An Implementation of FACE Recognition System (FARS) Using PCA and PSO Based Techniques

Mukesh Tiwari, Arun Kumar Shukla

Abstract—Feature selection (FS) is a universal optimization problem in machine learning, which reduces the number of features, removes irrelevant, noisy and redundant data, and results in acceptable recognition accuracy. It is the most important step that affects the performance of a pattern recognition system. Feature selection aims to choose a small number of relevant features to achieve similar or even better classification performance than using all features. It has two main conflicting objectives of maximizing the classification performance and minimizing the number of features. However, most existing feature selection algorithms treat the task as a single objective problem. In this paper we present a novel feature selection system, FARS, based on combination of particle swarm optimization (PSO) and Principle Component Analysis (PCA). The proposed PSO and PCA based feature selection system is utilized to search the feature space for the optimal feature subset where features are carefully selected according to a well defined discrimination criterion. The classifier performance and the length of selected feature vector are considered for performance evaluation using MATLAB in ORL face database.

Keywords: Face Recognition, Feature selection, PSO, PCA, ORL Dataset

I. INTRODUCTION

Face recognition has become a very active area of research in recent years mainly due to increasing security demands and its potential commercial and law enforcement applications [1]. Humans have the ability to recognize faces easily and effortlessly but in the area of image analysis and computer vision it remained as a difficult problem on which many years of research is going on. A complete review of techniques for face recognition can be found in [2]. An unknown digital image is identified from a database of known images in face identification whereas in face recognition the person's identity is confirmed by the system from a stored database of faces. To verify or identify a person in the digital image, features extracted from the digital image are compared with features of the images in the facial database. Face recognition has applications in legacy systems such as voter registration, passports and driver's licenses, crowd surveillance, human-computer interaction, multimedia management, smart cards,

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Mukesh Tiwari, Shepherd School of Engineering and Technology, Sam Higginbottom Institute of Agricultural Technology and Sciences, Allahabad-211007 (U.P). India.

Arun Kumar Shukla, Shepherd School of Engineering and Technology, Sam Higginbottom Institute of Agricultural Technology and Sciences, Allahabad-211007 (U.P). India.

Access control and authentication. Occlusion, pose variation and illumination problems are still challenging for face recognition. Face recognition as a biometric has an advantage that it requires no co-operation of the person unlike other biometrics.

The success of any Face Recognition methodology depends heavily on the particular choice of the features used by the (pattern) classifier. It is known that a good feature extractor for a face recognition system is claimed to select as more as possible the best discriminate features which are not sensitive to arbitrary environmental variations such as variations in pose, scale, illumination, and facial expressions. Feature extraction algorithms mainly fall into two categories: geometrical features extraction and, statistical (algebraic) features extraction [3] [4]. The geometrical approach, represent the face in terms of structural measurements and distinctive facial features that include distances and angles between the most characteristic face components such as eyes, nose, mouth or facial templates such as nose length and width, mouth position, and chin type. These featuresare used to recognize an unknown face by matching it to the nearest neighbor in the stored database

Face Recognition System Typical structures of face recognition system consist of three major steps, gaining of face data, extracting face feature and recognition of face. Fig. 1 shows typical structure of face recognition system in which subject under consideration given to the system for the recognition purpose this is consider to be acquisition of face image. Later on feature is extracted from the image and finally it is given for the recognition purpose. These steps are elaborated as follow.

A. Gaining of Face Data

Acquisition and Processing of Face Data is first step in the face recognition system. In this step face images is collected from different sources. The sources may be camera or readily available face image database on the website. The collected face images should have the pose, illumination and expression etc variation in order to check the performance of the face recognition system under these conditions. Processing of face database require sometimes otherwise causes serious affect on the performance of face recognition systems due changes in the illumination condition, background, Feature extraction methods commonly represent the face images with a large set of features in which features do not contribute equally to the face recognition task. Feature selection (FS) in pattern recognition involves the derivation of the feature subset from the raw input data to reduce the amount of data used for classification and simultaneously provide enhanced discriminatory power. The selection of an appropriate set of features often exploits the design criteria such as redundancy minimization and de-correlation, and minimization of the reconstruction error. For many pattern classification problems, a higher number of features lighting conditions, camera distance, and thus the size and orientation of the head. Therefore input image is normalized and some image transformation methods apply on the input image [5].

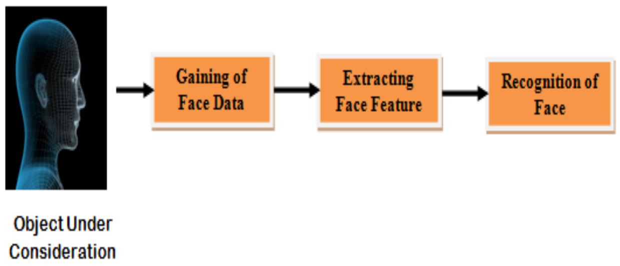

Fig. 1 Face Recognition System

B. Extracting Face Feature

Feature extraction process can be defined as the process of extracting relevant information from a face image. In feature extraction, a mathematical representation of original image called a biometric template or biometric reference is generated, which is stored in the database and will form the basis (vector) of any recognition task. Later these extracted features used in recognition. A grayscale pixel is considered as initial feature

C. Recognition of Face

Once the features are extracted and selected, the next step is to classify the image. Appearance-based face recognition algorithms use a wide variety of classification methods Such as PCA, LDA. In classification the similarity between faces from the same individual and different individuals after all the face images in database are represented with relevant features. Sometimes feature extraction & recognition process done simultaneously. used do not necessarily translate into higher recognition rate [6]

II. BACKGROUND

A. Principle Component Analysis (PCA)

Principal Component Analysis (PCA) operates on static data sets. PCA, also known as Karhunen-Loeve (KL) transformation or eigenspace is basically a statistical technique used in image recognition and classification. It is also, used for image compression. First time Kirby and Sirovich developed low-dimensional characteristic for face images at Brown University [7] [8]. Main emphasis of PCA is to transform the 2D image into 1D feature vector in subspace. This subspace is also, called eigenspace in which the covariance matrix is obtained as a result of facial features. The subspace formed as a result of PCA conversion makes use of facial feature to characterize different reference images or eigenfaces from the sample dataset. The orthonormal vector obtained as a result of Singular Value Decomposition (SVD) is projected on to a database, which results in a major reduction in a size of the coefficient used to symbolize the image. This property also, helps in reducing the overall analysis time by obtaining the best match among the probe and reference image.PCA converts a high dimensional data into low dimensional image in a linear fashion, in which the principle component are not correlated. The recognition rate of PCA based face recognition outperforms when the number of test images increases, but the rate of recognition decreases of the certain number. Size of the image is not superior issue in PCA based system but the important thing is that the number of probes images before PCA projection is large as compared to the number of reference images.In a similar manner, in the face recognition system, the principal components are computed using Eigen vectors and Eigen values. However, before applying PCA, the images are pre-processed and normalized to reduce the size of the data set. Then following stages are carried out [9]:

a. Creation of Eigen space: This involves computing the mean of the data set, subtracting the mean from every data set, calculating the covariance matrix S, computing the Eigen vector and Eigen values of S, sorting the Eigen vectors in descending order and selecting all non-zero Eigen values
b. Project the training image: At this stage, the dot product between the ordered Eigen vectors and image is calculated.
c. Identifying testing image: The image to be tested is projected on the existing Eigen faces, comparisons are made and the image is then identified Thus the steps in the algorithm are [10]:
    1) Select the images for learning and for a data set
    2) Calculate covariance matrix
    3) Calculate Eigen vectors and Eigen values of covariance matrix
    4) Project the images into Eigen Space
    5) Compare projections and determine the identity

B. Particle Swarm Optimization (PSO)

PSO proposed by Dr. Eberhart and Dr. Kennedy in 1995 is a computational paradigm based on the idea of collaborative behavior and swarming in biological populations inspired by the social behavior of bird flocking or fish schooling [11]. Recently PSO has been applied as an effective optimizer in many domains such as training artificial neural networks, linear constrained function optimization, wireless network optimization, data clustering, and many other areas where GA can be applied [12]. Computation in PSO is based on a population (swarm) of processing elements called particles in which each particle represent a candidate solution. PSO shares many similarities with evolutionary computation techniques such as GA's. The system is initialized with a population of random solutions and searches for optima by updating generations. The search process utilizes a combination of deterministic and probabilistic rules that depend on information sharing among their population members to enhance their search processes. However, unlike GA's, PSO has no evolution operators such as crossover and mutation. Each particle in the search space evolves its candidate solution over time, making use of its individual memory and knowledge gained by the swarm as a whole. Compared with GAs, the information sharing mechanism in PSO is considerably different. In GAs, chromosomes share information with each other, so the whole population moves

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like one group towards an optimal area. In PSO, the global best particle found among the swarm is the only information shared among particles. It is a one-way information sharing mechanism. Computation time in PSO is significantly less than in GAs because all the particles in PSO tend to converge to the best solution quickly [12].

III. Literature Survey

Some of the recent publications in this topic of research are briefly reviewed in the following.

Ramadan and Kader [13] have presented a feature selection algorithm using PSO for face recognition. PSO is applied on the coefficients (features) of Discrete Cosine Transform (DCT) and Discrete Wavelet Transform (DWT) to select the optimum features of image. The optimum subset of features is selected by PSO based on the fitness function. ORL database is used for testing the performance. Face recognition is carried out based on Euclidean distance between features of unknown face and the features of faces in the database. The proposed algorithm has better performance when compared to GA-based feature selection algorithms in terms of number of features selected and classification accuracy rate. Yun et al. [14] proposed feature selection methods using algorithms like Genetic algorithm and Particle Swarm Optimization. An algorithm which makes use of relevance of features is also proposed. A measure known as minimum redundancy and maximum relevance (MRMR) is used to select features, using which redundancy of features is minimized and relevance of features is maximized. This method, when used with genetic algorithm and PSO, provided quality feature set and achieved better accuracy rate.

Bing Xue et al. [15] has proposed a binary particle swarm optimization (BPSO) with two new fitness functions to minimize the number of features selected and to maximize the classification accuracy rate. First one linearly changes weights of fitness function and the other one uses two-stage fitness function. Experiment results have shown that the BPSO with the two new fitness functions provides better results compared to classification performance used as fitness function.

Unlerand Murat [16] has proposed a modified discrete PSO algorithm for feature selection. In this approach, the relevance and dependence of features to be included in the feature sub-set is dynamically decided by using an adaptive feature selection algorithm proposed by them. Experimental results show that it is computationally less expensive and provides improved recognition rate.

Yuanning Liu et al. [17] have proposed a modified multi-swarm PSO (MSPSO). The particles are split into set of subsets called sub swarms. Sub swarms are controlled and monitored by a scheduler. They introduced a mechanism to decide the survival of sub swarm called as survival of the fittest. An improved feature selection method (IFS) has also been designed. The proposed algorithm gave better results when compared to standard PSO, GA and grid search in terms of classification accuracy rate.

Liam Cervante et al. [18] has developed two new feature selection approaches based BPSO. The relevance and redundancy in the feature subsets is measure by mutual information and entropy. The two new algorithms are applied on training data from the dataset and the feature subset is selected. The subsets' classification performance is evaluated by a learning algorithm. The resulting feature set is found to have less number of features and achieved same or higher classification rate.

Bing Xue et al. [19] have proposed a new approach for feature selection based on PSO. In this approach, an external archive is introduced which stores solutions which are later used to determine global best of particles. Particles global best is chosen from the solutions in archive using selection methods such as random selection and roulette wheel selection. The proposed approaches perform better than the standard PSO. They select less number of features and have same or higher classification rate.

IV. Proposed Work

The given section provides the detailed understanding about the proposed face recognition system.

Table 1 PCA Algorithm for ORL Datasets

Input: ORL Face Dataset **Output:** Reduced Redundancy, Feature Selection
Process: **1:** Choose Data and divide into 3 different sets i. Training Set ii. Evaluation Set iii. Testing Set **2:** Apply PCA Algorithm on above all 3 datasets **3:** do Projection of Faces **4:** do classification of different Faces **End process**

Table 1 PCA+PSO Algorithm for Training Datasets

Input: ORL Face Dataset **Output:** Reduced Redundancy, Feature Selection
Process: **1:** Choose Data and divide into 3 different sets i. Training Set ii. Evaluation Set iii. Testing Set **2:** Apply PCA+PSO Algorithm on above all 3 datasets **3:** Calculate Fitness Function of all datasets $$F = \sqrt{\sum_{i=1}^{L} (M_i - M_0)'(M_i - M_0)}$$ $M_0 = means\ of\ corresponding\ classes$ $M_i = grand\ mean\ in\ the\ feature\ space$ $F = class\ scatter\ fitness\ function$ **4:** Find Maximum and Minimum value of all 3 datasets i. Training Set – Maximum and Minimum ii. Evaluation Set – Maximum and Minimum iii. Testing Set – Maximum and Minimum **5:** Apply PSO function **Input:** $X = Swarm$ $F = Swarm\ Fitness$ FE_max=Maximum number of function Evaluation (Iteration) $Fun = Function\ Specifire$ $err = Admissible\ error$ $LB = Lower\ bound$ $UB = Upper\ bound$ opt_f=Global optimum for function Retrieved optimized function features of faces **6:** do classification of different faces **End process**

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Here we listed algorithmic structure of the proposed face recognition system. In table 1 demonstrate the PCA analysis of for extracting the feature of an image. We divide ORL data sets into three different dataset where as apply principle component analysis algorithm for evaluating classification of different images. Next table contain combination of PCA with particle swarm intelligence algorithm in which we take different input parameters for functioning of PSO Algorithm. In the last different images return optimized function feature for process of classification

V. RESULT ANALYSIS

This section provides the analysis of obtained results and performance of the system implemented for face recognition.

A. *EPC (Expected Performance Curves)*

ROC analysis provides the technique to select optimal patterns and to discard suboptimal ones from the current context or the available class distribution

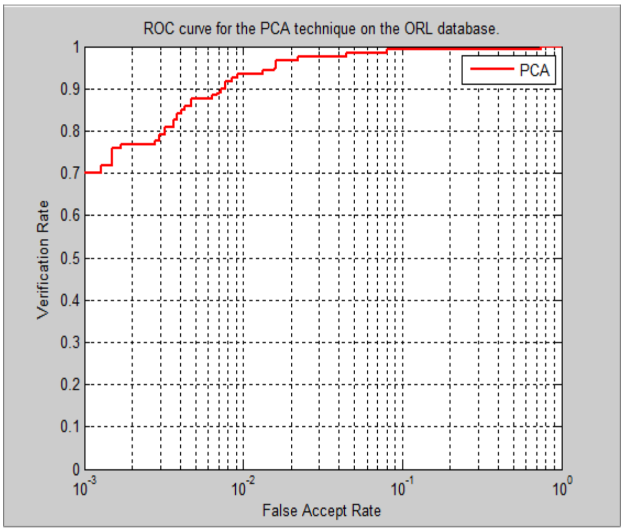

Fig. 2 ROC for PCA Face Recognition

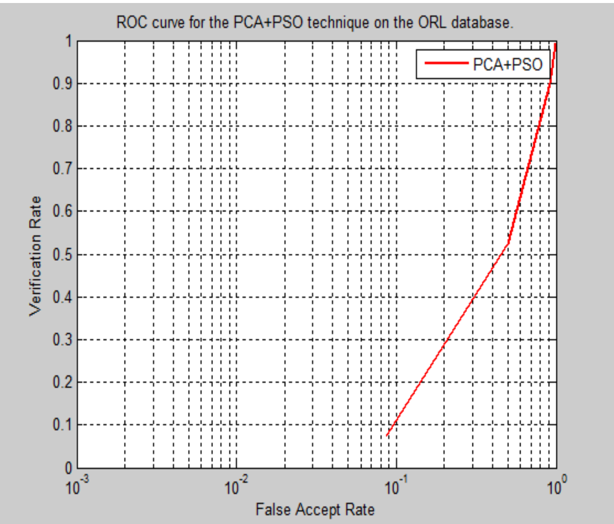

Fig. 3 ROC curve for PCA Face Recognition

The ROC curve for the proposed system is given the figure 2 shows the ROC for face detection using RCA technique and figure 3 shows the performance of face recognition using PCA and PSO based method. In order to represent the performance of the system X axis shows the false accept rate and the Y axis contains the verification rate of the input patterns. According to the obtained performance of system the face recognition rate for the classification is higher as compared to traditional classifier.

B. *CMC (Cumulative Match Characteristic)*

Method of measure accuracy for a biometric system in the closed-set is given by the CMC curve. In this approach the templates or query patterns are compared and ranked based on their similarity. The CMC shows how the biometric pattern appears in the ranks, based on the match patterns

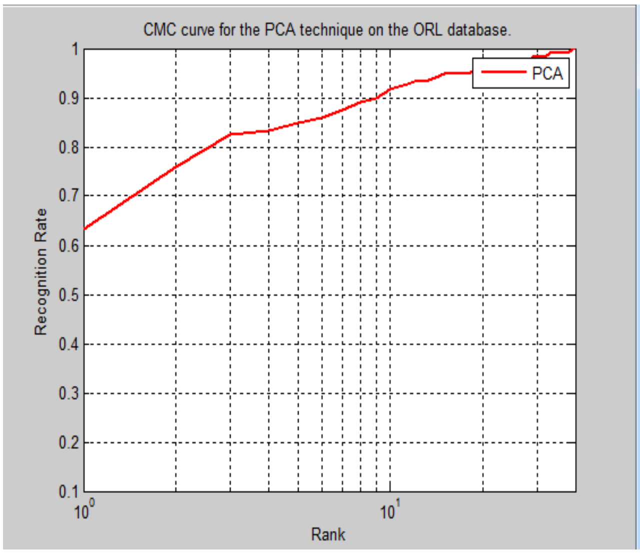

Fig. 4 CMC for PCA Face Recognition

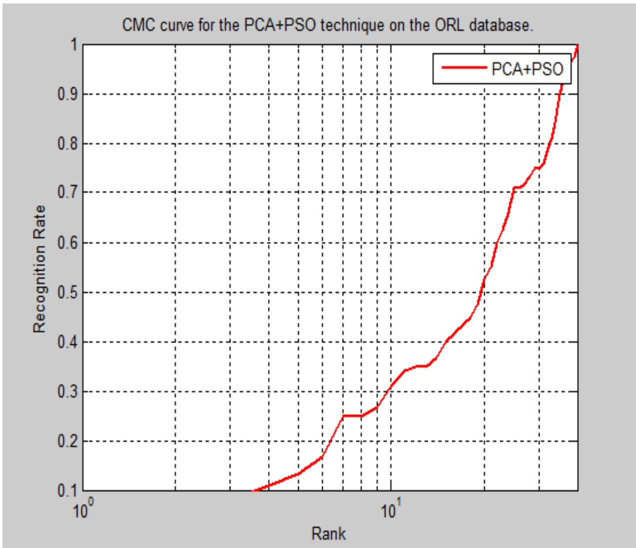

Fig. 5 CMC for PCA+PSO Face Recognition

The figure 4 shows the performance of PCA face recognition and figure 5 shows the performance of PCA and PSO for face recognition. According to the obtained results the accuracy of both the systems are adoptable. But the comparative performance of the proposed model is much accurate for face recognition as compared to traditional recognition. Thus the method is much adoptable for face recognition.

C. *EPC (Expected Performance Curves)*

Expected Performance Curves (EPC) really reflects the expected (and reachable) performance of systems.

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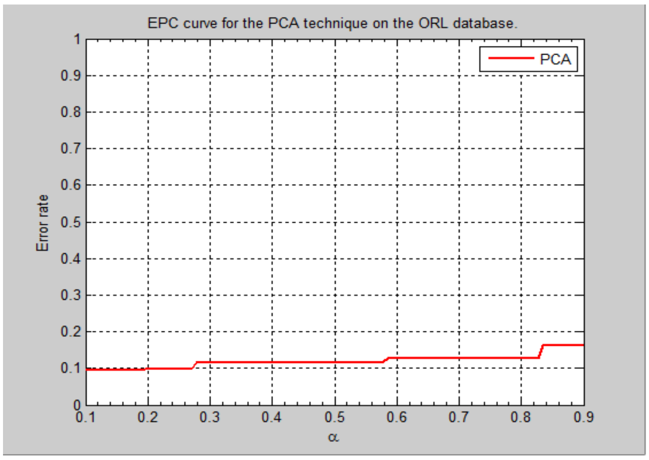

Fig. 6 EPC for PCA Face Recognition

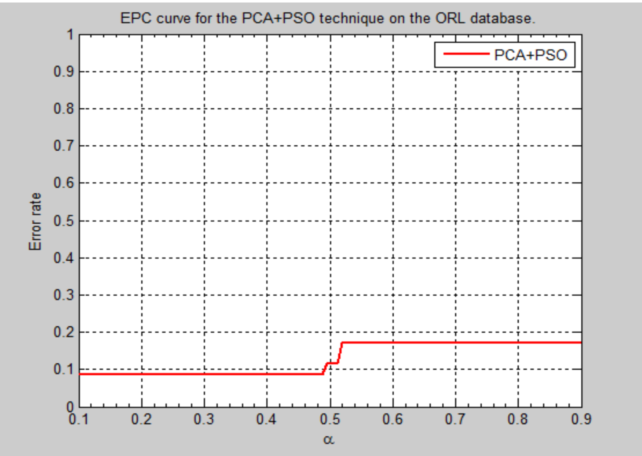

Fig. 7 EPC for PCA+PSO Face Recognition

The performance of the system in terms of PCA face recognition and PCA+PSO face recognition is given using figure 6 and 7. That actually represents the error rate of the system if the error rate of the classification is less than the performance is improving and providing much accurate classification rate. Thus the proposed model for PCA and PCA+PSO Face recognition is adoptable with the low error rate during the recognition task.

VI. CONCLUSION

Optimal feature selection (FS) is to find the minimal subset of features from original feature set that can represent the whole dataset. In this paper, a novel PSO and PCA based Face Recognition algorithm, FARS is proposed. In this domain the training and testing are the two phases for pattern learn from the past experience. These patterns are used with the computational model to prepare a data model by which the target objectives are accomplished. These techniques are frequently used in the new generation for optimizing the experience of human life.

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Mukesh Tiwari has comleted his B.Tech. in Computer Science and Engineering in the year 2014 from United Institute of technology. Currently he is pursuing M.Tech in Computer Science and Engineering from Sam Higginbotom Institute of Agriculture, Technology & Sciences, Deemed –to be-University in Allahabad (U.P.). He is area of interest is Image Processing, Network Security, Pattern Recognition.

Arun Kumar Shukla is currently working as Assistant Professor in the Computer Science and IT Department in Sam Higginbotom Institute of Agriculture, Technology & Sciences, Deemed –to be-University in Allahabad (U.P.). He has done his Bachelor of Engineering from Jawaharlal Institute of Technology from Khargone (M.P.) in the year 2006 and Mater of Engineering from I.E.T. –D.A.V.V., Indore in the year 2011. He has also worked on the post of Sr.Lecturer in Malwa Institute of technology, Indore from January, 2007 to June, 2011.

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