IRIS recognition based on PCA based Dimensionality reduction and SVM

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ABSTRACT
There are several Iris recognition0 techniques. But method proposed by Daugman is considered to be most efficient technique for IRIS segmentation and feature extraction. Recent studies have shown that there is better classifier which when properly trained with sufficient numbers of features are better than the hamming distance based classifier. But more number of features increases the computational complexity due to the need for feature optimization by kernel based classifiers. Hence in this work we propose a unique technique of first extracting huge numbers of features from the IRIS images and then reducing the features by using PCA based linear dimensionality reduction technique. We first segment the IRIS images with a technique proposed by Daugman, further Gabor features are extracted from the segmented IRIS image. These features are reduced using feature reduction technique. The features are classified using Multiclass support vector machine. We show that the accuracy of the IRIS recognition technique is very high using this method.

General Terms
Iris Recognition, Pattern Recognition.

Keywords
Feature Extraction, IRIS Segmentation, Kernel based classifier, KPCA, Support Vector Machine.

1. INTRODUCTION
A biometric system provides automatic recognition of an individual based on some sort of unique feature or characteristic possessed by the individual. Biometric systems have been developed based on fingerprints, facial features, voice, hand geometry, handwriting, the retina and the one presented in this paper, the iris [1].

IRIS recognition problem may be considered as a problem of classifying the features extracted from a test iris image to one of the feature groups which are taken as training images or iris image of known classes or persons. Feature classification based IRIS recognition techniques are more popular than the hamming distance based iris recognition problem, due to better efficiency of the classifiers than the distance based recognition system. The classifiers can interpolate the features extracted from IRIS images to a high dimensional vector plane and calculate the distance from the given IRIS features with that of features already taken as training samples. It is already proved that values are more separable at the high dimensional plane than the low dimensional plane. Therefore Classifier based IRIS recognition technique is preferred over hamming distance.

There are several good classifiers which can be used for classifying the features and hence recognizing IRIS. For example Neural Network, KNN classifier, SVM classifier, Neuro Fuzzy Classifiers are some of the most widely used classifiers.

Literature has already proved that Support vector machine or SVM based classifiers perform better than other peers in a complex iris recognition problem with thousands of classes and hundreds of features. But one of the major limitations of kernel based classifier is the speed. As the number of classes increases, the complexity of the classifier is also increased. Therefore kernel based classifiers cannot be used practically unless and until the features are optimized and the speed is improved.

In much literature, a dimensionality reduction technique is proposed to reduce the number of dimensions of the features extracted from the IRIS images. Dimensionality reduction techniques are dependent on the correlation of the features. Therefore the test dimensions are to be reduced along with the trained features for obtaining a dimension vector which is unique to both the input and output planes. This again has the limitation that the trained vectors needs to be stored non-reduced. Therefore dimensionality reduction becomes an optimization problem which only assists the kernel based classifiers to perform faster.

The core objective of this work is to device a technique to reduce the input and test dimensionality separately. We build a model based on the input dimensionality reduction and the model is applied on the test features to extract the reduced test features. Therefore the stored trained features are reduced features which solve the purpose of space complexity. This is particularly significant for classifiers that operate on network, as fetching huge number of features consumes more bandwidth.

2. BACKGROUND WORK
The biometrics trait iris - the colored circle that surrounds the pupil - contains many randomly distributed immutable structures, which makes each iris distinct from another [12]. The “early history” of iris biometrics can be considered as approximately up through 2001[3]. The first known algorithm for iris recognition is due to Daugman based on phase texture analysis [12]. The algorithm is based on Iris Codes generated using 2D Gabor wavelet. The accuracy obtained in the iris recognition system is found to be more. Another major contribution is due to Wildes [8]. The algorithm has made use of an isotropic band-pass decomposition derived from application of Laplacian of Gaussian filters to the image data. This algorithm explicitly models the upper and lower eyelids with parabolic arcs whereas Daugman excludes the upper and the lower portions of the image. The results of this system are good enough to recognize the individuals in minimum time period. Boashash and Boles [2] have presented a new algorithm based on zero-crossings. In this algorithm the zero crossings of the

wavelet transform are calculated at various resolution levels over concentric circles on the iris. Resulting one-dimensional (1-D) signals are then compared with the model features using different dissimilarity function. A similar type of system has been presented in which is based on zero-crossing discrete dyadic wavelet transform representation and has shown a high level of accuracy [11].Multi-resolution Independent Component Identification (M-ICA) which provides good properties to represent signals with time frequency is used in to extract the features of iris signals. The accuracy obtained is found to be low because the M-ICA does not give good performance on class-separability. Dargham et. al. has used self-organizing map networks for recognizing the iris patterns. In another algorithm by Li Ma et. al., circular symmetry filters are used to capture local texture information of the iris, which are then used to construct a fixed length feature vector. Nearest feature line algorithm is used for iris matching. Chen and Yuan have developed the algorithm for extracting the iris features based on fractal dimension [11]. The iris zone is partitioned into small blocks in which the local fractal dimension features are computed as the iris code. And finally the patterns are matched using the k-means and neural networks. Gabor filters and 2-D wavelet transforms are used by Wang etc. for feature extraction. For identification weighted Euclidean distance classification has been used. This algorithm is invariant to translation and rotation and tolerant to illumination. The classification rate on using Gabor is 98.3% and the accuracy with wavelets is 82.51%. Robert et. al. have presented a new algorithm for localization and extraction of iris. For localization a combination of the integro-differential operators with a Hough Transform is used while the concept of instantaneous phase or emergent frequency is used for feature extraction [11]. Iris code is generated by thresholding both the models of emergent frequency and the real and imaginary parts of the instantaneous phase. Hamming distance is used for matching. Li Ma. [7]et. al. have used Haar Wavelet transform to extract features from iris images. The transformation is applied four times on image of size 450X60 to obtain a 87-bit feature vector. For classification of feature vectors, weight vector initialization and winner selection strategy has been used [11]. The recognition ability of classifiers depends on the quality of feature used as well as the amount of training data available to them. Image features are mostly extracted on shape and texture of segmented objects. Karu et al. [5] define a methodology for automatically identifying textured regions within an image so that feature extraction algorithms are only used where texture can be quantified. The classification is mainly based on statistical measures used for texture classification such as DU measures, autocorrelation, co-occurrence matrices etc. Textured methods used can be categorized as: statistical, geometrical, structural, model-based and signal processing features [5]. Randen and Husoy conclude that most studies deal with statistical, model-based and signal processing techniques. Co-occurrence method is proved best for texture classification by Conners and Harlow [5].In human, iris structure is explained and classified using coherent Fourier spectra of the optical transmission [12]. CASIA-IrisV3 contains a total of 22,051 iris images from more than 700 subjects. It also consists of twins' iris image dataset. ND 2004-2005 database is the superset of Iris Challenge Evaluation (ICE) dataset, uses an Iridian iris imaging system for capturing the images [6]. The iris recognition system developed by Hamed Ranjzad [4] adopts Independent Component Analysis (ICA) to extract iris texture features. Image acquisition is performed at different illumination and noise levels. The iris localization is performed using integrodifferential operator and parabolic curve fitting. From the inner to outer boundary of iris, fixed number of concentric circles n with m samples on each circle is obtained.

Performance of Inverse Laplacian filter bank is similar to Laplacian pyramid in opposite direction in frequency domain. In Laplacian filter bank the bandwidths of band pass filters are increased with increasing the frequency center of them. Since texture detail information exists in high frequencies more than in low frequencies, these filter banks cannot analysis texture information exactly. In these filter banks high frequency information of texture cannot be extracted exactly because wide widths of filters in high frequency, mixes in band frequency information with each other [9].

Doughman‘s approach is there with highest accuracy of 99.9% and Kaushik Rai‘s approach with 99.5% is available now the only thing that can be done is to decrease the computational time and no. of features to obtain the same efficiency. By which one can overcome the deficiency of existing algorithms [13]. Although the area of the iris is small it has enormous pattern variability which makes it unique for every person and hence leads to high reliability. Feature of an image can be color, shape, edge, texture etc .Among these features color, shape, texture is most promising one. The texture extraction is the most important of all of these, which is proved to be highly reliable and efficient and provide more accuracy when compared to other features.

3. PROPOSED WORK

IRIS images from a specific database (here the proposed system is tested with UBIRIS and Casia IRIS database) is analyzed and the outer and the inner radious of the IRIS part is selected. IRIS part is segmented by first calculating Haugh Circules over the eye image and followed by selecting those Hough circles satisfying the radial dimensions selected first. Segmented IRIS image is further processed for removing eye yields by calculating the Hough lines and removing the highest Hough lines from the segmented IRIS part. Circular iris image is transformed to rectangular coordinate of fixed size. This image is filtered using 2 dimensional Gabor filter. The filter produces MxN non zero features where M,N is the size of the normalized rectangular IRIS image. These coefficients of filter output are used as high dimensional feature vector which is reduced using PCA. The reduced features are stored in the database and SVM is used to classify the features of given test IRIS image from the trained reduced feature vectors.

4. METHODOLOGY

Dimensionality reduction problem can be considered as a 2-step problem with feature extraction and feature selection. A feature extraction in dimensionality reduction problem is a step where using a mapping function new set of features are extracted from the existing feature values for example extracting the Eigen vectors from set of features acquired from images.

Feature selection process selects set of features from the transformed domain. The logic of the process is that there are certain number of features for which classifiers performs best and increasing features above that limit actually causes a degradation of classifier performance rather than improving it.

Hence dimensionality reduction helps improving the performance of the classifier. The Figure 1 shows complete procedure for algorithm.

The process of dimensionality reduction itself can be either a linear mapping where using a mapping function Ø set of features in one domain is transformed to the other domain.

PCA is a linear dimensionality reduction problem which can be stated mathematically as

Y=Ø(x)

Where length(y)<length(x)

Let X be an N-Dimensional Random Vector, represented as Linear combination of Ortho Normal Basis Vector, $[\varphi_1|\varphi_2|\ldots|\varphi_N]$ as

$$x(M)=\sum_{I=1}^{N} Yi\varphi i \text{ where } \varphi_I|\varphi_J = \begin{cases} 0 & i \neq j \\ 1 & i = j \end{cases} \quad (1)$$

Suppose we have to choose x to represent M (M<N) of the basis vectors. We can do this by replacing components $[Y_{M+1},\ldots, Y_N]^T$ with some preselected constants,

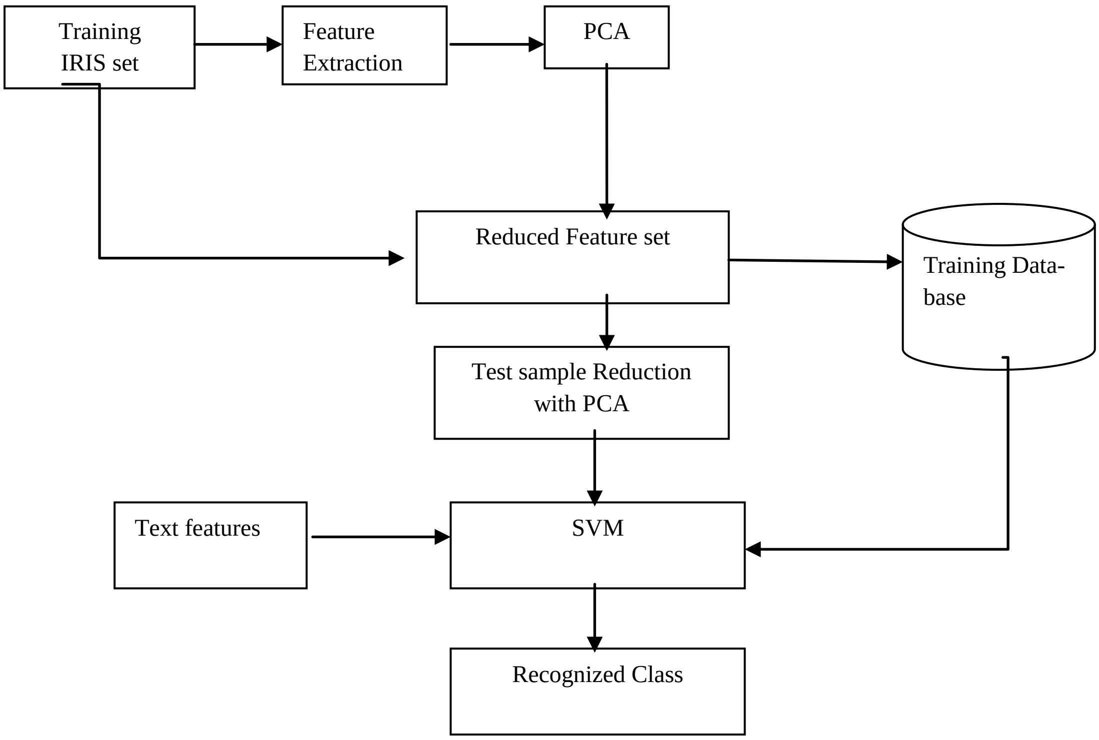

Fig 1: Schematic Diagram of Complete System

$$x'(M) = \sum_{I=1}^{N} Yi\varphi i + \sum_{I=M+1}^{N} Bi\varphi i \quad (2)$$

The representation error is then

$$\Delta x(M) = x(M) - x'(M) = \sum_{I=1}^{N} Yi\varphi i - \left(\sum_{I=1}^{N} Yi\varphi i + \sum_{I=M+1}^{N} Bi\varphi i\right) = \sum_{I=M+1}^{N} (Yi - Bi)\varphi i \quad (3)$$

We choose to measure this representation error by the mean squared magnitude of Δx

$$\bar{\varepsilon}^2(M) = E[|\Delta x(M)|^2] = E\left[\sum_{I=M+1}^{N} \sum_{J=M+1}^{N} (Yi - Bi)(Yj - Bj)\, \varphi i^T \varphi j\right] = \sum_{I=M+1}^{N} E(Yi - Bi)^2 \quad (4)$$

Among all the basis of $Ø_i$ and constants B_i choose the one that minimizes mean square error.

The Optimal values of Bi are found by computing the partial derivative of objective function and equating to zero

$$\frac{\partial E(Y_i - B_i)^2}{\partial B_i} = -2(E[Y_i] - B_i) = 0 \Rightarrow B_i = E(Y_i) \quad (5)$$

So we will replace discarded Y_i by its expected values.

The mean square error can be written as

$$\bar{\varepsilon}^2(M) = \sum_{i=M+1}^{N} \varphi_i^T \; \Sigma_X \varphi_i = \sum_{i=M+1}^{N} \varphi_i^T \lambda_i \varphi_i = \sum_{i=M+1}^{N} \lambda_i \qquad (6)$$

In order to minimize measures, λ_i will have to be smallest Eigen values.

The optimal* approximation of a feature vector with length N by a linear combination of M (M<N) independent vectors is obtained by projecting the random vector x onto the eigenvectors corresponding to the largest Eigen values of the covariance matrix. Hence in short it can be stated that the highest Eigen values extracted from Gabor filter result is used as a feature vector which is used as a training data for SVM classifier which classifies the largest Eigen values extracted from the test IRIS image. As Kernel based classifiers depends upon the linear separability of the features in the dimensional plane and PCA dimensionality reduction optimizes the features to produce the optimum sets of features that are linearly distinguishable the combination is best suited for a IRIS recognition problem as classification.

5. RESULTS

Results are calculated on the basis of following points-

5.1 Results based on Classification Accuracy

In Figure 2 Classification accuracy clearly shows that the proposed method is better than the SVM based IRIS recognition problem. The classification accuracy is attributed by selection of better separable feature vectors through PCA.
Less time for classification and optimization time also attributes to better IRIS recognition solution.

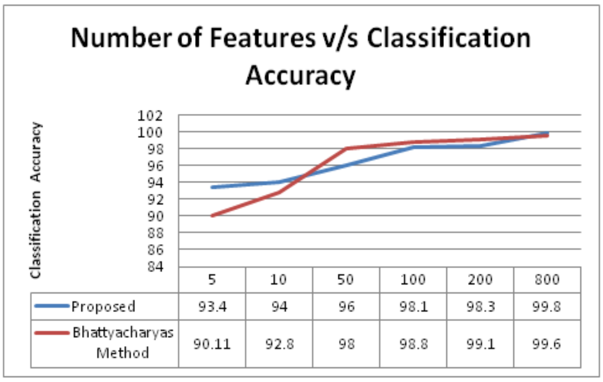

Fig 2: Classification accuracy

5.2 Results based on Optimization Iterations and Number of Feature Vectors

The performance graph demonstrates that as numbers of features are increased, classifier takes more iterations or time to optimize the features. But with dimensionality reduction technique the optimization process gets faster as the features are already optimized. It is clearly shown in Figure 3. Thus the numbers of features are less as compared to previous method so the optimization iteration.

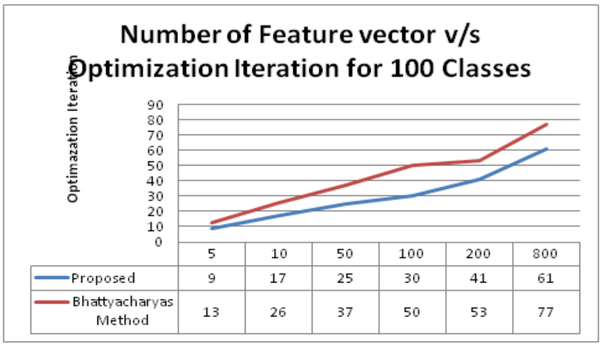

Fig 3: Number of classes v/s Optimization steps

6. CONCLUSION

This work proposes a linear dimensionality reduction technique with PCA which is applied on the conventional feature set extracted from 2 dimensional Gabor filtering as has been widely used over past two decades since Daugman had first proposed it. Therefore the technique does not require any alternative feature selection method and uses the existing one for scalability and adoptability. Results shows that the overall accuracy of the system is near 99.6% on CASIA IRIS database and 97% on MMU database. The performance is better than the existing method being proposed in Multiclass SVM based Iris recognition.

As the proposed system is based on linear dimensionality reduction so many possible cases are there in which FRR can be more due a line of acceptance that either a image will be accepted or rejected,which can be further improved by adopting non linear dimensionality reduction technique like KPCA with combined distance based classifier like KNN and kernel based classifier like SVM, this will provide a range of acceptance for each image.

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