# UNIVERSITY OF RUHUNA

## Faculty of Engineering

End-Semester 7 Examination in Engineering: May 2023

**Module Number: EE7204** **Module Name: Computer Vision and Image Processing**

**[Three Hours]**

[Answer **all questions**, each question carries **10 marks**]

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Q1 a) The bulbar conjunctival blood vessels, which are on top of the sclera of the eye, may be associated with diabetes retinal conditions. Figure Q1 (a) shows an image processing pipeline proposed by an engineer to extract sclera from an eye photograph. Answer the following questions based on Figure Q1 (a).

(i). Briefly describe image processing methods used in steps 1, 2, 3, and 4 of the image processing pipeline.

(ii). Propose an image processing method to extract blood vessels from the output of the proposed pipeline.

[5.0 Marks]

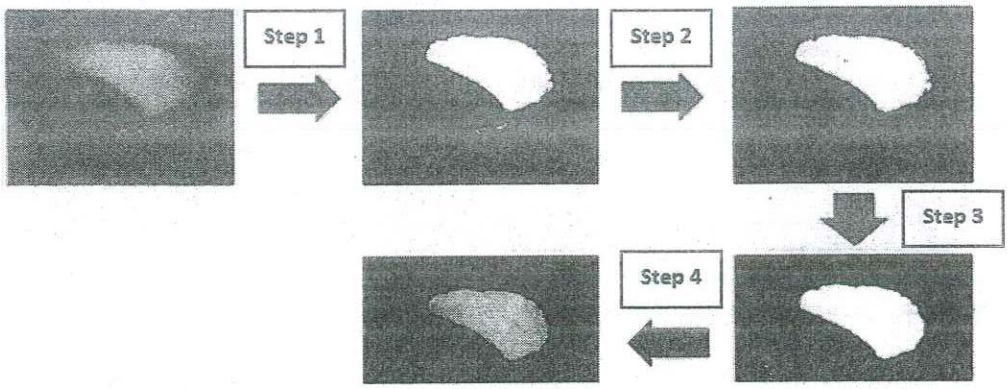



Figure Q1 (a)

b) (i). Consider the pixel p, which is at (2,4), as shown in Figure Q1 (b). Find the coordinates of $N_4(p)$ and $N_D(p)$. The size of the neighborhood is 3×3.

(ii). Consider the pixel q, which is at (6,1) as shown in Figure Q1 (b). Calculate the Euclidian distance and Chessboard distance between pixels p and q.

[4.0 Marks]

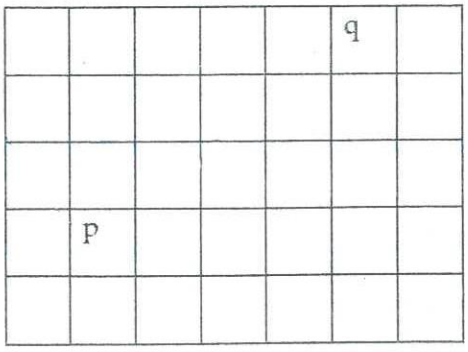
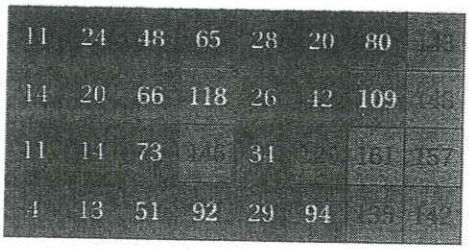


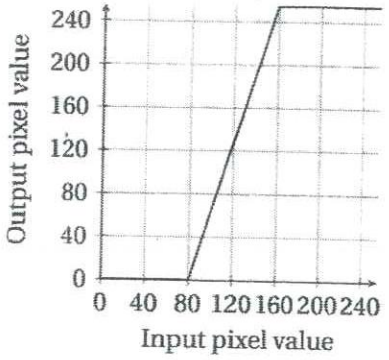

Figure Q1 (b)

c) Calculate the total number of colors in a 24-bit RGB model. [1.0 Mark]

Q2 a) Figure Q2 (a) shows an image and intensity transformation function. Show the resulting image after applying this intensity transformation [3.0 Marks]



(i) Image




(ii) Intensity transformation

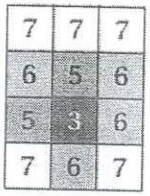
Figure Q2 (a)

b) Figure Q2 (b) shows three 3-bit images.

(i). Compute the histograms of the three images.

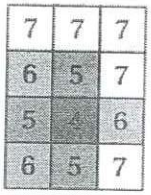
(ii). Identify the most similar pair of images using histograms.

[2.0 Marks]



(i)

(ii)



(iii)

Figure Q2 (b)

c) Equalize the histogram of the gray image shown in Figure Q2 (c). The gray levels given in the image are from 0 to 7. [2.5 Marks]

| | | | | |
|---|---|---|---|---|
| 5 | 5 | 5 | 5 | 5 |
| 4 | 5 | 6 | 5 | 4 |
| 4 | 6 | 6 | 6 | 4 |
| 4 | 5 | 6 | 5 | 4 |
| 5 | 5 | 5 | 5 | 5 |

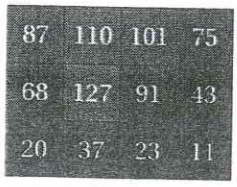
Figure Q2 (c)

d) Figure Q2 (d) shows a 3 × 4 image and a filter kernel.

(i). Filter the image using this kernel. Only consider the positions where the kernel fully overlaps with the image.

(ii). What is the purpose of this kernel?

[2.5 Marks]



(i) Image

| | | |
|---|---|---|
| 0.0751 | 0.1238 | 0.0751 |
| 0.1238 | 1.2042 | 0.1238 |
| 0.0751 | 0.1238 | 0.0751 |

(ii) A 3 × 3 kernel

Figure Q2 (d)

Q3 a) Figure Q3 (a) shows an image and its histogram.

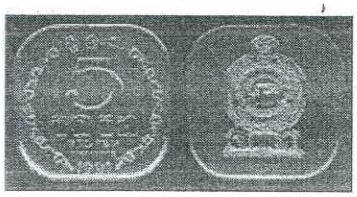
(i). Find a suitable global threshold to segment the image.

(ii). Sketch the expected segmentation.

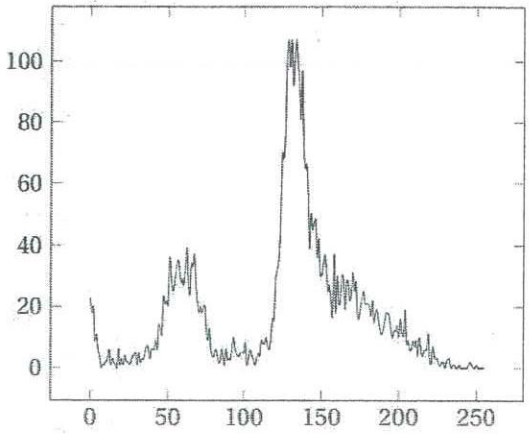
(iii). State an instance where the thresholding technique would fail.

(iv). Write a pseudo code to find the global threshold to segment small objects in an image.

[4.0 Marks]



(i) Image




(ii) Histogram

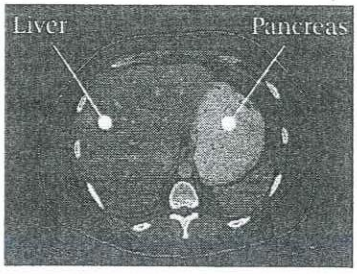
Figure Q3 (a)

b) Figure Q3 (b) shows an axial CT through the liver.

(i). Using (4,3) as the seed (pixel with intensity 227) and T = 15 as the threshold, carry out region growing. Use an 8-connected neighborhood. Use Figure Q3 (b) iii reproduced on page 5.

(ii). Use the result of Q3 b) (i) result to highlight a drawback in the region growing.

[4.0 Marks]



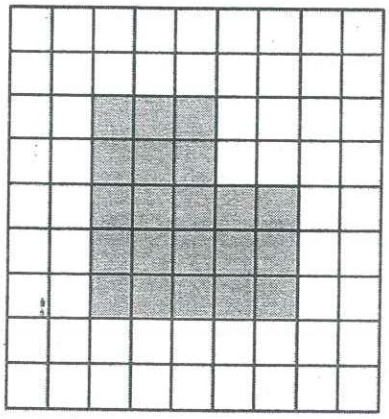

(i) Actual image

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 45 | 45 | 45 | 65 | 77 | 93 | 97 | 85 | 57 | 45 | 45 | 45 |
| 45 | 45 | 105 | 150 | 170 | 162 | 166 | 158 | 130 | 73 | 45 | 45 |
| 45 | 85 | 158 | 210 | 223 | 223 | 231 | 186 | 166 | 125 | 53 | 45 |
| 53 | 125 | 198 | 239 | 239 | 235 | 251 | 255 | 182 | 146 | 85 | 45 |
| 73 | 142 | 202 | 227 | 235 | 219 | 247 | 255 | 202 | 154 | 113 | 45 |
| 65 | 134 | 182 | 219 | 215 | 215 | 243 | 247 | 206 | 150 | 105 | 45 |
| 53 | 125 | 158 | 194 | 190 | 231 | 194 | 206 | 178 | 138 | 77 | 45 |
| 45 | 85 | 121 | 142 | 174 | 186 | 178 | 170 | 138 | 117 | 65 | 45 |
| 45 | 57 | 93 | 101 | 105 | 117 | 113 | 93 | 105 | 73 | 53 | 45 |

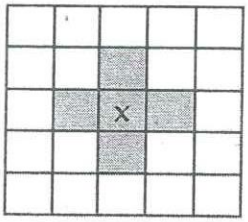
(ii) Low-resolution grid for segmentation

Figure Q3 (b)

c) Apply the morphological closing operation on the image shown in Figure Q3 (c) i. using the structuring element shown in Figure Q3 (c) ii. [2.0 Marks]



i. Binary Image




ii. Structuring element

Figure Q3 (c)

Q4 a) (i). What is computer vision?

(ii). List four (04) primary applications of computer vision.

(iii). Discuss how computer vision is significantly impacted by deep learning using three examples.

[6.0 Marks]

b) (i). Briefly describe four (04) challenges of object recognition.

(ii). List four (04) applications of face recognition.

[4.0 Marks]

Q5 a) (i). What is an interest point in relation to image processing?

(ii). How does the Scale-Invariant Feature Transform (SIFT) algorithm detect an interest point in an image?

(iii). What are the key steps involved in generating SIFT descriptors for image interest points?

(iv). How does SIFT handle scale and rotation invariance during feature detection and descriptor generation?

(v). What are the advantages and limitations of using SIFT for image feature detection and description compared to other algorithms?

[5.0 Marks]

b) (i). List two (02) applications of stereo vision.

(ii). Using an appropriate diagram, explain how cameras perform depth estimation in stereo vision.

(iii). Calculate the Sum of Squared Difference (SSD) window cost between the given two shaded windows of two images in images in Figure Q5 (b).

[5.0 Marks]

| | | | |
|---|---|---|---|
| 46 | 46 | 46 | 46 |
| 46 | 46 | 44 | 44 |
| 57 | 47 | 47 | 57 |
| 56 | 56 | 46 | 46 |

| | | | |
|---|---|---|---|
| 46 | 46 | 46 | 46 |
| 48 | 46 | 44 | 42 |
| 47 | 47 | 47 | 47 |
| 58 | 46 | 46 | 58 |

Figure Q5 (b)

To be attached to the answer script.

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 45 | 45 | 45 | 65 | 77 | 93 | 97 | 85 | 57 | 45 | 45 | 45 |
| 45 | 45 | 105 | 150 | 170 | 162 | 166 | 158 | 130 | 73 | 45 | 45 |
| 45 | 85 | 158 | 210 | 223 | 223 | 231 | 186 | 166 | 125 | 53 | 45 |
| 53 | 125 | 198 | 239 | 239 | 235 | 251 | 255 | 182 | 146 | 85 | 45 |
| 73 | 142 | 202 | 227 | 235 | 219 | 247 | 255 | 202 | 154 | 113 | 45 |
| 65 | 134 | 182 | 219 | 215 | 215 | 243 | 247 | 206 | 150 | 105 | 45 |
| 53 | 125 | 158 | 194 | 190 | 231 | 194 | 206 | 178 | 138 | 77 | 45 |
| 45 | 85 | 121 | 142 | 174 | 186 | 178 | 170 | 138 | 117 | 65 | 45 |
| 45 | 57 | 93 | 101 | 105 | 117 | 113 | 93 | 105 | 73 | 53 | 45 |

Figure Q3 (b) iii