Face Detection Technique by Gabor Feature and Kernel Principal Component Extraction Using K-NN Classifier with Varying Distance

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***Abstract* - Face recognition is always a hot topic in research. In this paper, we represent a robust method of face recognition using gabor feature extraction, kernel PCA and K-NN classifier. Gabor features are calculated for each face images then it's polynomial kernel function is calculated, it is directly applied to the K-NN classifier. The effectiveness of the proposed method is demonstrated by the experimental results on testing large number of images. The result shows good recognition rate. The proposed method uses ORL database.**

***Keyword* - Gabor filter, Kernel Principal Component Analysis, K-NN Classifier, ORL Dataset, Polynomial Kernel Function, Cos Distance.**

I. INTRODUCTION

Image processing, pattern recognition and computer vision is an active area of research which uses human face detection and recognition. Face detection and recognition are important steps for a wide range of applications such as identity verification, video-surveillance, lip tracking, facial expression extraction, gender classification, advanced human and computer interaction. Several methods are based on neural network approaches, Markov chain, skin color, and others are based on template matching [1]. Pattern localization and classification is the step, which is used to classify face and non- face patterns.

Appearance-based and model-based algorithms are the two categories of facial recognition. Appearance-based method represents a face in terms of several raw intensity images of pixels. An image is considered as a high-dimensional vector of related pixels. Statistical techniques are used to derive a feature vector from the image distribution. The sample test images are compared to the training set. Appearance methods are of two types linear or nonlinear. Linear appearance-based methods perform a linear dimensionality reduction. The face feature vectors are projected to the basis test vectors. The PCA, LDA, and Independent Component Analysis (ICA) are the linear dimensionality reduction technique [1], [2] Non-linear appearance methods are more complicated. Kernel PCA (KPCA) [3] is a method widely used. Model-based approaches can be 2-Dimensional or 3-Dimensional. These algorithms try to build a model of a human face. These models are often morphable. A morphable model allows classifying faces even when pose changes are present, and approaches are Elastic Bunch Graph Matching [4] or 3D Morphologic Models [5].

Gabor wavelets has kernels, similar to the response of the two-dimensional receptive field profiles of the human simple cortical cell, shows desirable features of capturing salient visual characteristics such as spatial localization, orientation, and spatial frequency [7]. Now, more and more researches conducting face recognition which uses Gabor wavelets to extract the human face features. But the size of Gabor face feature dimensions computed by each pixel is very large; so the complexity is very high. To reduce the dimensions, many researchers utilized simple down sampling technique to select feature points [8]. However these methods which used down sampling strategy still have high dimensions of feature matrix and, in addition, can lead to partial loss of feature discriminative information. Therefore, it causes accuracy reduction in the classification stage. So, researchers used PCA, LDA, ICA, KPCA or other feature extraction approaches to reduce the size of dimensions [9].

II. GABOR FILTER BANK

The Gabor filter extracted features from gray-level images, has been widely and successfully applied to different pattern recognition problems. A 2-D Gabor filter is a Gaussian kernel function modulated with sinusoidal plane wave will give spatial domain feature. It can be represented by

$$\Psi_{\omega,\theta}(x,y)=\frac{1}{2\pi\sigma^2}\exp\left(-\frac{x'^2+y'^2}{2\sigma^2}\right)\exp(j\omega x') \quad (1)$$

$$x'=x\cos\theta+y\sin\theta\ ,\quad y'=-x\sin\theta+y\cos\theta$$

Where (x, y) is the pixel position in the spatial domain, ω is angular frequency of a sinusoidal plane, θ is the anti-clockwise rotation of the Gaussian function (the orientation of the Gabor filter), and σ represents the sharpness of the Gaussian function along both x and y directions. The Gabor filters with the different frequencies and orientations, which form the Gabor filter bank, have been used to extract features of face images. Fig. 1 shows the Gabor filter bank with 5 different scales and 8 different orientations. The following equations give 5 frequencies (m = 1,2,…,5) and 8 orientations (n = 1,2,…,8) for the Gabor filter bank:

$$\omega_m = \frac{\pi}{2} \times \sqrt{2}^{-(m-1)} \quad , \quad \theta_n = \frac{\pi}{8}(n-1) \qquad (2)$$

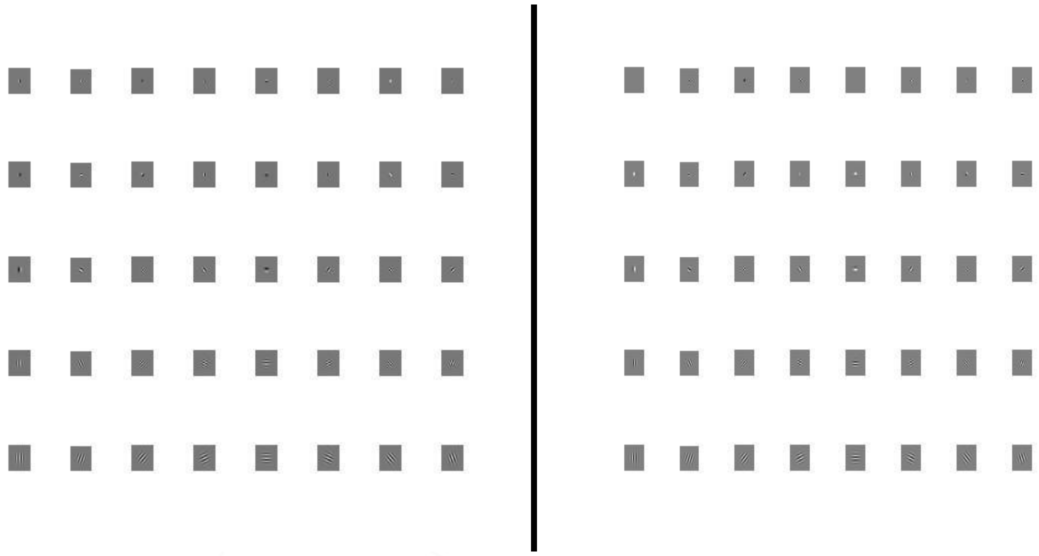

Fig.1 Real and Imagery part of the Gabor Filter Bank at 5 scale and 8 orientation.

III. Kernel PCA

Principal Component Analysis (PCA) is a powerful technique for reducing a large set of correlated variables to a smaller set of uncorrelated components, has been applied extensively for both face representation and face recognition. Kirby and Sirovich [11] showed that any particular face can be effectively represented along the eigen feature coordinate space. So that face can be reconstructed by small collection of eigen feature and the corresponding projections. PCA considers second order statistics (variances and covariances) of the input image. Since these second order statistics provide only the partial information on the statistics of face images, it might become necessary to incorporate the higher order statistics as well. PCA is extended to a nonlinear form by mapping nonlinearly the input space to a feature space, where PCA is applied [12]. It is quite difficult to perform PCA directly because it is computationally very extensive to compute the dot products in a high dimensional feature space. Fortunately, kernel techniques can be used to avoid this difficulty. The algorithm can be actually implemented in the input space by virtue of kernel tricks. The explicit mapping process is not required at all [13]. Steps to describe KPCA are as follows.

1) Compute kernel matrix of the feature vector space D = [Φ(x1) Φ(x2) … Φ(xM)].

$$K_{ij} = \Phi(\mathbf{x}_i) \cdot \Phi(\mathbf{x}_j) \qquad (4)$$

2) KPCA can be derived by solving the following eigenvalue equation

$$KA = MA\Lambda \quad \text{with} \quad A = [\alpha_1 \ \alpha_2 \ \ldots \ \alpha_M]$$
$$\Lambda = diag\{\lambda_1, \lambda_2, \ldots, \lambda_M\} \qquad (5)$$

Where A is relation of orthogonal eigenvector matrix M×M, Λ is a relation of M×M diagonal eigenvalue matrix with diagonal elements in decreasing order (λ1 ≥ λ2 ≥ … ≥ λM) and M is a constant (the number of training samples).

3) Eigenvector matrix V = [V1 V2 … VM], of KPCA, first, A should be normalized such that λi||αi||2 = 1, i = 1,2,…,M. The eigenvector matrix, V, is then derived as

$$V = DA. \qquad (6)$$

IV. Proposed Algorithm

Block diagram of the proposed algorithm is shown in Fig. 2. The input face images from the ORL database are given to a Gabor filter bank at 5 scales and 8 orientations for feature extraction.

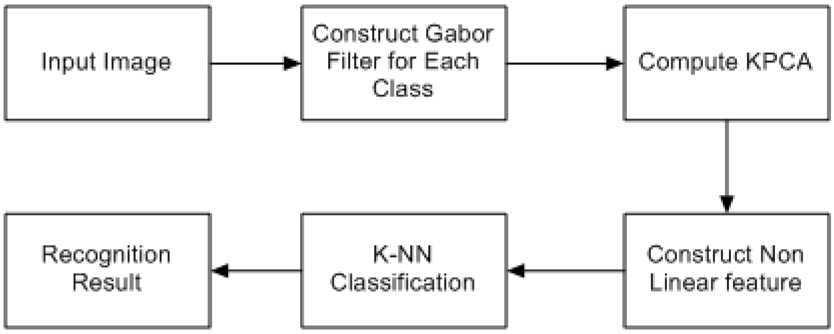

Fig.2 Block Diagram of Proposed Method

KPCA is used for reduction of dimensionality of face feature data. There are several different kernel functions which can be used in the KPCA method. We are using polynomial function.

V. RESULT

Face images from the ORL database are used to train and test the proposed face recognition system. The ORL database contains face images from 40 distinct persons. Each person has 10 different images taken at different times. We have used 400 face images of the ORL database of 40 persons are used for training and testing. We divided them into 2 sets with equal number of images for each class. One set is used for training and another is used for testing. We have used the cos distance vector to calculate the distance in K-NN classifier. This improves the recognition rate significantly as shown in Fig 3 and Table 1.

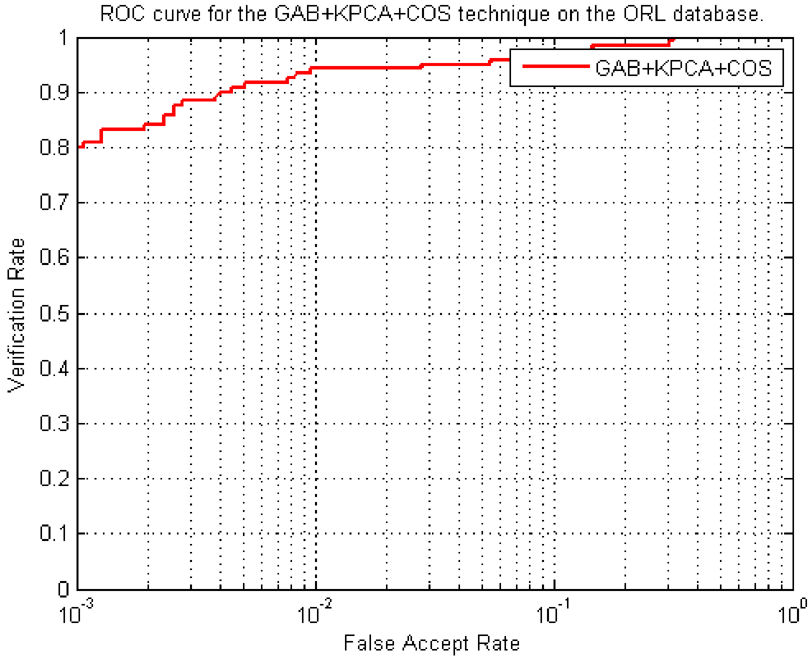

Fig 3: ROC Curve of Gabor KPCA with Cos distance

Table 1: Recognition Rate

Class Number	Proposed Method Result (%)
40	88.33

Finally, a face recognition algorithm presented in [14] by using RBF kernel method for feature extraction and SVM for classification. Their experiments over the ORL database result in the maximum recognition rate of 81.5% for K-NN classifier which is less accurate when compared with the maximum recognition rate of our proposed algorithm 88.33%.

VI. CONCLUSION

In this paper, we have proposed an efficient face recognition algorithm based on the Gabor filter bank of 5 scale, 8 orientation for feature extraction, KPCA algorithm with polynomial kernel function for feature reduction, and K-NN classifier with cos distance for classification. Comparisons between our proposed algorithm and the face recognition algorithm presented in [14] are conducted over the ORL database. The experimental results clearly demonstrate the effectiveness of our proposed algorithm with recognition rate of 88.33%.

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