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Designing and Implementation of an Efficient Real Time Iris Recognition System-A Review

Mr. Jyoti Prakash Singh*
Dept of CSE, LNCT Indore
(M.P.)-India

Mr. Santosh Varshney
Asst Professor, Dept. Of CSE, LNCT Indore
(M.P.)-India

Abstract*— A biometric system provides automatic identification of an individual based on a unique feature or characteristic possessed by the individual. Iris recognition is regarded as the most reliable and accurate biometric identification system available. Most commercial iris recognition systems use patented algorithms developed by Daugman, and these algorithms are able to produce perfect recognition rates but not includes time requirement in account. However, published results have usually been produced under favourable conditions, and there have been no independent trials of the technology. So to develop generalized real time and efficient iris recognition system this paper presents some serious modifications. The situations during iris acquisition plays a crucial role in recognition process and it is often found that they are very much vague or imprecise; it is not possible to handle it properly with the help of conventional techniques. This paper basically concentrates three serious modifications in available conventional iris recognition method for real time and efficient iris recognition. Mean wise modification proposed are in the pupil segmentation part, Feature extraction part for handling pupil illumination problem and iris matching part for providing high speed iris recognition. So the proposed work deals with not only the correction to the time requirement as well as deals with higher recognition efficiency requirement with some serious modifications in the conventional technique.

***Keywords*— iris recognition, morphological bridging, pupil segmentation, Iris matching.**

1. Introduction

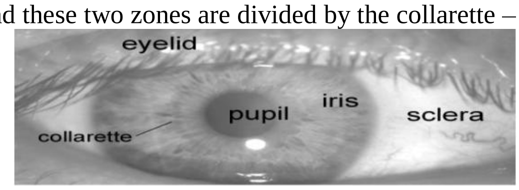
1.1 Biometric Technology

A biometric system provides automatic recognition of an individual based on some sort of unique feature or characteristic possessed by the individual. Biometric systems have been developed based on fingerprints, facial features, voice, hand geometry, handwriting, the retina [1], and the one presented in this thesis, the iris.

Biometric systems work by first capturing a sample of the feature, such as recording a digital sound signal for voice recognition, or taking a digital color image for face recognition. The sample is then transformed using some sort of mathematical function into a biometric template. The biometric template will provide a normalized, efficient and highly discriminating representation of the feature, which can then be objectively compared with other templates in order to determine identity. Most biometric systems allow two modes of operation. An enrolment mode for adding templates to a database, and an identification mode, where a template is created for an individual and then a match is searched for in the database of pre-enrolled templates. A good biometric is characterized by use of a feature that is; highly unique – so that the chance of any two people having the same characteristic will be minimal, stable – so that the feature does not change over time, and be easily captured – in order to provide convenience to the user, and prevent misrepresentation of the feature.

1.2 The Human Iris Structure and Characteristics

The iris is a thin circular diaphragm, which lies between the cornea and the lens of the human eye. A front-on view of the iris is shown in Figure 1.1. The iris is perforated close to its centre by a circular aperture known as the pupil. The function of the iris is to control the amount of light entering through the pupil, and this is done by the sphincter and the dilator muscles, which adjust the size of the pupil. The average diameter of the iris is 12 mm, and the pupil size can vary from 10% to 80% of the iris diameter [2]. The iris consists of a number of layers; the lowest is the epithelium layer, which contains dense pigmentation cells. The stromal layer lies above the epithelium layer, and contains blood vessels, pigment cells and the two iris muscles. The density of stromal pigmentation determines the color of the iris. The externally visible surface of the multi-layered iris contains two zones, which often differ in color [3]. An outer ciliary zone and an inner pupillary zone, and these two zones are divided by the collarette – which appears as a zigzag pattern.



I. Figure 1.1 – A front-on view of the human eye.

Formation of the iris begins during the third month of embryonic life [3]. The unique pattern on the surface of the iris is formed during the first year of life, and pigmentation of the stroma takes place for the first few years. Formation of the unique patterns of the iris is random and not related to any genetic factors [4]. The only characteristic that is dependent on genetics is the pigmentation of the iris, which determines its color. Due to the epigenetic nature of iris patterns, the two eyes of an individual contain completely independent iris patterns, and identical twins possess uncorrelated iris patterns. For further details on the anatomy of the human eye consult the book by Wolff [3].

1.3 Foundations of Iris Recognition

The iris is an externally visible, yet protected organ whose unique epigenetic pattern remains stable throughout adult life. These characteristics make it very attractive for use as a biometric for identifying individuals. Image processing techniques can be employed to extract the unique iris pattern from a digitized image of the eye, and encode it into a biometric template, which can be stored in a database. This biometric template contains an objective mathematical representation of the unique information stored in the iris, and allows comparisons to be made between templates. When a subject wishes to be identified by iris recognition system, their eye is first photographed, and then a template created for their iris region. This template is then compared with the other templates stored in a database until either a matching template is found and the subject is identified, or no match is found and the subject remains unidentified.

Although prototype systems had been proposed earlier, it was not until the early nineties that Cambridge researcher, John Daugman, implemented a working automated iris recognition system [1][2]. The Daugman system is patented [5] and the rights are now owned by the company Iridian Technologies. Even though the Daugman system is the most successful and most well known, many other systems have been developed. The most notable include the systems of Wildes et al. [7][4], Boles and Boashash [8], Lim et al. [9]. The algorithms by Lim et al. are used in the iris recognition system developed by the Evermedia and Senex companies. Also, the Noh et al. algorithm is used in the 'IRIS2000' system, sold by IriTech. These are, apart from the Daugman system, the only other known commercial implementations.

The Daugman system has been tested under numerous studies, all reporting a zero failure rate. The Daugman system is claimed to be able to perfectly identify an individual, given millions of possibilities. The prototype system by Wildes et al. also reports flawless performance with 520 iris images [7], and the Lim et al. system attains a recognition rate of 98.4% with a database of around 6,000 eye images. Compared with other biometric technologies, such as face, speech and finger recognition, iris recognition can easily be considered as the most reliable form of biometric technology [1]. However, there have been no independent trials of the technology, and source code for systems is not available. Also, there is a lack of publicly available datasets for testing and research, and the test results published have usually been produced using carefully imaged irises under favourable conditions.

2. Canny Edge Detection Algorithm

The Canny Edge Detector is one of the most commonly used image processing tools, detecting edges in a very robust manner. It is a multi-step process. The algorithm runs in 5 separate steps:

1) *Smoothing:* Blurring of the image to remove noise. An example of a Gaussian kernel of size = 5, that might be used is shown below:

$$K = \frac{1}{159}\begin{bmatrix} 2 & 4 & 5 & 4 & 2 \\ 4 & 9 & 12 & 9 & 4 \\ 5 & 12 & 15 & 12 & 5 \\ 4 & 9 & 12 & 9 & 4 \\ 2 & 4 & 5 & 4 & 2 \end{bmatrix}$$

2) *Finding gradients:* The edges should be marked where the gradients of the image has large magnitudes.

a. Apply a pair of convolution masks (in x and y) directions:

$$G_x = \begin{bmatrix} -1 & 0 & +1 \\ -2 & 0 & +2 \\ -1 & 0 & +1 \end{bmatrix}$$

$$G_y = \begin{bmatrix} -1 & -2 & -1 \\ 0 & 0 & 0 \\ +1 & +2 & +1 \end{bmatrix}$$

b. Find the gradient strength and direction with:

$$G = \sqrt{G_x^2 + G_y^2}$$

$$\theta = \arctan\left(\frac{G_y}{G_x}\right)$$

The direction is rounded to one of four possible angles (namely 0, 45, 90 or 135).

3) *Non-maximum suppression:* Only local maxima should be marked as edges.
4) *Double thresholding:* Potential edges are determined by thresholding.
5) *Edge tracking by hysteresis:* Final edges are determined by suppressing all edges that are not connected to a very certain (strong) edge.

Figure (2.1) shows the input iris image and figure (2.2) shows it edge detected output image after application of canny edge detector.

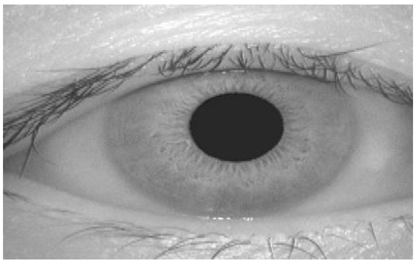


Figure (2.1)

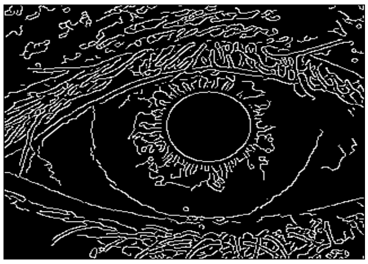


Figure (2.2)

3. **Morphological Bridging**

Morphological image processing is a collection of non-linear operations related to the shape or morphology of features in an image. According to available literature, morphological operations rely only on the relative ordering of pixel values, not on their numerical values, and therefore are especially suited to the processing of binary images. Morphological operations can also be applied to grayscale images such that their light transfer functions are unknown and therefore their absolute pixel values are of no or minor interest. Morphological techniques probe an image with a small shape or template called a structuring element. The structuring element is positioned at all possible locations in the image and it is compared with the corresponding neighborhood of pixels. Some operations test whether the element "fits" within the neighborhood, while others test whether it "hits" or intersects the neighborhood.

Morphological Bridging operation, bridges unconnected pixels, that is, sets 0-valued pixels to 1 if they have two nonzero neighbors that are not connected. For example:

1	0	0		1	1	0
1	0	1	becomes	1	1	1
0	0	1		0	1	1

Figure (3.1) shows an iris image in which the pupil is suffered from non uniform lightning; mean wise figure (3.2) shows the output of conventional canny detector. It is clearly evident from figure (3.2), that conventional canny edge detector fails to provide complete circle around pupil. Now figure (3.3) shows the output of canny edge detector with morphological edge bridging operation, and it is clear from the figure that the proposed edge operator provides efficient circle around the pupil even non uniform lightning conditions.

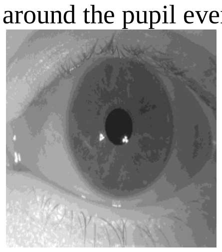


Figure (3.1)

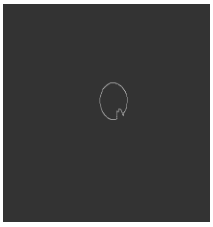


Figure (3.2)

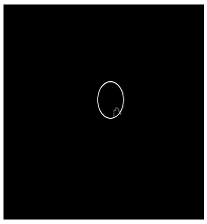


Figure (3.3)

4. **Normalization**

Once the iris region is successfully segmented from an eye image, the next stage is to transform the iris region so that it has fixed dimensions in order to allow comparisons. The normalization process will produce iris regions, which have the same constant dimensions, so that two photographs of the same iris under different conditions will have characteristic features at the same spatial location.

The most commonly used normalization technique is developed by Daugman's and known as Daugman's Rubber Sheet Model.

4.1. Daugman's Rubber Sheet Model

The homogenous rubber sheet model devised by Daugman [1] remaps each point within the iris region to a pair of polar coordinates (r, θ) where r is on the interval [0, 1] and θ is angle [0,2π].

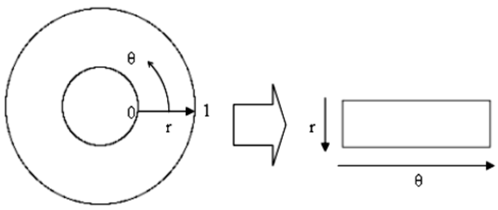


Figure (4.1) Daugman's Rubber Sheet Model

The remapping of the iris region from *(x,y)* Cartesian coordinates to the normalized non-concentric polar representation is modeled as

$$I(x(r,\theta), y(r,\theta)) \rightarrow I(r,\theta) \quad \text{… (4.1)}$$

Where

$$x(r,\theta) = (1-r)x_p(\theta) + rx_l(\theta)$$
$$y(r,\theta) = (1-r)y_p(\theta) + ry_l(\theta)$$

Where *I(x, y)* is the iris region image, *(x, y)* are the original Cartesian coordinates, *(r, θ)* are the corresponding normalized polar coordinates, and x_p, y_p and x_l, y_l are the coordinates of the pupil and iris boundaries along the θ direction. The rubber sheet model takes into account pupil dilation and size inconsistencies in order to produce a normalized representation with constant dimensions. In this way the iris region is modeled as a flexible rubber sheet anchored at the iris boundary with the pupil centre as the reference point.

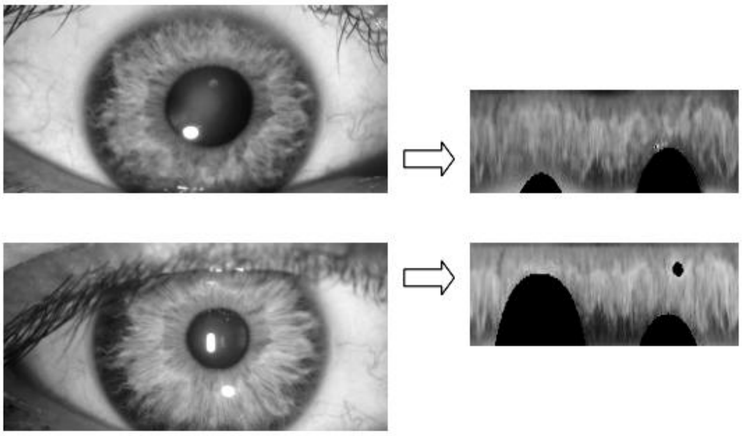


Figure (4.2). Illustration of the normalization process for two images of the same iris taken under varying conditions.

5. Feature Encoding and Matching

In the past most commonly wavelet feature extraction or gabor filters have been used to extract features of detected iris after making rubber sheet model. This process is very complex and not applicable for real time operations, because it consumes most of the timing requirement of the complete process. This paper utilized simple concept that the obtain rubber sheet model itself contains all unique information required to identify an individual person. Hence the basic idea of this paper is to convert the rubber sheet model in matrix form and utilize this matrix as a feature matrix of respective eye.

After the formation of feature matrix a pixel based matching is proposed in this paper for iris recognition process.

5.1 pixels Based Iris Matching

In the last few years is hamming distance based iris matching concept has been extensively utilized by the researchers, this technique is efficient, but again consumes large time. Therefore for the fast real time iris recognition this paper utilized pixel based matching for iris recognition. The concept is very simple, that calculate each difference of corresponding pixel values for the feature matrix of iris image to be recognize and the feature matrix available in database. The equation of difference is defined as

$$\mathrm{Diff} = \sum_{i=1}^{m} \sum_{j=1}^{n} F_i(i,j) - F_d(i,j) \quad \text{…(5.1)}$$

Usually a perfect match is found for the value of Diff =0. But sometimes user has to define a threshold value of Diff for proper recognition.

6. Methodology

The proposed methodology basically concentrates on following modification on conventional iris recognition system.

i. Development of highly efficient edge detection for iris using Morphological bridged canny edge detection instead of conventional canny edge detection with Hough transform.
ii. In feature extraction, formation of feature matrix after preparation of rubber sheet model instead of using 2-D Gabor transform method.
iii. For iris feature matching process pixel based matching is proposed which leads to efficient solution for real time recognition.

The proposed methodology starts with very basic segmentation of iris with modified technique and uses conventional method up rubber sheet model formation and ends with modified matching algorithm based on neural network. Figure (4.1) shows the complete proposed method with the help of flow chart.

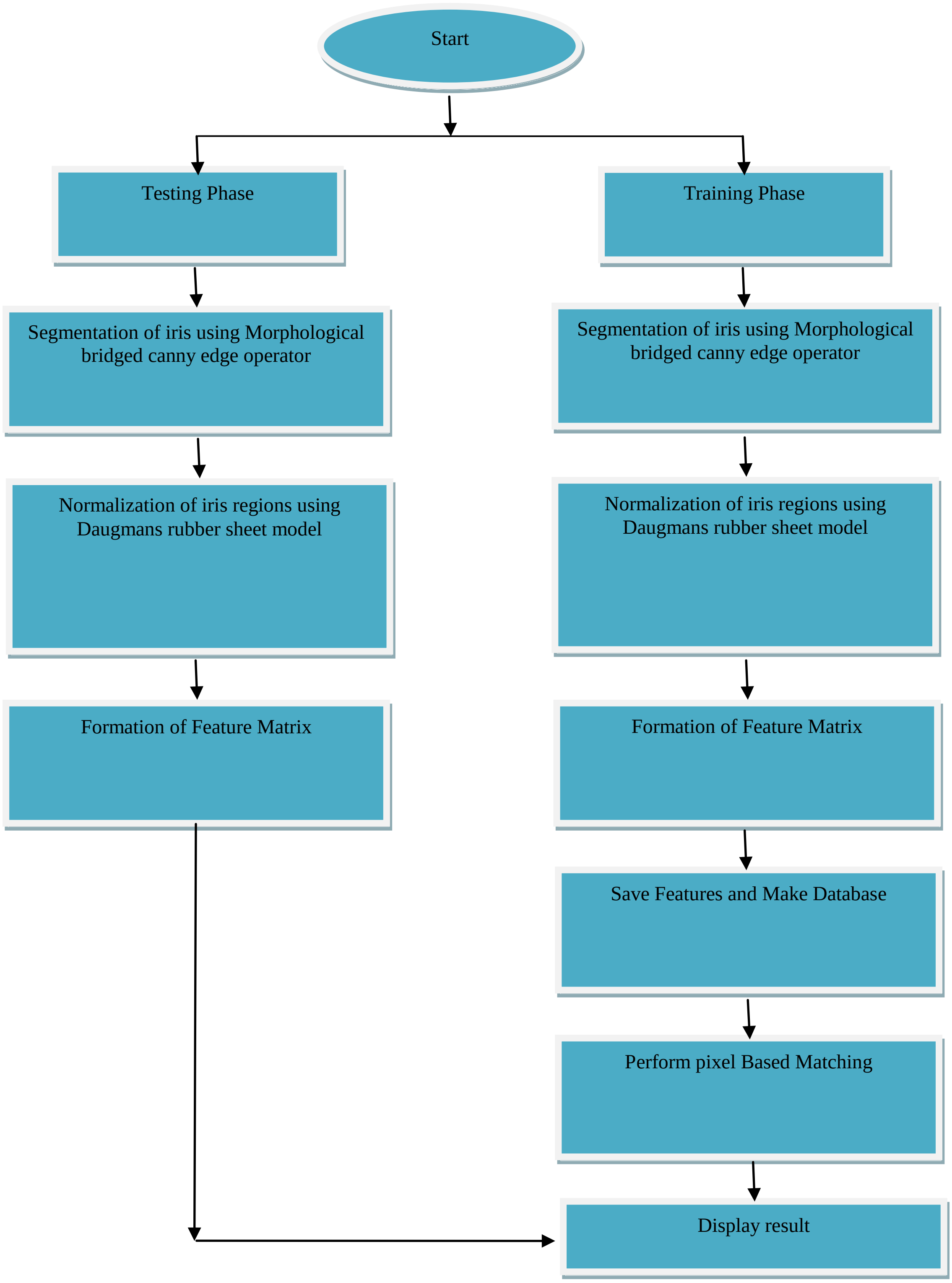


Figure (6.1) Proposed Methodology

7. CONCLUSIONS

Iris identification is a robust technology among all the biometric identification system available publically or commercially. In the current scenario available iris recognition systems are not able to cope up with the rapid technological advancement, and not able to provide a highly efficient recognition process. This is because of the random nature of images, like sometimes iris images suffer from non uniform illumination and pupil orientations. This paper presented a novel approach to handle this randomness presented in acquired iris images using proposed modifications and hence able to provide highly efficient recognition as compare to conventional techniques.

In addition to this use of pixel based recognition enables to make efficient decision making and fast recognition as compare to conventional iris recognition approach. Therefore able to provide an efficient solution of real time iris recognition problem.

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