CSE185 Midterm Exam Name: _____

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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: _____

Signature: _____

Note: 14 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. [20 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) = __200__

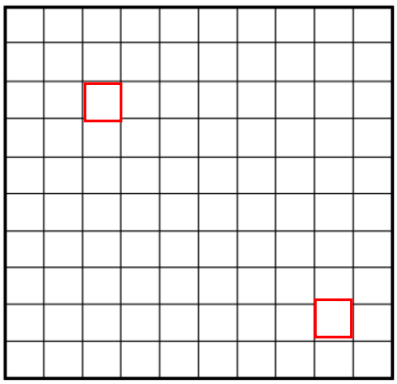
   (c) g is the Sobel filter, $g[.,.] = \begin{bmatrix} 1 & 0 & -1 \\ 2 & 0 & -2 \\ 1 & 0 & -1 \end{bmatrix}$ ----------→ h(3,3) = _-220___

   (d) g is the Roberts filter, $g[.,.] = \begin{bmatrix} 1 & 0 \\ 0 & -1 \end{bmatrix}$ ----------→ h(9,9) = __10____

$f[.,.]$

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

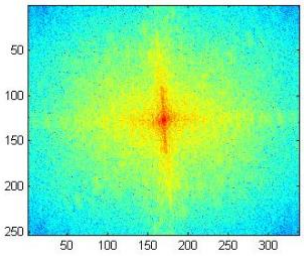
$h[.,.]$

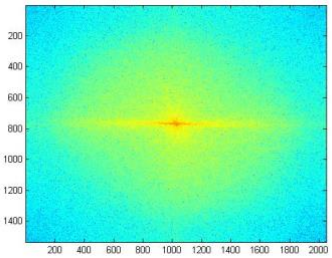


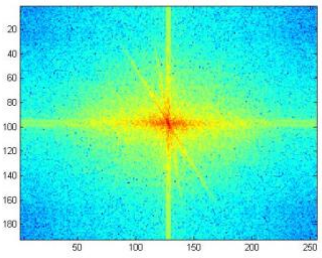
2. [15 points] Match the spatial domain image to the Fourier magnitude image. Explain your answers clearly.



1 2 3







a b c

1:b

2:c

3:a

3. [15 points] Match the texture images to the mean abs responses of filter bank. Explain your answers clearly.

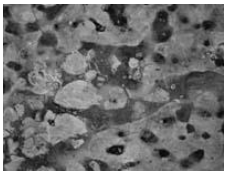
1. 

2. 

3. 

A. 

B. 

C. 

1:b

2:a

3:c

4. [5 points] Which of the following is true? Select all correct ones and explain 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.

    b, c, e

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., $\frac{\partial}{\partial x}(f * g)$?

    Without using Gaussian filter, the differentiation operation may amplify noise and gradients cannot be accurately estimated.

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?

As the convolutional operations are linear, we can use the associative property to reduce computational complexity.

7. [5 points] Canny edge detector. Which of the following statement is true? 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, b, c, d

this question is not well posed. So, if one answers with (a, b, c) or (a, b, c, d, e), or d is fine.

8. [10 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 $M = \begin{bmatrix} I_x^2 & I_x I_y \\ I_y I_x & I_y^2 \end{bmatrix} = \begin{bmatrix} 0.9 & 0.1 \\ 0.1 & 0.9 \end{bmatrix}$ where I_x, I_y are x and y image gradients, is this point on an edge? a corner? or a flat region?

I fix the typo in an email to the students as it should should be tr^2. If a student if tr, that is fine.

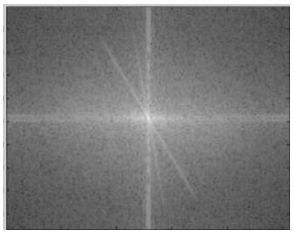
R=0.9*0.9-0.1*0.1-0.04 (0.9+0.9) > 0. The pixel is on a corner location.

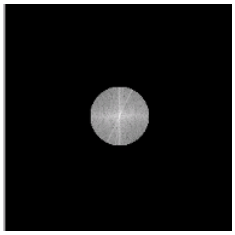
9. [5 points] Hough transform. Given one points (x, y) = (2, 6) in the image plane, write down the corresponding line in the Hough parameter space (describe a line in terms of m and b, your answer should be m=____).

Since y=mx+b, we have m=-(1/x)b+y/x in the parameter space. Thus, m=-0.5b+3

10. [5 points] 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) phase image

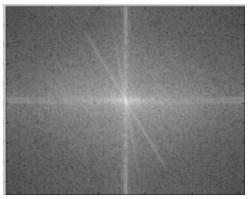

(c) filter

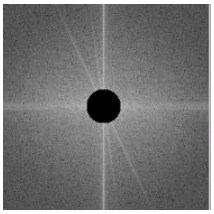

(d) filtered result

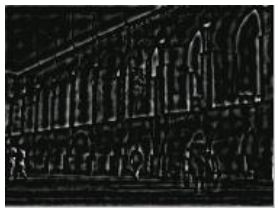
(c) represents the low-frequency filter.
(d) represents the low-frequency response.
Use (c) to recover the low-frequency response of (a), which can blur the image (a).

11. [5 points] 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) phase image


(c) filter


(d) filtered result

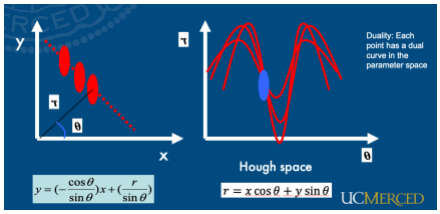
(c) (c) represents the high-frequency filter.
(d) (d) represents the high-frequency response.

Use (c) to recover the high-frequency response of (a), which can generate the boundary of (a).

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, c, e

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.



(x, y) -> (r cos theta, r sin theta). Thus, we can compute the slope to the point on the line as r sin theta/r cos thea => sin theta/cos theta. Thus, the slope of the line (perpendicular to the line segment) is - cos theta/sin theta. Using the triangle with r at the bottom, r = y sin theta, and thus, y = r/sin theta. Plug them into y=mx + b = -cos theta/sin theta + r / sin theta