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Efficient Method for Iris Recognition System

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ABSTRACT: This article, presents and evaluation an efficient iris recognition method that works well in imaging conditions with fewer restrictions. The iris images may degrade considerably due to picture blurring, posture variation, noise, and occlusion so the Circular Hough Transform (CHT) and Truncated Total Variation model are used to smoothing the uninteresting structures and retaining the significant edges that belong to Iris images, for achieve significant improvement in locate and separate the iris accurately from noises and other parts in an eye image. Doughman's rubber sheet model is used to make the split iris area regular and normalized. The Principal Component Analysis (PCA) method is used to identify features of iris patterns that are obtained from Eigen irises. A test image is projected onto the subspace occupied by the Eigen iris to do recognition. Then, recorded Eigen irises are compared with the test image by finding the normalized hamming distance between them. Results accurate of the suggested system have been up to 95.5%.

Keywords: Biometrics, Iris Recognition, Pattern Recognition, Principal Component Analysis, Truncated Total Variation, Doughman's Rubber Sheet Model.

1. INTRODUCTION

With more and more apps that need security in everyday life and more and more users, security is becoming increasingly important. This has made having an effective human-recognizable proof system based on biometrics is more important. In this way, there needs to be a validation/approval structure that can tell the difference between a person and a card or password-based identity system. When it comes to biometric models [1], they can be broken down into two groups: social and physiological. The physiological group includes fingerprints, eye prints, palm prints, and the shape of your face or hands. Categories like speaking, typing patterns, and walking patterns are all examples of behavioral categories. Because of progress in science and technology, biometrics can now be used where people's identities need to be established or con-firmed [2]. More people want better protection in their daily lives, which led to the development of a dependable and smart unique person identification system. Card or password-based recognition methods can be broken into if cards are lost or stolen, or passwords are forgotten. Because of this, biometric recognition methods are needed to identify people without using what they have or what they know. Among the many ways biometric technology has been used to make identification and verification more reliable are financial services, database access, border control, access control in restricted areas, and passenger control in airports [2]. Biometric technology in banking services has shown great potential for making customers feel safer and more comfort-able. For instance, biometrics-based banking and transfers will be safer, faster, and easier than the ways we do things now with credit and debit cards. You can use the retinal vascular structure feature for biometric recognition because it gives you safer results when identifying a person. Iris-based biometric identification is also very popular because it is very reliable and works well for proving who a person is [3]. The iris of a human being is very useful for science because iris patterns are very different in nature. It's most useful for steadiness since a person's iris doesn't change over time [4].

Many early iris recognition systems focused on differences in the iris's pattern. These can be broken down into four groups: stage-based methods [5], zero-intersection representation [6], texture investigation [7], and changes in brightness. Several professional iris capture systems, like the LG 2200 and LG 4000, use near-infrared light to take pictures of the

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iris. The suggested method uses the Circular Hough Transform (CHT) and the Truncated Total Variation model together to separate an iris from some unwanted noises. The experiment that was done showed that it worked well. After that, the suggested method [8] (PCA) to extract the iris texture and the hamming distance method [9] to identify people. The UBIRIS.v2 database was tested in this study, and the results were very accurate. These results made up a clever surveillance system.

The rest of the paper is set up like this: Parts 2 some related works are presented. part 3 and 4 talk about the proposed method's approach and algorithm, and Part 5 shows the results of the experiments and discussions of the proposed system. The paper comes to an end in Section 6 is conclusions.

2. RELATED WORK

The authors in [10] suggested a method to compare the three feature extraction techniques —Gabor filter, PCA, and independent component analysis (ICA) presented a strategy that included using the Hough transform, Doughman's rubber sheet model, and Hamming distance for segmentation, normalization, and classification, respectively. For the Gabor filter, their average accuracy was 92.85%.

The authors in [11] proposed a technique using PCA based on DWT to select iris template features and increasing iris recognition efficiency. Used converting the iris image into one frequency band and applying PCA for feature extraction and Euclidean Distance for classification. Their experiment on the CASIA database images shown recognition accuracy of 92.6%.

The authors in [12] proposed two comparative approaches. The first approach uses Fourier descriptors (FD) to extract iris features in the frequency domain. where the high spectrums represent fine details while the low spectrums provide the general description of the iris pattern. The second approach, principle component analysis (PCA) reduces the dimensionality of the feature values by using statistical techniques to determine the most significant feature. For the purpose of comparison, the Manhattan, Euclidean, and Cosine classifiers are subjected to the distance measuring method. It satisfied 80%, 92%, and 94% correct matching for PCA against 86%, 94%, and 96% for FD using Cosine, Euclidean, and Manhattan classifiers respectively.

The authors in [13] suggested a method to compare the two feature extraction techniques, PCA and Fourier descriptors (FD), This a method employed the Manhattan classifier, Doughman's rubber sheet model and the circular Hough transform for classification, normalization, and segmentation. Their average accuracy for PCA was 94%.

The authors in [14] proposed a method that applies PCA and then recognition is performed using Euclidean distance these methods called the smooth median filter. The iris/pupil boundary and sclera/iris boundary are found using a normalized Dougman rubber sheet. Their proposed algorithm has been tested on CASIA V3i database images and the experiment achieved an accuracy rate of 93.98%.

The authors in [15] presented a system for iris recognition in which they minimized the amount of data using PCA. Verifying the similarity between the features and the training image is done using the minimal distance. Without a reduction in performance, the cosine approach outperforms other methods. They tested their approach on two iris databases, CUHK and UTIRIS. Their experiment produced excellent results in terms of accuracy recognition, with CUHK accuracy coming in at 92.519% and UTIRIS accuracy coming in at 91.139%.

The authors in [16] suggested a method based on Principal Component Analysis (PCA) and Discrete Wavelet Transformation (DWT) for lowering the runtime required for iris template classification and extracting the best characteristics of an iris and also using SVM for classification. An iris image is divided into four frequency sub-bands using DWT. By employing PCA, one frequency sub-band rather than four has been exploited for further feature extraction. An experimental study using the CASIA.v4 iris image database shown recognition accuracy of 95.4%.

The authors in [17] proposed the improved iris recognition system including image registration as a main step as well as the edge detection method for feature extraction. Also proposed the PCA-based method as an independent iris recognition method based on a similarity score. The system proved to be efficient, and it saved time as it had a processing time of 6.56 sec, and it improved the accuracy to 89.99%.

3. METHODOLOGY

Usually, the following steps make up iris recognition processing: Getting an image (i), segmentation the iris (ii), Normalization (iii), extracting features (iv), and matching (v). This study used the Circular Hough Transform (CHT) and the Truncated Total Variation model to split the images and find the iris and pupil regions. Using Doughman's rubber sheet model, the split eye area was made to fit into a rectangle block with set polar measurements. For feature extraction, PCA was used on an iris that was normalized and of a constant size. To match the resemblance, the hamming distance was used. The steps we took to recognize an iris are shown in Figure 1.

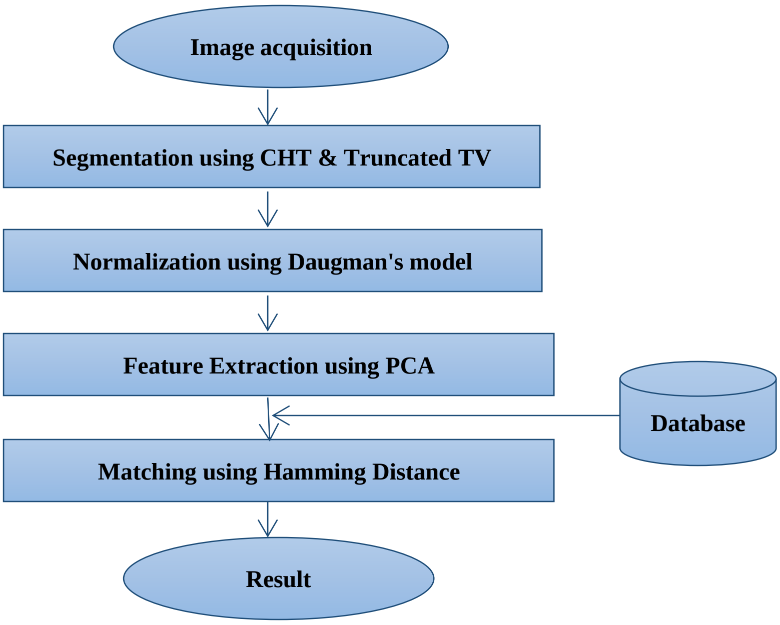


FIGURE 1. - Diagram of an iris recognition system

3.1 Image acquisition

In the first step of iris recognition, called "image acquisition," a series of high-quality pictures of the client's iris are taken with cameras and sensors. The images should clearly show the eye, especially the iris and pupil [18]. After that, some preparation steps may be used to improve the quality of the pictures, such as getting sharp images with enough resolution. Instead of taking pictures of eyes for this study, the UBIRIS v2 database is used. Some pictures of eyes from the UBIRIS.v2 collection are shown in Figure 2. The main goal of the UBIRIS.v2 database is to create a new tool that can estimate how possible it is to recognize irises using visible wavelengths when image conditions are far from ideal. In this field, the different camera distances, subject perspectives, lighting conditions, and non-ideal pictures in this database could be very helpful in figuring out the limits and possibilities of iris detection in the visible wavelength. There were two separate sessions for getting images. To improve the variety, the capture device's orientation, artificial light sources and, and position were changed from the first session to the second. For most people, the session resulted in 15 pictures per eye. It's important to stress that the only reason for this suggested helpful behavior is to ensure enough usable pictures for each subject and imaging session. One of the main things that sets the UBIRIS.v2 database apart from the others the distances significantly higher range between the subjects and the imaging framework [19].

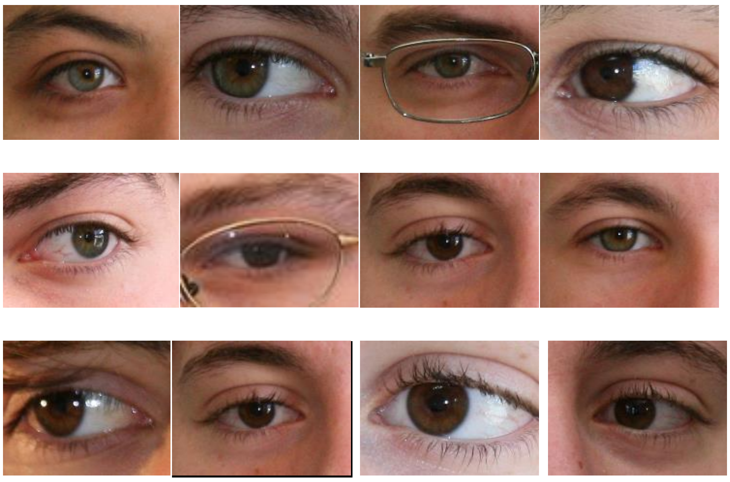


FIGURE 2. - Examples of the eye's images from the UBIRIS.v2 dataset

3.2 Iris segmentation

Iris segmentation is the next step in iris recognition. This is the process of separating the real iris area from the image of the digital eye. Two circles can be used to make a rough shape of the iris region shown in Figure 3. One circle will mark the boundary between the iris and the sclera, and the other will mark the boundary between the iris and the pupil.

• Circular Hough transform and a truncated TV model: The quality and accuracy of eye segmentation are affected by the source illumination's brightness and angle changes. This means that pre-processing has to be done before segmentation. The Single Scale Retinex (SSR) Algorithm is used to make the image's colors more consistent, and the Gaussian filter and median filter are used to eliminate the noise in the pattern pixels. A picture taken in a less restricted setting often includes complicated features like noise, eyebrows, and shadows. The suggested method used a truncated TV model, edge detection, which figures out the center and radius of the iris and pupil, removes noise, and finds the eyelid through the segmentation step. To get good iris segmentation, the first step is to find the edges of eye structures like the eyelid, pupil, and sclera in the pictures that are input. The suggested truncated TV [20] measures local pixel change and separate image structures; it regularizes energy. It also shows more important geometric features. These kinds of local gradient descriptors make it easy to recognize important picture structures from background features like the edges of the eyelids, sclera, and pupils in noisy eye images. Finding the exact location of the eye's structure can help you find the borders between the limbic system and the pupil, which is needed for correct iris segmentation. The Circular Hough transform (CHT) is used to identify the pupils and iris accurately.

This study uses an improved adaptation of CHT, which can be found in [21]. With this method, a two-stage CHT is carried out. In the first step, we keep bringing down the half circle because the brows and eyelashes are getting in the segmentation way. After the first step of CHT, an estimate of circle focus is gained. In the second step, we enable the re-seeking process the more accuracy to focus position and distinguish span. Improved CHT leads to a robust iris area confinement.

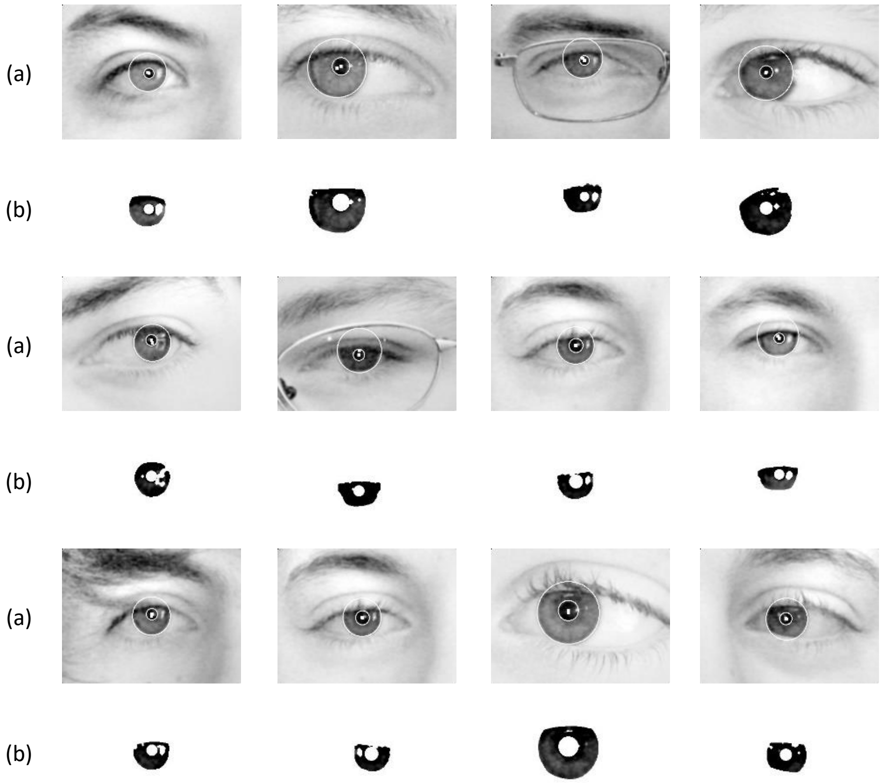


FIGURE 3. - (a) Internal and external iris boundaries, (b) Iris segmentation

3.3 Normalization

As soon as the iris area of an eye picture has been properly separated, it needs to be changed the iris region from a circle to a rectangular block of a fixed size. As a result of the normalization process, the iris regions will always have the same size. This means that two pictures of the same iris taken in different situations will have unique features in the same place [22]. The rubber-sheet approach by Doughman is used to make the iris image normalize in this study.

• Daugman's rubber-sheet model: Daugman's rubber-sheet model is the most common way to normalize the iris, un-wrapping the segmented iris to a fixed size The iris image is changed from a circular image into a rectangular image during the normalizing process. The circle intensities in the image of the iris are changed to polar intensities using Doughman's rubber sheet model. During the normalization process, "Doughman's Rubber Sheet Model" [23] changes the point of the iris from a polar coordinate pair (r, θ) to a Cartesian coordinate pair (x, y). Figure 4 shows the normalization process. The following formulas are used to perform the transformation.

$$\theta \in [0 \;\; 2\pi], \rho \in [0 \;\; 1], I(x(\rho,\theta), y(\rho,\theta)) \rightarrow I(\rho,\theta)$$

(1)
$$x(\rho,\theta) = (1-\rho)x_p(\theta) + \rho x_i(\theta)$$
$$y(\rho,\theta) = (1-\rho)y_p(\theta) + \rho y_i(\theta)$$

(2)
$$x_p(\theta) = x_{p0}(\theta) + r_p \cos(\theta)$$
$$y_p(\theta) = y_{p0}(\theta) + r_p \sin(\theta)$$

(3)
$$x_i(\theta) = x_{i0}(\theta) + r_i \cos(\theta)$$
$$y_i(\theta) = y_{i0}(\theta) + r_i \sin(\theta)$$

The polar coordinates are (ρ,θ), and the normalized Cartesian coordinates are (x, y). The iris region is I(x, y), and the coordinates of the limbus and pupil boundaries along the θ direction are (x_i, y_i) and (x_p, y_p). The coordinates of the iris and pupil centers are (x_{i0}, y_{i0}), and (x_{p0}, y_{p0}) [24].

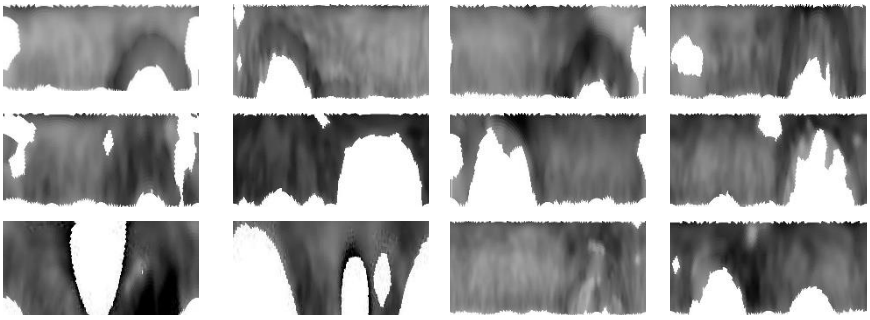


FIGURE 4. - Normalization iris images

3.4 Feature extraction

In an iris recognition system, feature extraction is the most crucial phase. The feature extraction technique involves minimizing the quantity of information needed to characterize a vast array of data found in an iris pattern. Effective feature extraction methods are largely responsible for the reduction of classification time and the successful recognition rate of two iris templates. Most iris detection techniques currently rely on local characteristics like phase, shape, etc. Where implementing iris image synthesis based on local characteristics is challenging.

• Principle component analysis: Principle Component Analysis (PCA) is an important approach in image representation and feature extraction. It is a method for expressing the data and finding identifying patterns in the iris to emphasize their differences and similarities [25]. When measurements are taken for many observed variables and a smaller set of artificial variables, known as principal components, is created to account for the majority of the variation in the observed variables, PCA is suitable. The principle components might be used as criteria or predictor variables in a later study.

The following are included in the mathematical analysis of PCA:

1. The equation provides the mean of each vector:

(4)
$$x_m = \frac{1}{N}\sum_{k=1}^{N} xk$$

2. The equation provides a collection of zero mean vectors that are obtained by subtracting the mean from each vector:

(5)
$$x_z = x_i - x_m$$

where x_z represents the zero mean vectors, xi denotes each column vector element, and xm represents the mean of each column vector.

3. The equation is used to construct the Covariance matrix:

$$c = [x_z \ T^* x_z] \quad (6)$$

4. The following equation calculates the Eigenvectors and Eigenvalues:

$$[c - yi] \ e = 0 \quad (7)$$

y's are the Eigenvalues, and e's are the Eigenvectors.

5. Zero mean vectors are multiplied by each eigenvector. The vector of features. The following equation yields the feature vector:

$$fi = [x_z]e \quad (8)$$

3.5 Matching

To determine similarities between two iris templates, the template created during the feature extraction step requires a matching metric. This measure provides two types of value ranges: one range for templates created from the same eye and another range for templates generated from various people's eyes. To determine if two templates are from the same or different person.

• Hamming Distance: Due to the need for bit-wise comparisons, the Hamming distance was used as the recognition matching measure. The degree of similarity or difference between two iris patterns was processed using the Hamming distance approach, including noise masking. Using the iris pattern bits in both noise masks with the same value as the '0' bits will be used to compute the Hamming distance. We now employ the bytes from the iris's actual area to calculate the Hamming distance, and we provide the formula for this updated measure [26].

$$HD = \frac{1}{N} \sum_{j=1}^{N} X_j (XOR) Y_j \quad (9)$$

N bits are represented by each of the two bit-wise templates, Y_j and X_j, that need to be compared. While it is theoretically possible for two identical iris templates to have a hamming distance of zero, this is not likely to happen in practice. Every two iris intra-class templates will differ in various ways. This is because noise will sometimes sneak through normalization and the normalization process isn't ideal. The Hamming distance between two templates will be calculated using a bit-wise shift to the left and right for one of the templates to account for rotational irregularities. The horizontal bits move in a way that is proportionate to the angular resolution that is applied, which is proportionate to the iris area's initial rotation. A 180-degree resolution on the iris transfers to a 2-degree rotation every shift. As explained by Doughman [27], this technique corrects alignment problems caused by rotational variations during the imaging process by using a normalized iris pattern. Only the smallest value of the Hamming distance is utilized since this indicates the greatest similarity between the two-templates.

4. ALGORITHM

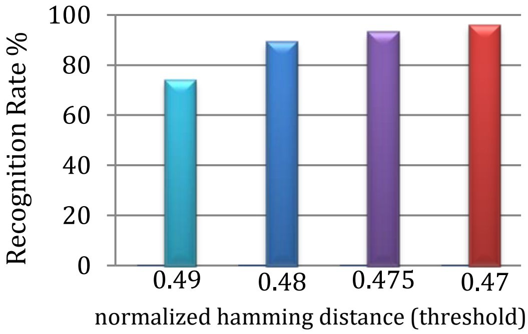
"Problem Definition": the biometric characteristic of the iris can be utilized to authenticate humans. Using the iris , this algorithm finds whether a person is authorized or not.

"The objectives are": This technique uses iris segmentation, normalization, PCA, and HD matching to identify a person.

Enter: Eye picture.
Output: An individual's recognition
Step 1: input the eye image.
Step 2: Gaussian filter and SSR are pre-processing used in step two.
Step 3: Segmenting the iris using the Truncated T V model and CHT.
Step 4: Apply Doughman's model to normalize iris data.
Step 5: PCA is used to create a feature vector to the approximate band.
Step 6: Create each image's signature.
Step 7: For the test image, follow steps 1 through 6.
Step 8: HD matching is used to determine if a match or no match exists.

5. EXPERIMENTAL RESULTS AND DISCUSSION

This section reports the evaluation and results of the suggested approach using the UBIRIS.v2 iris database. 1500 iris images, of which 900 were entered for training purposes in database and 600 for performance evaluation. In this work, we have de-vised a method to minimize the runtime while maintaining the highest level of accuracy. To find the distance between the iris features, used Hamming distance method. The access is granted If this distance is zero, this is difficult to achieve occlusions such as eyelashes, eyelids, noise effect iris features, and variation under different lightening conditions. where the different values of threshold effaced on the recognition rate. It is evident that when the threshold value is decreasing, the recognition system's accuracy increases. Different values of threshold and the recognition rate variation are shown in Figure 5.



threshold	0.49	0.48	0.475	0.47
Recognition Rate	73.56	88.84	92.84	95.5

FIGURE 5. - Explains the variation values of threshold with different of recognition rates

Principal component analysis used to create a feature extraction of iris images. where calculating the mean Eigen vectors, Eigen values, and the image similarity score to compare them with those of database images. this approach takes the surface characteristics mainly. The global feature extraction of iris images depicted in Figure 6.

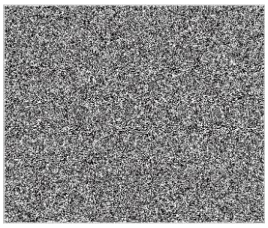


FIGURE 6. - The global feature extraction using PCA

Table 1 illustrates the accuracy of different approaches that described in the related work. It shows that our suggested methodology fared better than the other approaches where was recognition rate of proposed method of 95.4%.

Table 1. - Results & Comparison with other Methods

Methods	Recognition Rate (%)
H. Huma et al.[17]	89.99
A. R. Hashim et al. [15]	91.139
M.S. Azam et al.[11]	92.6
SG Firake et al.[10]	92.85
Y. A. Jasim et al.[14]	93.98
M. H. Hamd et al. [12]	94
MH Hamd et al. [13]	94
HK Rana et al.[16]	95.4
Our proposed	95.5

6. CONCLUSIONS

In the article, an effective iris recognition system was developed and assessed un-der less restricted imaging circumstances. In these situations, image blurring, posture variation, noise, occlusion, and variations in light may cause the iris images to be significantly deteriorated. The iris localization and segmentation in the article under presentation was done using the Truncated Total Variation model and the Circular Hough Transform. It also used Principal Component

Analysis (PCA) to shorten the runtime of matching these iris templates and extract the best characteristics from iris templates. Normalized the matching criteria for comparing the template with the test image using the Hamming distance. Utilizing the UBIRIS iris image database (version 2) for experimental assessment showed that the suggested method operates extremely efficiently. Experiments have shown that the suggested approach achieves good performance in accuracy. This demonstrates that the suggested segmentation and feature extraction technique combination is appropriate for increasing efficiency and dependability for image authentication.

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