IPA 2017 Lab Exercise 3

Assigned November 21st **Due Dec 11th 23:59**

Time you spent on this assignment: ____ hours

The maximum amount of points awarded for this assignment is **15 points**.

1 How to submit your report

Read carefully this document. Ask if you are unsure what to do, otherwise use common sense to solve the problems.

You should make the report of the exercise available as a PDF document. The hand-in for this laboratory exercises is done by using Moodle before the deadline containing:

- As attachments (.7z or .zip): the PDF document and ALL the code necessary to RUN your solution (including your chosen images, and an instruction file how to run your code, like a `readme.txt` and/or `makefile`). Please write (a lot of) comments in your source code, it is necessary.

You can discuss the results and solutions, **but you have to submit your own work. Warning! Plagiarism will not be tolerated.**

The PDF should include in the document your results and most importantly, a discussion of the results. Be careful: If the attached code does NOT run, we will reject your exercise completely. It is NOT necessary to include a copy of all the code in the PDF document, although key parts if you think are necessary to explain a point can be included.

Please follow the instructions. For this assignment you should not use any predefined signal and image processing routines (except for the I/O functions), if not otherwise stated. In particular predefined `pca` function should not be used and the matrix eigedecompoistion should be achieved with singular value decomposition `svd`.

The paper describing the methodology used this exercise can be obtained from: `http://openbio.sourceforge.net/resources/eigenfaces/TurkPentland1991a.pdf` Reading this paper is highly recommended.

2 PCA and Eigenfaces [9 Points]

1. (1 point) Load the dataset of faces from:
   `http://vda.univie.ac.at/Teaching/IPA/17w/Lab3/face_images.zip`.
   There are 34 subjects, each with 3 different facial expressions (Fig 1). In this part of the exercise only one image per subject should be used.

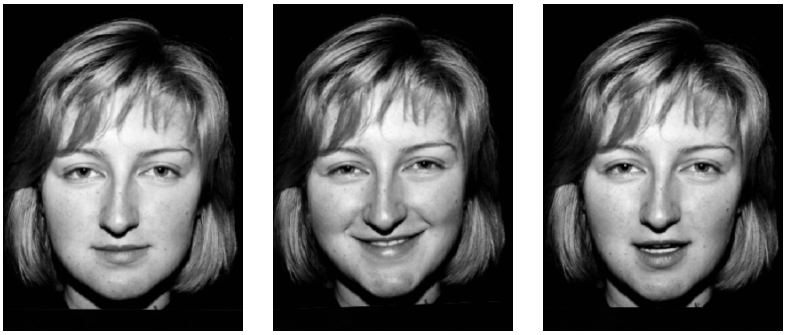

Figure 1: Dataset: Example of a subject with its three images.

   (Optional) Do all the lab exercises with a different dataset of face images of your choice, e.g., from `http://conradsanderson.id.au/lfwcrop/`.

2. (1 point) Compute and display the *mean face*.

3. (6 points) Perform Principal Component Analysis (PCA) of the loaded dataset using singular value decomposition (SVD). **Please note** that since there are way more pixels than subjects, you will need to apply the method presented in the above paper by M. Turk and A. Pentland to find the eigenvectors in a computationally feasible way.

   - How many principal components do you need to capture 80% of face variance?
   - Visualize the first $k = 16$ eigenfaces in a 4×4 grid.

4. (2 points) Reconstruct each subject's face as a linear combination of the first $k = \{1, 10, 20, 34\}$ eigenfaces. Visualize the results.

3 Face Recognition with Eigenfaces [6 Points]

For this part of the exercise a different face image should be loaded for each subject than the one used for computing the eigenfaces in Section 2.

1. (1 points) Repeat the reconstruction task (Section 2.4) with the newly loaded subject face. Note that the eigenfaces are not being recomputed here.

2. (5 points) Perform face recognition for a new face using eigenfaces as features learned in the previous section and by finding the closest example loaded in Section 2, using Euclidean distance in a 10-dimensional eigenface subspace. For each face display it's closest match and report the overall recognition accuracy.