Sri Lanka Institute of Information Technology

B.Sc. Honours Degree in Information Technology

Supplementary Examination
Year 4, Semester 1 (2022)

IT 4130 – Image Understanding and Processing

Duration: 3 Hours

August 2022

Instructions to Candidates:

- This paper has 5 questions.
- Answer all questions in the booklet given.
- The total mark for the paper is 100 marks.
- This paper contains 09 pages, including the cover page and worksheet.
- Electronic calculators are allowed.

Question 1 (24 marks)

a) Suppose you are required to find the boundaries of the original in the image (A). In the image (B), edges are detected, and a few edges are lost. Distinguish the fundamental transformation(s) that could be applied to the original image to find the edges and preserve the edge information. (6 marks)

Image (A)

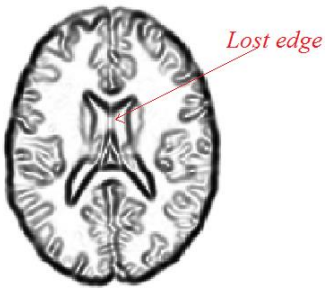


Image (B)

b) Assess THREE essential factors in image processing that can be effectively evaluated if you were to create a visual inspection software for automotive manufacturing. First, you should select techniques that are good for defect detection. (6 marks)

c) Assume that you are testing various noise filtering operators. The following figure demonstrates an application of a noise filter. Evaluate possible reasons for not having noise removed as in Output Image (B). (6 marks)

Input Image (A)

Output Image (B)

d) Digital images are prone to various types of noise. This is because pixel values do not reflect the accurate intensities of the actual scene in the image acquisition process. However, there are several ways that noise can be removed. One of the approaches is noise reduction using averaging. Analyze conditions you think must be met in practice to remove noise by averaging without blurring? (6 marks)

Question 2 (18 marks)

a) Figure (A) represents the values denoted in the input image. Compare different types of transformation(s) that can be used to generate the output image in Figure (B).

(4 marks)

1	2	3	4	1	1	2	1
2	2	3	0	1	2	2	1
3	0	38	39	37	36	3	0
4	1	40	44	41	42	2	1
1	2	43	44	40	39	3	1
2	0	39	41	42	40	2	0
0	2	0	2	2	3	1	1
0	2	1	3	1	0	4	2

Figure (A)

0	0	0	0	0	0	0	0
0	1	-31	-47	-36	-32	0	0
0	-44	70	37	31	60	-28	0
0	-42	34	12	1	50	-41	0
0	-37	47	8	-6	31	-32	0
0	-45	72	37	45	74	-36	0
0	6	-44	-38	-40	-31	-6	0
0	0	0	0	0	0	0	0

Figure (B)

b) " *Power law transform overcomes the limitation of log transform*." Assess whether the statement is correct or not in terms of power law transformation. Justify your answer.

(4 marks)

c) The histograms and images are given below. First, determine the quality of the figure image (**A**), (**B**), and (**C**) and suggest the most suitable techniques if the quality of the images is poor. When determining the techniques, you can decide which could be used to enhance the visual appearance of the images. (4 marks)

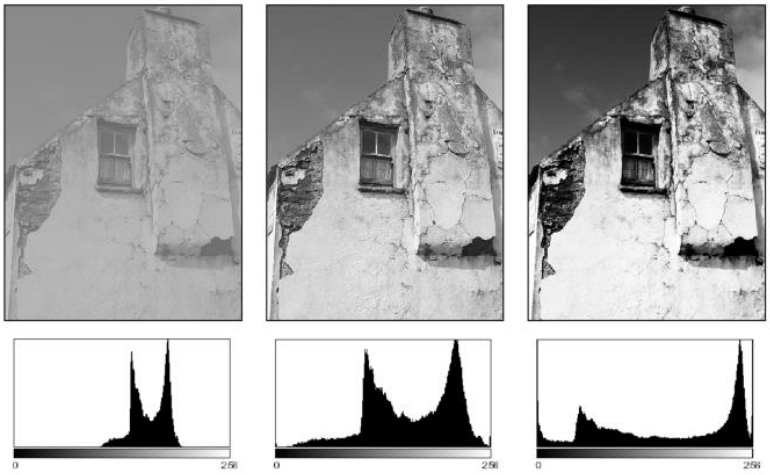


Figure (A) **Figure (B)** **Figure (C)**

d) A 3-bit grayscale image of size 5x5 is given below. Perform histogram equalization to the given image. Round the resulting intensities to the nearest integer. Discuss the effect of histogram equalization by comparing the two histograms. (6 marks)

3	4	2	0	0
1	1	4	0	0
0	2	4	1	1
0	0	1	4	2
0	0	1	2	5

Question 3 (20 Marks)

a) You were asked to compare edge detection operators to maintain the quality of the image. Considering the S*obel filter* and *Laplacian filter*, decide which filter is best to preserve the quality of the image. The below figure represents output images generated using Sobel filter (A) and Laplacian filter (B). (3 marks)

Sobel Filter Output (A)

Laplacian Filter Output (B)

b) Consider the following 3-bit 2D image and the intensity profile along the horizontal scan line of the image given in figure (**A**). Plot the *first derivative response* along the horizontal scan line. (4 marks)

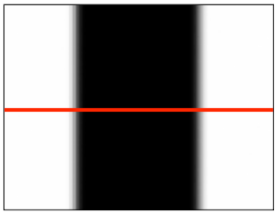


Figure (A)

c) The following figure (**A**) shows a weighted average filter, one of the simplest noise removable filters. Briefly explain why a weighted average filter works well than a box filter to remove small artifacts with less blurring. (5 marks)

$$\frac{1}{16} \times \begin{bmatrix} 1 & 2 & 1 \\ 2 & 4 & 2 \\ 1 & 2 & 1 \end{bmatrix}$$

Figure (A)

d) The following figure (A) below enlist a sequence of steps required to make the image look better and obtain like figure (B). Interpret the operations required and justify whether the order of operations is essential or not?

(4 marks)

Figure (A)

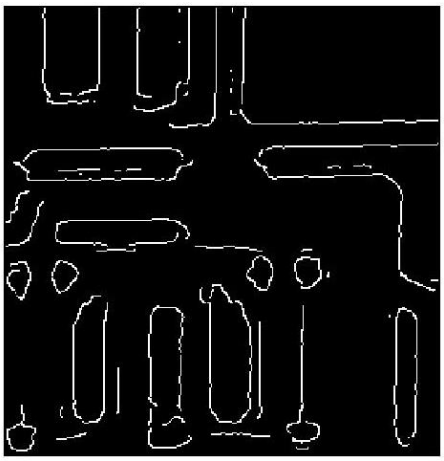


Figure (B)

e) Intensity metrics of a small part of an 8-bit grayscale image (P) are given below. The input image is filtered by a 3x3 Sobel filter in the X direction. The output values are recorded in the image (Q). What is the pixels A, B, and C values in the output image (Q)? Show your calculations as well. You may need to choose the correct filter based on figure (R). (4 marks)

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

Input Image (P)

	A			
		B	C	

Output Image (Q)

-1	0	1
-2	0	2
-1	0	1

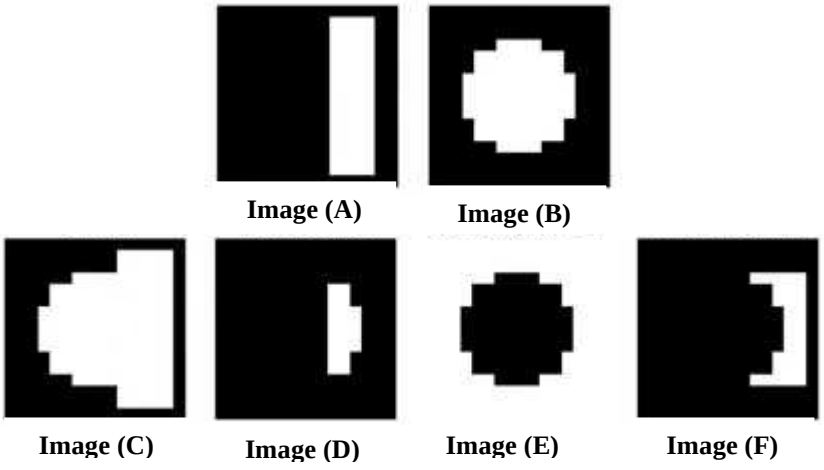
-1	-2	-1
0	0	0
1	2	1

Filters (R)

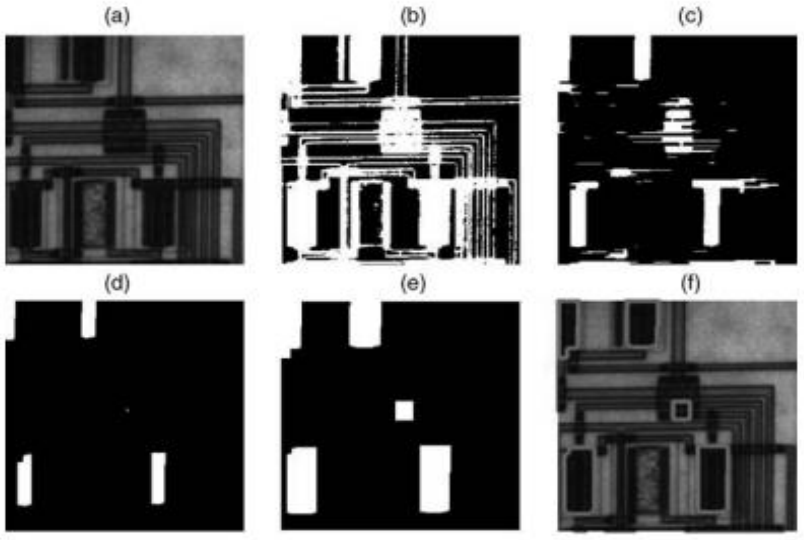
Question 4 (26 Marks)

a) "A structuring element is a matrix consisting of only 0's and 1's that can have any arbitrary shape and size. *Structuring elements are typically much smaller than the image being processed*". Do you agree with this statement? Justify your answer with an example of your own. (5 marks)

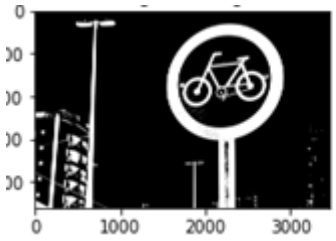
b) The following figure shows the results (C, D, E, and F) of applying different set operation(s) to the original images (**A**) and (**B**). Critique the technique(s) used to obtain the output set. (2 marks)



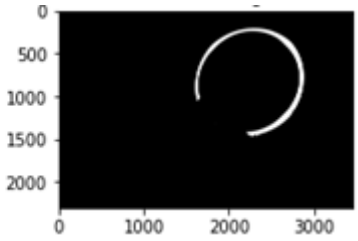
c) The following figure demonstrates different operations applied to the input image (a). Briefly explain the technique(s) used to obtain the output image (b), (c), (d), (e), and (f) from an input image (a). (4 marks)



d) Briefly explain the terminologies used in below figure to generate the output image (B) with respect to background and foreground pixels. (4 marks)



Input Image (A)



Output Image (B)

e) "Mathematical morphological operations are commonly used as a tool in image processing for extracting image components that are useful in the representation and description of region shape. *However, it can be used to remove noise and enhance the appearance of binary images*". Do you agree with this statement? Justify your answer. (4 marks)

f) Apply the Threshold operator to the following figure (A) using threshold value 22. After that, find the results of *the hit or miss* operation performed on the intermediate output image, using the structuring elements shown in Figure (B). Note that the origin is in the center of the structuring element. **Finally, show your answers (intermediate output and the hit or miss output) in the worksheet.** (7 marks)

0	0	0	0	2	5	9	14	20	0	0	0	0	0	0	0
0	0	0	2	5	9	14	20	0	0	0	0	0	0	0	0
0	0	1	4	8	13	19	0	0	0	0	0	0	34	0	0
0	0	3	7	12	18	0	0	0	0	0	31	31	31	0	0
0	2	6	11	17	0	0	0	0	0	29	28	28	29	0	0
1	4	9	15	21	0	0	0	0	0	28	26	26	27	0	0
3	7	13	19	0	0	0	0	0	0	0	26	27	0	0	0
6	11	17	0	0	0	0	0	0	0	30	0	29	31	0	0
11	16	20	0	0	0	0	0	0	0	34	0	0	35	0	0
15	19	0	0	0	0	0	0	0	38	0	0	0	0	0	0
21	0	0	0	0	31	0	0	0	0	0	0	0	0	0	0
0	0	0	0	26	29	28	0	0	0	0	0	0	0	0	0
0	0	0	27	29	29	29	29	0	0	0	0	0	0	0	0
0	0	0	0	29	29	29	30	0	0	0	0	0	0	0	0
0	0	0	0	30	30	30	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fig. (A)

0	1	0
	1	1

	1	
1	1	0
	0	0

	0	1
0	1	1
	0	

		0
0	1	1
	0	1

Fig. (B)

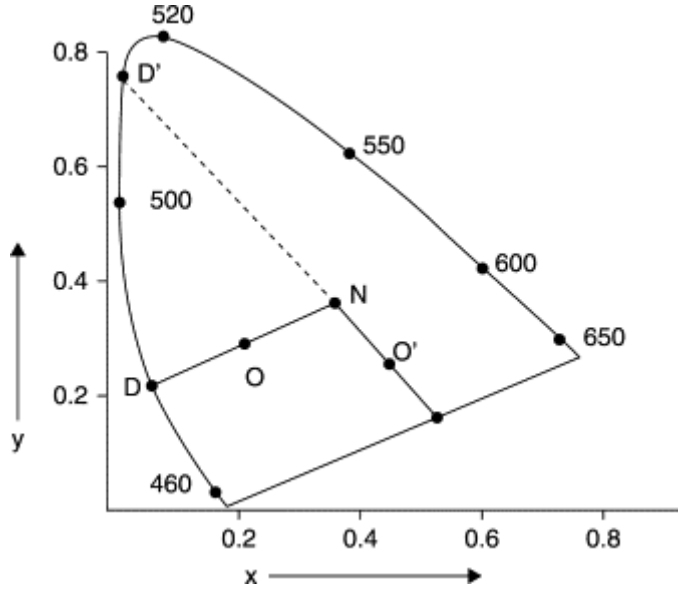
Question 5 (12 Marks)

a) "*It is impossible to produce all colors purely by combining specific wavelengths*." Do you agree with this statement? Justify your answer. (4 marks)

b) Briefly explain ONE example of the *additive nature of the color of light* and ONE *subtractive nature of color pigments.*

(2 marks)

c) The following chromaticity diagram shows all visible colors to human vision. Briefly explain what a line can generate by joining the point of equal energy to any point on the boundary. (2 marks)



d) Briefly explain where zero saturation is located by referring to the above figure.

(2 marks)

e) Briefly explain the importance of points 520, 460, and 650 by referring to the diagram above. (2 marks)

……. End of the Paper…….