Non Linear Dimensional Reduction Technique for Face Recognition

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***Abstract*—Face Recognition is rapidly growing field due to ease of its application in many vital security systems. In this paper, two non linear dimension reduction techniques namely LLE and ISOMAP are combined for implementing face recognition. Since face image database is believed to be non linear in nature due to varying pose, facial expressions and illuminations , superiority of non linear combination over linear combination is shown. Experimental results based on ORL database demonstrate effectiveness of above statement.**

***Keywords*— Face Recogntion , Linear dimensionality Reduction , Non linear dimensionality reduction, PCA, LDA, LPP, ISOMAP and LLE.**

I. Introduction

Face Recognition is most successful applications of computer vision and has always kept interest of scientists alive due to its wide applications. Security is one of the underlying issues of existence these days. Even though face recognition may not be most reliable biometric technique, its key advantage is it can be used for mass identification since personal presence of test subject is not mandatory as in case of other biometric techniques like fingerprints or iris scan or speech recognition.

Face Recognition basically identifies or recognizes one or more individual faces from known sample of treasury by adopting different image processing and pattern recognition technologies.

Appearance based methods are most commonly studied and developed for face recognition systems. In these methods, face image of size m× n pixels is represented as vector in image space of size $R^{m\times n}$. But this size is too large and this curse of dimensionality puts heavy load on computation and storage and negatively affects the real time performance of the system. To deal with this, first step is feature extraction (also called dimension reduction). it basically reduces number of random variables under consideration., by retaining only useful information and rejecting the redundant data. Thus, low dimensional representations of faces are obtained.

Many techniques are developed by researchers for feature extraction (or dimension reduction) for face recognition. They can be broadly classified as either linear methods or nonlinear methods.

II. Problem Statement

Linear dimension reduction techniques seek a meaningful low dimensional subspace in a high dimensional input space by linear transformation i.e. they perform linear mapping of data to a lower dimensional subspace in such a way that variance of data in low dimensional representation is maximized.

However, there are limitations to the linear methods for face recognition. Firstly, they fail to reveal the intrinsic distribution of a given data set. Secondly, if there are changes in pose, facial expression and illumination, the projections may not be appropriate and the corresponding reconstruction error may be much higher.

In Nonlinear methods, mapping is nonlinear and implicit. Due to large variations in expression, illumination and pose, the manifold of the face space is believed to be very complex and non-linear in nature. It is hard for linear dimensionality reduction method to search for internal characteristics of complex motion [4]. Thus much important data may loss probably. So mapping of data from high dimensional space to low dimensional space using nonlinear techniques is more effective, as it can reduce data dimension, reduces the computational complexity, keeps face topology integrated and is more resistant to different variations

In this paper, I have implemented linear and nonlinear combination of dimensional reduction for face recognition and compared their performance on the basis of computational time.

III. Algorithm Review

Principal Component Analysis (PCA), Linear Discriminant Analysis (LDA) and Locality Preserving Projection (LPP) are linear methods for feature extraction which are most commonly used in face recognition system. PCA is the most renowned method which uses Eigenface method to capture and utilize maximum variance among training images to find a basis vector which aims at obtaining most compact data representation. Each individual face can then be represented

exactly by a linear combination of eigenfaces. It extracts global features from database.

LDA utilizes face class information to represent face class efficiently. Differing from PCA, LDA searches for a group of basis vectors, which makes different class samples, have the smallest within-class scatter and the largest between-class scatter. Various measures are available for quantifying the discriminatory power, Fisher criterion is the common one:

$$J(W) = \frac{Wt.Sb.W}{Wt.Sw.W}$$

Where S_b is between-class scatter matrix and S_w is within-class scatter matrix. LDA has powerful discriminatory power hence can extract discriminatory features.

LPP is linear projective map that arise by solving a variational problem that optimally preserves the neighbourhood structure of data set [2]. It optimally preserves local neighborhood hence it is good to extract local features.

ISOMAP (Isometric Mapping) and LLE (Local Linear Embedding) are nonlinear feature extractions techniques. Supervised ISOMAP is a non linear full spectral technique that attempts to preserve pair wise geodesic distance between data points, also using class labels as guide. Hence, it preserves global features as well as discriminatory features.

LLE is sparse spectral technique that achieves a high dimensional input data point mapped to a global low dimensional coordinate system, while preserving the space relationship between the adjacent points [5]. Thus, it preserves the local unique features of face image.

In this paper, I have combined PCA, LDA and LPP to implement combination of linear feature extraction techniques. Further, I have combined non linear techniques of ISOMAP and LLE having similar properties as their counterpart. Then, their performance is compared based on computational time for each system.

IV. Experiments and Results

The ORL database of AT&T is employed as facial recognition platform.. The flow chart in this paper is shown in figure 1. The techniques discussed are simulated in MATLAB 7.0.

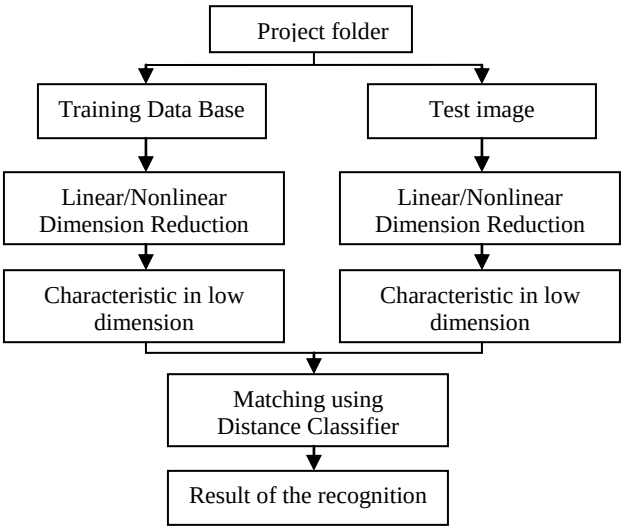

Fig1. Block Diagram

ORL database had images of 40 subjects with varying facial expressions, pose, some has beard or reduced glasses. There are 10 images per subject. 7 out of 10 images are used for training while rest of the 3 are used for testing. Varying number of subjects is used for each experiment and computational time taken for both linear and non linear combinational techniques are calculated.

TABLE I Experimental Results

No. Of training images	Time for linear combination(sec)	Time for Nonlinear combination(sec)
20	39.2046	27.0077
40	44.5319	34.6225
60	50.7369	40.7706
80	58.8880	47.3555
100	65.3116	55.4260
120	76.8785	64.8366

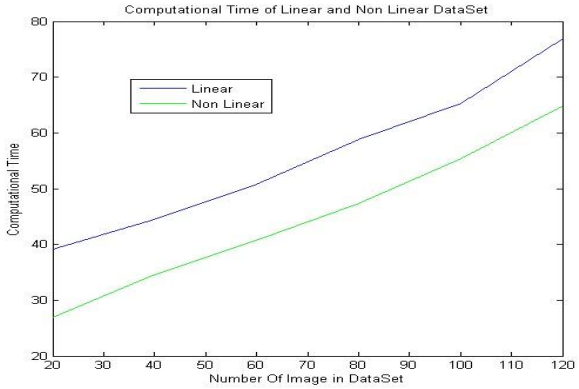

Fig2. Graph

V. Conclusion

Face recognition is one of the most challenging and important research topics of computer vision applications as far as biometric recognition is involved. In this paper, linear combination of PCA, LDA and LPP and Nonlinear combination of LLE and ISOMAP are implemented to extract facial features for face recognition. Results show that nonlinear method reduces computational complexity and time taken to recognize image is relatively less than linear combination.

VI. References

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