

ELL784/AIP701: Assignment 4

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Deadlines

1. Deadline for final submission of assignment report and all code: **14 November 2022, 11:59 PM.**

Instructions

1. While you are free to discuss all aspects of the assignment with your classmates or others, your code (for those registered for AIP701) and your results and report must be entirely your own. We will be checking for any copying, and this will be treated as plagiarism and dealt with accordingly. In case of any doubts in this regard, please ask us.
2. **For AIP701: You are free to use any platform to write and test your code. However, if you are using Python, please make sure you submit .py files for evaluation during the viva.**
3. All students should prepare a report, compiling all your results and your interpretation of them, along with your overall conclusions. In particular, you should attempt to answer all of the questions posed in the respective parts of the assignment below. Any graphs or other visualisations should also be included therein.
4. A single tar/zip file containing the source code (if applicable), report, and any other relevant files has to be submitted via Moodle. The zip/tar file should be structured as per the below guidelines:
 - Upon deflating all submission files should be under a directory with the student's entry number. E.g., if a student's entry number is 20XXCSXX999 then the tarball/zip submission should be named 20XXCSXX999.zip or equivalent, and upon deflating **all contained files** should be under a directory named ./20XXCSXX999 only.
5. The schedule for demos/vivas will be announced by your respective TAs, in advance. If for any reason you cannot attend in your scheduled slot, you must arrange for an alternative slot with your TA well in advance. Last-minute requests for rescheduling will normally not be accepted.

Weightage

For ELL784: This assignment is worth 4 marks or 4% of your overall course grade; a part-wise break-up is provided below.

For AIP701: The coding part of this assignment will additionally be worth 5 marks, which will amount to 25% of your grade for that course.

Objective

To explore the use of unsupervised learning methods for clustering data, and also for obtaining lower-dimensional representations.

Part 1 (ELL784: 2.5 marks; AIP701: 5 marks)

Data

In this part you will work with your personalised data set from Assignment 3, consisting of images of handwritten digits taken from the MNIST database.

Methodology

(a) Using an implementation of your choice, run K -means with $K = 10$ on your handwritten digits data set. Assess the clusters obtained: do they actually correspond to the digits 0–9? If you label each cluster with the digit that occurs most frequently within it, then what is your classification accuracy with this unsupervised method? What kinds of misclassifications are happening, and why? Now try re-running K -means with $K = 5$. Do your clusters make any sense in this case? Why or why not? (1.5 marks)

(b) Now we will try to use a lower-dimensional representation of our images for clustering them. In Assignment 2 you were already given, for your personalised data set, the top 25 principal components obtained by using PCA for dimensionality reduction. Visualise at least the top few components, and try to interpret what kind of variation in the data they're capturing. Now run K -means with $K = 10$ on your PCA representations. Repeat the analysis as in (a): how does this clustering in PCA space compare to that in raw pixel space? Is it better or worse? Why? (1 mark)

(c) **(AIP701 only)** Write your own GMM implementation, using the EM algorithm for parameter learning. Learn a GMM with 10 components on your data *in PCA space*. You may initialise the parameters using your K -means results from (b) above. Does the GMM give you better clustering? Try to interpret some of the data points which have mixed membership, *i.e.*, they have a significant posterior probability in more than one component. Also try a random initialisation of the parameters: how do the results change, compared to the K -means initialisation? (Code must be submitted for this. Code must be completely original and not make use of any machine learning libraries.)

Part 2 (ELL784: 1.5 marks)

For this part, you are provided with a mystery data set with 15,000 data points and 127 features. It can be downloaded from http://web.iitd.ac.in/~sumeet/A4/ass4_data.csv. In this file, each row corresponds to a data point, and the feature values for each point are listed separated by commas. This is actually a labeled data set, but you are not given the labels or even the number of classes (however, you may assume it is not greater than 20). Your job is to try and discover as much structure in this data set as you can, in an unsupervised fashion. Use K -means and/or GMMs, and first of all try to find out the number of classes/clusters. Then try to refine your clustering as much as possible: for instance, experiment with feature selection or reduction to see if that can give you tighter clusters. Once you feel you have a good clustering, submit your results to the Kaggle leaderboard (submission format and link to be shared separately via Piazza). Here it will be evaluated against the true classes, and a performance metric will be reported and used to rank your submission.