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Iris Recognition based on Radon Transform

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ABSTRACT
The iris image has been viewed as a texture image. Radon transform has been used for detecting essential lines and curves present in iris texturesThe Radon transformed iris image is divided into distinct non-overlapping blocks. The size of a block is chosen such that sufficient information must appear in it. Then the average variance in each block is computed. The variance of the pixel intensities in each block across all filtered images is used as the feature map. Experimental results are reported in terms of recognition rate to demonstrate performance of implemented algorithms. Eye images of variable sizes from CASIA V_1 and UPOL iris databases have been used for the experimentation.

General Terms
Security,Biometrics,Iris Recognition

Keywords
Daugmen's grid,Radon Transform,Variance,Recognition rate

1. INTRODUCTION
Biometric recognition system has been an important area of research in recent years. Recognition is defined as a process involving perception and associating the resulting information with one or combination of more than one of its memory contents. Traditional methods used for pattern recognition and classifications are statistical [1], feature based [2], transform based. [3] There are two important utilization of biometric systems i) Authentication or verification of a person's identity that is a person proves that he is the person who he claims to be and wants the access ii) Identification in which a person identity is sought by using the biometric sign available.

Traditional methods for personal identification are based on what a person possesses (a physical key, ID card, etc.) or what a person knows (a secret password, etc.). These methods have some problems. Keys may be lost, ID cards may be forged, and passwords may be forgotten. In recent years, biometric personal identification is receiving growing interests from both academia and industry. There are two types of biometric features: physiological (e.g. iris, face, and fingerprint) and behavioral (e.g. voice, signature and handwriting).

Human Iris is a biometric that offers premium performance. Its strength lies in the rich textural information contained in the underlying tissues. These textural patterns are unique to each eye of an individual and even distinct between twins. It contains unique texture and is complex enough to be used as a biometric signature [4]. Its complex pattern contain many distinctive features such as arching ligaments, furrows, ridges, crypts, rings, corona, freckles, and a zigzag collarets. Compared with other biometric features such as face and fingerprint, iris patterns are more stable and reliable.

It is unique to people and stable with age [5][6]. Furthermore, iris recognition systems can be non-invasive to their users [5][6]. The first complete iris based recognition system was designed and patented by J. Daugman [7].A typical automatic identification system Figure. 1 operates by acquiring iris print data from an individual, extracting a feature set from the acquired data, and comparing this feature set against the template feature set in the database.

In an identification scheme the comparison is done against templates corresponding to all the enrolled users in order to recognize the individual (a one-to-many matching); in a verification scheme, the comparison is done against only those templates

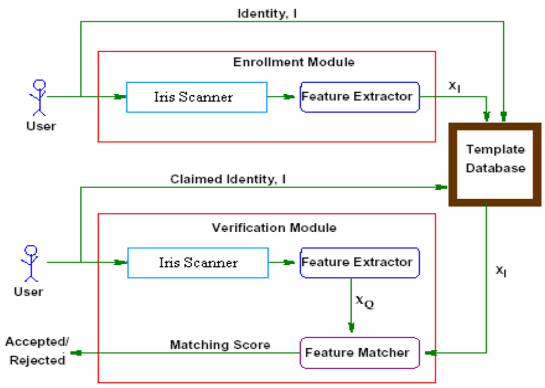


Figure. 1 Enrollment and verification module for Iris Recognition System

corresponding to the claimed identity in order to verify the claim (a one-to-one matching). Thus, identification and verification are two different problems with different inherent complexities [8]. The templates are typically created at the time of enrollment, and depending on the application may or may not require human personnel intervention.

A simple automatic iris recognition system has four important modules:

1.Sensor Module : An iris scanner captures iris print impression of a user.

2.Feature Extraction Module : The acquired iris data is processed to extract feature values. For example, the position and orientation of cups and cone points in a iris print image would be computed in the feature extraction module of a iris recognition system.

3 Matching Module : The feature values are compared against those in the template by generating a matching score. In this module, the number of matching patterns between the query and the template can be computed and treated as a matching score.

4.Decision-making Module : The user's claimed identity is either accepted or rejected based on the matching score generated in the matching module.Iris print matching algorithm compares two given iris prints and returns either a degree of similarity (without loss of generality, a score between 0 and 1) or a binary decision (mated/non-mated). Only a few matching algorithms operate directly on grayscale images; most of them require that an intermediate iris representation be derived through a feature extraction stage. Generally, representation of the iris print acquired during enrollment is referred as the template (T) and the representation of the iris print to be matched as the input (I). The feature extraction and matching algorithms are usually quite similar for identification problems. This is because the identification problem (i.e., searching for an input iris print in a database of N iris prints) can be implemented as a sequential execution of N one-to-one matches (verifications) between pairs of iris prints. This paper present iris recognition based on Radon transform. The complete Radon Transform based iris recognition have been performed sequentially in following ten steps.

Step:1 Read input eye image from CASIA V1 and UPOL iris data

Step:2 Localize circular iris image by using Dougman's grid and Active circular countor method.

Step:3 Remove the eyelids and eye lashes by using gray-level slicing.

Step:4 Convert circular iris image into flat-bed iris image by using Daugman's homogeneous rubber sheet model

Step:5 Normalisation of flat bed iris image and crop the iris image in the fix size.

Step:6 The Radon hotpot has been obtained from circular and flat bed localized iris images.

Step:7 The Radon transform iris image is then divided into 16×16 pixels distinct non-overlapping block

Step:8 The average variance of pixel intensities is used as the fature vector and stored in the database.

Step:9 Matching of two fixed length iris feature vectors has been achieved.

Step:10 Peformance of Radon Transform algorithms has been evaluated by calculating recognition rate for circular and flat bed localized iris.

The remainder of this paper is organized as follows. Section 2 describes iris image preprocessing, which involves iris localization, iris normalization and image enhancement. Basic principles of iris feature extraction using Radon transform are reviewed in detail in Section 3 Section 4 introduces computation of feature vector. Section 5 and Section 6 gives the experimental results and conclusion.

2. IRIS IMAGE PREPROCESSING

2.1 Circular iris localization

The initial stage concerns about the segmentation of the iris. This consists in localize the iris inner (pupillary) and outer (scleric) boundaries, assuming either circular or elliptical shapes for each border. Additionally, it is used to detect regions of the iris texture occluded by any other type of data, as eyelids, eyelashes, glasses or hair.

2.1.1 Circular iris localization using Daugman's grid Method

Initially the image of the eye from UPOL databases is converted to gray scale and its histogram is linearly stretched, as to be able to take benefit of all range given by the 256 levels of the gray scale. Then, following the ideas proposed by Daugman, [10][11] a grid is placed over the image and testing each of the points in the grid, the center of the iris, as well as the outer boundary; i.e., the border between the iris and the sclera, is detected making use of the circular structure of the latter.[9]

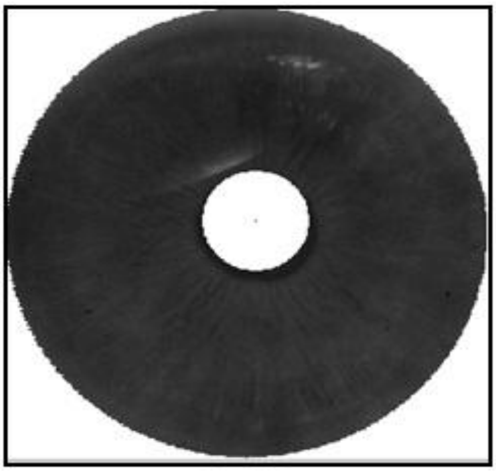


Figure.2 Sample of circular iris images from UPOL databases.

2.1.2 Circular iris localization using random circular contour method

Random circular contour is marked which contains iris and pupil region to eliminate the remaining portion of the eye.[11][12][13] A circular pseudo image is formed of the desired diameter. The inside region of the circle is set at gray level '1'(white) and the outside region to '0'(black). The diameter selected is such that the circular contour will encircle the entire iris. This diameter selection is crucial as it should be common for all iris images. In this method the diameter is set empirically.

Removing the portion of the iris occluded by the eyelids / eyelashes is very important because it affects the recognition results.[6][8]

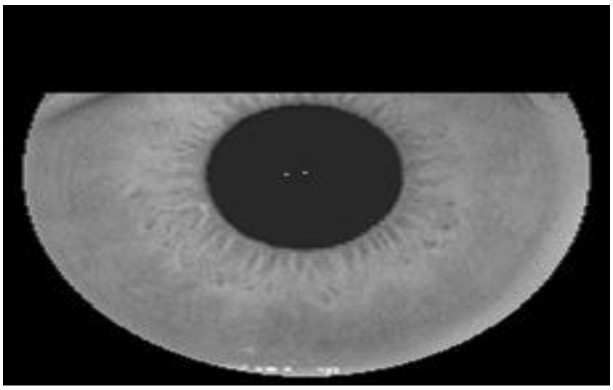


Figure 3. Sample circular iris images from CASIA-V1 databases.

2.2 Flat-bed iris localization

Image processing of the iris region is computationally expensive. In addition the area of interest in the image is a 'donut' shape, and grabbing pixels in this region requires repeated rectangular-to-polar conversions.[12] To make things easier, the iris region is first unwrapped into a rectangular region using simple trigonometry. The unwrapped normalized iris image still has low contrast and may have non-uniform brightness caused by the position of light sources.

All these may affect the subsequent feature extraction and matching. In order to obtain a better distributed texture in the iris, we first approximate intensity variations across the whole iris image.

This estimated background illumination is subtracted from the unwrapped normalized image to compensate for a variety of lighting conditions. Then we enhance the lighting corrected image by means of histogram equalization Such processing compensates for non-uniform illumination, as well as improving the contrast of the image.[9]

Figure 4. Sample flat bed iris images from the CASIA-V1 databases.

3. IRIS FEATURE EXTRACTION USING RADON TRANSFORM

3.1 Line property of Radon transform

The Radon transform is named after the Austrian mathematician Johann Karl August Radon. The main application of the Radon transform is CAT scans.where the inverse Radon transform is applied.The Radon transform can also be used for line detection.[14][15]

Radon transform of a 2-D image $f(x,y)$, denoted as $P_\theta(t)$, is defined as its line integral along a line inclined at an angle θ from the y-axis and at a distance t from the origin shown in Figure 5.

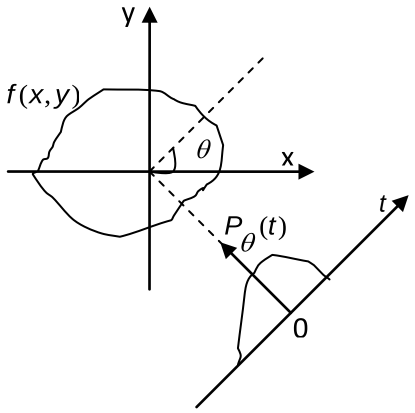


Figure 5. Radon transform $P_\theta(t)$ is the 1-D projection of $f(x,y)$ at an angle θ.

In other words $P_\theta(t)$ is the 1-D projection of $f(x,y)$ at an angle θ, and is given as

$$P_\theta(t) = \int\int f(x,y)\delta(x\cos\theta + y\sin\theta - t)dxdy \tag{1}$$

where,

δ is the dirac distribution.

The line property of Radon transform is an important property utilized for rotation estimation of the shapes in a localized iris image. Radon transform assumes a function that contains line, which is modeled with a delta function.

$$g(x,y) = \delta(y - p^* x - \tau^*) \tag{2}$$

Hence, the function has non-zero values only if (x,y) lies on the line with certain fixed parameters (p^*, τ^*). In this case the Radon transform is given by

$$\check{g}(p,\tau) = \int\int_{-\infty}^{\infty} \delta(y - p^* x - \tau)\delta(y - px - \tau)dxdy$$

(3)

$$= \int_{-\infty}^{\infty} \delta((p - p^*)x + \tau - \tau^*)dx$$

$$= \begin{cases} \dfrac{1}{\left|p - p^*\right|} & \text{for } p \neq p^* \\ 0 & \text{for } p = p^* \text{ and } \tau \neq \tau^* \\ \int_{-\infty}^{\infty} \delta(0)dx & \text{for } p = p^* \text{ and } \tau = \tau^* \end{cases}$$

(4)

Note that for $p = p^*$ and $\tau = \tau^*$, the result is written as infinite function integrated over an infinite interval, hence the result is infinite at that point. If the finite terms are neglected, Radon transform of a line produces a peak (with infinite value) in the parameter domain, and the position of the peak matches the line parameters. This property has the basis of edge feature detection in images [14], which is demonstrated in Figure 6.

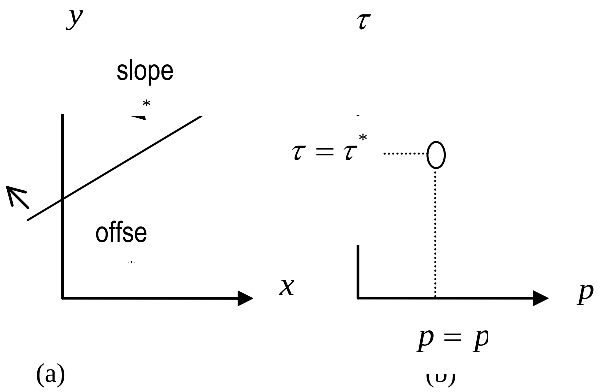


Figure 6.Line property (a) A 2-D function $g(x, y)$, (b) Corresponding Radon transform $\check{g}(p, \tau)$.

3.2 Directional feature extraction using Radon Transform

The Radon transform of a square integrable function f(x1, x2) is defined as,

$$RA(t,\theta) = \int f(x_1, x_2)\delta(x_1\cos\theta + x_2\sin\theta - t)dx_1dx_2$$

(5)

where,

δ is the Dirac distribution.

Radon transform computes the line integral along parallel paths in a certain direction. Radon transform effectively captures the intensity variations in an eye image, which helps in extracting genuine directional features in the localized iris image.

Figure 7. illustrates the significant variation in Radon projections of two different localized iris images.

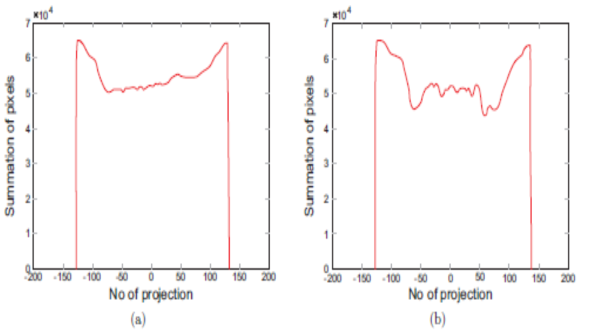


Figure 7. Radon projections in 0^0 for two different irises.

4. COMPUTATION OF FEATURE VECTOR

As the local features represent the iris texture information in better sense, the transformed iris image is then divided into distinct non-overlapping blocks of size 16 × 16 pixels. The size of a block is chosen such that sufficient information must appear in it. Then the average variance in each block is computed.

This results into 8 blocks in each row and 16 blocks in each column for the flat bed iris whereas 16 blocks in each row and column for circular iris. The total number of square blocks over the image is therefore 128 or 256.

The variance of the pixel intensities in each block across all filtered images is used as a feature map. The feature maps of all the selected eye images have been stored in the database. When a query eye image from the same database is given the iris feature vector for circular or flat bed iris is generated and matched with the feature vectors available in the database.The variance corresponds to the energy of the filter response and is therefore, a useful measure of in a local neighborhood and is defined as,

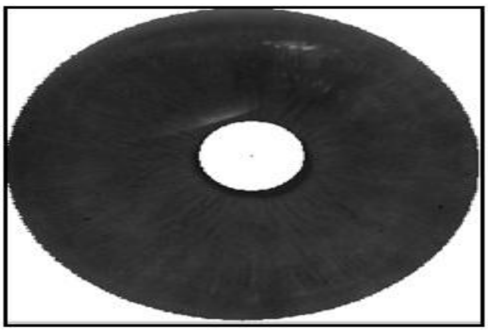
$$R = \sigma^2(i, j) \qquad (6)$$

where,

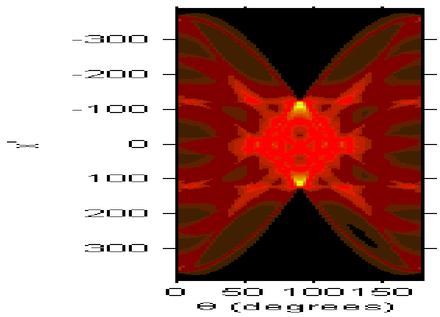
i = 1,2, ... ,8 and j = 1,2, ... ,16 for flat bed iris image.

i = 1,2, ... ,16 and j = 1,2, ... ,16 for circular iris image.

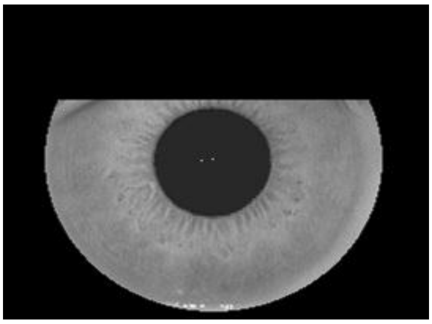
Thus, one-dimensional feature map corresponding to the images is obtained. The Radon hotplot and corresponding variance feature map for different localized iris images from CASIA V1 iris database and UPOL iris database have been illustrated in Figure8. to Figure 10. These feature maps are used to represent and match a query iris image.[16]



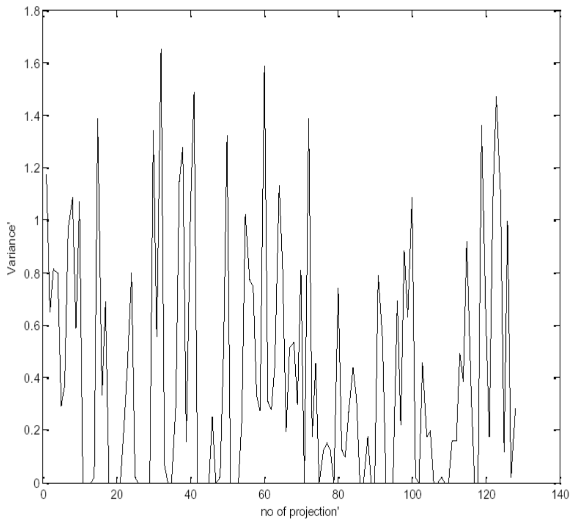
(a)



(b)

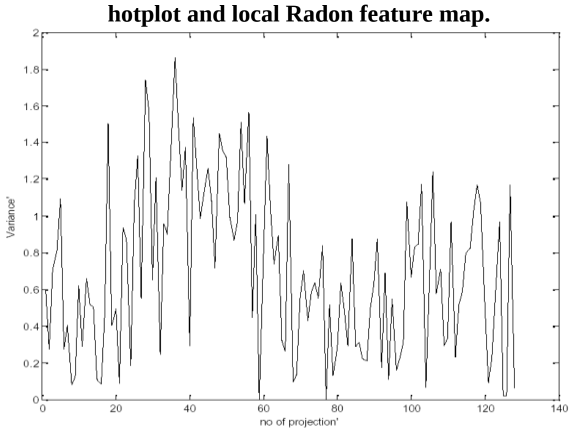


(a)



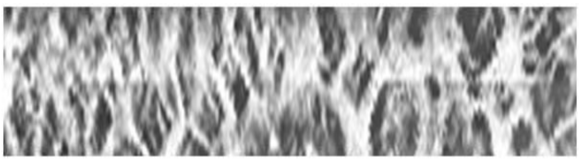
(b)

Figure 8. Circular iris image, corresponding Radon hotplot and local Radon feature map.

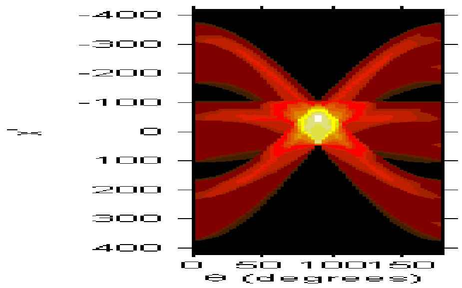


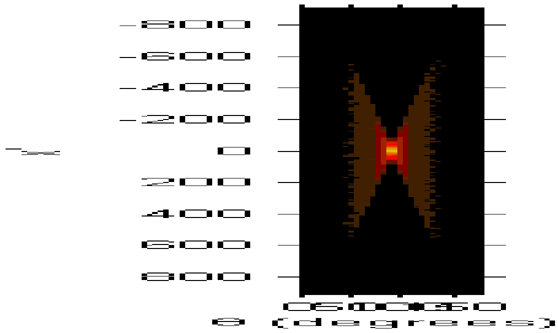
(c)

Figure 9. Circular iris image, corresponding Radon hotplot and local Radon feature map.

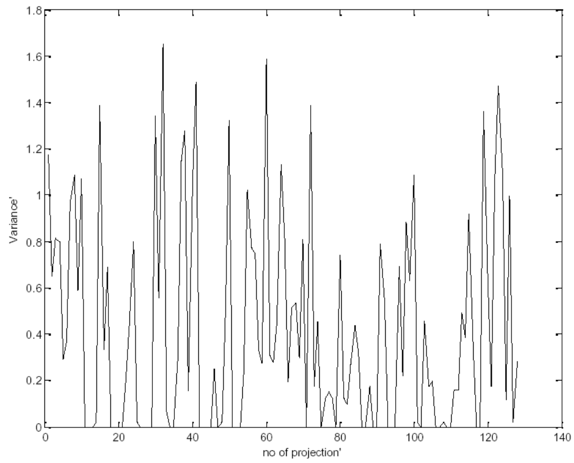


(a)





(b)



(c)

Figure 10. Flat bed iris image, corresponding Radon hotplot and local Radon feature map.

5. EXPERIMENTS AND RESULTS

The algorithm has been implemented and tested on Pentium-IV processor with 2.6 GHz, 512 MB RAM under MATLAB environment. From the CASIA V1 iris database we have selected 372 eye images of 108 different eyes (under different conditions) for 54 subjects and localized them in flat bed and circular iris images. The recognition rate for the proposed algorithms is carried out in two parts as in-database and out-database. In-database means training images and testing images are the same whereas for out-database training images and testing images are different. The result obtained for in-database are listed in Table 1. and result obtained for out-database are listed in Table 2.The results obtained for out-database degrades slightly because the iris images used for recognition have not been presented to the algorithm during training.

Table 1. In-database recognition rate.

Iris database	**Recognition rate**	
	Circular Iris	Flat-bed Iris
CASIA V_1	94.20%	95.60%
UPOL	93.33%	94.86%

Table 2. Out-database recognition rate.

Iris database	**Recognition rate**	
	Circular Iris	Flat-bed Iris
CASIA V_1	72.57%	74.34%
UPOL	69.22%	70.36%

6. CONCLUSIONS

This works present simple iris recognition algorithms. The radon transform has been successfully used for iris recognition. Radon transform computes the line integral along parallel paths in a certain direction. It is effectively captures the intensity variations in an eye image, which helps in extracting genuine directional features in the localized iris image. Directional variance features reported better results even for partial iris images without eyelashes and eyelids. The Radon hotplot and corresponding variance feature map for different localized iris images from iris databases are effectively used to represent and match a query iris image.

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