CS/RBE 549 Computer Vision Name:_____
Fall 2015 Monday 12 Oct 2015

Exam #1

DO NOT OPEN THIS EXAMINATION UNTIL YOU ARE TOLD TO DO SO!

Write your name at the top of this page now.

This examination is open book and open notes. Electronic devices are allowed to access stored information provided that they are operating in wireless mode.

No other electronic computing / communications devices are permitted. No wireless communication is allowed.

Write all your answers on the examination in the space provided. You may use the back of the examination for extra space. Partial credit will be given, but you must justify your work.

The examination will end exactly 90 minutes after it begins.
Good luck.

Problem 1: /15
Problem 2: /35
Problem 3: /30
Problem 4: /20
Total: /100

1. **Segmentation (15 pts).** An image has object and background pixels whose brightness values are distributed according to the exponential distribution with parameters α_o and α_b with $\alpha_o < \alpha_b$. α_o and α_b are each less than 0.98. The probability of a pixel having brightness x is given by

$$P_o(x) = (1 - \alpha_o)\alpha_o{}^x \text{ and } P_b(x) = (1 - \alpha_b)\alpha_b{}^x$$

It is desired to segment the image into object and background. Find the decision rule that maximizes the probability of a correct decision.

2. **Edge Detection (30 pts).** Ima Robot proposes an edge detector as follows:

   Convolve image $f(\vec{x})$with $g_{\sigma_1} = \frac{1}{2\pi\sigma_1^2} e^{-\frac{1|\vec{x}|^2}{2\,\sigma_1^2}}$ to form $h_1(\vec{x})$.

   Convolve $f(\vec{x})$with g_{σ_2} to form $h_2(\vec{x})$.

   Compute $h_3(\vec{x}) = \frac{h_2(\vec{x}) - h_1(\vec{x})}{\sigma_2 - \sigma_1}$.

   Find zero-crossings of $h_3(\vec{x})$.

a. (10 pts) Describe how $h_3(\vec{x})$ can be computed by a single convolution with some kernel $g(\vec{x})$. What is the convolutional kernel $g(\vec{x})$?

b. (5 pts) Sketch $g(\vec{x})$.

c. (10 pts) What is the Fourier transform $G(\vec{u})$ of $g(\vec{x})$?

d. (10 pts) As $\sigma_2 \to \sigma_1$, is this a good edge detector, that is, do zero-crossings of h_3 occur at edges? Why or why not? Hint: Consider $G(\vec{u})$ as $\sigma_2 \to \sigma_1$.

3. **Hough Transform.** In this problem *x*, *y*, *b*, and *m* may be positive or negative, integers or fractions. 2 lines in (*m*,*b*) space are given by

   L1: $b = 1$

   L2: $b = -2m + 2$

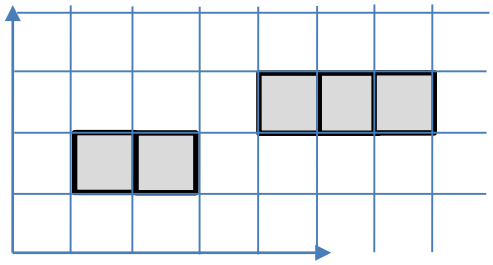
a. (10 pts) What are points P1 and P2 in (*x*,*y*) space corresponding to each of these lines?

b. (10 pts) What equation describes the line passing through points P1 and P2?

c. (10 pts) Line L3 in (*m*,*b*) space passes through (*m*,*b*) = (0,0). What is its corresponding P3 such that P3 lies along the line from part b?

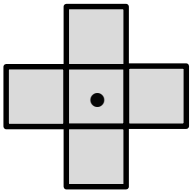
4. **Morphology.** The following binary image B

B=

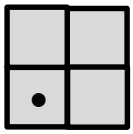


is operated on by structuring elements S1 and S2

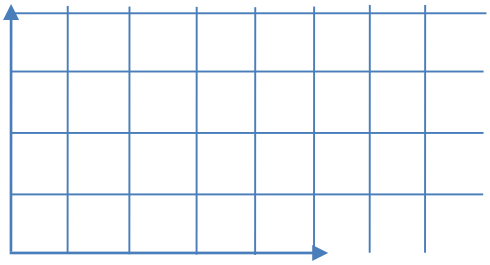
S1=



S2=



a. (10 pts) What is obtained by dilating B by S1 and then eroding that result by S2?



b. (10 pts) What is obtained by dilating B by S2 and then eroding that result by S1?