Pose Identification Using Isometric Projection

Ihtesham-Ul-Islam, Intaek Kim
Department of Communication Engineering
Myongji University
email: ihteshcise@yahoo.com, kit@mju.ac.kr

Abstract

In this paper we use the *Isometric Projection,* a linear subspace method, for manifold representation of the pose-varying-faces. *Isometric Projection* method for pose identification is evaluated on view varying faces and is compared with other global and local linear subspace methods.

I. Introduction

Research in face recognition has significantly increased in these past few years and several commercial face recognition systems have emerged in the biometrics market. But there are still some unavoidable problems in the variety of practical applications, such as; the people are not always frontal to the camera, so the pose problem is a big obstacle in a face recognition system.

Pose recognition can be very helpful in either view based face recognition or in a system which only accepts frontal-view face images. Face image is considered to be sampled from a nonlinear low-dimensional manifold which is embedded in the high dimensional ambient space. Thus a Classical linear dimensionality reduction technique such as PCA fails to discover it. Moreover, the nonlinear dimensionality reduction techniques like ISOMAP [1], LLE [2] and Laplacian Eigenmap [3] have been proposed for nonlinear manifold learning. The disadvantage of these methods is that they have no mapping functions. Though some out-of-sample extensions have been proposed, but when the number of features is larger than the number of samples, these extensions have to perform Singular Value Decomposition (SVD), which is very time consuming, and may not be applied to high dimensional data with large size.

For the problem in hand we need some dimensionality reduction technique which is able to retain the global geometry of the data like ISOMAP and which is linear as well. *Isometric Projection [4],* a linear subspace method, can be used in this situation which explicitly takes into account the manifold structure.

II. Isometric Projection

To model the manifold structure, this technique first constructs a nearest neighbor graph of the observed data and computes the shortest paths in the graph for all pairs of data points. Shortest path gives the estimate of global metric structure. Using techniques from Multi-Dimensional Scaling and requiring the mapping function to be linear, it obtain the objective function of Isometric Projection. That is

$$f^{opt} = \arg\min_f \sum_{i,j} (d_M(x_i, x_j) - d(f(x_i), f(x_j)))^2$$

where f is the embedding function, more about this equation is given in [4].

Finally, the optimization problem can be efficiently solved by techniques from spectral graph analysis and regression, which leads to Isometric Projection. It has the following main characteristics

1. Isometric Projection provides an optimal linear approximation to the true isometric embedding of the underlying data manifold. It tends to give a more faithful representation of the data's global structure than PCA does.
2. Isometric Projection is defined everywhere.
3. While the linear versions of Laplacian Eigenmaps [5] and LLE [6] need to apply SVD first which can be very computational expensive, Isometric Projection is computed by using spectral graph analysis and regression which are very efficient even for high dimensional data of large size.
4. Isometric Projection is fundamentally based on ISOMAP, but it does not have properties (2) above.

Ⅲ. Experiments

Here we report our experiments with the different techniques of dimensionality reduction for view based face classification. We used AT&T database for our experiments where we manually sort out the images into three classes namely *frontal-view*, *left-view* and *right-view.* The images are first normalized using the eye locations and resized to a fixed size. We use 40 *frontal*, *40 left-pose* and *40 right-pose* images for training. In the testing phase *55-frontal* and 66 *left-pose* and 66 right-pose images (total =187) are used. Some sample images are shown in figure 1. Moreover we use a K-Nearest Neighbor classifier in the classification stage. Results are shown in Table 1.

Table 1. Best performance of different techniques on pose identification.

Technique	PCA	LDA	LPP	NPE	IsoP
Accuracy	75.40%	86.10%	87.7%	88.3%	90.91%

IV. Conclusion

Isometric projections outperformed other linear and linear variants of nonlinear dimensionality reduction techniques for pose identification. The possible reason behind it is that Isometric -Projections preserves the global geometrical relations and tends to give more faithful representation of the data's global structure. Moreover, it explicitly takes into account the manifold structure.

Figure 1: Normalized Frontal-view, right-view and left-view images

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