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

Final Exam (Machine Vision)

Version Z

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: An image of 3 x 3 pixels has 4 grey levels {0, 1, 2, 3}. It is known that the binary image has a long vertical edge. The greyscale image histogram is given by the following table:

# pixels	0	4	0	5
Grey level	0	1	2	3

1.1 (5 points): Create the original image (there can be many correct solutions) and explain briefly.

3	3	3
3	1	3
1	1	1

5#3 grey level pixels and 4#1 grey level pixels

1.2 (5 points): Create the binary image and explain briefly how you obtained it.

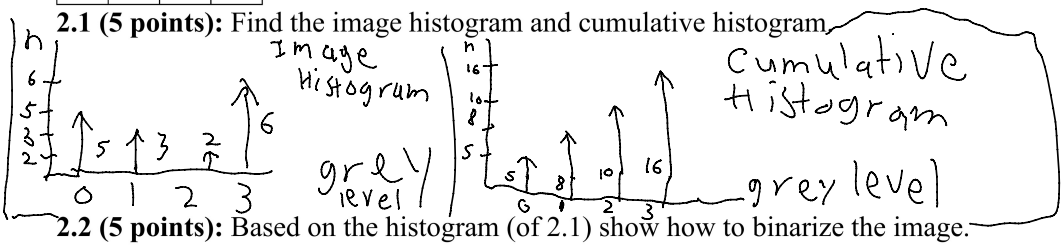
1	1	1
1	0	1
0	0	0

There are two numbers so I decided the higher number is 1 in the binary image, and 1 is 0 since it's the lower number in the binary image

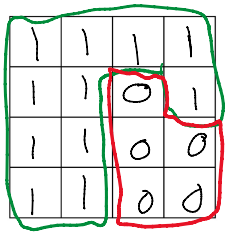
Problem 2: A 4 x 4 pixels image that has 4 greyscale levels is given below:

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

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



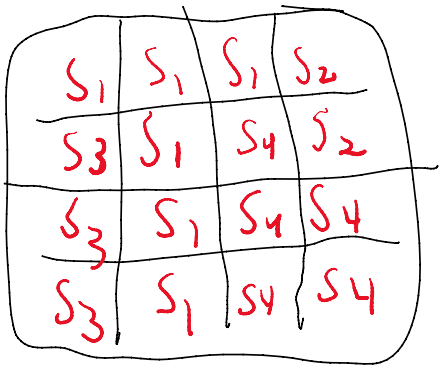
2.2 (5 points): Based on the histogram (of 2.1) show how to binarize the image.

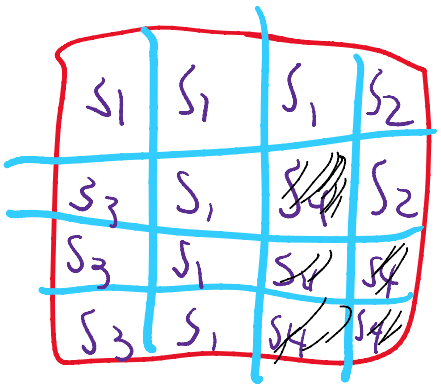


1, 2, 3 are 1

0 is 0 of course

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





3 white regions

1 Black Regions

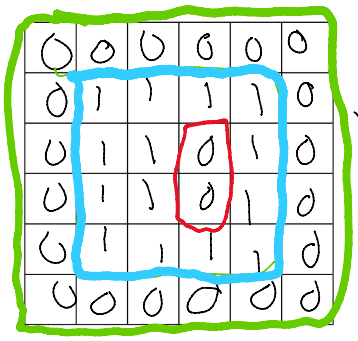
Problem 3: (True/False 1-point, brief explanation 1-point)

As the distance of an object from the camera increases the auto-focusing mechanism of the camera must move the image plain closer to the lens. (True) False

Yes if the distance increases, the auto-focusing mechanism must move closer to the camera can still see the object clearly

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 a parent of the white Region 2, and Region 2 is a parent of the 2-pixels Region 3. Explain briefly.



Black Region 1 surrounds white Region 2, and white region 2 surrounds region 3 black

4.2 (5 points): Pick up Region 2 of (4.1) and calculate its centroid.

$v = (1.1 + 1.2 + 1.3 + 1.4) + (1.1 + 1.2 + 1.4) + (1.1 + 1.2 + 1.4) + (1.1 + 1.2 + 1.3 + 1.4) = 34$ $v = (\frac{17}{18}, \frac{35}{36}) \Rightarrow (0.94, 0.97)$ is centroid

$u = (1.1 + 1.2 + 1.3 + 1.4) + (1.1 + 1.2 + 1.3 + 1.4) + (1.1 + 1.4) + (1.1 + 1.2 + 1.3 + 1.4) = 35$

Problem 5 (5 points): For the 4 x 4 image (below) that has 8 greyscale levels, suggest a monadic operation that causes the output image to have only 4 greyscale levels.

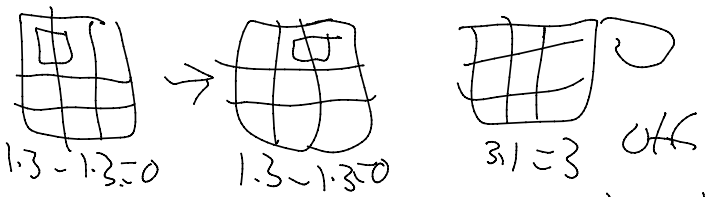
6	6	1	0
6	6	1	0
1	7	3	3
2	4	3	3

The monadic operation is subtract 4 from each pixel saturate at 0

2	2	0	0
2	2	0	0
0	2	0	0
1	0	0	0

Problem 6 (5 points): Convolve the 2-vector kernel [1 1]' with the 3 x 3 pixels image that has 4 greyscale levels. Be sure to suggest a normalizing factor. Explain the physical meaning of the resulting image. See problem 4 for a definition of the u and v axes.

3	3	3
1	1	3
0	1	0



→ u

0	0	0
1	-2	0
-1	1	0

↓ v

[1 1] is a u axis derivative it grades for vertical edges

Problem 7 (5 points): A corner detecting algorithm is applied to the 4 x 4 binary image below. Can the algorithms detect any corners? If so, how many? Explain briefly.

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

Yes 3 since theres 3 [1 1] images that have a corner

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

An image gradient may be computed by a convolution of the image with a derivative of Gaussian kernel. (True) False

Gradient images I_u and I_v are calculated with the derivative of Gaussian kernel method with a smoothing parameter σ.

Problem 9: Consider the 5 x 5 binary image and the 1x3 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

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

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

similar to row since there's full containment of part image [1,1,1] besides [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	1
0	0	0	0	1
0	0	0	0	0
0	0	0	0	0

It's opening sequence since more is opened

Problem 10 (5 points): A vehicle performs autonomous driving on one of the Florida Turnpike circular ramps. Mention two vision algorithms (discussed in class) that can be relevant to the task, and explain briefly.

Lane tracking is used to keep car on highway safely and distance sensing with pose estimation