INTRODUCTION TO IMAGE PROCESSING
(AML3141)

Time Allotted : 2½ hrs **Full Marks : 60**

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and any 4 (four) from Group B to E, taking one from each group.

Candidates are required to give answer in their own words as far as practicable.

Group – A

1. Answer any twelve: **12 × 1 = 12**

Choose the correct alternative for the following

(i) The initial step in any image processing technique is
(a) Segmentation (b) Masking
(c) Image acquisition (d) Normalization

(ii) An image is considered to be a function of a(x, y) where a represents
(a) Height of image (b) Width of image
(c) Amplitude of image (d) Resolution of image

(iii) In 8-distance measurement system distance between centre pixel and a corner pixel is:
(a) 2 unit (b) $\sqrt{2}$ unit (c) 1 unit (d) 1 unit

(iv) Haar transform is mainly used for:
(a) Image sharpening (b) Histogram equalization
(c) Multi-resolution image analysis (d) Color enhancement

(v) Which of the following transforms is based on square waveforms?
(a) Fourier Transform (b) Walsh Transform
(c) DCT (d) Laplace Transform

(vi) The degradation model in image restoration is generally represented as:
(a) $g(x,y)=f(x,y)+n(x,y)$ (b) $g(x,y)=f(x,y)*h(x,y)+n(x,y)$
(c) $g(x,y)=f(x,y)-h(x,y)$ (d) $g(x,y)=h(x,y)/f(x,y)$

(vii) Lossless compression ensures:
(a) Reduced image size with some data loss
(b) No data loss during reconstruction
(c) Elimination of redundancy through approximation
(d) High compression ratios at all times

(viii) In morphological image processing, the basic operations are:
(a) Filtering and compression (b) Erosion and dilation
(c) Thresholding and smoothing (d) Histogram equalization and stretching

(ix) In Run-Length Coding, compression is achieved by:
(a) Encoding image blocks separately
(b) Replacing sequences of repeated symbols with a count and value
(c) Converting image into frequency domain
(d) Predicting the pixel values

(x) Boundary detection using morphology can be performed by:
(a) Subtracting eroded image from the original
(b) Applying thresholding
(c) Using Gaussian filters
(d) Segmenting by region growing

Fill in the blanks with the correct word

(xi) The two main steps in digitisation are _____ & _____.

(xii) Fourier Transform is used to convert an image from _____domain to _____domain.

(xiii) _____ & _____determines the quality of a digital image.

(xiv) Moving an image from one location to another is called _____

(xv) _____ is the process of reducing image noise and minor details.

Group - B

2. (a) Explain the following terms with respect to digital image capturing:
(i) Sampling
(ii) Quantization. *[(CO3)(Understand/LOCQ)]*

(b) Why are arithmetic operations like addition and subtraction used in image processing? *[(CO4)(Understand/LOCQ)]*

(c) What is the difference between spatial domain filtering and frequency domain filtering? Write geometric transformations for translation, scaling, and rotation. *[(CO2) (Remember/LOCQ)]*

(d) An image f(x,y) has gray levels in the range [0, 255] and size 1024×1024 pixels. If the image is compressed to 256×256 pixels and gray levels reduced to [0, 63]:
(i) Compute the new resolution and gray-level range.
(ii) Determine the ratio of data reduction. *[(CO2)(Apply/IOCQ)]*

2 + 2 + 4 + 4 = 12

3. (a) Compute the Chessboard (D8) distance between p(1, 1) and q(4, 5). *[(CO3)(Analyse/HOCQ)]*

(b) Define digital image processing. Mention any three applications of digital image processing. *[(CO4)(Remember/LOCQ)]*

(c) Mathematically explain Adjacency & Connectivity in Digital Image. *[(CO4)(Remember/LOCQ)]*

(d) Consider the following two images. Find addition and subtraction of images are given by f1+f2 and f1−f2. Assume both the images are of the 8-bit integer type.

$$f1 = \begin{matrix} 100 & 100 & 100 \\ 50 & 50 & 50 \\ 200 & 150 & 150 \end{matrix} \quad \text{and} \quad f2 = \begin{matrix} 50 & 50 & 25 \\ 40 & 40 & 50 \\ 50 & 50 & 75 \end{matrix}$$

[(CO2)(Apply/IOCQ)]

3 + 3 + 3 + 3 = 12

Group - C

4. (a) Explain the properties of 2D Fourier Transform & Fast Fourier Transform (FFT). *[(CO3)(Understand/LOCQ)]*

   (b) Discuss the properties and applications of Hadamard transform & Discrete Cosine Transform. *[(CO4)(Remember/LOCQ)]*

   (c) Prove that gradient of image intensity due to Prewitt operator along horizontal direction can be obtained by convolving the image by [1 1 1] followed by $[-1\ 0\ 1]T$ and then scaling the result by 1/3, where, T denotes the transpose operation. *[(CO2)(Apply/IOCQ)]*

   (d) Perform histogram equalization of the following image

4	4	4	4	4
3	4	5	4	3
3	5	5	5	3
3	4	5	4	3
4	4	4	4	4

[(CO2)(Apply/IOCQ)]

3 + 3 + 3 + 3 = 12

5. (a) Determine the convolution and correlation between the following images:

$$f(x,y) = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \end{bmatrix} \text{ and } g(x,y) = \begin{bmatrix} 1 & 2 & 3 \\ 4 & 5 & 6 \\ 7 & 8 & 9 \end{bmatrix}$$

[(CO2)(Apply/IOCQ)]

   (b) Given an image with pixel intensities in the range [50, 180], perform linear stretching to map it to [0, 255]. Show the formula and calculations. *[(CO2)(Apply /LOCQ)]*

   (c) Given a 3×3 image matrix: [52 55 61; 59 79 61; 70 61 64]
   Perform histogram equalization step by step. *[(CO2)(Apply/IOCQ)]*

   (d) Explain how the edge detection is obtained by Prewitt and Sobel operators and compare these two techniques. *[(CO4)(Understand/LOCQ)]*

3 + 3 + 3 + 3 = 12

Group - D

6. (a) Analyze a situation where lossy compression would be preferred over lossless compression. Provide examples and reasons. *[(CO3)(Analyse/HOCQ)]*

   (b) What is the need for image compression? Explain the difference between lossy and lossless compression with examples. Explain the Image Degradation Model

in image restoration. What are the components of this model, and how do they affect the observed image? *[(CO4)(Remember/LOCQ)]*

(c) Describe mathematically Shannon-Fano Coding algorithm and discuss its limitations compared to Huffman coding. *[(CO2)(Apply/IOCQ)]*

4 + 4 + 4 = 12

7. (a) Explain why regularization is important in image restoration. *[(CO3)(Understand/LOCQ)]*

(b) If h(x,y)represents a linear motion blur of length 5 pixels, sketch its PSF (Point Spread Function). *[(CO2)(Apply/IOCQ)]*

(c) Explain the principle of Run-Length Coding (RLC). Encode the sequence: [255,255,255,0,0,255,255,0] using RLC. *[(CO2)(Apply/IOCQ)]*

(d) Derive the expression for the constrained least-squares estimate in the frequency domain. *[(CO2)(Apply/IOCQ)]*

3 + 3 + 3 + 3 = 12

Group - E

8. (a) Discuss how edge linking is done by local processing. Identify the various techniques that can be used for edge linking. *[(CO3)(Understand/LOCQ)]*

(b) Give the importance of thresholding and explain the steps involved in region based segmentation. *[(CO4)(Remember/LOCQ)]*

(c) Given a binary image A and structuring element B, compute the dilation (A⊕B) and erosion

(A⊖B): A = [[0 1 1 0], [1 1 0 0], [0 1 0 1], [0 0 1 1]] , B = [[1 1], [1 0]] *[(CO2)(Apply/IOCQ)]*

(d) Perform opening and closing operations on the given image

0	0	0	0	0
0	1	1	1	0
0	1	1	1	0
0	1	1	1	0
0	0	0	0	0

Image

0	1	0
1	1	1
0	1	0

Mask

[(CO2)(Apply/IOCQ)]

3 + 3 + 3 + 3 = 12

9. (a) Give the importance of thresholding and explain the steps involved in region based segmentation. *[(CO3)(Understand/LOCQ)]*

(b) Apply the Sobel operator to f(x, y) = [1 2 3; 4 5 6; 7 8 9] and compute gradient magnitude. *[(CO2)(Apply/IOCQ)]*

(c) What is an edge in an image? List any two popular edge detection operators. *[(CO2)(Apply/IOCQ)]*

(d) Why is edge linking required after edge detection? Write an example of a 3×3 mask for isolated point detection. *[(CO2)(Apply/IOCQ)]*

4 + 2 + 2 + 4 = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	44.79	47.91	7.3