International Journal of Advances in Engineering and Management (IJAEM)
Volume 5, Issue 5 May 2023, pp: 459-469 www.ijaem.net ISSN: 2395-5252

Development of iris recognition model using transform domain approaches with Hamming distance classifier

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Date of Submission: 05-05-2023 Date of Acceptance: 15-05-2023

ABSTRACT: Biometric traits includes fingerprint, facial, and iris recognition and so on are deployed for verification and/or identification in applications such as access control, border management, and identification systems. The iris trait is recorded as the most reliable and accurate biometric identification system. Most of the commercial iris recognition systems used algorithms developed by Daugman and these algorithms can produce recognition rates. In this paper, the iris model based on Principal Component Analysis, Daugman's rubber sheet model, Hough Transform with empirical mode decomposition iris model is proposed. The features of the iris dataset are extracted using EMD and HT. The extracted features of the iris images are tested on the CASIA V1 dataset. The dataset and test features of the iris are classified using Hamming distance to obtain the performance of the model.

Keywords: Iris, fingerprint, biometrics, rubber sheet model, principal Component Analysis.

I. INTRODUCTION

The physiological characteristics includes face, iris, fingerprints, palm prints, etc., and the behavioral characteristics includes signature, gait, walking style, keystroke, voice etc. As iris features are more unique, stable and can be visible from longer distances and as it uses mathematical pattern-recognition techniques on video images of one or both iris of an individual's because of this reason, compare to other biometric traits iris is more challenging and highly secured to identify the human. The human eye is externally visible and highly protected internal organ. In eye image, the physiological trait iris is a colored muscular ring of the eye which containing two zones such as pupillary zone (inner) and ciliary zone (outer zone). The term iris lies in between cornea and lens of the human eye as shown in Figure 1. Iris recognition has been used in various applications such as security screening in airports, hospitals and schools, shopping malls etc.

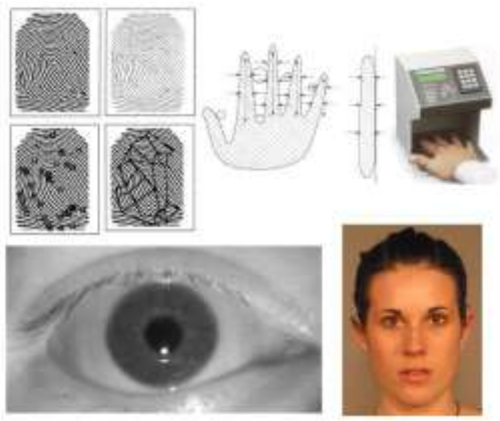

Fig.1: Different Biometrics

Issues in the design and implementation of a system for automated iris recognition can be subdivided into four parts Fig.2. The first stage is image acquisition. The second stage is concerned with localizing the iris per se from a captured image. The third stage is concerned with normalizing the localized iris from a captured image. The fourth part is concerned with matching an extracted iris pattern with candidate data base entries.

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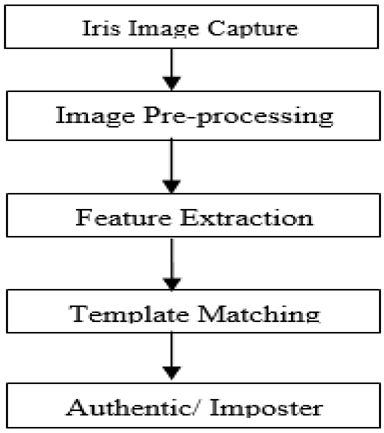

Fig.2 Schematic diagram of iris recognition

Image processing techniques can be employed to extract the unique iris pattern from a digitized image of the eye, and encode it into a biometric template, which can be stored in a database. Image pre-processing is divided into three steps: iris localization, iris normalization and image enhancement.

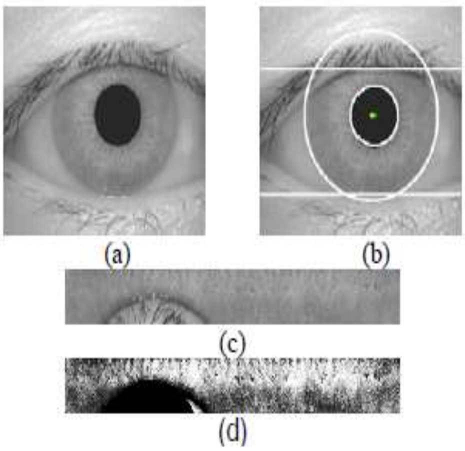

Fig.3 Iris image pre-processing
(a) Original iris image, (b) localized iris image, (c) normalized iris image, (d) enhanced iris image

Firstly, the iris modelsfocus on the software development only, not using hardware for capturing an iris image. The designed system will test with develop own iris image database from downloading iris image. Recognition algorithm is implemented in Python software. The software provides an excellent rapid application development with its image processing toolbox, and high-level programming methodology. Other than that, the system using iris image because the iris has many advantages and benefits for biometric technology. Here are just a few of the benefits using iris recognition in this system. Iris has high accuracy; one of the main benefits of using eye biometrics is the high accuracy that this technology provides. Everyone has an iris pattern that is distinct even twins. Both the left and right irises differ from one another as well. In theory, the accuracy of this technology should be at close to 100%. So, from these advantages will develop of iris recognition system.

II. LITERATURE SURVEY

Maram G Alaslani et al., [1] adopted pre-trained Convolutional Neural Network (Alex-Net) to extract the iris features. The iris was segmented and normalized using Circular Hough transform and Rubber sheet model respectively. The obtained iris features from Alex-Net are classified using multi-class Support Vector Machine (SVM). The experiments are conducted on IITD and CASIA-V1 database. Dongdong Zhao et al., [2] adopted iris template method based on local ranking. Firstly, the iris data was performed Exclusive OR operation with application specific string. The results obtained from the Ex-OR Operations are dividing into number of blocks and then the blocks are portioned into groups. Finally, the blocks in every group are ranked in accordance with their decimal values. The procedure of shifting and masking strategy are adopted to recognize iris. The experiments are conducted on CASIA, UBIRIS and MMU iris datasets.Juan Wang [3] generated multi-granularity hybrid features from the two-dimensional Gabor filters (GF) and GLCM techniques. The obtained features from both the GF and GLCM are classified using Extreme Learning Machine (ELM). Experiments are conducted on CASIA V-1 and CASIA V-4 iris database to evaluate the performance of the iris model. Hanaa S. Ali et al., [4] adopted Contrast-Limited Adaptive Histogram Equalization (CLAHE) on normalized images to enhance the quality of images and Speeded up Robust Features (SURFs) technique was applied on iris images to extract the effective features of iris. The fusion is performed at different levels in feature matching process. It is observed that more key points can be extracted using CLAHE technique. The obtained features are matched with test features using Euclidean Distance (ED) classifier. Experiments are conducted on CASIA V-4 iris database. Faundra and Sulistyaningrum [5] applied canny edge detection and Circular Hough transform to detect pupil edge, center, and the radius of pupil respectively. Next isolate the important part of iris based on zigzag collarette area and normalization of iris images are performed using Daugman Rubber Sheet Model to get fixed dimensions. The performances of iris model (segmentation and normalization based on zigzag collarette) algorithms are computed with a specific thresholding level technique which helps to remove eyelid and eyelash.C Khotimah and D Juniati [6] adoptedHough transform and Daugman's rubber sheet model to locate the iris area and to normalize the iris data set into blocks respectively. The box counting technique is applied on normalized data to extract the fractal dimension value of iris. The k-fold cross method is used to match the extracted features and test features. The test iris data was classified using K-Nearest Neighbor (K-NN) classifier on CASIA V-4 iris dataset. Bineet Kaur et al., [7] introduced discrete orthogonal moment (Tchebichef, Krawtchouk and Dual-Hahn) based features which extracts both global and local features from localized iris regions with k-Nearest Neighbor classifier. The obtained iris features are matched with test features using Manhattan distance. Experiments are conducted on CASIA Iris v4, IITD.v1, UPOL and UBIRIS.v2 iris database.Elsayed Radwan et al., [8] described Discrete Wavelet Transform (DWT) to extract the effective features of iris and Wavelet Neural Network (WNN) is used as a classifier to match the database images and test image images. In addition to this, WNN is used to solve the issue of orientation and intrinsic features of iris images. Finally, the global optimization techniques viz., Genetic and Meta-Heuristic algorithms are adopted to generate the optimal parameter values. Marco Augusto Rocchietti et al., [9] explained CRUZ algorithm for segmenting the inner pupil edge and generates the anatomical standards for the outer edge of iris. The accuracy loss in the segmentation can be improved by applying differential matrix while normalization procedure. The performance of the model is evaluated on CASIA database. However, the performance of iris model is not analyzed on various iris databases. Also, color images should be considered to carry out the operation using CRUZ algorithm using different classification systems.Piyush Samant et al., [10] explained Circular Hough Transform (CHT) approach to estimate the details of iris edge map and Rubber sheet model is applied on segmented iris to convert circular iris into rectangular structure with fixed dimension. The significant Discrete Cosine Coefficients (DCT) was extracted from the normalized iris using Zigzag, Raster, and Saw-tooth scanning techniques. Finally, the extracted features and test features are matched using mean square error on CASIA v-4 iris database. However, the model is limited only to near infrared iris images. So in future, the approach can be adopted for visible spectrum images to recognize iris.

Wenqiang Zhang et al., [11] adopted convolution neural network model (CNN) to train iris data. The NN uses only two connection layers (convolution layer and the pool layer), which decreases the number of parameters in the network (reduce the load of the server) and improves the training speed. The over-fitting issue of the model which leads to unable of identifying the iris images are reduced by adopting regularization and dropout method in the training procedure. However, the model has some shortcomings which unable to identify the images corresponding to the classification system and leads difficult to categorize recognition rates.Prashanth C R et al., [12] described Integro-Differential Operator to localize iris and pupil boundaries of human eye and Rubber sheet model is applied on segmented iris to convert circular iris into rectangular structure with fixed dimension. The wavelet transforms such as IWT and DWT are applied on normalized images to extract the significant iris features. Finally, the extracted iris features and test features are matched using Hamming Distance (HD). The performance of the model is evaluated on CASIA database. Dinesh Kumar Vishwakarma et al., [13] described two-fold techniques to recognize iris. The FIR and Gabor wavelet transform are applied on normalized images to extract the significant iris features. Finally, the extracted iris features and test features are matched using Euclidean Distance (HD) classifier. The performance of the model is evaluated on self-generated database consisting of images having red, green and blue segments.Kavita Joshi et al., [14] explained canny edge detection to detect the iris of an eye. The log Gabor wavelet and Haar wavelet techniques are applied on normalized images to obtain the iris features. Finally, the extracted features and test features are matched using Hamming Distance and the performance of iris model is evaluated on CASIA database.Prashanth C R et al., [15] adopted resizing, binarization, cropping and segmentation in the pre-processing stage. The transforms viz., Fast Fourier Transform and Principal Component Analysis are applied (at left portion and right portion of the iris) on normalized images to extract the features with absolute value. The coefficients generated from the FFT and PCA are fused to produce the final feature vectors. The fused features from both FFT and PCA and test features from the database are classified using Euclidean Distance. The performance of the model is evaluated on CASIA database.

Ying Chen et al., [16] described Scale Invariant Feature Transformation (SIFT) to extract the significant features of iris. To select the discriminative features, the strategies based on orientation probability distribution function (OPDF) and magnitude probability distribution function (MPDF) is employed to reduce the redundant feature key points and to reduce the dimensionality of feature element respectively. In addition to this strategy, fusion of OPDF and MPDF is used to select optimal sub feature.Finally, the features generated are tested on CASIA-V3 Interval, Lamp, and MMU-V1 iris database based on sub-region matching fusion.Rabab M. Ramadan [17] explained Spherical Wavelet Transform (SWT) to decompose the iris into sub images and the features of SWT are represented for the three-dimensional iris compression systems. The coefficients of Spherical coefficients yield superior adaptation for minimal set of features in its compression capabilities. The coefficients extracted from Haar wavelets generate excellent recognition rates on CASIA iris database.Shylaja S S et al., [18] explained Hough Transform (HT) to localize the position of eye images and extract the geometrical features which includes circular and elliptical features of iris images from a given face. The obtained features from HT are then matched using feed forward neural network classifier and the performance of the localization model is analyzed on Yale, Biod and local database. Ibrahim E. Ziedan and Mira Magdy Sobhi [19] explained dual iris column means approach to extract the significant features of iris. The segmentation of iris images is performed on unwrapped iris (horizontal and vertical segments) and adopts only vertical segments for recognition of dual iris. Finally Euclidean Distance is used as a classifier to match the database and test image. The coefficients extracted from HAAR wavelets generate better recognition rates on UPOL iris database.Qi Wang et al., [20] developed an optimization model to localize an iris and then SIFT feature is used to represent the boundary of iris along with eyelid for localization. The final points of boundary and eyelids of iris are solved using Supervised Descent Method (SDM) algorithm and the characteristics of outer boundary and eyelids of iris are generated using IRLS Technique.

III. PROPOSED MODEL

In this section, iris recognition is performed based on the combination of PCA, HT with EMD and Hamming distance is used to obtain the final features. The proposed model is shown in Figure 4. The experiments are conducted on CASIA V 1.0 iris database for the various combinations of Person inside Database (PID) and Person outside Database (POD).

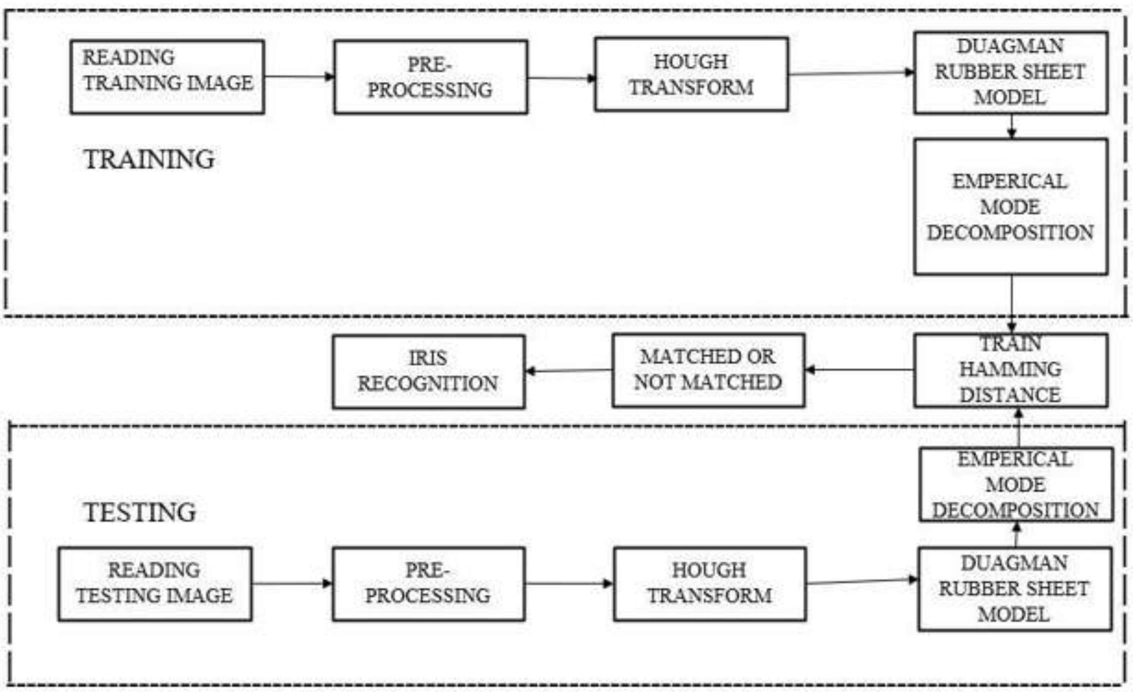

Fig.4 Proposed Methodology

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Training Images: Reading training images refers to the process of loading image data from a file or database into memory, to use it as input for a learning algorithm.In image classification tasks, for example, images are typically stored as files on disk, and each image is associated with a label that identifies the object or category it represents. During training, the images are read from disk and preprocessed (e.g., normalized, resized, augmented) to prepare them for the algorithm.In MATLAB, there are several functions that can be used for reading training images. One of the most used functions is imread (), which reads an image from a file and returns a matrix representing the image.It's important to note that the imread () function can read images in a variety of file formats, including JPEG, PNG, BMP, and TIFF, among others. The specific file format is determined by the file extension in the filename parameter passed to imread ().

Once the training images have been loaded into memory, they can be preprocessed and prepared for input to a machine learning algorithm. This may involve resizing the images, converting them to grayscale, normalizing pixel values, and performing data augmentation techniques to increase the size and diversity of the training data.

Fig.5: Trained CASIA Dataset Images

Testing Images: Iris recognition is a biometric authentication technology that uses the unique patterns found in the iris of the eye to identify individuals. Testing an image in iris recognition typically involves comparing the iris patterns in a new image against a database of pre-registered iris patterns to determine if there is a match.The testing process usually involves several steps. First, the image is pre-processed to enhance the iris region and extract the iris pattern. This involves locating the iris region in the image, normalizing the image to account for variations in lighting and camera distance, and removing noise and artifacts.Next, the iris pattern is compared to the pre-registered patterns in the database using a matching algorithm. The algorithm typically involves comparing the pattern's features, such as the texture, shape, and color, to determine the level of similarity between the patterns.Finally, the system produces a match score, which indicates the degree of similarity between the new image and the pre-registered patterns in the database. If the match score is above a certain threshold, the system identifies the individual as a match, and the authentication process is successful. If the match score is below the threshold, the individual is not identified, and the authentication process fails.Overall, testing an image in iris recognition requires precise image processing techniques and robust matching algorithms to ensure accurate and reliable identification.

Fig.6: Testing images

CASIA Iris Database: The Chinese Academy of sciences Institute of Automation (CASIA V 1.0) Iris database [16] is used to test the performance of proposed iris model. The database has seven hundred- and fifty-six-persons iris images from one hundred and eight unique eyes. The eye images are captured in two sessions for everyone with the size of 320×280 in BMP format. The samples of iris images of one person are shown in Figure 7.

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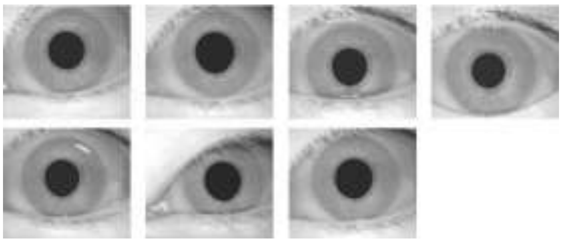

Figure 7: Samples of Iris images of a person

Image enhancement preprocessing is an important step in iris recognition to improve the quality and accuracy of the iris images used for identification.Segmentation is a critical step in the preprocessing stage of iris recognition. The aim of segmentation is to isolate the iris region from the rest of the image, which can be challenging due to the presence of eyelashes, eyelids, reflections, and other occlusions that can interfere with the feature extraction process.Segmentation is a critical preprocessing step in iris recognition, as it affects the accuracy and reliability of the subsequent feature extraction and matching steps. A well-designed segmentation technique can improve the performance of the iris recognition system by minimizing the effects of occlusions and ensuring that only the iris region is used for feature extraction and matching.The segmentation process in iris recognition typically involves the following steps:Pupil Localization: The first step in segmentation is to localize the pupil, which is the darkest region in the iris. This can be achieved using techniques such as intensity thresholding, edge detection, or template matching.Iris Localization: Once the pupil has been located, the next step is to detect the boundaries of the iris. This can be done using techniques such as edge detection, Hough transform, or active contour models.Occlusion Detection: After the iris has been localized, the next step is to detect and remove any occlusions, such as eyelids or eyelashes, that may be present in the image. This can be achieved using techniques such as morphological operations, texture analysis, or machine learning.

Canny edge detection is a popular technique used in iris recognition for extracting the edges of the iris boundary from the rest of the image. The Canny edge detection algorithm involves several steps, including Gaussian smoothing, gradient calculation, non-maximum suppression, double thresholding, and edge tracking by hysteresis. These steps help to reduce noise, enhance edges, and classify pixels based on their gradient magnitude. In iris recognition, the Canny edge detection algorithm can be applied to the iris image to obtain accurate iris boundary detection, which is important for segmentation and feature extraction. However, the Canny edge detection algorithm is sensitive to noise and parameter settings, so careful tuning is required to obtain optimal results. Overall, the Canny edge detection algorithm is a valuable tool for improving the accuracy and reliability of iris recognition systems.

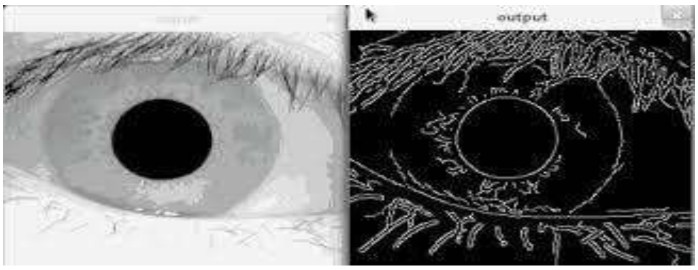

Fig 8: Gray Scale Image to Canny Edge Detection Image

In iris recognition, Principal Component Analysis can be applied to the iris image data to extract a set of features that are used for identification. The PCA features can then be compared to a database of previously stored PCA features to determine the identity of the iris. PCA has several advantages in iris recognition, including reducing the dimensionality of the iris image data, reducing the computational complexity of the identification process, and improving the accuracy and reliability of the system. However, PCA requires careful tuning of parameters such as the number of principal components to retain, and it may not work well with highly complex or noisy iris images. Overall, PCA is a powerful tool for feature extraction in iris recognition, and it has been widely used in many iris recognition systems.

The circular Hough transform is used for detecting the iris and pupil boundaries. This involves generating an edge map using the canny edge detection. Bias the derivative in the horizontal direction for detecting the eyelids and Bias the derivative in the vertical direction for detecting the outer circular boundary of the iris. Gradients were

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biased in the vertical direction for the outer iris/sclera boundary. Vertical and horizontal gradients were weighted equally for the inner iris/pupil boundary. The range of radius values to search for was set manually based on theoretical values depending on the database used.

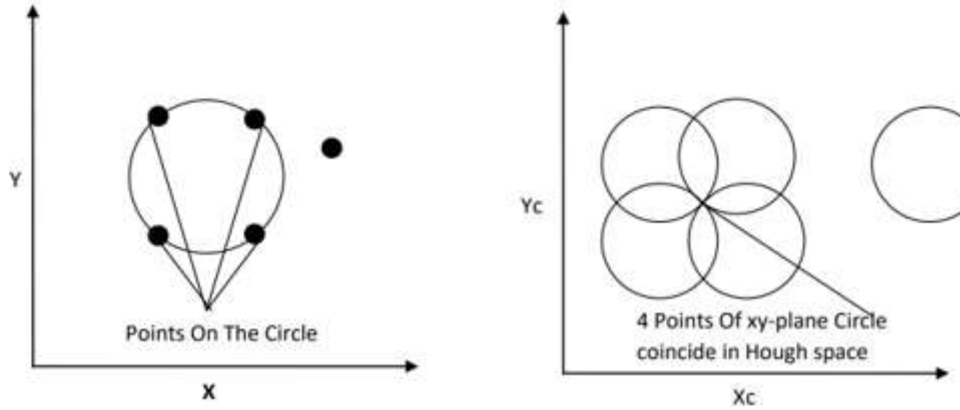

Fig 9: Circular Hough Transform

Here the circle of fixed radius is described. But if the circle is of unknown size, then the third parameter will be the radius of the circle. Then the circle will be of arbitrary size (Xc,Yc,r). And hence the accumulator will cast votes in three-dimensional accumulator.

The **Daugman's model** is highly accurate because it is based on the unique features of the iris, including its intricate texture and the random pattern of its blood vessels. It is also resistant to various forms of fraud, such as using photographs or contact lenses to fool the system, making it a popular choice for security applications. Overall, Daugman's rubber sheet model is an important innovation in iris recognition technology and has played a significant role in making this technology a reliable and secure means of biometric authentication.

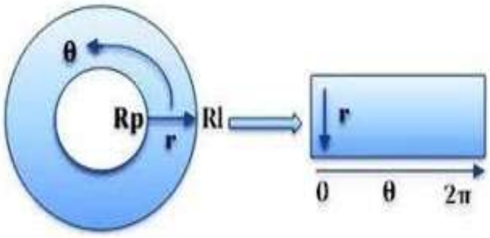

Fig 10: Rubber Sheet Model

Empirical mode decomposition is a general nonlinear, nonstationary time-series analysis method. The EMD method was initially proposed for the study of ocean waves (Huang et al. 1998a) and found immediate application in biomedical engineering (Huang et al. 1998b; Liang et al. 2000; Balocchi et al. 2004). The major advantage of EMD is that the basic functions are derived directly from the time-series itself. Hence the analysis is adaptive, in contrast to Fourier analysis, where the basis functions are linear combinations of fixed sine and cosine waves. The central idea of EMD time-series analysis is a sifting process to decompose a time-series into a set of IMFs having well-defined instantaneous frequencies by empirically identifying the physical time scales intrinsic to the time-series. The instantaneous frequency is defined by the time lapse between successive extrema.The EMD algorithm is an adaptive technique that iteratively decomposes a signal into a set of IMFs. The decomposition process starts with a signal called the envelope, which is obtained by finding the local maxima and minima of the signal. The envelope is then subtracted from the original signal to obtain a new signal, which is analyzed to find the next IMF. The process is repeated until no more IMFs can be extracted. Once the iris image is decomposed into IMFs using The EMD algorithm, the IMFs can be ranked based on their energy content, and the top-ranked IMFs can be selected as features for iris recognition. These features can be fed into a Hamming distance classifier, to perform iris recognition.

Hamming distance is a measure of similarity between two binary patterns, and it is commonly used in iris recognition for comparing iris codes. Iris codes are binary patterns that represent the unique features of an individual's iris, and they are extracted from the iris image using various techniques such as PCA or wavelet transforms.In iris recognition, the Hamming distance is used to compare the iris codes of two iris images to determine their similarity or dissimilarity. The

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Hamming distance is calculated by counting the number of bit positions where the corresponding bits of the two iris codes differ. A lower Hamming distance indicates a higher similarity between the two iris codes, while a higher Hamming distance indicates a lower similarity.

5. Definitions of Performance Parameters

In this section, the performance parameters definitions such as FAR, FRR, TSR and EER are defined to evaluate the proposed iris model.

False Accept Rate (FAR): It is the ratio of imposter subjects that are falsely accepted to the total number of subjects in the database as given in equation 1.

$$\mathrm{FAR} = \frac{\text{Number of imposter subjects falsely accepted}}{\text{Total number of subjects in the database}} \quad (1)$$

False Reject Rate (FRR): It is the ratio of genuine subjects that are falsely rejected to the total number of subjects outside the database as given in equation 2.

$$\mathrm{FRR} = \frac{\text{Number of genuine subjects falsely rejected}}{\text{Total number of subjects outside the database}} \quad (2)$$

True Successive Rate (TSR): It is the ratio of number of genuine subjects that are recognized correctly to the total number of subjects inside the database as given in equation 3.

$$\mathrm{TSR} = \frac{\text{Number of genuine subjects recognized correctly}}{\text{Total number of subjects inside the database}} \quad (3)$$

Equal Error Rate (TSR): It is the intersection ofFRR and FAR as given in equation 4.

$$\mathrm{EER} = \mathrm{FAR} - \mathrm{FRR} \quad (4)$$

Receiver operating characteristic curve (ROC curve):It is defined as a plot of genuine acceptance rate (GAR) against false acceptance rate (FAR). The biometric system results better, if the ROC curve is closer to the origin.

IV. RESULT ANALYSIS AND DISCUSSION

The experiments are conducted on MATLAB usingCASIA V1.0 dataset. The input image plays a critical role in the accuracy and reliability of the iris recognition system. By capturing high-quality images and pre-processing them to remove noise and artifacts, the performance of the system can be optimized for a wide range of applications. The input image should be carefully selected and processed to ensure the best possible performance of the iris recognition system.

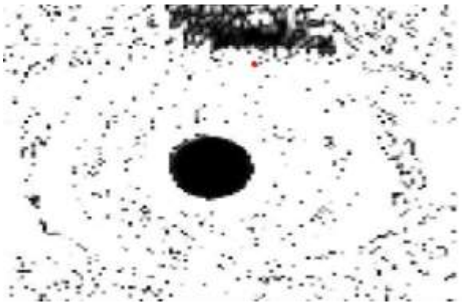

Fig 11: marked iris region

A marked iris image can be useful for improving the accuracy and reliability of an iris recognition system. By providing information on the location and features of the iris, the system can be optimized to handle real-world scenarios with varying levels of occlusion and noise. However, it is important to ensure that the markings are accurate and representative of the true features of the iris, to avoid introducing bias or errors into the recognition process.

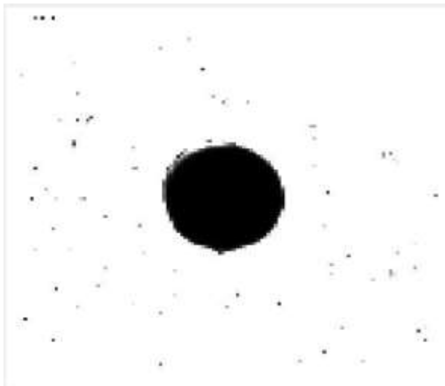

Fig 12: Detected iris region

In iris recognition, the detected region refers to the portion of the iris that is extracted and processed for the purpose of authentication or identification. This process involves capturing an image of the iris using a camera, detecting the location of the iris within the image, and then determining the boundaries of the iris. The detected region typically includes the circular or elliptical area of the iris that surrounds the pupil, known as the iris annulus. This area contains unique patterns and features that are used to generate a template for the iris that can be compared to other templates in a database to determine identity.The accuracy of iris recognition is highly dependent on the quality of the detected region, as any errors or inaccuracies in this area can lead to misidentification. Therefore, precise and reliable techniques for detecting and extracting the iris region are crucial for ensuring the effectiveness of iris recognition systems.

Fig 13: Rubber Sheet Model Conversion

The rubber sheet model is a useful technique for converting the iris image into a 2D representation for feature extraction and matching in iris recognition systems. While it can introduce some distortions or errors in the representation of the iris texture, these can be mitigated using optimization techniques and machine learning algorithms. Overall, the rubber sheet model is a valuable tool for improving the accuracy and speed of iris recognition systems.

For the different combinations of PID's with constant POD at 30, the percentage variations of optimum TSR, maximum TSR and EER are tabulated in Table 1. Hence it is observed that the percentage OTSR decreases and the percentage EER values increases with increase in PID's keeping POD constant.

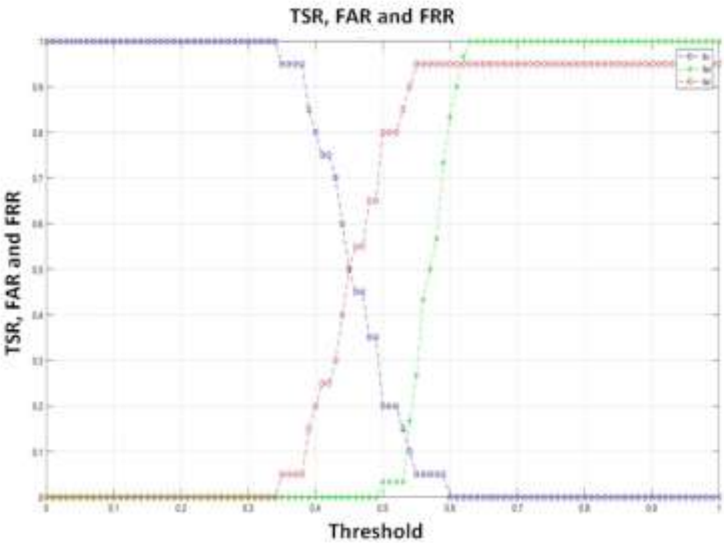

Figure 14: Performance parameters plot for PID and POD of 20:30

Table 1: Performance parameters for CASIA database keeping POD constant

PID	POD	EER	OTSR	MTSR
20	30	12.5	87.5	98
40	30	12.5	87.5	97.5
50	30	16.67	84	98
60	30	18.35	81.67	98

The model is compared with the different techniques and provides an accuracy of 98% as shown in table 2.

Table 2: Comparison of recognition rate with proposed and existing methods

Author	Feature Extraction	Recognition Rate
Sushil et al	1 D Log- Gabor	95.9%
Sheela et al	Hough Gradient	95%
Ankita et al	Gabor filtering	95%
Khary et al	Modified LBP	96%
Zexiet al	2-D Gabor filter	96.5%
Ganapati et al	Multi ICA and HoG	97.5%
Proposed Model	PCA+HT+EMD+HD	98%

V. CONCLUSION AND FUTURE SCOPE

The level of accuracy of an iris recognition system depends on the precision of the segmentation of an iris region. The eyelids and eyelashes which obstruct the upper and lower parts of the outer iris boundary are removed perfectly. This enhances the accuracy of the system in that only the iris region can be converted to biometric templates for matching. The Circular Hough transform method with Daugman's rubber sheet model-empirical model decomposition with Hamming Distance classification model is developed. The model resulted in a better performance rate with 98% when compared with the different state of the art model.

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