No. of Printed Pages : 7 **MMTE–003**

M.SC. (MATHEMATICS WITH APPLICATIONS IN COMPUTER SCIENCE [MSC (MACS)]

Term-End Examination

June, 2026

MMTE-003 : PATTERN RECOGNITION AND IMAGE PROCESSING

Time : 2 Hours *Maximum Marks : 50*

Note : *(i) Attempt any **five** questions.*

(ii) All questions carry equal marks.

(iii) Use of calculator is not allowed.

(iii) All symbols used have been their usual meaning.

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1. (a) Write Shannon-Nyquist theorem and discuss its role in the process of sampling. Also, discuss the term 'aliasing' and how it relates to Nyquist frequency. Determine the storage requirement for a 1024 × 1024, 24-bit colour image. 6

   (b) List the steps for transforming a 2-D signal to 2-D image. Consider the orthogonal matrix (A) and image matrix (*f*) given below : 4

$$A = \frac{1}{\sqrt{2}}\begin{bmatrix} 1 & 1 \\ 1 & -1 \end{bmatrix} \text{ and } f = [1]$$

   Apply orthogonal transform and verify that inverse orthogonal transformation gives us the original image (*f*).

2. (a) How Discrete Cosine Transform (DCT) differs from Discrete Fourier Transform (DFT) ? Discuss the rate of DCT in

image compression. Compute the DCT matrix for order 2. 5

(b) Describe the purpose of colour models. Compare RGB and CMY colour models. Transform the RGB cube by its CMY cube, Label all the vertices. Also, interpret the colours at the edges with respect to saturation. 5

3. (a) Explain the term 'Contrast Stretching'. Also, discuss 'Clipping' and 'Thresholding' as special cases of contrast stretching. Why thresholding operation results in the binary output ? Perform thresholding on image $f(x, y) = \begin{bmatrix} 0 & 10 & 50 \\ 5 & 95 & 150 \\ 110 & 150 & 190 \end{bmatrix}$ with threshold $(t) = 128$. 6

(b) Based on the analysis of the histogram of any image list the critical observations for the categorization of an image as : 4

(i) Under exposed image

(ii) Over exposed image

(iii) Low contrast image

(iv) High contrast image

4. (a) Describe the term 'Histogram equalization'. Perform Histogram equalization for the image : 8

$$f(x, y) = \begin{bmatrix} 2 & 3 & 3 & 2 \\ 4 & 2 & 4 & 3 \\ 3 & 2 & 3 & 5 \\ 2 & 4 & 2 & 4 \end{bmatrix}$$

(b) What is image sharpening ? List the filters used for image sharpening. 2

5. (a) Apply smoothing filter, weighted average filter and median filter on image $f(x, y) = \begin{bmatrix} 0 & 1 & 0 & 6 & 5 \\ 2 & 3 & 1 & 2 & 5 \\ 1 & 2 & \textcircled{7} & 5 & 4 \\ 1 & 0 & 6 & 5 & 2 \\ 2 & 3 & 5 & 7 & 6 \end{bmatrix}$ with mask of 3×3. 3

(b) Compare image enhancement with image restoration. 2

(c) What do you understand by the term 'Noise' in digital image ? Is it correlated with image ? Justify. Write Probability Distribution Function (PDF) for Gaussian Noise, Rayleigh Noise and Impulse Noise. 5

6. (a) What is Image Segmentation ? Write the steps to perform image segmentation using method of merging and method of splitting. Also, compare the two methods. 4

   (b) Explain K-means clustering with the help of a suitable example. Also, give the benefits and limitations. 6

7. (a) Differentiate between supervised machine learning technique and unsupervised machine learning techniques (give at least 5 comparisons). 5

   (b) Write Bayes theorem. How it applies to Bayesian classification ? Give properties of Bayes classifier. Given the variables cold (C) and not cold (C′).

Feature is fever (f). Prior probability of a person having cold is P(C) = 0.01. Probability of having fever, given that a person has cold is, P(f/c) = 0.4. Overall probability of fever P(f) = 0.02. Use Bayes theorem to find the probability that a person has cold, given that the person has fever. 5

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