

COMPUTER VISION

(CSEN 5233)

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: **$12 \times 1 = 12$**

Choose the correct alternative for the following

(i) Which of the following edge detection techniques is based on second-order derivatives?
(a) Canny (b) Sobel (c) Laplacian (d) Prewitt

(ii) Which edge detection method applies Gaussian smoothing before detecting edges?
(a) Sobel (b) Canny (c) Prewitt (d) Laplacian

(iii) Which morphological operation is used to fill gaps in binary objects?
(a) Erosion (b) Dilation (c) Closing (d) Opening

(iv) Which transform is most suitable for analyzing image texture in the frequency domain?
(a) Laplace Transform (b) Fourier Transform
(c) Hough Transform (d) Discrete Cosine Transform

(v) Which histogram operation increases the contrast of an image?
(a) Binarization (b) Normalization
(c) Equalization (d) Smoothing

(vi) Which of the following is NOT a texture descriptor?
(a) Co-occurrence matrix (b) Edge intensity
(c) Local Binary Pattern (LBP) (d) Gabor Filter

(vii) Which type of feature analysis considers spatial relationships between pixels?
(a) Shape-based (b) Color-based
(c) Texture-based (d) Statistical-based

(viii) PCA reduces dimensionality by:
(a) Increasing data variance (b) Increasing correlation
(c) Removing correlated features (d) Minimizing noise

Fill in the blanks with the correct word

- (xi) The _____ operator is a first-order derivative-based method used for edge detection in images.
- (xii) The _____ method combines Gaussian smoothing with edge detection to reduce noise and improve accuracy.
- (xiii) The segmentation technique that separates an image into foreground and background based on pixel intensity is called _____.
- (xiv) The K-Means clustering algorithm minimizes the _____ distance between data points and the cluster centroid.
- (xv) In supervised learning, the _____ classifier is based on the assumption that the features follow a Gaussian distribution.

Group - B

2. (a) Derive the mathematical expression for an edge detected using the Canny edge detection algorithm and analyze how the Gaussian filter affects the edge response. *[(CO2)(Analyse/IOCQ)]*

(b) Explain how gradient magnitude and direction are computed using the Sobel operator. Given the following 3×3 image patch, calculate the gradient magnitude and direction using the Sobel operator:

10	20	10
30	40	30
20	10	20

[(CO2)(Apply/IOCQ)]
6 + 6 = 12

3. (a) A moving object is captured in sequential frames. Derive the optical flow constraint equation and explain its significance in motion detection. *[(CO5)(Derive/IOCQ)]*

(b) Implement the Lucas-Kanade method for computing motion vectors from two consecutive image frames. *[(CO5)(Implement/IOCQ)]*

6 + 6 = 12

Group - C

4. (a) Describe the role of wavelet transform in image analysis. How does it differ from Fourier Transform? [(C03)(Understand/LOCQ)]
(b) Given an image signal, compute its Haar wavelet transform for a 1D case:

$X=[4,6,8,10]$, Perform one level of decomposition.

[(CO3)(Apply/LOCQ)]

(c) Compare Haar and Daubechies wavelets in terms of reconstruction accuracy and computational complexity.

[(CO4)(Compare/HOCQ)]

4 + 4 + 4 = 12

5. (a) Explain how Otsu's thresholding is used for image segmentation. Derive the mathematical formulation of the threshold selection criterion.

[(CO3)(Understand/LOCQ)]

(b) Consider a grayscale image with the following pixel intensities:

$$\begin{bmatrix} 50 & 50 & 100 & 100 \\ 50 & 50 & 100 & 100 \\ 150 & 150 & 200 & 200 \\ 150 & 150 & 200 & 200 \end{bmatrix}$$

Apply Otsu's method to find the optimal threshold value.

[(CO3)(Apply/LOCQ)]

(c) Analyze the advantages and limitations of Otsu's thresholding in real-time image processing applications.

[(CO4)(Analyse/HOCQ)]

4 + 4 + 4 = 12

Group - D

6. (a) Define intensity histograms for a gray scale image.

[(CO1)(Remember/LOCQ)]

(b) Perform histogram equalization of the following image:

$$\begin{matrix} 1 & 3 & 5 \\ 4 & 4 & 3 \\ 5 & 2 & 2 \end{matrix}$$

[(CO1)(Construct/HOCQ)]

(c) What do you mean by neighbours of a pixel? Define 4, 8 adjacencies of pixels in a grey scale image.

[(CO1)(Understand/LOCQ)]

2 + 6 + 4 = 12

7. (a) Define Euclidean distance, city block distance and chess board distance with suitable examples.

[(CO1)(Understand/LOCQ)]

(b) What is a feature vector in computer vision? Explain the role of feature vectors in pattern recognition and classification.

[(CO1)(Understand/LOCQ)]

(c) Explain why shape-based features are more useful in object recognition, while texture-based features are more effective in identifying background patterns.

[(CO4)(Evaluate/LOCQ)]

4 + 4 + 4 = 12

Group - E

8. (a) You are tasked with classifying handwritten digits using an Artificial Neural Network (ANN). Describe the architecture of an ANN that would be suitable for this task, including the choice of activation function and number of hidden layers.

[(CO3)(Apply/HOCQ)]

(b) Explain how the weights in the ANN are updated using the Backpropagation algorithm.

[(CO1)(Understand/LOCQ)]

(c) Discuss how overfitting can occur in ANN models and suggest two regularization techniques to overcome it. *[(C04)(Evaluate/IOCQ)]*

$$\mathbf{5 + 3 + 4 = 12}$$

9. (a) Explain the working principle of the Bayes Classifier. Derive the decision boundary equation in the case of two Gaussian-distributed classes. *[(C01)(Understand/LOCQ)]*

(b) You are given the following data points in 2D space:

(1,2),(2,3),(3,4),(10,12),(11,12),(12,14)

Apply the K-Means clustering algorithm with k=2. Clearly show the initial centroids, cluster formation, and how the centroids change after each iteration until convergence. *[(C06)(Construct/HOCQ)]*

$$\mathbf{6 + 6 = 12}$$

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	32.29	41.67	26.04