Sample 2

NATIONAL UNIVERSITY OF SINGAPORE

EE3206/EE3206E - INTRODUCTION TO COMPUTER VISION AND IMAGE PROCESSING

INSTRUCTIONS TO CANDIDATES :

1. This paper contains **FOUR (4)** questions and comprises **FIVE (5)** pages.
2. Answer all questions.
3. All questions carry equal marks.
4. This is a CLOSED BOOK examination.
5. This question paper is NOT to be taken out of the examination hall.

Question 1

(a) The discrete Fourier transform (DFT) of

$$f_1(x,y) = \begin{bmatrix} 1 & 1 & 1 & 1 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix} \quad \text{is} \quad F_1(u,v) = \frac{1}{4}\begin{bmatrix} 1 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 \end{bmatrix}$$

Obtain the DFT of

$$f_2(x,y) = \begin{bmatrix} 5 & 5 & 5 & 5 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix}, \; f_3(x,y) = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 \end{bmatrix} \text{ and } f_4(x,y) = \begin{bmatrix} 1 & 1 & 1 & 1 \\ 1 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 \end{bmatrix}$$

(9 marks)

(b) Compare the use of a Butterworth low-pass filter (LPF) and an ideal LPF to reduce noise in an image.
(4 marks)

(c) Discuss the suitability of using a Butterworth LPF to reduce noise in an image that has been contaminated by

(i) Gaussian noise

(ii) Salt-and-pepper noise

State clearly the reasons for your answer.

(8 marks)

(d) Apply 3×3 median filtering to the binary image in Figure 1 and show the result.
(4 marks)

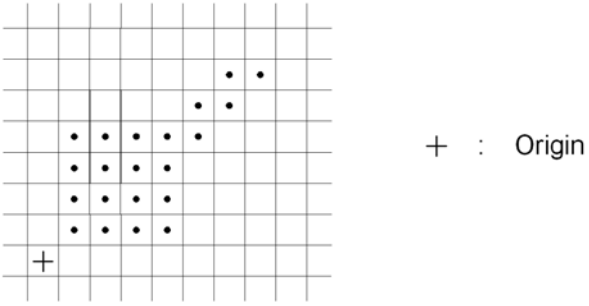

Figure 1

Question 2

Image I_1 is a 3-bit image with the gray level distribution given in the table below:

Gray level :	0	1	2	3	4	5	6	7
Number of pixels :	100	100	200	200	300	300	400	400

(a) The transformation function

$$s_k = 2r_k - 2$$

is applied to image I_1, where r_k and s_k denote the gray levels of the input and output images, respectively. Obtain the histogram of the output image.

(5 marks)

(b) Determine the transformation function that can be applied to image I_1 to obtain the histogram-equalized image I_2. Obtain and sketch the histogram of image I_2.

(9 marks)

(c) Obtain the Huffman code for the gray levels in image I_1. What is the coding efficiency?

(7 marks)

(d) With respect to this image, explain what is meant by coding the second extension of the source.

(4 marks)

Question 3

(a) Figure 2 shows part of an image. Use the Sobel operator to determine the gradient magnitude and direction at the shaded pixel in the centre of the sub-image.

(6 marks)

(b) Compare the Sobel and Roberts operators for the detection of edges.

(5 marks)

(c) Compare and contrast the suitability of edge-based methods and global thresholding for segmentation when scene illumination is significantly uneven.

(5 marks)

(d) Consider the image of Figure 3(a) and its histogram in Figure 3(b). Describe clearly the image processing steps that you would implement to obtain the area of each object.

(9 marks)

	10	10	10	10	10
	10	10	10	20	45
	10	10	35	50	50
	10	30	50	50	50
	10	45	50	50	50

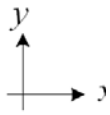

Figure 2

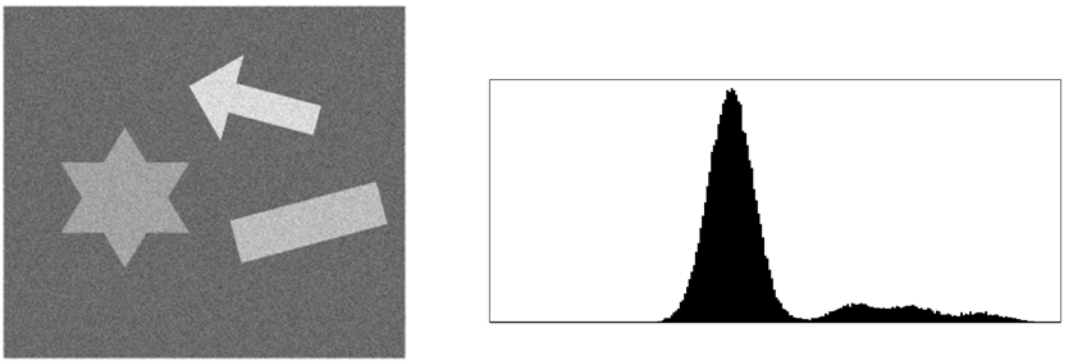

Figure 3

Question 4

(a) Compute the moments m_{00} m_{11}, m_{20} and m_{02} for the binary image shown in Figure 4.

(4 marks)

(b) The principal axis of an object is defined as the straight line passing through the object centroid such that the moment of inertia about the line is a minimum. The slope θ_A of the principal axis can be obtained by solving

$$\tan 2\theta_A = \frac{2\mu_{11}}{\mu_{20} - \mu_{02}}$$

where μ_{pq} is the central moment of order $p + q$.

(i) Calculate θ_A for the object in Figure 4.

(ii) Sketch the principal axis for each of the objects shown in Figure 5.

(15 marks)

(c) A definition of eccentricity is

$$\epsilon = \frac{\text{maximum radial distance}}{\text{minimum radial distance}}$$

Compute eccentricity for the object in Figure 4 and comment on the suitability of this feature for RST-invariant object recognition.

(6 marks)

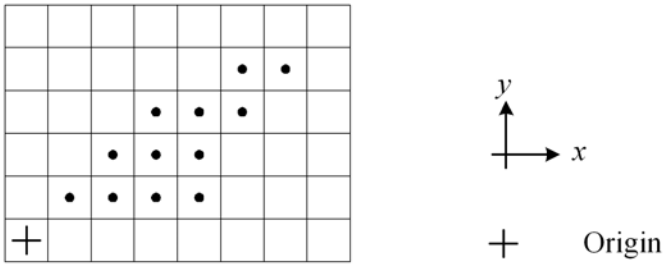

Figure 4

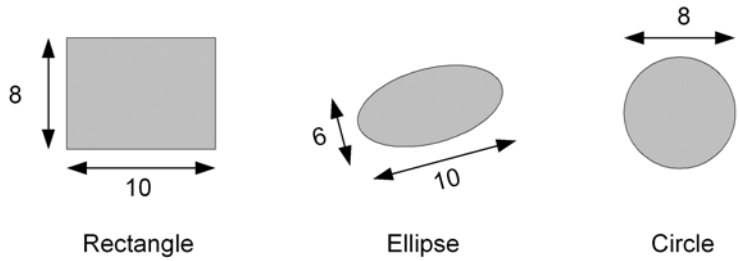

Figure 5

END OF PAPER