I SEMESTER

18LC01 / 18LW01 APPLIED MATHEMATICS

2 2 0 3

CO1: To model and solve discrete, continuous and mixed random variables probabilistic problems and compute cumulative, marginal and conditional distribution functions.
CO2: To compute moments, central moments auto correlation, cross – correlation, covariance, apply Chebyshev and Schwarz inequalities, Chernoff bound, derive characteristic functions, and apply central limit theorem.
CO3: To distinguish various types of stochastic process and model problems of stochastic nature to analyze effect of system performance
CO4: To employ the concept of vector space to study the nature of objects/signals and to check orthogonality of vectors. Also represent linear transformation as matrix for applications.

RANDOM VARIABLES: Continuous, Discrete and Mixed random variables, cumulative distribution function - joint distribution- marginal distribution - conditional distribution –statistical independence, (8+7)

EXPECTATION AND ESTIMATION: Moments, central moments – mean, variance, Chebyshev and Schwarz inequatlities, Chernoff bound, auto correlation, cross – correlation, covariance, characteristic functions, central limit theorem. (8+7)

RANDOM PROCESSES: Classification of Random processes, Poisson process, stationary process, wide sense stationary process, cross correlation, White Gaussian process, linear filter. (8+7)

VECTOR SPACES: Real vector spaces and subspaces – linear independence - basis and dimension, inner product space - orthonormal bases - Gram-Schmidt process, linear transformations - change of basis - inverse linear transformation, eigenvalues and eigenvectors. (8+7)

Total L: 32 + T: 28 = 60

REFERENCES:

1. H. Stark and J.W. Woods, " Probability and Random Process with Applications to Signal Processing", Pearson Education, 2012.
2. Roy D.Yates and David J Goodman " Probability and Stochastic Processes - A Friendly Introduction for Electrical and Computer Engineers" , John Wiley & Sons , 2012.
3. Saeed Ghahramani, "Fundamentals of Probability with Stochastic Processes", Pearson, New Delhi, 2016.
4. Howard Anton and Chris Rorres, "Elementary Linear Algebra", Wiley, USA, 2014.
5. David C Lay, "Linear Algebra and Its Applications", Pearson Education, New Delhi, 2013.

18LC02 INFORMATION THEORY AND CODING

2 2 0 3

CO1: To understand Gaussian random variable and its properties
CO2: To know different entropies and capacity of discrete and continuous channels
CO3: To study and analyze different source encoding and decoding techniques.
CO4: To compare and analyze various channel encoding and decoding methods.

GAUSSIAN RANDOM VARIABLES: Independence, conditional expectation, Gaussian Random variable, Jointly Gaussian Random Vector and its density function (4+4)

DISCRETE MEMORYLESS CHANNELS: self information, conditional entropy and mutual information, channel capacity theorem for DMC (5+5)

CONTINUOUS TIME CHANNELS: Average mutual information, AWGN channel capacity, introduction to MIMO channel capacity (5+5)

SOURCE CODING: Coding of memoryless sources, entropy and source coding theorem, Kraft inequality, Huffman code, LempelZiv coding, introduction to Rate distortion theory (8+8)

CHANNEL CODING: Need for error control coding - Random coding theorem of Shannon, (7,4) Hamming code and syndrome decoding, convolutional codes – Viterbi algorithm – Introduction to Turbo coding principles and parity check codes, Introduction to Network coding (8+8)

Total L: 30 + T: 30 = 60

REFERENCES:

1. T.Cover and J.Thomas, “Elements of Information Theory”, John Wiley, 2013.
2. S Haykin, “Communication Systems”, John Wiley & Sons, 2014.
3. Reza F M, "An Introduction to Information Theory", McGraw Hill, 2014.
4. Proakis J.G and Salehi M “Fundamentals of Communication Systems”Pearson ,2011.
5. David Tse and Pramod Viswanath, “Fundamentals of Wireless Communication”, Cambridge University Press, 2010.

18LC03 ADVANCED DIGITAL COMMUNICATIONS

3 0 0 3

CO1: To analyze the error performance of various digital modulation schemes in the presence of noise and interferences.
CO2: To design optimum equalizer with better error performance
CO3: To design spread spectrum and multiuser detection systems.
CO4: To understand the concept of synchronization with respect to time, frequency and phase.

SIGNALING THROUGH AWGN CHANNEL: Review of Signal Representation and Optimum Receivers, Definitions for SER, BER, SNR, average symbol energy, bit energy and Eb/No, decision boundary and decision regions for AWGN model with/without equal prior probability, Exact symbol error probability for several linear modulation schemes (ASK, FSK, PSK and QAM), union bound argument, Chernoff bound (15)

SIGNALING THROUGH BANDLIMITED CHANNELS: Nyquist criterion for zero ISI, Sync and Raised cosine pulse shaping, controlled ISI using duobinary signals (6)

SIGNALING THROUGH DISTORTING CHANNELS: ISI, Zero forcing equalization, Linear MMSE equalizers, Decision Feedback Equalizer, Fractionally Spaced Equalizer – Introduction to Adaptive Equalization (6)

BLOCK MODULATION SCHEMES: single carrier, multicarrier, cyclic prefix in the guard interval, OFDM, OFDMA, MC-CDMA, Introduction to Generalized block modulation schemes – GFDM, IFDMA, FBMC (9)

TIMING AND FREQUENCY SYNCHRONISATION: synchronization of baseband signals, oversampling, early late gate methods, delay locked loop and squaring loop, carrier synchronization, PLL and Costas loop, pilot aided and decision aided approaches (9)

Total L: 45

REFERENCES:

1. S Haykin, “Digital Communication Systems”, John Wiley & Sons, 2013.
2. Bernard Sklar, "Digital Communications", Pearson Education Asia, Sixth reprint, 2005.
3. Proakis J.G and Salehi M “Fundamentals of Communication Systems” Pearson ,2011.
4. Barry S, Lee E A and Messershmitt D J, “Digital Communications”, Kluwer Academic Press, 2004.
5. Lajos L Hanzo and Thomas Keller, “OFDM and MC-CDMA – A primer”, John Wiley and Sons Ltd, 2006.
6. Meyer H, Moeneclacy M, Fechtel S A, " Digital communication receivers ", John Wiley, New York, 1998.

18LC04 ADVANCED DIGITAL SIGNAL PROCESSING

3 2 0 4

CO1: To understand the fundamentals of DSP
CO2: To understand the basic concepts of multiresolution analysis
CO3: To design and analyze multirate systems.
CO4: To understand the adaptive algorithms and its applications.

REVIEW OF DIGITAL SIGNAL PROCESSING: DT signals and LTI Systems – Need for frequency domain analysis - Fourier transform for continuous and discrete time signals – Z-Transform - DFT – FFT - Use of FFT for power spectral estimation - Linear phase FIR filters – Realization of FIR filters. (11+6)

MULTIRESOLUTION ANALYSIS USING WAVELETS: Need for time frequency analysis - Heisenberg’s uncertainty principle - Short time Fourier transform - Need for wavelets - wavelet basis – concept of scale and its relation with frequency - Continuous time wavelet transform equation - Admissibility condition – Multi resolution analysis – Applications - Signal Denoising - Subband coding. (11 +8)

MULTIRATE SIGNAL PROCESSING: Review of Sampling Theory - Down sampling – Upsampling - Noble identities – Decimation and Interpolation with transversal filters and polyphase filters – Fractional sampling rate convertor - multistage implementation -

Two channel, QMF and Perfect Reconstruction Filter banks - Transmultiplexers - Timing Recovery in a Digital Demodulator.
(12+8)

ADAPTIVE SIGNAL PROCESSING: Linear MMSE based estimation - Adaptive linear combiner – Performance function – Gradient and Minimum Mean Square error – Gradient search by the method of steepest descent – LMS algorithm – Convergence of LMS algorithm – Applications. (11+8)

Total L: 45 + T: 30 = 75

TUTORIAL COMPONENT:

- FFT based periodogram with windowing
- Time and frequency domain analysis of decimators and interpolators.
- Multistage implementation of sampling rate convertors.
- Adaptive implementation of LMMSE FIR filter using LMS algorithm
- Denoising using Wavelets

REFERENCES:

1. Lonnie.C.Ludeman, “Fundamentals of Digital Signal Processing”, John Wiley and sons, 2000
2. K P Soman, “Insight into Wavelets: From Theory to Practice”, PHI Learning, 2013.
3. Vaidyanathan P P, “Multirate Systems and Filter banks”, Prentice Hall, 2008.
4. Fliege N J, "Multirate Digital Signal Processing", John Wiley and sons, 2010.
5. Bernard Widrow and Samuel D Stearns, “Adaptive Signal Processing”, Prentice Hall, 2008.

18LC05 COMMUNICATION ALGORITHMS ON FPGA

3 2 0 4

CO1: To explore the concepts of Verilog HDL coding
CO2: To understand the various FPGA architectures and its implementation issues
CO3: To model and implement digital signal processing algorithms on FPGAs
CO4: To model and implement digital communication modules on FPGAs

VERILOG HDL: HDL overview - Modules and ports - compiler directives - data types - operands and operators - gate level modeling - data flow modeling - behavioral modeling - structural modeling – primitives-Tasks and functions - Writing test bench – Timing issues.

(11+8)

FIELD PROGRAMMABLE GATE ARRAYS: Introduction – FPGA Technology – DSP Technology Requirement – Design Implementation – FPGA Architectures – Xilinx – Altera Flex – FPGA implementation issues.

(11+6)

DSP ALGORITHMS ON FPGA: Fixed and Floating point arithmetic - Design of Binary Adders, Multipliers, Dividers and MAC unit - Design of FIR Filters – Design of IIR Filters – DFT and FFT Algorithms, Approximate DSP Algorithms

(11+8)

DIGITAL COMMUNICATION MODULES ON FPGA: Error Control coders and decoders, encryption, scrambling, LMS Algorithm for channel estimation/equalization, pulse shaping, interpolation, decimation, Digital PLL, CORDIC implementations, Numerically controlled oscillator and SDR.

(12+8)

Total L: 45 + T: 30 = 75

TUTORIAL COMPONENT:

- Design and implementation of FFT and IFFT algorithm.
- Design and implementation of programmable PN sequence generator.
- Implementation of Universal Modulator and Demodulator using CORDIC
- OFDM Transmitter implementation using model based design

REFERENCES:

1. Samir Palnitkar, “Verilog HDL: A Guide to Digital Design and Synthesis”, Prentice Hall, 2003.
2. Uwe Meyer Baese, “Digital Signal Processing with Field Programmable Gate Arrays”, Springer, 2004.

3. Jeffrey H Reed, “Software Radio: A Modern Approach to Radio Engineering”, Pearson Education Asia, 2002.
4. James Tsui, “Digital Techniques for Wideband Receivers”, Prentice-Hall of India, 2005.
5. Roger Woods, John Mc Allister, Gaye Lightbody and Ying yi, “FPGA Based Implementation of Signal Processing Systems”, Wiley, 2008.
6. Keshab K Parhi, “VLSI Digital Signal Processing Systems: Design and Implementation”, John Wiley and Sons, 1999.

18LC51 ADVANCED DIGITAL COMMUNICATIONS LABORATORY

0 0 4 2

CO1: Design, simulate and analyze the performance of various digital modulation schemes and equalizers
CO2: Communicate about the system model, technical problems and solutions through verbal and written modes

In this course the students will be provided with an orientation program on the following equipment/software for duration of 15 hours. After this orientation each student is expected to formulate a complete an activity of interest which has to be derived from the orientation program under the guidance of a faculty. The details like background, problem definition, state of technology/ knowledge in that area by a good literature review (5 latest papers), objectives, methodology, equipment that can be used from the orientation program, results from the experiments and their interpretation with respect to the assumptions or background and a formal conclusion are expected in the report which is to be submitted at the end of the semester. This work is evaluated for the credit assigned. Expected hours needed for this work is 45 hours.

LIST OF EXPERIMENTS:

- BER Analysis of basic digital modulation schemes – ASK, FSK, BPSK, QPSK and QAM
- Adaptive Equalizer Design for signal transmission through distorting channels
- BER Analysis of multicarrier modulation schemes
- Vector Signal Analysis of different modulation schemes
- Analysis of Source Coding and Channel Coding techniques
- Synchronization in time and frequency domain

Total P: 60

II SEMESTER

18LC06 RF CIRCUIT DESIGN

3 2 0 4

CO1: To understand and design -networks and filters
CO2: To analyze and design the RF matching networks, power dividers and couplers.
CO3: To understand, analyze and design the RF Amplifier Circuits.
CO4: To understand and analyze the behavior of various Oscillator and mixer Circuits.

RF FILTER DESIGN: Definition - properties - networks – ABCD, Z, Y, h and S parameters – Filter Design by the insertion loss method – Filter Design by the insertion loss Methods, Filter Transformations, Filter Implementation. Stepped impedance Low pass filters. (12+8)

MATCHING NETWORK AND PASSIVE DEVICES: Matching with lumped Elements - Design of T and π matching network- Matching by micro strip line -Stub matching. Single stub matching – Double stub matching. Basic properties of dividers and couplers – T Junction Power divider – Wilkinson Power divider – Quadrature Hybrid – Coupled line Directional Coupler. (9+6)

RF ACTIVE DEVICES AND AMPLIFIER DESIGN: The Diode Model – Two Port Design Model: The output terminals of a two port RF Device, The bipolar Transistor, The heterojunction bipolar transistor , The GaAS MESFET, The High Electron Mobility Transistor. RF Amplifier Design - Two port power Gains- Stability circles- Tests for Unconditional stability - Low Noise amplifier Design – Low Noise MOSFET Amplifier –Broad Band Transistor Amplifier Design – Characteristics of Power Amplifiers and Amplifier classes-Design Examples. (12+8)

OSCILLATORS AND MIXERS: RF Oscillators –Oscillators using BJT and FET –Dielectric Resonator Oscillators – Oscillator Phase Noise. Mixers – Mixer Characteristics – Single –Ended Diode Mixer – Single-Ended FET Mixer- Balanced Mixer – Image Reject Mixer- Differential FET Mixer and Gilbert Cell Mixer. (12+8)

Total L: 45 + T: 30 = 75

TUTORIAL COMPONENT:
Design and analysis of

- Impedance matching networks
- Directional couplers.
- Passive filters.
- Amplifiers.
- Oscillator and mixer Circuits for RF Applications.

REFERENCES:

1. Rowan Gilmore and Les Besser, "Practical RF Circuit Design for Modern Wireless Systems", Vol II, Passive Circuit and Systems, Artech house, London, 2003.
2. David M Pozar, "Microwave Engineering", John Wiley and Sons, 2016.
3. Reinhold Ludwig and Pavel Bretchko, "RF Circuit Design: Theory and Applications", Pearson Education, 2011.

18LC07 COMMUNICATION NETWORKS

3 0 0 3

CO1: To analyse the principles of application layer protocols and methods adopted for end to end issues
CO2: To compare and analyse the various routing protocols for internetworking and examine the congestion control issues
CO3: To compare, analyse and implement the various MAC protocols in wired networks
CO4: To evaluate the performance of various wireless networks

END TO END CONNECTIVITY: Network Edge and core - Protocol Layers and their service models-Principle of network applications - web and HTTP - FTP- Electronic Mail-DNS – SNMP-Connectionless transport, End-to-End Issues, Connection Establishment and Termination (9)

INTERNETWORKING: Switching and bridging, basic internetworking, Internet protocol IPv4, IPv6, Routing algorithms, routing in the internet (RIP, OSPF, BGP), Multiprotocol Label Switching(MPLS) - Broadcast and Multicast routing, routing among mobile devices (9)

CONGESTION CONTROL AND RESOURCE ALLOCATION: Issues in Resource Allocation - Queuing Disciplines – Little's Theorem -TCP Congestion Control - Congestion-Avoidance Mechanisms - Quality of Service (8)

LINKING AND MULTIPLE ACCESS : Link layer services –framing –Error detection –multiple access protocols – Channel partitioning –Random access protocols – Ethernet- CSMA/CD -- Virtual LANs (9)

WIRELESS NETWORKS: Bits over Wireless networks – TCP performance over Wireless Links - Adaptive and Cross-Layer Techniques CSMA-CA-IEEE 802.11 standards – Multiple access in 802.11 -Wireless Ad Hoc Networks - Topology and Connectivity. (10)

Total L: 45

REFERENCES:

1. Anurag Kumar, D.Manjunath, Joy Kuri, "Communication networking - An Analytical Approach", Morgan Kaufmann Publishers 2004.
2. Kurose James F and Keith W Ross,"Computer Networking: A Top-Down Approach Featuring the Internet", Pearson Education, 2009.
3. Larry L Peterson and Bruce SDavie, "Computer networks: A system approach", Morgan Kaufmann Publishers 2010.
4. Vijay K Garg, "Wireless Communication and Networking", Morgan Kaufmann Publishers 2008
5. Behrouz A Forouzan, "Data Communication and Networking", Tata McGraw Hill, 2009.

18LC08 WIRELESS COMMUNICATIONS

3 0 0 3

CO1: To model wireless multipath channel according to its characteristics
CO2: To analyze AWGN and MIMO Channel Capacity
CO3: To understand the basics of multicarrier communications
CO4: To learn cellular systems, standards and their specifications

WIRELESS CHANNEL: Physical modeling for wireless channels- Input /output model of the wireless channel- Time and frequency coherence- Statistical channel models- Detection in a Rayleigh fading channel (10)

CAPACITY OF WIRELESS CHANNELS: AWGN Channel capacity, Capacity of Flat Fading Channels – Capacity of Frequency Selective Fading Channels– Time varying, Time Invariant Channels – Diversity Techniques - Narrowband MIMO model, Parallel Decomposition of the MIMO Channel, MIMO Channel Capacity – MIMO diversity gain – Space Time Coding. (12)

MULTICARRIER COMMUNICATIONS: OFDM based multiple access, Broadband wireless access using OFDM and OFDMA, frequency diversity and multiuser diversity, MIMO-OFDM techniques – closed loop and open loop. (12)

CELLULAR SYSTEMS AND STANDARDS: AMPS – GSM – IMT 2000 – Services provided by 3G Cellular Systems – Harmonized 3G Systems – UMTS - 3G UMTS signal processing - WCDMA, HSPA, HSPA+, Towards 4G, LTE and LTE advanced, 5G. (11)

Total L: 45

REFERENCES:

1. David Tse and PramodViswanath, "Fundamentals of Wireless Communication", Cambridge University Press, 2010.
2. Theodore S Rappaport, "Wireless Communications Principles and Practice", Pearson Education, Asia, New Delhi, 2009.
3. Lajos L Hanzo and Thomas Keller, "OFDM and MC-CDMA – A primer", John Wiley and Sons Ltd, 2006.
4. Andrea Goldsmith, "Wireless Communications", Cambridge University Press, 2009.
5. Singal T L, "Wireless Communications" Tata McGraw Hill, 2010.

18LC09 EMBEDDED SYSTEM DESIGN AND IOT

3 2 0 4

CO1: To understand embedded system design cycle and to explore embedded ARM processors.
CO2: To understand the on-chip peripherals of ARM Controllers and their configuration.
CO3: To get exposed to emerging IoT protocols, security and domain specific applications.
CO4: To develop Mobile App for IoT applications with the Cloud facilities for IoT.

COMPONENTS OF EMBEDDED SYSTEMS: Introduction to Embedded Systems, Embedded Design Life Cycle. Overview of ARM Processors. Functional block diagram of ARM Cortex-A, Cortex-R and Cortex-M series controllers and their features. (8+3)

PERIPHERAL INTERFACING TECHNIQUES: Memory Management - Program Memory, Data Memory. AHB and APB Bus Structure. GPIOs, Timer/Counters, Capture/Compare Modules, PWM, QEI, RTC, WDT, DMA, EEPROM and PLL. Serial Peripherals: UART, I2C, SPI, CAN and USB. Hardware and Software Interrupts, Analog Peripherals: ADC, DAC and Analog Comparators. (16+15)

IoT: Introduction, IoT protocols: MQTT and AMQP, IoT Security: AES and TLS1.2, FOTA, Consumer Electronics IoT, Automotive IoT, Health Care IoT and Industrial IoT. (11+7)

CLOUD AND APP FACILITIES FOR IoT: Amazon Web Services Cloud (AWS), MS Azure, IBM Bluemix, Carriots and Thing Speak, GE predix. MIT App Inventor and Android App Development tools. (10+5)

Total L: 45 + T: 30 = 75

TUTORIAL COMPONENT:

- GPIO interfacing
- Interfacing of Smart Sensors
- Implementing Serial Communication Protocols
- Remote Monitoring and Control through Web Browser using WiFi
- Cloud based Data Analysis

REFERENCES:

1. Arnold S. Berger, "Embedded Systems Design: An Introduction to Processes, Tools, and Techniques" CMP Books, 2002.
2. Jonathan W. Valvano, "Embedded Systems: Real-Time Interfacing to Arm(r) Cortex -M Microcontrollers: Volume 2", CreateSpace Independent Publishing Platform; 5th edition, 2012.
3. Jonathan W. Valvano, "Embedded Systems: Real-Time Interfacing to Arm(r) Cortex -M Microcontrollers: Volume 1", CreateSpace Independent Publishing Platform; 5th edition, 2011.
4. Tiva TM4C123GH6PM Microcontroller Datasheet
5. Arshdeep Bahga and Vijai Madisetti : A Hands-on Approach "Internet of Things", Universities Press 2015.

18LC52 COMMUNICATION NETWORKS LABORATORY

0 0 4 2

CO1: To simulate and analyze the performance of various application Layer protocols, MAC and routing protocols in simulation software tools
CO2: To students will be able to work in a team and communicate the technical solutions through verbal and written modes

In this course the students will be provided with an orientation program on the following equipment/software for duration of 15 hours. After this orientation each student is expected to formulate a complete an activity of interest which has to be derived from the orientation program under the guidance of a faculty. The details like background, problem definition, state of technology/ knowledge in that area by a good literature review (5 latest papers), objectives, methodology, equipment that can be used from the orientation program, results from the experiments and their interpretation with respect to the assumptions or background and a formal conclusion are expected in the report which is to be submitted at the end of the semester. This work is evaluated for the credit assigned. Expected hours needed for this work is 45 hours.

LIST OF EXPERIMENTS:

- Networking commands (Windows and LINUX)
- Packet and protocol analysis using Wireshark
- Performance evaluation of RIP and OSPF protocols using discrete event network simulator
- Construction of Layer2 and Layer3 protocol packets using traffic generator
- Configuration and realization of VLAN
- Design and simulation of MAC & Routing protocol for wireless networks

Total P: 60

18LC61 INDUSTRY VISIT & TECHNICAL SEMINAR

0 0 2 1

The student will make at least two technical presentations on current topics related to the specialization. The same will be assessed by a committee appointed by the department. The students are expected to submit a report at the end of the semester covering the various aspects of his/her presentation together with the observation in industry visits. A quiz covering the above will be held at the end of the semester.

Total P: 30

SEMESTER III

18LC53 COMMUNICATION SYSTEM DESIGN LABORATORY

0 0 4 2

CO1: To design, Simulate/Implement and analyze the performance of various components of wireless communication system
CO2: To communicate the design challenges and technical solutions through verbal and written modes

In this course the students will be provided with an orientation program on the following equipment/software for duration of 15 hours. After this orientation each student is expected to formulate a complete an activity of interest which has to be derived from the orientation program under the guidance of a faculty. The details like background, problem definition, state of technology/ knowledge in that area by a good literature review (5 latest papers), objectives, methodology, equipment that can be used from the orientation program, results from the experiments and their interpretation with respect to the assumptions or background and a formal conclusion are expected in the report which is to be submitted at the end of the semester. This work is evaluated for the credit assigned. Expected hours needed for this work is 45 hours.

LIST OF EXPERIMENTS:

- Wireless channel estimation and channel modeling
- Analysis of Space Time Coding Techniques
- Design and analysis of MIMO systems
- Implementation and Analysis of security algorithms for communication systems
- Implementation of a communication system in SDR platform
- Design and implementation of a Wireless Sensor Network application in embedded platform

Total P: 60

18LC71 PROJECT WORK-I

0 0 6 3

- ❖ Identification of a real life problem in thrust area
- ❖ Developing a mathematical model for solving the above problem
- ❖ Finalization of system requirements and specification
- ❖ Proposing different solutions for the problem based on literature survey
- ❖ Future trends in providing alternate solutions
- ❖ Consolidated report preparation of the above

Total P: 90

IV SEMESTER

18LC72 PROJECT WORK –II

0 0 28 14

The project work involves the following:

Preparing a project- brief proposal including

- Problem identification
- A statement of system / process specifications proposed to be developed (Block Diagram/ Concept tree)
- List of possible solutions including alternatives and constraints
- Cost benefit analysis
- Time line of activities

A report highlighting the design finalization [based on functional requirements & standards (if any)]

A presentation include the following

- Implementation phase(Hardware / Software / both)
- Testing and validation of the developed system
- Learning in the Project

Consolidated report preparation

Total P: 420

ELECTIVE THEORY COURSES

18LC21 DETECTION AND ESTIMATION

3 0 0 3

CO1: To understand the fundamentals of detection theory and Evaluate the performance of various detection techniques
CO2: To classify and Compute the performance of various techniques used in parameter estimation
CO3: To compare and analyze the performance of various Bayesian estimation techniques
CO4: To illustrate Distribution free estimation techniques and their applications in signal processing

STATISTICAL DECISION THEORY: Bayesian Hypothesis Testing - Likelihood Ratio Tests -Minimax Hypothesis Testing - Neyman Pearson Hypothesis Testing - Composite Hypothesis Testing - M'ary Hypothesis Testing. (8)

SIGNAL DETECTION IN DISCRETE TIME: Deterministic Signals - Stochastic Signals – Models and Detector Structures – Performance Evaluation - Chernoff Bounds - Applications of Detection in Signal Processing (8)

PARAMETER ESTIMATION: Fundamentals of Estimation Theory - Minimum Variance Unbiased Estimation – Cramer Rao Lower bound – Best Linear Unbiased Estimators - Linear Least Squares Estimation –Nonlinear Least Squares Estimation - Maximum Likelihood Estimation. (10)

BAYESIAN ESTIMATION: Bayesian philosophy – General Bayesian Estimators - Minimum Mean Square Error Estimators – Maximum A Posteriori Estimators – Linear MMSE Estimation. (9)

DISTRIBUTION-FREE ESTIMATION: Orthogonality Principle – Autoregressive Techniques - Discrete Wiener Filter, Continuous Wiener Filter, Generalization of Discrete and Continuous Filter Representations, Kalman Filter, Extended Kalman Filter - Applications of Estimation in Signal Processing. (10)

Total L: 45

REFERENCES:

1. Kay S M, "Fundamentals of Statistical Signal Processing, Volume 1: Estimation Theory", Prentice Hall, 1993.
2. Kay S M, "Fundamentals of Statistical Signal Processing, Volume 2: Detection Theory", Prentice Hall, 1998.
3. Thomas Schonhoff and Arthur AGiordano, "Detection and Estimation Theory", Prentice Hall, 2007.
4. Poor H V, "An Introduction to Signal Detection and Estimation", Springer-Verlang, 1994.
5. ScharfL L, "Statistical Signal Processing", Addison Wesley, 1991.

18LC22 COOPERATIVE COMMUNICATIONS

3 0 0 3

CO1: To understand basic terminologies of cooperative communication and estimate the performance through different channels
CO2: To analyze the performance of cooperative communication through transmission schemes with multiple relays and sources
CO3: To provide an in depth concepts on cooperative relaying through multicarrier modulation schemes
CO4: To motivate recent advanced concepts on cooperative communication systems to pursue research

COOPERATIVE COMMUNICATIONS: Introduction; Definitions and Terminology; Types of relaying protocol; One-way and two-way MIMO relaying protocols; System model and its terminologies; Pros and Cons of cooperation; Cooperative performance bounds; Application Scenarios (9)

WIRELESS RELAY CHANNEL: Propagation Modeling; Channel Modeling; Regenerative relay channels; Transparent relay channels; Distributed MIMO channel; Fundamental limits of Cooperative and Relay Networks; Gaussian Relay channels; Single and multi-relay fading channels (9)

TRANSMISSION SCHEMES: Cooperative transmission schemes; Two user transmission schemes; Cooperative transmission schemes with multiple relays; Cooperative communications with multiple sources (9)

COOPERATIVE RELAYING IN MIMO-OFDM SYSTEMS AND MAC: Overview of OFDM systems; Cooperative OFDM systems; Cooperative OFDM systems with multiple relays; Distributed space frequency codes; MAC control based cooperative networks; Networking and Cross layer issues in Cooperative Networks (9)

APPLICATIONS OF COOPERATIVE COMMUNICATION: Cooperative Relaying in multihop cellular networks; Peer-to-Peer-and Mobile AdHoc networks; Wireless Mesh Networks; Wireless Sensor and Actor Networks; Coordinated Multipoint Systems (CoMP); Cooperation for Nest Generation Wireless Networks (9)

Total L: 45

REFERENCES:

1. Misha Dohler and Yonghui Li, “Cooperative Communications: Hardware, Channel and PHY.” John Wiley & Sons, 2010.
2. Peter Hong Y W, Huang Wan-Jen and Jay Kuo C C, “Cooperative Communications and Networking: Technologies and System Design”, Springer, Newyork, 2010.
3. Ming Ding and Hanwen Luo, “Multi-point Cooperative Communication Systems: Theory and Applications”, Springer-Verlag, 2013.
4. Yan Zhang, Chen H H, Mohsen and Guizani, “Cooperative Wireless Communications”, CRC Press, 2009.
5. Jonathan Rodriguez, “Fundamentals of 5G Mobile Networks”, John Wiley & Sons, 2015.

18LC23 COGNITIVE RADIO SYSTEMS

3 0 0 3

CO1: To understand the fundamentals of Software Defined Radio and compare various SDR platforms
CO2: To explain the need for Cognitive Radio and its significance
CO3: To analyze the various methods of implementing the Cognitive Radio functions
CO4: To exemplify the research challenges in designing a Cognitive Radio Network and the applications

SOFTWARE DEFINED RADIO: Characteristics and Benefits of Software Radio, Design Principles of a Software Radio, Ideal SDR architecture, Radio Frequency Implementation Issues (9)

SDR PLATFORMS: Digital Hardware choices for SDR, Hardware platforms for SDR – Universal Software Radio Peripheral, Wireless open Access Research platform, RTL SDR receiver, comparison of different platforms, Software platforms for SDR-GNU Radio (9)

COGNITIVE RADIO TECHNOLOGY: Dynamic Spectrum Access; Digital dividend; Types of Cognitive Radio; Spectrum policies and Regulations; Information theoretic perspective on Cognitive Radio networks (9)

COGNITIVE RADIO TASKS: Spectrum sensing and its methods; Cooperative Spectrum sensing; Spectrum sharing; spectrum mobility; spectrum management; spectrum trading (9)

RESEARCH CHALLENGES AND APPLICATIONS: Optimization Techniques of Dynamic Spectrum Allocation, OFDM based Cognitive Radio; Security issues in cognitive radio; Game theory in Cognitive radio; crosslayer design for cognitive radio networks; applications of cognitive radio; IEEE 802.22 WRAN standard (9)

Total L: 45

REFERENCES:

1. Ahmed Khattab, Dmitri Perkins, Magdy Bayoumi, "Cognitive Radio Networks: From Theory to Practice", Springer-Verlag New York, 2013.
2. Bruce A Fette, “Cognitive Radio Technology”, Elsevier publication, BURLINGTON, 2009.
3. Joseph Mitola III, “Cognitive Radio Architecture: The Engineering Foundations of Radio XML”, Wiley Interscience Publication, NEW JERSEY, 2006.
4. Kwang-Cheng Chen and Ramjee Prasad, “Cognitive Radio Networks”, John Wiley & Sons, 2009.
5. Ekram Hossain, Dusit Niyato, Zhu Han, “Dynamic Spectrum Access and Management in Cognitive Radio Networks”, Cambridge University Press, 2009.

18LC24 HIGH PERFORMANCE NETWORKS

3 0 0 3

CO1: To apply knowledge of contemporary issues in multimedia networking and network management
CO2: To design, implement, and analyze Virtual private
CO3: To design, implement, and analyze software defined networks.
CO4: To use techniques and modern networking protocols for interconnecting objects

MULTIMEDIA NETWORKING: Streaming stored Audio and Video, VOIP-Best effort service, protocols for real time interactive applications, Beyond best effort, scheduling and policing mechanism, integrated services, and RSVP-differentiated services. (9)

NETWORK MANAGEMENT: Infrastructure for network management, The internet standard management framework –SMI, MIB, SNMP, Security and administration, ASN.1. (8)

VIRTUAL PRIVATE NETWORKS: Overview of VPN -Remote-Access VPN, site-to-site VPN, Tunneling to PPP, Security in VPN. MPLS operation, Routing, Tunneling and use of FEC, Traffic Engineering, MPLS based VPN, overlay networks-P2P connections. (9)

SOFTWARE DEFINED NETWORKING: Fundamental Characteristics of SDN - SDN Operation - SDN Devices - SDN Controller - SDN Applications - SDN in Other Environments: SDN Applied to the WAN, SDN Applied to Service Provider and Carrier Networks, SDN Applied to Mobile Networks, SDN Applied to Optical Networks. (10)

6LoWPAN: Introduction - 6LoWPAN Architecture - 6LoWPAN Format - Mobility and Routing - Application Protocols - Using 6LoWPAN (9)

Total L: 45

REFERENCES:

1. Kurose James F and Keith W Ross, “Computer Networking: A Top-Down Approach Featuring the Internet”, Pearson Education, 2009
2. Nader F.Mir, Computer and Communication Networks, first edition.
3. Paul Goransson, Chuck Black, Timothy Culver, “ Software Defined Networks: A Comprehensive Approach”, Morgan Kaufmann Publishers 2017
4. Zach Shelby, Carsten Bormann, “6LoWPAN: The Wireless Embedded Internet”, Wiley 2009
5. Larry L Peterson and Bruce S Davie, “Computer networks: A system approach”, Morgan Kaufmann Publishers 2010.

18LC25 GREEN COMMUNICATION

3 0 0 3

CO1: To understand the necessity and the design aspects of cooperative and green wireless communication.
CO2: To evolve new techniques and demonstrate their feasibility using mathematical validations and simulation tools.
CO3: To demonstrate the impact of the green engineering solutions in a global, economic, environmental and societal context.
CO4: To analyse and design cross layer approaches towards green communication and resource allocation.

COOPERATIVE COMMUNICATIONS AND GREEN CONCEPTS: Network architectures and research issues in cooperative cellular wireless networks; Cooperative communications in OFDM and MIMO cellular relay networks: issues and approaches; Fundamental trade-offs on the design of green radio networks, Green modulation and coding schemes (9)

COOPERATIVE TECHNIQUES: Cooperative techniques for energy efficiency, Cooperative base station techniques for cellular wireless networks; Turbo base stations ; Antenna architectures for cooperation; Cooperative communications in 3GPP LTE-Advanced, Partial information relaying and Coordinated multi-point transmission in LTE-Advanced. (9)

RELAY-BASED COOPERATIVE CELLULAR NETWORKS: Distributed space-time block codes ; Collaborative relaying in downlink cellular systems ; Radio resource optimization; Adaptive resource allocation ; Cross-layer scheduling design for cooperative wireless two-way relay networks ; Network coding in relay-based networks. (9)

GREEN RADIO NETWORKS: Base Station Power-Management Techniques- Opportunistic spectrum and load management, Energy-saving techniques in cellular wireless base stations , Power-management for base stations in smart grid environment , Cooperative multicell processing techniques for energy-efficient cellular wireless communications. (9)

ACCESS TECHNIQUES FOR GREEN RADIO NETWORKS : Cross-layer design of adaptive packet scheduling for green radio networks; Energy-efficient relaying for cooperative cellular wireless networks ; Energy performance in TDD-CDMA multihop cellular networks ; Resource allocation for green communication in relay-based cellular networks ; Green Radio Test-Beds and Standardization Activities. (9)

Total L: 45

REFERENCES:

1. Ekram Hossain, Dong In Kim, Vijay K. Bhargava , "Cooperative Cellular Wireless Networks", Cambridge University Press, 2011.
2. Ekram Hossain, Vijay K. Bhargava (Editor), Gerhard P. Fettweis (Editor), "Green Radio Communication Networks", Cambridge University Press, 2012.
3. F. Richard Yu, Yu, Zhang and Victor C. M. Leung "Green Communications and Networking", CRC press, 2012.
4. Mazin Al Noor, "Green Radio Communication Networks Applying Radio-Over-Fibre Technology for Wireless Access", GRIN Verlag, 2012.
5. Mohammad S. Obaidat, Alagan Anpalagan and Isaac Woungang,"Handbook of Green Information and Communication Systems", Academic Press, 2012.

18LC26 VEHICULAR SYSTEMS AND NETWORKS

3 0 0 3

CO1: To understand the basic concepts of vehicular networks and the applications
CO2: To describe MAC protocols and heterogeneous wireless communication used in vehicular networks
CO3: To explain the various routing protocols and IP address configuration
CO4: To analyze message scheduling and network mobility problem in vehicular networks

INTRODUCTION: Vehicular network definition, special characteristics, technical challenges, Evolution and progress, Vehicular network application and services, public safety application, vehicular traffic coordination, road traffic management. (9)

MAC PROTOCOLS & HETEROGENEOUS WIRELESS COMMUNICATION: DSRC spectrum and applications for vehicular networks, IEEE standards for MAC protocols - A cluster based, A distributed MAC protocol, Priority based secure MAC protocol, Introduction to heterogeneous wireless communications, enabling technologies for vehicular communication networks, platform for design and simulation. (9)

ROUTING IN VEHICULAR NETWORKS: Challenges and requirements for routing protocols, classification, basic solutions, Map based solutions, based on trajectories, based on traffic information. Adhoc IP address auto configuration problem, IP address auto configuration solution requirements, Analysis of solution space, IP address auto configuration in vehicular networks (9)

MESSAGE SCHEDULING: Context and motivations, congestion control approaches, dynamic message scheduling, Analysis and validation (9)

NETWORK MOBILITY: The network mobility problem, NEMO basic support protocol, NEMO route optimization, NEMO in vehicular scenario, Mobile ADhoc NEMO. (9)

Total L: 45

REFERENCES:

1. Hassnaa Moustafa and Yan Zhang, " Vehicular networks – Techniques, Standards and applications" CRC Press, New York, 2009.
2. Stephen Olariu and Michele C Weigle, " Vehicular networks – From theory to Practice", CRC Press, New York, 2009.
3. H. Hartensteinand K. P. Laberteaux, "VANET: Vehicular Applications and InterNetworking Technologies", Wiley, 2010
4. C. Sommer, F. Dressler, "Vehicular Networking",Cambridge University Press, 2015

18LC27 COMMUNICATION PROTOCOLS FOR IOT

3 0 0 3

CO1: To understand the design principles of IoT
CO2: To compare and analyze different standards for IoT
CO3: To give exposure to M2M Architecture and Light weight protocols
CO4: To design and Implement IoT applications

INTRODUCTION: Internet of things overview, Design principles for connected devices, Web thinking for connected devices , Internet Principles. (5)

6LOWPAN AND RPL: 6LoWPAN and RPL Standardization Adaptation Layer RPL Downward Routes, Multicast Membership, Packet Routing
(8)

ZIGBEE SMART ENERGY 2.0: REST Overview, ZigBee SEP 2.0 Overview, Function Sets and Device Types, ZigBee SE 2.0 Security
(8)

ETSI M2M ARCHITECTURE: Introduction to ETSI TC M2M, System Architecture, ETSI M2M Interactions Overview, Security in the ETSI M2M Framework, Interworking with Machine Area Networks (9)

COAP AND MQTT: Constrained application protocol overview, RFC 7252 , MQTT basics, Developing Projects , connecting to server ,Controlling Output Devices.
(9)

Case Studies:
Smart Grid, Industrial Automation and Building automation, Connected Car, Connected Home, Digital Health, Smart city (6)

Total : 45

Reference Books

1. Adrian McEwen,Hakim Cassimally "Designing the Internet of Things" John Wiley and Sons, Ltd , 2014.
2. Olivier Hersent, David Boswarthick, Omar Elloumi "The Internet of Things: Key Applications and Protocols", 2nd Edition John Wiley & Sons Ltd 2012.
3. Jan Holler, Vlasios Tsiatsis, Catherine Mulligan, Stamatis Karnouskos, Stefan Avesand, David Boyle "From Machine-to-Machine to the Internet of Things" Introduction to a New Age of Intelligence , Academic Press 2014
4. Peter Waher "Learning Internet of Things" 2015 Packt Publishing**.**

18LC28 RADIATING SYSTEMS

3 0 0 3

CO1: To Understand and Analyze the behavior of antenna with help of its performance parameters.
CO2: To understand and analyze the performance of array antennas for various applications.
CO3: To understand and design a micros trip patch antennas for wireless applications.
CO4: To evaluate the parameters of EMC Test antennas using antenna measurement techniques.

ANTENNA FUNDAMENTALS: Antenna fundamental parameters Radiation integrals, Radiation from surface and line current distributions, monopole, loop antenna; Mobile phone antenna - hand set antenna - base station antenna-Radiation Hazards.
(6)

RADIATION FROM WIRE AND APERTURE ANTENNAS: Radiated fields of infinitesimal and half wave dipole,; Introduction to numerical techniques Field equivalence principle, Radiation from Rectangular and Circular apertures, Uniform aperture distribution on an infinite ground plane; Slot antenna; Horn antenna; Reflector antenna, aperture blockage, and design consideration.
(12)

ARRAY ANTENNA: Linear array –uniform array, end fire and broad side array, gain, beam width, side lobe level; Two dimensional uniform array; Phased array, beam scanning, grating lobe, feed network, Linear array synthesis techniques – Binomial and Chebyshev distributions. (9)

MICRO STRIP ANTENNA: Radiation Mechanism and Excitation techniques : Microstrip dipole; Patch, Rectangular patch, Circular patch, and Ring antenna – radiation analysis from cavity model; input impedance of rectangular and circular patch antenna; Microstrip array and feed network; Applications of microstrip array antenna. (9)

EMC ANTENNA AND ANTENNA MEASUREMENTS: Concept of EMC measuring antenna; Tx and Rx antenna factors; Log periodic dipole, Bi-conical, Ridge guide, Multi turn loop; Antenna measurement and instrumentation – Gain, Impedance and antenna factor measurement; Antenna test range Design. (9)

Total L: 45

REFERENCES:

1. Balanis A, "Antenna Theory Analysis and Design", John Wiley and Sons, New York, 2009.
2. Krauss J D, "Antennas", John Wiley and sons, New York, 2009.
3. Bahl I J and Bhartia P, "Microstrip Antennas", Artech House,Inc.,1980
4. Stutzman W L and Thiele G A, "Antenna Theory and Design", John Wiley and Sons Inc., 1998.

18LC29 MULTIRATE SIGNAL PROCESSING

3 0 0 3

CO1: To understand two channel multirate filter banks
CO2: To design and analyze M-channel filter banks
CO3: To understand multirate filter banks with polyphase structures
CO4: To study about multirate filter banks and wavelets and its applications

INTRODUCTION: Review of sampling rate convertors and filter banks – two channel filter banks - paraunitary, biorthogonal, linear phase and transmultiplexer filter banks. (11)

M-CHANNEL FILTER BANKS: Filter banks with tree and parallel structure – complex modulated, cosine modulated and transmultiplexer filter banks. (11)

FILTER BANKS WITH POLYPHASE STRUCTURES: Fundamental polyphase structures – polyphase QMF banks – two-channel, M-channel, paraunitary and DFT polyphase filter banks. (11)

OCTAVE FILTER BANKS, WAVELETS AND APPLICATIONS: Tree structured and multicomplementary filter banks – filter banks and wavelets – applications – modems – speech and audio coding – image and video coding – multirate techniques with sensors. (12)

Total L: 45

REFERENCES:

1. Fliege N J, "Multirate Digital Signal Processing", John Wiley and sons, 2010.
2. Vaidyanathan P P, “Multirate Systems and Filter banks”, Prentice Hall, 2008.
3. Fredric J Harris, “Multirate Signal Processing for Communication Systems”, Prentice Hall, 2014.
4. Vikram Gadre and Aditya Abhyankar, “Multiresolution and Multirate Signal Processing: Introduction, Principles and Applications”, McGraw Hill, 2013.
5. Ronald E Crochiere and Lawrence R. Rabiner, “Multirate Digital Signal Processing”, Prentice Hall, 2013.

18LC30 ADAPTIVE SIGNAL PROCESSING

3 0 0 3

CO1: To gain basic knowledge in linear optimum filtering
CO2: To learn about the performance of LMS algorithms
CO3: To understand RLS algorithms.
CO4: To understand Kalman filter and various applications of adaptive filters

INTRODUCTION: Linear Filtering problem – Adaptive filters – Approaches to the development of adaptive filters – cost functions – Wiener filter – orthoganility principle – minimum MSE – Wiener Hopf Equations – error performance surface – linearly constrained minimum variance filter. (11)

STOCHASTIC GRADIENT-BASED ALGORITHMS: Steepest descent algorithm – stability analysis - Least Mean Square algorithm – stability and convergence analysis – variants of LMS algorithm (10)

RECURSIVE LEAST SQUARE ALGORITHMS: Matrix inversion lemma - Exponentially Weighted RLS – Sliding Window RLS – convergence analysis – operation of RLS in nonstationary environment – comparison of RLS and LMS algorithms. (10)

KALMAN FILTER AND FILTERING APPLICATIONS: Recursive minimum mean square estimation – state space model - Innovation process – Extended Kalman Filter - Adaptive Modeling & System Identification - Inverse Adaptive Modeling – Deconvolution – Equalization - Adaptive self tuning filter - Adaptive Line enhancer. - Harmonic cancellation with adaptive prediction. (14)

Total L: 45

REFERENCES:

1. Haykin S, “Adaptive Filter Theory", Prentice Hall Inc, 2012.
2. Widrow B and Stearns S D, "Adaptive Signal Processing", Prentice Hall inc., 2011.
3. Cowan C F N and Grant P M, "Adaptive Filters", Prentice Hall inc., 2010
4. Farhang Boroujeny, “Adaptive Filters Theory and Applications”, John Wiley & Sons, 2010
5. Alexander S T, "Adaptive Signal Processing: Theory and Applications ", Springer – Verlag, 2010.

18LC31 WAVELETS AND SUBBAND CODING

3 0 0 3

CO1: To understand the need of transforms and analyze the time - frequency plot

CO2: To obtain the knowledge of Wavelet basis and Continuous time Wavelet Transform
CO3: To acquire the concept of discrete wavelet transform and filter banks
CO4: To Understand the uses of Wavelets and multiwavelets

INTRODUCTION: Signal spaces - concept of Convergence - Hilbert spaces for energy signals. Fourier basis & Fourier Transform – Limitations of standard Fourier analysis – Need for Time-Frequency Analysis, Spectrogram plot – Windowed Fourier transform Tiling of the Time-Frequency Plane for STFT – Heisenberg's Uncertainty principle – Short time Fourier transform (STFT) Analysis- short comings of STFT- Need for Wavelets. (9)

CONTINUOUS WAVELET TRANSFORMS (CWT): Introduction, Continuous Time wavelets, Definition of CWT, The CWT as a correlation, Constant Q-Factor Filtering Interpolation and time frequency resolution, the CWT as an operator, inverse CWT. (9)

DISCRETE WAVELET TRANSFORM (DWT) AND MRA: Introduction, Approximation of vectors in nested linear vector spaces, example of an MRA-Bases for the approximations subspaces and Haar scaling function, Bases for detail subspaces and Haar wavelet, Formal definition of an MRA, Construction of a general orthonormal MRA, A wavelet basis for MRA, Interpreting orthonormal MRAs for Discrete time signals, Daubechies Wavelets, Relationship between Filter banks and wavelet basis, Important wavelets: Haar, Mexican hat, Meyer, Shannon, Daubechies (10)

ADVANCED TOPICS: Wavelet packets, Non - separable multidimensional wavelets, Bi-orthogonal basis-B-Splines, Lifting scheme of wavelet generation, Multiwavelets, Ridgelets, Curvelets. (9)

APPLICATIONS OF WAVELETS: Signal Denoising - Sub-band coding of Speech and music– Image Compression using 2-D DWT- JPEG 2000 standard - Fractal Signal Analysis. (8)

Total L: 45

REFERENCES:

1. Soman K P and Ramachandran K I, "Insight into Wavelets from Theory to Practice", Prentice Hall India, 2010
2. Jaideva C Goswami and Andrew K Chan, "Fundamentals of Wavelets – Theory, Algorithms and Applications", John Wiley and Sons, Inc., Singapore, 1999.
3. Vetterli M and Kovacevic J, "Wavelets and Subband Coding," Prentice Hall, 1995.
4. Fliege. N J, "Multirate Digital Signal Processing", John Wiley and Sons, Newyork,1994.
5. Wornell G W, "Signal Processing with Fractals: A Wavelet based Approach", Prentice Hall, 1995.

18LC32 DIGITAL IMAGE AND VIDEO PROCESSING

3 0 0 3

CO1: To understand the role human visual system in perception and the importance of various transforms
CO2: To learn the signal processing algorithms and techniques in image and video enhancement restoration
CO3: To understand image and videos processing in areas of classification, segmentation, storage and retrieval
CO4: To acquire an appreciating knowledge for the image and video processing issues and techniques, be able to apply these techniques to real world problems.

DIGITAL IMAGE AND VIDEO BASICS: Human visual system and image perception, Types of Images, Digitization of Images, Sampled Images, Quantized Images, Digital Video, Sampled video and colour vision models, 2D signals and systems; image transforms - 2D DFT, DCT, KLT, Harr transform and discrete Wavelet transform (10)

IMAGE AND VIDEO ENHANCEMENT AND RESTORATION: Linear Image Enhancement, Non-Linear Image Enhancement: Weighted median filters, Image Noise cleaning, Image Zooming, Image Sharpening, Edge Detection, Wavelet denoising, Image restoration, Video Enhancement, Filtering and restoration (10)

IMAGE AND VIDEO CLASSIFICATION AND SEGMENTATION: Statistical methods of segmentation, Texture classification and segmentation, Gradient and Laplacian type edge detection, Diffusion based edge detectors, video segmentation (8)

IMAGE AND VIDEO STORAGE, RETRIEVAL AND COMMUNICATIONS: Image and Video Indexing and retrieval, Video browsing and retrieval, Image and video communication networks, Image watermarking and authentication (9)

IMAGE AND VIDEO PROCESSING APPLICATIONS: Pixel-based model. Case study 1: Surveillance system, Space-frequency model. case study 2: Mosaic creation, Geometrical model. case study 3: Video restoration, Region-based model. Case study 4: object tracking (8)

Total L: 45

REFERENCES:

1. Gonzaleze and Woods, “Digital Image Processing”, 3rd edition , Prentice Hall, 2008
2. Chris Solomon, Toby Breckon ,"Fundamentals of Digital Image Processing A Practical Approach with Examples in Matlab",John Wiley & Sons,2011
3. Yao wang, Joem Ostarmann and Ya–quin Zhang, ”Video processing and communication” , 1st edition , PHI, 2015
4. Alan Bovik “Handbook of Image and Video Processing” 2nd Edition ,Academic Press,2005

18LC33 MULTIMEDIA COMPRESSION

3 0 0 3

CO1: To introduce the significance of data compression and the idea of various Huffman codes.
CO2: To develop the knowledge of generating tags, deciphering the tag in Arithmetic coding approaches, LZ77, LZ78, LZW and the application of static and dynamic dictionary approaches.
CO3: To introduce the concept of Audio compression and various audio compression standards and its applications.
CO4: To understand the need, concept of 2D and 3D compression and to develop the knowledge of various recent compression standards and techniques.

INTRODUCTION: Compression Techniques - Overview of information theory - lossless and lossy coding– Modeling and Coding - Taxonomy of compression techniques – Rate distortion theory - Huffman coding – Non-Binary Huffman codes – adaptive Huffman coding – Application of Huffman coding. (8)

ARITHMETIC CODING AND DICTIONARY TECHNIQUES: Introduction- coding a sequence – generating deciphering the tag – Generating a binary code – Uniqueness of arithmetic code – Algorithm, integer implementation – comparison of Huffman and arithmetic coding – Applications -Static and Adaptive dictionary – LZ77, LZ78, LZW approach – Applications - Facsimile encoding – run length coding – comparison of MH, MR, MMR and JBIG. Scalar and Vector Quantization (10)

AUDIO COMPRESSION: Audio compression techniques - frequency domain and filtering - basic sub-band coding -application to speech coding - G.722 - application to audio coding - MPEG audio - silence suppression - speech compression techniques – Vocoders. (10)

IMAGE COMPRESION: Predictive techniques - DPCM, DM - KL transform – discrete cosine, Walsh- Hadamard transform - JPEG, Wavelet based compression: quad-trees, EZW, SPIHT, JPEG-2000. (9)

VIDEO COMPRESSION: Video signal representation – Motion compensation – MPEG standards - Motion estimation techniques - H.261 family of standards - Motion video compression. (8)

Total L: 45

REFERENCES:

1. Khalid Sayood, “Introduction to Data Compression”, Morgan Kaufman, 2012.
2. Salomon D, “Data Compression The Complete Reference”, Springer, 2007.
3. Salomon D, “A Guide to Data Compression Methods”, Springer, 2002.
4. Jan Vozer, “Video Compression for Multimedia”, AP Press, New York, 1995.
5. Alistar Moffat, “Compression and Coding Algorithms”, Kluwer Academic Publishers, 2002.

18LC34 COMPUTER VISION AND MACHINE LEARNING

3 0 0 3

CO1: To understand the concept of imaging in machine learning
CO2: To obtain the knowledge of various signatures for machine learning in 2D and 3D
CO3: To acquire the concept of machine leaning algorithms
CO4: To apply the various machine learning algorithms for real world applications

IMAGES AND IMAGING OPERATIONS: Introduction-Image Processing Operations- Image Filtering Operation-Region Growing Methods -Thresholding, Adaptive, Thresholding-Edge Detection-Template Operators-Differential Gradient Operators-Circular Operator-Corner and Interest Point Detection-Basic Approaches to Texture Analysis. (10)

SHAPE AND BOUNDARY PATTERN ANALYSIS: Binary Shape Analysis-Connectedness-size filtering -Distance Functions - Skeletons and Thinning-Measures for Shape Recognition-Boundary Tracking Procedures- Centroidal Profiles-Occlusion-Boundary Length Measures-Methods of Line, Circle and Ellipse Detection. (9)

3D VISION AND MOTION: 3-D Vision Methods - Projection Schemes for 3D Vision- Photometric Stereo- Shape from Texture - Structured Lighting -Three-Dimensional Object Recognition Schemes-Orientation Technique. (8)

MACHINE LEARNING TECHNIQUES: Perceptron, multi-layer perceptron, backpropagation algorithm, Unsupervised learning and clustering **–** k-means clustering, fuzzy k-means clustering, hierarchical clustering, SVM, SIFT, SURF, Adaboost algorithms. (9)

MACHINE VISION APPLICATIONS: Case study1: Automated Visual Inspection of objects, Case study2: Inspection of Food Products, Case study3: Surveillance, Case study4: Vehicle Guidance in Agriculture, Case study5: Path Planning, Navigation and Egomotion (9)

Total L: 45

REFERENCES:

1. Michael Beyeler “Machine Learning for OpenCV” First Edition, Packt Publishers,2017
2. E. R. Davies, “Computer and Machine Vision: Theory, Algorithms, Practicalities”, 4th Edition, Elsevier Inc,2012.
3. Szeliski, Richard, “Computer Vision: Algorithms and Applications”,First Edition, Springer-Verlag London Limited, 2011.
4. C. Bishop, “Pattern Recognition and Machine Learning”, Springer, 2006.

18LC35 SPEECH SIGNAL PROCESSING

3 0 0 3

CO1: To model speech signal and learn its characteristics
CO2: To understand the time domain and frequency domain analysis of speech signals
CO3: To learn various coding techniques used in speech signal processing
CO4: To analyze various speech recognition methods

SPEECH SIGNAL MODELLING: Speech signal characteristics and classifications - Speech production mechanism - Acoustic Theory of speech production - Source – Filter model - Lossless Tube Models - Digital Model of speech signals. (9)

SPEECH SIGNAL ANALYSIS: Time domain Analysis for speech processing – Short time energy and magnitude - short time average zero crossing – Speech vs silence discrimination (9)

FRQUENCY DOMAIN ANALYSIS: Pitch period estimation using autocorrelation - Short time Fourier analysis- Definition and properties - Design of digital filter banks - Pitch detection - analysis by synthesis. (9)

SPEECH CODING: Linear predictive coding - principle - solution of LPC equation - Cholesky decomposition method - Durbin's method - Lattice formulation –Frequency domain coding – Model based coding – LPC residual coding. (9)

SPEECH RECOGNITION: Template training method - Hidden Markov Model-Gaussian Mixture model- connected word recognition- Speaker identification/Verification. (9)

Total L: 45

REFERENCES:

1. Rabiner LR and Schaffer RW, "Digital Processing of Speech Signals", Prentice -Hall, Englewod - Clitts, New Jersey, 1986.
2. Rebner LR K and Juang BH, "Fundamentals of Speech Recognition", Pearson Education, First Indian reprint 2003.
3. Kondoz, "Digital Speech", John Wiley and Sons Ltd., 1994.
4. Thomas FQuatieri, “Discrete Time Speech Signal Processing”, Pearson Education, 2002.
5. John R Deller, John Hansen and ProakisJG,“Discrete Time Processing of Speech Signals”, IEEE Press, 1999.

18LC36 ERROR CONTROL CODING

3 0 0 3

CO1: To understand the fundamentals of Finite fields and coding theory
CO2: To analyze the performance of various non-binary coding schemes
CO3: To compare various iterative coding and decoding techniques
CO4: To describe the operation and performance of LT and Raptor codes

FINITE FIELD ARITHMETIC: Set, Group, field, vector spaces, elementary properties of Galois fields, Galois field arithmetic, Addition of polynomials, Subtraction of polynomials, Multiplication of polynomials, Division of polynomials, Irreducible polynomial, Primitive polynomial, Construction of GF (2^m). (9)

BCH AND REED SOLOMON CODES: Non-binary BCH codes, Berlekamp–Massey Algorithm, Chien Search algorithm, Non-binary RS codes, REED SOLOMON Design, decoding of non-binary codes, Welch—Berlekamp Algorithm. (9)

TURBO CODES: Turbo Encoder, Different Types of Interleavers, Turbo Coding Illustration, Turbo Decoder, The BCJR Algorithm, Performance Analysis of the Turbo Codes, Effect of Number of Iterations on the Performance of the Turbo Codes, Effect of Puncturing on the Performance of the Turbo Codes (9)

LOW-DENSITY PARITY-CHECK (LDPC) CODES: LDPC code properties, representation using Tanner Graph, LDPC encoding, preprocessing method, LDPC decoding, Bit flipping algorithm, Sum Product algorithm, Min Sum algorithm. (9)

LT AND RAPTOR CODES: LT Codes design, Systematic LT codes, Raptor Codes (9)

Total L: 45

REFERENCES:

1. Peter Sweeney, “Error Control Coding from Theory to Practice”, John Wiley and Sons, 2002.
2. Shu Lin and Daniel J. Costello. Jr, "Error control coding", Pearson, Prentice Hall, 2nd edition, 2004.
3. Richard B Wells, “Applied Coding and Information Theory for Engineers”, Prentice Hall, 1st edition,1998.
4. K.Deeraga Rao, "Channel Coding Techniques for Wireless Communications", Springer, 1st edition, 2015.

18LC37 EVOLUTIONARY COMPUTATION

3 0 0 3

CO1: To assess the strengths and weaknesses of several approaches to evolutionary computation.
CO2: To gain experience in artificial neural network algorithms for particular classes of problems.
CO3: To gain experience in applying fuzzy logic algorithms for control based applications.
CO4: To apply techniques in evolutionary computation to problems such as control, optimization, and biological modeling.

INTRODUCTION: Soft Computing, requirement, different tools and techniques, usefulness and applications. Artificial Neural Network: Introduction, basic models, Hebb's learning, Perceptron, Multilayer feed forward network, Back propagation, Different issues regarding convergence of Multilayer Perceptron, Competitive learning, Self-Organizing Feature Maps, SVM, Applications. (10)

FUZZY SETS AND FUZZY LOGIC: Introduction, Fuzzy sets versus crisp sets, operations on fuzzy sets, Extension principle, Fuzzy relations and relation equations, Fuzzy numbers, Linguistic variables, Fuzzy logic, Linguistic hedges, Applications, fuzzy database. fuzzy controllers, fuzzy pattern recognition, fuzzy image processing. (9)

GENETIC ALGORITHM(GA): Different operators of GA, analysis of selection operations, Hypothesis of building blocks, Schema theorem and convergence of Genetic Algorithm, Advanced operators, Simulated annealing, Applications. (9)

ANT COLONY OPTIMIZATION: Ant foraging behavior - Theoretical considerations – ACO Algorithm – ACO Theory and model based search. (8)

PARTICLE SWARM & ARTIFICIAL BEE COLONY(ABC)OPTIMIZATION: Principles of bird flocking and fish schooling – Evolution of PSO – Operating principles – PSO Algorithm – Neighborhood Topologies – Convergence criteria – Behavior of real bees, ABC algorithm. (9)

Total L: 45

REFERENCES:

1. RajasekaranS and PaiG A V, “Neural Networks, Fuzzy logic, and Genetic Algorithms,” PHI, 2003
2. GoldbergD E, “Genetic Algorithms in Search and Optimization, and Machine Learning”, Addison-Wesley, 1989.
3. Marco Dorigo and Thomas Stutzle, “Ant Colony optimization”, Prentice Hall of India, New Delhi 2005.
4. Anupam Shukla, Rahul Kala, and Ritu Tiwari,” Real Life Applications of Soft Computing”, CRC Press, 2010
5. S.N.Sivanadam, S.N.Deepa, “Introduction to Genetic Algorithms” Springer, 2008
6. Kennedy J and Russel C Eberhart, “Swarm Intelligence”, Morgan Kaufmann Publishers, USA, 2001.

18LC38 DATA STRUCTURES AND ALGORITHMS

2 2 0 3

CO1: To illustrate and apply the concepts of data structures

CO2: To solve real time problems related to graph theory
CO3: To analyze the given model of the problem and design suitable algorithm
CO4: To formulate and solve the engineering problems involving data structures.

INTRODUCTION: Software Development process – Data structures - Abstract Data Types - Analysis of algorithms - Best, worst and average case time complexities - notations. (4+4)

ARRAYS : Operations - Implementation of one, two, three and multi dimensioned arrays – Sparse and dense matrices - Applications. (4+6)

STACK AND QUEUE: Stack operations - implementations - Applications: Function handling - Recursion – Expression Evaluation. Queue - operations - implementations - Priority Queues - Dequeues - Applications: Job scheduling. (6+4)

LISTS : Operations - Singly linked lists, doubly linked lists, Circular lists - Applications – Linked Stacks - Linked queues. (6+4)

TREES AND GRAPHS: Tree Terminologies - Implementation - Binary Tree: Properties –representation of trees, operations-Traversals- Expression trees - Infix, Postfix and Prefix expressions – Dijkstra's Algorithms-Floyd's Algorithm.GraphTerminologies-representations-graph search methods: Breadth first search, Depth first search, Minimum spanning trees-Multistage graph. (6+6)

SORTING: Insertion sort - Selection sort - Bubble sort - Radix sort - Algorithms and their time complexities. (4+6)

TUTORIAL COMPONENT:
1. Analysis of algorithms
2. Implementation of stack and queue
3. Evaluation of expressions
4. Singly and doubly linked lists implementation
5. Binary tree traversal.
6. Single source shortest path algorithm – Dijkstra's algorithm,
7. All pairs shortest path problem- Floyd's Algorithm
8. Graph search method implementation

Total L: 30+T: 30=60

REFERENCES:

1. SahniSartaj, "Data Structures, Algorithms and Applications in C++", Universities Press, Hyderabad, 2005.
2. Mark Allen Weiss, "Data Structures and Algorithm Analysis in C", Pearson Education, New Delhi, 2007.
3. Robert L Kruse, Bruce P Leung and Clovin L Tondo, "Data Structures and Program Design in C", Pearson Education, New Delhi, 2009.
4. VijayalakshmiPai G A, "Data Structures and Algorithms: Concepts Techniques and Applications", McGraw-Hill, 2009.
5. A. Chitra P T Rajan "Data Structures", Tata McGraw Hill Education, 2008.
6. Ellis Horowitz ,SartajSahni and SanguthevarRajasekaran, 'Computer Algorithms/C++', Orient Black Swan, 2008.

18LC39 RESEARCH METHODOLOGY AND INTELLECTUAL PROPERTY RIGHTS

3 0 0 3

CO1: To understand research problem formulation and research ethics
CO2: To apply technical knowledge in research writing
CO3: To understand the nature of intellectual property rights (IPR) and their new developments
CO4: To analyze the scope of patent rights

RESEARCH PROBLEM: Meaning of research problem - sources of research problem - criteria characteristics of a good research problem - errors in selecting a research problem scope and objectives of research problem - investigation of solutions for research problem, data collection, analysis, interpretation, necessary instrumentations **(**10**)**

LITERATURE SURVEY AND TECHNICAL WRITING: Effective literature studies approaches and analysis – plagiarism - research ethics - effective technical writing – report writing - paper developing – developing research proposal, format of research proposal **(**12**)**

INTELLECTUAL PROPERTY RIGHTS: Nature of Intellectual Property, patents, designs, trade and copyright - process of patenting and development - technological research, innovation, patenting, development - International Scenario, International cooperation on intellectual property - procedure for grants of patents - patenting under PCT **(**11**)**

NEW DEVELOPMENTS IN IPR AND SCOPE OF PATENT RIGHTS: IPR of biological systems, computer software etc - traditional knowledge - case studies - IPR and IITs - Licensing and transfer of technology - patent information and databases - geographical Indications - administration of patent system **(**12**)**

Total L: 45

REFERENCES:

1. Stuart Melville and Wayne Goddard, “Research methodology: an introduction for science & engineering students’”
2. Wayne Goddard and Stuart Melville, “Research Methodology: An Introduction” Ranjit Kumar, 2nd Edition, “Research Methodology: A Step by Step Guide for beginners”
3. Halbert, “Resisting Intellectual Property”, Taylor & Francis Ltd, 2007.
4. Mayall, “Industrial Design”, McGraw Hill, 1992.
5. Niebel, “Product Design”, McGraw Hill, 1974.
6. Asimov, “Introduction to Design”, Prentice Hall, 1962.
7. Robert P. Merges, Peter S. Menell, Mark A. Lemley, “Intellectual Property in New Technological Age”, 2016.
8. T. Ramappa, “Intellectual Property Rights Under WTO”, S. Chand, 2008