CS570 Artificial Intelligence

Lab #4: Clustering & Image segmentation

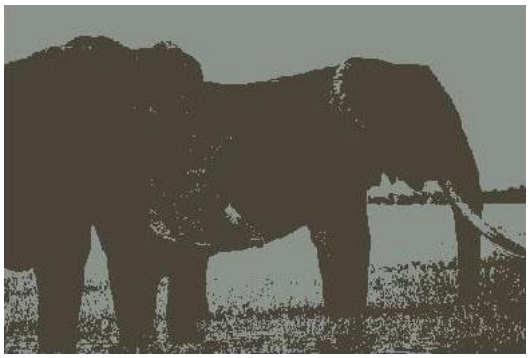
Out – 12/04/2011

Due – 22/04/2011 23:59

 # Programming homework

The goal of image segmentation is to partition an image into regions each of which has a reasonably homogeneous visual appearance or which corresponds to objects or parts of objects. Each pixel in an image is a point in a 3-dimensional space comprising the intensities of the red, blue, and green channels, and our segmentation algorithm simply treats each pixel in the image as a separate data point. The channel intensities are bounded by the interval [0, 1]. We illustrate the result of running K-means, for any particular value of K, by re-drawing the image replacing each pixel vector with the {R, G, B} intensity triplet given by the mean μ_k to which that pixel has been assigned. Results for various values of K are show in the following figures.

Original image



K=2

K=5

K=10

It should be emphasized that this use of K-means is not a particularly sophisticated approach to image segmentation, not least because it takes no account of the spatial proximity of different pixels. The image segmentation problem is in general extremely difficult and remains the subject of active research. [Bishop, 2006]

In this programming lab, you will implement K-means clustering algorithm and EM algorithm for Gaussian mixtures for image segmentation. In the "lab4.R" file, you will see the functions of "genData" and "drawResult". "genData" reads the given name of an image file and returns a set of data points comprising the intensities of {R, G, B}. "drawResult" gets the result of the clustering algorithm and plots the segmented image. Your task is to implement the functions of "Kmeans" and "EM4GM". These functions should return a matrix of cluster centres and a vector of integers indicating the cluster to which each point is allocated. More detailed explanations of input and output for each function are shown in the "lab4.R" file. In addition, an example of test code is also included in the "lab4.R" file.

(1) Implement the function of "Kmeans". (40 points)

(2) Implement the function of "EM4GM". (50 points)

 # Written homework

Solve the following problems.

(3) What is the difference between K-means clustering algorithm and EM algorithm for Gaussian mixtures? (10 points)

(4) Prove that EM algorithm for Gaussian mixtures indeed maximizes the likelihood function. (This is additional problem. 20 points) Hint: refer to Chapter 9 in [Bishop, 2006].

 # Submission format

Please submit the **[#ID]_[FIRSTNAME]_[LASTNAME]_lab4.[zip or tar]** file that contains the source code for the programming homework and the text file (in **pdf, txt, or doc** format) for the written homework. Also you can hand out a hard copy of your written homework, but if you want so, please let us know in advance. We will prepare a homework box.

[Bishop, 2006] Christopher M. Bishop. Pattern recognition and machine learning. Springer. 2006.