NATIONAL INSTITUTE OF TECHNOLOGY SILCHAR

Syllabus

M. Tech

Communication and Signal Processing Engineering (CSPE)

Department of Electronics and |Communication Engineering

Course Structure

M.Tech in Communication & Signal Processing Engineering

	Semester I		
Code	**Course Name**	**L–T-P**	**Credits**
EC 5101	Linear Algebra and Random Processes	3-0-0	3
EC 5102	Communication System Theory	3-0-0	3
EC 5103	Signal Processing Algorithms and Architectures	3-0-0	3
EC 513X	Elective I	3-0-0	3
EC 514X	Elective-II	3-0-0	3
EC 5104	Signal Processing Lab	0-0-3	2
EC 5110	Seminar	0-0-2	1
	Total credits	**15-0-5**	**18**

List of Electives

Elective-I
EC 5131 Adhoc and Sensor Networks
EC 5132 Optical Communication and Networks
EC 5133 RF and Microwave Integrated Circuits
EC 5134 Satellite Communications
EC 5135 Information Theory and Coding
EC 5136 Detection & Estimation Theory
EC 5137 EMI/EMC

Elective-II
EC 5141 Image Processing
EC 5142 Adaptive Filter Theory
EC 5143 Biomedical Signal Processing
EC 5144 Smart Antennas
EC 5145 Digital Speech Processing
EC 5146 Cognitive Radio

M.Tech in Communication & Signal Processing Engineering

Second Semester (Jan-May)							
Code	**Course Name**	**Type**	**L**	**T**	**P**	**C**	
EC 5111	Wireless Communications	DC	3	0	0	3	
EC 5112	Communication Networks	DC	3	0	0	3	
EC 5113	Statistical Signal Processing	DC	3	0	0	3	
EC 5114	Advanced Communication Lab	CL	0	0	3	2	
EC 5120	Colloquium		0	0	0	1	
EC 515x	Elective III	DE	3	0	0	3	
EC 156x	Elective IV/**Open Elective**	OE	3	0	0	3	
		Total				18	

Elective-III:

EC-5151 Radar Signal Processing
EC-5152 Pattern Recognition
EC-5153 MIMO Communication
EC-5154 Medical Image Processing
EC-5155 Human Computer Interface
EC-5156 Microwave and Millimeter Integrated Circuits

Elective IV/Open Elective:

EC-5161 Computer Vision
EC-5162 Soft Computing
EC-5163 Wireless Sensor Networks
EC-5164 Introduction to Machine Learning
EC-5165 Mobile Computing
EC-5166 Green ICT
EC-5167 Optimization Techniques

First Semester

EC 5101 Linear Algebra and Random Processes L T P C 3-0-0- 3

Introduction to linear algebra: Field, Group, Rings, axioms of algebra, Cartesian products, vector formation, vector space, orthogonality, basis vectors, metric, norms, Lp space, norm space, Cauchy's sequence, Hilbert space, Kernel Space,

Matrices, row space column space of matrix, Rank of a matrix, Linear Transformation, Spectral Decomposition (Eigen and SVD), matrix Inverse, Elementary and Invertible matrices, LU factorization, Fourier series and Transform space and representation of frequency components as basis of these spaces.

Order statistics, Mean, variance and other moments. Conditional Mean. Covariance, correlation coefficient, Markov inequality, Chebyshev inequality, and Chernoff bound, Joint moments, covariance matrices. Characteristic function.

MMSE Estimation: definition and estimation by a constant; linear estimation, MMSE Estimation: unconstrained; Orthogonality principle.

Convergence of sequence of real numbers, Convergence of random variables (almost surely, $r^{\wedge th}$ mean, in probability, in distribution), Law of large numbers (Weak and Strong) and Central Limit Theorem, Convergence of Binomial Distribution to Poisson, Discrete-time Markov Chains, definitions, examples.

Random processes: definitions, mean, auto-correlation, and auto-covariance function. First and higher order density of random processes, Independent and Stationary Increments Property, Gaussian random process, Brownian motion, Cross-correlation and cross-covariance, Cyclo-stationary processes, Random processes in linear systems. WSS processes in LTI systems.

Discrete Random Processes in LTI systems. Ergodicity, mean ergodicity, ergodicity with respect to the first and second order density function.

Texts/References:

1. K. Hoffman and R. Kunze: Introduction to Linear Algebra; Prentice-Hall, 1996, 2/e.
2. G. Strang: Introduction to linear algebra, Wellesley-Cambridge Press and SIAM, 2009, 4/e.
3. Kai Lai Chung: A Course in Probability Theory; Academic Press, 2001, 3/e
4. A. Papoulis and S. U. Pillai: Probability, Random Variables and Stochastic Processes, 4th Edn., McGraw-Hill, 2002.
5. Robert B. Ash and C. D. Dade: Probability and Measure Theory, Academic Press; 1999, 2/e

Course Outcome:

CO-1: Identify and Comprehend linear algebraic structures that appear in various areas of Communication and Signal Processing

CO-2: Identify and Apply properties of eigenvalues and orthogonality to analyze computational problems.

CO-3: Identify and Apply estimation techniques in solving real life problems in Communication and Signal Processing.

CO-4: Comprehend and Use the properties of random processes in real world situations for LTI systems.

EC 5102 **Communication System Theory** **L T P C 3-0-0- 3**

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Review of digital modulation schemes and receivers in additive white Gaussian noise channels, continuous phase modulation(CPM),minimum-shift keying(MSK),continuous phase frequency shift keying (CPFSK); Inter-symbol interference; Adaptive receivers and channel equalization: MMSE, ZFE; Carrier and clock synchronization; Effects of phase and timing jitter; Block codes, Convolutional codes and their performance evaluation; Coded modulation schemes: TCM; Turbo codes; Digital transmission over fading channels; Multi-channel and multi-user communication systems.

Texts/References Books:

1. S Benedetto and E Biglieri, Principles of Digital Transmission with Wireless Applications, Kluwer Academic, 1999.
2. R G Gallager, Principles of Digital Communication, Cambridge University Press, 2008.
3. J G Proakis, Digital Communication, McGraw Hill, 4th edition, 2000.
4. Ha H. Nguyen and Ed Shwedyk, A First Course in Digital Communications, Cambridge University Press, 2011
5. U Madhow, Fundamentals of Digital Communication, Cambridge University Press, 2008

Course Outcome (CO)

CO-1: Students can learn about different modulation techniques and their applications
CO-2: Student will be able to analyze the performance of wireless systems for different modulation schemes
CO-3: Students will become familiar with the wireless receiver design and channel equalization
CO-4: Students will get the knowledge of different carrier synchronization techniques
CO-5: Students will able to evaluate the performance of different channel coding techniques
CO-6: Students will be able model and analyze digital transmissions over fading channel

EC 5103 Signal Processing Algorithms and Architectures L T P C 3-0-0- 3

Orthogonal transforms: DFT, DCT and Haar; Properties of DFT; Computation of DFT: FFT and structures, Decimation in time, Decimation in frequency; Linear convolution using DFT;

Digital filter structures: Basic FIR/IIR filter structures, FIR/IIR Cascaded lattice structures, Parallel all pass realization of IIR transfer functions, Sine- cosine generator; Computational complexity of filter structures;

Multirate signal processing: Basic structures for sampling rate conversion, Decimators and Interpolators; Multistage design of interpolators and decimators; Poly-phase decomposition and FIR structures; computationally efficient sampling rate converters; **Arbitrary sampling rate converters based on interpolation algorithms:** Lagrange interpolation, Spline interpolation; Quadrature mirror filter banks; Conditions for perfect reconstruction; Applications in sub-band coding;

Digital Signal Processors introduction: Computational characteristics of DSP algorithms and applications; Techniques for enhancing computational throughput: Harvard architecture, parallelism, pipelining, dedicated multiplier, split ALU and barrel shifter;

TMS320C64xx architecture: CPU data paths and control, general purpose register files, register file cross paths, memory load and store paths, data address paths, parallel operations, resource constraints.

Texts/References:

1. J. G. Proakis and D. G. Manolakis, Digital Signal Processing: Principles, Algorithms and Applications, Pearson Prentice Hall, 2007
2. A.V. Oppenheim and R.W. Schafer, Discrete- Time Signal Processing, PHI, 2000.
3. S. K. Mitra, Digital Signal Processing: A Computer Based Approach, 3rd Edn., TMH, 2008.
4. R. Chassaing and D. Reay, Digital signal processing and applications with TMS320C6713 and TMS320C6416, Wiley, 2008.
5. Rulph Chassaing and Donald Reay, Digital signal processing and applications with TMS 320C6713 and TMS320C6416, Wiley, 2008.
6. TMS320C64x Technical Overview, Texas Instruments, Dallas, TX, 2001.
7. TMS320C6000 Peripherals Reference Guide, Texas Instruments, Dallas, TX, 2001.
8. TMS320C6000 CPU and Instruction Set Reference Guide, Texas Instruments, Dallas, TX, 2000.

Course Outcome:

CO-1: Students can able to **understand and apply** orthogonal transforms to signal processing applications.

CO-2: Students can able to **learn** and **implement** the digital filters to computational complexity problems.

CO-3: Students can able to **lean and apply** the multirate signal processing concepts to speech and signal compression applications.

CO-4: Students can able to **learn** the Computational characteristics of DSP algorithms and technique to improve computational throughput.

EC 5131 **Adhoc and Sensor Networks** **L T P C 3-0-0- 3**

Introduction of ad-hoc/sensor networks: Key definitions of ad-hoc/sensor networks, Advantages of adhoc/sensor networks, Unique constraints and challenges, Driving Applications.

Wireless Communications/Radio Characteristics

Ad-Hoc wireless networks

Media Access Control (MAC) Protocols: Issues in designing MAC protocols, Classifications of MAC protocols, MAC protocols.

*Routing Protocols:*Issues in designing routing protocols, Classification of routing protocols, Routing protocols. *Networking Sensors:* Unique features, Deployment of ad-hoc/sensor network, Sensor tasking and control, Transport layer and security protocols.

Sensor Network Platforms and Tools: Sensor network programming challenges, Embedded Operating System. *Applications of Ad-Hoc/Sensor Network and Future Directions:* Ultra wide band radio communication, Wireless fidelity systems.

Text/Reference books:

1.	Adhoc Sensor Network Theory and applications	Dharma Prakash Aggarwal	World Scientific Publishing Company
2.	Wireless Sensor Networks	Karl and Willig	Willey publication Ltd
3.	Adhoc Wireless Network	Murthy	Pearson publication

Course Outcome:

CO-1: Identify and comprehend the fundamentals of Ad-Hoc and Sensor netwrok

CO-2: Comprehend Media Access protocols and be able to use them in various applications.

CO-3: Understand various Routing protocols and be able to apply them in various applications.

CO-4: Comprehend embedded operating system and future direction of adhoc and Sensor network.

EC 5132 Optical Communication and Networks L T P C 3-0-0- 3

Introduction to optical networks: Telecommunication network architecture, services, circuit switching, and packet switching, optical networks, the optical layer, transparency and all-optical networks, optical packet switching, transmission basics, network evolution. *I. Technology:*

Propagation of signals in optical fiber: Light propagation in optical fiber, loss and bandwidth, chromatic dispersion, nonlinear effects, solitons and problems.

Components: Couplers, isolators and circulators, multiplexers and filters, optical amplifiers, transmitters, detectors, switches, wavelength converters and problems.

Modulation and Demodulation: Modulation, Subcarrier modulation and multiplexing, spectral efficiency, demodulation, error detection and corrections and problems.

Transmission system engineering: System model, power penalty, transmitter, receiver, optical amplifier, crosstalk, dispersion, fiber nonlinearities, wavelength stabilization, design of soliton systems, design of dispersion managed soliton system, overall design considerations and problems.

II. Networks:

Client layers of the optical layer: SONET/SDH, Multiplexing, SONET/SDH layers, SONET frame structures, SONET/SDH physical layers ATM, IP, storage area networks, ESCON, HIPPI and problems.

WDM Network elements: Optical line terminals, optical line amplifiers, optical add/drop multiplexers, optical crossconnects and problems.

WDM Network Design: Cost trade-offs: A detailed ring network example, LTD and RWA problems, Dimensioning Wavelength-Routing networks, statistical dimensioning models, maximum load dimensioning models and problems.

Control and Management: Optical layer services and interfacing, layers within the optical layer, multivendor interoperability, performance and fault management, configuration management and problems.

Network Survivability: Basic concepts, protection in SONET/SDH, protection in IP networks, why optical layer protection, optical layer protection scheme, internetworking between layers and problems.

Access Networks: Network architecture overview, enhanced HFC, FTTC and problems.

Photonic packet switching: Optical time division multiplexing, synchronization, header processing, buffering, burst switching, test beds and problems.

Development Consideration: The evolving telecommunications network, designing the transmission layer (using TDM, SDM, WDM), unidirectional versus bidirectional WDM systems.

Text Books:

1.	Optical Networks	R.Ramaswami, K.N.Sivarajan	Elsevier

References Books:

1.	Optical Communication System	J.Gower	Prentice Hall of India
2.	Optical Fiber Communication	John M. Senior	Pearson Education
3.	Optical Fiber Communication	Gerd Keiser	Mc Graw Hill
4.	Optical Networks	Rajiv Ramaswami	Elsevier
5.	Fiber-optic communication systems	Govind P. Agrawal	John Wiley & sons
6.	Fiber Optics and Optoelectronics	R.P. Khare	Oxford University Press

Course Outcome:

CO-1: Comprehend the fundamentals of Optical network and propagation of signals in optical fibre.

CO-2: Understand various optical components, modulation, demodulation process and Transmission system engineering models.

CO-3: Comprehend details about optical network, SONET/SDH and their control & management.

CO-4: Understand network survivability, access network and photonic packet switching.

EC 5133 RF and Microwave Integrated Circuits L T P C 3-0-0- 3

Introduction: Lower Frequency Analog Design and Microwave Design Versus Radio Frequency Integrated Circuit Design, RFIC used in a Communication Transceiver, Review of Transmission Line Theory, Distributed Transmission Lines, Smith Chart, Impedance Matching, Microstrip and Coplanar Waveguide Implementations, S Parameters, Components and Interconnects at High frequencies.
Issues in RFIC Design: Noise – Thermal Noise, Noise Power, Noise Figure, Phase Noise; Linearity and Distortion in RF Circuits – Third Order Intercept Point, Second Order Intercept Point, 1-dB Compression Point, Relationships between 1-dB compression point and IP3 Points, Broadband Measures of Linearity; Modulated Signals – PM, FM, MSK, QAM, OFDM.
LNA Design: Basic Amplifiers, Feedback Techniques, Noise in Amplifiers, Linearity in Amplifiers, Stability Analysis, Differential Amplifiers, Low Voltage Topologies and Use of on-chip Transformers, DC Bias, Broadband LNA Design, CMOS LNA Example.
Mixers: Basic Mixer Operation, Transconductance Controlled Mixer, Double Balanced Mixer, Mixer Noise, Linearity, Isolation, Genera Design Comments, Image Reject and Single-Sideband Mixer, Alternative Mixer Designs, CMOS Mixer Example.
Voltage Controlled Oscillators: LC Resonator, Analysis of Oscillator as Feedback System, Negative Resistance Oscillator, Differential Topologies, Colpitts Oscillator, Phase Noise Reduction Techniques, Quadrature Oscillators and Injection Locking. CMOS Example.
Frequency Synthesis: PLL Components, Continuous Time Analysis of PLL Synthesizers, Discrete Time Analysis for PLL Synthesizers, Transient Behaviors, Fractional – N PLL Frequency Synthesizers, CMOS Example.
Power Amplifiers: Introduction, Power Capability, Efficiency, Matching Considerations, Class A,B,C,D,E,F,G amplifiers, AC Load line, Transistor Saturation, Power Combining Techniques, Effects and Implications of Nonlinearity – Cross Modulation, AM – PM Conversion, Spectral Regrowth, Linearization Techniques, Feedforward, Feedback, Predistortion, CMOS Power Amplifier Example.

Text/Reference books:

1.	The Design of CMOS Radio-Frequency Integrated Circuits	Thomas H. Lee	Cambridge University Press
2.	Radio Frequency Integrated Circuit Design	Rogers and Plett	Artech House Publishers
3.	RF Power Amplifiers for Wireless Communications	Steve C. Cripps	Artech House Publishers
4.	Analysis and Design of Analog Integrated Circuits	Gray, Hurst, Lewis & Meyer	Wiley India Pvt Ltd
5.	Design of Analog CMOS Integrated Circuits	B. Razavi	TMH

Course Outcome:

CO-1: Understand the fundamentals of RF and Microwave IC design and various issues in RFIC Design.
CO-2: Comprehend and analyse various LNA design principles and be able to use in applications.
CO-3: Comprehend and analyse various Mixer design principles and be able to use in applications.
CO-4: Understand and analyse various VCO design principles and be able to use in applications.
CO-5: Understand and examine various Frequency Synthesis via PLL, power amplifier and be able to use in various applications.
CO-6: Be able to analyse and design RFICs for practical applications and lifelong learning.

EC 5134 **Satellite Communications** **L T P C 3-0-0- 3**

Evolution and growth of communication satellites, Kepler's laws of motion, orbits, altitude control; Satellite launch vehicles-Arianne, SLV space shuttle; Subsystems of communication satellite; Spectrum allocation and Bandwidth considerations; Propagation characteristics, Satellite transponders and other sub systems; Earth station technology; Analog and digital link design; Multiple access techniques-FDMA, TDMA, SS-TDMA; Interference in FDMA systems, Modern satellite communications.

Texts/References Books:

1. Satellite Communications	Dennis Roddy	TMH
2. Satellite Communications	Timothy Pratt, Charles W. Bostian, Jeremy E. Allnutt	Wiley India Pvt Ltd.
3. Digital Satellite Communication	T.T.Ha	MHE
4. Satellite Communications	Maini & Agrawal	Wiley India Pvt Ltd

Course Outcome:

CO-1: Understand the fundamentals of Kepler's Laws of motion applicable to satellite launching and orbital placement.

CO-2: Understand various subsystems of communication satellite.

CO-3: Understand the functionalities of satellite transponder and other subsystems. .

CO-4: Understand and analyse various multiple access technology used in satellite communication.

EC 5135 **Information Theory and Coding** **L T P C 3-0-0- 3**

Information Theory: Entropy and mutual information for discrete ensembles; asymptotic equi-partition property; Markov chains; Entropy Rates of a Stochastic Process.

Shannon's noiseless coding theorem: Encoding of discrete sources; Universal Source Coding; Discrete memory less channels; Shannon's noisy coding theorem and converse for discrete channels; Calculation of channel capacity and bounds for discrete channels; Differential entropy; Calculation of channel capacity for Gaussian channels.

Coding Theory: Linear Codes, distance bounds, generator and parity check matrices, error-syndrome table; Cyclic codes, generator and parity check polynomials; BCH codes and Reed-Solomon Codes; An overview of convolutional codes; Maximum likelihood decoding; MAP decoder; Introduction to turbo codes and LDPC codes.

Texts/ References:

1. T. M. Cover and J. A. Thomas, Elements of Information Theory, John Wiley, New York, 1991
2. R. W. Yeung, Information Theory and Network Coding, Springer, 2008
3. R.G. Gallagar, Information Theory and Reliable Communication, John Wiley & Sons, 1976.
4. R.B. Ash, Information Theory, Dover Publications, 1990.
6. D. J. Mackay, Information Theory, Inference and Learning Algorithms, Cambridge University Press, 2003.
7. W. Ryan and S. Lin, Channel Codes: Classical and Modern, Cambridge University Press, 2009.
8. R. W. Yeung, A First Course in Information Theory, Kluwer Academic, 2002.

Course Outcomes:

CO-1: Student can able to understand the basics of probability concepts, and information theory

CO-2: Student can able to evaluate entropy, conditional entropy, joint entropy, and mutual information

CO-3: Student should be able to draw state diagram, Trellis tree for different Markov processes. Also, they should be able to find the entropy of Markov processes.

CO-4: Student can able to analyse the optimum code length for source coding schemes and compare different source coding techniques with Shannon's source coding theorem

CO-5: Student can able to apply information theory to different channels to find the channel capacity of these channels

CO-6: Student should learn different channel coding schemes along with their coders and decoders.

EC 5136 **Detection & Estimation Theory** **L T P C 3-0-0- 3**

Detection theory, hypothesis testing, Bayes, minimax, and Neyman-Pearson criteria, signaling in additive Gaussian noise, receiver operating characteristic, M-ary hypothesis testing, MAP and ML decision rules. Estimation of random parameters, MMS and MAP estimates. Estimation of nonrandom parameters, Cramer-Rao inequality, consistent estimate, Bounds on estimation errors, composite hypotheses, Elements of sequential and non-parametric detection, Wiener-Hopf and Kalman filtering.

Reference/Text Books:

1.	An Introduction to Signal Detection and Estimation	H Vincent Poor	Springer
2.	Detection, Estimation and Modulation Theory, Vol-I	Harry L Van Trees	John Wiley & Sons

Course Outcome:

CO-1: Acquire basics of statistical decision theory used for signal detection and estimation, Classical and Bayesian Estimation Approaches.

CO-2: Comprehend the elements and structure of random and non-random parametric Estimation Methods- Maximum Likelihood Estimation, Maximum A Posterior i Estimation, Minimum Mean Square Error Estimation, Linear Minimum Mean Square Error Estimation.

CO-3: Learn Basic Estimation Performance Bounds such as Cramer-Rao Bound/inequality.

CO-4: Analyze sequential and non-parametric detection in discrete-time domain using filters.

CO-5: Gain ability to apply estimation methods to real engineering problems.

EC 5137 **EMI/EMC** **L T P C 3-0-0- 3**

BASIC THEORY: Intra and inter system EMI, Elements of Interference: Conducted and Radiated EMI emission and susceptibility, EMC Engineering Application.
COUPLING MECHANISM : Coupling paths, Coupling via the supply network, Common mode coupling, Differential mode coupling, Impedance coupling, Radiative coupling, Ground loop coupling, Cable related emissions and coupling, Transient sources, Automotive transients. Categorization of the electromagnetic interference: emission, susceptibility, transients, crosstalk, shielding and compatibility, signal integrity.
EMI MITIGATION TECHNIQUES: Working principle of Shielding, LF Magnetic shielding, Apertures and shielding effectiveness, Choice of Materials for H, E, and free space fields, Gasketting and sealing, PCB Level shielding, Principle of Groundin.
STANDARDS AND REGULATION: Need for Standards, EMI Standardizing for different application. IEC,
ANSI, FCC, AS/NZS, CISPR, BSI, CENELEC, ACEC. MIL461E
EMI TEST METHODS AND INSTRUMENTATION: Fundamental considerations, EMI Shielding
effectiveness tests, Open field test, TEM cell for immunity test, Shielded chamber , Shielded anechoic chamber, EMI test receivers, Spectrum analyzer, EMI test wave simulators, EMI coupling networks, Line impedance stabilization networks, Feed through capacitors, Antennas, Current probes.
BASICS OF BIOLOGICAL EFFECTS OF EM WAVES: Ionizing and non-ionizing radiation. Theoretic and diagnostic use of EM waves.Measurement techniques of EM radiation.Protective design techniques.

Text/References:

1. Henry W. Ott, “Electromagnetic Compatibility Engineering”, John Wiley & Sons Inc, Newyork, 2009.
2. Guide to Electromagnetic Compatibility”, Elsevier Science & Technology Books, 2002.
3. W Scott Bennett, “Control and Measurement of Unintentional Electromagnetic Radiation”, John Wiley & Sons Inc., (Wiley Interscience Series) 1997.
4. Dr Kenneth L Kaiser, “The Electromagnetic Compatibility Handbook”, CRC Press 2005. Paul, C.R., “Introduction to Electromagnetic Compatibility”, 2nd ed., Wiley (2010). David K. Cheng, “Field and Wave Electromagnetics” 2nd ed. Pearson Education, (2009).

Course Outcome:

CO-1: Understand EMC regulation and methods of eliminating interferences

CO-2: Explain about the Methods of grounding of cable shield, coupling mechanisms.

CO-3: Understand the concept of filtering and shielding

CO-4: Understand various test methods an instrumentations.

CO-5: Learning about basic biological effects of EM waves and their protective measures.

EC 5141 **Image Processing** **L T P C 3-0-0- 3**

Digital image fundamentals: Visual perception, image sensing and acquisition, sampling and quantization, basic relationship between pixels and their neighbourhood properties.

*Image Transformation:*2D DFT, DCT, Walsh-Hadamard transform, KLT, Harr transform and discrete wavelet transform.

Image enhancement in spatial domain: Fundamental concepts, enhancement by point processing, Gray-level transformations, histogram processing, spatial filters- averaging, order statistics; image sharpening.

Image filtering in frequency domain: Fundamental concepts, Smoothing and sharpening filtering in frequency domain, homomorphic filtering;

Image restoration: Degradation/ restoration process, noise models, restoration in presence of noise-only spatial filtering, linear position-invariant degradations, estimating the degradation function, inverse filtering, Wiener filtering, constrained least squares filtering.

Image compression: Lossy and lossless compression, entropy coding, transform coding, image coding standards.

Image analysis: edge and line detection, segmentation, feature extraction, classification; image texture analysis.

Morphological Image Processing: Basic operations- dilation, erosion, opening, closing, Hit-Miss transformations, Basic morphological algorithms and applications.

Color image processing: Color models RGB, HSI, YUV, pseudo-color image processing, full-color image processing, color transformation, color segmentation.

Texts/References Books:

1. Fundamentals of Digital Image processing, A. K. Jain Pearson Education, 1989
2. Digital Image Processing R. C. Gonzalez and R. E. Woods Pearson Education, 2001
3. Digital Image Processing using MATLAB R. C. Gonzalez , R. E. Woods and S.L. Eddins Pearson Education, 2004
4. Digital Image Processing G. A. Baxes John Wiley, 1994
5. Digital Image Processing and Computer Vision R.J. Schalkoff John Wiley, 1989
6. Image Processing Sid Ahmed McGraw -Hill, 1994
7. S.J. Solari Digital Video and Audio Compression McGraw-Hill, 1996

Course Outcome:

CO1: Review the fundamental concepts of a digital image processing system.

CO2: Analyze images in the frequency domain using various transforms.

CO3: Evaluate the techniques for image enhancement and image restoration.

CO4: Categorize various compression techniques and interpret image compression standards.

CO5: Interpret image segmentation and representation techniques.

EC 5142	Adaptive Filter Theory	L T P C 3-0-0- 3

*Introduction to Adaptive Filters:*Adaptive filter structures, issues and examples, Applications of adaptive filters:
Channel equalization, active noise control, Echo cancellation and beamforming.
Discrete time stochastic processes: Re-visiting probability and random variables, Discrete time random processes, Power spectral density – properties, Autocorrelation and covariance structures of discrete time random processes, Eigen-analysis of autocorrelation matrices.
Wiener filter, search methods and the LMS algorithm: Wiener FIR filter (real case), Steepest descent search and the LMS algorithm, Extension of optimal filtering to complex valued input, The Complex LMS algorithm. *Convergence and Stability Analyses:* Convergence analysis of the LMS algorithm, Learning curve and mean square error behavior, Weight error correlation matrix, Dynamics of the steady state mean square error, Misadjustment and stability of excess mean square error.

Variants of the LMS Algorithm: The sign-LMS and the normalized LMS algorithm, Block LMS, Review of circular convolution, Overlap and save method, circular correlation, FFT based implementation of the block LMS Algorithm.

Vector space framework for optimal filtering: Axioms of a vector space, examples, subspace, Linear independence, basis, dimension, direct sum of subspaces, Linear transformation, examples, Range space and null space, rank and nullity of a linear operator, Inner product space, orthogonality, Gram-Schmidt orthogonalization, Orthogonal projection, orthogonal decomposition of subspaces, Vector space of random variables, optimal filtering.

The lattice filter and estimator: Forward and backward linear prediction, signal subspace decomposition using forward and backward predictions, Order updating the prediction errors and prediction error variances, basic lattice section, Reflection coefficients, properties, updating predictor coefficients, Lattice filter as a joint process estimator, AR modeling and lattice filters, Gradient adaptive lattice.

RLS lattice filter: Least square (LS) estimation, pseudo-inverse of a data matrix, optimality of LS estimation, Vector space framework for LS estimation, Time and order updating of an orthogonal projection operator, Order updating prediction errors and prediction error power, Time updating PARCOR coefficients.

Text Books/ References:

1.	Adaptive Filter Theory	S. Haykin	Prentice Hall, Englewood Cliffs, NJ
2.	Adaptive Filters – Theory and Applications	B. Farhang-Boroujeny	John Wiley and Sons
3.	Fundamentals of Adaptive Filtering	Ali H. Sayed	John Wiley
4.	Statistical and Adaptive Signal Processing: Spectral Estimation, Signal Modeling, Adaptive Filtering and Array Processing	D. Manolakis, V. Ingle and S. Kogan	McGraw Hill
5.	Adaptive Signal Processing	B. Widrow and S. Stearns	Prentice-Hall

Course Outcome:

CO-1: Comprehend design and structure of adaptive filters and discrete time stochastic process.

CO2: Understand fundamentals of optimal filtering: Wiener filter and least mean square estimation methods.

CO3: Realize vector space analysis and understand its framework for optimal filtering

CO4: Comprehend basic intricacies of estimators and design of lattice filters.

CO5: Understand Least square (LS) estimation and its optimality in vector space.

CO6: Gain ability to comprehend and analyse adaptive filter theory problems and apply them in solving real life problem.

EC 5143 **Biomedical Signal Processing** **L T P C 3-0-0- 3**

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

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.

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.

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.

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 - Nonlinear 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 books:

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

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

Course Outcome:

CO1: Understand and able to analyse biomedical signals through application of transformation techniques.

CO2: Analyse the design techniques of Adaptive and optimal filtering Modelling for Biomedical signals - Detection of biomedical signals in noise.

CO3: Understands Cardio Vascular and Neurological intricacies and application of signal processing in analysing ECG and EEG signal parameters.

CO4: Gain ability to comprehend and analyse biomedical signal processing and apply in solving real life problems.

EC 5144 **Smart Antennas** **L T P C 3-0-0- 3**

INTRODUCTION: Antenna gain, Phased array antenna, power pattern, beam steering, degree of freedom, optimal antenna, adaptive antennas, smart antenna - key benefits of smart antenna technology, wide band smart antennas, Digital radio receiver techniques and software radio for smart antennas.

NARROW BAND PROCESSING: Signal model conventional beam former, null steering beam former, optimal beam former, Optimization using reference signal, beam space processing.

ADAPTIVE PROCESSING: Sample matrix inversion algorithm, unconstrained LMS algorithm, normalized LMS algorithm, Constrained LMS algorithm, Perturbation algorithms, Neural network approach, Adaptive beam space processing, Implementation issues.

BROADBAND PROCESSING: Tapped delay line structure, Partitioned realization, Derivative constrained processor, Digital beam forming, Broad band processing using DFT method.

DIRECTION OF ARRIVAL ESTIMATION METHODS: Spectral estimation methods, linear prediction method, Maximum entropy method, Maximum likelihood method, Eigen structure methods, Music algorithm – root music and cyclic music algorithm, the ESPRIT algorithm.

DIVERSITY COMBINING: Spatial diversity selection combiner, switched diversity combiner, equal gain combiner, maximum ratio combiner, optical combiner.

REFERENCES:

1. Lal Chand Godara, “Smart Antennas” CRC press, 2004.
2. Joseph C Liberti.Jr and Theodore S Rappaport, “Smart Antennas for Wireless Communication: IS-95 and Third Generation CDMA Applications”, Prentice Hall 1999.
3. Balanis, “Antennas”, John Wiley and Sons, 2005.

Course Outcome:

CO1: Understand key benefits of smart antenna technology,

CO2: Understand fundamentals of narrowband and broadband processing technologies for beam space processing.

CO3: Understand fundamentals of adaptive processing technologies; LMS and NN approaches and their implementation startegies.

CO4: Understand the direction of arrival estimation methods to combat fading in mobile communication

CO5: Understand diverse diversity combining techniques for achieving better diversity gain.

CO6: Gain ability to understand and analyse recent trends in antenna technology and apply to solve real life problems.

EC 5145 **Digital Speech Processing** **L T P C 3-0-0- 3**

Fundamentals of Digital Speech Processing: Anatomy & Physiology of Speech Organs, The process of Speech Production, The Acoustic Theory of Speech Production, Digital models for speech signals.

Time Domain Models For Speech Processing: Introduction, Window considerations, Short time energy and average magnitude Short time average zero crossing rate, Speech vs. silence discrimination using energy and zero crossing, Pitch period estimation using a parallel processing approach, The short time autocorrelation function, The short time average magnitude difference function, Pitch period estimation using the autocorrelation function.

Linear Predictive Coding (LPC): Basic principles of Linear Predictive Analysis: The Autocorrelation Method, The Covariance Method, Solution of LPC Equations: Cholesky Decomposition Solution for Covariance Method, Durbin's Recursive Solution for the Autocorrelation Equations, Pitch Detection and using LPC Parameters.

Homomorphic Speech Processing: Introduction, Homomorphic Systems for Convolution: Properties of the Complex Cepstrum, Computational Considerations, The Complex Cepstrum of Speech, Pitch Detection, Formant Estimation, Mel frequency cepstrum computation.

Speech Enhancement: Nature of interfering sounds, Speech enhancement techniques: spectral subtraction, Enhancement by re-synthesis, Comb filter, Wiener filter.

Automatic Speech Recognition: Basic pattern recognition approaches, parametric representation of speech, evaluating the similarity of speech patterns, Isolated digit Recognition System, Continuous digit Recognition System.

Hidden Markov Model for Speech Recognition: Hidden Markov Model (HMM) for speech recognition, Viterbi algorithm, Training and testing using HMMs, Adapting to variability in speech (DTW), Language models.

Speaker Recognition: Issues in speaker recognition and speech synthesis of different speakers. Text to speech conversion, Calculating acoustic parameters, synthesized speech output performance and characteristics of text to speech, Voice processing hardware and software architectures.

Text Books:

1. Digital processing of speech L.R Rabiner and S.W. Schafer Pearson Education, signals Delhi, India
2. Speech Communications: Human Douglas O'Shaughnessy IEEE Press & Machine
3. Fundamentals of Speech L.R Rabinar and B.H. Juang and B. Pearson Education Recognition Yegnanarayana
4. Discrete time processing of J. R. Deller, Jr., J. H. L. Hansen and Wiley-IEEE Press, NY, speech signal J. G. Proakis USA

References:

1. Discrete Time Speech Signal Processing: Thomas F. Quateri Pearson Principles and Practice Education
2. Speech and Audio Signal Processing Ben Gold and Nelson Morgan Wiley
3. Speech Recognition Claudio Becchetti and Lucio Wiley

Course Outcome:

CO1: Qualitatively describe the mechanisms of human speech production and how the articulation mode of different classes of speech sounds determines their acoustic characteristics,

CO2: Understand Time Domain Models For Speech Processing

CO3: Understand Linear Predictive Coding and Homomorphic speech processing techniques.

CO4: Understand fundamentals of Speech Enhancement and automatic speech recognition system.

CO5: Comprehend basics of Hidden Markov Model for speech recognition and speech synthesis for speaker recognition.

EC 5146 **Cognitive Radio** **L T P C 3-0-0- 3**

INTRODUCTION TO COGNITIVE RADIOS Digital dividend, cognitive radio (CR) architecture, functions of cognitive radio, dynamic spectrum access (DSA), components of cognitive radio, spectrum sensing, spectrum analysis and decision, potential applications of cognitive radio

SPECTRUM SENSING Spectrum sensing, detection of spectrum holes (TVWS), collaborative sensing, geo-location database and spectrum sharing business models.

OPTIMIZATION TECHNIQUES OF DYNAMIC SPECTRUM ALLOCATION Linear programming, convex programming, non-linear programming, integer programming, dynamic programming and stochastic programming.

DYNAMIC SPECTRUM ACCESS AND MANAGEMENT Spectrum broker, cognitive radio architectures, centralized dynamic spectrum access, distributed dynamic spectrum access.

SPECTRUM TRADING Introduction to spectrum trading, classification to spectrum trading, radio resource pricing, brief discussion on economics theories in DSA, classification of auctions.

Text / Reference Books

1. Ekram Hossain, Dusit Niyato, Zhu Han, “Dynamic Spectrum Access and Management in Cognitive Radio Networks”, Cambridge University Press, 2009.
2. . Kwang-Cheng Chen, Ramjee Prasad, “Cognitive radio networks”, John Wiley & Sons Ltd., 2009.
3. Bruce Fette, “Cognitive radio technology”, Elsevier, 2nd edition, 2009.
4. .Huseyin Arslan, “Cognitive Radio, Software Defined Radio, and Adaptive Wireless Systems”, Springer, 2007
5. Francisco Rodrigo Porto Cavalcanti, Soren Andersson, “Optimizing Wireless Communication Systems” Springer, 2009
6. Linda Doyle, “Essentials of Cognitive Radio”, Cambridge University Press, 2009 Mode of Evaluation: Assignments, Internal Mid Examinations, External End Examination.

Course Outcomes:

CO1: Understand the fundamental concepts of cognitive radio networks
CO2: Develop the cognitive radio, as well as techniques for spectrum holes detection that cognitive radio takes advantages in order to exploit it.
CO3: Understand technologies to allow an efficient use of TVWS for radio communications based on two spectrum sharing business models/policies.
CO 4: Understand fundamental issues regarding dynamic spectrum access, the radio-resource management and trading, as well as a number of optimisation techniques for better spectrum exploitation.
CO 5: Understanding of machine learning algorithms as an application to Cognitive Radio.
CO 6: Understanding of the applications of auction theory as an economic approach to enable the emerging cognitive radio systems very useful.

SECOND SEMETSER

EC 5111 WIRELESS COMMUNICATIONS L T P C 3-0-0- 3

Overview of current wireless systems and standards; wireless channel models- path loss and shadowing models; statistical fading models; narrowband and wideband fading models; MIMO channels.

Diversity in wireless communications - Non-coherent and coherent reception; error probability for uncoded transmission; realization of diversity: time diversity; frequency diversity: DSSS and OFDM; receiver diversity: SC, EGC and MRC; transmit diversity: space-time codes;

Information theory for wireless communications- Capacity of fading channels: ergodic capacity and outage capacity; high versus low SNR regime; capacity of MIMO channels;

Multiuser wireless communications: multiple access: FDMA, TDMA, CDMA and SDMA schemes; interference management: power control; multiuser diversity;

Wireless link design;

Queuing Theory in wireless communication; Erlang laws.

Texts / References:

1. A. J. Goldsmith, *Wireless Communications*, Cambridge University Press, 2005.
2. D. Tse and P. Viswanath, *Fundamentals of Wireless Communications*, Cambridge University Press, 2005.
3. A. Molisch, *Wireless Communications*, John Wiley & Sons, 2005.
4. S. Haykin and M. Moher, *Modern Wireless Communications*, Pearson Education, 2005.
5. T. S. Rappaport, *Wireless Communications*, Prentice Hall, 1996.
6. G. L. Stuber, *Principles of Mobile Communications*, Kluwer, 1996.
7. T. Cover and J. Thomas, *Elements of Information Theory*, John Wiley & Sons, 1991.

Course Outcomes:

CO1: Discuss the cellular system design and technical challenges.
CO2: Analyse the Mobile radio propagation, fading, diversity concepts and the channel modelling.
CO3: Analyse the design parameters, link design
CO4: Analyse Multiuser Systems

EC 5112 COMMUNICATION NETWORKS L T P C 3-0-0-3

Course Outline:

Introduction: Basics of Data Communications for networking; Packet switching, Store-&-Forward operation; Layered network architecture, Overview of TCP/IP operation.

Data Link Layer: Framing; error control, error detection, parity checks, Internet Checksum and Cyclic Redundancy Codes for error detection; Flow control and ARQ strategies; HDLC protocol.

Media Access Control (MAC): MAC for wired and wireless Local Area Networks (LAN), Pure and Slotted ALOHA, CSMA, CSMA/CD, IEEE 802.3; ETHERNET, Fast ETHERNET, Gigabit ETHERNET; IEEE 802.11 WiFi MAC protocol, CSMA/CA; IEEE 802.16 WiMAX.

Network Layer: Routing algorithms, Link State and Distance Vector routing; Internet routing, RIP, OSPF, BGP; IPv4 protocol, packet format, addressing, subnetting, CIDR, ARP, RARP, fragmentation and reassembly, ICMP; DHCP, NAT and Mobile IP; IPv6 summary.

Fundamentals of Queuing Theory: Simple queuing models, M/M/- Queues, M/G/1/ Queues, queues with blocking, priority queues, vacation systems, discrete time queues.

Transport Layer: UDP, segment structure and operation; TCP, segment structure and operation. Reliable stream service, congestion control and connection management.

Network Security: Basics of cryptographic systems, symmetric and public key cryptography, certificates, authentication and use of trusted intermediaries; Security for Wi-Fi systems.

Introduction to Mobile Networking.

Suggested Readings:

Texts / Reference Books:

1. A. S. Tanenbaum, Computer Networks, 3/e, PHI, 1997.
2. J.F. Kurose and K. W. Ross: Computer Networking, A Top-Down Approach, 4/e, Pearson/Addison Wesley, 2008.
3. D. Bertsekas and R. Gallagar, Data Networks, 2/e, PHI, 1992.
4. A. Leon-Garcia and I. Widjaja: Communication Networks; 2/e, McGraw Hill, 2004.
5. W. Stallings, Data and Computer Communication, 7/e, Prentice-Hall, 2004.

Course Outcomes:

- CO-1: Independently understand basic communication network technology and its components.
- CO-2: Identify the different types of network topologies and their functionalities for communication
- CO-3: Realize the attributes of layered architecture and functionalities of the OSI model and TCP/IP model.
- CO-4: Analyse the flow control, error control attributes and routing algorithms for communication networking
- CO-5: Realize queuing models and analytical implementation of the various algorithms.

EC 5113 STATISTICAL SIGNAL PROCESSING L T P C 3-0-0- 3

Review of random variables and random processes, Hilbert space of random variables, response of linear systems to wide-sense stationary inputs, spectral factorization theorem and innovation processes, autoregressive moving average processes; Linear minimum mean-square error (LMMSE) estimation: minimum mean- square error (MMSE) estimation of jointly Gaussian random variables, LMMSE, orthogonality principle and Wiener Hoff equation; FIR Wiener filters, linear prediction-forward and backward predictions, Levinson- Durbin Algorithm and lattice filter; IIR Wiener filters: non-causal Wiener filter, innovation and causal Wiener filter; Kalman filters: Gauss-Markov state variable models; innovation and Kalman recursion, steady-state behaviour of Kalman filters; Adaptive filters: steepest descent solution of FIR Wiener filter, LMS algorithm- convergence, steady-state behaviour and practical considerations, RLS algorithm- method of least-squares, recursive solution and square- root algorithms, application of adaptive filters-equalization and noise cancellation. Spectral Estimation: Smoothed and windowed periodograms, minimum variance, maximum entropy and parametric methods for spectral estimation, frequency estimation.

Texts/References

1. M. H. Hayes, Statistical Digital Signal Processing and Modeling, John Wiley & Sons, Inc., 2002.
2. S. Haykin, Adaptive Filter Theory, Prentice Hall, 2001.
3. D.G. Manolakis, V.K. Ingle and S.M. Kogon, Statistical and Adaptive Signal Processing, McGraw Hill, 2000.
4. S. J. Orfanidis, Optimum Signal Processing, 2nd Edition, 2007 republication of the 1988 McGraw-Hill edition.
5. S. M. Kay, Fundamentals of Statistical Signal Processing: Estimation Theory, Prentice Hall, 1993.
6. H. V. Poor, *An Introduction to Signal Detection and Estimation*, 2nd edition, Springer, 1994.
7. B. Widrow and S. D. Stearns, Adaptive Signal Processing, Prentice Hall, 1985.

Course Outcomes:

CO1: Apply the fundamentals of statistical signal processing techniques.

CO2: Illustrate the underlying principle of different filtering techniques.

CO3: Analyze behavior of various real life problems using different statistical methods.

CO4: Implement the different tools and techniques for signal processing and communication related problems

CO5: Design the different type filters for practical applications.

EC-5151 **RADAR SIGNAL PROCESSING** **L T P C 3-0-0-3**

Review of Radar range performance computations, Detection Processes. Deterministic and statistical behavior model of radar signals, Moving target indication (MTI) and pulse Doppler processors. Pulse compression waveforms for higher resolution and SNR, lower side-lobe. Detection using Coherent and non-coherent integration and constant false alarm rate (CFAR). Single and multi-target tracking algorithms. adaptive processing algorithms for clutter and jamming suppression. 2D radar imaging (Synthetic Aperture Radar) and basic design parameters.

References:

1. Fundamentals of Radar Signal Processing by Mark A. Richards
2. Introduction to Radar Systems by Merrill Skolnik
3. Synthetic Aperture Radar (Signal Processing and Digital Filtering) by J. Patrick Fitch and C.S. Burrus
4. Radar Foundations for Imaging and Advanced Concepts (Electromagnetics and Radar) by Roger J. Sullivan and John N. Entzminger
5. Radar Design Principles: Signal Processing and the Environment by Nathanson Fred E.

Course Outcome:

CO-1: To Learn the principles and objectives of basic signal processing methods for radars.

CO-2: To understand the Radar signal model and processing.

CO-3: To build a concept of interference suppression methods for noise, clutter, and jamming.

CO-4: To evaluate radar signal processing algorithm and limitations.

CO-5: To develop a concept of Synthetic Radar imaging.

EC-5152 PATTERN RECOGNITION L T P C 3-0-0-3

1. Pattern Classifier Overview of pattern recognition, Discriminant functions, Supervised learning, Parametric estimation, Maximum likelihood estimation, Bayesian parameter estimation, Perceptron algorithm, LMSE algorithm, Problems with Bayes approach, Pattern classification by distance functions, Minimum distance pattern classifier.

2. Unsupervised Classification Clustering for unsupervised learning and classification, Clustering concept, C-means algorithm, Hierarchical clustering procedures, Graph theoretic approach to pattern clustering, Validity of clustering solutions.

3. Structural Pattern Recognition Elements of formal grammars, String generation as pattern description, Recognition of syntactic description, Parsing – Stochastic grammars and applications, Graph based structural representation.

4. Feature Extraction and Selection Entropy minimization, Karhunen– Loeve transformation, Feature selection through functions approximation, Binary feature selection.

5. Recent Advances Neural network structures for Pattern Recognition, Neural network based Pattern associators, Unsupervised learning in neural Pattern Recognition, Self-organizing networks, Fuzzy logic Fuzzy pattern classifiers, Pattern classification using Genetic Algorithms.

References:

1. Robert J.Schalkoff, Pattern Recognition Statistical, Structural and Neural Approaches, John Wiley & Sons Inc., New York, 1992.
2. Tou and Gonzales, Pattern Recognition Principles, Wesley Publication Company, London, 1974.
3. Duda R.O., and Har P.E., Pattern Classification and Scene Analysis, Wiley, New York, 1973.
4. Morton Nadier and Eric Smith P., Pattern Recognition Engineering, John Wiley & Sons, New York, 1993.

Course Outcome:

CO-1: Understand basic concepts in pattern recognition

CO-2: Gain knowledge about state-of-the-art algorithms used in pattern recognition research

CO-3: Understand pattern recognition theories such as Bayes classifier linear discriminant analysis.

CO-4: Apply pattern recognition techniques in practical problems.

EC 5153 MIMO COMMUNICATIONS L T P C 3-0-0-3

UNIT-I (10 Hours):
Introduction: Diversity-multiplexing trade-off, transmit diversity schemes, advantages and applications of MIMO systems
Analytical MIMO channel models: Uncorrelated, fully correlated, separately correlated and keyhole MIMO fading models, parallel decomposition of MIMO channel.
UNIT-II (10 Hours):
Power allocation in MIMO systems: Uniform, adaptive and near optimal power allocation.
MIMO channel capacity: Capacity for deterministic and random MIMO channels, Capacity of i.i.d., separately correlated and keyhole Rayleigh fading MIMO channels.
UNIT-III (10 Hours):
Space-Time codes: Advantages, code design criteria, Alamouti space-time codes, SER analysis of Alamouti space-time code over fading channels, Space-time block codes, Space-time trellis codes, Performance analysis of Space-time codes over separately correlated MIMO channel, Space-time turbo codes.
MIMO detection: ML, ZF, MMSE, ZF-SIC, MMSE-SIC, LR based detection
UNIT-IV (10 Hours):
Advances in MIMO wireless communications: Spatial modulation, MIMO based cooperative communication and cognitive radio, multiuser MIMO, cognitive-femtocells and large MIMO systems for 5G wireless.

<u>**Text/Reference Books:**</u>

1. B. Clerckx and C. Oestges, MIMO wireless networks, Elsevier Academic Press, 2nd ed., 2013.
2. T. M. Duman and A. Ghrayeb, Coding for MIMO communication systems, John Wiley and Sons, 2007.
3. N. Costa and S. Haykin, Multiple-input multiple-output channel models, John Wiley & Sons, 2010.
4. J. Choi, Optimal Combining & Detection, Cambridge University Press, 2010.
5. A. Chokhalingam and B. S. Rajan, Large MIMO systems, Cambridge University Press, 2014.

<u>**Course Outcomes**</u>

CO1: Students should be able to understand the trade-off between spatial diversity and spatial multiplexing concepts, and should be able to analyze of different MIMO channel models.

CO2: Students should do the evaluation of different power allocation schemes in MIMO and derive the MIMO channel capacity.

CO3: Students should understand space-time codes and analyze MIMO detection schemes.

CO4: Students should learn the recent advancements of MIMO communications.

EC 5154 MEDICAL IMAGE PROCESSING L T P C 3-0-0-3

IMAGE FUNDAMENTALS AND PRE-PROCESSING

Image perception, MTF of the visual system, Image fidelity criteria, Image model, Image sampling and quantization – two dimensional sampling theory, Image quantization, Optimum mean square quantizer, Image transforms – 2D-DFT and other transforms. Image enhancement – point operation, Histogram modelling, spatial operations, Transform operations.

BASICS OF MEDICAL IMAGE SOURCES

Radiology- The electromagnetic spectrum-Computed Tomography-Magnetic Resonance Tomography –ultrasound-nuclear medicine and molecular imaging-other imaging techniques-radiation protection and dosimetry.

MEDICAL IMAGE REPRESENTATION

Pixels and voxels – algebraic image operations - gray scale and color representation- depth-color and look up tables - image file formats- DICOM- other formats- Analyse 7.5, NifTI and Interfile, Image quality and the signal to noise ratio- MATLAB based simple operations.

MEDICAL IMAGE ANALYSIS AND CLASSIFICATION

Image segmentation- pixel based, edge based, region based segmentation. Image representation and analysis, Feature extraction and representation, Statistical, Shape, Texture, feature and image classification – Statistical, Rule based, Neural Network approaches.

APPLICATIONS AND CURRENT TRENDS

Image retrieval in pathology – mammography – Biomedical applications – Web related applications – ADL (Alexandria Digital Library) – AMORE (Advanced Multimedia Oriented Retrieval Engine) – BDLP (Berkeley Digital Library Project) – Blob world CANDID (Comparison Algorithm for navigating digital image databases) – CBVQ (content based visual query) – CHROMA (colour hierarchical Representation Oriented Management Architecture).

REFERENCES:

1. Wolfgang Birkfellner, „Applied Medical Image Processing – A Basic course‟, CRC Press, 2011.
2. Atam P.Dhawan, „Medical Image Analysis‟, Wiley Interscience Publication, NJ, USA 2003.
3. R.C.Gonzalez and R.E.Woods, "Digital Image Processing‟, Second Edition, Pearson Education, 2002.
4. Anil. K. Jain, „Fundamentals of Digital Image Processing‟, Pearson education, Indian Reprint 2003.
5. Alfred Horowitz, „MRI Physics for Radiologists – A Visual Approach‟, Second edition Springer Verlag Network, 1991.
6. Kavyan Najarian and Robert Splerstor," Biomedical signals and Image processing",CRC – Taylor and Francis,New York,2006
7. John L.Semmlow,"Biosignal and Biomedical Image Processing Matlab Based applications" Marcel Dekker Inc.,New York,2004
8. Jerry L.Prince and Jnathan M.Links," Medical Imaging Signals and Systems"- Pearson Education Inc. 2006.

Course Outcomes:

CO-1: Students can able to understand the fundamentals of medical image processing techniques

CO-2: Students can able to learn medical image acquisition devices.

CO-3: Students will be able to apply image processing concepts for medical images.

CO-4: Students will be able to analyse Morphology, Segmentation techniques and implement these in medical images.

CO-5: Students will be able to develop computational methods and algorithms to analyse and quantify biomedical data.

EC 5155 **HUMAN COMPUTER INTERFACE** **L T P C 3-0-0-3**

Direct Human interaction:

Visual based: Hand-written text recognition(character, word and sentence), Human Pose and Gaze estimation, Gesture recognition. (Traditional signal processing methods, machine learning / AI based methods).Basics of Natural Language processing.

Audio Based: Speaker recognition, Speech to text conversion, single speaker and multi-speaker scenario. Sound signal analysis for source, direction and content separation . (Traditional signal processing methods, machine learning / AI based methods)

Biomedical Signal Processing based: EEG and EMG signal processing and analysis for interaction with automated control systems and intelligent systems.

Environment sensing and augmentation:

Augmented Reality: Depth sensors: IR-based (kinect), Ultra sound based (sonar modules), laser based (Lidar), RF based(see through obstacles) methods; multi-sensor based cost effective methods. Stitching the computer generated environment and the perceived real world.

Reference Material:

1. Multiview Geometry – Hartley & Zisserman
2. Radar Estimation – Van Trees.
3. Applied Mathematics – Gilbert Strang.
4. Neural Networks - Simon Haykin.
5. Intelligent Systems- Indrani Kar
6. Speech and Language Processing: D Jurafsky, J Martin.
7. Estimation and Detection (Vol1,Vol2): Van Trees.

Course Outcome:

CO-1: Basic understanding of conventional and non-conventional methods for signal sensing and analysis.
CO-2: Understanding usage of traditional and modern day signal processing and inference methods.
CO-3: Understanding existing application based concepts in signal processing and methods of their application
CO-4: Apply the signal processing and machine learning/AI concepts in state of the art applications like, augmented reality and assistive robotics.

EC 5156 Microwave & Millimetre-wave Integrated Circuits L T P C 3-0-0- 3

Module -1:
Introduction to Monolithic Microwave Integrated Circuits (MMICs) technology, different types of MMIC, Advantages, disadvantages and application of MMICs, MMIC fabrication techniques, Thick and Thin film technologies and materials, Encapsulation and mounting of active devices, Introduction to MM-Wave Integrated Circuits, GaAs Fabrication Technology and various processes, Materials used for MM-wave Integrated Guides.

Module -2:
Passive Circuit elements: Transmission lines for Microwave Integrated Circuits, Discontinuities, Lumped elements Passive Components: Introduction, Power transfer in parallel-coupled guides, Parallel Guide Directional Couplers, Other Directional Couplers, Ring Resonator Filters.

Module -3:
Active Semiconductor circuit elements: Schottky-barrier diodes, Varactor diodes, p-i-n diodes, Bipolar Transistors, MESFETs, HEMTs Active Components: Introduction, Image Guide Detector Circuits, Oscillators, Electronic Phase Shifters, Balanced Mixers, Amplifiers, High Frequency Devices, Low Noise MM-wave Amplifiers, Monolithic Mixers.

Module -4:
Measurement Techniques: Introduction, Test fixture measurements, Probe station measurements, Thermal and cryogenic measurements, Experimental field probing techniques, MM-wave measurement techniques: Electric field probe, Measurement of Attenuation constant and guide wavelength. Measurement at Radiation Loss at bents.

Module -5:
System Application: MICs in Phased Array Radars, MICs in Satellite Television Systems, Microwave Radio Systems, Monolithic MM-wave Transceiver.

<u>Books recommended:</u>

Textbooks:

1. MMIC Design by I. D. Robertson, The Institution of Electrical Engineers, U.K., 1995.
2. Microwave Integrated circuit by K. C. Gupta, A. Singh, John Wiley & Sons, 1974.
3. Millimeter wave Integrated Circuit by E. Carey and S. Lidholm, Springer, 2005.
4. Millimeter Wave and Optical Dielectric Integrated Guides and Circuits by S. K. Koul, John Wiley & Sons, 1997.
5. Microwave Integrated Circuits by I. Kneppo, J. Fabian, P. Bezousek, P. Hrnicko and M. Pavel, Springer.

Reference books:

1. Stripline-like Transmission lines for Microwave Integrated circuits, B. Bhat, S. K. Koul, Wiley Eastern Ltd., New Delhi.

<u>Course Outcomes:</u>

CO-1: State the concept of MMIC and MM-wave technology along with their fabrication techniques.
CO-2: Comprehensive knowledge of the passive circuit elements for microwave and MM-wave technology.
CO-3: Illustrate basic of active elements for microwave and MM-wave technology.
CO-4: Enhance skills of different measurement techniques for microwave and MM-wave technology.
CO-5: Design systems and its application for microwave and MM-wave technology.

EC 5161 **Computer Vision** **L T P C 3-0-0- 3**

Image formation from geometrical perspective: Pinhole Camera model, Epipolar Geometry, Camera parameters, Essential matrix, Fundamental Matrix, Camera Calibration (calibration from predefined pattern, calibration from scene structure)

Multiview 3D reconstruction: Stereo (depth from binocular view, rectification, one (or two) disparity map estimation technique(s)), Multi-view stereo (depth from 3 cameras, N number of cameras, Bundle adjustment).

Statistical Modelling of images: Markov Random field, Conditional random field, Gibb's sampling, Loopy Belief propagation based approximation.

3D reconstruction from single image: Shape from Shading, Depth from Defocus.

Structure from Motion: Optical flow and structure from optical flow in cases: object motion (Rigid and non-rigid motion), and Ego motion (camera motion).

Inverse problems in CV: Image restoration for images blurred by non-uniform motion. Super-resolution (image registration and interpolation techniques)

Lightfield Photography: Definition, Capturing techniques, Fourier Slicing and Digital Re-focussing.

Computational Photography: HDR imaging, Super slo-mo vodeo capturing.

Reference Materials:

1. Multiview Geometry – Hartley & Zisserman
2. Robot vision - B.K.P.Horne
3. Radar Estimation – Van Trees.
4. Applied Mathematics – Gilbert Strang.

Course Outcomes:

CO-1: Understanding of various image capturing methods and the geometrical concepts behind.

CO-2: Ability to mathematically model computer vision problems.

CO-3: Understand advance concepts like Fourier slicing, perturbed Fourier analysis, restricted isometric and basis pursuit

CO-4: Ability to model computer vision problems using learning based methods.

EC 5162 SOFT COMPUTING L T P C 3-0-0-3

1. Introduction to Soft Computing Soft computing Constituents, Characteristics of Neuro Computing and Soft Computing, Difference between Hard Computing and Soft Computing, Concepts of Learning and Adaptation.

2. Neural Networks Basics of Neural Networks: Introduction to Neural Networks, Biological Neural Networks, McCulloch Pitt model. Supervised Learning algorithms: Perceptron (Single Layer, Multi-layer), Linear separability, Delta learning rule, Back Propagation algorithm. Un-Supervised Learning algorithms: Hebbian Learning, Winner take all, Self-Organizing Maps, Learning Vector Quantization.

3. Fuzzy Set Theory Classical Sets and Fuzzy Sets, Classical Relations and Fuzzy Relations, Properties of membership function, Fuzzy extension principle, Fuzzy Systems- fuzzification, defuzzification and fuzzy controllers.

4. Hybrid system Introduction to Hybrid Systems, Fuzzy Neuron, Fuzzy BP Architecture, Learning in Fuzzy BP, Application of Fuzzy BP Networks, Adaptive Neuro Fuzzy Inference System (ANFIS).

5. Genetic Algorithms and its applications Inheritance Operators, Cross over types, inversion and Deletion, Mutation Operator, Bit-wise Operators, Convergence of GA, Applications of GA.

Reference Books:

1. Neural Networks, Fuzzy Logic and Genetic Algorithms: Synthesis & Applications, S.Rajasekaran, G. A. Vijayalakshami, PHI.
2. Genetic Algorithms: Search and Optimization, E. Goldberg.
3. Neuro-Fuzzy Systems, Chin Teng Lin, C. S. George Lee, PHI.
4. Genetic Algorithms: Search, Optimization and Machine Learning, Davis E. Goldberg, Addison Wesley, N.Y., 1989.

Course Objectives:

CO-1: To understand the basic principles, techniques, and applications of soft computing.

CO-2: Understanding of the basic areas of Soft Computing including Artificial Neural Networks, Fuzzy Logic and Genetic Algorithms.

CO-3: Apply the soft computing tool to solve real world problems.

CO-4: Analysing the mathematical background for carrying out the optimization associated with neural network learning.

CO-5: Elaborate alternative solutions to conventional problem solving techniques in image processing, pattern recognition and classification.

EC 5163 WIRELESS SENSOR NETWORKS L T P C 3-0-0-3

UNIT-I (10 Hours):
Sensor Network Concept: Introduction, Networked wireless sensor devices, Advantages of Sensor networks, Applications, Key design challenges.
Network deployment: Structured versus randomized deployment, Network topology, Connectivity, Connectivity using power control, Coverage metrics, Mobile deployment.

UNIT-II (10 Hours):
Localization and Tracking: Issues and approaches, Problem formulations: Sensing model, collaborative localization. Coarse-grained and Fine-grained node localization. Tracking multiple objects.

UNIT-III (10 Hours):
Wireless Communications: Link quality, shadowing and fading effects
Medium-access and sleep scheduling: Traditional MAC protocols, Energy efficiency in MAC protocols, Asynchronous sleep techniques, Sleep-scheduled techniques, and Contention-free protocols

UNIT-IV (10 Hours):
Routing: Metric-based approaches, Multi-path routing, Lifetime-maximizing energy-aware routing techniques, Geographic routing Sensor network Databases: Data-centric routing, Data-gathering with compression State space decomposition and Synchronization: Issues and Traditional approaches, Finegrained clock synchronization, and Coarse-grained data synchronization; Querying; Data-centric storage and retrieval; the database perspective on sensor networks; Security: Privacy issues, Attacks and countermeasures.

<u>Text/Reference Books:</u>

1. Feng Zhao, Leonidas and Guibas, Wireless Sensor Networks: An Information Processing Approach, Morgan Kaufmann Series in Networking 2004.
2. Bhaskar Krismachari, Networking Wireless Sensors, Cambridge University Press.
3. C.S Raghavendra, Krishna M, Sivalingam, TaiebZnati, Wireless Sensor Networks, Springer.
4. Kazem Sohraby, Daniel, Minoli, and TaiebZnati, Wireless Sensor Networks: Technology, Protocols, and Applications, Wiley Inter Science.

<u>Course Outcomes</u>

CO1: Students should be able to understand the sensor network concepts and network deployment.

CO2: Students should learn localization and tracking.

CO3: Students should understand wireless communication aspects in WSN and analyze medium access and sleep scheduling.

CO4: Students should analyze the routing and synchronization techniques.

EC 5164 Introduction to Machine Learning L T P C 3-0-0-3

INTRODUCTION:
Machine Learning - Machine Learning Foundations –Overview – Design of a Learning system - Types of machine learning –Applications Mathematical foundations of machine learning - random variables and probabilities - Probability Theory – Probability distributions -Decision Theory- Bayes Decision Theory - Information Theory

SUPERVISED LEARNING:
Linear Models for Regression - Linear Models for Classification – Naïve Bayes - Discriminant Functions -Probabilistic Generative Models -Probabilistic Discriminative Models - Bayesian Logistic Regression. Decision Trees - Classification Trees- egression Trees - Pruning. Neural Networks - Feed-forward Network Functions - Back- propagation. Support vector machines - Ensemble methods- Bagging- Boosting

UNSUPERVISED LEARNING:
Clustering- K-means - EM Algorithm- Mixtures of Gaussians. The Curse of Dimensionality - Dimensionality Reduction - Factor analysis - Principal Component Analysis - Probabilistic PCA Independent components analysis

PROBABILISTIC GRAPHICAL MODELS:
Graphical Models - Undirected graphical models - Markov Random Fields - Directed Graphical Models -Bayesian Networks - Conditional independence properties - Inference – Learning Generalization - Hidden Markov Models - Conditional random fields(CRFs)

ADVANCED LEARNING:
Sampling –Basic sampling methods – Monte Carlo. Reinforcement Learning- K-Armed Bandit Elements - Model-Based Learning- Value Iteration- Policy Iteration. Temporal Difference Learning Exploration Strategies- Deterministic and Non-deterministic Rewards and Actions Computational Learning Theory - Mistake bound analysis, sample complexity analysis, VC dimension. Occam learning, accuracy and confidence boosting

REFERENCES:

1. Christopher Bishop, “Pattern Recognition and Machine Learning” Springer, 2007.
2. Kevin P. Murphy, “Machine Learning: A Probabilistic Perspective”, MIT Press, 2012.
3. Ethem Alpaydin, “Introduction to Machine Learning”, MIT Press, Third Edition, 2014.
4. Tom Mitchell, "Machine Learning", McGraw-Hill, 1997.
5. Trevor Hastie, Robert Tibshirani, Jerome Friedman, "The Elements of Statistical Learning", Springer, Second Edition, 2011.
6. Stephen Marsland, “Machine Learning - An Algorithmic Perspective”, Chapman and Hall/CRC Press, Second Edition, 2014.

Course Outcome:

CO1. Gain knowledge about basic concepts of Machine Learning

CO2. Identify machine learning techniques suitable for a given problem

CO3. Solve the problems using various machine learning techniques

CO4. Apply Dimensionality reduction techniques.

CO5. Design application using machine learning techniques

EC 5165 MOBILE COMPUTING L T P C 3-0-0-3

UNIT-I (10):
Introduction to Personal Communications Services (PCS): PCS Architecture, mobility management, Networks signaling; Global System for Mobile Communication (GSM) System.
Overview: GSM Architecture, Mobility management, Network signaling; General Packet Radio Services (GPRS): GPRS Architecture, GPRS Network Nodes, Mobile Data Communication; WLANs (Wireless LANs) IEEE 802.II standard.

UNIT-II (10):
Wireless Application Protocol (WAP): The Mobile Internet standard, WAP Gateway and Protocols, wireless mark up Languages (WML).
Wireless Local Loop (WLL): Introduction to WLL Architecture, wireless Local Loop Technologies.
Third Generation (3G) Mobile Services: Introduction to International Mobile Telecommunications 2000 (IMT 2000) Vision.

UNIT-III (10):
Global Mobile Satellite Systems; case studies of the IRIDIUM, ICO and GLOBALSTAR systems.

UNIT-IV (10):
Wireless Enterprise Networks: Introduction to Virtual Networks, Blue tooth technology, Blue tooth Protocols; Server-side programming in Java, Pervasive web application architecture, Device independent example application
Wideband Code Division Multiple Access (W-CDMA) and CDMA 2000; Mobile IP.

Text/Reference Books:

1. J. Schiller, Mobile Communication, Pearson Education.
2. Talukder, Mobile Computing, TMH.
3. Burkhardt, Pervasive Computing, Pearson Education.
4. Raj Kamal, Mobile Computing, Oxford University Press.
5. Hansmann, Merk, Principles of Mobile Computing, Springer.
6. Garg, Wireless Communication & Networking, Elsevier.
7. Singhal, The Wireless Application Protocol : Writing Applications for the Mobile Internet, Pearson Education

Course Outcomes

CO1: Students should be able to understand the introduction to PCS and overview of different communication standards.
CO2: Students should learn WAP and WLL.
CO3: Students should understand Global Mobile Satellite Systems and learn related case studies.
CO4: Students should learn and analyze wireless enterprise networks, mobile IP, and different CDMA techniques.

EC 5166 **Green ICT** **L T P C** **3-0-0-3**

Introduction to Green ICT, Fundamental Trade-offs on the Design of Green Radio Networks, Algorithms for Energy-Harvesting Wireless Networks, Physical and MAC Layer Optimization for Energy-Harvesting Wireless Networks, Green Modulation and Coding Schemes in Energy-Constrained Wireless Networks, Cooperative Techniques for Energy-Efficient Wireless Communications, Opportunistic Spectrum and Load Management for Green Radio Networks, Challenges in Wireless Information and Power Transfer, Multi-Objective Resource Allocation Optimization for SWIPT in Small-Cell Networks, Efficient Wireless Power Transfer Minimization Algorithms.

Text/Reference Books:

1. Green Radio Communication Networks E. Hossain, V. K. Bhargava, G. P. Fettweis Cambridge

2. Wireless Information and Power Transfer: A New Paradigm for Green Communications D. N. K. Jayakody, J. T. S. Chatzinotas, S. Durrani Springer

3. Green Communication and Networking J. L. Mauri, J. J. P. C. Rodrigues Springer

4. Green Networking and Communications: ICT for Sustainability S. Khan, J. L. Mauri CRC Press

Course Objective:

CO1: To understand the principles of green communications and the trade-offs exist in it while satisfying the user demands in the network.

CO2: To design the green networks by optimizing its different layers to solve the coexistence problems due to huge power dissipation.

CO2: To design the self-sustainable cooperative networks by energy harvesting the ambient sources and optimal power management over the operating devices.

CO3: To study the challenges in simultaneous wireless information and power transfer (SWIPT) along with the optimization of resource allocations.

EC 5167 Optimization Techniques L T P C 3-0-0-3

Mathematical foundations and basic definitions: concepts from linear algebra, geometry, and multivariable calculus.

Linear optimization: formulation and geometrical ideas of linear programming problems, simplex method, revised simplex method, duality, sensitivity analysis, transportation and assignment problems.

Nonlinear optimization: basic theory, method of Lagrange multipliers, Karush-Kuhn-Tucker theory, convex optimization. Numerical optimization techniques: line search methods, gradient methods, Newton's method, conjugate direction methods, quasi-Newton methods, projected gradient methods, penalty methods.

Applications: Wireless channel estimation, water-filling power allocation, optimization for MIMO systems, OFDM systems, MIMO-OFDM, cooperative communications, image reconstruction: deblurring and denoising.

Reference Books:

1. S. S. Rao, Engineering Optimization: Theory and Practice, 4th Edition, John Wiley &Sons (2009)
2. M. S. Bazarra, J.J. Jarvis, and H.D. Sherali, Linear Programming and Network Flows, WSE, 2003
3. U. Faigle, W. Kern, and G. Still, Algorithmic Principles of Mathematical Programming, Kluwe, 2002
4. D.P. Bertsekas, Nonlinear Programming, 2nd Ed., Athena Scientific, 1999
5. M. S. Bazarra, H.D. Sherali, and C. M. Shetty, Nonlinear Programming: Theory and Algorithms, John Wiley, WSE, 2004
6. G. V. Reklaitis, A. Ravindran, K. M. Ragsdell, Engineering Optimization: Methods andApplications, Wiley (2006)
7. R. Fletcher, Practical methods of optimization, 2nd Edition, Wiley, 2000, New York

Course Outcomes:

CO1 Students can learn about the fundamentals of linear algebra and multivariable calculus.

CO2 Students will be able to formulate and solve linear programming problems.

CO3 Students will be able to determine the optimum solution to constrained and unconstrained.

CO4 Students will be able to formulate and solve non-linear optimization problems.

CO5 Student can solve optimization problems related to advanced communications and signal processing techniques.

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