Biometric Access Control System Using Automated Iris Recognition

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Abstract— **A biometric access control system is developed using automated iris recognition. Based on the fact that a human iris contains patterns that are best suited for identification, the use of low cost equipment can help iris recognition to become a standard in security systems. In this paper the database containing images from a low cost camera is assessed, and the overall recognition performance was measured. The pattern matching is performed using statistical metrics. The real-time experimental results on a group of 50 persons are presented. The results showed that a system using low cost equipment can be constructed with a promising 95% accuracy rate.**

Keywords: **Biometric, Iris Recognition, Correlation.**

I. Introduction

DUE to higher security needs biometrics based systems are becoming one of the best secure and reliable systems. The iris due to its unique biological properties is suited for the identification of an individual. It contains a large amount of discriminating information in its pattern. According to a survey [1] performed by the National Physical Laboratory, UK, iris recognition outperforms other biometric identification methods (e.g. fingerprints, voice and face recognition) proving the technology to be the best.

One of the earliest developments in iris recognition system was presented by Dougman [2, 3, and 4]. The algorithms developed by Daugman in [2] are currently being used by many commercial and public entities including British Telecom, US SandiaLabs,

UK National Physical Laboratory, NCR, Oki, IriScan, Iridian, Sensar, and Sarnoff [6]. Their results reported almost a zero percent tolerance with a database of millions of iris samples [5]. A survey on neural approaches towards iris recognition is presented in [6]. In most of the techniques, the whole or part of the image of the iris is used. This requires

- Computations on the image, thus demanding high computation power from the processor which cost a high capital investment.

In this research, instead of using the iris image for pattern matching, just the iris pupil boundary is used as the iris signature. The signatures are then processed and are converted to one dimensional array while pattern matching is performed by comparing simple statistical operations resulting:

- Low computation power requirements
- Cost reduction in the imaging device as compared to dedicated and sophisticated imaging device needed for 2-D pattern matching.

Different databases were also used for training purposes, e.g. the CASIA Database. However, for completeness of the project, a database of 50 users is also developed. The users were then tested the algorithm in real-time.

II. Problem Statement

This project aims towards devising an access control system for a secure perimeter, which allows access only those people who are identified by the officials using biometric identification of iris recognition. Moreover, it is also required that the computations required for the algorithm be minimized.

III. The Iris Recognition Algorithm

In this research project, the main goal was to create a biometric access control system based on Iris Signature Recognition. The proposed system is completely automated as it grants/denies access based on the decision if the person is an authorized person or an intruder.

The algorithm consists of two main parts

1. Signature Extracting
2. Signature Matching

In the following subsections a discussion on the iris recognition algorithm is presented.

A. Signature Extraction

The first step in the iris recognition system is to extract the signature from the image. It is worth mentioning that computations with a 2-D image are far more complicate and intricate compared to a 1-D vector. Since we are looking for a simple technique that is both efficient yet effective, we preferred to work on the iris pupil boundary rather than the pattern on the iris or other similar features. Hence, the main feature to be extracted was the iris-pupil boundary, that now we will call the iris signature. It is known that every single individual has a different iris signature. Even two identical twins have individual iris signature. Biometric scientists claim that for a same person, the iris signatures for both of the eyes are distinct [3, 6].

The iris signature extraction is performed using a method discussed in the following subsections.

Obtaining the Image

The first step in signature extracting is to obtain a picture rich enough, that offers the desired features. The image acquisition device used in this research is a HSK-6700 Iriscope. The Iriscope acquires a 640x480 pixel RGB photograph of the eye. An RGB sample is shown in Fig. 1.

Fig. 1 RGB input image of an eye

B. Greyscale Conversion

After taking the image it is converted to greyscale for removing the colours from it. As a colour picture has more data size so converting it to greyscale will reduce the overall calculations on the image. The image converted to greyscale is shown in Fig. 2.

Fig. 2 Greyscale image of the eye

Detecting the Edges

The iris-pupil boundary can roughly be marked using edge detection. Edge detection returns a binary image with zeros and ones. The threshold on the edge detection is tuned to remove less contrasting edges. In this research edge detection is performed using canny edge detection algorithm. It consists of three main steps [7].

1. **Noise reduction through convolution with a Gaussian filter.**

   In two dimensions, Gaussian filter is the product of two one dimension Gaussian filters, one per direction [8][9]:

   Where "x" is the distance from the origin in the horizontal axis, "y" is the distance from the origin in the vertical axis, and "σ" is the standard deviation of the Gaussian distribution.

   When applied in two dimensions, this formula produces a surface whose contours are concentric circles with a Gaussian distribution from the center point. Values from this distribution are used to build a convolution matrix which is applied to the original image. Each pixel's new value is set to a weighted average of that pixel's neighborhood. The original pixel's value receives the heaviest weight (having the highest Gaussian value) and neighboring pixels receive smaller weights as their distance to the original pixel increases.

2. **Estimate of edge strength using Sobel filter pair.**

   Mathematically, the Sobel filter pair uses two 3×3 kernels which are convolved with the original image to calculate approximations of the derivatives - one for horizontal changes, and one for vertical. If we define *A* as the source image, and G_x and G_y are two images which at each point contain the horizontal and vertical derivative approximations, the computations are as follows[10]:

   The x-coordinate is here defined as increasing in the "right"-direction, and the y-coordinate is defined as increasing in the "down"-direction. At each point in the image, the resulting gradient approximations can be combined to give the gradient magnitude, using:

   .

3. **Edge tracking**

   Edge tracking is then performed along edges in the image starting in the positions that have edge strength higher than a certain threshold (T). Tracking is continued, marking only local edge maximums as edges, until the edge strength falls below another threshold (T).

The binary image after edge detection is shown in Fig. 3 with ones on the dark pixels and zeros on the bright pixel.

C. Finding the Centre of pupil

Since we need the iris–pupil boundary, the pupil has to be grabbed from the image. The pupil being a large dark spot in the middle of the image holds the weight of the image. It was seen after many experiments that the centroid of the image always lays within the pupil. Once a point within the pupil is detected, the boundary can also be found out. The centroid of the image is calculated by dividing the sum of x-coordinates and the sum of y-coordinates with the area of the image. It was individually made sure for all the images in the database that the centroids laid anywhere within the pupil. In Fig.4 the white dot within the pupil represents the centroid of the image.

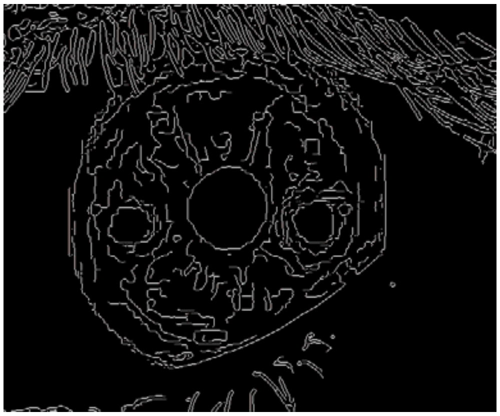

Fig. 3 Canny edge detected image of an eye

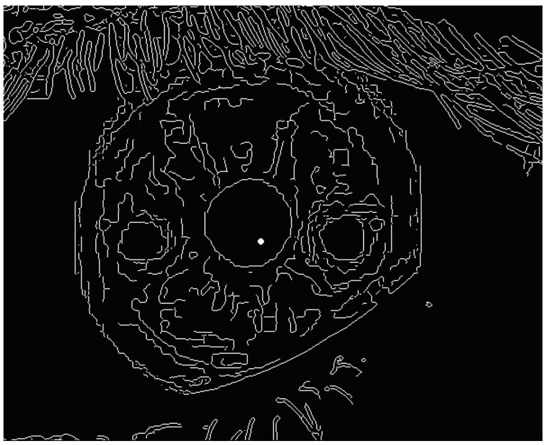

Fig. 4 Image with calculated centroid

The centroid of the image can now be used to find the iris-pupil boundary. Points on the iris-pupil boundary are searched in counter-clockwise direction by finding the distance between the image centroid and the first pixel with a value one (denoting the iris-pupil boundary). This procedure is repeated for a whole revolution. The distances can be seen in Fig. 5.

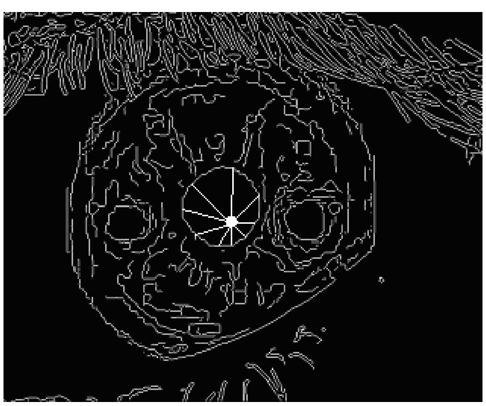

Fig. 5 Distances of the iris-pupil boundary from the centroid of the image

The distances thus help in finding the coordinates of the iris-pupil boundary using Pythagoras theorem. Although all the points on the iris-pupil boundary can be found using the above procedure, still a vector of these coordinates cannot be used as a feature vector. This is due to the fact that the pupil can be at any location in the image and the centroid of the image is never in the centre of the pupil.

D. Cropping the Pupil

Now using the distances measured from the centroid of the image, the highest and lowest pixels are found out. Similarly, the left most and the right most pixels are found out. The extreme points on the iris give us four sides of the iris. The iris can now be cropped from the image as can be seen in Fig. 6

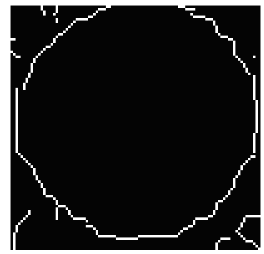

Fig. 6 Pupil extracted from the original image

This cropped image of iris will now be used to find the centroid of the iris. Several experiments with different images taken under different conditions verified that this centroid always lie on the same location in the pupil. A definite centroid now enables the algorithm to extract the correct feature vector, i.e. the iris signature. The centroid of the pupil is shown in Fig. 7.

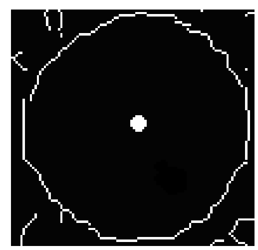

Fig. 7 Image with calculated centre of the pupil

E. Extracting the Signature

We are now able to extract the real feature of interest, i.e., the iris signature. The iris signature is a vector of distances from the centroid of the pupil to the iris-pupil boundary. Hence distances were found in a counter-clockwise direction as shown in Fig. 8 and stored in a vector.

This vector can vary if the image taken is slightly tilted or the iris is contracted or expanded due to different light conditions. In order to avoid such situations it is required to perform some basic operations.

To make the signature rotation invariant (camera tilt), the signature values were rearranged in such a way that the signature was started with the maximum distance found and maintain the continuation in the counter-clockwise direction. This way the rotation problem was resolved.

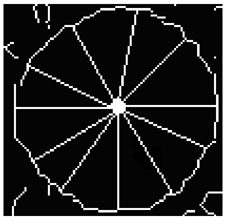

Fig. 8 Finding the iris signature

To avoid the situation where the iris is contracted or expanded under different light intensities or different focal points, the fact that the iris-pupil boundary remains the same is used. The contraction or expansion varies the distances in same proportion from the center to the boundary. The set of distances or the distance vector can be made invariant using normalization. Hence, the variations related to different light conditions and focuses were resolved. A typical iris-signature is shown in Fig. 9.

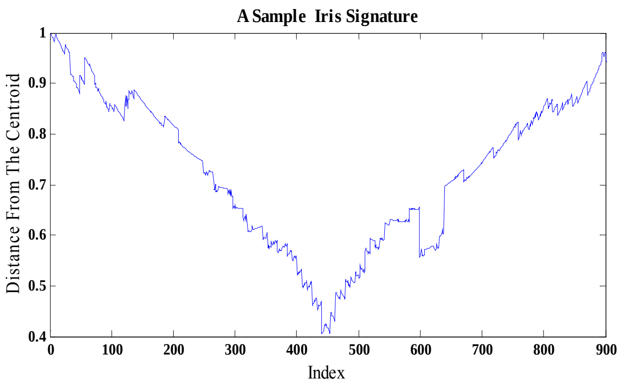

Fig. 9 A sample Iris Signature

F. Signature Matching

Signature matching is the phase where the signature patterns are classified for an authorized or unauthorized user. There are many ways found in the literature. We have selected four statistical properties for pattern classification, namely, correlation, Euclidean distance, mean and standard deviation.

The main decision is taken by the comparison of "correlation". We find the correlation of the input signature with the signatures of each individual. The correlation is high if the input signature belongs to the individual and low otherwise. The correlation matching is then verified by the other three properties. This verification confirms if the input signature is actually the signature of that particular individual.

Pattern Matching Using Correlation

In general statistical usage, correlation refers to the departure of two random variables from independence [8]. If we have a series of "n" measurements of different signals then the sample correlation r_{xy} between two signals written as x_i and y_i where $i = 1, 2, ..., n$, can be found out as:

$$r_{xy} = \frac{\sum(x_i - \bar{x})(y_i - \bar{y})}{(n-1)s_x s_y},$$

Where $\bar{x}$ and $\bar{y}$ are the mean of the samples; and s_x and s_y are sample standard deviations.

A ±5% threshold value was set for each co-ordinate of iris signatures present in the database. The input signature is compared with each signature in the database. If the co-ordinates are in ±5% of the co-ordinates of training signatures then using simple calculation it is compared that with which signature it resembles the most. After this step some other properties as Mean, Median and Standard Deviation is also compared between the two signatures for precision in results.

The metric correlation is used in a number of applications in pattern matching. For example, correlation technique for pattern matching has been used in MRI applications [12]. An advantage of pattern matching in MRI is that it is less sensitive to spurious phase that may arise in MRI [12]. Likewise, it is also used in face recognition along with 2-D Fourier transforms [13]. This technique has also been used in nuclear power plant monitoring systems. Simplified schemes to compare the signal envelopes were developed using cross-correlation and Eigenvalues [14]. Correlation technique is also used in lip tracking. Correlation is used as a medium to track lip pattern matching [15]. It is important to note that correlation has proven to be a useful tool for pattern matching especially for static data. Hence, we have also implied the correlation method for iris signature matching. The correlation results were verified further by other statistical properties such as euclidean distance, mean and standard deviation of the two "Signatures".

IV. Real-Time Experimental Results

In order to verify the proposed algorithm, a case study on a group of 50 students of Air University was prepared. The real-time expriment was performed using a dedicated camera 'Iriscope HSK6700'. The camera is a 1.3 Mega pixel imaging device. The purpose of using this camera was also to show that even a low cost imaging device is also able to construct a delicate recognition system. The interfacing was performed on Pentium IV with 1GB memory. The programming platform wa MATLAB. The image acquisition was performed in difference situations with variable light intensity and ambience.

A total of 550 samples were collected. 400 samples were used for training setting the other 150 samples blind to the algorithm. Access control was tested and verified using the 150 samples. It was seen that the algorithm proved to be quite efficient with almost 95% accuracy.

A summary of the experiment can be seen in TABLE I.

TABLE I
Experimental Results

Observation	Result
Total Users	50
Samples of each user	11

Total Samples	550
Total trained Samples	400
Total Samples Tested	150
Threshold Value (per co-ordinate)	±5%
Legal Access	142
Illegal Access	8
Percentage of correct Access	95%

V. CONCLUSIONS

A biometric access control system is developed using iris recognition based individual identification. The iris pupil boundary is used as the feature for identification. This reduced the computational load on the processor avoiding the 2-D computations on the image. Pattern matching is performed using correlation and other statistical measures. Real-time experimental results based on a database of 50 individuals show promising results with an overall classification accuracy of more than 95% using simple mathematical operations in a very low cost.

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