Roll No.											

GAIN MORE KNOWLEDGE
REACH GREATER HEIGHTS

PRESIDENCY UNIVERSITY

BENGALURU

End - Term Examinations – December 2025

Date: 12-12-2025 **Time:** 01:00pm– 04:00pm

SCHOOL: SOCSE	**PROGRAM:** B. TECH IN INFORMATION SCIENCE AND ENGINEERING	
COURSE CODE: CAI3400	**COURSE NAME:** IMAGE PROCESSING AND ANALYSIS	
SEMESTER: V	**MAX MARKS**: 100	**WEIGHTAGE**: 50%

CO - Levels	**CO1**	**CO2**	**CO3**	**CO4**
Marks	**24**	**24**	**26**	**26**

Instructions:

(i) Read all questions carefully and answer accordingly.

(ii) Do not write anything on the question paper other than roll number.

Part A

Answer ALL the Questions. Each question carries 2marks. **10Q x 2M=20M**

1.	"Perceived brightness is not a simple function of the intensity of the region"- Explain the phenomenon behind this.	**2 Marks**	**L2**	**CO1**
2.	Explain how pixel adjacency relationships help in region-growing during segmentation. Give a small example.	**2 Marks**	**L3**	**CO1**
3.	Differentiate Gray level slicing and Bit Plane slicing	**2 Marks**	**L2**	**CO2**
4.	Explain an application where sharpening filters enhance edges for object detection (e.g., number plate extraction in an automatic toll system).	**2 Marks**	**L3**	**CO2**
5.	Define image restoration. How image restoration helps in forensic image analysis?	**2 Marks**	**L2**	**CO3**
6.	What is inverse filtering? Explain why inverse filtering amplifies noise.	**2 Marks**	**L4**	**CO3**
7.	A fingerprint image requires ridge pattern clarity. – How does **line detection** help enhance ridge flow direction?	**2 Marks**	**L3**	**CO3**

8.	Define bit Plane Coding. Why is RLC more effective for binary or bit-plane images?	**2 Marks**	**L2**	**CO4**
9.	Why is image compression necessary in modern multimedia systems? Explain with two real-time examples.	**2 Marks**	**L4**	**CO4**
10.	A scanned document image contains large white backgrounds and long sequences of identical pixel values. **Explain how RLE compresses such an image. Give one example of how a run like "0000001111" would be stored using RLE**	**2 Marks**	**L3**	**CO4**

Part B

Answer the Questions. **Total Marks 80M**

11.	**a.**	Explain sampling and quantization in digital image processing with diagrams	**10 Marks**	**L2**	**CO1**
	b.	A smart traffic monitoring system uses cameras placed at highway junctions. Explain how each fundamental step of a digital image processing system (image acquisition, enhancement, restoration, segmentation, representation, recognition) is used in this application. Draw the DIP system block diagram and relate each block to the real-time case.	**10 Marks**	**L3**	**CO1**
Or					
12.	**a.**	Explain color fundamentals and models (RGB, CMY/CMYK, HIS).	**10 Marks**	**L2**	**CO1**
	b.	Explain adjacency, connectivity, and region properties in images with examples.	**10 Marks**	**L3**	**CO1**

13.	**a.**	i. Explain Homomorphic Filtering ii. Perform Histogram Equalization of the image $$I=\begin{bmatrix} 12 & 9 & 12 & 10 \\ 12 & 14 & 8 & 10 \\ 9 & 13 & 12 & 10 \\ 12 & 14 & 12 & 10 \end{bmatrix}$$	**10 Marks**	**L2**	**CO2**
	b.	In Fig. I, a security camera captures noisy low-light images of a garden.	**10 Marks**	**L3**	**CO2**

<table>
<tr><td></td><td></td><td>
Fig. I

i. Explain how smoothing spatial filters reduce random noise caused by the sensor.
ii. Demonstrate how applying a mean filter enhances overall scene clarity.</td><td></td><td></td><td></td></tr>
<tr><td colspan="6">Or</td></tr>
<tr><td>14.</td><td>a.</td><td>Explain the Basic Gray Level Transformations functions</td><td>10 Marks</td><td>L3</td><td>CO2</td></tr>
<tr><td></td><td>b.</td><td>A 3-bit image (L = 8) has the following histogram:
<table>
<tr><th>Gray Level</th><th>0</th><th>1</th><th>2</th><th>3</th><th>4</th><th>5</th><th>6</th><th>7</th></tr>
<tr><td>Pixels</td><td>500</td><td>700</td><td>900</td><td>800</td><td>600</td><td>400</td><td>300</td><td>100</td></tr>
</table>
Total pixels = 4300.

The desired (target) distribution is:

P(z) = {0.05, 0.10, 0.20, 0.25, 0.20, 0.10, 0.06, 0.04}

Tasks

1. Compute the normalized histogram and its CDF.
2. Compute the target CDF.
3. Perform histogram matching using the CDF-to-CDF mapping rule.
4. Determine the final matched gray level for each input level.</td><td>10 Marks</td><td>L2</td><td>CO2</td></tr>
</table>

<table>
<tr><td>15.</td><td>a.</td><td>An 8×8 grayscale image is given below. Using the Optimal Thresholding (Iterative Threshold Selection) method, segment the</td><td>10 Marks</td><td>L2</td><td>CO3</td></tr>
</table>

image into two regions. Perform all steps clearly, including: initial threshold selection, grouping of pixels, mean computation of each group, threshold update, and convergence check. Finally, display the segmented binary image.

12	18	22	25	28	30	32	35
14	17	20	23	26	29	31	34
10	15	18	22	24	27	30	33
11	16	19	21	25	28	31	36
50	52	55	57	60	62	65	67
48	51	53	56	59	61	63	66
45	48	50	54	57	60	62	64
43	46	49	52	55	58	61	63

b. A satellite image of a flood-affected region needs to be segmented to distinguish water bodies from land pixels. Because illumination and reflectance vary across the scene, a single global threshold is not directly obvious. The image-processing system uses **optimal threshold selection through iterative class-mean computation**. — **10 Marks** | **L3** | **CO3**

Define optimal thresholding, explain how **class means μ_land and μ_water** affect threshold selection, and derive the iterative formula used to update the threshold until it converges.

Or

16. a. Explain the concept of edge detection in digital image processing. Discuss different types of edges, edge models, gradient operators and Laplacian-based methods with suitable examples — **10 Marks** | **L2** | **CO3**

b. Perform the image segmentation of an image into two region by histogram method — **10 Marks** | **L3** | **CO3**

12	18	20	22	25	28	30	32
14	16	19	21	24	27	29	31
10	13	17	20	23	26	28	30
11	15	18	22	25	27	29	32
40	42	45	47	48	50	52	55
38	41	43	46	49	51	53	54
36	39	42	44	47	50	52	53
35	38	40	43	46	48	51	52

17. a. A CCTV surveillance camera captures a grayscale video frame. Due to lighting variations, the following pixel intensities dominate the frame and their observed probabilities are: — **10 Marks** | **L4** | **CO4**

		<table><tr><td>**Intensity (Symbol)**</td><td>**Probability**</td></tr><tr><td>80</td><td>0.28</td></tr><tr><td>120</td><td>0.22</td></tr><tr><td>150</td><td>0.18</td></tr><tr><td>200</td><td>0.14</td></tr><tr><td>220</td><td>0.10</td></tr><tr><td>255</td><td>0.08</td></tr></table> a) Generate Huffman codes for the intensities. b) Compute the entropy. c) Compute the average code length. d) Calculate coding efficiency and redundancy. e) If the frame contains 10,000 pixels, compute: • Number of bits transmitted using Huffman coding • Compare with fixed-length coding (8 bits/pixel) • Compute compression ratio			
	b.	Consider the following 5 × 5 3-bit grayscale image (pixel values in 0–7): $$I_1 = \begin{bmatrix} 7 & 6 & 5 & 4 & 3 \\ 7 & 7 & 6 & 5 & 4 \\ 6 & 6 & 5 & 4 & 3 \\ 5 & 5 & 4 & 3 & 2 \\ 4 & 4 & 3 & 2 & 1 \end{bmatrix}$$ (a) Perform bit-plane slicing and extract bit-planes 2 (MSB), 1, and 0 (LSB). Write each bit-plane as a 5×5 binary matrix. (b) For bit-plane 2 and bit-plane 1, convert each bit-plane to a 1-D row-wise sequence (left→right, top→bottom) and apply Run-Length Coding (RLC) (use the format *(value, run-length)* where value ∈ {0,1}). Show the RLC output for each chosen plane. (c) Compute the number of bits required to send the RLC output for each plane assuming you encode runs as:	**10 Marks**	**L3**	**CO4**

		1 bit for the run value (0/1) + 3 bits to store run length (since maximum run length ≤25 fits in 5 bits, but use 3 bits here if you limit to lengths ≤7 — state your assumption). Using that assumption, compute total bits for each plane's RLC and compare compressibility. Which plane compresses better and why?			
Or					
18.	**a.**	A robot receives commands from {F, L, R, S} (Forward, Left, Right, Stop) with probabilities: **Symbol** **Probability** F 0.50 L 0.10 R 0.30 S 0.10 Encode and decode the sequence { F R L F S}	**10 Marks**	**L4**	**CO4**
	b.	With reference to digital image processing, compare and explain the probability density functions (PDFs) of Gaussian noise, Rayleigh noise, Exponential noise, Uniform noise, and Impulse (Salt-and-Pepper) noise.	**10 Marks**	**L3**	**CO4**