Assignment 5. k-Means Clustering for Image Segmentation and Compression

Due Date: December 2, 11:30 pm

Late submission

If you submit the assignment late

- ◇ 10% penalty will be applied if the submission is before December 6, 11:30 pm (if the mark before applying the penalty is 78 out of 100, after applying the penalty it is 78 - 7.8 = 70.2 out of 100);
- ◇ Submission after December 6, 11:30 pm is not accepted.
- ◇ An MSAF will only extend the submission deadline to December 6, 11:30 pm.
- ◇ The submission has to be made before the interview, otherwise the 2% weight of the interview will be lost.

Description:

In this assignment you are required to implement the k-means clustering algorithm and apply it to image segmentation and compression. This experiment is similar to the experiment reported in section 9.1.1 of PRML [1].

Find an appropriate function in the matplotlib library to read a colour image as a 3D array. In this format, each pixel is represented as a point in the three-dimensional space, whose components are the intensities of red, blue and green channels (the colour of the pixel is determined by these intensities). The goal of image segmentation is to partition the image into regions each of which has a reasonably homogeneous appearance or which corresponds to objects or parts of objects [2]. You will do this using the k-means clustering algorithm. Each pixel in the image is treated as a separate data point and the clustering groups pixels that have similar colours. After obtaining the clustering you have to reconstruct the image by using the center of the cluster as reconstruction of a pixel. This way compression is achieved since the number if bits needed to store the image is much lower, i.e. only $\log_2 k$ bits per pixel instead of 8 or 16 bits per pixel for the original image. Note however, that more efficient compression algorithms for images are used in practice (e.g., JPEG).

You will have to write a python program and a report. In the report you have to present the results for two colour images of your choice. For each image, you have to run the clustering algorithm for $k = 2, 3, 10, 20, 40$ (at least) until convergence at least three times, each time with a different initialization. Use two initialization strategies: 1) randomly pick the centers from the data points (use this two times); 2) pick the centers such that they have a sufficiently large distance between them. You decide how to implement the second strategy and then describe it in your report.

In the report you have to include the original images and their reconstructions for the five values of $k = 2, 3, 10, 20, 40$ (at least) obtained whith each initialization of the

algorithm. You have to also include the mean squared error (MSE) between the original image and its reconstruction for each case. Organize this information nicely in one or two tables. Additionally, include the number of iterations until convergence for each case (nicely organized in one or two tables).

The report should contain a discussion of the results: for each image and each k, which initialization strategy led to better clustering judging based on a) the MSE; b) the visual reconstruction? Does always a smaller MSE correspond to a more pleasing visual reconstruction? Is one initialization strategy better than the other all the time or almost all the time? Include any other observations you might find useful.

Submission Instructions:

- Submit the report in pdf format, the python file (with extension ".py") containing your code, and a short demo video. The video should be 1 min or less. In the video, you should scroll down your code, show that it runs and that it outputs the results for each part of the assignment. The main Python file in the project should be clearly distinguishable. Some feedback might be written on your report, so, please DO NOT ZIP YOUR FILES. Submit the files in the Assignments Box on Avenue.

  Naming convention:
  "studentMacId_studentNumber_A5_report", "studentMacId_studentNumber_A5_code".

References

[1] C. M. Bishop, *Pattern Recognition and Machine Learning,* Springer, 2006 (ISBN 9780387848570), available for free download.

[2] D. A. Forsyth and J. Ponce, *Computer Vision: A Modern Approach*, Prentice Hall, 2003.