JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

Secure Access to Bank Accounts at Cash Machines using Iris Recognition System

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Abstract : *Iris recognition system has become very important, especially in the field of security, because it provides high reliability. Because of its excellent dependability, the iris recognition system has become quite significant, particularly in security. Many academics have proposed novel approaches for improving the effectiveness of the iris recognition system. Various approaches for achieving excellent performance in iris recognition are presented in this thesis. Three feature extraction algorithms are employed to extract features from an iris image in the proposed system: Histogram of Oriented Gradient (HOG), Gray Level Co-Occurrence Matrix (GLCM), and Local Binary Pattern (LBP). In the classification stage, however, two classifiers are used: KNearest Neighbors (KNN) and Support Vector Machine (SVM). Before extracting features, the iris image goes through several stages: first, image resizing, which unifies all image sizes, second, segmentation, which determines the iris region in the eye image, and finally, normalization, which converts the iris region to a suitable shape with specific dimensions. The proposed methods have been tested on the UPOL and IITD iris databases. When the HOG+KNN approach was utilized, however, the proposed system had a 100% recognition rate.*

IndexTerms **- Iris Recognition; Histogram of Oriented Gradient; Support Vector Machine; Biometric Authentication.**

I. Introduction

Biometrics have had the potential to play an important role in personal identification. Individuals are identified using a biometrics system based on their physical or personal features. Fingerprints, faces, voices, signatures, keystrokes, palm structure, hand geometry, DNA, retina, ear structure, gate identification, and iris are all biometrics. Biometric systems based on fingerprints, facial features, voice, hand geometry, handwriting, the retina, and the iris have been created. Some of these have been successfully used in a number of large-scale public applications, enhancing user confidence and reducing identity fraud. According to this innovation, an entire security system that is based on iris recognition is given, which permits access to only those individuals whose iris matches the database and denies access to everyone else, very consistently. There are four stages to this system: The first stage is image acquisition. This photograph was taken under proper lighting, with distance and other factors affecting image quality taken into account. Because image quality is key in iris localization, this stage is critical. Image segmentation comes in second. The iris region of the image is isolated in this step. Iris segmentation is a critical phase in the system's overall performance. To generate an iris template, unique characteristics from the segmented iris are extracted in the feature extraction stage. This template was also applied for recognition purposes. Fourth is usually Matching. The extracted patterns are mapped to previously extracted and stored patterns in the database [6]. The degree of similarity determines whether or not an identification may be achieved. Iris recognition is a biometric identification approach that utilizes an individual's unique iris pattern [7]. Iris is a visible internal organ of our body whose patterns are complex random patterns that are extremely distinctive and stable. Iris recognition is widely acknowledged as the most accurate biometric technology currently utilized for human verification. Because of the stability, uniqueness, and non-invasiveness of the iris pattern, iris recognition has been acknowledged as the best and most accurate biometric technique among numerous biometric techniques such as face identification, finger recognition, and hand and finger geometry. The iris region, which is between the pupil and the white sclera, has many minute visible features that are unique to each person, such as freckles, coronas, stripes, furrows, and crypts. Even the same person's eyes have distinct traits [6]. Furthermore, the chances of finding two people with identical traits are nearly nil, making the system efficient and dependable in terms of security.

II. Related works

The patented method developed by John Daugman[6][7] is used in the majority of commercial Iris recognition systems. Daugman's algorithm uses the integro differential operator to discover the inner and outer boundaries of Iris, as well as the upper and lower eyelid boundaries. The circular Iris region is unwrapped into a rectangular block of fixed dimension using Daughman's rubber sheet model for Normalization. 2-D Gabor is utilized for feature extraction, while hamming distance is employed for code matching. The theoretical false match probability in this method is 1 in 4 million. The purpose of examining the human iris is to identify a person. In the year 1880, Albert Bertillon was the first to detect the problem. He was a French physicist who used his irises to identify criminals.

This problem was investigated by Leonard Flom and Aran Safir in 1987. The iris remains stable throughout a person's life, according to their patent. Except for rare abnormalities, all of the features are quite consistent in terms of number and position. Every iris is unique, and no two people can have identical irises, according to research.

John Daugman's "Biometric personal identification system based on iris analysis"[1] was patented in 1990. In a live video image of a person's face, the image analysis system detects the iris. It isolates the eye and forms a circular papillary border between the iris and pupil portions of the picture, as well as another circular boundary between the iris and sclera portions of the image, and a number of annular bands inside the iris image. The iris code is then added, and the code is compared to stored iris codes using Hamming distance.

Richard Wildes patented the "Automated non-invasive recognition system and technique" [2] in 1997. Two cameras are used in this setup. The first one has a low resolution, whereas the second one has a good resolution. Because of the papillary, limbic, and eyelid boundaries, the image captured from the second camera is reduced on the iris. The reduced image is then compared to the stored photos in the next stage.

Mitsuji Matsushita received a patent for an "iris identification system and iris identification method" in 1999[4]. Customers are identified using this iris recognition system. The camera initially recognizes a customer's head, locates the position of the eyes, zooms in, and photos the irises. Only the relevant iris data is extracted by the computer in order to identify the customer. Human IRIS identification has some benefits, but it also has some drawbacks.

A method for optimal creation of iris codes for iris recognition was proposed by Yang Hu et al.[5]. The typical iris code is the solution to an optimization problem that minimizes the distance between feature values and iris codes, as shown by this method.This method also demonstrates that by adding words to the goal function, more effective iris codes for the optimization problem can be obtained. The first objective term, which takes advantage of the spatial correlations between bits in different places of an iris code, has been examined. The second goal is to reduce the impact of less reliable bits in iris codes. These two objective terms can be used separately or in combination to solve the optimization problem.

Smereka[3] (2010) proposed a method for segmenting non-ideal photographs that are impacted by elements such as blurring, specular reflection, occlusion, illumination change, and off-angle images. The image was pre-processed using the Haar wavelet transform and contour filter, and the edges of the iris were detected using the Circular Hough Transform and Hysteresis thresholding. The performance of the ICE database was tested in this experiment.

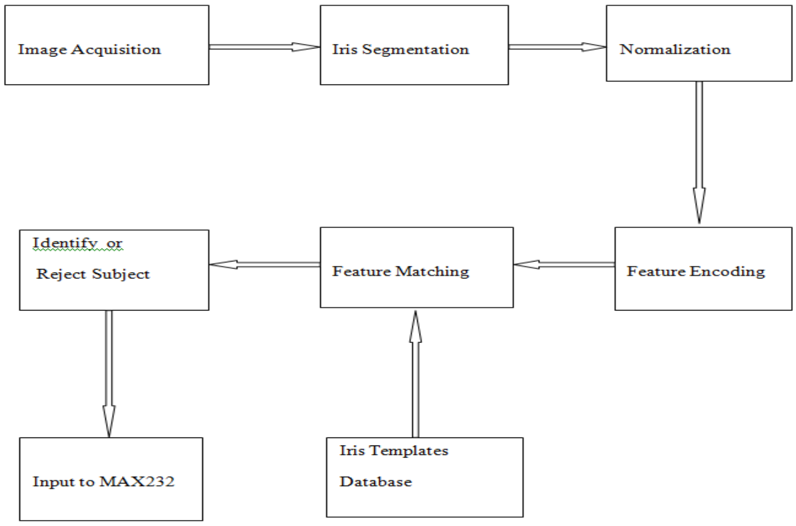
Rai et al.[8] suggested a code matching approach based on the combination of two methods to improve accuracy. The iris picture is extracted using the circular Hough transform, followed by the detection and removal of the eye zigzag collarette region of the iris was studied using 1-d Log Gabor filters and Haar wavelets. The support vector machine and hamming distance technique were used to recognize the extracted features. Experimental results demonstrate a great recognition rate when features were extracted from a specific region of the iris, where more complex patterns are present, and feature recognition was performed using a combination of support vector machines and Hamming distance. eyelids and eyelashes using the parabola detection technique and trimmed median filters.

The iris and pupil boundaries are detected using the circular Hough transform and then normalized using the Dougmans rubber sheet model, according to Sunil S Harakannanavar1 et al. [1]. The fusion is done at the patch level. The image is converted into 3A-3 patches for mask image and converted rubber sheet model for fusing. The sliding window technique is used to convert patches. In order to retrieve local information for each pixel. To analyze iris images, block-based empirical mode decomposition as a low pass filter extracts the final features of iris images. Finally, using the Euclidean Distance (ED) classifier, the database and test images are compared.

III. METHODOLOGY

The main methodology of this thesis is presented as a flow chart in this chapter. After that, each stage is described in detail. To begin, a description of the two databases used in this thesis is provided. The pre-processing stage of iris recognition is then discussed. The iris segmentation stage and the methodology employed in this stage are then discussed in depth. The iris normalization stage is next detailed, along with the technique utilized in this stage. The feature extraction algorithms are then extensively explained. Finally, the classification methods (SVM and KNN) are described in depth.

Fig 3.1. Steps for Iris recognition



The main technique of this thesis is depicted as a flow chart in this chapter.

Step 1: Image capture is one of the most difficult aspects of automated iris recognition since it needs to obtain a high-quality image of the iris while remaining non-invasive to the human operator.
Step 2: Iris localization is used to detect the iris's and pupil's edges, enabling the iris region to be extracted.
Step 3: Normalization is used to convert the iris area into fixed dimensions, removing dimensional irregularities between eye images caused by iris stretching caused by pupil dilatation caused by variable levels of illumination.
Step 4: A rectangle region is created by unwrapping the normalized iris region.
Step 5: Finally, extract the most distinguishing characteristic in the iris pattern so that a template comparison can be performed. To construct the iris code, the collected iris region is encoded using the Gabor transform. As a result, the matching step can make a decision.

A. Image Acquisition:
A suitable camera is used to acquire images. We employ various cameras for various applications. If we need an x-ray image, we use an x-ray-sensitive camera (film). We utilize cameras that are sensitive to infrared light to get infrared images. We employ cameras that are sensitive to the visual spectrum for everyday photography (family photos, etc.). The initial stage in every image processing system is image acquisition.

B. Image Segmentation:
Iris segmentation [9] is the process of automatically detecting the iris and pupil boundaries of an iris in an eye picture and excluding the surrounding regions. This technique helps in the accurate and precise extraction of iris features for personal identification. The primary goal of segmentation is to eliminate non-useful regions, such as those outside of the iris (eyelids, eyelashes, and skin).
The quality of the eye picture determines the success of the segmentation process. The iris and pupil boundaries are determined by the segmentation process, which is then converted to a suitable template during the normalization stage.

Fig 3.2: Image of an eye appears the iris, pupil, and sclera.

The first step in image segmentation is feature detection; the accuracy of localization is strongly dependent on true edge identification of the iris boundaries. Following edge detection, the iris and pupil boundaries are determined.
After detection, this clever edge detector is shown in the diagram below.

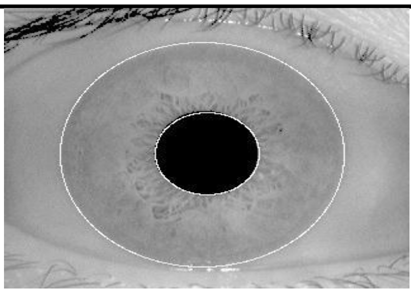


Fig 3.3: Segmented Iris Image

Following edge detection, the iris and pupil boundaries are determined. The Hough transform is another method of recognizing geometric object attributes, and it was utilized to find the circles in the edge image in this case. For each edge pixel, the weights of the points on the circles surrounding it at various radii are increased if they are also edge points, and these weights are added to the accumulator array. After all radii and edge pixels have been checked, the accumulator array's maximum is utilized to find the circle's center and radius. Because the pupil is always inside the iris, the Hough transform is applied to the iris outer boundary using the entire picture, and then to the pupil only, rather than the entire eye.

Fig 3.4: Canny Edge Image

C. Normalization:

After successfully segmenting the iris from an eye image, the iris component must be transformed to a required dimensional pattern in order to extract the characteristics. The normalizing method creates iris regions with the same fixed dimensions, resulting in unique characteristics at the same spatial location in two images of the same iris taken under different conditions. Dimensional [3] discrepancies in the normalized iris might occur as a result of pupil size expansion, which causes iris size stretching.

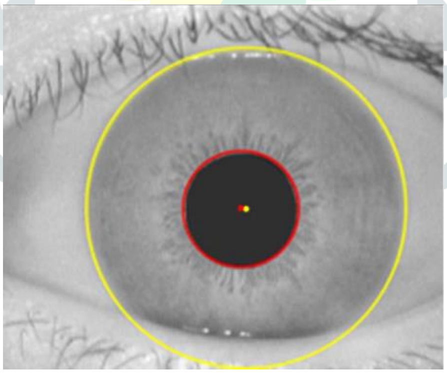


Fig 3.5: The Centers of the Pupil and the Iris are not Concentric

D. Feature Extraction:

The iris pattern is ready for feature extraction after the normalizing phase for the iris component is completed. The most crucial stage in an iris recognition system is extracting features from the iris image; this system, in particular, is dependent on the characteristics collected from the iris pattern. Three methods are employed to extract features from the iris in this study; this paper methods differ in terms of how features are extracted. These approaches are the HOG, GLCM, and LBP approaches; however, a comprehensive explanation of these approaches will be provided in the sections that follow.

1. Histograms of Oriented Gradients(HOG's):

Dalal and Triggs [10] created the Histogram of Oriented Gradients (HOG) feature descriptors in 2005, which are used in image processing and computer vision to recognize objects [25]. It has achieved great performance in computer vision by devising novel approaches to a variety of problems relating to object identification, feature extraction, and recognition [11]. HOG divides the input image into square cells. The primary principle behind the Histogram of Oriented Gradient descriptors is that the distribution of intensity gradients can be used to characterize the look of objects inside an image, and these descriptors can be implemented by dividing the image into small areas called cells. Then, for each cell, a histogram of gradient directions is created; these histograms comprise the descriptor. Furthermore, histograms can be normalized by computing intensity over a larger section of the image, known as a block, and then normalizing all cells within the block. Computing the intensity over a vast area of the image, on the other hand, can enhance the accuracy. Because the HOG descriptor works on local cells, it has a few distinct advantages over other approaches [11].

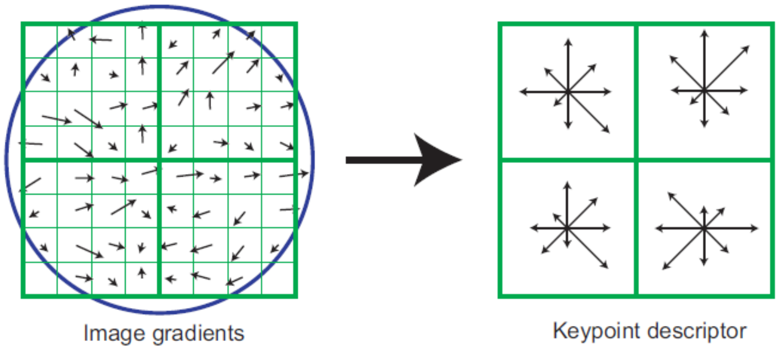


Fig 3.6.1: Image Gradients and Orientation Histogram

When Dalal and Triggs presented the HOG algorithm, Dalal suggested certain HOG parameter values for high performance. Setting window size to 64x128, block size to 16x16, and cell size to 8x8 is recommended. However, because this approach is now a built-in function in many image processing software (e.g., Matlab), there is no need to change any parameters [10].

2. Gray Level Co-Occurrence Matrix (GLCM):

A way of extracting features from patterns is the GLCM approach. It's been used for a variety of things, including extracting textural features from images [12]. Furthermore, GLCM is a matrix with the same number of rows and columns as the number of gray levels. It considers a widely used statistical method for extracting features from images.Furthermore, the Gray Level Dependence Matrix (GLCM) is a two-dimensional histogram of gray levels for pixel pairs[13]. A displacement vector d with radius and direction is used to calculate GLCM. Consider the following image, which has 44 pixels and is represented by four gray-tone values ranging from 0 to 3. The GLCM for this image is shown in (Table). # i j) represents the number of times grey tones have been used, with I and j representing neighbors. Furthermore, GLCM calculates by providing the number of times the two neighbor's elements in the matrix should be repeated in the same order. For example, for two elements (1, 0), the number of times the two elements' neighbors (1, 0) are repeated in the same order is calculated, and the value of repetition is stored in the GLCM matrix at location (1, 0). A later example will provide a more detailed explanation of the GLCM's functioning mechanism. GLCM dimensions, on the other hand, are determined by the 'NumLevels' argument, which takes one of the following values (2,4,8,16,32,64,128,256...etc.).

1	0	0	1
0	2	1	0
2	3	0	1

Table 1: Example of original image

Gray tone	0	1	2	3
0	#(0,0)	#(0,1)	#(0,2)	#(0,3)
1	#(1,0)	#(1,1)	#(1,2)	#(1,3)
2	#(2,0)	#(2,1)	#(2,2)	#(2,3)
3	#(3,0)	#(3,1)	#(3,2)	#(3,3)

Table 2: General form of GLCM

Horizontal (0°) takes coordinates (0, D), Vertical (90°) takes coordinates (-D, 0), Bottom left to top right (45°) takes coordinates (-D, D), and Top left to bottom right (135°) takes coordinates (-D, D) (-D, -D). Where D is the distance parameter, which is set to 1 by default, and for each offset parameter, a separate GLCM is produced, which may impact the proposed method's performance [14].

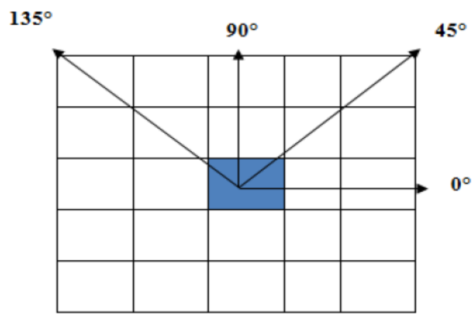


Fig 3.6.2: GLCM angles

On image 44 pixels, we analyze GLCM angels (See Table). When = 0°, we check the first location of the GLCM (0,0) and calculate how many times the neighbor's elements 0 and 0 are repeated in the horizontal direction and in two directions (left to right and right to left), we find two times repeated, once from left to right and once from right to left, and we put value 2 in location (0,0) in the GLCM matrix. Then, in the same case, we check the second GLCM (0,1) location and calculate how many times neighbor's elements 0 and 1 are repeated in the horizontal direction and in two directions (left to right and right to left), and we find four times repeated, so we put value 4 in Gray tone location (0,1) in GLCM. The identical procedures were followed in the remaining situations (45°, 90°, and 135°) with the exception of the direction of rotation.

3. Local Binary Pattern (LBP):

The LBP approach is a simple technique for extracting features from patterns that can identify pixels in an image by thresholding the neighbors of each pixel and converting the findings to a binary value. The input image is segmented into 'NxN' local regions in the LBP technique, with each region consisting of a '3x3' neighborhood of each pixel of the central pixel's value. After that, each pixel will be allocated a name based on its intensity value, the binary patterns in each block will be distributed, and the results will be represented as an 8-bit integer. Finally, the patterns are calculated and applied to the feature to represent it.

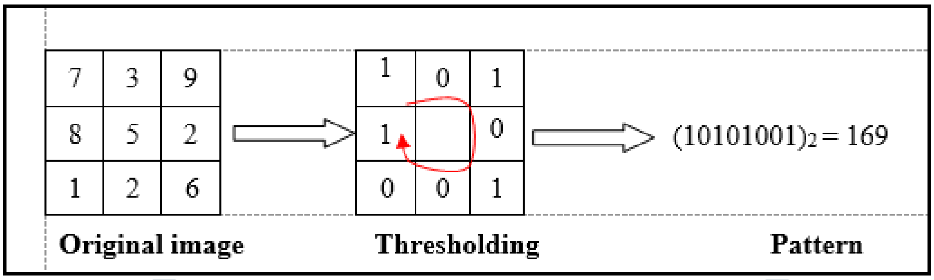


Fig 3.6.3: Mechanism of LBP approach

This explains the main mechanism of the LBP approach: an input image is divided into several blocks by the LBP approach, each block is divided into '3x3' neighborhood pixels (9 cells), and each pixel is encoded by its intensity value, then threshold the value of the central pixel, and LBP orders all surrounding pixels within the block from the upper-left corner down to the right one depending on whether they have a bigger or smaller intensity value than t. Finally, a binary number (10101001) is obtained, which is transformed into a decimal number (169) and put in a one-dimensional array.

E. Classification:

Two distinct classifiers are employed in this thesis. Support Vector Machine (SVM) and K-Nearest Neighbor are the two algorithms (KNN). These classifiers are trained and tested using features derived from iris patterns; each classifier is trained many times using the same collection of iris images before being tested using a different set of iris images.

1. Support Vector Machine(SVM):

Vapnik, Boser, and Guyon introduced the Support Vector Machine (SVM) in 1992. SVM is a classification approach that is based on learning. It belongs to the family of linear classifiers. In other words, SVM is a classification and prediction tool that uses machine learning theory to improve predictability while avoiding the removal of relevant data. Neural Information Processing Systems included SVM. The most difficult aspect of using SVM is selecting the right kernel for the applications that require it. SVM offers several advantages, including ease of training, suitability for high-dimensional data, and the ability to precisely manage the trade-off between classifier complexity and error.

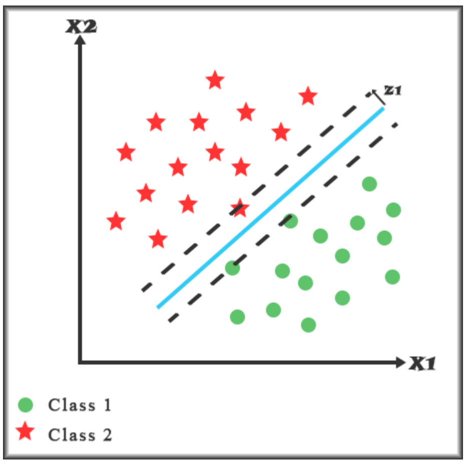


Fig 3.7.1: Support Vector Machine Mechanism

The SVM method chooses the "Optimal Separating Hyperplane," which is the point closest to the border between two classes (OSH). Line Z1 runs across the middle of the distance between the class-1 circles and the class-2 stars. It is typical to find two or more points in the same level, such as two circles in class-1. The spacing between Line Z1 and the second class is then maintained. SVM may compute additional points of two classes by increasing the distance between Line Z1 and classes [15].

2. K-Nearest Neighbor (k-NN):

The KNN classifier is one of the most basic object classification algorithms, and it works under supervision. KNN is utilized in machine learning, regression, and pattern recognition applications [14]. Furthermore, it is simple to use and highly effective in a variety of classification-based applications. Its function is based on taking the check data's neighboring value in a feature space.
Furthermore, it is a nonparametric statistic because it makes no assumptions about the probability distributions of the variables. In addition, the KNN method classifies objects in three steps [15]:

• Calculates the distance between all training vectors and the test vector.

• Selects K nearest vectors and computes the average distance between them.

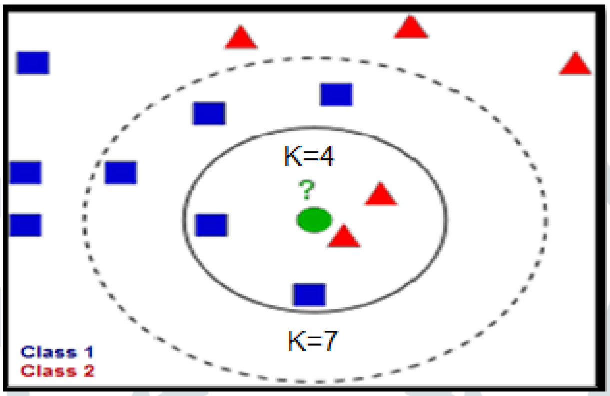


Fig 3.7.2: K-Nearest Neighbor mechanism

The blue squares represent the first Class, while the red triangles indicate the second Class, and these Classes are depicted on a feature space in the above figure. The data indicated by a green circle, for example, is new data that we want to add to the combined red and blue set; this phase is known as categorization. There is a way to check the nearest neighbor in order to do classification; in the figure, the red triangle is the closest neighbor for the new data (green circle), hence the new data is added to Class 2.The categorization procedure in this example is based on the nearest neighbor, hence this technique is known as Nearest Neighbor.
Furthermore, if K = 4, we have four closest objects. Thus, there are two red items and two blue objects; new data will be added to the red objects in this example. On the other hand, if we set k = 7, we'll have two red objects and five blue objects, which implies we'll have to add the additional data to the blue objects (Class 1). In the KNN method, it is beneficial to prioritize k neighbors at the same time; we should prioritize them all equally. If K = 4, for example, there are two blue (Class 1) and two red (Class 2) items, but the new data (green circle) is closer to red objects than others, thus it is added to red objects (Class 2).

IV. PROPOSED METHOD

This proposed methodology can be used in the ATM authentication field. Current ATM authentication technologies, like credit cards, are small, light, and easily misplaced if the user is careless. Also, if someone other than the user knew the PIN code and had the credit card, they could simply deceive the original user by taking funds from the account. As a result, existing ATM authentication has numerous weaknesses.
As a result, employing Iris-based authentication in the realm of ATM authentication provides consumers with increased security and privacy. The user's biometrics are recorded via the authentication client's camera during the registration phase, extracted, encrypted, and stored in the Bank database. Principal Component Analysis (PCA) is used to extract the iris features from the recorded iris image. After that, the extracted feature is merged with the reference subject (RS). The AES technique is then used to encrypt the fused feature, resulting in an Iris. The suggested system takes the iris dataset as input. The data was gathered from a number of iris data collection websites. The system then uses this collection of iris images as the user's biometric input. The properties are stored once the dataset is translated to the database engine.
The datasets were tested on the ICE database, which was provided by NIST for the Iris Challenge Evaluation (ICE) 2005. The ICE database contains 1,426 photographs from 132 patients in the right eye and 1,527 images from 132 subjects in the left eye. These photographs were taken using the LG EOU 2200 and are intended to show a wider range of quality than the camera would ordinarily capture. As a result, the necessity for an Identity Provider is decreased even more. Furthermore, because this key is created directly from user biometrics and is user intrinsic, it is substantially more difficult to compromise than elements that are artificially connected to a person. All of this information is compiled into an Iris object. After enrolling with the banking system, each user receives an Iris model, which is saved in the database. This could be used as a reference in the banking application's other transaction parts.

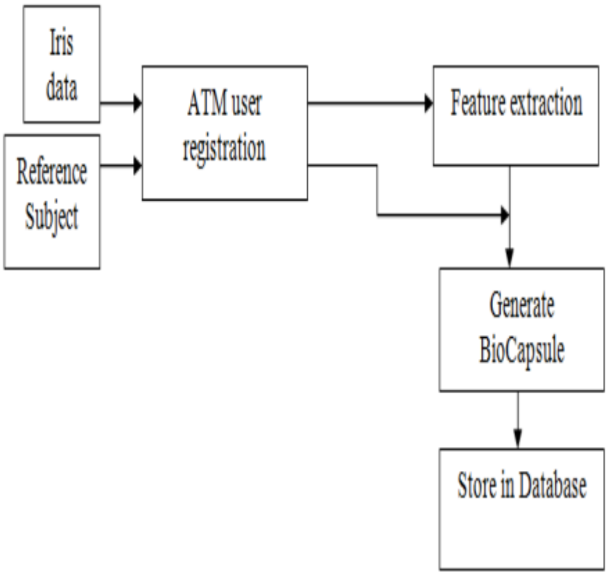


Fig 4.1: ATM user registration

The preprocessed photos are used for key extraction. The iris image segmentation and polar transformation stages in preprocessing aid to mitigate scaling and distortion issues in biometric images. Kernel Principal Component Analysis was performed to extract the keys (PCA).

Fusion's mission is to improve biometric security. The RS hides user data through fusion, enabling security and maintaining privacy. This fusion considers user biometrics and RS equally. The contribution of designing equitable treatment of user biometrics and the RS is also consolidated in the security. The fusion procedure is demonstrated using one user's iris image and personal details. To generate BCs, the suggested fusion mechanism is a generic procedure that may be combined with existing biometric systems. Also, to demonstrate how the fusion works with the biometric system.

The AES technique is then used to encrypt the fused feature, resulting in an Iris. It will store the iris after it has been generated in the bank database for further verification. Traditional preprocessing, feature extraction, and template generation procedures are used without change in the proposed model; "secure fusion" is applied before template generation and after feature extraction. This attribute makes the suggested fusion more deployable while also maintaining the same domain of inputs and outputs, theoretically allowing fusion at additional levels (e.g., signal, template).

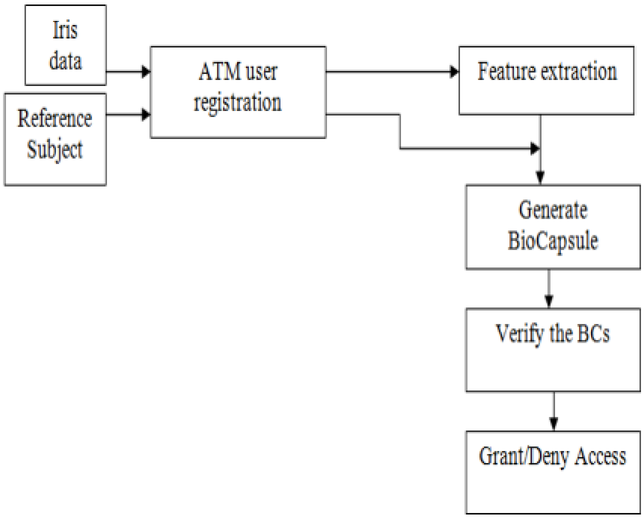


Fig 4.2: ATM User Authentication

The BCs are compared during the verification phase. The Iris created during the registration process is compared to the Iris created during the verification process. The same iris extraction techniques that were employed during the registration phase are utilized during the verification. Principal component analysis and AES are once again employed to acquire the identical iris features that were obtained during the registration phase. As part of the verification process, the biometrics dataset should also be input into the system. In practice, every customer's iris will be collected throughout both the registration and verification phases. The images of the iris will be subjected to a PCA technique, which will extract features that can be utilized to fuse with the Reference Subject. The AES technique is then used to encrypt the fused feature. The user makes the authentication request at the moment of cash withdrawal. If the user wishes to get the funds, he or she must meet the proposed authentication conditions. The administrator then compares it to the Iris already in the Bank database. If the Iris currently stored and the one created during the request are identical, the user will be granted access authorization. The user's access will be prohibited if the Iris produced during this phase is different.

V. EXPERIMENTAL RESULTS

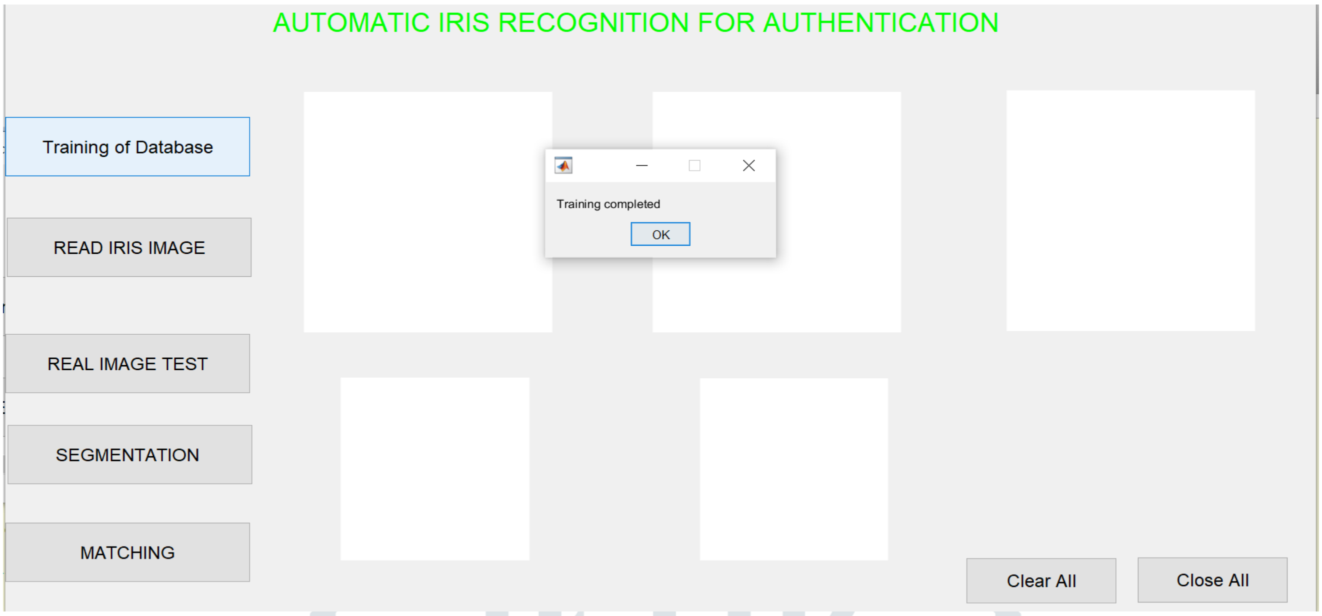


Fig 5.1: GUI of Training Database

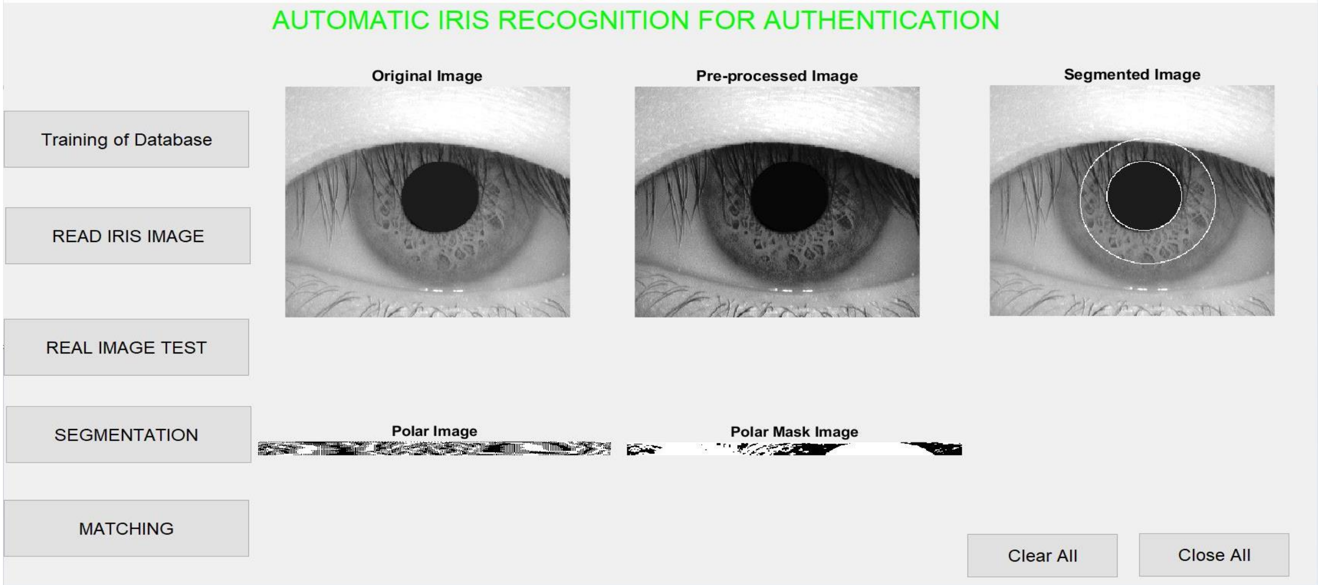


Fig 5.2: GUI of Segmented Image

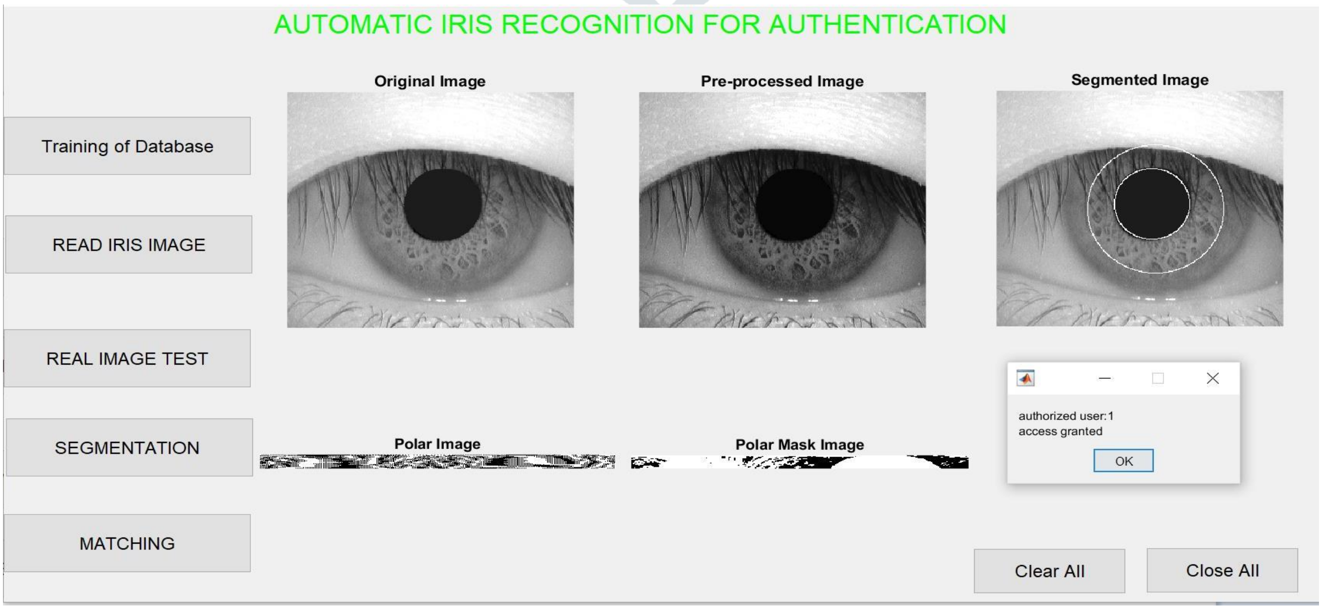


Fig 5.3: GUI of Authorized User

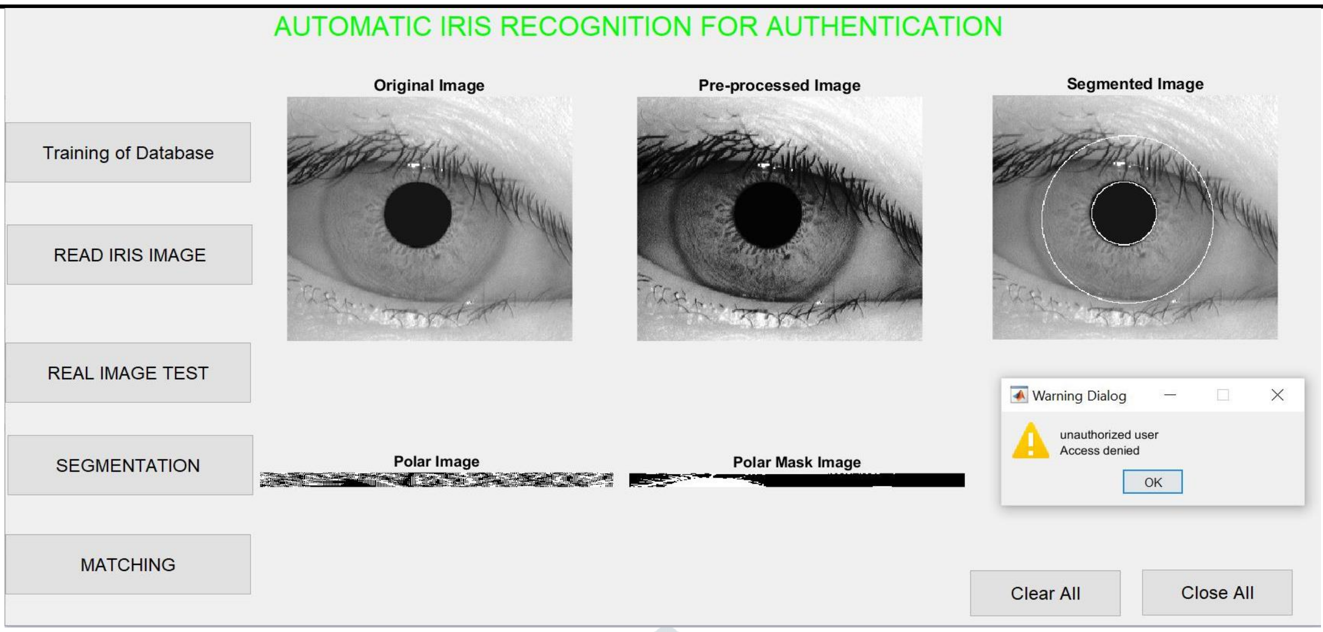


Fig 5.4: GUI of Unauthorized User

VI. CONCLUSION

A user-friendly, secure, privacy-preserving, and revocable secure-fusion-based biometric authentication system is designed in this suggested work. The suggested method entails key extraction: the extracted feature is employed in a "secure fusion" to blend the user's biometrics and user data, and the fused biometrics is encrypted to generate an Iris for authentication. The proposed BC mechanism has a number of desirable characteristics: The technique is secure and resistant to various threats, ensuring the security of user biometrics and maintaining user privacy.

Traditional techniques and other BCS and CB systems perform similarly when compared to existing approaches. Users do not need to be trained, and the system is simple to use and transparent to them because they do not need to remember a password or carry a token. These characteristics distinguish the proposed BC mechanism as a user-centric authentication method.

VII. REFERENCES

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