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Performance of Machine Learning Classifier Technique for Iris Recognition

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Abstract: Biometric identification is the important process for verifying the user uniqueness and eliminates the fraud actions. In this paper the user identities are managed by using the iris recognition system because the iris internal features are protected against the damage that will enhance the authentication. The iris recognition system image. Finally the matching is performed by different classifier Support Vector Machine (SVM), Hidden Markov Model (HMM) and Artificial Neural Networks (ANN) approaches which matches the two templates and eliminates the unauthorized identities. The performance of the proposed system is analyzed in terms of false acceptance rate, false rejection rate and equal error rate.

Key words: Biometric Identification · Iris recognition · Preprocessing · Feature extraction · Segmentation · Matching · Support vector machine · Hidden markov model and artificial neural networks

INTRODUCTION

In the recent years personal identifications are managed based on their privacy keys such as id's, PAN card number, secret password and so on. These privacy key may lost for several reasons like password forgotten, id card may be missing and so on [1]. So, the personal information is managed by applying the biometric based intelligent systems. The Biometric system uses the human essential characters for establishing the access control in the particular environment because it granted the authentication permission with a few seconds [2]. There are several biometric features such as iris, retina, nail, fingerprint, face,voice, DNA, palm, lip, keystroke, signature and hand are used to establish the security for user personal information [3]. From the above listed biometric features, the iris features have several advantages when compared to other features because it is stable, complex patterns are unique, the internal organ parts are saved against from the damage, it has fine texture parts and most important it has a unique iris pattern d epends on their genetic information [4]. In addition the iris features are consuming less than 5 seconds for to verify the user information during the pattern matching process. So, this paper uses the iris biometric feature to manage the human identities and achieve the authentication system. The captured iris images are preprocessed and the related regions are segmented by applying the hybrid Sobel edge segmentation method [5]. Then the iris statistical features are extracted which is stored as the template in the database. When the user wants to enter the particular system, the user captured iris images are matched with the template for granting the access permission [6]. The matching process is done with the help of several classifiers such as Support Vector Machine (SVM) [7], Artificial Neural Networks (ANN) [8] and Hidden Markov Model (HMM) [9].

The main contributions of this paper are:

- Removing noise from the captured iris image
- An effective approach, to segment the region and extract the feature from the iris image
- Template matching is performed by different classifiers.
- Analyzing the performance of the different classifiers.

Related Works: This section discusses that the different approaches for iris recognition system that is used to identify the human uniqueness by extracting the human behavioral features. *Saminathan et al.,* [10] authorized the user identities by using the iris biometric features with the help of the support vector machine matching algorithm. The author uses the Chinese Academy of Sciences –

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Institute of Automation database for matching the iris templates which consist of 4800 elements and each row has the 2800 elements when matching. Then the system matches the iris with the highest accuracywhen compared to the other existing matching method. *Hanfei, et al.,* [11] propose a system that use to manage the person's uniqueness in the prison management system. The iris images are preprocessed and the coarse-to-fine related features are extracted from the iris image. Then the iris feature region are segmented which is matched by the template by using the correlation function. The matching is done with the help of several features which produces the better result during the person identification in prison management.

Tallapragada et al., [12] uses the multi class kernel fisher analysis method for grouping the iris images into different group because the kernel method achieves better result when matching the iris image. Then the Hidden Markov Model is used to match the iris images with the help of the images presents in the other group. Then the performance of the proposed system is evaluated with the help of the existing convolution support vector machine based classifier. *Sundaram et al.,* [13] proposed an iris recognition system for managing the user identities. The system consists of different stages, namely iris localization, normalization, feature extraction and feature matching approach. Then the author extracts the GLCM Haralick features of the iris image and those features are matched with the help of the probabilistic neural networks. Thus the performance of the proposed system is evaluated with existing systems.

Yachna Kumari et al., [14] uses the CASIA iris database for recognizing user uniqueness. In this paper the image has been segmented and normalized by applying the Soble, canny edge detector and the 1-D Gabor features are extracted from the image. Finally the template matching has been done with the help of the hamming distance. Then the performance of the system is analyzed by the performance measure PSNR and MSE value. So, the proposed system recognizes the person's uniqueness and the performance of the system is evaluated by using the different classifiers. The following section describes the working flow of the proposed system.

Proposed System: The user identity management paid the lot of attention in now-a-days. So, the paper proposed an approach to recognize the user identities with the help of the IITDelhi iris image database [15]. The dataset consists of captured iris images which is stored in the form of a grayscale image. Then the proposed system has following stages which are shown in the Figure 1.

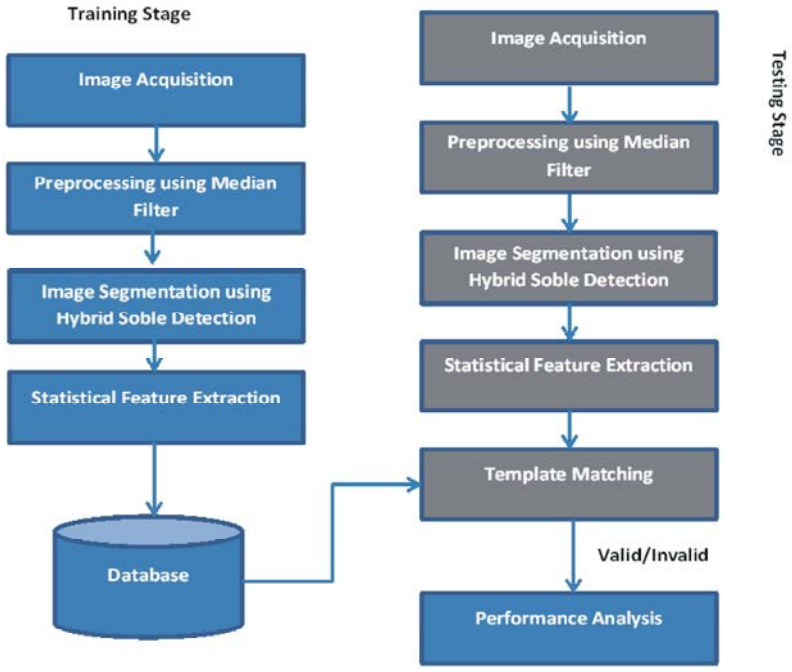

Fig. 1: Proposed Block Diagram for Iris based Biometric Approach

The above Figure 1 explains that the proposed system working process which has two different stages, namely training and testing stage. In the testing stage the iris images are captured from the camera and the preprocessing is done with the help of the median filter. Then the iris regions are segmented by hybrid Sobel edge detection method and the statistical features are extracted from the iris image which is stored as a template in the database. In the testing stage, the extracted features are matched with the templates in the database for analyzing the person's uniqueness. Finally the performance is evaluated for justifying better matching classifier in the proposed system.

Preprocessing: The first step in the iris recognition system is preprocessing which is used to improve the performance of the further matching process. Before performing the preprocessing, the images have to be converted into RGB image to a grayscale image. In our proposed system uses the IIT Delhi database which consists of a grayscale image, so there is no need to convert the images. The median filter [16] eliminates the noise from the grayscale image without affecting the quality of the original image. This filter removes the impulse noise in the iris image with pixel by pixel because each pixels presents in the image will provide the lot of information during the template matching process. Initially the center pixel is identified and compared with the nearer neighborhood pixel value for analyzing the noise pixel value. If the iris pixel is corrupted by any noise which is replaced by the median value. The median value is calculated as follows, sorting all the neighborhood values in ascending order and then pick the center value presents in the list, finally the corrupted pixel value is replaced by this center value. This process is repeated for up to the end of noise condition which will improve the performance of the proposed system.

Image Segmentation: Image segmentation is the process of partitioning the whole images into smaller regions which is done with the help of the Hybrid Sobel Edge detection [17] with the Multi Swarm Optimization algorithm. The Multi Swarm Optimization helps during the fine edge searching while edge detection process and its establish the balance between the exploration and exploitation. The Sobel edge detection method forms the two different 3x3 matrix to estimate the gradient value of the each pixel in the x and y direction. During the gradient calculation process the intensity direction has been increased to obtain the best gradient value. The direction is estimated with the Multi Swarm Optimization technique and the sample gradient value of the each pixel is shown in following matrix.

Then the proposed segmentation algorithm uses the convolution values to detect the edges of the iris image. The edge magnitude of the iris image is estimated as follows.,

$$|G| = \sqrt{Gx^2 + Gy^2} \tag{1}$$

The segmented iris images consist lot of information which is used during the feature extraction and the pattern matching. The detailed procedure is explained in the following section.

Feature Extraction: Feature Extraction is the next stage which is used to form the templates in the iris recognition system. In this system uses the statistical features [18] such as, mean, variance and pixel correlation to form the templates. Then the important statistical features are extracted as follows:

Then the extracted features are considered as the template which is stored in the database for further matching processing.

Template Matching: The final step is template matching which is used to compare the user query into the templates presents in the database. In this paper the template matching is done with the help of the three different classifiers such as Support Vector Machine (SVM), Hidden Markov Model (HMM) and Artificial Neural Networks (ANN).

Hidden Markov Model (HMM): The next classifier is a Hidden Markov Model (HMM) [19] which is based on the statistical Bayesian network approach. In the HMM approach the state of the each feature are not directly visible to all but the output of the each feature is visible to all that is based on the probability of the feature. So, before doing the template matching, the features are trained based on the Baum-Welch algorithm for creating the better training set. The training is done as follows,

$$\overline{\Pi_i} = \gamma_1(i)\overline{a_{ij}} = \frac{\sum_{t=1}^{T-1}\zeta_t(i,j)}{\sum_{t=1}^{T-1}\gamma_t(i)}, \overline{b_j(k)} = \frac{\sum_{t=1}^{T}\gamma_t(j)}{\sum_{t=1}^{T-1}\gamma_t(j)} \tag{2}$$

$$\zeta_t(i,j) = \frac{\alpha_t(i)a_{ij}b_j(o_{t+1})\beta_{t+1}(j)}{\sum_{i=1}^{N}\sum_{j=1}^{N}\alpha_t(i)a_{ij}b_j(o_{t+1})\beta_{t+1}(j)} \tag{3}$$

Then the matching is performed as follows, initially the sequence of observing features are identified and the probability values are calculated based on the probability the features are classified into the valid and invalid.

Artificial Neural Networks: The next classifier is the Artificial Neural Networks (ANN) [20] is one of the supervised neural networks which works similar to the brain activities. The neural network has three layers, namely input layer, hidden layer and output layer. The input layer receives the extracted features as input, each layer has weight and bias value for reducing the error while train the neural network. The hidden layer receives the input from the input layer and transform into the output form which is done as follows,

$$Net\ output = \sum_{i=1}^{N} x_i * w_i + b \tag{4}$$

During the net output calculation the neural network is trained by using the Levenberg-Marquardt learning algorithm which updates the weights and bias as defined as,

$$X_{k+1} = X_k - [J^T J + \mu I]^{-1} J^T e \tag{5}$$

This training process produces the related output for all the features present in the neural networks. In the testing phase, the query template feature is compared to the output of the neural network, when it replies 0 the template is invalid else valid.

Support Vector Machine (SVM): Support Vector Machine (SVM) [21] is the binary classifier which separates the statistical feature templates into two classes. Initially the hyper plane should be chosen to separate the two classes for avoiding the mis-classification data. Let x and y are the input and related output class, then the hyper plane has been chosen to divide the output class labels y{1,-1} and the hyper plane is,

$$w.x + b = 0 \tag{6}$$

Then,

$$y_i(w.x + b) \geq 1\ where\ i = 1,2,3,\ldots.N \tag{7}$$

The above Figure 3 discuss that the hyper plane should be separable the data and minimize the difference between data. Then the difference between the hyper plane is calculated as follows,

-1	0	+1
-2	0	+2
-1	0	+1

Gx

+1	+2	+1
0	0	0
-1	-2	-1

Gy

Fig. 2: Sample Sobel and MSO convolution kernel

$$d_+ + d_- = \frac{2}{\|w\|} \tag{8}$$

Based on the train data, the new entered features are matched with the template present in the hyper plane as follows,

$$Distance = \frac{1}{N}\sum_{i=1}^{N} X_i \oplus Y_i \tag{9}$$

where X_i is the given iris template and Y_i is the stored template in the database. Based on the distance the templates are classified into the acceptable and unacceptable.

Based on the above procedure the iris user query template is matched with the database templates which provides the efficient authentication system. Then the performance of the proposed system is evaluated as follows.

Performance Analysis: This section deals that the performance evaluation of the proposed system template matching classifier. The proposed system uses the IIT Delhi iris image data set for the iris recognition process and the sample grayscale iris image is shown in the Figure 4.

The above image noise has been removed by using the median filter and the statistical features are extracted from the segmented image. Finally the template matching is done with the help of the different classifier. Then the performance of the system is evaluated evaluated with the help of False Acceptance Rate (FAR), False Rejection Rate (FRR) and Equal Error Rate (ERR) and Matching Accuracy.

False Acceptance Rate (FAR): False Acceptance Rate (FAR) [22] is the process of calculating the rate of unauthorized user acceptance during the identity identification process. The FAR is estimated by using the following equation 10.

$$FAR = \frac{Number\ of\ features\ accepted}{Number\ of\ features\ tested} * 100 \tag{10}$$

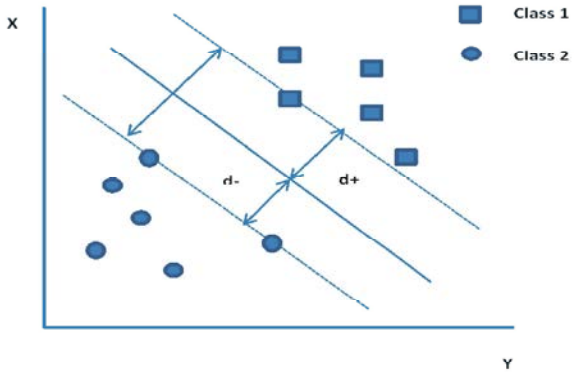

Fig. 3: Support Vector Machine with Hyper plane

Fig. 4: Sample IIT Delhi Iris Database Image

Table 1: Important Statistical Features

Features	Related Formula
Entropy	$\sum_{i,j=0}^{n-1} -\ln(P_{ij})\,P_{ij}$
Correlation	$\sum_{i,j=0}^{n-1} P_{ij}\,\frac{(i-\mu)(j-\mu)}{\sigma^2}$
Energy	$\sum_{i,j=0}^{n-1} (P_{ij})^2$
Variance	$\sum_{i=0}^{n-1}\sum_{j=0}^{n-1}(i-\mu)^2.p(i,j)$
Mean	$\sum_{i=0}^{2(n-1)} i.p_{x+y}(i)$
Inertia	$\sum_{i,j=0}^{n-1}(i-j)^2.p(i,j)$

Table 2: False Acceptance Rate for Different Classification Technique

S.No	Classification Techniques	False Acceptance Rate (FAR)	False Rejection Rate (FRR)	Equal Error Rate (ERR)
1	HMM	0.27703	0.254	0.256
2	ANN	0.15608	0.18762	0.13206
3	SVM	0.15084	0.17317	0.13012

Table 3: Matching Accuracy of Different Classification Techniques

S. No	Classification Techniques	Entropy Matching Accuracy	Correlation Accuracy Matching	Mean Matching Accuracy
1	HMM	92.10 %	91.36%	92.013%
2	ANN	97.20 %	97.46%	98.01%
3	SVM	99.92 %	99.936%	99.956%

False Rejection Rate (FRR): False Rejection Rate (FRR) [23] is the process of incorrectly rejecting the authorized user during the matching process which was measured in terms of percentage. The FRR is measured by using the following equation 11.

$$FRR = \frac{Number\ of\ original\ features\ rejected}{Number\ of\ original\ features\ tested} * 100 \qquad (11)$$

Equal Error Rate (ERR): Equal Error Rate [24] is the rate in which acceptance and rejections are equal which is easily calculated from the above described FAR and FRR values.

From the equation 10,11 False Acceptance Rate, False Rejection Rate and Equal Error Rate of different classifier value is obtained which is shown in the Table 1 and the related graph is shown in the following Figure 5.

The above table 2 shows that the error rate value of all the classifier methods in which the Artificial Neural Networks and the Support Vector Machine has the minimum error rate when compared to all the methods because it minimize the error value during the training stage its self based on the selected features such as Inertia, Entrop,Engery and Mean value. Based on the above values the related Figure 5 is drawn.

The above Figure 5 shows that the comparison of different classifiers, which has the minimum error rate value this lead to increase the matching accuracy during the template matching process. Then the accuracy of the proposed system is evaluated using the extracted features like Entropy, Correlation and Mean which is discussed as follows:

From the above discussion the SVM method provides the best classification results when compared to the other classifiers. Even though the Artificial Neural Networks reduce the error rate during the training, the SVM achieves the best matching accuracy because the SVM method uses the efficient features while matching the templates. Thus the proposed SVM technique ensures the best accuracy and the performance metrics are used to justify that the iris biometric system ensure the authentication to the user identities from the unauthorized activities.

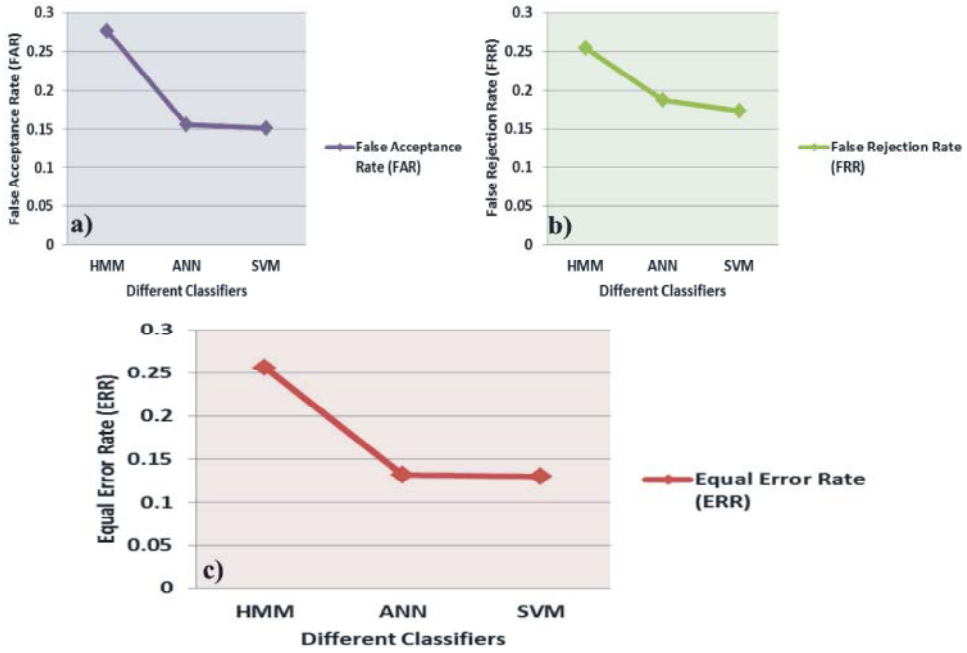

Fig. 5: a FAR value b) FRR value and c) EER value for different Classification Techniques

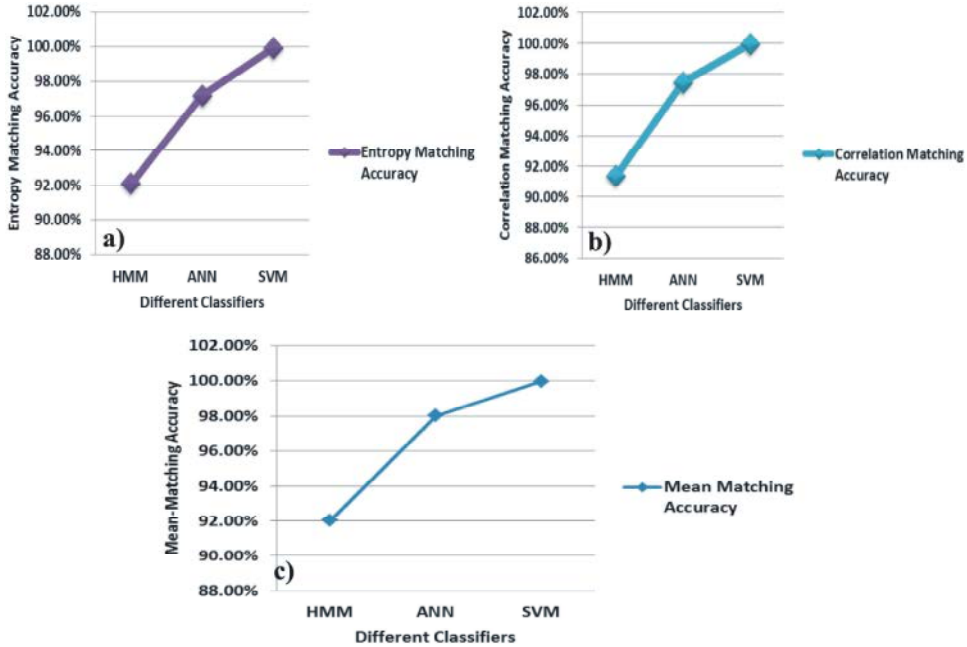

Fig. 6: a) Entropy Accuracy, b) Correlation Accuracy and c) Mean Matching Accuracy of Different Classification Techniques

Conclusion and Future Works: This paper recognizes the user uniqueness using the iris biometric features and the different classifier techniques. In this paper uses the IIT Delhi iris image database for ensuring the authentication system. Initially the iris images are preprocessed using the median filter which removes the impulse noise present in the iris image and then the related regions are segmented by applying the hybrid Sobel Edge detection method. From the segmented region the statistical features are extracted which is used to create the template for the matching process. The matching process is done with the help of the SVM, HMM and ANN networks. Finally the performance analysis used to evaluate the efficiency of the proposed system in that the SVM classifier provides

better results when compared to the other classifier. Further the performance is improved by using the efficient training set which is obtained by the optimization algorithm and other hybrid techniques with neural networks.

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