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Iris Recognition using Gabor Wavelet, Harris Corner and Random Forest Classifier

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Abstract – **This paper presents the use of biometric identification through iris recognition, in specific environments that require a high level of security, such as penitentiaries. The image processing technique is utilized to process the human iris database images. It finds the centre coordinates along with the radius for the iris. Noise elimination around the iris image is also performed. The extracted features are the inputs for the random forest classifier which provides the output in the form of class for the identification of the person. In this paper, a hybrid approach of feature extraction based on different combination of Gabor wavelet and Harris Corner method is proposed. Random forest classifier is used for classification of extracted features. The simulation results are tested for the publicly available databases; CASIA iris image database, IIITD CLI iris image database, and achieve outperforming results for the iris matching. The hybrid feature extraction provides 98.9% of accuracy with proposed experimental setup.**

Keywords – **Gabor Wavelet, Iris Recognition, Wavelet Moment, Random Forest Classifier.**

I. Introduction

With the recent development of information technology and the need for higher security standards, intelligent systems for the identification and verification of people have become a very useful tool and a very interesting field of research. Traditional methods (cards, keys, etc.) have given way to biometric technology, which uses physiological characteristics to distinguish people. One of them is biometrics based on the iris pattern, characterized by having high stability and discriminating power [1].

In terms of recognition performance, systems for identifying individuals from the iris image are characterized by very low errors of false acceptance or false refusal. However despite its high performance, various difficulties in the process of identification still exist. Problems are encountered especially in the segmentation and normalization of the iris. Inaccurate segmentation leads to a false determination of the iris region, which leads to a false constitution of the iris profile [2]. While inadequate normalization of the iris region leads to non-optimized sampling and representation of the iris texture. The effect of these two problems is observed by a small correspondence when comparing the iris profiles of the same class, which increases recognition errors.

Moreover, a better knowledge of the presence and the location of the discriminant information of the iris makes it possible to optimize the normalization. A normalization method developed with this knowledge in mind can favour areas of the iris that are rich in discriminating information compared to other regions [3].

Consequently, by improving the way in which the iris is segmented and then standardized, it is necessary to improve the recognition performance of the recognition system by increasing the rate of good identification [4].

There are several biometric technologies and among them the iris whose recognition uses it as a unique form of identification to allow or deny access to secure and confidential areas. Iris recognition is often confused with retinal scan. An iris recognition system will capture an image of the eye and then analyse the colour surrounding the pupil. Thus, iris recognition will capture an image of the texture of the iris, while a retinal scan will capture an image of the structure of the blood vessels in the eye. Since the iris is visible while the blood vessels are not, it is much easier to capture an image of the iris [5].

Section two presents a generalized frame if biometric iris recognition framework. Section three describes the proposed methodology. Simulation results are explained is section four followed by the conclusion in section five.

II. Iris Biometric System

In a biometric identification system, a series of general steps must be performed (not all of them should always be done) as shown in Figure 1.

In the particular case of the identification systems by means of the iris, in each of these stages a subset of

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actions must be carried out, which are detailed below:

A. Acquisition

It is obtaining the image of the iris with a specific device.

B. Pre-processing

This stage is divided into the segmentation, standardization and improvement stage.

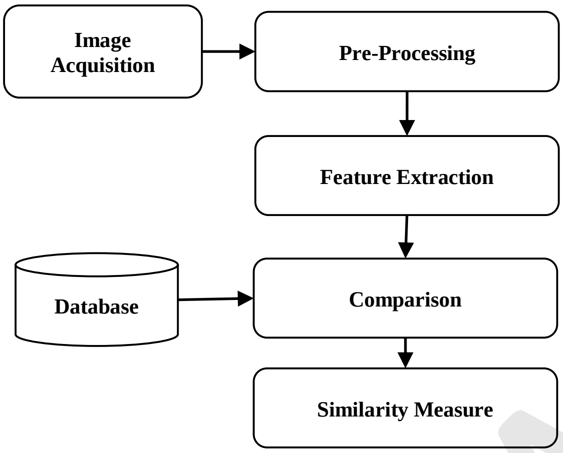

Figure 1: General stages of a biometric iris identification system

In the segmentation stage the iris is isolated from the rest of the image. If the iris is not isolated correctly, the correct identification can be difficult.

- In the normalization stage it is possible that the image of the isolated iris is independent of the size of the pupil, because it can vary in each image. Normalizing the image involves transforming the annular region of the iris into a rectangular region of constant dimensions.
- The improvement stage prepares the normalized image by modifying it and preparing it for the extraction stage.

C. Feature Extraction

At this point the representation of each image (or iris) is obtained in order to be easily compared with the rest of the images. In the extraction stage different methods can be used to extract the characteristics of an image, among which we can mention DWT, Gabor wavelet, among others.

D. Comparison

At this stage a measure of difference between the templates compared is computed, and based on this measure it is decided whether the codes have been generated by the same iris or not. Among the most used methods can be mentioned the Hamming Distance and the Euclidean Distance to perform the verification (determine if the person is who they say they are) or the identification (determine the identity of an individual, comparing the image against the entire Database).

III. PROPOSED METHODOLOGY

Motivated by the results obtained by [6] and their flexibility for the fusion based feature extraction in biometric recognition of the iris, it is proposed to represent the texture features of the iris. Figure 2 represents the flow diagram of the new proposal, which shows the peculiarities of the use of various features in the stage of extraction of traits.

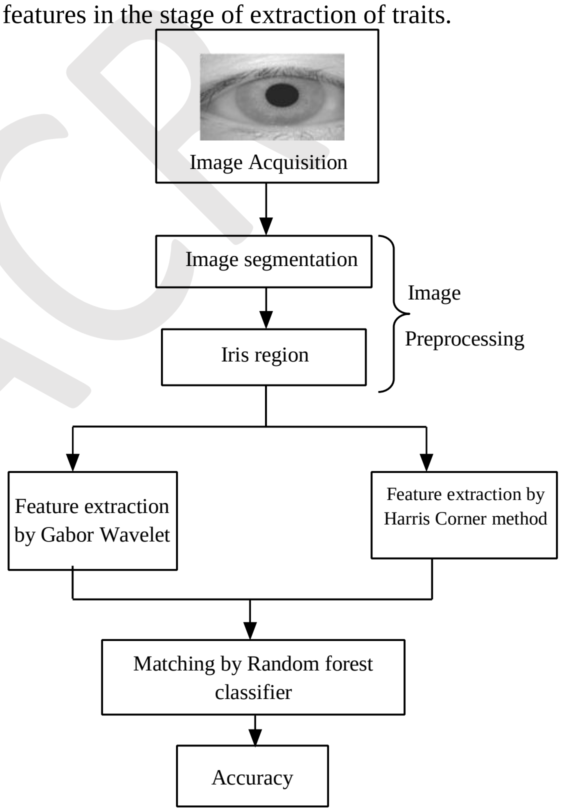

Figure 2: Flow diagram for proposed approach

The main steps of the method will be explained below:

A. Pre-Processing

We worked with a database of human iris obtained from publicly available databases; CASIA iris image database, IIITD CLI iris image database.

1) CASIA Iris Image Database:

The database contains 108 image folders having 7 images in each folder. So the total number of iris image sample is 756 in CASIA database [7].

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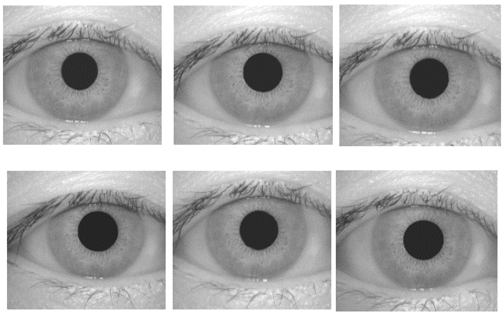

Figure 3: Sample images from CASIA dataset [7]

2) *IITD CLI Iris Image Database:*

The database contains 127 image folders having 10 images in each folder. So the total number of iris image sample is 1270 in IITD CLI database [8].

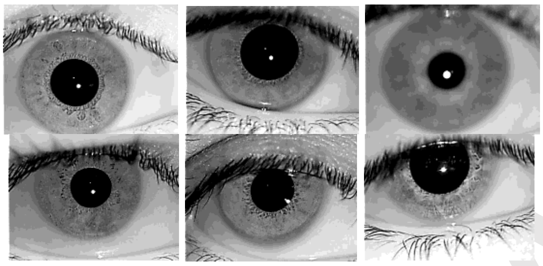

Figure 4: Sample images from IITD CLI dataset [8]

The dimensions of the images are 320×240, in BMPformat [5] [6].

Obtaining coordinates of the center and radius of iris and pupil. First, edge detection is applied with the canny method; then the process continues using a gamma adjustment of the image; to the resulting image obtained previously a non-maximum suppression is applied; subsequently the threshold method is applied to the image.

Finally, the Hough transform is applied to find the maximum in the Hough space and, therefore, the parameters of the circle (row and column of the center of the iris and its radius).

In order to obtain the coordinates of the center and radius of the pupil, the same previous method is carried out, only taking into account at the end the coordinates of the center and radius of the iris to determine those of the pupil.

Main input image of IRIS is further cropped according to calculated coordinate from above process and this cropped image is used for feature extraction.

B. *Feature Extraction*

Two feature extraction methods are used for proposed Iris recognition.

1) *Gabor Wavelet*

The directional decompositions for image analysis were probably initiated by Gaussian windowing in the 2D Fourier domain, and continued 4D filters as well as the directional Gabor wavelets proposed by J. Daugman [9]. The use of Gabor's wavelets for the image is often linked to the consideration of the human visual system.

Gabor wavelets are constructed by isotropic Gaussian windowing of a complex plane wave of frequency F in direction θ [10]:

$$\psi^{\theta}(x) = \frac{e^{-\|x\|^2/2}}{2\pi} e^{-j(x^T\omega_0)} \quad (1)$$

Where, $\omega_0 = F[\cos(\theta)\,;\sin(\theta)]^T$

The decomposition depends on the number of orientations K that one fixes, and that one can distribute evenly in $[0,\pi]$.

$$\theta \in \Theta = \left\{\frac{k\pi}{K}; 0 \le k \le K\right\} \quad (2)$$

We can then decompose any real 2D signal (x) by scalar product with the following atoms:

$$\left\{\psi^{\theta}_{j,u}(x) = 2^{-j}\psi^{\theta}\left(2^{-j}(x-u)\right)\right\}_{\theta\in\Theta, j\in\mathbb{Z}, u\in\mathbb{R}^2} \quad (3)$$

2) *Harris Corner Method*

Harris corner detection is a post-processing technique used for smile recognition by the lip corner data, eye detection and many more [11]. Harris corner detector has to detect the corners in the iris image I_I. Going stepwise, firstly I_I is used to create gradient image through filtering it with Gaussian Mask. And then the Harris corner method is imposed [11].

Harris Corner Algorithm [12]:

1. Find the vertical gradient and horizontal gradient represent as follows:

$$\mathrm{M} = \begin{pmatrix} P & R \\ R & Q \end{pmatrix} = \begin{pmatrix} I_x^2 & I_{xy} \\ I_{xy} & I_y^2 \end{pmatrix} \quad (1)$$

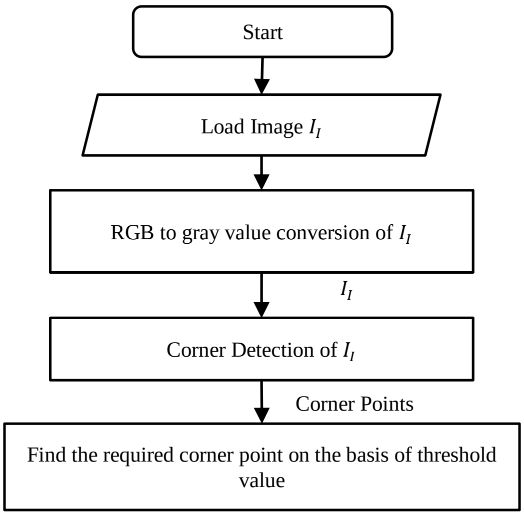

Figure 5: Flow diagram of Harris Corner detection

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2. Compute x and y derivatives of image:
$$I_x = G_\sigma^x * I, \quad I_y = G_\sigma^y * I \tag{2}$$
3. Compute product of derivatives at every pixel:
$$I_x^2 = I_x * I_x, \quad I_y^2 = I_y * I_y, \quad I_{xy} = I_x * I_y \tag{3}$$
4. Apply Gaussian filter to the image:
$$w_{\mu,v} = \exp\left(\frac{-1}{2}\left(\mu^2 + v^2\right) / \delta^2\right) \tag{4}$$
Where, $w_{\mu,v}$ is a Gaussian window [12].
5. Calculate the r value of the pixel:
$$R_r = \left\{I_x^2 + I_y^2 - \left(I_x I_y\right)^2\right\} - k\left\{I_x^2 + I_y^2\right\}^2 \tag{5}$$
6. Selection of local extreme points.
7. Threshold determination and define the corner point.

C. Classification by using Random Forest Classifier

The random forest technique modifies the Bagging method applied here to trees by adding a de-correlation criterion between these trees. The idea behind this method is to reduce the correlation without increasing the variance too much. The principle is to randomly choose a subset of variables that will be considered at each level of choice of the best node of the tree.

Consider a training set $S = \{(x_1, y_1), \ldots, (x_m, y_m)\}$, a has the number of attributes of the examples of X. Also consider S_t a bootstrap containing m instances obtained by resampling with replacement of S. Let $\{h_1, \ldots h_t\}$ be set of T decision trees. Each tree h_t is built from S_t. For each node of the tree, the partitioning attribute is chosen by considering a number $f\,(f < a)$ of randomly selected attributes (among the attributes a). To classify a new instance x, the random forest classifier performs a uniformly weighted majority vote of classifiers in that set for instance x. The algorithm illustrates this principle [13].

Algorithm:

Input: $S = \{(x_1, y_1), \ldots, (x_m, y_m)\}$, *the training set.*
Input: T, *the number of decision trees in the random forest.*

For $t = 1, \ldots, T$ *do*

1. *Generate a Bootstrap sample* S_t *of size* m *from* S
2. *Create a decision tree* h_t *from* S_t *by recursively repeating for each node of the tree the following steps:*
   a. *Randomly select* f *attributes among* a *attributes.*
   b. *Choose the partitioning attribute among* f
   c. *Partition the node into two child nodes*

End for

Output: H, *the random forest classifier*

IV. Simulation And Results

MATLAB (2014a) based simulation scenario has been developed.

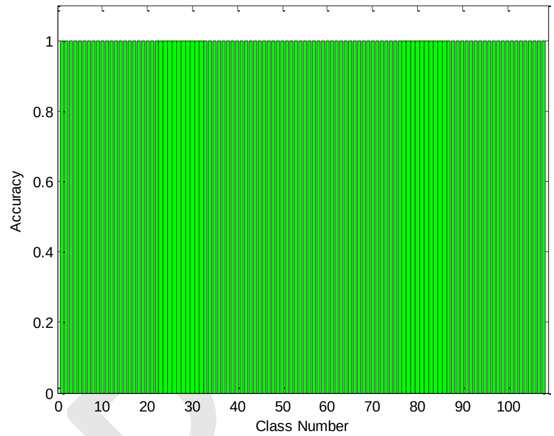

Figure 6: Accuracy graph for proposed approach

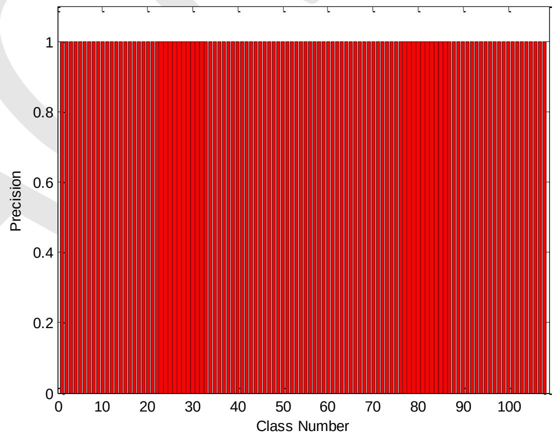

Figure 7: Precision graph for proposed approach

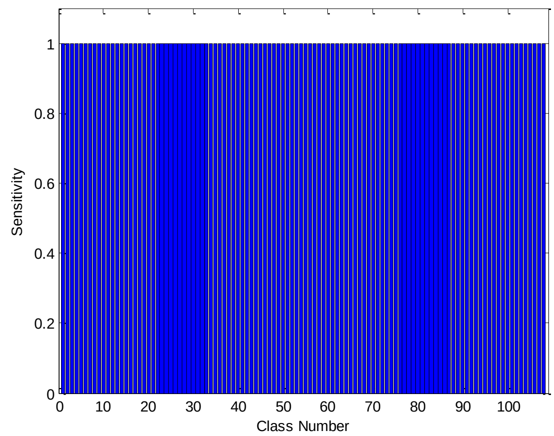

Figure 8: Sensitivity graph for proposed approach

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Table 1: Comparative analysis

Method	Classifier used	Accuracy (%)
Cross-sensor Iris Recognition Performance using IIITD CLI Database [14]	Naive Bayes Nearest Neighbor Classification	89.92%
Proposed Approach using IIITD CLI Database	Random Forest Classifier	93.2%
Proposed Approach using CASIA Database	Random Forest Classifier	98.9%

V. CONCLUSION

The recognition of iris is currently one of the most accurate biometric techniques. In an iris recognition system, pre-processing, especially iris segmentation, plays a very important role. The raw iris image is segmented with canny edge detector. Further hybrid features (Gabor wavelet + Harris Corner) is used with random forest classifier. This work achieved maximum accuracy of 98.9% with the CASIA database while the IITD CLI database attains the accuracy of 93.2%. It is interesting to see the iris feature extraction in future, iris images obtained in less controlled environments, for example, under different lighting conditions.

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