INTERNATIONAL JOURNAL OF APPLIED ENGINEERING RESEARCH, DINDIGUL
Volume 1, No 3, 2010



REVIEW ARTICLE ISSN - 0976-4259

# Analysis of statistical feature extraction for Iris Recognition System using Laplacian of Gaussian filter

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## ABSTRACT

Biometrics deals with identification of individuals based on their biological or behavioural characteristics. Iris recognition is one of the newer biometric technologies used for personal identification. It is one of the most reliable and widely used biometric techniques available. In general, a typical iris recognition method includes capturing iris images, testing iris liveness, image segmentation, and image recognition using traditional and statistical methods. Each method has its own strengths and limitations. In this paper, we present a novel approach for statistical feature by using Laplacian of Gaussian filter to iris recognition. Our goal is to develop best algorithm that enhances iris images, reduces noise to the maximum extent possible, extracts the important features from the image, and matches those features with data in an iris database. This approach will be simple and effective, and can be implemented in real-time. Experiments are performed using iris images obtained from CASIA database (Institute of Automation, Chinese Academy of Sciences) and Matlab application for its easy and efficient tools in image manipulation.

**Keywords:** Iris recognition, image processing, canny edge detection, Hough transform; statistical features, laplacian of Gaussian filter.

## 1. Introduction

Biometrics involves recognizing individuals based on the features derived from their Physiological and behavioral characteristics. Biometric systems provide reliable recognition schemes to determine or confirm the individual identity. A higher degree of confidence can be achieved by using unique physical or behavioral characteristics to identify a person; this is biometrics. A physiological characteristic is relatively stable physical characteristics, such as fingerprint, iris pattern, facial feature, hand silhouette, etc. This kind of measurement is basically unchanging and unalterable without significant duress. Applications of these systems include computer systems security, e-banking, credit card, access to buildings in a secure way. Here the person or object itself is a password. User verification systems that use a single Biometric indicator are disturbed by noisy data, restricted degrees of freedom and error rates. Multi biometric systems tries to overcome these drawbacks by providing multiple evidences to the same identity hence the performance may be increased. The automated personal identity Authentication systems based on iris recognition are reputed to be the most reliable among all biometric methods: we consider that the probability of finding two people with identical iris pattern is almost zero. The uniqueness of iris is such that even the left and right eye of the same individual is very different. That's why iris recognition technology is becoming an important biometric solution for people identification Compared to fingerprint; iris is protected from the external environment behind the cornea and the eyelid. No subject to deleterious effects of aging, the small-scale radial features of the iris remain stable and

INTERNATIONAL JOURNAL OF APPLIED ENGINEERING RESEARCH, DINDIGUL
Volume 1, No 3, 2010



REVIEW ARTICLE ISSN - 0976-4259

fixed from about one year of age throughout life. In this paper, we implemented the iris recognition system by composing the following four steps. The first step consists of preprocessing. Then, the pictures' size and type are manipulated in order to be able subsequently to process them. Once the preprocessing step is achieved, it is necessary to detect the images. After that, we can extract the texture of the iris. Finally, we compare the coded image with the already coded iris in order to find a match an impostor. These procedures can be viewed as depicted in fig.1

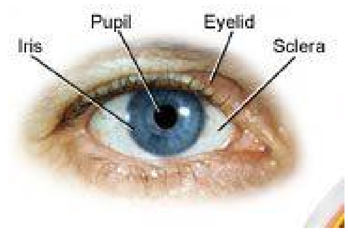


**Figure 1:** The outer structure of iris

A sample iris image is shown in Fig1. Since it has a Circular shape when the iris is orthogonal to the sensor, iris recognition algorithms typically convert the pixels of the iris to polar coordinates for further processing. An important part of this type of algorithm is to determine which pixels are actually on the iris, effectively removing those pixels that represent the pupil, eyelids and eyelashes, as well as those pixels that are the result of reflections. In this algorithm, the locations of the pupil and upper and lower eyelids are determined first using edge detection. This is performed after the original iris image has been down sampled by a factor of two in each direction. The best edge results came using the canny method.The pupil clearly stands out as a circle and the upper and lower eyelid areas above and below the pupil is also prominent. A Hough transform is then used to find the center of the pupil and its radius. Daugman is the first one to give an algorithm for iris recognition. His algorithm is based on Iris Codes. For the preprocessing step i.e., inner and outer boundaries of the iris are located. Feature extraction algorithm uses the modified complex valued Gabor filter. For matching, Hamming Distance has been calculated by the use of simple Boolean Exclusive – OR operator and for the perfect match give the hamming distance equal to zero is obtained. The algorithm gives the accuracy of more than 99.9%. Also the time required for iris identification is less than one second.

### 1.1 Elements of a recognition system

As Figure 1 shows, most iris recognition systems consist of five basic modules leading to a decision:

- The acquisition module obtains a 2D image of the eye using a monochromatic CCD camera sensitive to the NIR light spectrum.
- The segmentation module localizes the iris's spatial extent in the eye image by isolating it from other structures in its vicinity, such as the sclera, pupil, eyelids, and eyelashes.

INTERNATIONAL JOURNAL OF APPLIED ENGINEERING RESEARCH, DINDIGUL
Volume 1, No 3, 2010



REVIEW ARTICLE ISSN - 0976-4259

- The normalization module invokes a geometric normalization scheme to transform the segmented iris image from Cartesian coordinates to polar coordinates.
- The encoding module uses a feature-extraction routine to produce a binary code.
- The matching module determines how closely the produced code matches the encoded features stored in the database.

We use circular Hough transform for localization and Dugman's rubber sheet model for normalization then we use two different feature extraction methods one is log Gabor wavelet for phase analysis and second is laplacian of Gaussian filter for statistical analysis. These two methods are described below.

### 1.2 Localization/segmentation (Hough transform)

The Hough Transform is considered as a very powerful tool in edge linking for line extraction [11]. Its main advantages are its Insensitivity to noise and its capability to extract lines even in areas with pixel absence (pixel gaps) [6]. Image segmentation is typically used to locate objects and boundaries (lines, curves, etc.) in images. Segmentation process is the most important and difficult steps in the image processing system. The circle is simpler to represent in parameter space, compared to the line, since the parameter of the circle can be directly transfer to the parameter space. The equation of the circle is:

$$(x-a)^2 + (y-b)^2 = r^2 \qquad (1)$$

As it can be seen the circle to get three parameter r, a & b, where a & b are the centre of the circle in the direction x & y respectively and r is the radius .Then we have a n dimensional parameter space (three dimensional space for a circle) [7].

## 2. Canny edge detection

The Canny Edge Detector is one of the most commonly used image processing tools, detecting edges in a very robust manner. The Canny edge detection algorithm is known to many as the optimal edge detector. A third criterion is to have only one response to a single edge. The algorithm runs in 5 separate steps:

1. Smoothing: Blurring of the image to remove noise.
2. Finding gradients: The edges should be marked where the gradients of the image has large magnitudes. Compute the derivatives ($D_x(x, y)$ and $D_y(x, y)$) of the image in the x and y directions i.e., use central differencing using the following 3 × 3 kernels:

Then compute the gradient magnitude and the angle of magnitude:

$$D = \sqrt{D_x^2(x,y) + D_y^2(x,y)} \quad \theta = \arctan\left(\frac{D_y(x,y)}{D_x(x,y)}\right) \qquad (2)$$

3. Non-maximum suppression: Only local maxima should be marked as edges. The "non-maximal suppression" step keeps only those pixels on an edge with the highest gradient

REVIEW ARTICLE ISSN - 0976-4259

magnitude. These maximal magnitudes should occur right at the edge boundary, and the gradient magnitude should fall off with distance from the edge.

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. As edge detection is a fundamental step in computer vision, it is necessary to point out the true edges to get the best results from the matching process.

### 2.1 Normalization

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 [8].

### 2.2 Daugman's Rubber Sheet Model

Daugman suggested normal Cartesian to polar transformation that maps each pixel in the iris area into a pair of polar coordinates (r, θ), where r and θ are on the intervals of [0 1] and [0 2π] [2].This unwrapping can be formulated as

$I(x(r, \theta), y(r, \theta))\ I(r, \theta)$ Such that

$x(r, \theta)\ (1-r)\ X_P(\theta) + r\ x(\theta)\quad y(r, \theta)\ (1-r)\ Y_P(\theta) + r\ y(\theta)$

where $I(x, y)$, $(x, y)$, $(r, \theta)$, $(x_p, y_p)$, $(x_i, y_i)$ represent the iris region, Cartesian coordinates, polar coordinates, coordinates of the pupil and iris boundaries along θ direction respectively. Thus this representation often called as rubber sheet model.

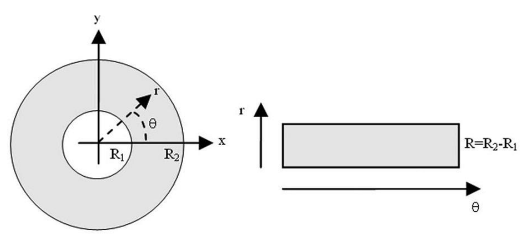


**Figure 2:** Daugman's rubber sheet model

### 2.3 Feature extraction/feature encoding (Laplacian of Gaussian Filters)

The Laplacian is a 2-D isotropic measure of the 2nd spatial derivative of an image. The Laplacian of an image highlights regions of rapid intensity change and is therefore often used for edge detection. The Laplacian is often applied to an image that has first been smoothed with something approximating a Gaussian Smoothing filter in order to reduce its sensitivity to noise. The operator normally takes a single gray level image as input and produces another gray level image as output.

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REVIEW ARTICLE ISSN - 0976-4259

Following statistical features are extracted in this paper by using Laplacian of Gaussian filter:-

(a) Mean

(b) Variance and

(c) Standard deviation of the circles

(d) Pixel correlation

Mean

$$\overline{X^c} = \sum_{i=1}^{N^c} X_i^c, c = \overline{1, C} \ldots\ldots\ldots\ldots (6)$$

Variance

$$S^{c^2} = \frac{1}{N^c-1}\sum_{i=1}^{N^c}\left(X_i^c - \overline{X_i^c}\right)^2 \ldots\ldots\ldots (7)$$

Std. deviation

$$d = \sqrt{\frac{1}{N^c-1}\sum_{i=1}^{N^c}\left(X_i^c - \overline{X_i^c}\right)^2} \ldots\ldots\ldots\ldots (8)$$

Pixel correlation

R = corrcoef (X) returns a matrix R of correlation coefficients calculated from an input matrix X whose rows are observations and whose columns are variables. The matrix $R = corrcoef(X)$ is related to the covariance matrix $C = cov(X)$ by

$$R(i,j) = C(i,j) / \sqrt{(C(i,i)C(j,j))} \ldots\ldots\ldots\ldots (9)$$

C – Number of circles in the segmented iris,

$X_i^c$ – Intensity (gradient) value of *i*th pixel of the *c*th circle,

$N^c$ – Number of pixels along the cth circle

These extracted features are stored in the database for
Identification process. Using these features; an image can be viewed as a feature vector Fc,C =1,C of that image having desired number of circles.In order to encode features, the Wildes et al. system decomposes the iris region by application of Laplacian of Gaussian filters to the iris region image. The filters are given as

$$\nabla G = -\frac{1}{\pi\sigma^4}\left(1 - \frac{\rho^2}{2\sigma^2}\right) e^{-\rho^2/2\sigma^2} \qquad \ldots\ldots\ldots\ldots(10)$$

Where $\sigma$ is the standard deviation of the Gaussian and $\rho$ is the radial distance of a point from the centre of the filter. The filtered image is represented as a Laplacian pyramid which is able to compress the data, so that only significant data remains. Details of Laplacian

REVIEW ARTICLE ISSN - 0976-4259

Pyramids are presented by Burt and Adelson . A Laplacian pyramid is constructed with four different resolution levels in order to generate a compact iris template.

## 3. Iris Code Matching

The two iris code templates are compared by computing the hamming distance between them using equation 11.

$$HD = \frac{1}{N}\sum_{j=1}^{N} X_j (XOR) Y_j \qquad (11)$$

Where, Xj and Yj are the two iris codes, and N is the number of bits in each template. The Hamming Distance

is a fractional measure of the number of bits disagreeing between two binary patterns The Hamming distance approach is a matching metric employed by Daugman for comparing two bit patterns and it represents the number

of bits that are different in the two patterns. Another matching metric that can be used to compare two templates is the weighted Euclidean distance which involves much computation and this metric is especially used when the two templates consist of integer values. Normalized correlation matching technique also involves significant amount of computation. And hence Hamming Distance matching classifier is chosen as it is more reasonable compared with Weighted Euclidean Distance and Normalized correlation matching classifiers, as it is fast and simple.

## 4. Results

**Table 1:** Experimental results Laplacian of Gaussian filter

| HD Criterion | Observed false match rate (FAR %) In proposed method |
|---|---|
| 0.01 | 0 (experimentally) |
| 0.02 | 0 |
| 0.03 | 0 |
| 0.04 | 0 |
| 0.05 | 0 |
| 0.06 | 0 |
| 0.07 | 1 |
| 0.08 | 1 |
| 0.09 | 1 |
| 0.12 | 1 |
| 0.15 | 1 |

## 5. Conclusion

In this paper, we described a fast and effective real-time algorithm for localizing and segmenting the iris and pupil Boundaries of the eye from database images. Our approach detects the center and the boundaries quickly and reliably, even in the presence of eyelashes, under very low contrast interface and in the presence of excess illumination. This paper can

REVIEW ARTICLE ISSN - 0976-4259

enhance the performance of iris recognition system by using the canny edge detection and statistical features for iris recognition. In which we tested the comparison of two iris patterns by using Hamming distance. We have successfully developed this new Iris Recognition system capable of comparing two iris images. This identification system is quite simple requiring few components and effective enough to be integrated within security systems that require an identity check. Results have demonstrated 97% accuracy rate with a relatively rapid execution time. It is suggested that this algorithm can serve as an essential component for iris recognition applications. The experimental results show that the outputs of this paper are satisfactory. It will be better if more statistical features are used such as pixels correlation in the iris area.

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