CS 5390/7390 Midterm Fall 2020 Name: _____

This is a take home, open-book exam. Answers **must be handwritten** and submitted to Canvas as a single pdf. Your answers should fit in the space provided. Your answers should primarily be text, but you may include text, sketches, diagrams, graphs, mathematical formulas or code to best express your answers,

You may use any informational resources available to you including the textbook, research articles, OpenCV website, forum boards. You **may NOT use other students** in the class or post questions about these questions anywhere. If you wish clarity on questions, or directions, you may ONLY ask the instructor.

**If** you used websites or other sites other than the text and tutorial sites listed references in our course syllabus or linked through Canvas assignments and breakout room activities, please **include those links as entries in the textbo**x on Canvas in addition to uploading the pdf with your answers.

Your answers to this, in addition to work submitted for HW and Projects, will form the basis for questions during the conference-style portion of the exam that comprises 40% of your grade.

## I. Theoretical Foundations Concepts

1. (a) What is the convolution theorem? (b) How can you use that to decide on an approach to implement efficient smoothing efficiently?

2. (a) What is an image derivative and how might that be useful. (b) Provide a **specific example** of how to implement it, noting any particular characteristics of the output that we need to understand in order to interpret properly.

**3.** (a) What type of information does the second derivative of an image provide?
(b) How would you compute the second derivative in the **spatial domain**?
(c) How would you compute second derivative of an image in the **frequency domain?**

4. (a) Explain why color images are customarily represented in a BGR color model system. Include a description that relates to characteristics of the human visual system.

5. (a) What is the HSV color model? What correspondence does that have to the human visual system? And when would that be useful?

6. (a) What is bilinear interpolation? (b) Describe the scenario in which it is relevant. (c) Compare that to at least one other type of interpolation.

7. (a) What is quantization of an image? (b) Where is that relevant in a discussion comparing analog and digital images? (c) How is that different from sampling?

8. Why is it important to smooth an image before applying an edge detector?

9. Geometric transformations are often classified according to the preservations of different characteristics and the type of transformation. (a) What types of transformations on the 2D plane are possible in the type know as “rigid transformations” (b) What is the difference between an affine transformation and a projective transformation in these terms? (i.e. how are geometric elements transformed/preserved on a plane?)

## II. Mathematical and Computational Tools

10. (a) What is the gradient of an image and why is it useful? (b) Provide specific description of how to compute it, including specific kernels required and a mathematical or code expression of computation.

11. (a) What steps comprise the Canny Edge Detector method? (b) What is the purpose of non-maximal suppression in the Canny Edge Detection?

12. (a) Write a mathematical expression that defines a binary image, $g$, by thresholding an image, $f$, against a constant value $t$. (b) Is this a linear or non-linear operation?

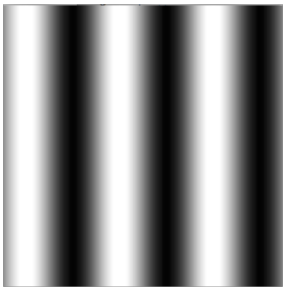
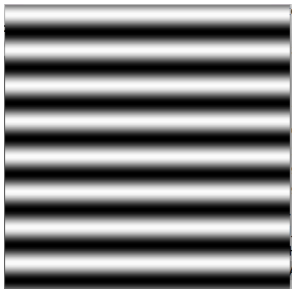
13. What is the difference between a Laplacian Pyramid and a Gaussian Pyramid? Why might you use one over the other?

14. Suppose that you were interested in detecting diagonal lines in an image, rather than vertical and horizontal. (That is you want to apply a feature detector that will respond more to edges at 45 and 135 degrees than edges at 0 and 90 degrees.) Define the values of a 7x7 spatial domain kernel to achieve this:

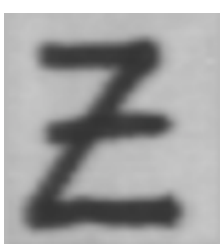
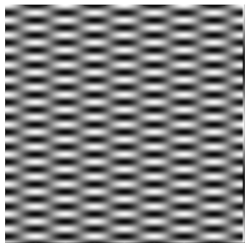
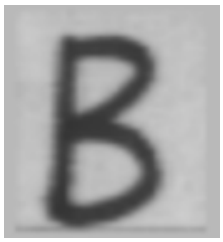
| | | | | | | |
|---|---|---|---|---|---|---|
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |

## III. Visual Understanding and Interpretation

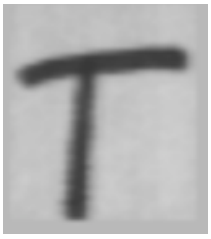
1. In each row below, the left column shows a 128x128 spatial domain image with intensity determined from function(s) of spatial location.
   (a) Sketch the magnitude spectrum in the frequency domain associated with each image in column B.
   (b) In column C, write the equation, or line of code, that defines the intensity as a function of spatial location at a single point (x, y). (Determine the function too!)

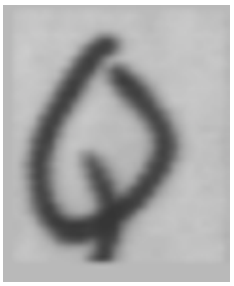
| A (intensity image) | B (magnitude spectrum) | C (function) |
|---|---|---|
|  | | |
|  | | |

Which image in the first set goes with the magnitude spectrum in the second set?

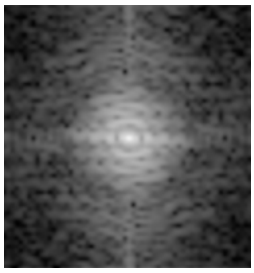




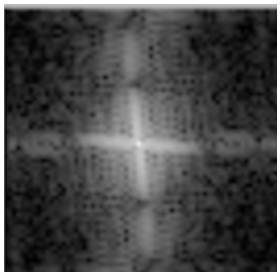
1: _____ 2: _____ 3: _____

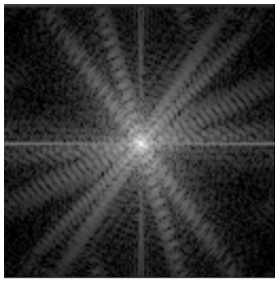


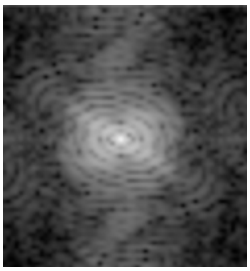


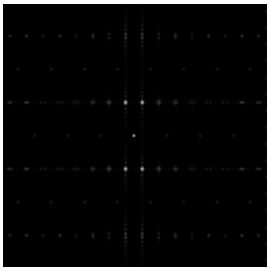
4: _____ 5: _____ 6: _____

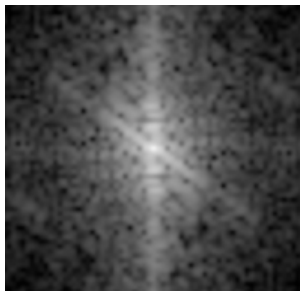

A


B

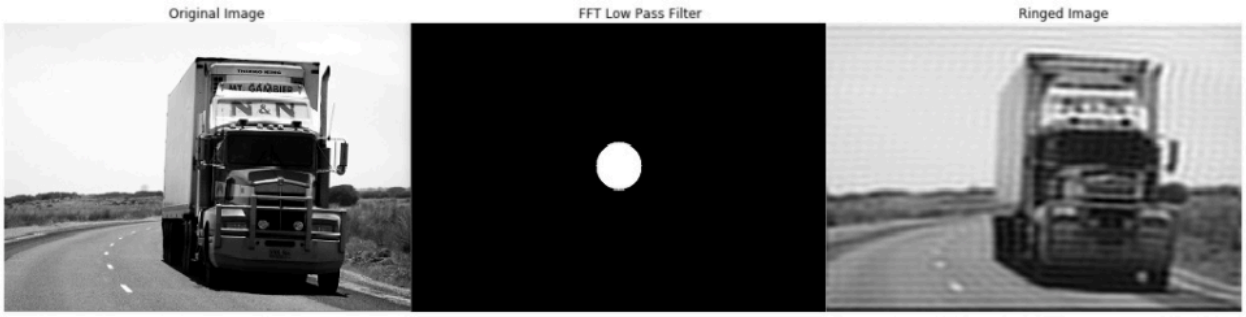

C


D


E


F

Below you will see an image on the left, a frequency domain filter shown as an intensity image in the middle and the effect of applying that filter on the right. (a) Explain what this filter is intended to do, visually. (b) Can you explain how a frequency domain filter, designed in this way, relates to the human visual system and its sensitivity to spatial frequency? (c) Please describe the visual artifacts that appear in the resulting image and (d) the likely cause and a reasonable approach to a solution.




Low Pass Filter