Sample A

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) Obtain $F_1(u, v)$, the Fourier transform of $f_1(x, y) = 10 + 6\text{rect}(2x, y/3)$.

(ii) Sketch the image function $f_2(x, y) = \text{rect}[(x - 4)/3, 2y - 6)]$ and obtain its Fourier tranform $F_2(u, v)$.

(b) A digital image $f(x, y)$ is of size 1000×1000. Denoting the DFT of $f(x, y)$ by $F(u, v)$, obtain the DFTs of the following functions in terms of $F(u, v)$:

(i) $f_1(x, y) = 2f(x, y)$

(ii) $f_2(x, y) = f(x + 100, y)$

(iii) $f_3(x, y) = f(x, y) + 100$

(18 marks)

Question 2

(a) State whether you would expect the following noise-removal methods to work well in reducing salt noise in images. Explain your answers.

(i) Median filter

(ii) Minimum mean-square error (MMSE) filter

(iii) Image averaging

(b) The following tranformation functions are applied to images with gray levels $r_k = 0, 1, \ldots, 255$. Sketch the transformation functions, and describe in general the effects of each one.

(i) $T_1(r_k) = 255 - r_k$

(ii) $T_2(r_k) = \begin{cases} 2r_k & 0 \leq r_k \leq 127 \\ 255 & 128 \leq r_k \leq 255 \end{cases}$

(iii) $T_3(r_k) = \begin{cases} 255 & 80 \leq r_k \leq 100 \\ r_k & \text{elsewhere} \end{cases}$

(iv) $T_4(r_k) = 255(r_k/255)^{0.5}$

(20 marks)

Question 3

(a) Explain why Huffman coding of an image will lead to fewer bits in representing the image.

(b) The histograms of two 3-bit images, I_1 and I_2 are given in the table below.

Gray level		0	1	2	3	4	5	6	7
Number of pixels	I_1	0	230	160	160	110	110	230	0
	I_2	0	20	400	500	80	0	0	0

(i) Calculate the entropy of I_1 and I_2 in bits.

(ii) Huffman coding is applied to I_1. Calculate the coding efficiency, η_1, average code word length, $\bar{L}_1$, and compression ratio, CR_1.

(iii) I_2 is coded using Huffman compression, resulting in compression ratio CR_2. Without doing any calculations, explain whether CR_2 is greater than, equal to, or less than CR_1.

(20 marks)

Question 4

(a) In the applications listed below, what image acquisition device (e.g., 2D CCD camera, scanner, etc) would you use to obtain a digital image of the object of interest? Explain your answer.

S/No.	Object of interest	Application
1	Lateral (side) X-ray of the skull	Analysis of tooth alignment
2	Painting	Virtual art gallery
3	Printed circuit board	Inspection for missing components
4	Machine part moving along a conveyor belt	Inspection for manufacturing defects

(b) Show the result of applying the Laplacian operator to the image of Figure 1. Explain the use of the Laplacian operator as an edge detector.

(c) Figure 2 shows an edge map where each "x" indicates an edge point. It is desired to use the Hough transform to detect the straight lines present in the 80×80 image.

(i) What is the Hough transform of the circled edge point in ab parameter space?

(ii) The accumulator array is set up as follows:

$$\begin{array}{ll} \text{Array size:} & 0 \le a \le 2, \quad 0 \le b \le 80 \\ \text{Cell size:} & \Delta a = 0.1, \quad \Delta b = 1 \end{array}$$

Assuming that the edge points come from two straight lines, estimate the locations of the accumulator cells with the two highest votes.

(22 marks)

0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	10	0	0	10	0	0
0	0	10	10	0	0	0	0
0	0	10	10	10	0	0	0
0	0	10	10	10	10	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0

Figure 1

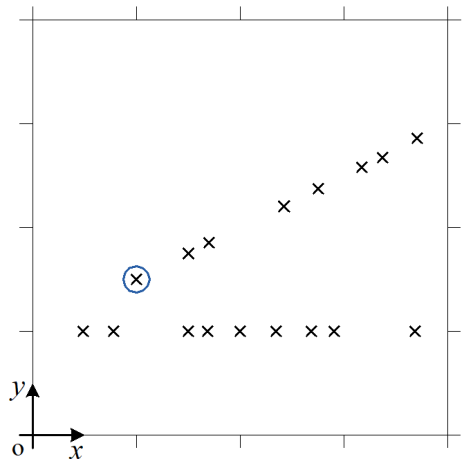

Figure 2

Question 5

(a) Sketch the distance-angle and slope-density functions for the elliptical contour shown in Figure 3.

(b) A 4-level image contains textures T1 and T2 (Figure 4).

(i) Can gray-level histogram statistics be used to classify the two textures? Explain your answer.

(ii) Local property statistics may be used to quantify texture. The forward difference in the y direction, represented by the mask

$$\begin{bmatrix} +1 \\ -1 \end{bmatrix}$$

is applied to texture T1. Sketch the histogram of the result.

(iii) Explain why the above local property is not suitable for differentiating between textures T1 and T2. Suggest a suitable local property and explain how the two textures may be classified. Your solution should include the definition of a suitable texture descriptor and the texture values obtained for each of the textures.

(20 marks)

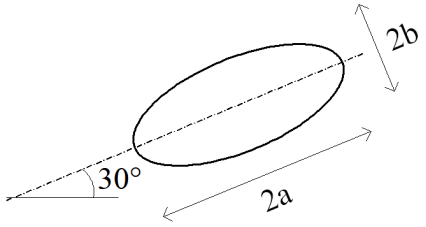

Figure 3

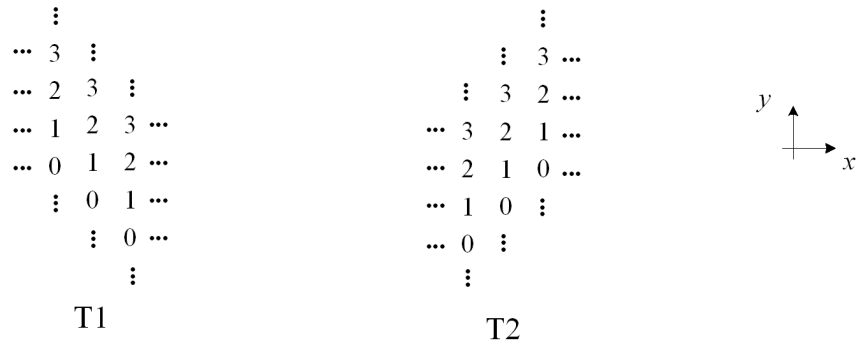

Figure 4