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CHENNAI

Final Assessment Test(FAT) - Apr/May 2025

Programme	B.Tech.	Semester	Winter Semester 2024-25
Course Code	BCSE403L	Faculty Name	Prof. Geetha S
Course Title	Digital Image Processing	Slot	A2+TA2
Time	3 hours	Class Nbr	CH2024250502021
		Max. Marks	100

Instructions To Candidates

- Write only your registration number in the designated box on the question paper. Writing anything elsewhere on the question paper will be considered a violation.

Course Outcomes

CO1: Ascertain and describe the basics of image processing concepts through mathematical interpretation.
CO2: Acquire the knowledge of various image transforms and image enhancement techniques involved.
CO3: Demonstrate the image restoration process and its respective filters required and attain the knowledge of color image processing techniques.
CO4: Experiment with the various image segmentation and morphological operations for a meaningful partition of objects.
CO5: Design the various basic feature extraction procedures and illustrate the various image compression techniques and their applications.

Section - I
Answer all Questions (1 × 10 Marks)

01. a. A pharmaceutical company produces small glass vials used for packaging liquid medicines. Each vial must undergo 100% automated visual inspection to ensure there are no cracks or air bubbles. At present, a human inspector checks each vial by visually examining magnified images displayed on a screen. However, this process is slow and error-prone. The production manager believes that automating the inspection process will improve accuracy, reduce costs, and enhance production speed. The proposed solution is to use a high-resolution camera to capture images of each vial, analyze them using an image processing system, and trigger an automated reject mechanism if defects are detected. Your task is to design an automated inspection system capable of detecting cracks and air bubbles in glass vials. Explain the system using a clear workflow and a block diagram. (5M)

b. Given c=1 and γ=0.5, apply Gamma Correction transformation to compute the new intensity values for r=0, 64,128,192, 255. If the transformation is applied to an image, describe its effect on dark and bright regions. Suggest a scenario where gamma correction with γ>1 would be useful. (5M)

Section - II **[10] (CO1,2/K3)**
Answer all Questions (6 × 15 Marks)

02. a. Consider an image strip of size 50 × 100 shown in Fig. (1) given below. The image consists of five vertical stripes. The gray levels of the stripes from left to right are 128, 64, 32, 16 and 8. The corresponding widths of the stripes are 35, 30, 20, 10 and 5 pixels respectively. If this stripe image is coded by a variable-length coding, determine its efficiency.

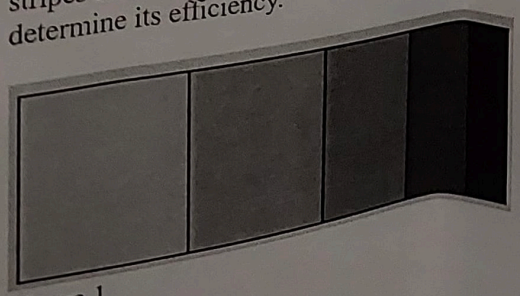


Figure 1

i. Derive the probability of appearance (that forms the histogram) of each intensity level. Calculate the entropy of the image. [2]
ii. Derive the variable-length code that could compress the image. [4]
iii. Calculate the average length of the fixed-length code and that of the derived variable-length code. [2]
iv. Calculate the compression ratio of the image size (in bits) between using the fixed-length and variable-length coding. Calculate the relative coding redundancy. [2]
b. With respect to the JPEG image compression technique, answer the following:
i. Why is zig-zag scanning preferred in the JPEG standard? [1]
ii. What is 'blocking artifact' in a DCT-based image-compression scheme? [2]
iii. What is the role of the quantization matrix in JPEG compression? [2]

[15] (CO5/K3)

03. a. Consider the following 5X5 image patch:

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

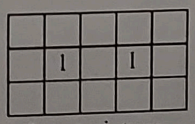
Figure 2

i. Compute the LBP values for the center 3 × 3 region of the image patch shown in Fig. 2. How does LBP capture texture features? [4]
ii. If this image represents different textures, how would LBP help distinguish them? [1.5]
iii. What happens to the LBP values if brightness is uniformly increased by 1? Would the texture information remain unchanged? Why? [1.5]
b. For the same Fig. 2, compute and analyze the GLCM features for texture classification.
i. Construct the GLCM matrix for a given direction (e.g., 0° (horizontal), 45°, 90° (vertical), or 135°) [4]
ii. Compute the following texture features from GLCM: [2]
- Contrast
- Correlation
- Energy
- Homogeneity

iii. If two different textures produce similar GLCM feature values, what additional methods could be used for better classification? [1]
iv. Compare GLCM-based texture analysis with Local Binary Patterns (LBP). In which scenarios would GLCM be more effective than LBP? [1]

[15] (CO5/K4)

04. a. The input picture and structuring element are shown below. Perform the opening and closing of the input picture. [10]



Input picture

0	1	0
1	1	1
0	1	0

Structuring element

Figure 3

b. A particular inspection program captures black and white photographs of items as they move along a conveyor belt. Parts must be separated into two categories: " those with holes and those without." A sample image captured by the inspection camera is provided below: [5]

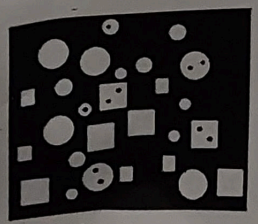


Figure 4

Propose a method using morphological operators for identifying and locating the objects in each category in the image so that a robotic system may pick them up and deposit them in various bins. Assume that the imaging system knows where each picture pixel is on the conveyor belt at all times

05. a. A satellite image of an agricultural field is captured in grayscale, where different intensity values represent different crop types. A remote sensing analyst wants to segment a particular crop region using the region growing algorithm. A seed pixel is selected at (3,4) with intensity I = 128. The algorithm includes neighboring pixels if their intensity difference from the seed is within a threshold of ±10. [7]

[15] (CO

$$\begin{bmatrix} 98 & 102 & 110 & 120 & 135 & 140 \\ 105 & 112 & 118 & 126 & 138 & 144 \\ 108 & 116 & 124 & 128 & 136 & 148 \\ 112 & 119 & 126 & 130 & 140 & 150 \\ 115 & 122 & 128 & 132 & 142 & 155 \\ 118 & 126 & 130 & 138 & 148 & 160 \end{bmatrix}$$

Figure 5

b. A traffic monitoring system captures grayscale images of vehicles on a highway at night. The patch of an image captured is shown in Fig. 6

$$\begin{bmatrix} 25 & 30 & 28 & 50 & 180 & 200 \\ 27 & 35 & 32 & 55 & 190 & 210 \\ 30 & 40 & 38 & 60 & 195 & 220 \\ 35 & 45 & 42 & 70 & 185 & 215 \\ 40 & 50 & 48 & 75 & 175 & 205 \\ 45 & 55 & 52 & 80 & 170 & 200 \end{bmatrix}$$

Figure 6

i. To detect vehicles, apply the global thresholding technique to separate bright vehicle headlights from the darker background. [4]

ii. What happens if the initial threshold is set too high or too low? [2]

iii. Compare and evaluate global thresholding with Otsu's thresholding for automated threshold selection. [2]

[15] (CO4/K5)

06. a. A professor of archaeology doing research on currency exchange practices during the Roman Empire recently became aware that four Roman coins crucial to his research are listed in the holdings of the British Museum in London. Unfortunately, he was told after arriving there that the coins recently had been stolen. Further research on his part revealed that the museum keeps photographs of every item for which it is responsible. Unfortunately, the photos of the coins in question are blurred to the point where the date and other small markings are not readable. The cause of the blurring was the camera being out of focus when the pictures were taken. As an image processing expert and friend of the professor, you are asked as a favor to determine whether computer processing can be utilized to restore the images to the point where the professor can read the markings. You are told that the original camera used to take the photos is still available, as are other representative coins of the same era. Propose a step-by-step solution to this problem. [7]

b. A self-driving car relies on camera-based lane detection to navigate roads safely. However, due to poor lighting conditions, the lane boundaries are not clearly visible. You need to apply an edge detection algorithm to extract lane markings from the given grayscale image.

$$\begin{bmatrix} 10 & 15 & 20 & 25 & 30 & 35 \\ 12 & 18 & 24 & 28 & 32 & 38 \\ 50 & 55 & 60 & 65 & 70 & 75 \\ 52 & 58 & 62 & 67 & 72 & 78 \\ 100 & 105 & 110 & 115 & 120 & 125 \\ 102 & 108 & 112 & 118 & 122 & 128 \end{bmatrix}$$

Figure 7

i. Apply the Sobel operator to compute the gradient magnitude at each pixel. Use the following Sobel kernels: [5]

$$G_x = \begin{bmatrix} -1 & 0 & 1 \\ -2 & 0 & 2 \\ -1 & 0 & 1 \end{bmatrix} \quad G_y = \begin{bmatrix} -1 & -2 & -1 \\ 0 & 0 & 0 \\ 1 & 2 & 1 \end{bmatrix}$$

ii. How would edge detection behave in a noisy image? Suggest a preprocessing step to handle noise before applying edge detection. [1.5]
iii. For a curved road, what modifications would you make in the edge detection approach to enhance lane boundary detection? [1.5]

[15] (CO3/K4)

07. a. Given the following binary image representing multiple handwritten digits:

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

Where:

- 1 represents a foreground pixel (digit).
- 0 represents the background.

i. Identify and isolate distinct regions of connected pixels representing individual digits by scanning the image row-wise from left to right and top to bottom [2]
ii. For each distinct region, calculate the bounding box enclosed with the connected pixels and the pixel count of the foreground pixels within each region [3]

b. You are provided with the histogram of an image as follows:

Value	0	1	2	3	4	5	6	7
Frequency	4	0	0	0	4	3	2	3

For further analysis, your manager requests that the image be transformed to match the following target histogram:

Value	0	1	2	3	4	5	6	7
Frequency	1	0	3	0	5	0	7	0

i. Perform histogram specification to transform the original image histogram into the desired target histogram [7].
ii. Identify and present the new pixel values that match the specified histogram. Provide a step-by-step explanation of your process and the resulting transformed image histogram [3]

[15] (CO1,2/K3)

BL-Bloom's Taxonomy Levels - (K1-Remembering,K2-Understanding,K3-Applying,K4-Analysing,K5-Evaluating,K6-Creating)