Syllabus

Digital Signal & Image Processing

Course Code	Course Name	Credits
CSC701	Digital Signal & Image Processing	4

Course Objectives :

1. To understand the fundamental concepts of digital signal processing and Image processing.
2. To explore DFT for 1-D and 2-D signal and FFT for 1-Dsignal
3. To apply processing techniques on 1-D and Image signals.
4. To apply digital image processing techniques for edge detection.

Course outcomes :

On successful completion of the course learner will be able to :

1. Apply the concept of DT Signal and DT Systems.
2. Classify and analyze discrete time signals and systems
3. Implement Digital Signal Transform techniques DFT and FFT.
4. Use the enhancement techniques for digital Image Processing
5. Differentiate between the advantages and disadvantages of different edge detection techniques
6. Develop small projects of 1-D and 2-D Digital Signal Processing.

Prerequisite: Applied Mathematics

Module No.	Unit No.	Topic details	Hrs.
1.0		**Discrete-Time Signal and Discrete-Time System**	14
	1.1	Introduction to Digital Signal Processing, Sampling and Reconstruction, Standard DT Signals, Concept of Digital Frequency, Representation of DT signal using Standard DT Signals, Signal Manipulations(shifting, reversal, scaling, addition, multiplication).	
	1.2	Classification of Discrete-Time Signals, Classification of Discrete- Systems	
	1.3	Linear Convolution formulation for 1-D and 2-D signal (without mathematical proof), Circular Convolution (without mathematical proof), Linear convolution using Circular Convolution. Auto and Cross Correlation formula evaluation, LTI system, Concept of Impulse Response and Step Response, Output of DT system using Time Domain Linear Convolution.	
		(Refer Chapters 1, 2 and 3)	

2.0		**Discrete Fourier Transform**	08
	2.1	Introduction to DTFT, DFT, Relation between DFT and DTFT, IDFT	
	2.2	Properties of DFT without mathematical proof (Scaling and Linearity, Periodicity, Time Shift and Frequency Shift, Time Reversal, Convolution Property and Parsevals' Energy Theorem). DFT computation using DFT properties.	
	2.3	Transfer function of DT System in frequency domain using DFT. Linear and Circular Convolution using DFT, Convolution of long sequences, Introduction to 2-D DFT **(Refer Chapter 3)**	
3.0		**Fast Fourier Transform**	06
	3.1	Need of FFT, Radix-2 DIT-FFT algorithm,	
	3.2	DIT-FFT Flow graph for N=4 and 8, Inverse FFT algorithm.	
	3.3	Spectral Analysis using FFT **(Refer Chapters 3 and 4)**	
4.0		**Digital Image Fundamentals**	08
	4.1	Introduction to Digital Image, Digital Image Processing System, Sampling and Quantization	
	4.2	Representation of Digital Image, Connectivity	
	4.3	Image File Formats: BMP, TIFF and JPEG. **(Refer Chapters 5 and 6)**	
5.0		**Image Enhancement in Spatial domain**	10
	5.1	Gray Level Transformations, Zero Memory Point Operations,	
	5.2	Histogram Processing, Histogram equalization.	
	5.3	Neighborhood Processing, Spatial Filtering, Smoothing and Sharpening Filters, Median Filter. **(Refer Chapters 7 and 8)**	
6.0		**Image Segmentation**	06
	6.1	Segmentation based on Discontinuities (point, Line, Edge),	
	6.2	Image Edge detection using Robert, Sobel, Previtt masks, Image Edge detection using Laplacian Mask. **(Refer Chapter 9)**	
		Total	52

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Chapter 1 : Introduction to Digital Signal Processing 1-1 to 1-17

Syllabus :

Introduction to Digital Signal Processing, Sampling and Reconstruction, Standard DT Signals, Concept of Digital Frequency, Representation of DT signal using Standard DT Signals, Signal Manipulations(shifting, reversal, scaling, addition, multiplication).

1.1 Introduction 1-1
1.1.1 Digital Signal Processing System 1-2
1.1.2 Advantages of Digital signal Processing over Analog Signal Processing 1-3
1.1.3 Difference between DSP and ASP 1-3
1.1.4 Limitations of Digital signal Processing 1-4
1.2 Signals 1-4
1.2.1 Continuous and Discrete Time Signals 1-4
1.2.2 Continuous Valued and Discrete Valued Signals 1-6
1.2.3 Deterministic and Random Signals 1-6
1.3 Concept of Frequency in the Continuous and Discrete Time Signals 1-6
1.3.1 Concept of Frequency in Continuous Time Signals 1-6
1.3.2 Concept of Frequency in Discrete Time Signals 1-7
1.3.3 Converting a Analog Signal to a Discrete Time Signal 1-8
1.4 Aliasing and Nyquist Rate 1-9
1.4.1 Anti Aliasing Filter 1-13
1.5 Basic Elements of a DSP System 1-13
1.5.1 Solved Examples 1-14
1.6 Applications of DSP 1-17

Chapter 2 : Discrete Time Signal and System 2-1 to 2-29

Syllabus :

Classification of Discrete-Time Signals, Classification of Discrete- Systems Linear Convolution formulation for 1-D and 2-D signal (without mathematical proof), Auto and Cross Correlation formula evaluation, LTI system, Concept of Impulse Response and Step Response, Output of DT system using Time Domain Linear Convolution

2.1 Introduction 2-1
2.1.1 Representation of Discrete Time Signals 2-1
2.1.2 Elementary Discrete Time Signals 2-2
2.2 Classification of Discrete Time Signals 2-4
2.2.1 Even and Odd Signals 2-5
2.2.2 Periodic and Aperiodic Signals 2-7
2.2.3 Energy and Power Signals 2-8
2.3 Operation on Signals 2-10
2.3.1 Time Shifting 2-10
2.3.2 Time Reversal 2-12
2.3.3 Time Scaling 2-12
2.3.4 Scalar Multiplication 2-13
2.3.5 Signal Addition and Multiplication 2-14
2.3.6 Solved Examples on Signals 2-14
2.4 Discrete Time Systems 2-17
2.4.1 Representation of a Signal in Terms of Weighted Sum of Shifted Discrete Impulse 2-20
2.5 Impulse Response and Convolution 2-21
2.5.1 Computation of Linear Convolution 2-22
2.5.2 Linear Convolution using Graphical Method 2-22
2.5.2(A) Solved Examples on Graphical Method 2-22
2.5.3 Linear Convolution using Tabular Method 2-26
2.5.3(A) Solved Examples on Tabular Method 2-27
2.6 Correlation 2-27
2.6.1 Solved Examples on Correlation 2-28

Chapter 3 : Discrete Fourier Transform (DFT) 3-1 to 3-68

Syllabus :

Introduction to DTFT, DFT, Relation between DFT and DTFT, IDFT, Properties of DFT without mathematical proof (Scaling and Linearity, Periodicity, Time Shift and Frequency Shift, Time, Reversal, Convolution Property and Parsevals' Energy Theorem). DFT computation using DFT properties. Transfer function of DT System in frequency domain using DFT. Linear and Circular Convolution using DFT, Convolution of long sequences, Introduction to 2-D DFT Circular Convolution (without mathematical proof), Linear convolution using Circular Convolution. Spectral Analysis using FFT

3.1 The Fourier Transform 3-1

3.2 Discrete Time Fourier Transform 3-2
3.2.1 Solved Examples on DTFT of Standard Signals 3-2
3.3 Relationship between DTFT and DFT 3-4
3.4 Discrete Fourier Transform (DFT) 3-4
3.4.1 Solved Examples on DFT of Simple Signals 3-5
3.5 The Fourier Spectrum 3-13
3.6 Inverse Discrete Fourier Transform (IDFT) 3-14
3.7 Computing DFT by Matrix Method 3-15
3.7.1 Solved Examples of DFT 3-16
3.8 Discrete Fourier Transform (DFT) Properties 3-29
3.8.1 Linearity 3-29
3.8.2 Periodicity 3-30
3.8.3 Circular Time Shift 3-31
3.8.4 Circular Frequency Shift 3-38
3.8.5 Time Reversal 3-39
3.8.6 Symmetry Property 3-40
3.8.7 Complex Conjugate Property 3-44
3.8.8 Parseval's Theorem 3-45
3.8.9 Multiplication of Two Sequences 3-46
3.8.10 Circular Convolution Property 3-47
3.9 Circular Convolution 3-47
3.9.1 Concentric Circle Method 3-47
3.9.1(A) Solved Example on Concentric Circle Method 3-47
3.9.2 Matrix Method 3-51
3.9.2(A) Solved Example on Matrix Method 3-51
3.9.3 Getting Linear Convolution from Circular Convolution 3-54
3.9.4 Solved Examples 3-54
3.10 Filtering of Long Duration Signals 3-60
3.10.1 Overlap - Save Method 3-60
3.10.2 Overlap - Add Method 3-62
3.10.3 Solved Examples on Method 3-64
3.11 Summary of DFT properties 3-66
3.12 2 D- Discrete Fourier Transform (2-DFT) 3-66
3.12.1 The Separability Property 3-66
3.12.2 Solved Examples on 2- DFT 3-67

Chapter 4 : Fast Fourier Transform 4-1 to 4-41

Syllabus :

Need of FFT, Radix-2 DIT-FFT algorithm, DIT-FFT Flow graph for N=4 and 8, Inverse FFT algorithm.

4.1 Introduction 4-1
4.2 Computational Complexity of DFT 4-1
4.3 Decimation In Time FFT (DIT-FFT) 4-2
4.4 Bit Reversal Format 4-6
4.4.1 Solved Examples on Bit Reversal Format 4-6
4.5 Decimation in Frequency FFT (DIT-FFT) 4-17
4.5.1 Solved Examples on DIT-FFT 4-20
4.6 Computational Complexity Comparison between DFT and FFT 4-30
4.6.1 Solved Examples on Computation of Inverse DFT using FFT Algorithms 4-31
4.6.2 Filtering using FFT Algorithms 4-37

Chapter 5 : Introduction to Image Processing 5-1 to 5-14

Syllabus :

Introduction to Digital Image, Digital Image Processing System, Image File Formats : BMP, TIFF and JPEG.

5.1 Introduction 5-1
5.2 What Do We Mean by Image Processing ? 5-1
5.3 Images 5-2
5.4 The Electromagnetic Spectrum 5-3
5.5 Units of Intensity 5-3
5.6 Basic Elements/Steps of an Image Processing System 5-4
5.7 Image Types 5-9
5.8 Image File Formats 5-12
5.9 Image Processing, Computer Graphics and Computer Vision 5-13

Chapter 6 : Sampling and Quantization 6-1 to 6-10

Syllabus :

Sampling and Quantization, Representation of Digital Image

6.1 Introduction 6-1
6.2 Sampling 6-1
6.3 Quantization 6-5
6.4 Isopreference Curves 6-8
6.5 Non-uniform Sampling 6-9
6.6 Physical Resolution 6-9
6.6.1 Solved Examples on Physical Resolution 6-9

Chapter 7 : Image Enhancement in Spatial Domain 7-1 to 7-35

Syllabus :

Gray Level Transformations, Zero Memory Point Operations, Neighborhood Processing, Spatial Filtering, Smoothing and Sharpening Filters, Median Filter.

7.1 Introduction 7-1
7.2 Spatial Domain Methods 7-1
7.3 Point Processing / Zero Memory Operation 7-2
7.4 Neighbourhood Processing 7-9
7.4.1 Low Pass Filtering (Smoothing) 7-10
7.4.2 Noise 7-10
7.4.3 Low Pass Averaging Filter 7-11
7.4.4 Low Pass Median Filtering 7-14
7.5 Highpass Filtering 7-16
7.6 High-Boost Filtering 7-18
7.7 Zooming 7-19
7.7.1 Replication 7-20
7.7.2 Linear Interpolation 7-21
7.8 Solved Examples 7-22
7.9 Comparison of Contrast Stretching and Thresholding 7-34

Chapter 8 : Histogram Modelling 8-1 to 8-20

Syllabus :

Histogram Processing, Histogram equalization.

8.1 Introduction 8-1
8.1.1 Mean and Standard Deviation of Histogram 8-3
8.2 Linear Stretching 8-3
8.2.1 Solved Examples on Linear Stretching 8-3
8.3 Histogram Equalization 8-6
8.3.1 Solved Examples on Histogram Equalization 8-7
8.4 Histogram Specification 8-12
8.4.1 Solved Example Histogram 8-12
8.5 Solved Examples on Histogram Modelling 8-13

Chapter 9 : Segmentation 9-1 to 9-23

Syllabus :

Segmentation based on Discontinuities (point, Line, Edge), Image Edge detection using Robert, Sobel, Previtt masks, Image Edge detection using Laplacian Mask. Connectivity

9.1 Introduction 9-1
9.2 Image Segmentation based on Discontinuities 9-2
9.2.1 Point Detection 9-2
9.2.2 Line Detection 9-2
9.2.3 Edge Detection 9-3
9.3 Detection of Edges 9-5
9.3.1 Computing the Gradient 9-5
9.4 Finding Gradients using Masks 9-6
9.4.1 Roberts Mask 9-7
9.4.2 Prewitts and Sobel Operators 9-8
9.4.3 Compass Operators 9-11
9.5 Image Segmentation using the Second Derivative - the Laplacian 9-13
9.5.1 Laplacian of Gaussian Operator 9-14
9.5.2 Canny Edge Detector 9-16
9.6 Connectivity 9-16
9.6.1 Solved Examples on Connectivity 9-18
9.7 Distance Transform 9-18
9.7.1 Solved Examples on Distance Transform 9-19
9.8 Additional Solved Examples 9-19

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