Problem Set 3

CMSC 426

Due October 4, 2012

1. **Creating filters - 15 Points**. You may use Matlab in answering these questions. The fspecial command may be particularly helpful for (a), but note that you will have to do more than just call that function to get a correct answer. Explain your reasoning in creating these filters. Especially, explain how you decided on the size of the filter.
    a. Create the smallest possible 1D Gaussian filter with sigma = 1, that captures 99% of the values of a full Gaussian.
    b. Build a 1D filter of $1/(1+x^4)$. This should also be the smallest possible filter that captures 99% of the values of the full filter.
    c. Create a 2D filter that computes the derivative of an image in the diagonal direction (ie., in the direction of the vector (1,1)). That is, this filter estimates the amount the image would change if you move one pixel in a diagonal direction. Apply this filter to the "image"

1	2	3	4	5	6	7	8
2	4	6	8	10	12	14	16
3	6	9	12	15	18	21	24

Show the results that you would get for the middle row of the image.

Hint:

Horizontal Derivative

0	0	0
- ½	0	½
0	0	0

Image

1	2	3	4	5	6	7	8
2	4	6	8	10	12	14	16
3	6	9	12	15	18	21	24

Diagonal Derivative

?	?	?
?	?	?
?	?	?

Image

1	2	3	4	5	6	7	8
2	4	6	8	10	12	14	16
3	6	9	12	15	18	21	24

2. **Image Gradients - 15 Points**:
   a. Consider the following, small image:

1	2	3	4	5
3	4	5	6	7
5	6	**7**	8	9
7	8	9	10	11
9	10	11	12	13

   Compute the magnitude and the direction of the gradient for the central point (**7**). Suppose *x* values increase as you go to the right, and *y* values increase as you go down.

   b. Now consider a different image. Suppose the intensity of an image at location (3,7) is 17, and the gradient is equal to (3,-2). Use this to estimate the intensity you would expect to see at location (3.1, 7.3) if you were able to measure intensities with subpixel accuracy. (If you are mathematically inclined, you can say that you are using the Taylor series expansion).

   c. Consider an image in which the intensities can be described as $I(x,y) = (x-2)^2 + (y-1)^2$. What is the gradient at the pixel (3,2)?

3. **Edge Detection - 20 points**
    a. Consider performing Canny edge detection on the following image. Assume that it has already been smoothed, so you don't have to worry about performing smoothing, which makes things messier. Suppose also that we use a very low threshold for determining an edge. The magnitude of the gradient must only be larger than 1. First, what is the image gradient at each pixel?

100	100	100	10	0
100	100	100	10	0
100	100	100	10	0
10	10	10	10	0
0	0	0	0	0

    b. For the image above, which pixels would be edges? You don't need to provide an answer for pixels on the boundary of the image, just the 3x3 square of pixels in the middle.
    c. Now consider the following image:

10	0	0	0	0
100	10	0	0	0
100	100(c)	10	0	0
100	100	100(b)	10(a)	0
10	10	10	0	0
0	0	0	0	0

    For each point labeled (a), (b), and (c), what is the image gradient?
    d. For each point labeled (a), (b), and (c), is that point an edge?

4. **Challenge problem, 10 points:** Suppose you have a 1D image described by the equation I = cos(x/100). You run a 1D edge detector on this image, in which you smooth with a Gaussian with a sigma of 1.5, and then find points in which the magnitude of the derivative is greater than a threshold, T, and which are locally maximal (ie., you apply non-maximum suppression). Where would you find the edges? What are the set of possible answers that you could get for all possible values of sigma and T?

    Hint: You should read about the Fourier series or the Fourier transform, either in the class notes on convolution, or in one of the text books, if you want to do this problem.