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Multi-algorithmic IRIS Recognition

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ABSTRACT
Modern societies give higher relevance to personal recognition system that contribute to the increase of security and reliability, essentially due to terrorism and other extremism or illegal activities. The objective of this work is to present a multi-algorithmic biometric authentication system for physical access control based on iris pattern for high security access. The CASIA database of IRIS images provided by **C**hinese **A**cademy of **S**ciences **I**nstitute of **A**utomation is used and the system is implemented in MATLAB. The iris recognition is based on Daugman's approach and multiple classifiers using Hamming distance and Neural networks. In Daugman's approach, the iris features are extracted using 2D Gabor Wavelets. The proposed work provides match for iris pattern if hamming distance is below 0.15 whereas for the existing works it is 0.20. The Neural Classifier uses a feed forward network with three hidden layers and used after normalization and feature extraction phase. Features given to neural network are Energy, Entropy, Standard deviation, Covariance. The error rate has been reduced from e^{-3} to e^{-5} in this proposed work. The multi-algorithmic approach together with improvement in segmentation and matching stages is found to report higher verification accuracy with lower error rate.

Keywords
Iris Recognition, 2D Gabor Wavelets, Hamming Distance, Neural Classifier, Feed Forward Network, CASIA

1. INTRODUCTION
Biometrics, described as the science of recognizing an individual, based on physiological or behavioral traits and it is accepted as a legitimate method for determining an individual's identity, Biometric solutions analyze human characteristics for security, authentication and identification purposes [1]. Most work environments use behavioral biometrics like ID badges/ smart cards, passwords, Personal Identification Number (PINs), voice and signatures. Physiological biometrics include physical traits of an individual like hand geometry, fingerprint, vein, eye patterns and facial features. Among the various physical biometric traits used for personal authentication in highly secured environment, Iris patterns have attracted a lot of attention for the last few decades in biometric technology because they have stable and distinctive features for personal identification. Most works on personal identification and verification using iris patterns have been done in the 1990s.

Facial recognition faces many problems since face itself is a 3D object that varies depending on the angle, pose, illumination and age. In this, even best current algorithms have error rates of 43% to 50% [2]. On the other hand, iris begins to form in the third month of gestation, and the structures creating its patterns become unchangeable in two or three years. Furthermore, the iris pattern does not correlate with genetic determination since its forming depends on the initial environment of the embryo. This yields to the fact that even the left and the right irises for the same person are not identical.

Iris has become an interesting biometric modality with low false acceptances especially when there is a need to search a large database due to high pattern variability among different persons. Multi-algorithms techniques are used in order to reduce false rejection rates. It has been recently reported that many people fail to provide the particular biometrics in all situations. Though many security forces have launched fingerprint identification for border crossing, airport security, approximately two percent of population does not have a legible fingerprint biometrics system. Thus iris has been taken as a biometric feature in this work.

2. LITERATURE REVIEW
The French ophthalmologist Alphonse Bertillon seems to be the first to propose the use of iris pattern (color) as a basis for personal identification [3]. In 1981, after reading many scientific reports describing the iris great variation, Flom and San Francisco ophthalmologist Aran Safir also suggested using the iris as the basis for a biometric. In 1987, they began collaborating with computer scientist John Daugman of Cambridge University in England to develop iris identification software who published his first promising results in 1992 [4]. Flom and Safir were conferred patent [5] for their algorithm in 1987.

Daugman collaborating with Flom and Safir developed and introduced the application and usage of iris as a biometric characteristic for individual identification. Daugman has used 2D Gabor filters and phase coding to obtain 2048 binary feature code and tested his algorithm on many images successfully [6]. Daugman used multi-scale Gabor wavelets to demodulate the texture phase information. This algorithm segment iris image using Integro - differential operator and filter the iris image with a family of Gabor filters that generate 2048-bit complex valued iris code [7,8]. The difference between the two iris code is computed by measuring their Hamming distance. This algorithm is most widely implemented in the available systems in the world.

Boles and Boashash [9] generated one-dimensional 1-D signals by calculating the zero-crossings of wavelet transform at various resolution levels over concentric circles on the iris.

Comparison of the 1-D signals with model features using dissimilarity functions does the matching. Wildes [10] represented the iris texture with a Laplacian pyramid constructed with four different resolution levels and used the normalized correlation to determine whether the input image and the model image are from the same class.

Lim [11] method is based on key local variations. The local sharp variation points denoting the appearance or vanishing of an important image structure are utilized to represent the characteristics of the iris. This algorithm uses one-dimensional intensity levels to characterize the most important information and position sequence of local sharp variation points are recorded using wavelets. The matching has been performed by Exclusive OR operation to compute the similarity between a pair of position sequences.

Some of the problems present in the existing approaches are outlined below and have been resolved in the proposed system.

1) Eyelids and eyelashes bring about some noise edges and occlude the effective regions of the iris. This may lead to the inaccurate localization of the iris, resulting in the false non-matching.
2) The corneal and specular reflections will occur on the pupil and iris region. When the reflection occurs in the pupil from iris/ pupil border, the detection of the inner boundary of the iris fails.
3) The orientation of the head with the camera may result in the orientation of the iris image to some extent.

In the most general case, a classifier generates a score value for each class. In this case the sum, product, maximum, minimum, or the median of the scores of all classifiers can be calculated and the class with the highest value is regarded as the combined result. However, to actually build a multiple classifier system, one needs a number of basic classifiers. The multi-algorithm use of iris recognition as a means of authentication has been originally proposed by Flom and Safir. Daugman has proposed an operational iris recognition system in 1994 [12]. Since then, iris biometric is evolved as a standard reference model for verification.

In this research work, a multiplier classifier using improved hamming distance method and Neural Network approach is suggested to reduce the error rate in the iris authentication system.

3. IRIS RECOGNITION

Iris recognition is considered to be the most reliable and is an emerging biometric solution for authentication in highly secured environments. Iris is the colored part of the eye behind the eyelids and in front of the lens. It is the only internal organ of the body that is externally visible. Figure 1 shows the front view of human eye and Figure 2 shows the Iris Recognition system.

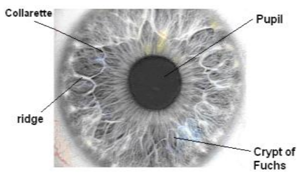


Figure 1 Image of Human Iris

The iris is protected by the eye's cornea and its function is to control the light intensity levels. The pupil is the aperture for the light entrance and it is controlled by the iris. The iris is embedded with tiny muscles that dilate and constrict the pupil size [13].

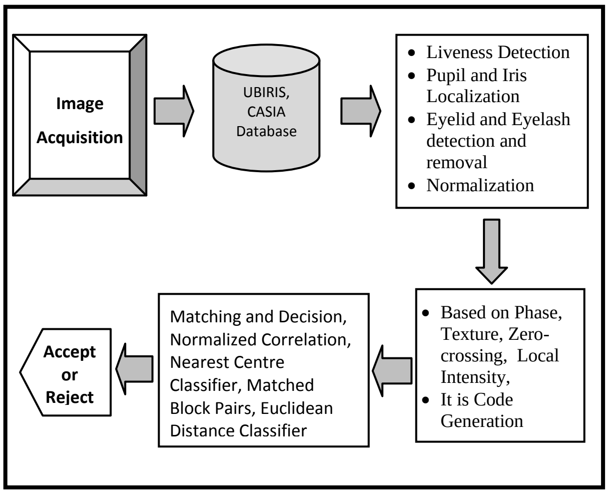


Figure 2 Iris Recognition System

The iris is considered to be a reliable biometric for human identification for several reasons :

- It is an internal organ that is well protected against damage and wear by a highly transparent and sensitive membrane (the cornea). This distinguishes it from fingerprints, which can be difficult to recognize after years of certain types of manual labor.
- The iris is mostly flat, and its geometric configuration is only controlled by two complementary muscles (the sphincter pupillae and dilator pupillae) that control the diameter of the pupil. This makes the iris shape far more predictable than, for instance, that of the face.
- The iris like fingerprints has a fine texture that is determined randomly during embryonic gestation. Even genetically identical individuals have completely independent iris textures, whereas DNA (genetic "fingerprinting") is not unique for the about 0.2% of the human population who have a genetically identical twin.

3.1 Iris Images - CASIA Database

In order to make the iris recognition system to work efficiently a high quality image of the iris has to be captured. The acquired image of the iris must have sufficient resolution and sharpness to support recognition. The images used in the proposed work are from CASIA database captured using infrared cameras with high contrast and low reflections for good quality images. A sample image is shown in figure 3.

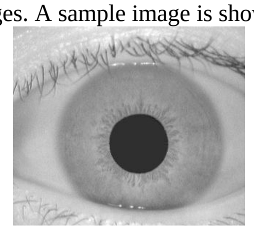


Figure 3 Eye image from CASIA database

The CASIA database contains 756 grayscale eye images with 108 unique eyes or classes and 7 different images of each unique human eye. Images from each class are taken from two sessions with one interval between sessions. The images are captured especially for iris recognition research using specialized digital optics developed by National Laboratory of Pattern Recognition, China. The eye images are mainly from persons of Asian decent, whose eyes are characterized by irises that are densely pigmented with dark eyelashes.

Noise and artifacts exists in iris images, and they have a negative impact on the system performance. Such artifacts include the eyelash occlusion, the eyelid occlusion and the specular reflections. Figure 4 shows an iris image contaminated with both eyelash occlusion and eyelid occlusion. Therefore these should be detected and eliminated from the subsequent recognition process.

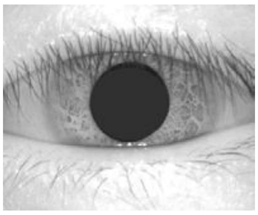


Figure 4 Occluded Eye Image

Figure 5 Iris image with specular reflections

Specular reflections are mirror like reflections, such as the light reflected on a tranquil water surface (Figure 5). Similarly in the iris image acquisition procedure, the specular reflections occur in such a way that the light source gets reflected and captured by the camera. The strong reflection intensity in the image results in high pixel values deviate absolutely from the original iris patterns. This constitutes a major source of distortion and therefore should be eliminated, in order to make the iris recognition more accurate.

3.2 Iris Recognition System using Daugman's algorithm

An effective iris based authentication system is implemented based on Daugman's algorithm through improvement in iris segmentation. The steps of the first algorithm are as follows :

Step 1: Image acquisition is the first phase but the work uses images from CASIA database.

Step 2: Iris localization takes place to detect the edge of the iris as well as that of the pupil, thus extracting the iris region.

Step 3: Normalization is done to remove the dimensional inconsistencies between eye images due to stretching of iris caused by pupil dilation from varying levels of illumination.

Step 4: The normalized iris region is unwrapped into a rectangular region.

Step 5: Finally the most discriminating feature in the iris pattern is extracted to construct the iris code using Gabor filters. The iris code is compared with the templates to generate a matching score.

The iris and pupil of the eye image are segmented using canny edge detectors and circular Hough transform. Image processing of the iris region is computationally expensive. The iris region is first unwrapped into a rectangular region. Hence, the localized iris region is then normalized into a rectangular block to account for imaging inconsistencies.

3.2.1 Pupil Edge Detection

Pupil is a dark black circular region in an eye image. Hence pupil detection [14] is equivalent to detecting the black circular region. The steps involved in detecting pupil is as follows,

1) The eye image in figure 6 is converted to a binary image using a threshold value of 40, that is, if the pixel value is less than 40 it is converted into 255 (white) and if the pixel value is greater than 40 it is converted in to 0 (black) as in equation 1

   $g(x) = 1$ for $f(x) > 40$; $g(x) = 0$ for $f(x) \leq 40$ (1)

   where f(x) is original and g(x) is image after thresholding.
2) The resulting image will contain the pupil and some other noises (pixels whose value is less than 40 for e.g., eyelash).
3) To remove these noises morphological erosion and dilation is applied over the image.
4) The hit and miss operator is applied to segment only the circle region in the image (Figure 7).
5) A bounding box is drawn in figure 8 by searching for the first black pixel from top, bottom and from sides of image.
6) The length or breadth of the box gives diameter of pupil. The centre of bounding box gives the centre of the pupil.

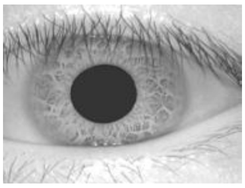


Figure 6 Input Eye image

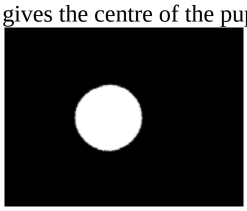


Figure 7 Segmenting Pupil

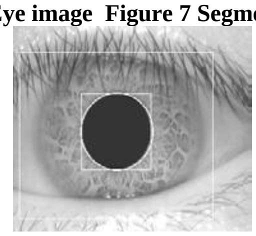


Figure 8 Bounding box around pupil

The noise is also eliminated in this procedure. The pupil is detected as shown in figure 8. The proposed method has proven very efficient and reliable when tested with CASIA iris database. From all 70 iris images, this algorithm correctly determined the center and radius of 66 exemplars (99.6%) with a very low failure rate.

3.2.2 Iris Detection

After detecting the pupil edge, the iris/ sclera border is detected. The iris/sclera is low in contrast and may be partly occluded by eyelids and eyelashes. The contrast of the iris region is increased by first applying Gaussian smoothing and then Histogram equalization. The boundary of the enhanced iris image is found by using canny edge detector. The Canny operator is optimum even for noisy images as the method bridge the gap between strong and weak edges of the image by connecting the weak edges in the output only if they are connected to strong images. Hence the edges are more likely to be the actual ones. Therefore compared to other detection method, this Canny operator is less fooled by spurious noise.

The iris/sclera region is low in contrast and may be partly occluded by eyelids and eyelashes. The steps for iris detection are:

1) A bounding box of height equal to that of the pupil and width equal to up to eight times (as the size of the iris varies from 10% to 80% to that of the pupil) is drawn as in figure 9. Only regions within this bounding box are used to detect iris/sclera boundary.
2) The contrast of the iris region is increased, by first applying Gaussian smoothing and then by histogram equalization.
3) Canny edge detector is applied to find the edges of the enhanced image and probabilistic circular Hough transform is applied to the edge detected image to find the centre and radius of the iris using the equation 2.

   $(x_i-x_c)^2 + (y_i-y_c)^2 = r^2$ (2)

   where (x_c, y_c) is the center of iris , (x_i, y_i) is the iris co- ordinate pixel and r is the radius of the iris.
4) The CASIA database images have radius (r) in the range of 100 to 120. Hence, the radius parameter in the Hough transform is set between 95 and 125.

5) The pupil and iris are not concentric. The centre of the iris lies within the pupil area and hence the probability that the centre of the iris lying in this area is high. Therefore the centre parameters (xc,yc) are taken to be the pupil area. This reduces the number of edge pixels to be computed.
6) By applying Hough transform we can find the iris centre and radius (Figure 10).

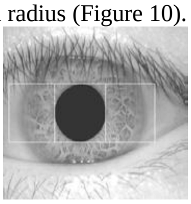


Figure 9 Bounding Iris

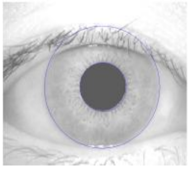


Figure 10 Iris boundary - Hough Transform

3.2.3 Iris Normalization

Once the iris region is localized, the next stage is to normalize this part in order to enable generation of the iris code and their comparisons. The variations in eye image due to optical size of the iris, position of pupil and the iris orientation change from person to person. The Cartesian to polar transform of the iris region is based on the Daugman's Rubber sheet model, which is used to unwrap the iris region.

The steps are as follows :

1) The centre of the pupil is considered as the reference point. The iris ring is mapped to a rectangular block in the anti-clockwise direction.
2) Radial resolution is the number of data points in the radial direction. Angular resolution is the number of radial lines generated around iris region.
3) Radial direction is taken to be 64 data points and horizontal direction is 360 data points.
4) Using equation (3) the doughnut iris region is transformed to a 2D array with horizontal dimensions of angular resolution and vertical dimension of radial resolution.

   $$I(x(r, \theta), y(r, \theta)) \rightarrow I(r, \theta) \quad (3)$$

   where $I(x, y)$ is the iris region, (x, y) and (r, θ) are the Cartesian and polar coordinates respectively. The range of θ is $[0\text{-}2\pi]$ and r is $[0\text{-}1]$. $x(r, \theta)$ and $y(r, \theta)$ are defined as linear combination set of pupil boundary points.
5) Normalization produces the image of unwrapped iris region of size 360 X 64 is shown in figure 11.

Figure 11 Normalized into Polar Coordinates

6) The unwrapped image has very low contrast and has noises. To obtain a good feature extraction the texture must be clear and the contrast must be high. Median filter is applied to remove the noises and Histogram equalization is used to increase the contrast of the normalized image.
7) Figure 12 shows the enhanced normalized image after histogram equalization. It shows rich texture suitable for feature extraction.

Figure 12 Enhanced Normalized Image

3.3 Feature Extraction

In order to provide accurate recognition of individuals, the most discriminating information present in an iris pattern must be extracted. Only the significant features of the iris must be encoded for comparison between templates. Most iris recognition system makes use of band pass decomposition of the iris image to create a biometric template. Wavelet is powerful in extracting features of textures and the template generated using this also needs a corresponding matching metric, which gives a measure of similarity between two iris templates. The proposed method is carried out using Gabor filters, which generates 2048 bits of information from 256 feature vectors, giving better accuracy, takes less computation time and processing is simple. The normalized iris image is divided into multiple regions. Each local region is transformed in to a complex number with 2-D Gabor filters. The real and imaginary part of the complex number is encoded in to 1 or 0 depending on the sign. The steps for feature extraction and matching is as follows,

1) The normalized iris image is divided into 8 parts of 45 degrees interval each.
2) Each part is further sub divided into 8 regions to form sixty-four small channels.
3) From figure 13 it is apparent that the eyelids and eyelashes can occlude the irises in the regions between 45 and 135 degrees, 270 and 315 degrees. Hence only the top two channels in these regions are considered for the feature extraction. Therefore the iris is divided in to forty channels, which are mostly not occluded, by eyelashes or eyelids.

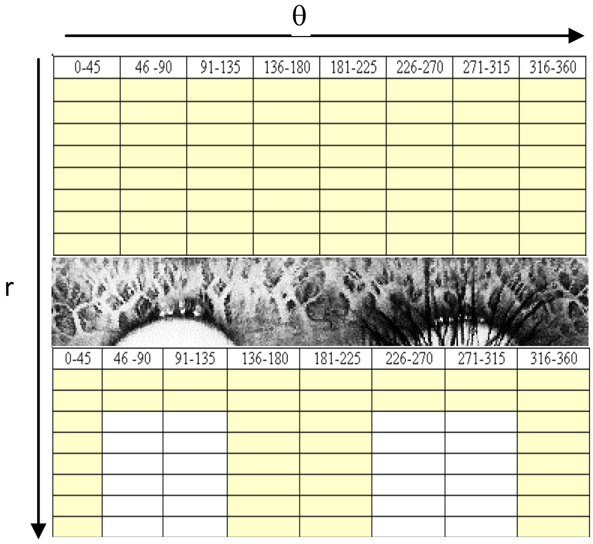


Figure 13 Multi channel Feature Extraction

4) A bank of thirty Gabor filters is generated using the 2D Gabor wavelet equation (4)

   $$G(x, y; \theta, \omega) = \exp\{-1/2\,[x'^2 / \delta x'^2 + y'^2 / \delta y'^2]\} \exp(i\omega(x + y)) \quad (4)$$

   $$x' = x\cos\theta + y\sin\theta \quad (5)$$

   $$y' = y\cos\theta - x\sin\theta \quad (6)$$
5) The frequency parameter is often chosen to be power of 2. In this work, the central frequencies used are 2, 4, 8, 16, and 32. For each frequency the filtering is performed at orientation 0, 30, 60, 90, 120 and 150 degrees. So, there are thirty filters with different frequencies and directions.

3.4 Hamming Distance Matching Classifier

The template that is generated in the feature encoding process need a corresponding matching metric, that gives a measure of similarity between two iris templates. This metric should give one range of values when comparing templates generated from the same eye, known as intra-class comparisons. Another range of values when comparing templates created from different irises is known as inter-class comparisons. Among the different matching classifiers, Hamming distance (HD) approach is a matching metric employed by Daugman for comparing two bit patterns and it represents the number of bits that are different in the two patterns and hence can be decided whether the two patterns are generated from the same iris or from different ones.

$$HD = \frac{1}{N}\sum_{j=1}^{N} X_j (XOR) Y_j \quad (7)$$

where X_j and Y_j are the two bit patterns that is computed and N=2048. Basically when the bit in pattern X_j is different than that of pattern Y_j, the Exclusive-OR gives a result of 1 and these ones are accumulated till all the bits in the two patterns are compared. Finally the result is divided by N, the total number of bits constituting the iris code. Ideally, the HD between two iris codes generated for the same iris pattern should be zero. When the HD is large i.e. closer to 1, the difference in two patterns are more different and the two patterns are to be identical when this distance is closer to 0. Hence by choosing properly the threshold value for matching decision, one can better iris recognition results with very low error probability.

In the normalization or unwrapping part, Daugman's rubber sheet model does not take into account the rotational inconsistencies. So in order to overcome this problem the HD of two templates is calculated with one template being shifted left and right bit -wise trials and the corresponding HD values are calculated from successive shifts. This bit-wise shifting in the horizontal direction corresponds to rotation of the original iris region by an angle that can be known from the angular resolution used. The calculated lowest HD value is 0 used since this corresponds to the best match between the two templates.

In cases where a person might move his neck while his eye is being photographed, that causes a shift in the angle axis. To prevent that, shift the matrix cyclic for about 20 columns and try to find the HD not only for the current matrix but also for all the shiftings. The minimal result is the desired one. Closer this distance to zero, the more probable the two patterns are identical. Thereby properly choosing the threshold, one can get better iris recognition system with very low error probability.

The threshold value of 0.15 has been chosen for matching iris patterns in this work and if the HD is below 0.15, the two iris pattern are given a match and is a genuine attempt. If HD is greater than 0.15 the two iris patterns are given a mismatch and is an imposter attempt. HD is chosen as a matching metric. It is found from the experiments that the HD between two irises belonging to the same eye is less than 0.15. This algorithm presented an iris recognition system with improvement in segmentation stage with an improved accuracy of 99.2% when compared with the existing iris recognition [16] reported at 98.6%.

4. IRIS RECOGNITION USING NEURAL NETWORKS

Among the different algorithms suggested for verification of iris patterns, neural network approach is one of the recent and reliable technological methods of iris recognition which is practiced by some organizations today. Iris is a non identical organism made of colorful muscles including robots with shaped lines. These lines are the main causes of making everyone's iris non identical and characterizes the iris features. Attributes are generated from these features and given as input to neural networks.

4.1 Neural Networks (NN) Algorithm

An effective iris based authentication system is implemented based on Daugman's algorithm through improvement in iris segmentation using Feed Forward Neural Network.

4.2 Features Extracted

The features extracted are co-variance, energy, entropy and standard deviation. These are given as input to the Feed forward neural network. In Hamming Distance algorithm a template should be created from the database. The template should be used to provide authentication. But in NN algorithm the features are calculated using the equations below

Average = sum(sum(image))/(size(1)*size(2)) (8)
Average of Average = sum(sum(image))/(255*1000) (9)
Energy = sum(normalized) (10)
Entropy = entropy(image) (11)
Standard Deviation = std(std(double(image))) (12)
co-variance = cov(double(image)) (13)
co-variance = sum(sum(co-variance))
/ (length(co-variance)*1000) (14)

Neural Network is chosen as a matching metric. The existing system of Neural networks works with an error rate of e^{-3} but the proposed system performs better with less error rate of e^{-5} and the proposed work has reduced the iteration time from 0.14 sec to 0.02 sec.

5. MULTI-ALGORITHMIC SYSTEM

The multi-algorithm biometric system proposed focuses on fusion of algorithms at the matching score level and the advantage of utilizing as much information as possible from each algorithm. The system has been designed successfully and it is found to overcome the drawbacks of traditional methods of authentication. The use of two algorithms is done at the classifier level.

5.1 Proposed Multiple Classifier System

The flowchart for the proposed multi-algorithm iris authentication is given in the figure 14. The steps are:

Step 1: Image acquisition – CASIA database is used.
Step 2: Iris localization takes place to detect the edge of the iris as well as that of the pupil, thus extracting the iris region.
Step 3: Normalization is done to remove the dimensional inconsistencies between eye images due to stretching of iris caused by pupil dilation from varying levels of illumination.

There are two algorithms used. Case 1 is Hamming Distance algorithm and Case 2 is Neural Network algorithm. The above mentioned three steps are common for both and the steps followed for individual cases are as follows :

Case 1

Step 1 : The normalized iris region is unwrapped into a rectangular region.
Step 2 : The most discriminating feature in the iris pattern is extracted to construct the iris code using Gabor filters. Hamming distance classifier is used. The iris code is compared with the templates to generate a matching score.
Step 3: The calculated hamming distance value is compared with the threshold value. If the hamming distance value is less than the threshold it gives authentication.

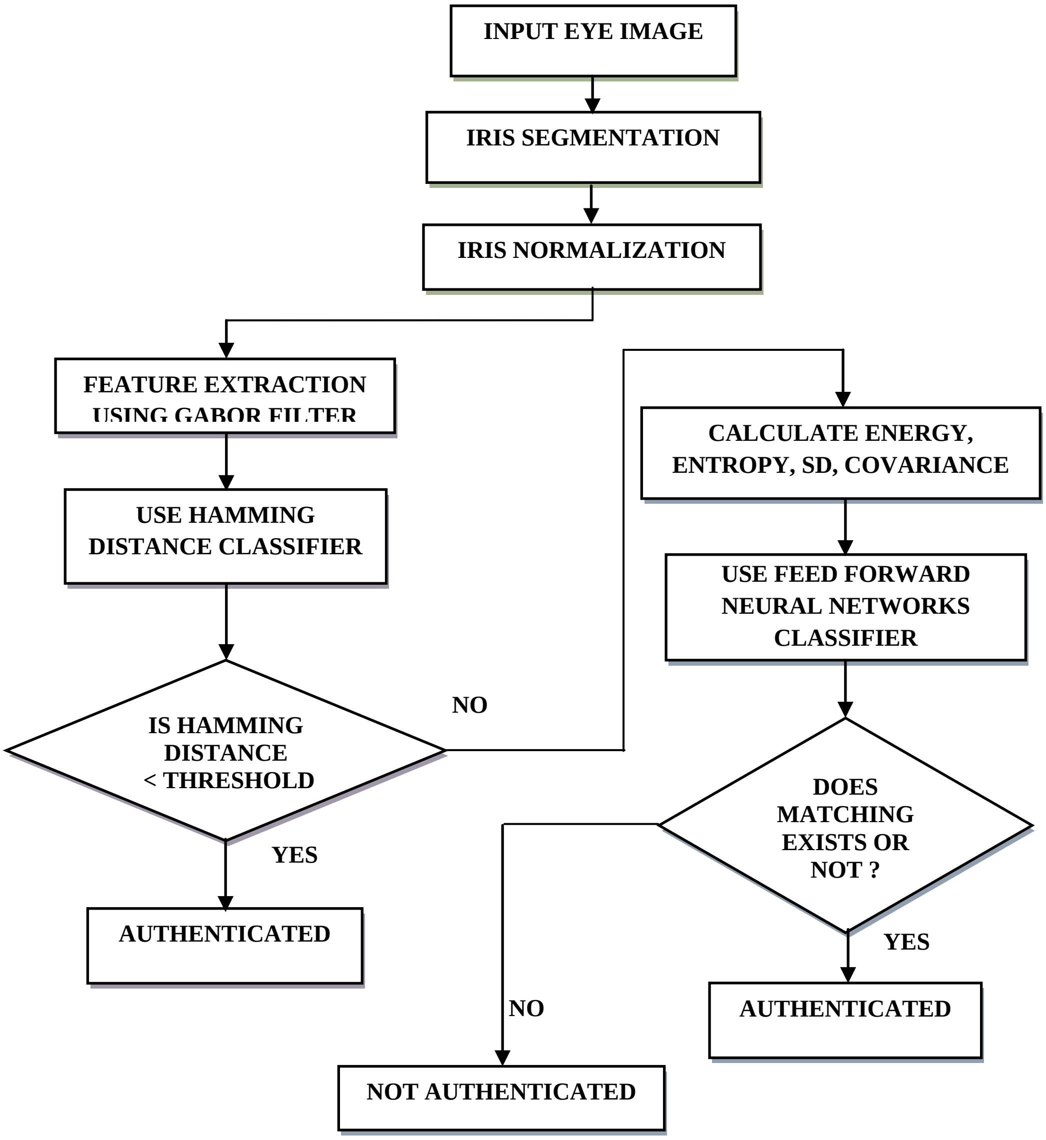


Figure 14 Flowchart for Proposed Multi Algorithmic Recognition System

Step 4: If the hamming distance value is greater than the threshold, the second algorithm is used to check for authentication.

Case 2

Step 1: From the normalized iris region the features like energy, entropy, standard deviation and co-variance are calculated and given as input to Feed Forward Neural Network Classifier.

Step 2: The Feed Forward Neural network has three hidden layers and the acquired image is compared with the database.

Step 3: It provides authentication if matching exists with the database and the person is indicated depending on 'y' value of the algorithm. If there is no matching it provides no authentication to the user.

6. MATCHING CLASSIFIERS

Detection of recognition errors is important in many areas, such as improving recognition performance and saving manual effort. Multiple classifiers has been chosen for improving the performance of the iris recognition system. Need for multiple classifiers emerges when a single classifier cannot improve recognition-error detection performance compared with the current detection scheme using a simple threshold mechanism. Although the single classifier does not improve recognition error performance, it serves as a baseline for comparison. The multiple classifier approach assigns a classifier to detect the presence or absence of errors and additional features are considered for recognition. A multiple classifier system is a powerful solution to difficult pattern recognition problems involving large class sets and noisy input because it allows simultaneous use of arbitrary feature descriptors and classification procedures. Decisions by the classifiers can be represented as rankings of classifiers and different instances of a problem. The rankings can be combined by methods that either reduce or re-rank a given set of classes.

6.1 Performance Measurements

Biometric systems show variations in measuring human characteristics or behavior. A measure of variation is embedded into these systems; in technical language this translates intolerance of false rejection error and false acceptance error. The proportion of false rejections is known as Type I error and the proportion of false acceptance as Type II error. Type I and Type II errors can be translated in false acceptance and false rejection curves which are related to system's sensitivity threshold setting. Since the tolerance level is adjustable, there is a tradeoff between the two errors. The multi algorithm system proposed is evaluated using the two performance measures. They are Accuracy and Receiver Operating Characteristics Curve (ROC).

7. PERFORMANCE ANALYSIS

Human Iris Pattern Recognition System implemented with improvement in Segmentation algorithm is found to give better results. Both the algorithms are tested for 75 eye images of 25 individuals with 3 samples per person.

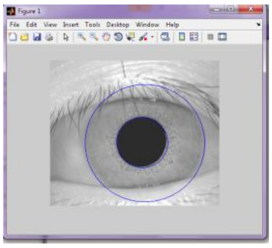
7.1 Results - Hamming Distance Algorithm

The first segmentation method localized 24 images out of 30. This is due to poor intensity separability between sclera, iris and pupil. The proposed method successfully localized 28 images out of 30. The two exemplars are due to iris images having high degree of overlapping eyelashes and eyelids. The success rate is evaluated using equation below

$$\text{SucessRate} = \frac{\text{No.of Localized IRIS Images}}{\text{Total No.of IRIS Images in Database}} \times 100 \quad (15)$$

Reading of an Image

Enrolling of the Image



Iris and Pupil Detection

Recognition of the Image

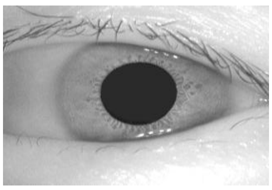
Figure 15 Recognition using HD algorithm

The hamming distance is 0.12 subject is Authenticated.

Iris Pattern Recognition System implemented with improvement in Segmentation algorithm is found to give an accuracy of **99.2%** in comparison with that of **98.6%** from existing segmentation method [15].

7.2 Results - Neural Network Algorithm

The proposed method successfully localized 29 images out of 30. The research reported has reduced the time for iteration from 0.14 to 0.02 secs.

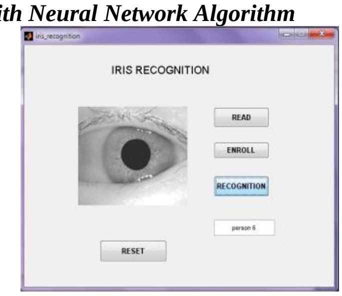


Input Iris Image

Reading of the Image

Hamming Distance is greater then 0.15

Checking with Neural Network Algorithm



Recognition of the image

Figure 16 Recognition using Neural Network Algorithm

Values of Features Extracted

Average = 316.1500; Average of average = 27.7716
Energy = 160 ; Entropy = 0; Bag = 316.1500
Standard Deviation = 28.0170; Co-variance = 596.7637
Data = 3.1615 0.2777 1.6000 0 0.2802 5.9676 3.1615
y = 0 **PERSON 1** **Authenticated**

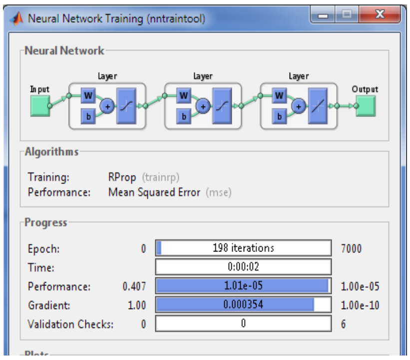


Figure 17 Training Graph

The training graph (Figure 17) shows the input layer, three hidden layers and an output layer. The number of iterations is found to be 198 and the time taken is 0.02 sec. The proposed system performs better with less error rate of e^{-5} than the existing rate of e^{-3}. Thus improvement in time and accuracy are achieved in Neural networks algorithm. The performance analysis graph is shown in the figure 18, is a linear function of target and output.

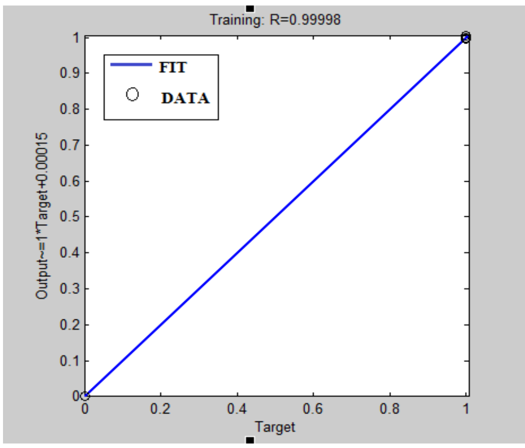


Figure 18 Performance Analysis Graph

7.3 Results - Multi-algorithm

The parameters used for the analysis are False Acceptance Rate and False Rejection Rate. Table 1 gives the FAR and FRR values for the existing method [15], Proposed Hamming Distance algorithm and the Multi-algorithm.

Table 1 Performance Analysis table

	Existing method [15]	Proposed Hamming Distance Algorithm	Multi-algorithm
FAR	**FRR**	**FRR**	**FRR**
0	1.9	1.65	0.8
0.1	1.58	1	0.6
0.2	1.25	0.9	0.5
0.3	1.18	0.8	0.4
0.4	1.02	0.7	0.4
0.5	0.9	0.5	0.3
0.6	0.75	0.4	0.2
0.7	0.62	0.3	0.2
0.8	0.62	0.3	0.18
0.9	0.57	0.25	**0.1**
1	0.57	0.2	**0.1**

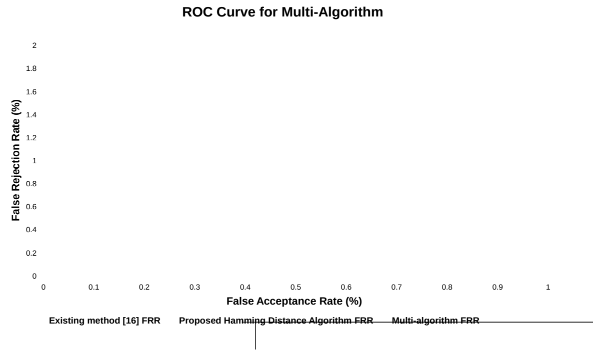


Figure 18 ROC curve for Multi -Algorithm

The ROC curve for the multi- algorithm compared with single Hamming distance Algorithm and the Existing hamming distance algorithm is shown in figure 18. The accuracy of the system is high when its ROC curve is close to the axes. Since the ROC curve for Multi- Algorithmic approach is very close to the axes, it is inferred that Multi-algorithm will give more accurate result for authentication.

8. CONCLUSION

A multi-algorithmic biometric system by fusion of two algorithms at the classifier stage for iris authentication in a highly secured pervasive environment has been designed and implemented successfully and it is found to overcome the drawbacks of traditional method. Experimental results prove that by combining multiple algorithms, this system improves the matching performance, increase population coverage, deter spoofing and facilitate indexing. An efficient iris recognition system using Gabor filters has been implemented with improvement in segmentation algorithm. It is found from the experiments that HD between two irises of the same eye is less than 0.15. The accuracy of the proposed approach is 99.2%. Another efficient matching classifier algorithm - Feed Forward Neural network has been suggested for iris authentication system which works with an error rate of e^{-3} and reduced iteration time of 0.02 sec.

The Multi- Algorithmic approach combines the features of Hamming distance Classifier and Neural Network Classifier for authentication of iris patterns. The error rate has been reduced with an improvement in feature extraction procedure. It is found that Multiple Classifiers improve the performance of a Biometric authentication with better accuracy of 99.5% and reduced false rejection rate. The present work can be extended by testing more samples of iris images and using different algorithms in neural network. Since the images in the CASIA database are mainly eyes of Chinese people the testing could be done for ethnic group.

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