Sample 1

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. Start the answer to each question on a fresh page.
6. This question book is NOT to be taken out of the examination hall.

Question 1

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

(9 marks)

(b) 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

(9 marks)

(c) The following tranformation functions are applied to an image with gray levels $r = 0, 1, \ldots, 255$. Describe, in general, the effects of each of the transformations:

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

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

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

(7 marks)

Question 2

(a) The 5×5 11-level image below is to be enhanced using histogram equalisation. Obtain the transformation function that achieves this and show the histogram-equalised image.

(10 marks)

1	1	1	1	1
1	1	1	1	1
2	2	2	2	2
3	3	3	3	3
5	5	5	5	5

(b) The histograms of three 6-level images, I_1, I_2 and I_3, are given in the table below.

Gray level		0	1	2	3	4	5
Number of pixels	I_1	230	230	160	160	110	110
	I_2	175	165	170	150	180	160
	I_3	0	20	400	500	80	0

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

(ii) Without doing any computation, state which one of the three images has the most information content. Explain your answer.

(iii) Derive the Huffman code for I_1.

(iv) Briefly explain why run-length coding is unlikely to result in high compression ratios in images containing significant amounts of fine textural features.

(15 marks)

Question 3

(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?

(8 marks)

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. Compare the use of the Laplacian and Sobel operators as edge detectors.

(6 marks)

(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 representation of the circled edge point in θ-ρ parameter space?

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

$$\begin{array}{ll} \text{Array size:} & -90^\circ < \theta \leq 90^\circ, \quad -30 < \rho \leq 30 \\ \text{Cell size:} & \Delta\theta = 5^\circ, \quad \Delta\rho = 1 \end{array}$$

Assuming that the edge points come from two straight lines, estimate the locations of the accumulator cells with the two largest values.
(Hint: What are the equations of the lines?)

(11 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

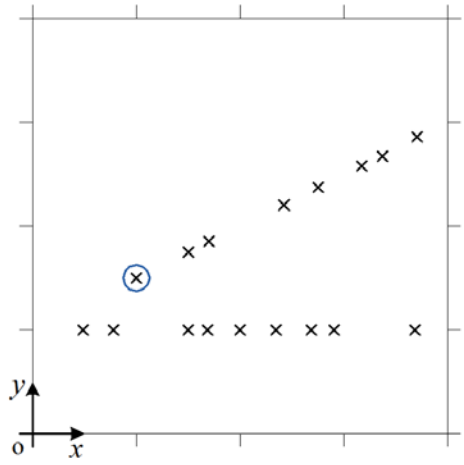

Figure 2

Question 4

(a) Sketch the distance-angle and slope-density functions for the elliptical contour shown in Figure 3. Are the signatures invariant to rotation, scaling and translation of the object?

(10 marks)

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

(i) Describe briefly a general procedure for image segmentation using textural properties/features. Your answer should cover the salient points.

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

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

$$[\,-1 \quad 1\,],$$

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

(iv) 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.

(15 marks)

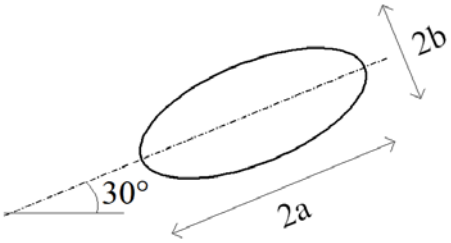

Figure 3

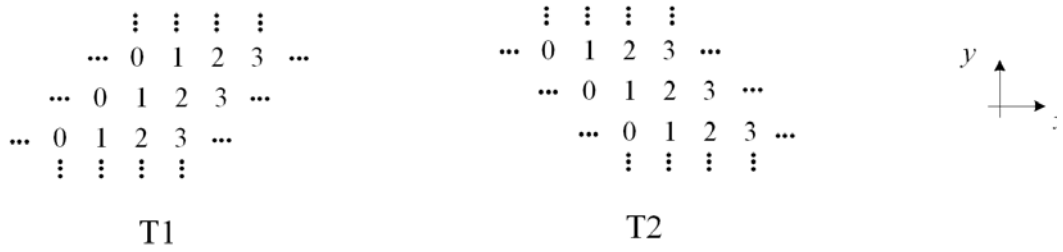

Figure 4

END OF PAPER