CURRICULUM AND SYLLABUS FOR

M.TECH IN ELECTRONICS

WITH SPECIALIZATION IN

SIGNAL PROCESSING

of Cochin University of Science & Technology (CUSAT)
at

Govt. Model Engineering College, Thrikkakara
(Managed by IHRD, Govt. of Kerala)

Proposed Course Structure for M.Tech in Electronics with Specialization in Signal Processing

First Semester

Course Code	Name of Course	Internal Marks	Ext. Marks	Total Marks	Credits
SP101	Fundamentals of Spectral estimation	50	50	100	3
SP102	Advanced Digital System Design	50	50	100	3
SP103	Digital Communication Techniques	50	50	100	3
	Laboratory	50	50	100	
SP109	Digital Signal Processing Lab -1	50	50	100	1
SP110	Digital Signal Processing Lab-2	50	50	100	1
SP111	Seminar	50	50	100	1
	Electives	50	50	100	
	Elective-1	50	50	100	3
	Elective-2	50	50	100	3
Total Credit					18

Second Semester

Course Code	Name of Course	Internal Marks	Ext. Marks	Total Marks	Credits
SP201	Adaptive signal processing	50	50	100	3
SP202	VLSI architectures for DSP	50	50	100	3
SP203	Digital Image Processing	50	50	100	3
	Laboratory	50	50	100	
SP209	Digital Signal Processing Lab -3	50	50	100	1
SP210	Digital Image Processing Lab	50	50	100	1
SP211	Seminar	50	50	100	1
	Electives	50	50	100	
	Elective-1	50	50	100	3
	Elective-2	50	50	100	3
Total Credit					18

Third Semester

Course Code	Name of Course	Internal Marks	Ext. Marks	Total Marks	Credits
SP301	Project work	100	200	300	18

Fourth Semester

Course Code	Name of Course	Internal Marks	Ext. Marks	Total Marks	Credits
SP401	Project work	100	200	300	18

List of Electives

First Semester

Course Code	Name of Course	Internal Marks	Ext. Marks	Total Marks	Credits
First Semester Electives					
SP104	Multidimensional Signal Processing	50	50	100	3
SP105	Biomedical Signal Processing	50	50	100	3
SP106	Multirate Signal Processing	50	50	100	3
SP107	Digital Signal processors	50	50	100	3
SP108	Digital Control systems	50	50	100	3

Second Semester

Course Code	Name of Course	Internal Marks	Ext. Marks	Total Marks	Credits
Second Semester Electives					
SP204	Array signal processing	50	50	100	3
SP205	Signal Compression Techniques	50	50	100	3
SP206	Wavelet Transforms- Theory and Applications	50	50	100	3
SP207	Artificial Neural Networks	50	50	100	3
SP208	Advanced Microprocessor Architectures				
SP209	Speech Processing	50	50	100	3

SP 101 Fundamentals of Spectral estimation

Module 1:

Fundamentals of Discrete Time Signal Processing:

Mathematical representation of Signals, Transform Domain representation of Continuous and Discrete signals, Fourier Series and Fourier Transforms, Sampling, DFT, Z Transform, Representing narrow band signals, Discrete Time systems, Analysis of LTI Systems, Response to Periodic inputs, Correlation analysis and spectral density, Minimum phase and system invertibility, All pass systems, Minimum phase and all pass decomposition, Spectral factorization.

Module 2:

Random variables, vectors and sequences:

Review of Random variables and Random vectors, Discrete time stochastic processes, Linear systems with stationary random inputs, Whitening and innovations representations- Transformations using eigen and triangular decomposition, Discrete Karhunen Loeve transform, Principles of estimation theory.

Module 3

Linear signal models: Linear non parametric signal models, parametric pole zero signal models, Mixed Processes and the Wold decomposition, all-pole models, Linear Prediction, Autoregressive models, all zero models, Moving average models, pole-zero models, Auto regressive Moving Average Models.

Module 4

Non Parametric spectral estimation: Spectral analysis of deterministic signals, Estimating auto correlation of stationary random signals, estimating power spectrum of stationary random signals- periodogram, Blackmann Tukey method, Welch Bartlett method.

Module 5

Parametric Model Based spectral analysis: Spectral analysis based on AR, MA or ARMA, relation between model parameters and the auto correlation sequence, Power spectrum estimation using an AR model- the Yule Walker method.

Text Book:

1.Statistical and Adaptive signal processing- Manalokis, Ingle and Kogon, Artech House INC., 2005.

2.Digital Signal Processing, A Computer Based approach- Sanjit K Mitra, Tata McGraw-Hill

References:

1.Introduction to spectral analysis, Stoica, R L Moses, Prentice Hall

2.Modern Spectral Estimation Theory and Applications, Kay S M, Prentice Hall

SP 102 Advanced Digital System Design

Module 1

MSI and LSI circuits and their applications: Arithmetic circuits, comparators, Multiplexers, Code Converters, XOR & AOI Gates, Wired Logic, Bus-oriented structures, Tri-state bus systems, Propagation Delay

Module 2

Sequential Circuit Design: Clocked Synchronous State Machine Analysis, Mealy and Moore machines, Finite State Machine design procedure –state diagrams, state tables, state reduction methods, state assignments. Incompletely specified state machines, implementing the states of FSM

Module 3

Designing with Programmable Logic Devices: Read Only Memories, Programmable Array Logic, Programmable Logic Arrays, PLA minimization and PLA folding, Other Sequential PLDs, Design of combinational and sequential circuits using PLDs. XILINX FPGAs – Configurable Logic Block (CLB), Input/ Output Block(IOB), Programmable Interconnection Points(PIP), XILINX CPLDs

Module 4

Asynchronous sequential circuits: Derivation of excitation table, Race conditions and cycles, Static and dynamic hazards, Methods for avoiding races and hazards, essential hazards, Designing with SM charts – State machine charts, Derivation of SM charts, and Realization of SM charts.

Module 5

Advanced Topics in Boolean algebra: Shannon's Expansion Theorem, Consensus Theorem, Reed Muller Expansion, Design of Static Hazard free and dynamic hazard free logic circuits, Threshold logic, Symmetric functions

TEXT BOOKS

1. Fundamentals of Digital Design, Charles H. Roth, Jr., PWS Pub.Co. 1998.
2. Digital Design Fundamentals, Kenneth J Breeding, Prentice Hall, Englewood Cliffs, New Jersey,1989.

REFERENCES

1. A Systematic Approach to Digital Design, William I. Fletcher, PHI, 1996.
2. Introduction to Digital Design, James E. Palmer, David E. Perlman, Tata McGraw Hill, 1996.
3. Logic Synthesis, S.Devadas, A.Ghosh and K.Keutzer, McGraw Hill, 1994.
4. Logic Design Theory, N.N Biswas, Prentice Hall of India, 1st Edn,1993.
5. Digital Design Principles and Practices, John F. Wakerly, Prentice Hall, 4th Edition, 2001

SP 103 Digital Communication Techniques

Module I :

Random Variables and processes: Review of random variable: Moment generating function, Chernoff bound, Markov's inequality, Chebyshev's inequality, Central limit theorem, Chi square, Rayleigh and Rician distributions, correlation, Covariance matrix- Stationary processes, wide sense stationary processes, ergodic process, cross correlation and autocorrelation functions- Gaussian process

Module II :

Communication over Additive Gaussian noise channels: Characterization of communication signals and systems- signal space representation-connecting linear vector space to physical waveform space- scalar and vector communication over memory less channels. Optimum waveform receiver in additive white gaussian noise (AWGN) channels

Module III :

Cross correlation receiver, Matched filter receiver and error probabilities. Optimum receiver for signals with random phase in AWGN channels-optimum receiver for binary signals- optimum receiver for M-ary orthogonal signals- probability of error for envelope detection of M-ary orthogonal signals, Optimum waveform receiver for colored gaussian noise channels- Karhunen-Loeve expansion approach, whitening

Module IV :

Digital communication over fading channels Characterization of fading multipath channels- Statistical models for fading channels- Time varying channel impulse response- narrow band fading models- wideband fading models- channel correlation functions- key multipath parameters- Rayleigh and Ricean fading channels, Optimum non-coherent receiver in random amplitude, random phase channels- performance of non-coherent receiver in random amplitude, random phase channels- performance in Rayleigh and Rician channels- performance of digital modulation schemes such as BPSK, QPSK, FSK, DPSK etc over wireless channels

ModuleV :

Communication over band limited channels: Communication over band limited channels- Optimum pulse shaping- Nyquist criterion for zero ISI, partial response signaling- equalization techniques- zero forcing linear equalization- decision feedback equalization

Text Book:

1. J.G Proakis, " Digital Communication", MGH 4th edition, 1995

Reference Books:

1. Edward A. Lee and David G. Messerschmitt, " Digital Communication", Allied Publishers (second edition)
2. J Marvin K. Simon, Sami M. Hinedi and William C Lindsey, " Digital communication techniques" PHI
3. William Feller, " An introduction to Probability Theory and its applications", vol 11, Wiley 2000
4. Sheldon M. Ross, " Introduction to probability models", Academic press, 7th edition

SP 104 Multidimensional signal processing

Module 1

Multidimensional Discrete signals and Multidimensional systems: Frequency domain characterization of multidimensional signals and systems, sampling two dimensional signals, processing continuous signals with discrete systems,

Discrete Fourier analysis of multidimensional signals: Discrete Fourier series representation of rectangularly periodic sequences, Multidimensional DFT, definition an properties, Calculation of DFT, Vector radix FFT, Discrete Fourier transforms for general periodically sampled signals, relationship between M dimensional and one dimensional DFTs.

Module 2

Design and implementation of two dimensional FIR filters: Implementation, Design using windows, Optimal FIR filter design- least squares design, Design of cascaded and parallel 2 D FIR filters, Design and implementation of FIR filters using transformations

Module 3

Multidimensional Recursive systems: Finite order difference equations- realizing LSI systems using difference equations, recursive computability, boundary conditions, ordering the computation of output samples, Multidimensional Z Transforms, stability of 2 D recursive systems, stability theorems, Two dimensional complex cepstrum.

Module 4

Design and implementation of two dimensional IIR filters: classical 2 D IIR filter implementations, Iterative implementation of 2 D IIR filters, signal flow graphs- circuit elements and their realizations, state variable realizations, Space domain Design techniques- Shank's method, Descent methods, Iterative pre-filtering design method, Frequency domain design techniques, stabilization techniques.

Module 5

2 dimensional Inverse problems: Constrained iterative signal restoration; iterative techniques for constrained deconvolution and signal extrapolation, reconstructions from phase or magnitude, Reconstruction of signals from their projections: Projection slice theorem, Discretization of the Reconstruction problem, Fourier domain reconstruction algorithms, Convolution/ back-projection algorithms, iterative reconstruction algorithms, Fan beam algorithms, Projection of discrete signals.

Text Book

1. Multidimensional Digital Signal Processing - Dan E Dudgeon and R M Mersereau, Prentice Hall

References

1. Digital Signal and Image Processing- Tamal Bose, John Wiley publishers.

2. Two dimensional signal and Image Processing- J S Lim, Prentice Hall.

SP 105 Biomedical Signal Processing

Module 1

Introduction to Biomedical Signals - Examples and acquisition of Biomedical signals - ECG, EEG, EMG etc - Tasks in Biomedical Signal Processing - Computer Aided Diagnosis. Origin of bio potentials

Module 2

Review of linear systems - Fourier Transform and Time Frequency Analysis (Wavelet) of biomedical signals- Processing of Random & Stochastic signals - spectral estimation – Properties and effects of noise in biomedical instruments - Filtering in biomedical instruments

Module 3

Concurrent, coupled and correlated processes - illustration with case studies - Adaptive and optimal filtering -Modeling of Biomedical signals - Detection of biomedical signals in noise - removal of artifacts of one signal embedded in another -Maternal-Fetal ECG - Muscle-contraction interference. Event detection - case studies with ECG & EEG - Independent component Analysis - Cocktail party problem applied to EEG signals - Classification of biomedical signals.

Module 4

Cardio vascular applications : Basic ECG - Electrical Activity of the heart- ECG data acquisition – ECG parameters & their estimation - Use of multiscale analysis for ECG parameters estimation - Noise & Artifacts- ECG Signal Processing: Baseline Wandering, Power line interference, Muscle noise filtering – QRS detection - Arrhythmia analysis - Data Compression: Lossless & Lossy- Heart Rate Variability – Time Domain measures - Heart Rhythm representation - Spectral analysis of heart rate variability - interaction with other physiological signals.

Module 5

Neurological Applications : The electroencephalogram - EEG rhythms & waveform - categorization of EEG activity - recording techniques - EEG applications- Epilepsy, sleep disorders, brain computer interface. Modeling EEG- linear, stochastic models - Non linear modeling of EEG - artifacts in EEG & their characteristics and processing - Model based spectral analysis - EEG segmentation - Joint Time-Frequency analysis - correlation analysis of EEG channels - coherence analysis of EEG channels.

Text Book

1. Biomedical Signal Processing: Principles and techniques, D.C.Reddy, Tata McGraw Hill, New Delhi, 2005

2. Biosignal and Biomedical Image Processing, Marcel Dekker, Semmlow, 2004

Reference Books:

1. Biomedical Signal Processing & Signal Modeling, Bruce, Wiley, 2001

2. Bioelectrical Signal Processing in Cardiac & Neurological Applications, Sörnmo, Elsevier

3. Biomedical Signal Analysis, Rangayyan, Wiley 2002.

5. Introduction to Biomedical Engineering, 2/e, Enderle, Elsevier, 2005

SP 106 Multirate Signal Processing

Module 1

Review of Single-Rate Discrete-Time Signals and Systems: Discrete-Time Signals, Discrete-Time Systems, Discrete-Time Fourier Transform, Discrete Fourier Transform The z-Transform, Structures for Discrete-Time Systems, Sampling the Continuous-Time Signal.

Basic Sampling alteration schemes: Time-Domain Representation of Down-Sampling and Up-Sampling, Frequency-Domain Characterization of Down-Sampling and Up-Sampling, Decimation and Interpolation-Identities, Cascading, Sampling-Rate Alteration Devices, Polyphase Decomposition, Multistage Systems.

Module 2

Filters in Multirate Systems: Spectral Characteristics of Decimators and Interpolators, Filter Specifications for Decimators and Interpolators, Computation of Aliasing Characteristics, Sampling Rate Alteration of Band pass Signals

FIR Filters for Sampling Rate Conversion Direct Implementation Structures for FIR Decimators and Interpolators, Poly-phase Implementation of Decimators and Interpolators, Memory Saving Structures for FIR Poly-phase Decimators and Interpolators, Computational Efficiency of FIR Decimators and Interpolators

Module 3

IIR Filters for Sampling Rate Conversion: Direct Implementation Structures for IIR Filters for Decimation and Interpolation, Computational Requirements for IIR Decimators and Interpolators, IIR Filter Structures Based on Polyphase Decomposition.

Sampling Rate Conversion by a Fractional Factor: Sampling Rate Conversion by a Rational Factor, Spectrum of the Resampled Signal, Polyphase Implementation of Fractional Sampling Rate Converters, Rational Sampling Rate Alteration with Large Conversion Factors, Sampling Rate Alteration by an Arbitrary Factor, Fractional-Delay Filters

Module 4

Lth-Band FIR Digital Filters

Lth-Band Linear-Phase FIR Filters: Definitions and Properties, Polyphase Implementation of FIR Lth-Band Filters, Separable Linear-Phase Lth-Band FIR Filters, Minimum-Phase and Maximum-Phase Transfer Functions, Halfband FIR Filters

Complementary FIR Filter Pairs

Definitions of Complementary Digital Filter Pairs, Constructing High pass FIR Filters, Analysis and Synthesis Filter Pairs, FIR Complementary Filter Pairs

Module 5

Multirate FIR Filter Banks: Two Channel FIR Filter bank, Alias free filter banks, Perfect reconstruction and Near Perfect reconstruction, Orthogonal Two channel FIR filter bank, Tree structured Multi-channel filter banks, Filter banks with equal pass bands, Octave Filter banks.

Text Book

1. Multirate filtering for Digital Signal processing- MATLAB applications, Ljiljana Milic, Information Science Reference, Hershey- New York, 2009

Reference

1. Multirate systems and filter banks. P.P. Vaidyanathan Prentice Hall. PTR. 1993.
2. Multirate digital signal processing . N.J. Fliege. John Wiley 1994.
3. Multirate Digital Signal Processing, R.E. Crochiere. L. R Prentice Hall. Inc.1983

SP 107 Digital signal processors

Module 1

DSPs and Conventional Microprocessors, Circular Buffering, Architectural features of DSP- Von Neumann, Harvard, Super Harvard architectures, Fixed vs. Floating point DSP processors, Programming in C vs Programming in assembly, speed benchmarks for DSPs, Multiprocessing for high speed DSP applications.

Module 2

TMS 320 C 55 x Digital Signal Processor: Architecture overview, Buses, memory maps, software development tools- C compiler, assembler, linker, Code Composer studio, Addressing modes and instruction set, pipelining and parallelism in TMS 320C 55X, Mixed C and Assembly programming

Module 3

TMS 320 C 6x: Architecture, Functional Units, Fetch and Execute Packets, Pipelining, Registers, Linear and Circular Addressing Modes, Indirect Addressing, Circular Addressing,TMS320C6x Instruction Set, Assembly Code Format, Types of Instructions, Assembler Directives, Linear Assembly, ASM Statement within C, C-Callable Assembly Function, Timers, Interrupts, Multichannel Buffered Serial Ports, Direct Memory Access, Memory Considerations, Fixed- and Floating-Point Formats, Code Improvement, Constraints

Module 4

SHARC Digital Signal Processor: - Architecture - IOP Registers - Peripherals - Synchronous Serial Port - Interrupts -Internal/External/Multiprocessor Memory Space - Multiprocessing - Host Interface - Link Ports

Module 5

Some Practical applications of Digital Signal Processors: Sine wave generators, Noise generators, DTMF Tone detection, Adaptive echo cancellation, Acoustic echo cancellation, Speech enhancement

Text Books:

1. Digital Signal Processing: A Practical guide for Engineers and scientists, Steven W Smith, Newness(Elsevier), 2003
2. Digital Signal Processing and applications with the C6713 and C6416 DSK, Rulf Chassaing, Wiley-Interscience, 2005
3. Real time Digital Signal Processing, Sen M Kuo, Bob H Lee, John Wiley and Sons, 2001.

References:

1. Digital Signal Processing Implementation using the TMS320C6000 DSP Platform, 1st Edition; Naim Dahnoun
2. Digital Signal Processing - A Student Guide,1st Edition, T.J. Terrel and Lik-Kwan Shark; Macmillan Press Ltd.
3. Digital Signal Processing: A System Design Approach, 1st Edition, David J Defatta J, Lucas Joseph G & Hodkiss William S ; John Wiley
4. Digital Signal Processing- A Practical approach, E C Elfeachor and B W Jervis, Pearson, 2005.
5. A Simple approach to Digital Signal processing, 1st Edition, Kreig Marven & Gillian Ewers; Wily Interscience
6. DSP FIRST - A Multimedia Approach, 1st Edition, James H. McClellan, Ronald Schaffer and Mark A. Yoder; Prentice Hall

SP 108 Digital Control Systems

Module 1

Sampling process: Sampling process- continuous and sampled signal, uniform impulse sampling- time domain and frequency domain analysis, aliasing, sampling theorem, data reconstruction, zero order hold, first order hold.

Module 2

Z Transform methods: Z transform definition- theorem, inverse Z Transform, mapping s plane to Z plane, linear constant coefficient difference equation, solution by recursion and Z transform method, principles of discretization.

Module 3

Design of digital control systems: Digital Control systems, pulse transfer function, Z Transform analysis of closed loop and open loop systems, steady state accuracy, characteristic equation, stability, tests for stability, frequency domain analysis, Bode diagrams- gain margin, phase margin, root locus techniques

Module 4

Design of Digital Control Systems: Cascade and feedback compensation using continuous data controllers, digital controller- design using bilinear transformation, root locus based design, digital PID controllers, Dead beat control design.

Module 5

State variable methods: State variable techniques for digital control systems, state space models- algebraic transformation-canonical forms, interrelations between Z Transform models and state variable models, controllability, observability, stability, response between sampling instants using state variable approach, state feedback, pole placement using state feedback, dynamic output feedback, SISO systems, effect of finite word length on controllability and closed loop placement, case study examples using MATLAB/clones.

Texts/References

1.Digital Control systems, Benjamin C Kuo, Saunders College publishing, 1997.
2.Digital control and state variable methods, M Gopal, Tata McGraw Hill publishers, 1997.
3.Discrete time control systems, Katsuhito Ogata, Prentice Hall
4.Digital Control systems, Constantine H Houpis and Gary B Lamont, McGraw Hill

SP 201 Adaptive Signal Processing

Module 1

Adaptive systems: definitions and characteristics, Open and Closed loop adaptation, Adaptive linear combiner, Performance function, Gradient and minimum mean square error, performance function, Gradient and minimum mean square error, Alternate expressions of gradient

Module 2

Theory of adaptation with stationary signals: Input correlation matrix, Eigen values and eigen vectors of the i/p correlation matrix

Searching the performance surface: Basic ideas of gradient search, Stability and rate of convergence, Learning curve, Newton's method, Steepest descent method, Comparison

Module 3

Gradient estimation and its effects on adaptation: Gradient component estimation by derivative measurement, performance penalty, Variances of the gradient estimate, effects on the weight – vector solution, Excess mean square error and time constants, misadjustments, total misadjustments and other practical considerations.

Module 4

Important adaptive algorithms: LMS Algorithm, Derivation, Convergence of the weight vector, learning curve, noise vector in weight vector solution, mis adjustment, performance, Z Transforms in Adaptive signal processing, other adaptive algorithms- LMS Newton , Sequential regression, Recursive least squares, adaptive recursive filters, random search algorithms, Adaptive Lattice predictor, Adaptive filters with orthogonal signals.

Module 5

Applications of Adaptive signal processing: Adaptive modeling of a multi-path communication channel, adaptive model in geophysical exploration, Inverse modeling, Adaptive interference canceling: applications in Bio-signal processing

Text Book:

1.Adaptive signal processing: Widrow and Stearns, Pearson
2.Statistical and Adaptive signal processing- Manalokis, Ingle and Kogon, Artech House INC., 2005.

References

1.Adaptive filter theory- 4th edition, Simon Haykin, Prentice Hall
2.Adaptive filters- A H Sayed, John Wiley
3.Adaptive filtering primer with MATLAB – A Poularikas, Z M Ramadan, Taylor and Francis Publications
4.Digital Signal and Image processing- Tamal Bose, John Wiley publications.

SP 202 VLSI Architectures for DSP

Module 1

Pipelining and parallel processing- pipelining of FIR filters, Parallel processing, pipelining and parallel processing for low power,

retiming- definitions and properties, solving system of inequalities, retiming techniques,

unfolding- algorithm for unfolding, properties of unfolding, critical path, unfolding and retiming, applications

folding- folding transformation, register minimization techniques, register minimization in folded architectures.

Module 2

Fast convolution – Cook Toom Algorithm, Winograd Algorithm, Iterated convolution, Cyclic convolution

Algorithmic strength reduction in filters and transforms- Parallel FIR filters, DCT and IDCT, Pipelined and parallel recursive and adaptive filters- pipeline interleaving in Digital filters, Pipelining in IIR digital filters, Parallel processing for IIR filters, Low power IIR filter design using pipelining and parallel processing.

Module 3

Scaling and round off noise – scaling and round off noise, state variable description of digital filters, scaling and round off noise computation, round off noise in pipelined IIR filters, Round off noise computation using state variable description, slow down, retiming and pipelining

Module 4

Digital lattice filter structures- Schur algorithm, Digital basic lattice filters, Derivation of one multiplier Lattice filter, Derivation of scaled-normalized lattice filter, Round off noise calculation in Lattice filters.

Bit level arithmetic architectures- parallel multipliers, interleaved floor plan and bit plane based digital filters, bit serial filter design and implementation, Canonic signed digital arithmetic.

Module 5

Synchronous, wave and asynchronous pipelines- Synchronous pipelining and clocking styles, clock skew and clock distribution in bit level pipelined VLSI designs, Wave pipelining, asynchronous pipelining

Text Book

1. VLSI DSP Systems- Design and Implementation – Keshab K Parhi, John Wiley, 2004.

References

1.Digital Signal Processing with Field Programmable Gate Arrays - Uwe Meyer Baese, Springer Verlag 2001.

2.Digital Signal Processors : Architectures , Implementations and applications, Sen M Kuo, Woon-Seng S. Gan, Prentice Hall, 2004

3.DSP integrated circuits, Lars Wanhammar, Academic Press, 1999.

SP 203 Digital Image processing

Module 1

Digital Image fundamentals: representation, elements of visual perception, simple image formation model, image sampling and quantization, basic relationship between pixels, imaging geometry.

Review of Matrix theory results: Row and Column ordering, Doubly Block Toeplitz for 2 D linear convolution, Doubly Block Circulant Matrices for circular convolution, Kronecker products, Unitary and orthogonal matrices.

Unitary Transforms for Image processing: General Unitary Transforms, DFT, DCT, DST, Hadamard Transform, Haar Transform, , Karhunen Loeve Transform.

Module 2

Image Enhancement: Spatial Domain Methods: point processing - intensity transformations, histogram processing, image subtraction, image averaging. Spatial filtering- smoothing filters, sharpening filters, Frequency Domain methods- low pass filtering, high pass filtering, homomorphic filtering, generation of spatial masks from frequency domain specifications

Module 3

Image restoration: Degradation model, Diagonalization of circulant and doubly block circulant matrices, Algebraic approaches- Inverse filtering, Wiener filtering, Constrained Least Squares restoration, Interactive restoration, Geometric transformations.

Module 4

Image Compression: Fundamentals, redundancy: coding, interpixel, psychovisual, fidelity criteria, Models, Elements of information theory, error free compression - variable length, bit plane, lossless predictive, lossy compression- lossy predictive, transform coding, Fundamentals of JPEG image compression, Wavelet based compression techniques- EZW, SPIHT,JPEG 2000.

Module 5

Image Segmentation: Detection of discontinuities- point, line, edge and combined detection, edge linking and boundary description, local and global processing using Hough Transform- Thresholding, Region oriented segmentation – basic formulation, region growing by pixel aggregation, region splitting and merging, use of motion in segmentation.

Color Image Processing: color models- RGB, CMY, YIQ, HIS, Pseudo coloring, intensity slicing, gray level to color transformation.

Text Book

1.Digital Image Processing- Gonzalez and Woods, Pearson education, 2002.

2.Fundamentals of Digital Image Processing – A K Jain, Pearson education, 2003.

References

1.Digital Image Processing- W K Pratt, John Wiley, 2004

2.Digital Signal and Image Processing- Tamal Bose, John Wiley publishers.

3.Two dimensional signal and Image Processing- J S Lim, Prentice Hall.

SP 204 Array Signal Processing

Module 1

Spatial Signals: Signals in space and time. Spatial frequency, Direction vs. frequency. Wave fields. Far field and Near field signals

Module 2

Sensor Arrays: Spatial sampling, Nyquist criterion. Sensor arrays. Uniform linear arrays, planar and random arrays. Array transfer (steering) vector. Array steering vector for ULA. Broadband arrays

Module 3

Spatial Frequency: Aliasing in spatial frequency domain. Spatial Frequency Transform, Spatial spectrum. Spatial Domain Filtering. Beam Forming. Spatially white signal

Module 4

Direction of Arrival Estimation : Non parametric methods - Beam forming and Capon methods. Resolution of Beam forming method. Subspace methods - MUSIC, Minimum Norm and ESPRIT techniques. Spatial Smoothing

Module 5

Higher order statistics in Signal Processing: Moments, Cumulants and poly spectra, Higher order moments and LTI systems

Text Book

1.Array Signal Processing: Concepts and Techniques., Dan E. Dugeon and Don H. Johnson. (1993). Prentice Hall.

2.Statistical and Adaptive signal processing- Manalokis, Ingle and Kogon, Artech House INC., 2005.

References

1.Spectral Analysis of Signals. Petre Stoica and Randolph L. Moses. (2005, 1997) Prentice Hall.

2.Array Signal Processing [Connexions Web site].February 8, 2005. Available at: http://cnx.rice.edu/content/col10255/1.3/

SP 205 Signal Compression Techniques

Module 1

Review of Information Theory: The discrete memoryless information source - Kraft inequality; optimal codes, Source coding theorem. Compression Techniques - Lossless and Lossy Compression - Mathematical Preliminaries for Lossless Compression -Huffman Coding - Optimality of Huffman codes - Extended Huffman Coding – Adaptive Huffman Coding - Arithmetic Coding - Adaptive Arithmetic coding, Run Length Coding, Dictionary Techniques - Lempel-Ziv coding, Applications - Predictive Coding - Prediction with Partial Match – Burrows Wheeler Transform, Dynamic Markov Compression.

Module 2

Rate distortion theory: Rate distortion function R(D),Properties of R(D); Calculation of R(D) for the binary source and the Gaussian source, Rate distortion theorem, Converse of the Rate distortion theorem, Quantization - Uniform & Non-uniform - optimal and adaptive quantization, vector quantization and structures for VQ, Optimality conditions for VQ, Predictive Coding - Differential Encoding Schemes

Module 3

Mathematical Preliminaries for Transforms, Karhunen Loeve Transform, Discrete Cosine and Sine Transforms, Discrete Walsh Hadamard Transform, Lapped transforms - Transform coding - Subband coding -Wavelet Based Compression - Analysis/Synthesis Schemes

Module 4

Data Compression standards: Zip and Gzip, Speech Compression Standards: PCM-G.711, ADPCM G.726, SBC G.722, LD-CELP G.728, CS-ACELP (-A) G.729, MPC-MLQ , G.723.1, GSM HR VSELP, IS-54 VSELP, IS-96 QCELP, Immarsat - B APC, MELP, FS 1015, LPC10, FS1016, CELP, G721.

Module 5

Audio Compression standards: MPEG, Philips PASC, Sony ATRAC, Dolby AC-3,

Image Compression standards: JBIG, GIF, JPEG & JPEG derived industry standards, CALIC, SPIHT, EZW, JPEG 2000.

Video Compression Standards: MPEG, H.261, H.263 & H264.

Text books

1. “Introduction to Data Compression”, Khalid Sayood, Morgan Kaufmann Publishers., Second Edn., 2005.
2. “Data Compression: The Complete Reference”, David Salomon, Springer Publications, 4th Edn., 2006.
3. “Elements of Information Theory," Thomas M. Cover, Joy A. Thomas, John Wiley & Sons, Inc., 1991.

Reference books

1. “Rate Distortion Theory: A Mathematical Basis for Data Compression”, Toby Berger, Prentice Hall,Inc., 1971.
2. “The Transform and Data Compression Handbook”, K.R.Rao, P.C.Yip, CRC Press., 2001.
3. “Information Theory and Reliable Communication”, R.G.Gallager, John Wiley & Sons, Inc., 1968.
4. “Multiresolution Signal Decomposition: Transforms, Subbands and Wavelets”, Ali N. Akansu, Richard A. Haddad, Academic Press. 1992
5. “Wavelets and Subband Coding”, Martin Vetterli, Jelena Kovacevic, Prentice Hall Inc., 1995.

SP 206 Wavelet Transforms: Theory and applications

Module 1

Continuous Wavelet Transform: Continuous time frequency representation of signals,tThe Windowed Fourier Transform, Uncertainty Principle and time frequency tiling, Wavelets, specifications, admissibility conditions, Continuous wavelet transform, CWT as a correlation, CWT as an operator, Inverse CWT.

Module 2

Discrete wavelet Transform: Approximations of vectors in nested linear vector spaces, Example of an MRA, Formal definition of MRA, Construction of genera orthonormal MRA, a Wavelet basis for MRA, Digital filtering interpretations- Decomposition and Reconstruction filters, examples of orthogonal basis generating wavelets, interpreting orthonormal MRA for Discrete time signals, Mallat algorithm Filter bank implementation of DWT

Module 3

Alternative wavelet representations- Biorthogonal Wavelets: biorthogonality in vector space, biorthogonal wavelet bases, signal representation using biorthogonal wavelet system, advantages of biorthogonal wavelets, biorthogonal analysis and synthesis, Filter bank implementation, Two dimensional Wavelets, filter bank implementation of two dimensional wavelet transform.

Module 4

Lifting scheme: Wavelet Transform using polyphase matrix factorization, Geometrical foundations of the lifting scheme, lifting scheme in the z- domain, mathematical preliminaries for polyphase factorization, Dealing with Signal Boundary.

Module 5

Applications: Image Compression: EZW Coding, SPIHT, Wavelet Difference Reduction Compression Algorithm, Denoising, speckle removal, edge detection and object isolation, audio compression, communication applications – scaling functions as signaling pulses, Discrete Wavelet Multitone Modulation.

Text Book

1.Insight into wavelets: From theory to Practice- K P Soman and K I Ramachandran, Prentice Hall of India

2.Wavelet Transforms: Introduction to theory and applications- R M Rao and A S Bopardikar, Pearson

References

1.Wavelets and filter banks- G Strang and T Q Nguyen, Wellesley Cambridge Press, 1998.

2.Fundamentals of Wavelets: Thory, Algorithms and Applications- J C Goswamy and A K Chan, Wiley-Interscience publications, John Wiley and sons, 1999

3.Wavelets and Multiwavelets- F Keinert, SIAM, Chapman and Hall/CRC, 2004

4.Ten Lectures on Wavelets- Ingrid Daubechies, SIAM, 1990

5.Wavelet Analysis- The scalable structure of Information- H L Resnikoff, R. O. Wells,Jr., Springer, 2004.

SP 207 Artificial Neural Networks

Module 1

Introduction to ANNs: Classical AI and Neural Networks, Human brain and the biological neuron, Artificial Neurons, Neural Networks and architectures, feed forward and feedback architectures, geometry of binary threshold neurons and their networks, Supervised and unsupervised learning, concepts of generalization and fault tolerance

Supervised learning: Perceptrons and LMS, Back propagation Neural Networks, Fast variants of Back propagation

Module 2

Statistical pattern recognition perspective of ANNs: Bayes theorem, Implementing classification decisions with the Bayes theorem, interpreting neuron signals as probabilities, Multilayered networks, error functions, posterior probabilities, error functions for classification problems, Support vector machines, RBFNNs, regularization theory, learning in RBFNNs, Image classification application, PNNs

Module 3

Recurrent Neural Networks: Dynamical systems, states, state vectors, state equations, attractors and stability, linear and non linear dynamical systems, Lyupanov stability, Cohen Grossberg theorem, Attractor neural networks: Associative learning, associative memory, Hopfield memory, Simulated annealing and the Boltzmann Machine, BAM, ART principles, Self Organizing Maps.

Module 4

Fuzzy Systems: Fuzzy sets, Membership functions, Measures of fuzziness, Fuzzification and defuzzification, Fuzzy relations, Neural Networks and Fuzzy logic, Fuzzy neurons, Fuzzy perceptron, Fuzzy classification networks using Backpropagation, Fuzzy ART

Module 5

Genetic algorithms and Evolutionary programming: Genetic algorithms – operators, working, Genetic algorithm based machine learning classifier system. Swarm Intelligent Systems: Ant Colony Systems (ACO): Biological concept, artificial systems - Applications, Particle Swarm Intelligent Systems – PCO method, Applications.

Text Book

1. Neural Networks, A Class room approach, Satish Kumar, Tata McGraw Hill, 2004
2. Artificial Intelligence and Intelligent Systems, N.P Padhy, Oxford University Press, 2005.

References

1. Introduction to Artificial Systems, J M Zurada, Jaico Publishers
2. Neural Networks –A Comprehensive Foundation, Simon Haykins, PHI
3. Advanced Methods in Neural Computing, Wasserman P.D, Van Nostrand Reinhold, NewYork.
4. Fuzzy Logic with Engineering Applications, Timothy J. Ross: TMH
5. Methods of Optimization". G. R Walsh, John Wiley & Sons.
6. Fuzzy Logic and Genetic Algorithms, Rajasekharan & Pai Neural Networks, PHI
7. Artificial Intelligence, Elaine Rich, Kevin Knight, Tata McGraw Hill, 2006
8. Artificial Neural Networks, Yegnanarayana, PHI, 1999
9. Introduction to Artificial Intelligence, E.Cherniak, D. McDermott, Addison – Wesley Pub. 1987
10. Fundamentals of Neural Networks- Architectures, Algorithms and Applications- L. Fausett, Pearson-Education, 2007.

SP 208 Advanced Microprocessor Architectures

Module 1

Introduction to general structure of advanced microprocessors, Discussions on bus architecture, instruction sets, interrupts, shared data problem, interrupt latency, memory hierarchy, pipelining and RISC principles.

Module 2

Instruction Pipeline, Design consideration and performance models, Dependency detection and resolution, Branch handling strategies, Static and dynamic pipeline, Scheduling techniques

Module 3

Vector processor: Memory processor interface, vectorization techniques, Performance issues, Advanced Pipelined Processor, Superpipelined processor, Superscaled processor: Instruction scheduling, Software pipelining, VLIW.

Module 4

Cache Memory, Organization, Cache addressing, Multilevel caches, Virtual Memory, Paged, segmented and paged organizations Address translation: Direct page table translation, Inverted page table, Table look aside buffer, Virtual memory accessing rules.

Module 5

Overviews of some popular PC System and Microprocessor Architectures – PCI System Architecture, PCMCIA System Architecture, Plug and Play System Architecture, Card Bus System Architecture.

TEXT BOOKS

1. Computer Architecture a quantitative approach,(International Student Edition) 3rd Edition, J.Hennessy and Patterson, Morgan Kaufmann, 2000
2. Advanced Microprocessors", (Computer Engineering Series)Daniel Taback; Mc-Graw Hill

REFERENCES

1. Architecture of high performance computers, Volume-1, RN Ibbett and N P Topham

SP209 Speech Signal Processing

Module 1

Speech Production :- Acoustic theory of speech production-Excitation, Vocal tract model for speech analysis, Formant structure, Pitch. Articulatory Phonetic -Articulation, Voicing, Articulatory model. Acoustic Phonetics- Basic speech units and their classification

Module 2

Speech Analysis :- Short-Time Speech Analysis, Time domain analysis- Short time energy, short time zero crossing Rate, ACF. Frequency domain analysis- Filter Banks, STFT, Spectrogram, Formant Estimation & Analysis, Cepstral Analysis

Module 3

Parametric representation of speech :- AR Model, ARMA model. LPC Analysis- LPC model, Auto correlation method, Covariance method, Levinson-Durbin Algorithm, Lattice form, LSF, LAR, MFCC, Sinusoidal Model, GMM, HMM

Module 4

Speech coding :- Phase Vocoder, LPC, Sub-band coding, Adaptive Transform Coding, Harmonic Coding, Vector Quantization based Coders, CELP

Module 5

Speech processing :- Fundamentals of Speech recognition, Speech segmentation. Text-to-speech conversion, speech enhancement, Speaker Verification, Language Identification, Issues of Voice transmission over Internet

Text Books

1.Discrete-Time Speech Signal Processing: Principles and Practice by Thomas F. Quatieri Publisher: Prentice Hall; ISBN: 013242942X; 1st edition (October 29, 2001)

2.Digital Processing of Speech Signals, Rabiner and Schafer, Prentice Hall, 1978.

Reference

1.Speech Communications : Human & Machine by Douglas O'Shaughnessy, IEEE Press, Hardcover 2nd edition, 1999; ISBN: 0780334493.

2.Speech and Audio Signal Processing : Processing and Perception of Speech and Music by Nelson Morgan and Ben Gold, July 1999, John Wiley & Sons, ISBN: 0471351547.

3.Speech Processing and Synthesis Toolboxes by Donald G. Childers, John Wiley & Sons, September 1999; ISBN: 0471349593

4.Fundamentals of Speech Recognition, Rabiner and Juang, Prentice Hall, 1994