Name:		

HW #3

- 1. Use OpenCV to compute the Sobel edges of the grayscale image of HW0. Also compute the Marr-Hildreth edges (zero-crossings of $\nabla^2 g$ $\sigma^* f$) for various values of σ . Try 1, 2, 4, 8, 16. Do you get closed contours?
- 2. Show that if f(x)
 - a. is an odd function, that is, f(x) = -f(-x), and
 - b. it is pure imaginary, i.e. no real component,

then its Fourier Transform is also odd and real. Hint: Decompose the Fourier Transform into 2 integrals: one from $-\infty$ to 0 and another from 0 to ∞ .

3. If an edge detector is as follows:

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

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

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

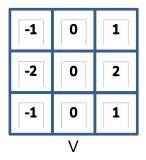
Find zero-crossings of $h_3(\vec{x})$.

- a. 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. Sketch $g(\vec{x})$.
- c. What is the Fourier transform $G(\vec{u})$ of $g(\vec{x})$?
- d. 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 $\sigma_2 \to \sigma_1$.
- 4. The following operators are proposed to detect diagonally oriented edges:

1	1	0	
1	0	-1	
0	-1	-1	
NF			

0	1	1	
-1	0	1	
-1	-1	0	
NW			

- (a) How are these operators related to the Sobel H and V operators?
- (b) Suggest two different ways in which to combine the NW and NE operators into a single measure of edge strength. What are the relative strengths and weaknesses of each?
- (c) Express the NW operator as the convolution of [0 1;-1 0] and another different 2×2 operators
- 5. Your teammate proposes to convolve the Sobel vertical edge detector mask V with the 3x3 blurring mask B.



2	3	2		
3	4	3		
2	3	2		
В				

- a) What is the resulting combined convolutional mask for applying V first, then B?
- b) Does convolving with B first then V produce the same result as convolving with V first then B? Why or why not?
- c) Is the convolution V * B separable into a convolution of an x-only mask (that is, a mask with dimensions $M \times 1$) followed by a y-only (with dimensions $1 \times N$) mask? If not, explain why not. If so, what are the x and y masks?