CSE185 Midterm Exam Name: Adrian Darian

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You must sign this form before taking the exam. You will not receive any credit if your signature (handwritten or digital) is not on this paper.

Name: Adrian Darian

Signature: Adrian Darian

Note: 13 questions on both sides, maximum 100 points. Write all the steps to show how you come up with the answers. You will have 50% of the points if you only show the answers without all the necessary steps or explanations.

1. [15 points] Given an image f, compute the filtered output h at pixel (x, y) by applying the filter g, Here we have zero paddings for pixels outside the image.

   (a) $g[.,.] = \frac{1}{2}\begin{bmatrix} 1 & 0 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & -1 \end{bmatrix}$ ----------→ h(9,9) = 10

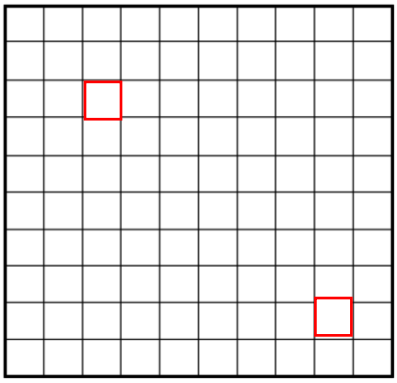
   (b) g is the max filter of size 5x5, i.e., $g = \max(.)$ ----------→ h(3,3) = 410

   (c) g is the Sobel filter, $g[.,.] = \begin{bmatrix} 1 & 0 & -1 \\ 2 & 0 & -2 \\ 1 & 0 & -1 \end{bmatrix}$ ----------→ h(3,3) = 0

$f[.,.]$

0	0	0	0	0	0	0	0	0	0
0	80	80	80	80	80	80	80	80	0
90	90	90	200	90	90	90	90	90	90
0	70	70	70	70	70	70	70	70	0
60	60	60	60	60	60	60	60	60	60
0	50	50	50	50	50	50	50	50	0
40	40	40	40	40	40	40	40	40	40
0	30	30	30	30	30	30	30	30	0
20	20	20	20	20	20	20	20	20	20
0	10	10	10	10	10	10	10	10	10

$h[.,.]$



A) $\begin{bmatrix} 30 & 30 & 0 \\ 20 & 20 & 20 \end{bmatrix} \cdot \begin{bmatrix} 1/2 & 0 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & -1/2 \end{bmatrix} = 15 - 5 = 10$

C) $\begin{bmatrix} 80 & 80 & 80 \\ 90 & 90 & 200 \\ 70 & 70 & 70 \end{bmatrix} = \begin{bmatrix} 80\times1 & 80\times0 & 80\times-1 \\ 90\times2 & 90\times0 & 90\times-2 \\ 70\times2 & 70\times0 & 70\times-1 \end{bmatrix} = \begin{bmatrix} 80 & 0 & -80 \\ 180 & 0 & -180 \\ 70 & 0 & -70 \end{bmatrix}$

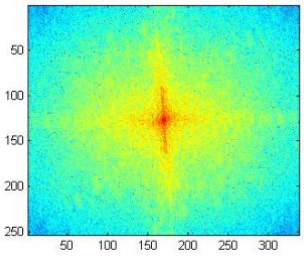
$= 0$

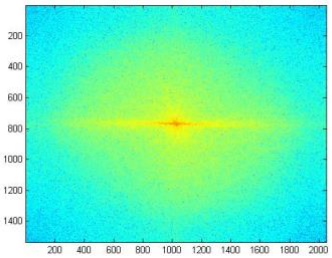
B) $\begin{bmatrix} 0 & 0 & 0 & 0 & 0 \\ 0 & 80 & 80 & 80 & 80 \\ 90 & 90 & 90 & 200 & 90 \\ 0 & 70 & 70 & 70 & 70 \\ 60 & 60 & 60 & 60 & 60 \end{bmatrix} = 80 + 200 + 70 + 60 = 410$

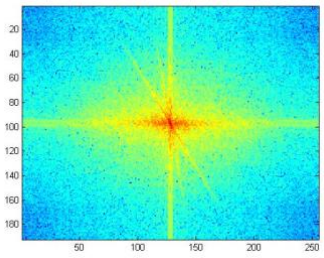
2. [15 points] Match the images in the first row to the Fourier magnitude images in the second row. Explain your answers clearly.



1 2 3







a b c

1 is b, because the dominant vertical lines

2 is c, because vertical and horizontal and diagonal lines

3 is a, because vertical and horizontal lines

3. [15 points] Match the texture images on the right column to the mean absolute responses of filter banks on the left column. Explain your answers clearly.

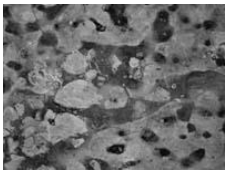
mean

1. 

2. 

3. 

A. 

B. 

C. 

1 is C, edges go ↑ and ↓ plus there is a white aka vertical line

2 is A, the white box lines up with the slant

3 is B, white box correlates to the blob

4. [5 points] Which of the following statements are true? Select all correct ones and explain your answers (e.g., you can select a, b, c, d, e as your answers).
    a. The intrinsic camera parameters have to do with how a point in the 3D world is projected mapped onto image plane (i.e., involving rotation and translation).
    b. A Gaussian filter removes high-frequency components
    c. A 2D Gaussian filter can be factored into two 1D Gaussian filters
    d. In Canny edge detector, non-maximum suppression is used to connect short edges
    e. The low-frequency components of an image describe the most dominant edges.

A, b, d, e all explain the opposite of the truth

5. [5 points] Let f be an image and g be a Gaussian filter. When we compute x image gradient, why do we want to apply Gaussian filter first, i.e., $\frac{\partial}{\partial x}(f * g)$? Explain your answer clearly.

We want to apply it first to reduce the noise and contrast

6. [5 points] Let f be an image and g be a Gaussian filter. When we compute x gradient, why can we first compute $\frac{\partial}{\partial x} g$ and then convolve an image f with $\frac{\partial}{\partial x} g$? What are the advantages? Explain your answer clearly.

Apply a smooth filtering allow us to convolve the image as lowpass frequency i.e. fourier transform filter

7. [5 points] Canny edge detector. Which of the following statements are true (e.g., you can select a, b, c, d, e as your answers)? Explain your answers for full credits.
    a. Non-maximum suppression is used to select a pixel that is close to the true edge
    b. The edges found by a Canny edge detector are determined by the Gaussian kernel scale. If we use small kernel width, we will have more tiny edges.
    c. In hysteresis process, we start with high thresholds and then low thresholds
    d. a, b and c are correct
    e. a and b are correct

A larger process is needed beforehand then we can connect the edges

8. [5 points] For Harris point detector, the corner response $R = \det(M) - 0.04\ tr(M)$ where det and tr are the determinant and trace of a matrix. For a point where $M = \begin{bmatrix} I_x^2 & I_x I_y \\ I_y I_x & I_y^2 \end{bmatrix} = \begin{bmatrix} 0.16 & 0.2 \\ 0.2 & 0.25 \end{bmatrix}$ where I_x, I_y are x and y image gradients, is this point on an edge? a corner? or a flat region? Explain your answer clearly.

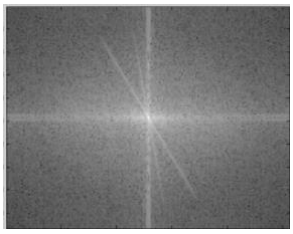
corner, because the larger changes in the gradient in the (x,y) directions

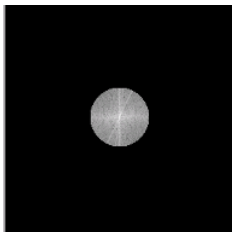
9. [5 points] Hough transform. Given one points (x, y) = (2, 6) in the image plane, write down the corresponding line in the Hough parameter space (describe a line in terms of m and b, your answer should be m=____). Explain your answer clearly.

$y = mx + b \rightarrow m = -\frac{1}{x}b + \frac{y}{x} = -\frac{1}{2}b + \frac{6}{2} = -\frac{b}{2} + 3$

10. [5 points] (a) is the input image, (b) is the magnitude image in the Fourier domain. Explain why after applying the filter (c) to (b) in the frequency domain that we can recover (d) in the spatial domain


(a) Input


(b) magnitude image

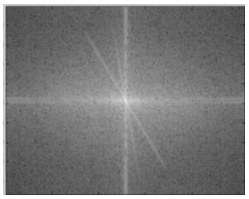

(c) filter

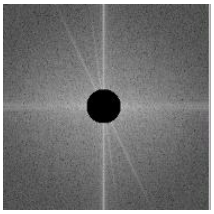

(d) filtered result

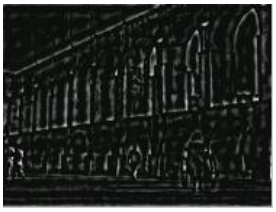
Using the Gaussian filter, we get a low frequency of the input image. Giving us a blurred result

11. [5 points] (a) is the input image, (b) is the magnitude image in the Fourier domain. Explain why after applying the filter (c) to (b) in the frequency domain that we can recover (d) in the spatial domain


(b) Input


(b) magnitude image


(c) filter


(d) filtered result

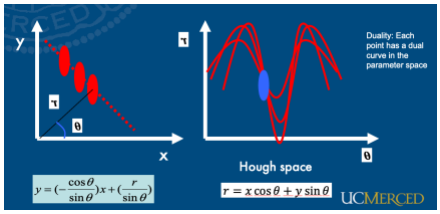
Using Sobel filter we detect high frequency, after apply the filter we only output the lines to the result

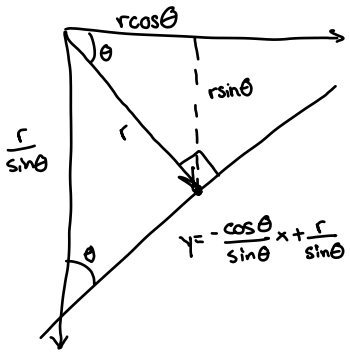
12. [5 points] Which of the following statements are true? Explain your answers clearly.
    a. Line fitting with least squares minimization gives a closed form solution.
    b. Line fitting with least squares minimization is not sensitive to outliers.
    c. Hough transform can be efficiently applied to model fitting when the number of parameters is small.
    d. Model fitting with RANSAC generates the same answer every time.
    e. Line fitting with RANSAC is less sensitive to outliers than with least squares minimization

A and E is correct

b is incorrect cause it is sensitive
C is incorrect cause Hough does not perform well with large param
d is incorrect cause it in not the same every time

13. [10 points] We usually represent a line with $y = mx + b$. Where m is the slope, and b is the offset. Note each point (x, y) in the Euclidean space is represented by $(r\cos\theta, r\sin\theta)$ in the polar coordinate. For line fitting with the Hough transform in the polar coordinate, first show how we represent a line with $y = \frac{-\cos\theta}{\sin\theta}x + \frac{r}{\sin\theta}$. Then show for each (θ, r), we have a line in the Hough space $r = x\cos\theta + y\sin\theta$. Explain every step to earn full credit. (Hint: you need to represent m, b in terms of r, θ.





y=mx+b
b=-mx+y