriptive statistical analysis of different feature detection operators is performed, features extracted is encoded using Haar wavelets and for classification hammingdistance as a matching algorithm is used. The system was tested on the UBIRIS database. The edge detection algorithm, Canny, is found to be the best one to extract most of the iris texture. The success rate of feature detection using canny is 81%, False Accept Rate is 9% and False Reject Rate is 10%.

KEYWORDS

Iris, Canny, Daugman, Prewitt, Zero Cross, Sobel

1. INTRODUCTION

The contemporary advances of information technology and the growing requirements for security in an interlinked society, has created a huge demand for intelligent personal identification system. In addition to this, as people become more connected electronically, the capability to accomplish an exceedingly precise automatic personal identification system is considerably more critical. For identification and verification ofindividuals, to controlaccess to the secured areas or materials, technologies that exploit biometrics have great potential. Biometric identification refers to the identification of humans by their distinctive measurable physiological or behavioral characteristics [1]. Since many of these are unique to an individual, biometric identifiers are fundamentally more dependable and it relates a person with an earlier recorded identities based on how one is or what one does.

An ideal biometric should possess four characteristic, namely, universality, uniqueness, permanent and collectability. Universality means each person should possess the characteristic; uniqueness means no two persons should share the characteristic;*permanent*is that the characteristic neither should change nor be alterable and *collectable*meansthe characteristic is readily presentable to a sensorand is easily quantifiable.Facial imaging, hand and finger geometry, eye-based methods,signature, voice, vein geometry, keystroke, and finger- and palm-print imaging etc. are some of the currently pursued biometric traits in security system.

Iris can be used as an optical biometric trait for identifying a personsince it has a highly detailed pattern that is unique and permanent [2][3][4]. Arching ligaments, furrows, ridges, crypts, rings, corona, freckles and zigzag collarette[2] are the various unique features of the iris. These features provide extraordinary textural patterns that are distinctive to each eye of an individual and are even distinct between the two eyes of the same individual[4].

The image of eye comprises of iris, pupil, sclera, eyelid and eyelashes. The detection of the iris from the eye image can be performed by segmenting the annular portion between the pupil and sclera.Iris recognition techniques identify a person by mathematically analyzing the unique patterns of iris and making comparisons with an already existing knowledge base. The overall performance of iris recognition system is decided by the accuracy of conversion of iris features into iris code. The UBIRIS database is used to implement and test the model for the iris recognition system. [5]

2. METHODOLOGY

The unique iris pattern from a digitised image of the eye is extracted and encoded into a biometric template using the image processing techniques. This can later be stored in the knowledge base. The unique information in the iris is represented as objective mathematical representation. This is checked against templates for resemblances. When a person wishes to be authorised by an iris recognition system, their eye has to be first photographed, and a template is created for their iris region. The template is compared with the other templates in the knowledgebase. The comparison can be made till a matching template is found and the person is recognized, or no match is found and the person is overruled.

There are five main steps for the iris recognition process. The first step is the enrolment, where the eye image is captured. The next step is the segmentation of the iris from the other parts of the eye image. Normalization is the third step, in which the iris pattern is scaled to a constant size. Iris is represented as iris code in the fourth step. The classification phase is the final step, where a matching technique is used to find out the similarity between the two iris code.Figure1 depicts the schematic for an Iris recognition system.

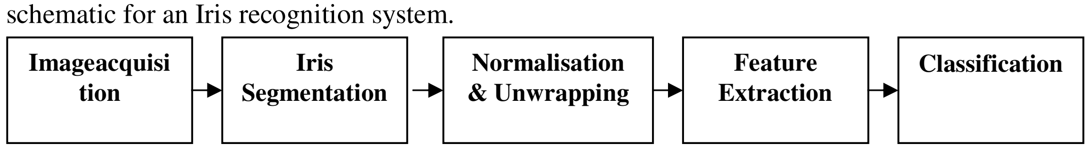

Figure 1. Schematic of Iris Recognition system

2.1. Iris Segmentation

The upper and lower parts of the iris region are obstructed by the eyelids and eyelashes. Iris pattern can also get corrupted by the specular reflections within the iris region.The artefacts are separated and the circular iris region is detected.The quality of eye imageswill greatly influence the success of segmentation.Thus a good segmentation algorithm involves two procedures, iris localization as well as noise reduction. For finding the boundary between the pupil and iris, as well as the boundary between the iris and the sclera of the acquired image, iris localization process is used.In the localization process, the noises (non-iris parts) are removed from the acquired image and this process is referred as noise reduction. Pupil, sclera, eyelids, eyelashes,and artefacts are the noises in the acquired image [6]. The flow diagram of the iris segmentation is as depicted in Figure 2.

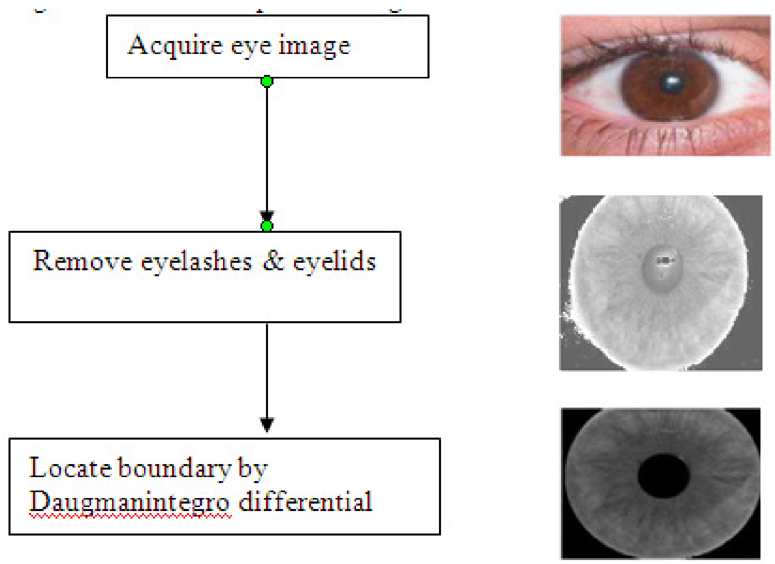

Figure 2. Steps of Iris segmentation

The centre pixel is determined for the image obtained from the noise reduction process. A circular strip of the iris image is obtained based on the centre co-ordinates of the pupil. For detecting the inner and outer boundary ($B_{in\ or\ out}$) of the iris, Integro-Differential operator [4] was used. The integro-differential operator is shown in equation (1).

$$B_{in\ or\ out} = max_{(r,x_o,y_0)} \left| G_\sigma(r) \times \frac{\partial}{\partial r} \oint_{r,x_o,y_0} \frac{I(x,y)}{2\pi r} ds \right| \quad (1)$$

In the above equation, the eye image is denoted by $I(x,y)$, the radius to search for by 'r', Gaussian smoothing function by $G_\sigma(r)$ and s is the contour of the circle given by r,x_0,y_0. By changing the radius and centre*x* and *y* position of the circular contour, the operator explores for the circular path to identify the maximum change in the pixel value. In order to accomplish precise localization, the operator is applied iteratively.

2.2. Iris Normalization and Unwrapping

After segmenting the iris region from an eye image, it is transformed to fixed dimensions so that comparisons can be easily made. Transforming iris into polar coordinates is known as *unwrapping* process. Iris region will be mapped into a constant dimension by the normalization process, and thus two photographs of the same iris under different conditions will have same characteristics features. Figure 3 illustrates a normalised iris image.

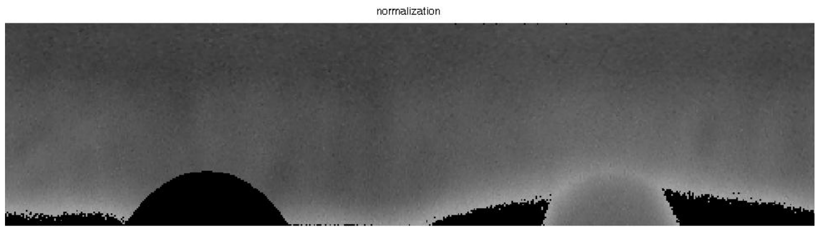

Figure 3. Normalized iris image

2.3. Feature Extraction

In the process of feature extraction, the most distinguishing information present in an iris pattern is extracted. The substantial features of the iris are encoded so that evaluation between templates can be done. This helpsin the precise identification of the individual.

Initially, histogram equalization is carried out to enrich the iris texture in the normalized image.The canny edge detector [7] is used to extract the iris texture from the normalized image. For reducing the dimension, the 2D image of the edge is detected and transformed into a 1D energy signal by the use of vertical projection. A set of low frequency and high frequency coefficients are obtained by applying discrete wavelet transform to these 1D energy signals. The low frequency coefficients, which have a dimension of 64 bytes, can be considered as the iris templates. The high frequency coefficients do not comprise of any significant information and hence can be omitted. Figure 4 depicts the different steps associated with the feature extraction stage.

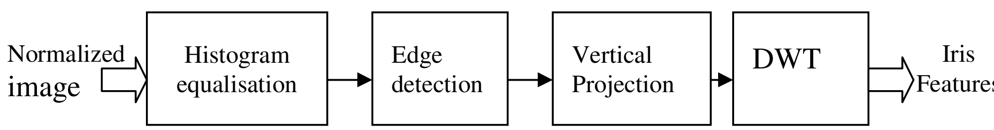

Figure 4. Feature Extraction Stages

2.3.1. Histogram Equalization

Through histogram equalisation the local contrast of many images can be significantly improved and the intensities can be better distributed on the histogram. This allows for areas of lower local contrast to gain a higher contrast without affecting the global contrast and is accomplished by effectively spreading out the most frequent intensity values. Figure 5 shows the image attained after histogram equalization. The occlusion of the eyelid is represented as domes in the unwrapped image.

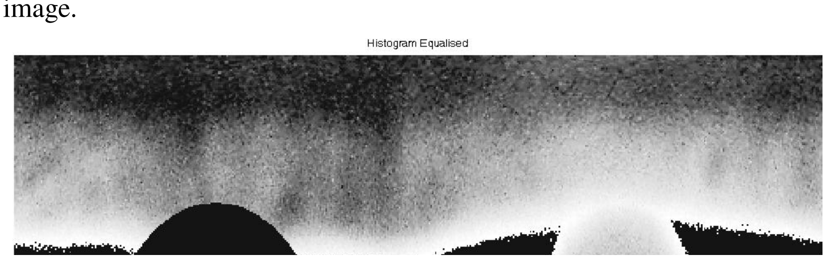

Figure 5. Histogram Equalised Image

2.3.2. Edge Detection

Edge Detection is performed using the classical operators which are classified into three main categories vis a visGradient, Laplacian Based and Canny. The Gradient- based operator include Roberts[8], Sobel[9] and Prewitt[9] edge detection operators while the Laplacian-based include LOG[9] and Zero Cross edge[9] detection operator and the Canny edge detector [9][10]. Iris texture in the normalized image will be improved by histogram equalization process. By the use of these edge detection operators, the iris texture is extracted and comparative study is carried out. It is found that canny edge detection technique is able to obtain most of the iris texture from the enhanced image.

2.3.3. Vertical Projection

Vertical projection reduces the system complexity by converting the 2D signal to 1D signal. For vertical projection, energy of each row of the edge detected image is calculated and is converted into a row vector. The generalized equation is shown in equation (2).The dimension of normalized image is $m \times n$and is taken as128×512. Hence, after vertical projection its dimension is m, which is equal to 128.

$$\begin{bmatrix} x_{11} & \cdots & x_{1n} \\ \vdots & \ddots & \vdots \\ x_{m1} & \cdots & x_{mn} \end{bmatrix} \rightarrow \left[\sum_{i=1}^{n} |x_{1i}|^2 \quad \cdots \quad \sum_{i=1}^{n} |x_{mi}|^2 \right] \tag{2}$$

2.3.4. Discrete Wavelet Transform

The discrete wavelet transform (DWT) divides the signal into mutually orthogonal set of wavelets [11]. The signal x is passed through a series of filters and DWT is calculated. Initially a low pass filter with impulse response g[n] is used to pass the samples, which results in to a convolution and is given in equation (3).

$$Y[n] = (x * g)[n] = \sum_{k=-\infty}^{\infty} x[k]\, g[n-k] \tag{3}$$

A high pass filter h[n] is also used simultaneously to pass the signal. The outputs from the high pass filter give the detail coefficientsand low pass filters give the approximation coefficients. Thedimensions of the coefficients are 64 bytes each, since the dimension of 1D signal is 128 bytes. These two filters are referred as quadrature mirror filter. Here Haar wavelet [12] is used for wavelet transform. After wavelet transform, a set of low frequency coefficients and high frequency coefficients each of dimension 64 bytes is obtained. After DWT, it is observed that approximation coefficients contain information and detailed coefficients do not have any information. Hence approximation coefficients with dimensions 64 bytes is selected as feature vector and stored in database.

2.4. Classification

In recognition stage the features of the input eye image is compared with that of the features that is already stored in the database and if it matches, the corresponding eye image is identified otherwise it remains unidentified. Since a bitwise comparison is necessary Hamming distance was chosen for identification

2.4.1. Hamming Distance

The Hamming distance [13] gives a measure ofdifference between two bit patterns$x_k$andy_k. In the classification stage, the comparison of iris code is done by hamming distance approach. Hamming distance D is given by equation (4).

$$D = \frac{1}{n}\sum_{k=1}^{n} x_k \oplus y_k \quad (4)$$

where, x and y are the two bit patterns of the iris code. n indicates number of bits. Hamming distance D gives out the number of disagreeing bits between x and y.

Ideally, the hamming distance between two iris codes generated for the same iris pattern should be zero; however this will not happen in practice due to fact that normalization is not perfect. The larger the hamming distances (closer to 1), the more thetwo patterns are different and closer this distance to zero, the more probable the two patterns are identical. By properly choosing the threshold upon which we make the matching decision, one can get good iris recognition results with very low error probability.

3. Results and Discussions

The system was tested using the UBIRIS database [5] which included 1877 images from 241 persons collected in two sessions. The images collected in the first photography session were low noise images. On the other hand, images collected in the second session were captured under natural luminosity factor, thus allowing reflections, different contrast levels, and luminosity and focus problems thus making it a good model for realistic situations.

Fifty sets of eye images from UBIRIS database was taken for identification. Each set consists of three eye images of a person taken at different time. From each set a single eye image was randomly selected and its features were stored in the database. Therefore a total of 50 images were used for simulation. These images are called registered images since its feature is stored in the knowledge base. The main challenge in the identification is to identify the other two images in each set whose features are not stored. 50 images whose features are not stored in the database are also used to test the algorithm. These images are called as unregistered images. An efficient algorithm should identify all registered images and reject all unregistered images. Performance of iris acceptance algorithm is validated using four parameters -False Reject (FR), False Accept(FA), Correct Reject(CR) and Correct Accept(CA). FR is obviously the case where we judge a pattern as not the target one while it is. FA is when the pattern is considered as the target one while it is not. CR is when the pattern is correctly judged as being not the target one. Finally, CA is when the pattern is correctly considered to be the targeted one. These outcomes are illustrated in Figure 6. It was found that an optimum result is obtained at hamming distance threshold of 0.4. If hamming distance, between the iris code in the knowledgebase and the testing iris code, is less than the threshold then the person is authentic and accepted otherwise rejected as imposters.

Using MATLAB, a comparison study between different classical operators, Canny, Sobel, Prewitt, Roberts, log and zero cross was also done. The operators were applied to the enhanced normalized image. The results, presented in Figure 7, show the performance of each of the operators. It was found that the Canny operator outperforms the others; in fact it was the only operator which was able to extract most of the iris texture.The success, false acceptance and false rejection of the Iris recognition are recorded for various edge detection operators -Prewitt, Robert, Sobel, Zero Cross, Log and Canny system. The statistical details of the success ratio (SR), false acceptance ratio (FAR) and false rejection ratio (FRR) of Prewitt, Robert, Sobel, Zero Cross, Log and Canny edge detection operators are given in Table1. The mean value success ratio of Canny is greater than the other operators. Similarly the success ratio of Zero Cross and Log operators are greater than Prewitt, Robert and Sobel. The mean value of false acceptance ratio and false rejection ratio of Canny is less than other operators. The performance of an operator is said to be acceptable when the magnitude of SR is high and magnitude of FAR or FRR is low. In this study, it is found thatCanny edge detection technique is the most efficient to capture the iris texturewhen compared to the other operators.

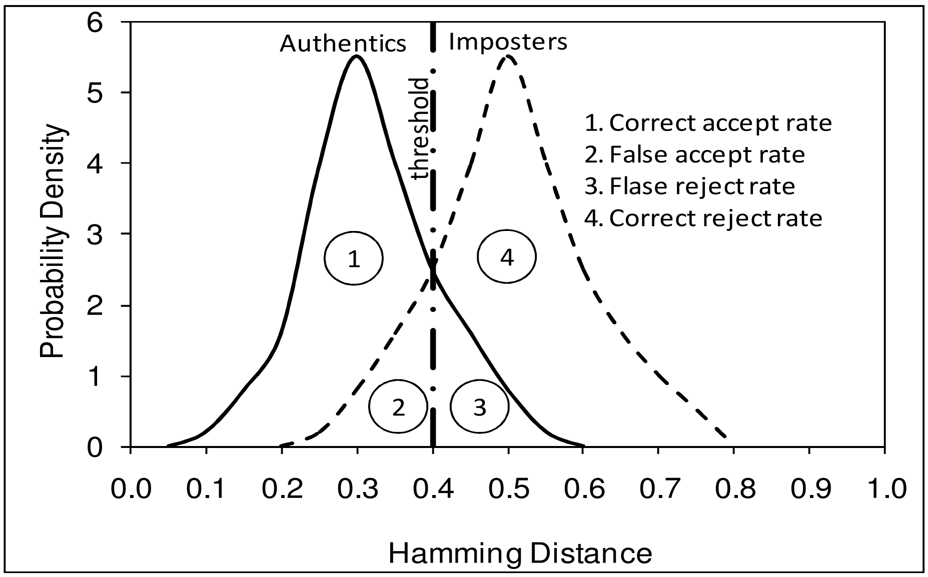

Figure 6.Decision making in iris biometric system

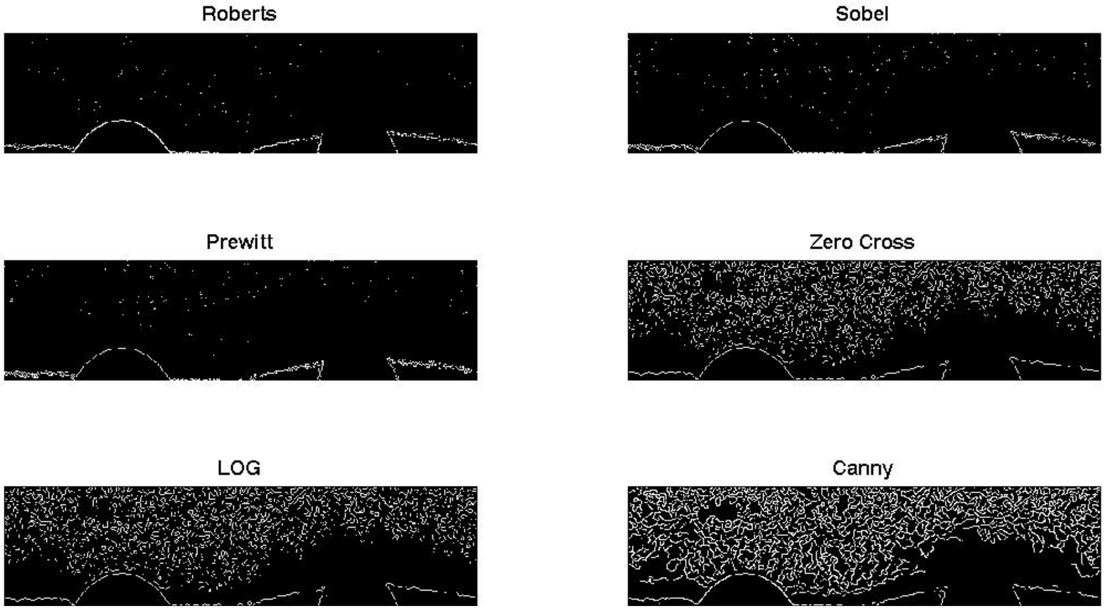

Figure 7.Detection of iris edge using various operators

Table 1. The statistical details of SR, FAR and FRR of Iris Identification System using various edge detection operators

Iris System Performance Parameters	Statistical Parameter	Edge Detection Operators					
		Prewitt	**Robert**	**Sobel**	**Zero Cross**	**Log**	**Canny**
Success ratio	Mean	0.54	0.56	0.54	0.67	0.67	0.81
	SD	0.06	0.09	0.07	0.06	0.06	0.07
False acceptance ratio	Mean	0.23	0.23	0.25	0.18	0.16	0.09
	SD	0.24	0.25	0.26	0.18	0.18	0.10
False rejection ratio	Mean	0.24	0.21	0.21	0.15	0.17	0.10
	SD	0.25	0.22	0.23	0.16	0.18	0.12

4. CONCLUSIONS

In the proposed system the iris region is segmented from an eye image using Daugman's integro-differential operator. Then it is normalised in order to counteract the imaging inconsistencies using Daugman's polar representation. From the obtained normalised iris pattern the features are extracted using edge detection operators such as Prewit, Sobel, Robert, Log, Zero crossing and Canny. Statistical analysis is performed in order to test how well each operators generate the iris code which can be identified against a database of pre-registered iris patterns. The algorithm is tested against 100 eye images out of which 50 are registered and other 50 are unregistered. The results of the present study indicate that the canny operator is best suited operator to extract features of iris for comparison.The success rate of feature detection using Canny is found to be 81%, False Acceptance Rate is 9% and False Rejection Rate is 10%.Hence it may be concluded that model proposed in this study is effective for segmentation and classification of iris with less loss of features.This algorithm can be further developed in the future for iris image capture from the moving face.

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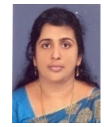

Binsu C. Kovoor is working as Assistant Professor in Information Technology, Cochin University of Science and Technology 2000 onwards. Her areas of interest include biometric security system, pattern recognition, database systems, data mining, data structures, streaming audio and video signals etc. She has a Life membership in ISTE and IE.

Dr. Supriya M. H joined as a faculty in the Department of Electronics, Cochin University of Science & Technology in 1999. Her fields of interests are Target Identification, Signal Processing, Bioinfomatics, Steganography and Computer Technology. She has presented papers in several International C onferences in Europe, USA, and France. She is actively involved in Research and Development activities in Ocean Electronics and related areas and has a patent and about 87 research publications to her credit. She is a Life member of IETE and ISTE.

Dr. K.Poulose Jacob, Professor of Computer Science at Cochin University of Science and Technology since 1994, is currently Director of the School of Computer Science Studies. His research interests are in Information Systems Engineering, Intelligent Architectures and Networks. He has more than 90 research publications to his credit. He has presented papers in several International Conferences in Europe, USA, UK, Australia and other countries. Dr. K.Poulose Jacob is a Professional member of the ACM (Association for Computing Machinery) and a Life Member of the Computer Society of India.