Computer Vision I

Homework 3

Given October 5, 2018; Due: October 12, 2018

Image Features and Image Segmentation

1. Consider a 8x8 image f(x,y) such that $f(x, y) = |x - y|$ for $x, y = 0, 1, \ldots, 7$.
   (a) Find the magnitude and orientation of the gradient by using the Prewitt maks. (Disregard boundaries)
   (b) Repeat using the Sobel masks.
2. Suppose that the intensities of a 3x3 neighborhood are given by the planar equation $I(r, c) = pr + qc + h$, with $r, c = -1, 0, 1$.
   (a) Find the image gradient at (0,0).
   (b) Show that the Prewitt masks compute estimates of p and q .
   (c) Show that the Laplacian mask has zero response:

0	-1	0
-1	4	-1
0	-1	0

3. Compute the C matrix and find its eigenvalues, to detect the corner in the image given in Figure 1, when using a neighborhood of 7×7.
4. Find the Hough transform (using the normal equation of a line) for the lines enclosing an object with vertices A=(2,0), B=(2,2) and C=(0,2). Sketch the modified object enclosed by lines replacing (rho,theta) of the given object lines with (rho*rho,theta + 90). Calculate the area of the modified object.
5. The sides of a convex polygon have Hough transform (using the normal equation of a line):

Side	ρ	Θ
AB	3	90
BC	3	0
CD	$\sqrt{3}$	60
DA	$-\sqrt{2}/2$	-45

0	0	0	0	0	0	0	0	0	0	40	40	40	40	40	40	40	40	40	40
0	0	0	0	0	0	0	0	0	0	40	40	40	40	40	40	40	40	40	40
0	0	0	0	0	0	0	0	0	0	40	40	40	40	40	40	40	40	40	40
0	0	0	0	0	0	0	0	0	0	40	40	40	40	40	40	40	40	40	40
0	0	0	0	0	0	0	0	0	0	40	40	40	40	40	40	40	40	40	40
0	0	0	0	0	0	0	0	0	0	40	40	40	40	40	40	40	40	40	40
0	0	0	0	0	0	0	0	0	0	40	40	40	40	40	40	40	40	40	40
0	0	0	0	0	0	0	0	0	0	40	40	40	40	40	40	40	40	40	40
0	0	0	0	0	0	0	0	0	0	40	40	40	40	40	40	40	40	40	40
0	0	0	0	0	0	0	0	0	0	40	40	40	40	40	40	40	40	40	40
40	40	40	40	40	40	40	40	40	40	0	0	0	0	0	0	0	0	0	0
40	40	40	40	40	40	40	40	40	40	0	0	0	0	0	0	0	0	0	0
40	40	40	40	40	40	40	40	40	40	0	0	0	0	0	0	0	0	0	0
40	40	40	40	40	40	40	40	40	40	0	0	0	0	0	0	0	0	0	0
40	40	40	40	40	40	40	40	40	40	0	0	0	0	0	0	0	0	0	0
40	40	40	40	40	40	40	40	40	40	0	0	0	0	0	0	0	0	0	0
40	40	40	40	40	40	40	40	40	40	0	0	0	0	0	0	0	0	0	0
40	40	40	40	40	40	40	40	40	40	0	0	0	0	0	0	0	0	0	0
40	40	40	40	40	40	40	40	40	40	0	0	0	0	0	0	0	0	0	0
40	40	40	40	40	40	40	40	40	40	0	0	0	0	0	0	0	0	0	0
40	40	40	40	40	40	40	40	40	40	0	0	0	0	0	0	0	0	0	0

Figure 1: Checkerboard for corner detection

(a) Draw the polygon in image space and indicate the coordinates of the four vertices.

(b) The polygon is rotated 30 degrees counterclockwise around the image space origin. Find the Hough transform for the sides of the rotated polygon.

6. Assume that regions in an image have an intensity distribution that is planar combined with Gaussian noise. Thus the intensity value at a point (x,y) of the region can be identified as

$$I(x, y) = Ax + By + C + N(0, \sigma)$$

Derive the likelihood ratio-based merge criterion under this assumption.

7. (Old exam problem) An image region has the following histogram:

Gray Value	1	2	3	4	5	6
Count	1	2	3	2	1	1

(a) Show the iterations when the mean shift algorithm is run to find an estimate of the mode (peak) of the histogram, using windows of diameter 4, and with the initial window centered at $x = 4$

(b) Let a be the mode found by the mean shift algorithm in the previous part. If the region is approximated by a, how much is the fitting error?

(c) Assuming that the fitting error is due to additive zero mean uncorrelated Gaussian noise, what is the likelihood that this model is correct?