An Effective method for Iris Recognition based on Discrete Cosine Transform

Priyanka Mukherjee[1], Ankita Dutta[2], Pranab Das[*]
[1, 2, 3]*Dept of Computer Science and IT, Don Bosco College of Engineering and Technology,*
Assam Don Bosco University, Guwahati, India
preah13@gmail.com, ankita.dutta17@gmail.com, pranab.das@dbuniversity.ac.in

Abstract: ***Iris is considered to be the most unique attribute possessed by an individual and is regarded as the most reliable form of biometric authentication. In this work we have implemented a simple but very effective method for iris recognition based on Discrete Cosine Transform. Here firstly the iris image is pre-processed and segmented. After preprocessing, the segmented image is then further processed for feature extraction. This is done by finding the two dimensional Discrete Cosine Transform of the segmented iris image. The transformed image contains the unique features of the iris embedded in it. This key feature is then matched using simple statistical measure such as correlation. The proposed approach has been tested on publicly available MMU-database which contains 384 iris images, i.e. 6 images each (i.e.3 left and 3 right) of 64 persons. The images are: 24 bit - RGB, 576 x 768 pixels, file format: PNG. The irises were scanned by TOPCON TRC50IA optical device connected with SONY DXC-950P 3CCD camera. An accuracy of 82% with an EER of 18% has been achieved with this method.*** **The proposed work is a part of an ongoing project and in future it is intended to implement the project using ANN.**

Index terms: Biometric authentication, segmentation, feature extraction, matching, Discrete Cosine Transform (DCT), correlation.

I. INTRODUCTION

With the advancement in science and technology, there is a pressing demand for security in every aspect of life. Some of the commonly used methods for personal identification are passwords, PIN, ID cards, etc. However these types of methods have several drawbacks. Moreover depending upon the type and level of authentication the feature or characteristic chosen should also be unique. Various authentication and identification systems such as facial features, voice, signature, figure print, DNA matching have been explored in the past decades in field of biometric authentication. However Iris recognition has formed the base of biometric authentications in recent years replacing all previous forms of authentications due its reliability and uniqueness; even the right and left iris of the same person is unique. The uniqueness of iris can be quoted in the words of Daugman, [1] as 'An advantage of the iris shares with fingerprints is the chaotic morphogenesis of its minutiae'.

Iris can be identified as a color portion lying between the retina and the pupil as shown in Figure 1(a), a front view of human eye is shown in Figure 1(b). The important feature of iris which makes it a unique feature for authentication is that it is a protected organ of human and its formation starts from the third month of embryonic life and continues till second year of birth and then stays unique throughout the person's life [2].

Various research groups such as Tisse et al [3], Ma et al [4], Zu et al [5], and wildes et al [6] has proposed authentication systems based on Haar wavelet. Rydgren et al [7] has proposed a system based on wavelet packet, Kshamaraj et al [8] has a proposed a system based on Gabor filters.

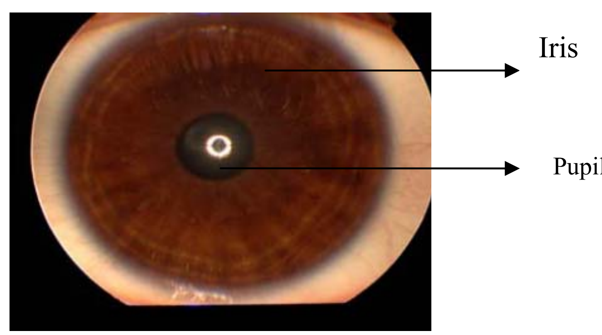

Figure 1(a) Database Iris image.

Figure 1(b) Front on view of human eye.

A. The Human iris

The iris is a thin circular diaphragm, which lies between the cornea and the lens of the human eye. 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. 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 multilayered iris contains two zones, which often differ in color. An outer ciliary zone and an inner pupillary zone, and these two zones are divided by the collarette –which appears as a zigzag pattern. Formation of the iris begins during the third month of embryonic life. 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. 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.

II. METHODOLOGY

The objective of this work is to develop a simple iris recognition system for person identification. For this, the basic steps are:

- **segmentation**-locating the iris region from the eye image,
- **feature extraction**- extracting features from the segmented region and finally
- **matching**- to match the incoming input eye image to that present in the database using the developed algorithm.

The algorithm proposed in this paper is based in segmenting the iris region using thresholding, using 2-DCT to extract features from the iris image and then performing correlation based matching.

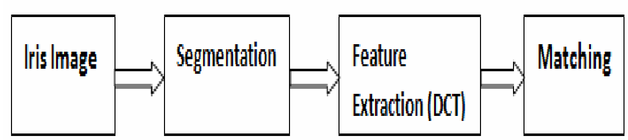

Figure2. Block diagram of the proposed system.

III. DISCRETE COSINE TRANSFORM

The discrete cosine transform (DCT) represents an image as a sum of sinusoids of varying magnitudes and frequencies. The DCT2 function computes the two-dimensional discrete cosine transform (DCT) of an image. The DCT has the property that, for a typical image, most of the visually significant information about the image is concentrated in just a few coefficients of the DCT. For this reason, the DCT is often used in image compression applications.

Two Dimensional of DCT of an M by N matrix A is defined by follows:

$$B_{pq} = \alpha_p \alpha_q \sum_{m=0}^{M-1} \sum_{n=0}^{N-1} A_{mn} \cos\frac{\pi(2m+1)p}{2M} \cos\frac{\pi(2n+1)q}{2N}, \quad \begin{matrix} 0 \le p \le M-1 \\ 0 \le q \le N-1 \end{matrix}$$

$$\alpha_p = \begin{cases} 1/\sqrt{M}, & p=0 \\ \sqrt{2/M}, & 1 \le p \le M-1 \end{cases} \quad \alpha_q = \begin{cases} 1/\sqrt{N}, & q=0 \\ \sqrt{2/N}, & 1 \le q \le N-1 \end{cases}$$

The value B_{pq} are called the DCT coefficients of A. The DCT is an invertible transform and its inverse is given by:

$$A_{mn} = \sum_{p=0}^{M-1} \sum_{q=0}^{N-1} \alpha_p \alpha_q B_{pq} \cos\frac{\pi(2m+1)p}{2M} \cos\frac{\pi(2n+1)q}{2N}, \quad \begin{matrix} 0 \le m \le M-1 \\ 0 \le n \le N-1 \end{matrix}$$

$$\alpha_p = \begin{cases} 1/\sqrt{M}, & p=0 \\ \sqrt{2/M}, & 1 \le p \le M-1 \end{cases} \quad \alpha_q = \begin{cases} 1/\sqrt{N}, & q=0 \\ \sqrt{2/N}, & 1 \le q \le N-1 \end{cases}$$

The inverse DCT equation can be interpreted as meaning that any M by N matrix A can be written as a sum of MN function of the form:

$$\alpha_p \alpha_q \cos\frac{\pi(2m+1)p}{2M} \cos\frac{\pi(2n+1)q}{2N}, \quad \begin{matrix} 0 \le p \le M-1 \\ 0 \le q \le N-1 \end{matrix}$$

The property or capability of DCT to compress energy makes DCT a good candidate for pattern recognition tasks [10]. DCT decomposes a signal into its corresponding frequency components. When DCT is applied to a M X N matrix the 2-DCT concentrates all the important information into few coefficients located in the upper left corner of the resulting valued M X N matrix.

IV. Correlation Based Matching

To classify the DCT matrices or the features obtained from DCT, correlation is applied to the resulting DCT matrices to find matches or similarity between image/matrix.

Here we employ correlation based pattern classification. The correlation is a numeric measure of the strength of linear dependence between two random variables. In statistics, dependence refers to any statistical relationship between two variables or two sets of data. The most familiar measure of dependence between two quantities is the Pearson product-moment correlation coefficient or the "Pearson's correlation". It ranges from -1 to +1. Pearson correlation is +1 in the case of a perfect positive (increasing) linear relationship (correlation), −1 in the case of a perfect decreasing (negative) linear relationship (anti-correlation) and some value between −1 and 1 in all other cases, indicating the degree of linear dependence between the variables. As it approaches zero there is less of a relationship (closer to uncorrelated). The closer the coefficient is to either −1 or 1, the stronger the correlation between the variables. If we have a series of n measurements of X and Y written as xi and yi where i = 1, 2,..., n, then the sample correlation coefficient can be used to estimate the population Pearson correlation 'r' between X and Y. The sample correlation coefficient is written as:

$$r_{xy} = \frac{\sum_{i=1}^{n}(x_i - \bar{x})(y_i - \bar{y})}{(n-1)S_x S_y}$$

Where and are the sample means of X and Y and and are the sample standard deviations.

V. Experimental Results and Discussions

Here we have experimented the algorithm on 354 iris images. On matching an individual's iris image with other images which were not from the same person, correlation values ranging from 0.5 to 0.6 and lower were found. Based on the experimentation four threshold values have been taken into consideration i.e 0.75, 0.76, 0.77, 0.78. Based on the correlation values' error rates an optimal threshold value for the system has been found. The correlation value thus allows distinguishing and authenticating if the DCT of the incoming iris image matches the one present in the database.

We then evaluate the performance of our method in terms of the following measure rate:

- **False Acceptance Rate**: The false acceptance rate, or FAR, is the measure of the likelihood that the biometric security system will incorrectly accept an access attempt by an unauthorized user. A system's FAR typically is stated as the ratio of the number of false acceptances divided by the number of identification attempts.

- **False Rejection Rate**: The false rejection rate, or FRR, is the measure of the likelihood that the biometric security system will incorrectly reject an access attempt by an authorized user. A system's FRR typically is stated as the ratio of the number of false rejections divided by the number of identification attempts. In a practical scenario a low FAR & a high FRR would ensure that any unauthorized person will not be allowed access. In this case a threshold value of 0.77 shows a low FAR and high FRR. Thus a correlation value of 0.77 have been set to authenticate the identity of an individual

- **Equal Error Rate**: A biometric system determines the threshold values for its FAR and FRR and when both the rates are equal it is referred to as Equal Error Rate. In this paper an equal error rate of 18% have been attained which gives an accuracy of 82% of the system.

Table 1 shows representation of the false acceptance and false rejection rate at various threshold values. Figure 3 shows the graphical representation of FAR and FRR values at various threshold levels. It also gives the point of intersection of this two error rates called the ERR.

Table 1: Error Rates.

Threshold	FAR (%)	FRR (%)
0.75	66	7
0.76	41	13
0.77	18	25
0.78	21	12

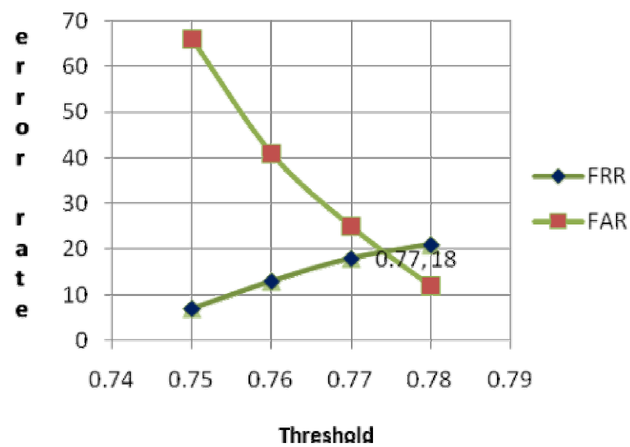

Figure 3: Graphical representation of FAR and FRR.

The point in the graph where the values of FAR and FRR meet is known as the equal error rate (EER). The lower the equal error rate higher is the performance of the system.

V1.CONCLUSION

In this paper we have proposed a biometric system based on iris recognition using discrete cosine transform and correlation based matching. The proposed method is simple however effective. The experimental results show the effective of our approach, however we intend to develop an ANN based algorithm in future to achieve a better accuracy rate.

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