Sardar Patel Institute of Technology

Bhavan's Campus, Munshi Nagar, Andheri (West), Mumbai-400058, India

(Empowered Autonomous College Affiliated to University of Mumbai)

End Semester Examination

Dec. 2024

Max. Marks: 100 **Duration: 3 Hrs**

Class: T. Y. B. Tech. (AIML, DS) **Semester: V**

Course Code: AI302, DS204 **Program: Computer Science and Engineering**

Name of the Course: Fundamental of Signal and Image Processing

Instructions:

(1) All questions are compulsory.

(2) Draw neat diagrams and write equations wherever necessary.

(3) Assume suitable data if necessary.

Course Outcomes:At the end of the course student will be able to:

(1) Interpret DT signal and perform signal manipulation in Time Domain and frequency domain.

(2) Evaluate the techniques for enhancing and Segmenting Images.

(3) Categorize various Compression techniques and standards for Images.

(4) Apply signal and Image Processing Algorithms in practical Applications.

Q. No.		Max. Marks	CO-BL
Q.1a	Consider the discrete-time signal $x[n] = \{2, 4, -1, 3\}$ and an FIR system with impulse response $h[n] = \{1, -1, 2\}$. 1. Evaluate the system's response by performing linear convolution and analyze whether the system is linear, time-invariant, and stable. 2. Create a new sequence $x'[n]$ by delaying $x[n]$ by 1 unit. Compute the convolution $y'[n] = x'[n] * h[n]$ and explain the effect of time-shifting on the output. [5+5 Marks]	10	1-3
Q.1b	For the discrete-time signals given below, analyze whether they are periodic or aperiodic, and determine the period of periodic signals, even or odd, energy or power, causal or noncausal. 1. $x_1[n] = sin(2\pi n/4)$ 2. $x_2[n] = a^{-n}u[n]$ Is it possible to have a system whose input-output relationship can be defined by $x_1[n]$ and $x_2[n]$? If yes, how? If no, why? Determine mathematically. [4+4+2 Marks]	10	1-3

<table>
<tr><td>Q.2a</td><td>Consider the discrete-time signal: $x[n] = \{3, 1, -2, 4, -1, 5\}$, its corresponding DFT X[k], and an additional observation of noise in the frequency domain defined as $N[k] = \{0.1, -0.05, 0.05, -0.1\}$:
1. Let $y[n] = 2x[n]$. Compute $Y[k]$, and determine its relationship with $X[k]$.
2. Let, $z[n] = x[n-2]$. Compute $Z[k]$, and determine its relationship with $X[k]$. [5+5 Marks]
3. Verify the Parseval's theorem for x[n]. [Bonus: 5 Marks]</td><td>10</td><td>1-4</td></tr>
<tr><td>Q2.b</td><td>Consider the signal $x[n] = \{2, 4, 6, 8, 10\}$ and the filter impulse response $h[n] = \{2, -1, 1\}$.
1. Evaluate the output $y[n]$ using the overlap-add method for filtering the signal $x[n]$ with $h[n]$.
2. Analyze the overlap-save method for the same filtering operation and show how it handles signal segmentation. [5+5 Marks]</td><td>10</td><td>1-3</td></tr>
<tr><td>Q.3a</td><td>Input Image A is given below.
1. Apply Histogram Equalization Transformation.
2. Obtain Frequency Table of output Image B.
3. Plot Histogram of Input and Output image.
<table><tr><td>Gray Level</td><td>0</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td></tr><tr><td>Frequency</td><td>0</td><td>0</td><td>0</td><td>614</td><td>819</td><td>1230</td><td>819</td><td>614</td></tr></table>
OR
Consider the input image as shown in figure below. The image is preprocessed and the preprocessed image is furher compressed using Block Compression Technique. Evaluate the pre-processing module as mentioned below:
Decompose the image into four blocks. Filter the image to remove the noise present in the image. Suggest and apply the appropriate pre-processing technique on the first block only.
$\begin{bmatrix} 80 & 82 & 90 & 80 & 92 & 75 \\ 93 & 80 & 255 & 12 & 95 & 10 \\ 10 & 89 & 81 & 81 & 92 & 40 \\ 100 & 60 & 6 & 200 & 155 & 10 \\ 10 & 111 & 170 & 102 & 25 & 2 \\ 100 & 60 & 106 & 32 & 45 & 10 \end{bmatrix}$</td><td>10

10</td><td>2-4

2-4</td></tr>
</table>

Q.3b	Consider the image as given below. Segment the image using Split and Merge technique such that the difference between maximum pixel value and minimum pixel value in the segmented image must be less than 10. $\begin{bmatrix} 80 & 82 & 30 & 33 \\ 83 & 81 & 35 & 32 \\ 80 & 89 & 81 & 81 \\ 88 & 82 & 86 & 84 \end{bmatrix}$	10	2-4
Q.4a	Consider a data stream consisting of the following symbols: {A, B, C, D}. The corresponding probabilities for these symbols are as follows:$P(A) = 0.6, P(B) = 0.2, P(C) = 0.1, P(D) = 0.1$. You are tasked with compressing the data stream. 1. Construct the Huffman code for the given probabilities. 2. Compute the average codeword length for the Huffman code and evaluate the compression efficiency of Huffman coding by calculating the average codeword length. 3. Perform arithmetic encoding for the sequence $S = ABCD$ and provide the final encoded value. 4. Compare the compression efficiency of Huffman coding and arithmetic coding. 5. Analyze when each method would be more efficient. [2+2+2+2+2 Marks]	10	3-5
Q.4b	Evaluate region filling algorithm to fill the image given below. $\begin{bmatrix} 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 1 & 1 & 0 \\ 0 & 1 & 0 & 1 & 0 \\ 0 & 1 & 0 & 1 & 0 \\ 0 & 1 & 1 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 \end{bmatrix}$	10	3-5
Q.5a	Design a Digital Signal Processing (DSP)-based system for the measurement and analysis of noise pollution in a hospital located in a crowded area. The system should: • Utilize sensors to capture environmental noise and analyze it. • Display an appropriate error message on the screen if the noise level exceeds a user-defined threshold value. Specifically, address the following: 1. Draw the block diagram or process framework of the complete DSP system. Justify the purpose and necessity of each block in the system. 2. Write an algorithm or flowchart to illustrate the functioning of the system. Discuss the working of the entire system in detail.	10	4-6

Q.5b	Design a system to detect suspicious objects in airport areas. The primary objective is to detect suspicious objects in air- port areas is to enhance security and safety. 1. Draw Block Diagram/ Framework of the complete system that accepts input image, pre-process the image and displays the appropriate output. Describe the functions of each block. 2. Draw flowchart/write Algorithm of the different processes involved in the System. Describe the proposed methodology to address the problem.	10	4-6

Course Outcomes	Marks in ESE	Marks in MSE	Total marks for each course outcome
CO1	30	20	50
CO2	30	10	40
CO3	20	-	20
CO4	20	-	20