A Review on Face Recognition Algorithms

Sonali Goel[1] and Neera Batra[2]

1. Maharishi Markandeshwar University, Mullana, Haryana
2. Maharishi Markandeshwar University, Mullana, Haryana

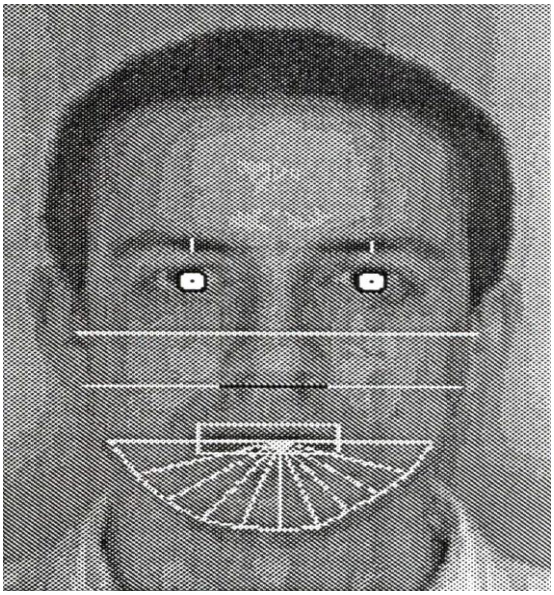
Abstract: *Face Recognition is the process through which a person is identified by his facial image. With the help of this technique it is possible to use the facial image of a person to authenticate him into any secure system. Face recognition approaches for still images can be broadly categorized into holistic methods and feature based methods. Holistic methods use the entire raw face image as an input, whereas feature based methods extract local facial features and use their geometric and appearance properties [2]. A large number of face recognition algorithms have been developed in last decades. In this paper an attempt is made to review a wide range of methods used for face recognition comprehensively. This includes PCA, LDA, ICA, and SVM.*

Keywords: *Principal Component Analysis (PCA), Linear Discriminant Analysis (LDA), Face Recognition, Independent Component Analysis (ICA), Eigenfaces and Pattern recognition.*

Introduction

The identification of a person by their facial images can be done in a number of different ways such as by capturing an image of the face in the visible spectrum using an inexpensive camera or by using the infrared patterns of facial heat emission. Facial Recognition in visible light typically model key features from the central portion of the facial image using a wide assortment of cameras in visible light system extract features from the captured images that do not change over time while avoiding superficial features such as facial expression or hair. The challenges of facial recognition in the visible spectrum include reducing the impact of variable lightning and detecting a mask or photograph. Most research on face recognition falls into two main categories- feature-based and holistic. Geometric approaches dominated in the 1980's where simple measurements such as the distance between the eyes and shapes of lines connecting facial features were used to recognize faces, while holistic methods became very popular in the 1990's with the well known approach of Eigen-faces [3] .

Feature-based approaches to face recognition basically rely on the detection and characterization of individual facial features and their geometrical relationships. Such features generally include the eyes, nose, and mouth. The detection of faces and their features prior to performing verification or recognition makes these approaches robust to positional variations of the faces in the input image.



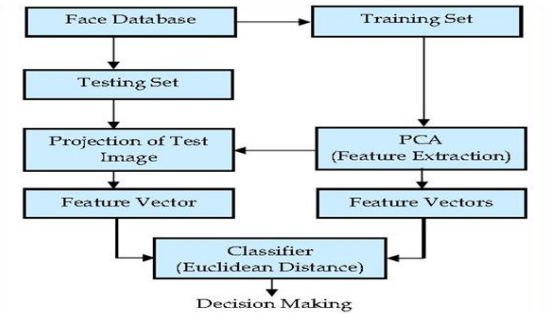
Holistic or Global approaches to face recognition involve encoding the entire facial image and treating the resulting facial code as a point in a high-dimensional space. Thus, they assume that all faces are constrained to particular positions, orientations and scales. Even though holistic methods such as neural networks are more complex to implement than their geometric counterparts, their application is much more straight forward whereby an entire image segment can be reduced to a few key values for comparison with other stored key values and no exact measures or knowledge such as eye locations or the presence of moustaches needs to be known [4]. The problem with this grab all approach was that noise, occlusions such as glasses and any other non face image attribute could be learned by the holistic algorithm and become part of the recognition result even though such factors are not unique to faces.

Feature-based approaches were more predominant in the early attempts at automating the process of face recognition. Some of this early work involved the use of very simple image processing techniques (such as edge detection, signatures, and so on) for detecting faces and their features. An edge map was first extracted from an input image and then matched to a large oval template with possible variations in position and size. The presence of a face was then confirmed by searching for edges at estimated locations of certain features like the eyes and mouth.

Face Recognition Algorithms

Principle Component Analysis (PCA)

PCA also known as Karhunen-Loeve method is one of the popular methods for feature selection and dimension reduction. Recognition of human faces using PCA was first done by Turk and Pentland and reconstruction of human faces was done by Kirby and Sirovich [8]. The recognition method known as eigenface method defines a feature space which reduces the dimensionality of the original data space. This reduced data space is used for recognition. But poor discriminating power within the class and large computation are the well known common problems in PCA method. This limitation is overcome by Linear Discriminant Analysis (LDA). LDA is the most dominant algorithms for feature selection in appearance based methods [9]. But many LDA based face recognition system first used PCA to reduce dimensions and then LDA is used to maximize the discriminating power of feature selection. The reason is that LDA has the small sample size problem in which dataset selected should have larger samples per class for good discriminating features extraction. Thus implementing LDA directly resulted in poor extraction of discriminating features.



Methodology:

Find the principal component use the following method:

1. Get the data: Suppose X1, X2....., XM is N x 1 Vectors

$$X = 1/M \sum_{i=1}^{M} Xi$$

2. Subtract the Mean:

$$\phi_i = \overline{X_i} - X$$

3. Calculating the covariance matrix: form of matrix A = [Φ1, Φ2….ΦM] (N x M matrix) then compute

$$C = 1/M \sum_{n=1}^{M} \phi_n \phi_n = A^T A$$

4. Calculating the eigenvector and eigen value of the covariance matrix.

5. Choosing components and forming a feature vector: Once eigenvectors are found from the covariance matrix, the next step is to order them by eigenvalue, highest to lowest. This gives the components in order of significance. The eigenvector with the highest eigenvalue is the principle component of the data set. Choose the highest eigenvalue and forming a feature vector.

6. Deriving the new datasets: Once chosen the components (eigenvectors) that wish to keep in the data and formed a feature vector, imply take the transpose of the vector and multiply it on the left of the original data set transposed.

PCA is basically a technique to represent the feature vector in the lower dimensionality space. So, by considering all the pixel values of image as the feature vector, we are getting better representation of image. That is why this technique is working better than DCT based technique even in large pose and illumination variations

Linear Discriminant Analysis(LDA)

The purpose of discriminant analysis is to classify objects i.e. people, customers, things, etc. into one of two or more groups based on a set of features that describe the objects e.g. gender, age, income, weight, preference score, etc. If one can assume that the groups are linearly separable, one can use linear discriminant model (LDA). Linearly separable suggests that the groups can be separated by a linear combination of features that describe the objects. If only two features, the separators between objects group will become lines. If the number of features is three, the separator is a plane and if the number of features i.e. independent variables is greater than three, the separators become a hyper-plane [10].

Methodology The steps in LDA are as follows:

1. Samples for class1 and class2

2. Calculate the mean of class1 and class2 i.e. Mu1 and Mu2

3. Covariance Matrix of the first class and second class i.e. S1 and S2

4. Calculate within-class scatter matrix by using given equation

Sw = S1 + S2

5. Calculate between-class scatter matrix by using given equation

SB = (Mu1-Mu2)*(Mu1-Mu2)

6. Calculate the mean of all classes

7. The LDA projection is then obtained as the solution of the generalized eigenvalue problem

$$Sw^{-1}S_B W = \lambda W$$

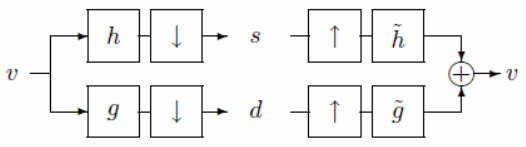
$W = eig(Sw^{-1}sb)$ Where W is projection vector

Independent Component Analysis (ICA)

Independent component analysis (ICA) is a method for finding underlying factors or components from multivariate (multidimensional) statistical data. There is need to implement face recognition system using ICA for facial images having face orientations and different illumination conditions, which will give better results as compared with existing systems . What distinguishes ICA from other methods is that, it looks for components that are both statistically independent and non Gaussian. The ICA is similar to blind source separation problem [11] that boils down to finding a linear representation in which the components are statistically independent. ICA had better recognition rate as compared with PCA with statistically independent basis images and also with statistically independent coefficients. Face recognition using ICA with large rotation angles with poses and variations in illumination conditions. A novel subspace method called sequential row column independent component analysis for face recognition. In ICA each face image is transformed into a vector before calculating the independent components.

Gabor Wavelet

For enhancing face recognition high intensity feature vectors extracted from Gabor wavelet transformation of frontal face images combined together with ICA. Gabor features have been recognized as one of the best representations for face recognition. In recent years, Gabor wavelets have been widely used for face representation by face recognition researchers, because the kernels of the Gabor wavelets are similar to the 2D receptive field profiles of the mammal cortical simple cells, which exhibits desirable characteristics of spatial locality and orientation selectivity. Previous works on Gabor features have also demonstrated impressive results for face recognition. Typical methods include the dynamic link architecture (DLA) elastic bunch graph matching (EBGM) [12] , Gabor Fisher classifier (GFC), and AdaBoosted GFC (AGFC). Gabor features are also used for gait recognition and gender recognition recently.In previous work, authors proposed to represent face images using the local Gabor binary patterns (LGBP), which combines Gabor magnitudes with local binary patterns (LBP) operator . Improved results were achieved when compared with the LBP and the GFC.



Wavelet based technique is working better than DCT based technique and PCA based technique even in large pose and illumination variations.

Artificial Neural Network (ANN)

Multi-Layer Perceptron (MLP) with a feed forward learning algorithms was chosen for the proposed system because of its simplicity and its capability in supervised pattern matching. It has been successfully applied to many pattern classification problems. A new approach to face detection with Gabor wavelets & feed forward neural network was presented. [11]The method used Gabor wavelet transform and feed forward neural network for both finding feature points and extracting feature vectors. A hybrid neural network solution was presented in which combine local image sampling, a self-organizing map neural network and a convolution neural network. The self-organizing map provides a quantization of the image samples into a topological space where inputs that are nearby in the original space are also entertainment, convenience in human life. Smart home technology can be especially useful for elderly or working women living alone in metros and for disabled persons who wish to live independently. Elderly/disabled persons or women can take the advantages of smart home technologies such as monitoring system, emergency system, dangerous kitchen appliance detection, fall detection etc.

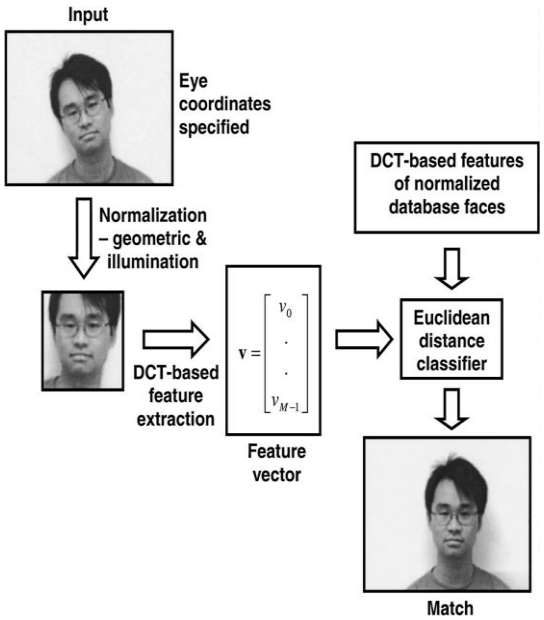
Support Vector Machine (SVM)

Support Vector Machines (SVM) is one of the most useful techniques in classification problems. One clear example is face recognition. However, SVM cannot be applied when the feature vectors defining samples have missing entries. A classification algorithm that has successfully been used in this framework is the all-known Support Vector Machines (SVM) which can be applied to the original appearance space or a subspace of it obtained after applying a feature extraction method.

SVM classifier over traditional neural network is that SVMs can achieve better generalization performance.

Discrete Cosine Transform (DCT)

Ahmed, Natarajan, and Rao (1974) first introduced the discrete cosine transform (DCT) in the early seventies. DCT is a very well known signal analysis tool used in compression standards due to its compact representation power [6]. It has data independent nature. It is an invertible linear transform that expresses a finite sequence of data points in terms of a sum of cosine functions oscillating at different frequencies.



DCT based face recognition system performs well when there are less pose and illumination variations. DCT based recognition system is simple, but is not suitable for the conditions where there are large pose or illumination variations.

Use of PCA Algorithm in Face Recognition

This paper defines the benefits of PCA with k-means clustering algorithm for face recognition. PCA is simplest, easy and efficient algorithm. It works well in less or more pose or illuminant

variation. It uses the concept of Euclidean distance for calculating the distance between two objects. For the tracking of human faces, it uses the concept of eigenfaces [1] [6]. It is the most efficient technique of Dimensionality Reduction and based on multiple images as input.

CONCLUSION

This paper has attempted to review a significant number of papers to cover the recent development in the field of face recognition. This paper defines the advantages of PCA algorithm for face recognition under various conditions.

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