Name: Summer Poissonnier

COT 4930, EEL 4930, COT 5930, EEL 5661 Robotic Applications (Fall 2021)

Final Exam (Machine Vision)

Version X

60 minutes (2:15-3:15 PM); Canvas Assignment window opens at 1:45 and closes at 3:45 PM. You have 30 minutes to scan your work and upload it to Canvas Assignments. Missing the submission window (that is, submission before 3:45) may carry up to 5-point penalty (on the scale of 0-10%). There is a 2-point penalty for not writing on the test form.

Take home, open books and notes. Please work independently and adhere to the time limits.

The total points of the exam problems are 69. The maximum score (that will be scaled to the range of 0-10%) is set to **40 points (out of 69)**. You may skip some problems, or try as many as you can, as all the partial credits add up.

Problem 1: Two separate questions 1.1 and 1.2:

1.1 (5 points): A perspective camera has a focal length of f = 15 [mm]. A box is standing parallel to the camera at a distance of 2 [m]. One of the box's edges creates a line in the image that runs between two image points (200, 100) and (150, 120) [mm]. What is the true length of the box edge? Show and explain your calculations.

1.2 (5 points): Suggest the pixel levels of a 3 x 3 image that has 8 greyscale levels, whose cumulative histogram grows linearly. Explain briefly.

1	**0**	**2**
3	**7**	**4**
5	**6**	**0**

Explanation:

#pixels	2	1	1	1	1	1	1	1
Grey Level	0	1	2	3	4	5	6	7

Cumulative:

#pixels	2	3	4	5	6	7	8	9
Grey Level	0	1	2	3	4	5	6	7

Problem 2: A 4 x 4 pixels image that has 4 greyscale levels is given below:

3	3	3	3
3	3	3	3
0	1	1	0
1	0	1	2

2.1 (5 points): Find the image histogram and cumulative histogram.

#pixels	3	4	1	8
Grey Level	0	1	2	3

Cumulative:

#pixels	3	7	8	16
Grey Level	0	1	2	3

2.2 (5 points): Based on the histogram (of 2.1) show how to binarize the image.

1	1	1	1
1	1	1	1
0	0	0	0

0	0	0	0

A reasonable threshold level may be threshold 1.

Pixels with grey levels {0,1,2} are mapped to '0'

Pixels with grey level {3} are mapped to '1'

2.3 (5 points): Run a connectivity analysis of the binarized image (of 2.2) and show the label of each region.

S1	S1	S1	S1
S1	S1	S1	S1
S2	S2	S2	S2
S2	S2	S2	S2

There is 1 white and 1 black region.

Problem 3: (True/False 1-point, brief explanation 1-point)

If an image is absolutely noise free then a Sobel kernel and a Derivative-of-Gaussian kernel produce identical output images. **False**

- **The two methods detect the edge in image processing. They have the same goal but different results.**

Problem 4: In all the grids of this exam, the origin (0,0) is in the upper left corner. The u-axis goes from left to right, and the v-axis goes from top to bottom.

4.1 (5 points): Create a 6 x 6 binary image that has 3 labeled regions. Region 1 is the parent of the other two 2-pixels white regions. Explain briefly.

1	1	1	1	1	1

1	1	1	1	1	1
0	1	0	1	1	0
1	0	1	0	1	1
1	1	1	1	0	1
1	1	1	1	0	0

One region is black and Two regions are white.

4.2 (5 points): Pick up one of the white regions of (4.1) and calculate its centroid.

Area = m00 = 18

1st momentum = (0x1 + 1x1)+(0x1 + 1x1 + 2x1 + 3x1 + 4x1)+(0x1 + 1x1 + 2x1 + 3x1 + 4x1) = 21

Momentum 01 = 21

Centroid = (1.17, 1.17)

Problem 5 (5 points): The 4 x 4 binary output image (below) is obtained by a monadic operation on some input image. The input image has two regions – the white region has an area of 5 pixels. Find the input image and suggest the monadic operation.

1	1	1	0
1	1	1	0
1	0	0	0
1	1	1	1

2	2	2	1
2	2	2	1
2	1	1	1
2	2	2	2

The monadic operation is to cause a darkening of the input image.

Problem 6 (5 points): Convolve the 2 x 2 kernel of 1's with the 3 x 3 pixels image with 4 greyscale levels (shown below). Be sure to suggest a normalizing factor. Cells that involve boundary effect are declared "invalid". Are there any "valid" output image pixels? See problem 4 for a definition of the u and v axes.

3	3	3
1	1	3
0	1	0

0	0	IV
0	-2	IV
-1	1	IV

Problem 7 (5 points): A Transpose Sobel edge detector is applied to the binary image below. How many edges are produced? A Hough Transform is then used to detect the best line in the image. What are the ρ and θ parameters of the best line? Explain briefly.

0	1	0	0
1	1	1	0
0	0	0	0
0	0	1	0

Problem 8: (True/False question 1-point, Brief explanation 1-point)

An autonomous vehicle follows another car at a constant distance. Some of the vision algorithms that assist the car following include area calculation of a rectangular black sticker attached to the leading car license plate and calculation of several Hu moments to assure that the correct sticker is being viewed. **True**

- **Hu moments are used for comparing shapes.**

Problem 9: Consider the 5 x 5 binary image and the 1x4 structuring image (below).

0	1	1	1	1
1	1	0	0	0
1	1	0	0	0
0	0	0	1	0
0	0	0	1	0

1	1	1	1

9.1 (5 points): Perform an erosion morphological operation, and briefly explain your calculations.

0	1	1	1	1
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0

9.2 (5 points): Follow up (9.1) by a dilation morphological operation on the result of 9.1, and briefly explain your calculations. How is the sequence of actions called – opening or closing?

1	1	1	1	1
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0

The sequence of actions is called opening

Problem 10 (5 points): A robot performs assembly of two mechanical parts by screwing a single bolt that fell into the conveyor from a gravity feeder. Mention two vision algorithms that can be relevant to the robotic task. Explain briefly.