Computer Vision CS 543/ECE 549
Homework 2

Due date: 11th March 2010

General instructions: Do not use built-in code or code from the Internet for the Hough transform, K-means, or mixture of Gaussians. Explain your algorithms in paragraph form, with equations where they are helpful.

Problem 1**.** Circle detection using Hough Transform: For the given motorbike image compute gradient and detect circles using Hough transform. Submit an image showing detected circles overlayed on the top of original image and a pseudo code for the algorithm. Explain your algorithm in words and equations (not code), including the parameterization of your Hough space, how to generate votes, the grid resolution in Hough space, how to compute local maxima, etc. (30%)

Problem 2**.** K Means Clustering: Break the sunflower image into 16x16 blocks. Perform K-means based on RGB pixel intensities, with K = 5, 10, 50, 100. Replace blocks of the original image with the cluster centers and measure pixel error. Try 3 random initializations(choosing a random patch as the cluster center) for each K-means and display the solution that minimizes SSD. Report mean SSD for each initialization. (20%)

Problem 3**.** Segmentation using Gaussian Mixture Model: a). Derive EM for multivariate gaussian mixture with K components.

$$P(x; \mu_1, \ldots, \mu_K, \pi_1, \ldots, \pi_K, \Sigma_1, \ldots, \Sigma_K) = \sum_{k=1}^{K} \pi_k P(x; \mu_k, \Sigma_k) \qquad (1)$$

Show all steps including application of Bayes rule and computation of derivatives of different terms. Derive and state EM update formulae for each π_k, μ_k and Σ_k. (20%)

b) Perform foreground background segmentation on the butterfly RGB image provided to you. Initialize foreground by the pixels inside the box shown in red and background by the rest. The top left and bottom right corners of this box are $[(29, 104)(475, 248)]$. Model both $P(foreground|Image)$ and $P(background|Image)$ as separate GMM each with appropriate number of clusters and estimate the model parameters by EM. You may use K-means for initializing EM. Show the log likelihood ratio as an intensity image and the final pixel segmentation (make all the background pixels blue). Explain your choice of the number of mixture components for foreground and background.