Assignment 5: CS 663, Digital Image Processing

Due: 6th November before 11:55 pm

Instructions for submission are at `www.cse.iitb.ac.in/~suyash/cs663/submissionStyle.pdf`
5 points are reserved for submission in the described format.

1. In this part, you will implement the mean shift algorithm with a Gaussian kernel, for the purpose of clustering points in 2D. First, generate a set of 3000 points from the following probability density function using the MATLAB function 'mvnrnd': $p(\mathbf{x}) = \frac{0.4}{2\pi\sqrt{|\mathbf{C_1}|}} e^{-(\mathbf{x}-\mu_1)^T \mathbf{C_1}^{-1}(\mathbf{x}-\mu_1)} + \frac{0.6}{2\pi\sqrt{|\mathbf{C_2}|}} e^{-(\mathbf{x}-\mu_2)^T \mathbf{C_2}^{-1}(\mathbf{x}-\mu_2)}$ where $\mu_1 = (0,0), \mu_2 = (5,5), \mathbf{C_1} = (2,0;0,2), \mathbf{C_2} = (2,1;1,2)$. Note that $\mathbf{x}, \mu_1, \mu_2$ are vectors in 2D whereas $\mathbf{C_1}$ and $\mathbf{C_2}$ are 2×2 matrices. Please see the code I provided in the lecture slides for the correct way of generating samples from this type of a probability density function (in particular, note that the following is the **incorrect** way of generating samples from this pdf: s_1 = sample from Gaussian with μ_1 and $\mathbf{C_1}$, s_2 = sample from Gaussian with μ_2 and $\mathbf{C_2}$, final sample = $0.4s_1 + 0.6s_2$).
   Plot these points in the form of a scatterplot and include it in your report. Now, your job is to cluster these points using mean shift using a Gaussian kernel using parameters $\sigma_x = \sigma_y = 2$. Plot the clustered points as a scatterplot overlaid on the first plot, but using a different color, and include this in your report. Calculate the minimum, maximum and average number of iterations for the convergence of each point and mention it in the report. [45 points]

2. In this part, you will implement mean shift for filtering and segmentation of a color image. Use the two color images provided in the homework folder. In this case, the points are in 5D. Use a Gaussian kernel for the mean shift procedure with spatial sigma = 12 and intensity sigma = 20. While performing the mean shift iterations on any point, compute the weighted average using only those points falling within a 23×23 square centered at (x_t, y_t) where (x_t, y_t) are the spatial coordinates of the point in the current iteration (note that these spatial coordinates will change in every iteration). In your report, display the initial image, and the filtered image. Given the filtered image, we will now perform segmentation on it using K-means in the joint spatial and intensity space, using $K = 100$. Display the segmented image in your

report - assign all pixels in a segment a color value equal to the average of the color of all pixels in that segment. (Note: ordinarily for mean shift, the segmentation is performed by grouping together all those points that converged to the approximately the same point within some tolerance threshold, and assigning them to the same segment. This avoids having to pick a K, though you do have to define appropriate tolerance thresholds. This procedure is also a bit more time-consuming and tedious to implement, and given the paucity of time, we shall just drop this part.) [30 (smoothing) + 20 (segmentation) = 50 points]