EE462, EE9SO25, EE9CS728

Machine Learning for Computer Vision

Coursework 4 (25% mark)

Release on 01 Dec 2014, the report due in 2 weeks (on 14 Dec 2014, 11:59pm)

About lectures 13-14 (PCA, Face recognition)

This course work requires Matlab programming. Use the provided face data.

Submission instructions: Submit the ***Matlab code and data*** that you wrote, as well as, the report, through the Blackboard system, electronically. And drop a hardcopy of the report in the homework dropbox at EEE 1017. Write your full name and CID number on the top of the first page.

Note: Some questions require writing your lines of code in the report also. The questions marked* are about theories, answering them does not require Matlab programming.

***Q1.** (Mathematical proof) Find the expression of the eigenvectors and eigenvalues of the data covariance matrix $S = \frac{1}{N} X' X'^T$, where $X' = [\dots, x_i - \bar{x}, \dots]$, in the form of using the eigenvectors and eigenvalues of $X'^T X'$. Explain how this is made useful in practice.

Write your own lines of code to do the following questions. Use the given resolution i.e. 46x56 pixels of the face images provided. If necessary, you may resize down the images, in which case some score deduction will apply.

Q2. Partition the provided data into your training and testing data, in a way you choose. Explain briefly the way you partitioned.

Q3. Write your lines of code for doing PCA on your training data, by directly computing the eigenvectors and eigenvalues of the data covariance matrix *S* (you can use **eig**). Show your code in the report.

Q4. Show and discuss the results in **Q3**, including: show the eigenvectors, the eigenvalues, and the mean image, which you computed above, in the report. How many eigenvectors may we choose to use in general? Explain why.

Q5. Write your lines of code for doing PCA on your training data, by using the expression that you found in **Q1** i.e. using the eigenvectors and eigenvalues of $X'^T X'$. You can use **eig**. Show your code in the report.

Q6. Show and discuss the results in **Q5**.

Q7. Discuss the results in **Q4** and **Q6** in comparison.

Hereinafter, you are supposed to use your PCA code in **Q5**. However, you can use your PCA code in **Q3**, in which case score deduction will apply as appropriate.

Q8. Pick at least 3 face images of your choice (from both the training and testing dataset), and do their reconstruction by the PCA bases you learnt from the whole training data. Vary the number of bases to use, and show the respective reconstruction results in comparison to the original images. Discuss the results. Write your own lines of code, show the code in the report.

Q9. Do the PCA-based face recognition by the method 1 in the lecture note 13-14, with your training and testing dataset above. Report the recognition accuracy (success rate), and discuss all the parameter values and experimental settings you used. Show example success and failure cases (with the confusion matrix if helpful), and explain the results. You can use the previous code in coursework 3, for the confusion matrix.

Q10. Try the method 2 (in the lecture note 13-14), by both the class means and nearest neighbours, for face recognition by PCA. Use the same training and testing dataset as above. Report the recognition accuracies, and discuss all the parameter values and experimental settings you used. Show example success/failure cases (with the confusion matrices, if helpful), and discuss the results.

Q11. Discuss the results in **Q9** and **Q10** in comparison, in terms of time/accuracy, and other aspects as you observe.