Sri Lanka Institute of Information Technology

B.Sc. Honours Degree in Information Technology

Final Examination
Year 4, Semester 1 (2023)

IT 4130 – Image Understanding and Processing

Duration: 3 Hours

June 2023

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 10 pages, including the cover page and worksheet.
- ◆ Scientific Calculators allowed.

Question 1   (25 marks)

a) The following figure demonstrates an application of edge detection. Briefly explain possible reasons for losing few edges in the Output Image (**B**). Justify your answer.

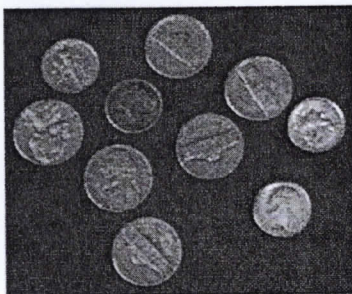<div align="right">(6 marks)</div>
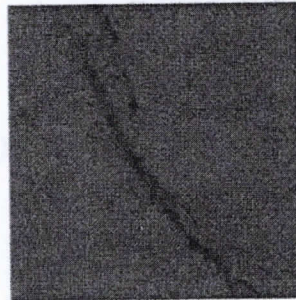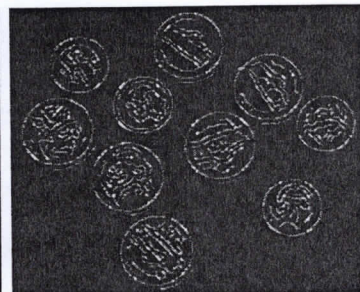

Input Image (A)   Output Image (B)

b) Machine vision helps to solve complex industrial tasks reliably and consistently. Assess THREE essential factors in image processing that can be effectively evaluated during the automatic inspection of industry applications. Justify the answer with an example.

<div align="right">(6 marks)</div>

c) The following figure demonstrates an application of finding edges. Edge provides several derivative estimators, each of which implements one of these definitions. For some of these estimators, you can specify whether the operation should be sensitive to horizontal edges, vertical edges, or both. Briefly explain the technique(s) used to obtain the output image (**B**) and Output image (**C**) from an input image (**A**). Based on the techniques(s) justify whether they should be sensitive to any specific direction of edges.

<div align="right">(6 marks)</div>
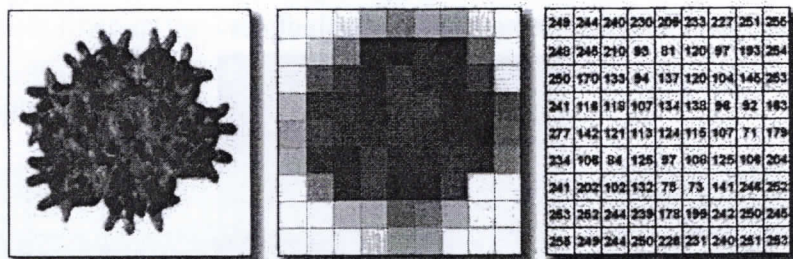

Input Image (A)   Output Image (B)   Output Image (C)

d) The following figure demonstrates the basic properties of a digital image. Briefly explain the technique(s) used to obtain the output image (**B**) and Output image (**C**) from an input image (**A**). (2 marks)

Input Image (A)   Output Image (B)   Output Image (C)

e) The following figure (**A**) shown below enlists a sequence of steps required to make the image look better as shown in figure (**B**). Interpret the operations required and justify the importance of the operations. (3 marks)
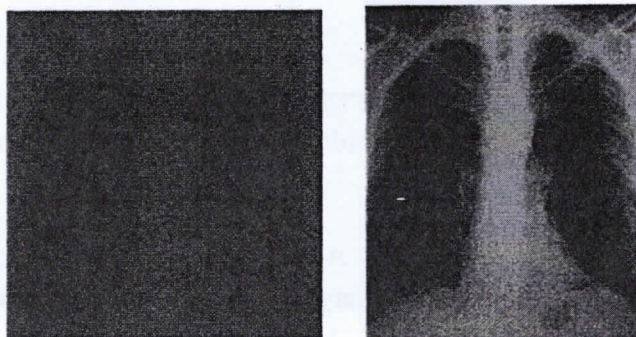

Figure (A)   Figure (B)

f) The histograms of input image Figure (**A**) and a processed image Figure (**B**) are given below. Suggest suitable technique(s) which could be used to satisfy the visual appearance given in figure (**B**). (2 marks)
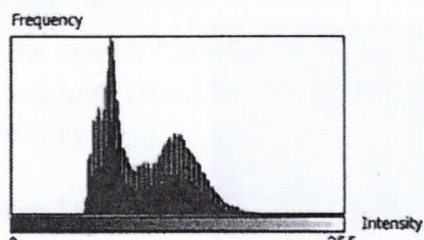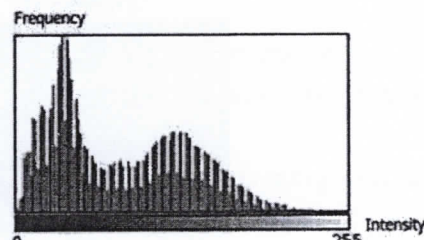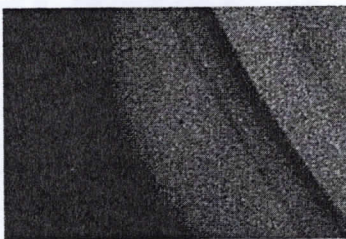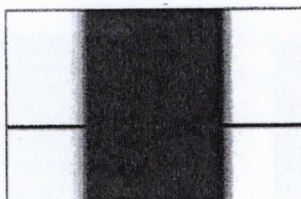

Figure (A)   Figure (B)

3

Question 2 (20 marks)

a) The following Figure (**A**) consists of a very high noise component. Justify how to remove the noise component by comparing different techniques. (6 marks)

Figure (A)

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 second derivative response along the horizontal scan line shown above. Explain why ·zero crossing· is useful in detecting edges. (5 marks)

Figure (A)

c) Figure **A** represents the noisy pixel values. Asses which type of noise is presented. Compare different type of transformation(s) that can be used to denoise from the image. (2 marks)

|	172	165	167	165	170	
Noisy Pixel	170	0	166	172	171	
	171	175	255	173	169	Noisy Pixel
	177	165	164	165	168	
	173	174	171	168	166	

Figure (A)

d) "*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)

e) Perform histogram equalization to the 3-bit image given below. (3 marks)

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

4

Question 3 (20 Marks)

a) You were asked to construct an edge detector using a *Sobel filter* and *Laplacian filter*. Decide which filter is the best for preserving image data of input image (**A**) without affecting noise. The below figure represents output images generated using Sobel filter (**B**) and Laplacian filter (**C**). Justify your answer. (4 marks)
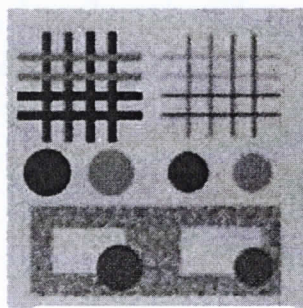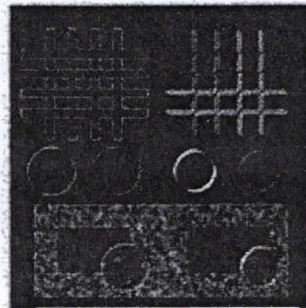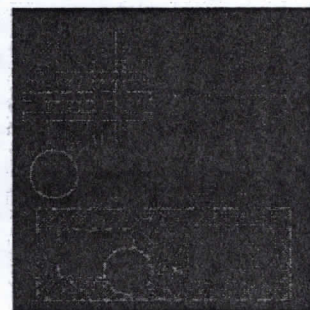
| Input Image (A) | Output Image (B) | Output Image (C) |

b) 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)

$\frac{1}{16} \times$

1	2	1
2	4	2
1	2	1

Figure (A)

c) The following Image (**A**) shown below enlist a sequence of steps required to make the image look better as shown in Image (**B**). Interpret the operations required and justify whether the order of operations is important or not? (5 marks)

Image (A)   Image (B)

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d) Intensity metrics of a small part of an 8-bit gray scale image (**P**) is given below. The input image is filtered by a 3x3 **Prewitt filter in X direction,** and the output values are recorded in output image (**Q**). What are the values of the pixels **A, B, and C** in the output image (**Q**)? Show your calculations as well. You may need to pick the correct filter based on the given figure (**R**). (6 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
-1	0	1
-1	0	1

-1	-1	-1
0	0	0
1	1	1

Filters (R)

6

Question 4 (25 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. (6 marks)

b) The following figure shows the result (**B**) of applying morphological operation(s) to the input image (**A**). Critique the technique(s) used to obtain the output (**B**). (2 marks)

| Input Image (A) | Output Image (B) |

c) The following figure shows the results (**C, D and E**) of applying different set operation(s) to the original images (**A**) and (**B**). Critique the technique(s) used to obtain the output set. (3 marks)
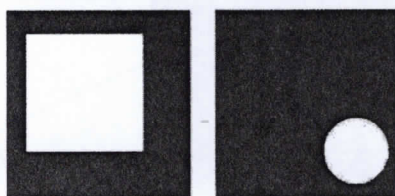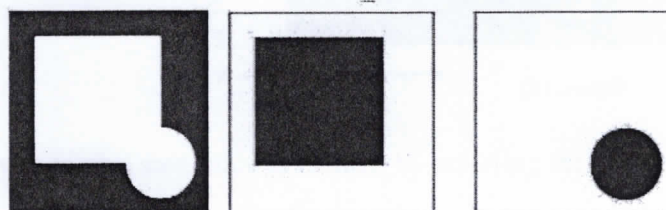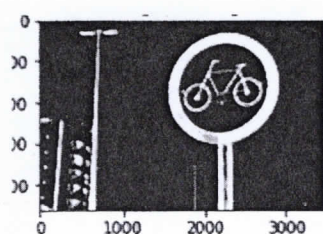

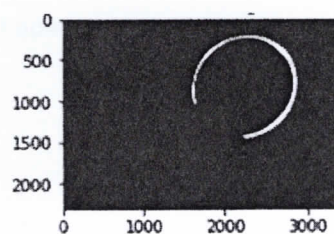Image (A)   Image (B)

Image (C)   Image (D)   Image (E)

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)

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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) Threshold the following figure (A) using threshold value 22. After that, find the results of *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. **Show your answers (intermediate output and the hit or miss output) in the given worksheet.**
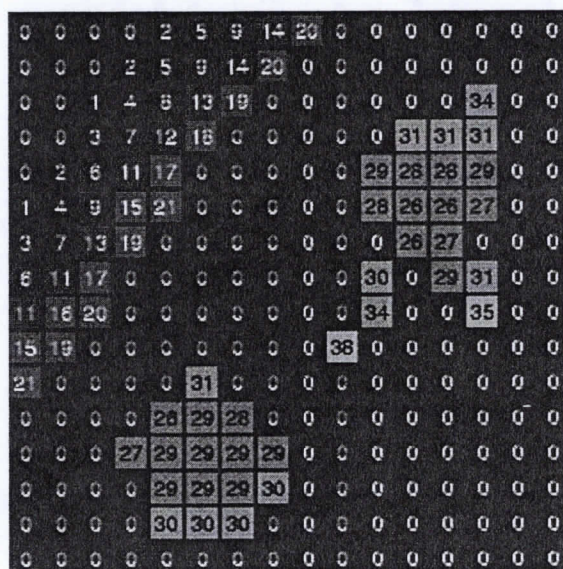
(6 marks)

Figure. (A)

Figure. (B)

8

Question 5   (10 Marks)

a) *"It is not possible 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 *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 can be generated by a line joining the point of equal energy to any point on the boundary.   (1 marks)
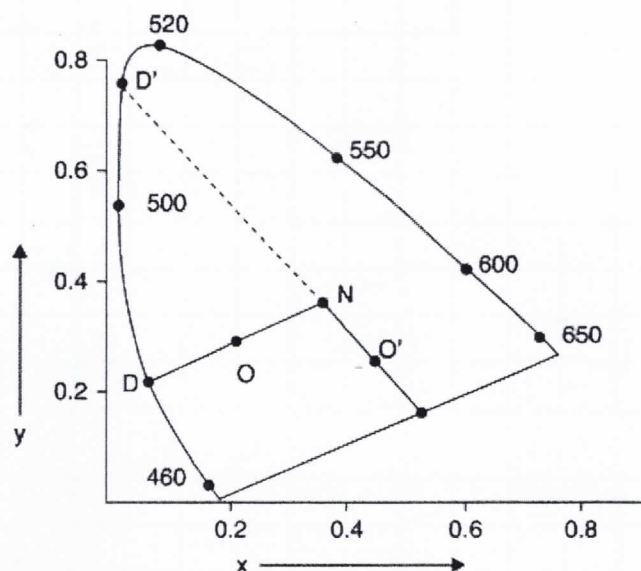
d) Briefly explain where zero saturation is located by referring the above figure.

                                                                                (1 marks)

e) According to the figure above briefly explains the importance of points 520, 460 and 650.

                                                                                (2 marks)

.... End of the Paper...................