Sample B

EE4704 IMAGE PROCESSING AND ANALYSIS

Sample Paper [1] [2] [3] [4] [5]

[1] The paper is meant to give you some idea of the types of questions to expect in the final exam.
[2] Other types of problem questions are to be expected.
[3] The difficulty level may also be different.
[4] Some of the questions are extracted from past exam papers.
[5] Solutions are not available.

Question 1

(a) (i) The discrete Fourier transform (DFT) of

$$f_1(x, y) = [0 \quad 0 \quad 0 \quad 1]$$

is denoted by $F_1(u)$. Calculate $|F_1(u)|$.

(ii) Obtain the DFT of

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

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

(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.

(d) Apply 3×3 median filtering to the binary image in Figure 1 and show the result. How would the result be different if 5×5 median filtering is used? Comment on your answer.

(24 marks)

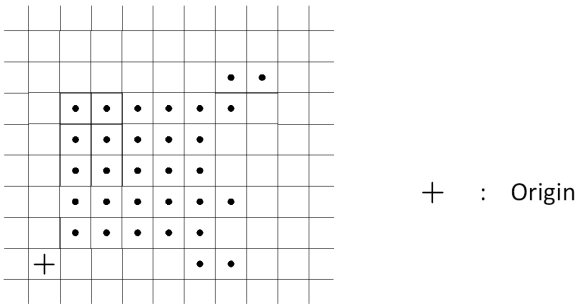


Figure Q1

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.

(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.

(c) It is desired to transform the image such that its histogram approximates the gray level distribution below. Obtain the transformation function.

Gray level :	0	1	2	3	4	5	6	7
Number of pixels :	0	0	0	0	500	500	500	500

(21 marks)

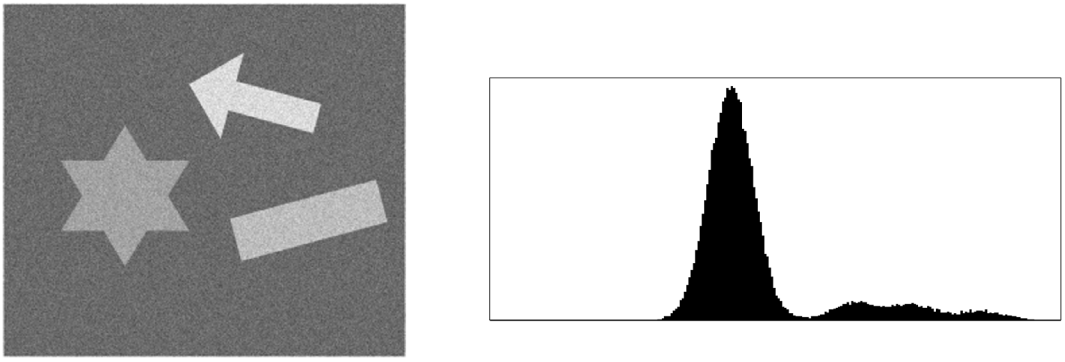
Question 3

(a) Explain how gradient operators may be used to obtain edges and their orientations in digital images.

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

(c) 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.

(16 marks)



(a) (b)

Figure Q3

Question 4

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

(b) A definition of eccentricity is

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

Calculate ϵ for the object in Figure 4(a).

(c) The *principal axis* of an object may be defined as the straight line passing through the object centroid with slope θ_A given by

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

where μ_{pq} is the central moment of order $p + q$. Calculate θ_A for the object in Figure 4 and sketch the principal axis.

(d) For the object of Figure Q4(b), calculate the length of the major axis. Sketch the major and minor axes and the bounding box.

(25 marks)

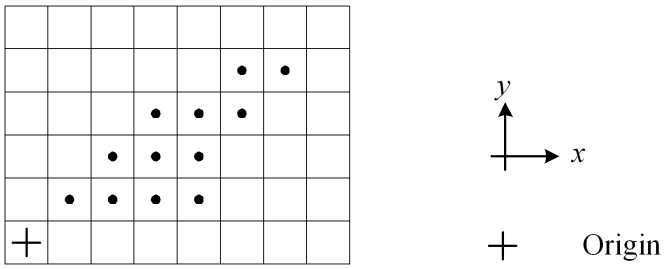


Figure Q4(a)

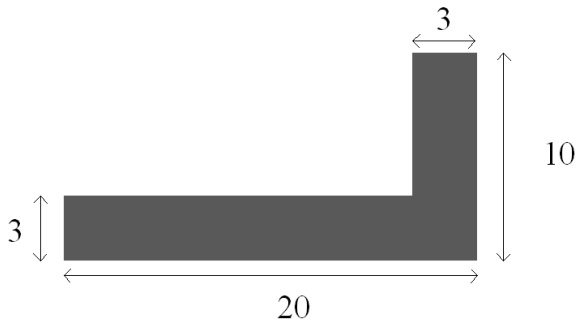


Figure Q4(b)

Question 5

Figure Q5 shows a set P and structuring element C.

(a) Obtain the dilation of P by C:

$$A = P \oplus C$$

(b) Obtain the opening of P by C:

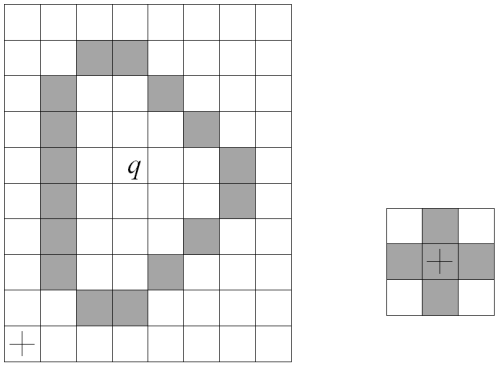
$$B = P \circ C$$

(c) Beginning with pixel q, a procedure to fill the region enclosed by P is:

$$X_k = (X_{k-1} \oplus C) \cap P^c, \quad k = 1, 2, 3, 4, ..$$

where $X_0 = q$ and C is the structuring element shown. Obtain the result after step $k = 2$.

(14 marks)



Set P (shaded pixels) C

Figure Q5