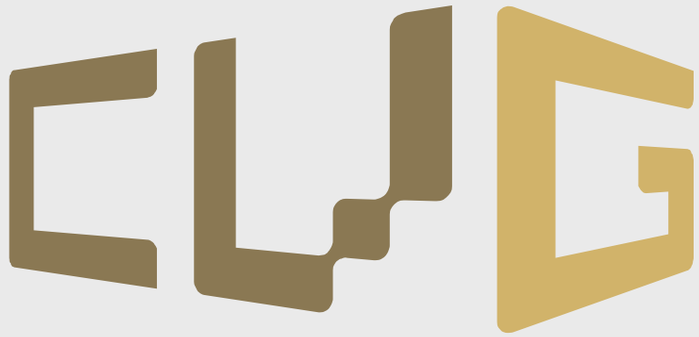


Computer Vision
and Geometry Lab

Computer Vision

Exercise Session 7

Assignment 6

- 3 Tasks:
  - Preprocess the image for image segmentation in the L*a*b* color space.
  - Implement the mean-shift algorithm for image segmentation.
  - Implement the Expectation-Maximization algorithm for image segmentation.

Preprocessing the Image

- Smoothing the image
  - Use a 5x5 Gaussian kernel with $\sigma = 5.0$
  - Use matlab “fspecial” and “imfilter” functions.
- Converting RGB to L*a*b* color space
  - Use matlab “makecform” and “applycform” functions.

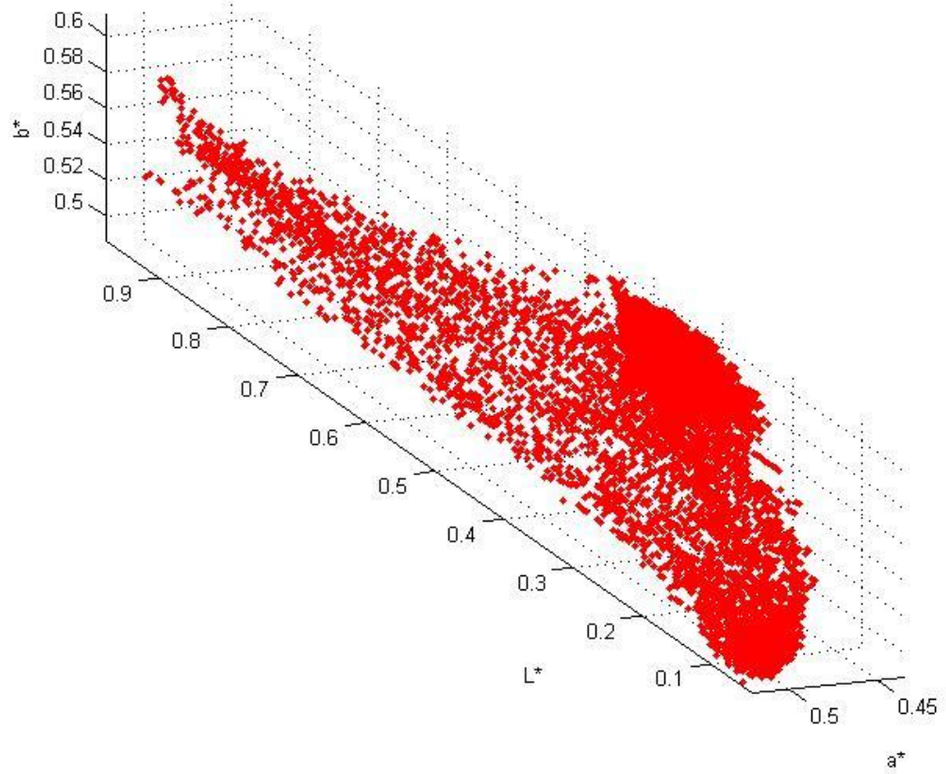
original image

smoothed image

l*a*b* image

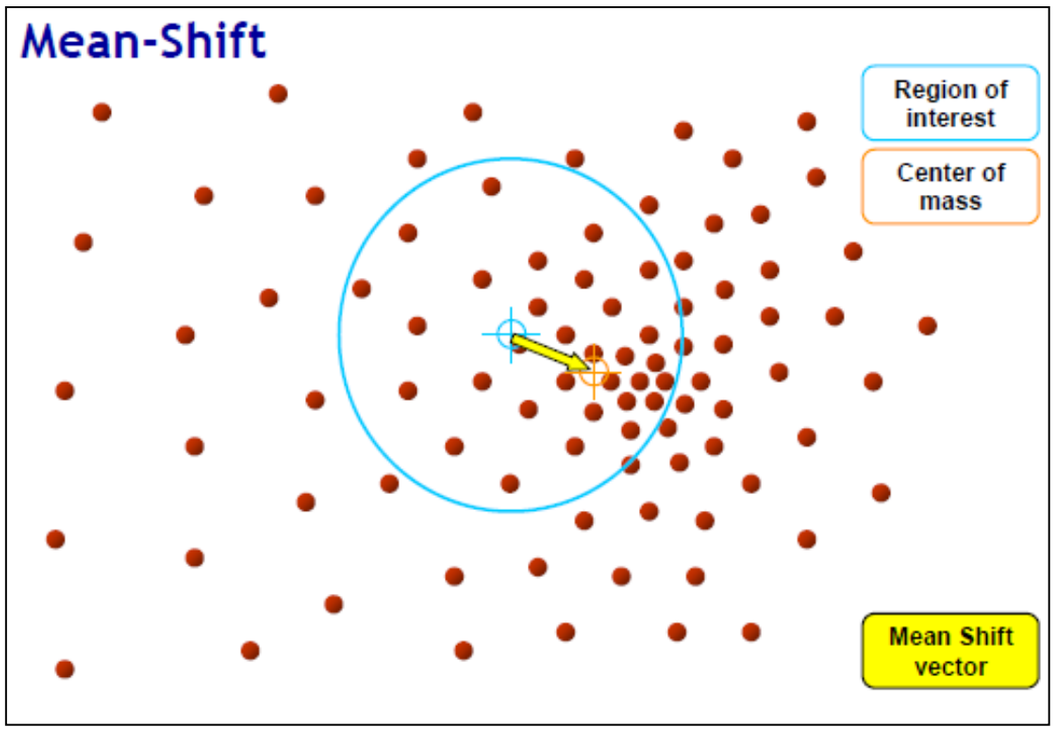
Mean-Shift Segmentation

- Create the density function X in the L*a*b* space.
  - L x 3 matrix, where L = no. of pixels in the image and 3 for each dimension of L*a*b*.



Mean-Shift Segmentation

- Compute the mean of all the pixels that lies within a spherical window of radius r.
- Shift this window to the mean.
- Repeat until convergence.



EM Segmentation

- Expectation step:
  - Compute $I_{lk} = p(\alpha_k \mid x_l, \theta_k^{(s)})$ for all segments 1:k and all pixels 1:L.

$$I_{lk} = p(\alpha_k \mid x_l, \theta_k^{(s)}) = \frac{\alpha_k^{(s)} p(x_l \mid \theta_k^{(s)})}{\sum_{k=1}^{K} \alpha_k^{(s)} p(x_l \mid \theta_k^{(s)})}$$

- The conditional probability is given by

$$p(x_l|\theta_k^{(s)}) = \frac{1}{(2\pi)^{n/2} \left|\Sigma_k^{(s)}\right|^{1/2}} \exp -\frac{1}{2}(x_l - \mu_k^{(s)})^T \Sigma_k^{(s)-1}(x_l - \mu_k^{(s)})$$

- I is a LxK matrix. (s) denotes the value at iteration s.

EM Segmentation

- Maximization step:
  - Computes $\alpha_k^{(s+1)}$, $\Sigma_k^{(s+1)}$ and $\mu_k^{(s+1)}$ for all K segments by maximizing the expectation of the complete log likelihood $p(X|\Theta)$ under I over the parameters Θ

$$\alpha_k^{(s+1)} = \frac{1}{L}\sum_{l=1}^{L} I_{lk} \qquad \mu_k^{(s+1)} = \frac{\sum_{l=1}^{L} x_l I_{lk}}{\sum_{l=1}^{L} I_{lk}} \qquad \Sigma_k^{(s+1)} = \frac{\sum_{l=1}^{L} I_{lk}\left\{(x_l - \mu_k^{(s+1)})(x_l - \mu_k^{(s+1)})^T\right\}}{\sum_{l=1}^{L} I_{lk}}$$

EM Segmentation

- Initialization:
  - Need to initialize $\alpha_{1:k}^{(0)}$ $\Sigma_{1:k}^{(0)}$ and $\mu_{1:k}^{(0)}$.
  - $\alpha_k^{(0)} = \frac{1}{K}$ which gives every segment uniform weightage at initialization.
  - $\Sigma_k^{(0)}$ is a 3x3 matrix and could be initialized as a diagonal matrix with elements corresponding to the range of the L*, a* and b* values.
  - Each of $\mu_{1:k}^{(0)}$ is a 3x1 vector that represents a point in the L*a*b* space. A good way to initialize is to spread them equally in the L*a*b* space.

Hand-in

- Assignment 7 should be submitted latest by
  - Friday, 8 November 2019, 11:59 PM