# Comparison of Methods of Feature Generation for Face Recognition

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***Abstract*** **The paper is concerned with the recognition of faces at application of different methods of global feature generation. We check the selected choice of transformations of images, leading to the numerical representation of the face image. The investigated approaches include the linear and nonlinear methods of transformation: principal component analysis (PCA), Kernel PCA, Fisher linear discriminant analysis (FLD), Sammon transformation and stochastic neighbor embedding with t-distribution (tSNE). The representation of the image in the form of limited number of main components of transformation is put to the input of support vector machine classifier (SVM). The numerical results of experiments will be presented and discussed.**

***Keywords*** **face recognition, transformation of data, classification, SVM.**

## ABSTRACT

The paper will compare the methods of recognizing the individuals on the basis of their visual face. To do it we have to represent the face by the set of numerical features. The most important point in feature representation of the face is to find the transformation method of the highest compression ability of the images, able to pack the global distribution of pixels into smallest possible number of the significant features. In this paper we will limit our considerations to few of them, including PCA, LDA, Kernel PCA, Sammon transformation and stochastic neighbor embedding. The mentioned above transformations have been found to be valuable in efficient visualizing the distribution of different classes of multidimensional systems in 2D coordinate system [7].

The original face image (the matrix) will be represented by the vector $\mathbf{x} = [x_1, x_2, ..., x_N]^T$ formed by the succeeding rows of the matrix. Let us assume that the set of such vectors representing the images is of zero mean value. The PCA and LDA transformations of any member of such set is described by the linear relation [1,7]

$$\mathbf{y}=\mathbf{W}\mathbf{x}$$

of the transformation matrix $\mathbf{W} = [\mathbf{v}_1, \mathbf{v}_2, ..., \mathbf{v}_K]^T$ defined in a different ways, according to the method. The PCA transformation of data results in representation of the image by the so called eigen-face and LDA – by the Fisher-face [1].

The nonlinear version of PCA, called Kernel PCA (KPCA) represents the ordinary PCA defined on the nonlinear mapping of the vectors $\mathbf{x}$ [2]. Instead of original vectors we take in this transformation their nonlinear mapping $\boldsymbol{\varphi}(\mathbf{x})$ and the whole procedure is done now on the covariance matrix $\mathbf{R}_{\varphi\varphi}=E[\boldsymbol{\varphi}(\mathbf{x})\boldsymbol{\varphi}(\mathbf{x})^T]$.

The Sammon transformation belongs to the nonlinear mappings [5] designed to minimize the differences between corresponding inter-point distances in the original and transformed spaces. The method conserves (as much as possible) the distance between each pair of points in both spaces.

The last considered transformation is a stochastic neighbor embedding with a t Student distribution [3]. It starts by converting the high dimensional Euclidean distances between data points into the conditional probabilities that represent similarities between objects. It tries to find the map points (vectors $\mathbf{y}_i$ and $\mathbf{y}_j$) of the high-dimensional data points ($\mathbf{x}_i$ and $\mathbf{x}_j$) in a way to minimize a Kullback-Leibler divergence between the joint probability distribution $p_{ij}$ in high-dimensional space and a joint probability distribution $q_{ij}$ in the transformed (lower dimensional) space.

These transformations were used for generation of the features applied as the input information to the neural SVM classifier and random forest of Breiman. The numerical experiments have been done on a set of face images representing up to 20 classes of people (both women and men) represented by 20 individuals in different poses and different illumination. The size of original images was 100×100, resized next to 50×50.

The results correspond to the application of 10-fold cross validation approach at application of SVM as a classifier (the testing of samples not taking part in learning). Analyzing the results we can observe very good performance of the nonlinear tSNE method. The smallest are not only the mean values of the misclassification errors for each number of classes, but also standard deviations of errors in each trial. Surprisingly, the application of FLD has resulted into relatively high errors.

Application of random forest as the classifier has resulted into a slightly different distribution of errors. However, we can observe better performance of this classifier at the highest number of classes (20).

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