

**M.E. ELECTRONICS AND TELE-COMMUNICATION ENGINEERING
FIRST YEAR SECOND SEMESTER-2025**

COMPUTER VISION AND PATTERN RECOGNITION

Time: 3 hours

Full Marks: 100

Answer any five questions, taking at least two from each group.

GROUP A

1. a) How the 2D projection of a 3D scene point can be obtained using a camera? Show that a 3D scene point $P(x, y, z)$ and its 2D projection $Q(x', y')$ are related by: $x' = \left(\frac{f}{z}\right)x$; $y' = \left(\frac{f}{z}\right)y$, where, f denotes the focal length of the camera. 2+5
- b) How can you differentiate between the four characters – 'A', 'B', 'O', and 'I' in a binary image using a topological feature? Define your topological feature. 3+1
- c) What do you mean by connected components in an image? Show different steps of a sequential 4-Connected Component Labeling (CCL) algorithm. 1+3
- d) Find the number of components and their sizes (in terms of number of pixels) in the following 5x5 binary image using your CCL algorithm in 1(c): 5

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

In the above figure, a '1' denotes a foreground pixel and a '0' denotes a background pixel.

2. a) What is image segmentation? Explain exhaustive partitioning and exclusive partitioning in this context. 5
- b) Define histogram of an image. Discuss, with an example, how histogram can be utilized in image segmentation. 2+5
- c) Show with an example how quad-tree can be used to represent an image. 3
- d) Discuss, with an example, how region split-and-merge algorithm can segment an image with the help of quad-tree. 5
3. a) Define: i) a linear spatial image filter, and ii) an order statistic image filter with examples. 3+3
- b) Consider the following 4x4 image: 6

55	59	56	65
98	228	70	60
60	52	5	75
61	55	62	54

Apply the example order statistic filter in 3a) on the above image. You can assume a filter mask of size 3x3.

[Turn over

Ex/PG/ETCE/PC/T/122A/2025

- c) Explain why edge in an image can be detected using derivatives. **2**
 d) Obtain the coefficients of a 3x3 Laplacian mask, and show how this can be used for detection of edges in an image. **6**
4. a) What do you mean by optic flow? Why detection of optic flow is important? **2+1+7**
 Derive expressions for flow vectors based on Horn and Schunk approach.
 b) Briefly state the importance of deep learning and graph cuts for image segmentation. Present a medical image segmentation framework with necessary mathematical details involving these two paradigms. **2+2+6**

GROUP B

5. a) With a neat block diagram discuss the basic building blocks of a pattern recognition system. **3**
 b) Explain what is meant by parametric decision making. **2**
 c) State and explain Bayes' Theorem. Show how this theorem can be used for parametric decision making. **2+3**
 d) For class A, feature x is normally distributed with $\mu = 1$ and $\sigma = 2$. For class B, the same feature x is normally distributed with $\mu = 4$ and $\sigma = 1$. The prior probabilities of the two classes are $P(A) = 1/3$ and $P(B) = 2/3$. What is the probability that a sample with the feature value $x = 3$ belongs to class A? **10**
6. a) Explain what is meant by non-parametric density estimation. **2**
 b) Establish $p(x) = k/NV$, as a general formulation of the non-parametric density estimation problem (symbols have their usual meanings). **6**
 c) Given a dataset $X = \{4, 5, 5, 6, 8, 11, 12, 14, 15, 15, 16, 17\}$, estimate the density of $p(x)$ using Parzen window at
 i) $x = 14$ with a window size of 2
 ii) $x = 6$ with a window size of 4 **6**
 d) Consider a three-dimensional feature space. Given two samples from class A, are located at (1, 2, 4), and (2, 2, 3) respectively. Similarly, two samples from class B are located at (5, 3, 6) and (5, 2, 4) respectively. Obtain the class of a sample located at (3, 4, 4) using kNN algorithm, with i) $k = 1$, and ii) $k = 3$. Use city-block distance as the distance measure. **6**
7. a) Differentiate between classification and clustering. **2**
 b) What is hierarchical clustering? Give an example. Apply any hierarchical clustering algorithm on the following data with Euclidean distance as the distance measure: **2+1+6**

Sample	x	y
1	1	1
2	2	0
3	0	4
4	5	6
5	8	12

c) What is partitional clustering? Give an example. Apply k-Means algorithm on the following data with Euclidean distance as the distance measure: **2+1+6**

Sample	x	y
1	1	1
2	5	4
3	4	4
4	2	1
5	8	6

Assume two clusters, with the first two samples as the respective seeds.

8. a) How SVM can help in classification of patterns? Mathematically argue that the optimum hyperplane classifier of a SVM is unique. Mention what are support vectors. **2+6+2**
- b) What is egocentric video? Briefly explain the problem of video summarization. Show how an egocentric video summarization problem can be solved with deep learning and pattern clustering. **1+2+7**