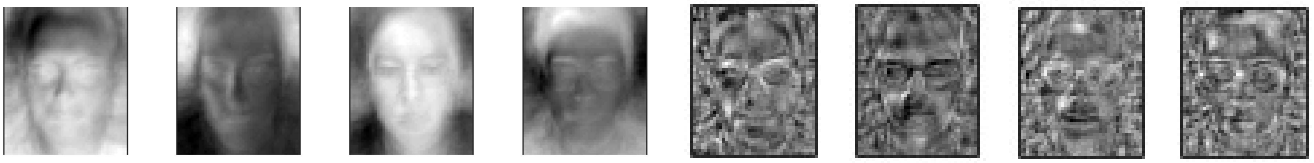
EE468/EE9SO29/EE9CS729

Pattern Recognition

Coursework on PCA (Eigenface), PCA-LDA (Fisherface) ensemble, for face recognition [50% mark]



Release on 16 Oct 2018, the report due on 20 Nov 2018 (midnight)

The coursework requires Python or Matlab programming. Use the provided face data (face.mat), which stores raster-scanned face images (46x56 pixels) in columns. In all questions, you can use any existing toolbox/code, if needed.

Submission instructions:

One joint report by each pair

Page limit: 4-6 A4 pages per report with 10 font size (use the IEEE standard double column paper format, either in MS word or latex).

http://www.pamitc.org/cvpr16/files/egpaper_for_review.pdf

http://www.pamitc.org/cvpr16/files/cvpr2016AuthorKit.zip

Explain physical meanings and discussions behind your answers, within the scope of lectures. ***Quality and completeness of discussions within the page limit*** will be marked.

Source code is not mandatory, unless specified. Optionally, this can go to appendices, which do not count for the page limit.

Submit the report **in pdf** through the Blackboard system. No hard copy is needed. Write your full names and CID numbers on the first page.

If you have questions, please use https://goo.gl/m6Mnov or contact

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Q1.

[10] Eigenfaces

a. Partition the provided face data into your training and testing data, in a way you choose. Explain briefly the way you partitioned. Apply PCA to your training data i.e. compute the eigenvectors and eigenvalues of the covariance matrix $S=(1/N)AA^T$ directly. Show and

discuss, including: the eigenvectors and eigenvalues, the mean image, how many eigenvectors are with non-zero eigenvalues, and how many eigenvectors are to be used for face recognition. Give physical meanings behind your answers.

b. Use the low-dimensional computation of eigenspace i.e. using $(1/N)A^TA$ of your training data. Show and discuss, in comparison to a), including: if the eigenvectors and eigenvalues obtained are identical, what are the pros/cons of each method. Show respective *measurements* for your answers.

[15] Application of Eigenfaces

Hereinafter, we use the low-dimensional PCA technique and the same data partition (into training and testing), as in the above.

a. Do face image reconstruction while varying the number of PCA bases learnt. Show and discuss the results quantitatively and qualitatively for different face images.

b. Perform PCA-based face recognition by the NN classification and alternative method learnt i.e. using the reconstruction errors. Report and discuss, including: recognition accuracies (success rates), example success and failure cases, the confusion matrices, time/memory, by varying the hyper-parameter values. Give insights and reasons behind your observations.

Q2. [5] Generative and Discriminative Subspace Learning

(No computer programming is needed.)

PCA is a generative model, by which input images or data can be reconstructed (i.e. maximum variance is retained after projection). LDA is a discriminative model, which extracts better features for classification. Say we are interested in subspace learning that fulfils both aspects or controls a balance between the two aspects.

Mathematically formulate the problem (i.e. the objective or goal function to optimise) that learns the subspace for generative and discriminative features at the same time.

And mathematically derive the solution that optimises the defined problem. If needed, you may use the Lagrange multiplier formulation, gradient-based optimization, eigenvector-eigenvalue, and/or generalized eigenvector-eigenvalue analyses.

Q3. [20] LDA Ensemble for Face Recognition

Use the provided face data, and the same data partition into training and testing as in Q1.

PCA-LDA

Perform the PCA-LDA based face recognition with the NN classifier. Report and discuss, including:

- recognition accuracies by varying the hyper-parameter values, e.g. M_pca and M_lda
- ranks of the scatter matrices,
- the confusion matrix, example success and failure cases

Explain and discuss the results, (and their physical meanings) in comparison to those of **Q1**.

PCA-LDA Ensemble

Show, measure and discuss the results, including:

- randomisation on data samples (i.e. bagging)
- randomisation in feature space
- the number of base models, the randomness parameter,
- the error of the committee machine vs the average error of the individual models
- fusion rules
- recognition accuracy and confusion matrix

Show and discuss the results, quantitatively and qualitatively, by varying the parameter values/architectures. Give insights and reasons behind your answers.