ECSE 415 - Assignment 4

Face Detection

Due: November 22nd, 2018, 23:55

This assignment permit you to practice using eigenvectors to perform face detection and identification. You will obtain a set of images containing faces, use principal components analysis (PCA) to characterize them, then use that information to automatically identify those faces in unseen data. You will then compare your implementation's performance to the Viola-Jones face detector (use publicly-available code; cite appropriately).

Submit your solution via myCourses. All submitted material is expected to be the student's own work or appropriately cited (academic integrity guidelines can be found here). Submissions received after the deadline up to 24 hours late will be penalized by 30%. Projects received later than 24 hours will not be graded.

Your submission should be a single .zip file, with the report (e.g., a Jupyter notebook) and relevant code. External code should also be included in the submission. Code which returns errors will be penalized; use a virtual Python environment to verify that your code can execute correctly. Submit the requirements file (using "pip freeze") as needed. Submissions which do not meet the submission specifications will be penalized by 10%. The assignment is out of **55 points**.

1 Data Acquisition

You will need a group picture containing at least three people, with their faces clearly visible. This image will be used to evaluate the performance of your implementation. Display the image.

Find additional pictures for each individual; the required number of pictures varies with a number of factors, but ten for every person should suffice. These images will be used to build our representation of faces, and should be cropped to be the same size containing only faces. The dimension and use of color is left as a design decision; consider smaller greyscale images if you run into computational issues, or for reducing the dimensionality of the data. Describe how you selected the images with respect to the conditions of the detection/classification methods (**5 points**).

You can download publicly-available images (e.g., celebrities) or acquire your own, but the images must be submitted in .png or .jpeg format.

2 Eigenvector Representation

Use PCA to find the eigenvector representation of your training data (**5 points**). Plot the variance explained by every vector in descending order (total variance explained vs. number of principal components) (**2 points**). Do you need all the vectors to represent the data? Discuss (**3 points**).

How well-clustered is your data? For every sample, find the nearest neighbour (L_2 distance), and check whether it is of the same class. What fraction of your data has a neighbour of the same class? Do this both in the original pixel space and the eigenspace, then compare the values; would you expect there to be a significant difference? (**10 points**).

3 Face Detection & Identification

You will now detect the faces in the group image. Use a sliding window to detect whether a section of the image contains a face. Set a threshold on the distance in eigenspace between the window contents and your training data. (**15 points**).

You will now try to recognize each of the people in the group image. For the windows in which a face is detected, map the window to your eigenspace and find the nearest neighbour from your data. Identity of the test case will be based on the identity of the closest person in the training set. How well does the method work? How many false positive face detections do you get? For mis-identified faces, report the number of neighbours you need before getting the correct label (correct identification would use 1). In which situations would expect the approach to fail, and what could you do to improve it? (**15 points**).

4 Viola-Jones Comparison

Use an existing implementation of the Viola-Jones face detector, and compare the results with your detector (e.g. how many false positives do you obtain?). Under what conditions would you expect the Viola-Jones detector to work when PCA does not? (**5 points**).