**SYLLABUS**

**FOR**

**TWO-YEAR M. TECH. PROGRAMME**

**IN**

**SIGNAL PROCESSING & ENGINEERING**



|  |
| --- |
| **NAAC – A Grade** |

**DEPARTMENT OF INSTRUMENTATION & ELECTRONICS ENGINEERING**

**COLLEGE OF ENGINEERING & TECHNOLOGY**

**(An Autonomous and Constituent College of BPUT, Odisha)**

**Techno Campus, Mahalaxmi Vihar, Ghatikia,**

**Bhubaneswar-751029, Odisha, INDIA**

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**COURSE: M. Tech. (IE – Signal Processing and Engineering)**

**Duration: 2 years (Four Semesters)**

**Abbreviations Used: U= UG, I= Integrated, P= PG**

**PC= Professional Core PE= Professional Elective OE= Open Elective**

**LC= Lab Course MC= Mandatory Course AC= Audit Course**

**L= Lectures P= Practical/Laboratory IA\*= Internal Assessment**

**T= Tutorial PA= Practical Assessment EA=End-Semester Assessment**

**\*Internal Assessment Max. Mark (30 marks) consists of Mid Semester (20 marks) and Quiz+Assignment (10 marks)**

**Subject Code Format:**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** |
| **Prog (U/I/P)** | **Type (PC/PE/OE/LC/MC/AC)** | **Department (CE/EE/IE/ME/…)** | **Semester (1/2/…/0)** | **Serial No. (1/2/3/…/99)** |

**1st SEMESTER**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Sl. No.** | **Subject** **Type** | **Subject Code** | **Subject****Name** | **Teaching Hours** | **Credit** | **Maximum Marks** |
| **L** | **T** | **P** | **IA** | **EA** | **PA** | **Total** |
| 1 | Core 1 | PPCIE103 | Advanced Digital Signal Processing | 3 | 0 | 0 | 3 | 30 | 70 | - | 100 |
| 2 | Core 2 | PPCIE104 | Digital Image and Video processing | 3 | 0 | 0 | 3 | 30 | 70 | - | 100 |
| 3 | Professional Elective 1(Any One) | PPEIE104 | Linear Algebra for Signal Processing  | 3 | 0 | 0 | 3 | 30 | 70 | - | 100 |
| PPEIE105 | Stochastic Processes |
| PPEIE106 | Microcontroller & Programmable Digital Signal Processor |
| PPEIE107 | Mixed Signal VLSI Design |
| 4 | Professional Elective 2(Any One) | PPEIE112 | DSP Architectures  | 3 | 0 | 0 | 3 | 30 | 70 | - | 100 |
| PPEIE113 | Optical Signal Processing |
| PPEIE114 | Time Frequency Analysis & Wavelets |
| PPEIE115 | Cognitive Radio |
| 5 | Mandatory  | PMCMH101 | Research Methodology & IPR  | 2 | 0 | 0 | 2 | 30 | 70 | - | 100 |
| 6 | Lab 1 | PLCIE103 | Advanced Digital Signal Processing Lab- I | 0 | 0 | 4 | 2 | - | - | 100 | 100 |
| 7 | Lab 2 | PLCIE104 | Digital Image and Video processing Lab | 0 | 0 | 4 | 2 | - | - | 100 | 100 |
| **Total** | **14** | **0** | **8** | **18** | **150** | **350** | **200** | **700** |
| 8 | Audit 1 | Any one subject from Appendix-I | 100 |
| **Grand Total** | **800** |

**2nd SEMESTER**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Sl. No.** | **Subject** **Type** | **Subject Code** | **Subject****Name** | **Teaching Hours** | **Credit** | **Maximum Marks** |
| **L** | **T** | **P** | **IA** | **EA** | **PA** | **Total** |
| 1 | Core 3 | PPCIE203 | Machine Learning  | 3 | 0 | 0 | 3 | 30 | 70 | - | 100 |
| 2 | Core 4 | PPCIE204 | Detection and Estimation Theory | 3 | 0 | 0 | 3 | 30 | 70 | - | 100 |
| 3 | Professional Elective 3(Any One) | PPEIE204 | Statistical Signal Processing | 3 | 0 | 0 | 3 | 30 | 70 | - | 100 |
| PPEIE205 | VLSI Signal Processing |
| PPEIE206 | Wireless Communication |
| PPEIE207 | Information Theory and Coding Techniques |
| 4 | Professional Elective 4(Any One) | PPEIE208 | Digital Design and Verification | 3 | 0 | 0 | 3 | 30 | 70 | - | 100 |
| PPEIE209 | Radar Signal Processing |
| PPEIE210 | Adaptive Signal Processing |
| PPEIE211 | Wireless Sensor Network |
| 5 | Practical 1 | PPRIE201 | Mini Project with Seminar | 0 | 0 | 4 | 2 | - | - | 100 | 100 |
| 6 | Lab 3 | PLCIE203 | Advanced Digital Signal Processing Lab- II | 0 | 0 | 3 | 2 | - | - | 100 | 100 |
| 7 | Lab 4 | PLCIE204 | Machine Learning Lab | 0 | 0 | 4 | 2 | - | - | 100 | 100 |
| **Total** | **12** | **0** | **12** | **18** | **120** | **280** | **300** | **700** |
| 8 | Audit 2 | Any one subject from Appendix-II | 100 |
| **Grand Total** | **800** |

**3rd SEMESTER**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Sl. No.** | **Subject** **Type** | **Subject Code** | **Subject****Name** | **Teaching Hours** | **Credit** | **Maximum Marks** |
| **L** | **T** | **P** | **IA** | **EA** | **PA** | **Total** |
| 1 | Professional Elective 5(Any One) | PPEIE304 | Biomedical Signal Processing | 3 | 0 | 0 | 3 | 30 | 70 | - | 100 |
| PPEIE305 | Internet of Things |
| PPEIE306 | Multimedia Signal Processing |
| PPEIE307 | Audio Signal Processing |
| 2 | Open Elective  | Any one subject from Appendix-III | 3 | 0 | 0 | 3 | 30 | 70 | - | 100 |
| 3 | Project 1 | PPRIE301 | Phase-I Dissertation | 0 | 0 | 20 | 10 | - | - | 100 | 100 |
| **Total** | **6** | **0** | **20** | **16** | **60** | **140** | **100** | **300** |

**4th SEMESTER**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Sl. No.** | **Subject** **Type** | **Subject Code** | **Subject****Name** | **Teaching Hours** | **Credit** | **Maximum Marks** |
| **L** | **T** | **P** | **IA** | **EA** | **PA** | **Total** |
| 1 | Project 2 | PPRIE401 | Phase-II Dissertation | 0 | 0 | 32 | 16 | - | - | 100 | 100 |
| **Total** | **0** | **0** | **32** | **16** | **-** | **-** | **100** | **100** |

**Abstract of Credit and Marks Distribution**

|  |  |  |  |
| --- | --- | --- | --- |
| **Sl. No.** | **Semester** | **Maximum Credits** | **Maximum Marks** |
| 1 | 1st Semester | 18 | 800 |
| 2 | 2nd Semester | 18 | 800 |
| 3 | 3rd Semester | 16 | 300 |
| 4 | 4th Semester | 16 | 100 |
| **Total** | **68** | **2000** |

**NB:**

* **Any one of the Courses in Appendix-I is to be Decided by the Concerned Department for Audit-1 (1st Sem)**
* **Any one of the Courses in Appendix-II is to be Decided by the Concerned Department for Audit-2 (2nd Sem)**
* **Any one of the Courses in Appendix-III is to be Decided by the Concerned Department for Open Elective (3rd Sem)**

**Semester-1**

**Core 1: Advanced Digital Signal Processing (PPCIE103)**

**Prerequisite:**

Digital Signal Processing, Mathematics

**Course Outcomes:**

After the successful completion of the course, student will be able to

1. study the modern digital signal processing algorithms and applications.
2. apply theory of multirate DSP and solve numerical problems and write algorithms
3. apply theory of prediction and find solution of normal equations
4. Analyze the power spectrum estimation (4 or 5 methods).
5. Have an in-depth knowledge of use of digital systems in real time applications
6. Apply the algorithms for wide area of recent applications.

**Module I:** Multirate Digital Signal Processing

Introduction, Decimation by a Factor D, Interpolation by a Factor I, Sampling Rate Conversion by a Rational Factor I/D, Implementation of Sampling Rate Conversion: Multistage Implementation of Sampling Rate Conversion, Sampling Rate Conversion of Band-pass Signals, Sampling Rate Conversion by an Arbitrary Factor: Applications of Multirate Signal Processing, Digital Filter Banks.

**Module II:** Linear Prediction and Optimum Linear Filters

Random Signals, Correlation Functions, and Power Spectra, Innovations Representation of a Stationary Random Process, Forward and Backward Linear Prediction, Properties of the Linear Prediction-Error Filters, AR Lattice and ARMA Lattice-Ladder Filters, Wiener Filters for Filtering and Prediction

**Module III:** Power Spectrum Estimation

Estimation of Spectra from Finite-Duration Observations of Signals, Computation of the Energy Density Spectrum, Estimation of the Autocorrelation and Power Spectrum of Random Signals: The Periodogram, The Use of the DFT in Power Spectrum Estimation, Nonparametric Methods for Power Spectrum Estimation: Parametric Methods for Power Spectrum Estimation.

**Text Books:**

1. John G. Proakis, Dimitris G. Manolakis, Digital Signal Processing: Principles, Algorithms, and Applications,4/e Pearson.
2. Alan V. Oppenheim, Ronald W. Schafer, Discrete-Time Signal Processing, Pearson Education India, 2011.

**Reference books:**

1. Digital signal processing. By Nagoorkani, Tata McGraw-Hill Education.

**Core 2: Digital Image & Video Processing (PPCIE104)**

**Prerequisites:**

Basic knowledge in Digital Signal Processing, Knowledge of engineering mathematics including transform theory and matrix algebra is an advantage.

**Course Outcomes:**

On successful completion of the course, students should be able to:

1. Describe the basic issues and the scope of image processing, and the roles of image processing and systems in a variety of applications.
2. Demonstrate a good understanding of the history and the current state-of-the-art image processing systems and applications which constantly push the boundaries and raise challenges in other fields of studies such as mathematics, physics, and computer systems engineering.
3. Identify areas of knowledge which are required, select an appropriate approach to a given image processing task, and critically evaluate and benchmark the performance of alternative techniques for a given problem by simulation using, e.g. Matlab.
4. Ability to design or specify basic image or video processing algorithm in the context of a complete application with a high level of proficiency via software and hardware systems

**Module I**

Introduction: Digital Image Fundamentals, Image Transforms: Fourier, Hadamard, Walsh, Discrete cosine and Hotelling Transforms.

Image Enhancement: Intensity Transformations, Histogram modification, Histogram equalisation, Smoothing, Filtering (Spatial Domain and Frequency Domain), Sharpening, Homomorphic filtering.

Image Restoration: Degradation Models, PSF, circulant and block-circulant matrices, de-convolution, restoration using inverse filtering, Wiener filtering and maximum entropy-based methods.

**Module II**

Image Segmentation: Pixel classification, Bi-level thresholding, Multi-level thresholding, P-tile method, Adaptive thresholding, Spectral & spatial classification, Edge detection, Hough transform, Region growing.

Image compression: Fundamental concepts of image compression - Compression models - Information theoretic perspective - Fundamental coding theorem - Lossless Compression: Huffman Coding- Arithmetic coding - Bit plane coding - Run length coding - Lossy compression: Transform coding - Image compression standards.

**Module III**

Image Registration: Match measurement, Matching of binary pattern, Distortion tolerant matching, Applications of image registration techniques.

Morphological Image Processing: Dilation, Erosion, Duality, Opening, Closing, Hit-or-Miss Transformation, Basic morphological algorithm, Extraction of connected components, Thinning.

Video Processing: Representation of Digital Video, Spatio-temporal sampling; Motion Estimation; Video Filtering; Video Compression, Video coding standards.

**Texts Books:**

1. A.K. Jain, Fundamentals of digital image processing, Prentice Hall of India, 1989.
2. R. C. Gonzalez, R. E. Woods, Digital Image Processing, Pearson Education. II Ed.,2002
3. W. K. Pratt, Digital Image Processing, Prentice Hall, 1989

**References Books:**

1. A. Rosenfold and A. C. Kak, Digital image processing, Vols. 1 and 2, Prentice Hall, 1986.
2. H. C. Andrew and B. R. Hunt, Digital image restoration, Prentice Hall, 1977
3. R. Jain, R. Kasturi and B.G. Schunck, Machine Vision, McGraw-Hill International Edition, 1995
4. A. M. Tekalp, Digital Video Processing, Prentice-Hall, 1995
5. A.Bovik, Handbook of Image & Video Processing, Academic Press, 2000

**PE 1: Linear Algebra for Signal Processing (PPEIE104)**

**Prerequisite:**

Fundamentals of Calculus, Some experience with transformation geometry.

**Course Outcome:**

Upon successful completion of this course students will be able to:

1. Use computational techniques and algebraic skills essential for the study of systems of linear equations, matrix algebra, vector spaces, eigenvalues and eigenvectors, orthogonality and diagonalization.
2. Use visualization, spatial reasoning, as well as geometric properties and strategies to model, solve problems, and view solutions, especially in R2 and R3, as well as conceptually extend these results to higher dimensions.
3. Use technology, where appropriate, to enhance and facilitate mathematical understanding, as well as an aid in solving problems and presenting solutions
4. Communicate and evaluate mathematical statements, ideas and results, both verbally and in writing, with the correct use of mathematical definitions, terminology and symbolism.

**Module I**

Fundamentals of Matrix Computations: Matrix rank, Solving linear system of equations using matrices, LDU factorisation, QR decomposition, Eigen values, Eigen vectors and spectrum, Properties of Eigen values and Eigen vectors of Hermitian matrices, Normal matrices, Unitary matrices, Diagonalizability, Orthogonal diagonilization, Orthogonal Bases and Gram-Schmidt, The Singular Value Decomposition, Iterative Methods for Linear Systems, The Least Squares Problem, Gaussian Elimination and Its Variants.

**Module II**

Linear Algebra: Vector Spaces and Subspaces, Linear combination and linear span, Linear dependence and linear independence of vectors, Basis and dimension of vector space, finite dimensional vector spaces, Examples of finite and infinite dimensional vector spaces, Direct Sums, Ordered Bases and Coordinate Matrices, The Row and Column Spaces of a Matrix, The Complexification of a Real Vector Space.

**Module III**

Linear Transformations: Linear Transformations, Sum, product and inverse of Linear Transformations, The Kernel and Image of a Linear Transformation, Isomorphism, The Rank Plus Nullity Theorem, Linear Transformations from Fn to Fm, Change of Basis Matrices, The Matrix of a Linear Transformation, Four fundamental subspaces of Linear Transformations, Change of bases, Diagonalization and the Psuedo inverse, Linear functional, Inner Product Spaces, Cauchy-Schwarz Inequality

**Text Book:**

1. Gilbert Strang, "Linear Algebra and its Applications”, 3rd edition, Thomson Learning Asia, 2003.

**Reference Books:**

1. Steven Roman, “Advanced Linear Algebra”, Third Edition, Springer,2008
2. C. Lay, “Linear Algebra and its Applications,” 3rd edition, Pearson Education (Asia) Pte. Ltd, 2005.
3. Kenneth Hoffman and Ray Kunze, "Linear Algebra," 2nd edition, Pearson Education (Asia) Pte. Ltd/ Prentice Hall of India, 2004.
4. Bernard Kolman and David R. Hill, "Introductory Linear Algebra with Applications”, Pearson Education (Asia) Pte. Ltd, 7th edition, 2003.

**PE 1: Stochastic Process (PPEIE105)**

**Prerequisites:**

Probability Theory

**Course Outcomes:**

On successful completion of the course, students should be able to

1. Analyze the power of stochastic processes and their range of applications.
2. Apply the fundamentals of probability theory and random processes to practical engineering problems.
3. Demonstrate well known classes of stochastic processes such as Markov Process, Diffusion Process, Bernoulli Process, and Poisson Process.
4. Analyze the properties of stochastic processes, especially random walks, branching processes, applied to real problems.

**Module I**

Elements of Probability Theory: Basic Definitions from Probability theory, Random variables, Conditional Expectation, Characteristic Function, Gaussian Random Variables, Types of Convergence and Limit Theorems.

Basics of Theory of Stochastic Processes: Introduction, Definition of a Stochastic Process, Classification of random processes according to state space and parameter space, Types of Stochastic Processes, Elementary Problems, Examples of Stochastic Processes.

**Module II**

Markov Process: Chapman-Kolmogorov Equation, Generator of a Markov Process, Ergodic Markov Processes, Diffusion Process: Backward and Forward Kolmogorov Equations, Multidimensional Diffusion Processes, Connection with Stochastic Differential Equations, Examples of Diffusion Processes, Bernoulli Process, Brownian Motion.

Poisson Processes: Definition and Properties of a Poisson Process, Combining and Splitting Poisson Processes, Non- homogeneous Poisson Processes.

**Module III**

Branching Processes: Definition and examples of Branching processes, probability generating function, mean and variance, Galton-Watson Branching process, probability of extinction. Renewal Theory: Renewal Processes, Renewal Function and Renewal Equations, Renewal Theorems, Stationary Renewal Processes.

Stationary Processes: Weakly stationary and strongly stationary processes, moving average and auto regressive processes, Random walks, large deviations, and martingales.

**Text Books:**

1. G. R. Grimmett and D. R.Stirzaker, “Probability and Random Processes”, 3rd Edition, Oxford University Press, 2001.
2. S.M. Ross, “Stochastic Processes”, 2nd Edition, Wiley, 1996 (WSE Edition).

**Reference Books:**

1. H.M. Taylor and S. Karlin, “An Introduction to Stochastic Modeling”, 3rd Edition, Academic Press, New York, 1998.
2. G.A. Pavliotis, “Stochastic Processes and Applications”, Springer.
3. Robert G. Gallager, “Stochastic Processes”, Cambridge University Press.
4. J. Medhi, “Stochastic Processes”, 3rd Edition, New Age International, 2009.

**PE 1: Microcontrollers and Programmable Digital Signal Processors (PPEIE106)**

**Prerequisites:**

Microprocessors and Microcontrollers, Assembly Language Programming, Digital Signal Processing, Use of MATLAB

**Course Outcomes:**

At the end of this course, students will be able to

1. Compare and select ARM processor core based SoC with several features/peripherals based on requirements of DSP applications.
2. Identify and characterize architecture of Programmable DSP Processors
3. Develop small applications by utilizing the ARM processor core and DSP processor based platform.
4. Apply tools like Code Composer Studio for DSP applications

**Module I**

The Architecture of ARM7: Programming model – Modes of Operation, Registers, Current Program Status Registers, Exceptions and Interrupts, Pipeline, Memory Management and Memory Protection, ARM Processor families.

ARM Instruction set: Data Processing Instructions, Branch Instructions, Load-Store Instructions, Software Interrupt Instructions, Program Status Register Instructions, Thumb Instruction Set. Exception Handling, Interrupts, Interrupt Handling Schemes.

**Module II**

ARM Cortex-M Processors: Cortex M0, Modes and States, Programming Model, Memory Model, Nested Vectored Interrupt Controller, Power Management using Sleep Modes, Assembly Programming of ARM7; ARM SoC- Features of LPC 214x series- Block Diagram, Memory Map, Low Power models, Timers, Interrupt sources.

Programmable DSP (P-DSP) Processors: Architectural structure of P-DSP- MAC unit, Barrel shifters.

**Module III**

VLIW architecture and TMS320C6000 series, architecture study, data paths, cross paths, Introduction to Instruction level architecture of C6000 family, Assembly Instructions memory addressing, for arithmetic, logical operations.

**Text Books:**

1. Sloss Andrew N, Symes Dominic, Wright Chris, “ARM System Developer's Guide: Designing and Optimizing”, Morgan Kaufman Publication, 2004
2. Venkatramani B. and Bhaskar M. “Digital Signal Processors: Architecture, Programming and Applications”, TMH, 2nd Edition, 2002

**Reference Books:**

1. Joseph Yiu, “The definitive guide to ARM Cortex-M3”, Elsevier, 2nd Edition, 2011.
2. Steve Furber, “ARM System-on-Chip Architecture”, Pearson Education, 2001.
3. Donald S. Reay, “Digital Signal Processing Using the ARM Cortex M4”, Wiley, 2015
4. LPC 17xx Product Datasheets.

**PE 1: Mixed-Signal VLSI Design (PPEIE107)**

**Pre-requisites:**

Integrated Circuit Design, Analog VLSI, Analog Signal Processing, Digital Signal Processing

**Course Outcomes:**

At the end of the course, students will demonstrate the ability to:

1. Interpret the practical situations where mixed signal analysis is required.
2. Analyze and handle the inter-conversions between signals.
3. Design systems involving mixed signals
4. Test simple mixed signal circuits

**Module I**

Analog and discrete-time signal processing, introduction to sampling theory; Analog continuous time filters: passive and active filters; Basics of analog discrete-time filters and Z-transform.

Switched-capacitor filters- Non-idealities in switched-capacitor filters; Switched-capacitor filter architectures; Switched- capacitor filter applications.

**Module II**

Basics of data converters; Successive approximation ADCs, Dual slope ADCs, Flash ADCs, Pipeline ADCs, Hybrid ADC structures, High-resolution ADCs, DACs.

Mixed-signal layout, Interconnects and data transmission; Voltage-mode signalling and data transmission; Current- mode signaling and data transmission.

**Module III**

Introduction to frequency synthesizers and synchronization; Basics of PLL, Analog PLLs; Digital PLLs; DLLs.

Mixed-signal circuits, Test and diagnostic equipment, Mixed-signal testing challenges, DC and Parametric Measurements – Continuity, Leakage currents, Power supply currents, DC references and regulators, Impedance measurements, DC offset measurements, DC gain measurements, DC power supply rejection ratio, DC common- mode rejection ratio.

**Text Books:**

1. R. Jacob Baker, CMOS mixed-signal circuit design, Wiley India, IEEE press, reprint2008.
2. M. Burns et al., An introduction to mixed-signal IC test and measurement by, Oxford University press, first Indian edition, 2008.
3. Rudy V. De Plassche, CMOS Integrated ADCs and DACs, Springer, Indian edition, 2005.

**Reference Books:**

1. Behzad Razavi, Design of analog CMOS integrated circuits, McGraw-Hill, 2003.
2. R. Jacob Baker, CMOS circuit design, layout and simulation, Revised second edition, IEEE press, 2008.
3. Arthur B. Williams, Electronic Filter Design Handbook, McGraw-Hill, 1981.
4. R. Schauman, Design of analog filters by, Prentice-Hall 1990.

**PE 2: DSP Architecture (PPEIE112)**

**Prerequisite:**

Number system (Binary, Floating and Fixed Point Numbers), Architecture of Microprocessor, Addressing modes and Timing Diagram, Basics of Assembly and C’ Language.

**Course Outcomes:**

At the end of this course, students will able to

1. Recognize the fundamentals of fixed and floating point architectures of various DSPs.
2. Learn the architecture details and instruction sets of fixed and floating point DSPs
3. Infer about the control instructions, interrupts, and pipeline operations.
4. Illustrate the features of on-chip peripheral devices and its interfacing along with its programming details.
5. Learn the DSP programming tools and use them for applications.

**Module I**

Programmable DSP Hardware: Processing Architectures (von Neumann, Harvard), DSP core

algorithms (FIR, IIR, Convolution, Correlation, FFT), IEEE standard for Fixed and Floating Point Computations, Special Architectures Modules used in Digital Signal Processors (like MAC unit, Barrel shifters), On-Chip peripherals, DSP benchmarking.

**Module II**

Structural and Architectural Considerations: Parallelism in DSP processing, Texas Instruments TMS320 Digital Signal Processor Families, Fixed Point TI DSP Processors: TMS320C1X and TMS320C2X Family, TMS320C25 –Internal Architecture, Arithmetic and Logic Unit, Auxiliary Registers, Addressing Modes (Immediate, Direct and Indirect, Bit- reverse Addressing), Basics of

TMS320C54x and C55x Families in respect of Architecture improvements and new applications fields, TMS320C5416 DSP Architecture, Memory Map, Interrupt System, Peripheral Devices, Illustrative Examples for assembly coding.

**Module III**

VLIW Architecture: Current DSP Architectures, GPUs as an alternative to DSP Processors, TMS320C6X Family, Addressing Modes, Replacement of MAC unit by ILP, Detailed study of

ISA, Assembly Language Programming, Code Composer Studio, Mixed C and Assembly Language programming,

On-chip peripherals, Simple applications developments as an embedded environment.

**Text Books:**

1. B. Venkataramani & M. Bhaskar, Digital Signal Processor, Architecture, Programming and Applications, (2/e), McGraw- Hill,2010
2. S. Srinivasan & Avtar Singh, Digital Signal Processing, Implementations using DSP Microprocessors with Examples from TMS320C54X, Brooks/Cole, 2004.

**Reference Books:**

1. M. Sasikumar, D. Shikhare, Ravi Prakash, “Introduction to Parallel Processing”, 1st Edition, PHI, 2006.
2. Fayez Gebali, “Algorithms and Parallel Computing”,1st Edition, John Wiley & Sons, 2011
3. Rohit Chandra, Ramesh Menon, Leo Dagum, David Kohr, Dror Maydan, Jeff Mc Donald, “Parallel Programming in Open MP”, 1st Edition, Morgan Kaufman,2000.

**PE 2: Optical Signal Processing (PPEIE113)**

**Prerequisites:**

Optical Fiber Communication or any related course of Under Graduate Level

**Course Objectives:**

* + Learn the transform domain approach of different optical components like slit, lens, free space etc.
	+ Acquire knowledge about various spectral analysis tools, filters and OSA
	+ Get an overall picture about various photo receivers

**Course Outcome:**

At the end of this course, students will able to

1. Familiarize the basic theory of light propagation, concept of spatial frequency etc.
2. Illustrate basic concepts of light propagation, spatial frequency and Spectral analysis
3. Ability to develop optical filters, modulators and detectors for various applications of light processing
4. Apply the spectrum analysis on optical signal for different application.

**Module I**

Need for OSP, Fundamentals of OSP, The Fresnel Transform, Convolution and impulse response, Transform of a slit, Fourier Transforms in Optics, Transforms of aperture functions, Inverse Fourier Transform. Resolution criteria. A Basic Optical System, Imaging and Fourier Transform conditions. Cascaded systems, scale of Fourier Transform Condition. Maximum information capacity and optimum packing density. Chirp, Z transform and system Coherence.

**Module II**

Spectrum Analysis, Spatial light Modulators, special detector arrays. Performance parameters for spectrum analyzers. Relationship between SNR and Dynamic range. The 2 D spectrum Analyzer. Spatial Filtering, Linear Space Invariant systems, Parseval’s theorem, Correlation,

Input/ Output Spectral Densities, Matched filtering, Inverse Filtering. Spatial Filters. Interferometers. Spatial filtering systems. Spatial Modulators. Applications of Optical Spatial Filtering, Effects of small displacements.

**Module III**

Heterodyne systems. Temporal and spatial interference. Optimum photo detector size, Optical radio. Direct detection and Hetero dyne detection. Heterodyne spectrum Analysis. Spatial and temporal Frequencies. The CW signal and a short pulse. Photo detector geometry and bandwidth. Power spectrum analyzer using a CCD array.

**Text Books:**

1. Anthony VanderLugt, Optical Signal Processing, John Wiley & Sons. 2005.
2. D. Casasent, Optical data Processing-Applications Springer-Verlag, Berlin, 1978
3. P.M. Dufffieux, The Fourier Transform and its applications to Optics, John Wiley and sons 1983

**Reference Books:**

1. Dr. Hiroshi Ishikawa, Ultrafast All-Optical Signal Processing Devices: Wiley
2. Francis T. S. Yu, Suganda Jutamulia, Optical Signal Processing, Computing, and Neural Networks: Krieger Publishing Company
3. Joseph W. Goodman, Introduction to Fourier Optics, second edition Mc Graw Hill.
4. Govind p. Agrawal, "Fiber-Optic Communication Systems”, 3rd ed, Wiley India.
5. Dr. R.K. Singh, "Fiber-Optic Communication Systems”, Wiley India.

**PE 2: Time Frequency Analysis and Wavelets (PPEIE114)**

**Prerequisites:**

Exposure to Signals and Systems and some basic Engineering Mathematics

**Course Outcomes:**

At the end of this course, students will able to

1. Construct various wavelet bases and know how to use them as a tool for analysing functions;
2. Describe properties of various wavelet bases;
3. Be familiar with multi-resolution analysis;
4. Analyse computational aspects of Fourier and wavelet transforms

**Module I**

Introduction Review of Fourier Transform, Parseval Theorem and need for joint time-frequency Analysis. Concept of non-stationary signals, Short-time Fourier transforms (STFT), Uncertainty Principle, and Localization/Isolation in time and frequency, Hilbert Spaces, Banach Spaces, and Fundamentals of Hilbert Transform.

Bases for Time-Frequency Analysis: Wavelet Bases and filter Banks, Tilings of Wavelet Packet and Local Cosine Bases, Wavelet Transform, Real Wavelets, Analytic Wavelets, Discrete Wavelets, Instantaneous Frequency, Quadratic time-frequency energy, Wavelet Frames, Dyadic wavelet Transform, Construction of Haar and Roof scaling function using dilation equation and graphical method

**Module II**

Multiresolution Analysis: Haar Multiresolution Analysis, MRA Axioms, Spanning Linear Subspaces, nested subspaces, Orthogonal Wavelets Bases, Scaling Functions, Conjugate Mirror Filters, Haar 2-band filter Banks, Study of up samplers and down samplers, Conditions for alias cancellation and perfect reconstruction, Discrete wavelet transform and relationship with filter Banks, Frequency analysis of Haar 2-band filter banks, scaling and wavelet dilation equations in time and frequency domains, case study of decomposition and reconstruction of given signal using orthogonal framework of Haar 2-band filter bank

**Module III**

Wavelets: Daubechies Wavelet Bases, Daubechies compactly supported family of wavelets; Daubechies filter coefficient calculations, Case study of Daub-4 filter design, Connection between Haar and Daub-4, Concept of Regularity, Vanishing moments. Other classes of wavelets like Shannon, Meyer, and Battle-Lamarie.

Bi-orthogonal wavelets and Applications: Construction and design. Case studies of biorthogonal 5/3 tap design and its use in JPEG 2000. Wavelet Packet Trees, Time-frequency localization, compactly supported wavelet packets, case study of Walsh wavelet packet bases generated using Haar conjugate mirror filters till depth level 3. Lifting schemes for generating orthogonal-bases of second generation wavelets. JTFA Applications: Riesz Bases, Scalograms, Time- Frequency distributions: fundamental ideas

**Text Books:**

1. Michael W. Frazier, "An Introduction to Wavelets through Linear Algebra”, Springer, 1999.
2. Stephane Mallat, "A Wavelet Tour of Signal Processing", Academic Press, Elsevier, 1998, 1999, Second Edition.

**Reference Books:**

1. Multirate Digital Signal Processing created by Prof.Vikram M. Gadre in NPTEL.
2. Barbara Burke Hubbard, "The World according to Wavelets - A Story of a Mathematical Technique in the making", Second edition, Universities Press (Private) India Limited 2003.
3. P.P. Vaidyanathan, "Multirate Systems and Filter Banks", Pearson Education, Low Price Edition.

**PE 2: Cognitive Radio (PPEIE115)**

**Prerequisite:**

Wireless Communication, Mobile Communication

**Course Outcomes:**

At the end of this course, students will be able to

1. Apply the fundamental concepts of Software defined Radios.
2. Implement the fundamental concepts of cognitive radio networks.
3. Develop the cognitive radio, as well as techniques for spectrum holes detection that cognitive radio takes advantages in order to exploit it.
4. Analyze technologies to allow an efficient use of TVWS for radio communications based on two spectrum sharing business models/policies.
5. Interpret fundamental issues regarding dynamic spectrum access, the radio-resource management and trading, as well as a number of optimisation techniques for better spectrum exploitation.

**Module I**

Introduction to Software Defined Radios (SDR)

Definitions and potential benefits, software radio architecture evolution, technology tradeoffs and architecture implications.

SDR Architecture: Essential functions of the software radio, basic SDR, hardware architecture, Computational processing resources, software architecture, top level component interfaces, interface topologies among plug and play modules

**Module II**

Introduction to Cognitive Radios

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 (spectrum of commons, real time secondary spectrum market).

**Module III**

Dynamic Spectrum Access and Management:

Spectrum broker, cognitive radio architectures, centralized dynamic spectrum access, distributed dynamic spectrum access, learning algorithms and protocols.

Spectrum Trading

Introduction to spectrum trading, classification to spectrum trading, radio resource pricing, brief discussion on economics theories in DSA (utility, auction theory), classification of auctions (single auctions, double auctions, concurrent, sequential).

**Text Books:**

1. Ekram Hossain, Dusit Niyato, Zhu Han, “Dynamic Spectrum Access and Management in Cognitive Radio Networks”, Cambridge University Press, 2009.
2. Joseph Mitola III, “Software Radio Architecture: Object-Oriented Approaches to Wireless System Engineering”, John Wiley & Sons Ltd. 2000.

**Reference Books:**

1. Kwang-Cheng Chen, Ramjee Prasad, “Cognitive radio networks”, John Wiley & Sons Ltd., 2009.
2. Bruce Fette, “Cognitive radio technology”, Elsevier, 2nd edition, 2009.
3. Huseyin Arslan, “Cognitive Radio, Software Defined Radio, and Adaptive Wireless Systems”, Springer, 2007
4. Francisco Rodrigo Porto Cavalcanti, Soren Andersson, “Optimizing Wireless Communication Systems” Springer, 2009.
5. Linda Doyle, “Essentials of Cognitive Radio”, Cambridge University Press, 2009.

**MC: Research Methodology & IPR (PMCMH101)**

**Module I:**

Introduction to RM: Meaning and significance of research. Importance of scientific research in decision making. Types of research and research process. Identification of research problem and formulation of hypothesis. Research Designs.

Types of Data: Primary data Secondary data, Design of questionnaire; Sampling fundamentals ad sample designs, Methods of data collection, Measurements and Scaling Techniques, Validity & Reliability Test.

**Module II:**

Data Processing and Data Analysis-I, Data editing, Coding, Classification and Tabulation, Descriptive and Inferential Analysis, Hypothesis Testing- Parametric Test (z test, t test, F test) and non-parametric test (Chi square Test, sign test, Run test, Krushall-wallis test).

**Module III:**

Data Analysis II: Multivariate Analysis- Factor Analysis, Multiple Regression Analysis. Discriminant Analysis, Use of Statistical Packages.

**Reference Books:**

1. Research Methodology, Chawla and Sondhi, Vikas

2. Research Methodology, Paneerselvam, PHI

**Course Outcomes:**

**CO1:** Understood the Meaning of research problem, Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem.

**CO2:** Got the knowledge of How to get new ideas (Criticizing a paper) through the Literature Survey (i.e. Gap Analysis).

**CO3:** Understood the Filing patent applications- processes, Patent Search, Various tools of IPR, Copyright, Trademarks.

**CO4:** Understood How to apply for Research grants and Significance of Report Writing, Steps in Report Writing, Mechanics and Precautions of Report Writing, Layout of Research Report.

**CO5:** Got the knowledge of How to write scientific paper & Research Proposal - Structure of a conference and journal paper, how (and How Not) to write a Good Systems Paper:

**Lab 1: Advanced Digital Signal Processing Lab-I (PLCIE103)**

**Prerequisite:**

Basic knowledge of LabVIEW S/W, C’ language, Signal and System.

**Course Outcome:**

At the end of this course, students will be able to,

1. Learn the DSP programming tools and use them for applications.
2. signal conversion processes (A/D and D/A) using LabVIEW.
3. Design different filters (Low-pass FIR and IIR ﬁlter, Adaptive filter).
4. Implement fixed and floating point numbers, design and analyze fixed point digital filtering system.
5. Interface DSP Development Kit (TMS320C6713/ TMS320C6748) along with its programming details.

**List of Experiments:**

Exp.1

Study of sampling, quantization & reconstruction aspects of analog-to-digital and digital-to-analog signal conversion processes using LabVIEW.

1. Study of sampling, aliasing effect & to compute the FFT in analog to digital conversion.
2. Study of Quantization of an analog signal by a 3-bit A/D converter: output signal, quantization error, and histogram of quantization error.
3. Generation of Bitstream (b3b2b1 in binary format) from the quantized discrete waveform
4. Study of signal reconstruction by using sinc function & convolution method.

Exp.2

Design of Low-pass FIR and an IIR ﬁlter using LabVIEW.

1. Design of FIR ﬁltering system,
	1. using Digital Filter Design (DFD) toolkit
	2. without using DFD VI
2. Design of IIR ﬁltering system
	1. using Digital Filter Design (DFD) toolkit
	2. without using DFD VI

Exp.3

Study of ﬁxed-point and ﬂoating-point implementations.

1. Conversion of datatypes in LabVIEW
2. Study of overflow handling (for Signal multiplication)
	1. conversion of single- or double-precision values to Q-format
	2. Q15 format conversion for, scalar input and output
3. compute the required number of scaling
4. Study of scaling approach to avoid overflow, without using the MathScript node feature.

Exp.4

Design and analysis at fixed point digital filtering system.

1. Computing number of scaling with DFD toolkit.
	1. Fixed-point analysis using DFD toolkit (no scaling)
	2. Fixed-point analysis using DFD toolkit (one scaling)
2. Study of Fixed-point FIR ﬁltering system.
3. Study of Fixed-point IIR ﬁltering system in Direct form.

Exp.5

Study of adaptive ﬁlter (using the LMS algorithm) by two adaptive systems.

1. System identiﬁcation
2. Noise cancellation.

Exp. 6 & 7

Any two from the above experiment (Exp.1 to Exp.5) to be implemented in hardware – SPEEDNI33/ TMS320C6713/ TMS320C6748 DSP Development Kit.

Mini Project

Two mini-projects will be completed by the students.

**Lab 2: Digital Image and Video Processing Lab (PLCIE104)**

**Pre-Requisite**

Signals and System, Digital Signal Processing

**Course Outcome**

After completion of the course, the student is able to

1. Execute different arithmetic operations on images and Linear algebra.
2. Implement different Image enhancement techniques
3. Design masks for image smoothing and sharpening operations
4. Design algorithms for image compression and morphological image processing.
5. Analyse and synthesize codes for image restoration and segmentation.

**List of Experiments**

Experiment-1

1. Introduction to basic operations on matrix, techniques in DSP and linear algebra
2. Write a program to read and display digital image using MATLAB.
3. Write a program to perform zooming and shrinking an image.
4. To write and execute programs for image arithmetic operations (addition, subtraction etc).

Experiment-2

1. Write a program to obtain Negative image.
2. Write a program for intensity slicing in an image (Log transformation and Power-law transformation)
3. Write a program to obtain Flip image

Experiment-3

1. Write a program to show threshold operation in image
2. Write a program to show contrast stretching in an image

Experiment-4

1. Write a program to plot the histogram of an image and perform histogram equalization

Experiment-5

1. Write and execute programs to remove noise using spatial filters (image smoothing)
	1. Average filter
	2. Weighted average filter
2. Write a program for edge detection using different operators. (Image sharpening)
	1. Gradient operator
	2. Laplacian Operator
	3. Un-sharp masking and high-boost filtering.
	4. Robert, Prewitt and Sobel operator

Experiment-6

1. Write a program for image segmentation by using various thresholding technique
	1. P-tile method
	2. Adaptive
	3. Bi-level and multi-level thresholding

Experiment-7

1. Generate the basis matrix for DCT, DFT, Hadamard, Walsh and Hotelling Transform
2. Write and execute programs for image frequency domain filtering using the above transform.

Experiment-8

1. Generate various image noise models.
2. Write programs for image restoration using Mean filter, Median filter and Wiener filter.

Experiment-9

1. Write and execute programs to perform image compression using lossy technique
2. Write and execute programs to perform image compression using lossless technique

Experiment-10

1. Write and execute program for image morphological operations like erosion, dilation, opening and closing.

**Audit -1**

**[To be decided by the Department]: Refer Appendix-I**

**Semester-2**

**Core 3: Machine Learning (PPCIE203)**

**Prerequisite:**

Theory of Probability and Statistic, Basics of image processing and signal processing.

**Course outcomes:**

At the end of this course student will be able to:

1. Evaluate and compare solutions by various learning approaches for a given problem.
2. Apply deep learning to combinatorial optimization problems.
3. Provide you with the knowledge and expertise to become a proficient data scientist.
4. Without the knowledge of IOT design system for pattern analysis.

**Module I**

Supervised Learning (Regression/Classification): Basic methods: Distance-based methods, Nearest-Neighbours, Decision Trees, Naive Bayes; Linear models: Linear Regression, Logistic Regression, Generalized Linear Models; Support Vector Machines, Nonlinearity and Kernel Methods

**Module II**

Unsupervised Learning: Clustering: K-means/Kernel K-means; Dimensionality Reduction: PCA and kernel PCA; Matrix Factorization and Matrix Completion; Generative Models (mixture models and latent factor models)

**Module III**

Evaluating Machine Learning algorithms and Model Selection, Introduction to Statistical Learning Theory, Ensemble Methods (Boosting, Bagging, Random Forests); Sparse Modeling and Estimation, Deep Learning and Feature Representation Learning

**Text Books:**

1. Kevin Murphy, Machine Learning: A Probabilistic Perspective, MIT Press, 2012
2. Trevor Hastie, Robert Tibshirani, Jerome Friedman, The Elements of Statistical Learning, Springer 2009 (freely available online).

**Reference Books:**

1. Christopher Bishop, Pattern Recognition and Machine Learning, Springer, 2007.

**Core 4: Detection & Estimation Theory (PPCIE204)**

**Prerequisites:**

Probability & Random Variable

**Course Outcomes:**

At the end of this course, students will be able to

1. Get the knowledge of the mathematical background of signal detection and estimation.
2. Apply classical and Bayesian approaches to formulate and solve problems for signal detection and parameter estimation from noisy signals.
3. Derive and apply filtering methods for parameter estimation.
4. Apply the concept of Maximum Likelihood Estimation in signal processing.

**SYLLABUS CONTENTS:**

**Module-I**

Stochastic Processes: Time Average and Moments, Ergodicity, Power Spectral Density, Covariance Matrices, Response of LTI System to Random Processes, Cyclostationary Process, and Spectral Factorization.

Detection Theory: Detection in White Gaussian Noise, Correlator and Matched Filter Interpretation, Bayes’ criterion of Signal Detection, MAP, LMS, Entropy Detectors, Detection in Colored Gaussian Noise, Karhunen-Loeve Expansions and Whitening Filters.

**Module-II**

Estimation Theory: Minimum Variance Unbiased Estimators, Cramer-Rao Lower Bound, Examples of Linear Models, System Identification, Markov Classification, Clustering Algorithms.

Topics in Kalman and Weiner Filtering: Distance Time Wiener-Hopf Equation, Error Variance Computation, Causal Discrete Time Wiener Filter, Discrete Kalman Filter, Extended Kalman Filter, Examples, and Specialized Topics in Estimation: Spectral Estimation Methods like MUSIC, ESPIRIT, and DOA Estimation.

**Module-III**

Deterministic Parameter Estimation: Least Squares Estimation- Batch Processing, Recursive Least Squares Estimation, Best Linear Unbiased Estimation, Likelihood and Maximum Likelihood Estimation.

Random Parameter Estimation: Bayesian Philosophy, Selection of a Prior PDF, Bayesian Linear model, Minimum Mean Square Error Estimator, Maximum a Posteriori Estimation.

**Text Books:**

1. Steven M. Kay, “Fundamentals of Statistical Signal Processing, Volume I: Estimation Theory”, Prentice Hall, 1993.
2. Steven M. Kay, “Fundamentals of Statistical Signal Processing, Volume II: Detection Theory”, 1st Edition, Prentice Hall, 1998.

**Reference Books:**

1. Thomas Kailath, Babak Hassibi, Ali H. Sayed, “Linear Estimation”, Prentice Hall, 2000.
2. H. Vincent Poor, “An Introduction to Signal Detection and Estimation”, 2nd Edition, Springer, 1998.
3. Bernard C. Levy, “Principles of Signal Detection and Parameter Estimation”, Springer, New York, 2008.
4. Jerry M. Mendel, “Lessons in Estimation Theory for Signal Processing, Communication and Control”, Prentice Hall Inc., 1995.

**PE 3: Statistical Signal Processing (PPEIE204)**

**Prerequisites:**

Probability Theory, Probability, Random Variable and Stochastic Problem

**Course Outcomes:**

At the end of this course student will be able to

1. Analyze random process and statistical time series.
2. Characterize random processes in terms of its statistical properties, including the notion of stationarity and ergodicity.
3. Manipulate and describe the notion of the power spectral density of stationary random processes.
4. Analyze the principles and application of different adaptive filters.

**Module I**

Review of random variables: distribution and density functions, moments, independent, uncorrelated and orthogonal random variables; Vector-space representation of Random variables, Schwarz Inequality Orthogonality principle in estimation, Central Limit theorem, Random process, stationary process, autocorrelation and auto covariance functions, Spectral representation of random signals, Wiener Khinchin theorem, Properties of power spectral density, Gaussian Process and White noise process

Linear System with random input, Spectral factorization theorem and its importance, innovation process and whitening filter

Random signal modelling: MA (q), AR(p), ARMA (p,q) models

**Module II**

Parameter Estimation Theory: Principle of estimation and applications, Properties of estimates, unbiased and consistent estimators, MVUE, CR bound, Efficient estimators; Criteria of estimation: the methods of maximum likelihood and its properties; Baysean estimation: Mean Square error and MMSE, Mean Absolute error, Hit and Miss cost function and MAP estimation

Estimation of signal in presence of White Gaussian Noise (WGN) Linear Minimum Mean-Square Error (LMMSE) Filtering: Wiener Hoff Equation FIR Wiener filter, Causal IIR Wiener filter, Noncausal IIR Wiener filter Linear Prediction of Signals, Forward and Backward Predictions, Levinson Durbin Algorithm, Lattice filter realization of prediction error filters.

**Module III**

Adaptive Filtering: Principle and Application, Steepest Descent Algorithm Convergence characteristics; LMS algorithm, convergence, excess mean square error Leaky LMS algorithm; Application of Adaptive filters; RLS algorithm, derivation, Matrix inversion Lemma, Intialization, tracking of non-stationarity

Kalman filtering: Principle and application, Scalar Kalman filter, Vector Kalman filter. Spectral analysis: Estimated autocorrelation function, periodogram, Averaging the periodogram (Bartlett Method), Welch modification, Blackman and Tukey method of smoothing periodogram, Parametric method, AR(p) spectral estimation and detection of Harmonic signals, MUSIC algorithm.

**Text Books:**

1. M D Srinath, P K Rajasekaran, R Viswanathan, Introduction to Statistical Signal Processing with Applications, “Pearson”
2. Steven M. Kay, “Statistical Signal Processing: Vol. 1: Estimation Theory, Vol. 2: Detection Theory," Prentice Hall Inc., 1998.
3. Jerry M. Mendel, “Lessons in Estimation Theory for Signal Processing, Communication and Control," Prentice Hall Inc., 1995

**Reference Books:**

1. Ralph D. Hippenstiel, “Detection Theory- Applications and Digital Signal Processing”, CRC Press, 2002.
2. Bernard C. Levy, “Principles of Signal Detection and Parameter Estimation”, Springer, New York, 2008.
3. Harry L. Van Trees, “Detection, Estimation and Modulation Theory, Part 1 and 2," John Wiley & Sons Inc. 1968.
4. Neel A. Macmillan and C. Douglas Creelman, “Detection Theory: A User's Guide (Sec. Edn.)” Lawrence Erlbaum Associates Publishers, USA, 2004.
5. Monson H. Hayes, “Statistical Digital Signal Processing and Modelling," John Wiley & Sons Inc., 1996.

**PE 3: VLSI Signal Processing (PPEIE205)**

**Prerequisites:**

Concepts of DSP systems and its architecture, Basic knowledge on DSP Concepts and FIR digital filters.

**Course Outcomes:**

At the end of this course student will be able to

1. Use the various VLSI architectures and algorithms for digital signal processing.
2. Analyze the various pipelining and parallel processing techniques
3. Calibrate the techniques of critical path and Algorithmic Strength Reduction in the filter structures.
4. Know fast convolution, systolic architecture, digital lattice filter structures and bit level arithmetic architecture.
5. Describe the basic ideas of power Analysis in DSP systems.

**Module 1**

DSP Concepts: Linear system theory, DFT, FFT, realization of digital filters. Typical DSP algorithms, DSP applications. Data flow graph representation of DSP algorithm.

**Module II**

Architectural Issues: Binary Adders, Binary multipliers, Multiply Accumulator (MAC) and Sum of Product (SOP). Pipelining and Parallel Processing, Retiming, Unfolding, Folding and Systolic architecture design.

Fast Convolution: Cook-Toom algorithm, modified Cook-Toom algorithm, Winograd algorithm, modified Winograd algorithm

**Module III**

Algorithmic strength reduction in filters and transforms: DCT and inverse DCT, parallel FIR filters.

Power Analysis in DSP systems: Scaling versus power consumption, power analysis, power reduction techniques, power estimation techniques, low power IIR filter design, Low power CMOS lattice IIR filter.

**Text Books:**

1. Keshap K. Parhi, VLSI Digital Signal Processing Systems, Design and Implementation, John Wiley, 2007.
2. U. Meyer-Baese, Digital Signal processing with Field Programmable Arrays, Springer, 2007.

**Reference Books:**

1. V. K. Madisetti, VLSI Digital Signal Processors: An Introduction to Rapid Prototyping and Design Synthesis, IEEE Press, New York, 1995.
2. S. Y. Kung, H. J. Whitehouse, VLSI and Modern Signal Processing, Prentice Hall, 1985.

**PE 3: Wireless Communication (PPEIE206)**

**Prerequisites:**

Probability and Statistics, Digital Communication

**Course Outcomes:**

At the end of the course the student will be able to

1. Evaluate system capacity in a cellular network
2. Model a given wireless channel
3. Evaluate BER of a given modulation format in a given wireless channel
4. To analyze fading statistics
5. Compute the spectrum of a given modulation format
6. Analyze a given equalization scheme

**Module I**

Cellular concepts: Cell structure, frequency reuse, cell splitting, channel assignment, handoff, interference, capacity, power control; Wireless Standards: Overview of 2G and 3G cellular standards.

Signal propagation: Propagation mechanism, reflection, refraction, diffraction and scattering, large scale signal propagation and lognormal shadowing.

**Module II**

Fading channels: multipath and small scale fading- Doppler shift, statistical multipath channel models, narrowband and wideband fading models, power delay profile, average and rms delay spread, coherence bandwidth and coherence time, flat and frequency selective fading, slow and fast fading, average fade duration and level crossing rate.

Multiple access schemes: FDMA, TDMA, CDMA and SDMA. Modulation Schemes: MSK and GMSK, multicarrier modulation, OFDM.

**Module III**

Receiver structure: diversity receivers- selection and MRC receivers, RAKE receiver, equalization: linear-ZFE and adaptive, DFE, Maximum Likelihood Sequence Estimation (MLSE)

MIMO and space time signal processing, spatial multiplexing, diversity/multiplexing trade-off. Performance measures: outage, average snr, average symbol/bit error rate.

System examples: GSM, EDGE, GPRS, CDMA 2000 and WCDMA.

**Text Books:**

1. T. S. Rappaport, Wireless digital communications: Principles and practice, 2ndEd., Prentice Hall India, 2007.
2. W. C. Y. Lee, Wireless and Cellular Telecommunications, 3rd Ed., MGH, 2006.
3. Andrea Goldsmith, Wireless Communications, Cambridge University Press, 2005.

**Reference Books:**

1. G. L. Stuber, Principles of mobile communications, 2nd Ed., Springer, 2007.
2. Simon Haykin and Michael Moher, Modern Wireless Communication, Pearson education, 2005.

**PE 3: Information Theory and Coding Techniques (PPEIE207)**

**Pre-Requisite:**

Communication Engineering, mathematics

**Course Outcome:**

After completion of the course, the student is able to

1. Determine the amount of information per symbol and information rate of a discrete memoryless source and can Design the channel performance.
2. Comprehend various error control code properties
3. Apply linear block codes for error detection and correction
4. Apply convolution codes for performance analysis & cyclic codes for error detection and correction.
5. Design BCH & RS codes for Channel performance improvement against burst errors.

**Module I**

Entropy, Relative Entropy, and Mutual Information: Entropy, Joint Entropy and Conditional Entropy, Relative Entropy and Mutual Information, Chain Rules, Data-Processing Inequality, Fano’s Inequality

Typical Sequences and Asymptotic Equipartition Property: Asymptotic Equipartition Property Theorem, Consequences of the AEP: Data Compression, High-Probability Sets and the Typical Set

**Module II**

Source Coding and Data Compression: Kraft Inequality, Huffman Codes, Optimality of Huffman Codes, Shannon– Fano–Elias Coding, Competitive Optimality of the Shannon Code

Channel Coding Theorem, Zero-Error Codes, Fano’s Inequality and the Converse to the Coding Theorem

**Module III**

Linear Binary Block Codes: Introduction, Generator and Parity-Check Matrices, Repetition and Single-Parity-Check Codes, Binary Hamming Codes, Error Detection with Linear Block Codes, Weight Distribution and Minimum Hamming Distance of a Linear Block Code, Hard-decision and Soft-decision Decoding of Linear Block Codes, Cyclic Codes, Parameters of BCH and RS Codes, Interleaved and Concatenated Codes

**Text Books:**

1. Elements of Information Theory by Thomas Cover, Joy Thomas, second edition, A JOHN WILEY & SONS, INC., PUBLICATION
2. Channel Codes: Classical and Modern by William Ryan, Shu Lin, Cambridge University Press

**Reference Books:**

1. Information Theory and Reliable Communication by Robert Gallager, ISBN: 978-0-471-29048-3

**PE 4: Digital Design and Verification (PPEIE208)**

**Pre requisite:**

Digital Electronic Circuits, VLSI Design

**Course Outcomes:**

At the end of this course, students will be able to

1. Perform front end design and verification techniques and create reusable test environments.
2. Verify increasingly complex designs more efficiently and effectively.
3. Apply different EDA tools like Vivado, Anadigm etc. to digital design implementations.
4. Design and implement complex digital circuits on FPGA/ FPAA.

**Module I**

Revision of basic Digital systems: Combinational Circuits, Sequential Circuits, Logic families. Synchronous FSM and asynchronous design, Metastability, Clock distribution and issues, basic building blocks like PWM module, pre-fetch unit, programmable counter, FIFO, Booth's multiplier, ALU, Barrel shifter etc.

**Module II**

Verilog/VHDL Comparisons and Guidelines, Verilog/ VHDL: HDL fundamentals, simulation, and test bench design, Examples of Verilog/VHDL codes for combinational and sequential logic.

**Module III**

Programmable Logic Devices: Introduction, Evolution: PROM, PLA, PAL, Architecture of PAL's, Applications, Programming PLD's, FPGA with technology: Antifuse, SRAM, EPROM, MUX, FPGA structures, and ASIC Design Flows, Programmable Interconnections, Coarse grained reconfigurable devices.

**Text Books:**

1. Volnei A. Pedroni, Circuit Design and Simulation with VHDL, 2ed, MIT Press, 2010
2. Douglas Smith, “HDL Chip Design: A Practical Guide for Designing, Synthesizing & Simulating ASICs & FPGAs Using VHDL or Verilog”, Doone publications, 1998.

**Reference Books:**

1. Samir Palnitkar, “Verilog HDL: A guide to Digital Design and Synthesis”, Prentice Hall, 2nd Edition, 2003.
2. Christophe Bobda, “Introduction to Reconfigurable Computing, Architectures, Algorithms and Applications”, Springer, 2007.

**PE 4: Radar Signal Processing (PPEIE209)**

**Pre requisites:**

Analog and digital communication systems, DSP, Basic Radar engineering.

**Course Outcomes:**

At the end of this course, students will be able to

1. Revisit analysis of radar fundamentals and design matched filters in noise environment
2. Perform modeling with various parameter configurations can be efficiently achieved.
3. Comprehend types of pulse compression techniques for increasing range resolution.
4. Analyze statistical framework necessary for the development of automatic target detection.

**Module I**

Introduction to RADAR Systems: - History and Application of RADAR, Basic RADAR Functions, Elements of pulsed RADAR, Review of Signal processing Concepts and operations, A preview of Basic Radar signal processing, radar system components, Advance RADAR Signal processing.

Signal Models: -Components of a RADAR signal, amplitude models, types of clutters, noise model and signal to noise ratio, jamming, and frequency models: The Doppler shift, spatial models, spectral model.

**Module II**

Sampling and quantization of pulsed RADAR Signals:-Domain and criteria for sampling radar signals, Sampling in the fast time dimension, Sampling in slow time: selecting a pulse repetition interval, sampling the Doppler spectrum, Sampling in the spatial and angle dimension, Quantization, I/Q imbalance and Digital I/Q.

RADAR Waveforms:-Introduction, the waveform matched Filter, Matched filtering of moving targets, the ambiguity function, The pulse burst waveforms, frequency modulated pulse compression waveforms, Range side lobe control for FM Waveforms, the stepped frequency waveform, Phase modulated pulse compression waveforms, COSTAS Frequency Codes.

**Module III**

Doppler Processing: -Alternate form of Doppler spectrum, Moving Target indication(MTI), Pulse Doppler processing, dwell-to-dwell stagger, Pulse pair Processing, additional Doppler processing issues, clutter mapping and moving target detector, MTI for moving platforms: adaptive displaced phase centre antenna processing.

Detection Fundamentals: -Radar Detection as hypothesis testing, threshold detection in coherent systems, threshold detection of RADAR signals.

Constant False Alarm Rate (CFAR) Detection: The effect of unknown interference power on false alarm probability, Cell Averaging (CFAR), Order static CFAR, Additional CFAR Topics.

**Text Books:**

1. Fundamental of Radar Signal Processing, Mark A. Rechard, McGrawhill, New York 2005

**Reference Books:**

1. Principles of RADAR and Sonar Signal Processing, Francois Le Chevalier, Artech House-2002
2. Radar Systems, Peak Detection and Tracking, Michael O kolawole,2010, Elesvier

**PE 4: Adaptive Signal Processing (PPEIE210)**

**Prerequisites:**

Basics of Signals and Systems, DSP, Familiarity with linear algebra and random process theory

**Course Outcomes:**

At the end of this course, students will be able to

1. Comprehend design criteria and modeling adaptive systems.
2. Apply mathematical models for error performance and stability of adaptive systems.
3. Analyze gradient estimation based on performance surface in adaptive systems.
4. Implement LMS algorithm for signal processing applications.
5. Design of Kalman filter for adaptive noise cancellation

**Module I**

Introduction to Adaptive Filters: Adaptive filter structures, issues and examples. Applications of adaptive filters, Channel equalization, active noise control. Echo cancellation, 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.

**Module II**

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 (mse). Misadjustment and stability of excess mse. 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 as an orthogonal projection computation problem.

**Module III**

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:**

1. S. Haykin, Adaptive Filter Theory, Prentice Hall, Englewood Cliffs, NJ, 1991
2. B. Farhang – Boroujeny, Adaptive Filters Theory and Applications,John Wiley and Sons, 1999.

**PE 4: Wireless Sensor Networks (PPEIE211)**

**Pre requisite:**

Basic programming knowledge

**Course Outcomes:**

At the end of this course, students will be able to

1. Describe and explain radio standards and communication protocols for wireless sensor networks.
2. Devise appropriate data dissemination protocols and model links cost.
3. Explain the function of the node architecture and use of sensors for various applications.
4. Be familiar with architectures, functions and performance of wireless sensor networks systems and platforms

**Module I**

Introduction to Wireless Sensor Networks: Course Information, Introduction to Wireless Sensor Networks: Motivations, Applications, Performance metrics, History and Design factors

Network Architecture: Traditional layered stack, Cross-layer designs, Sensor Network Architecture

Hardware Platforms: Motes, Hardware parameters

Introduction to ns-3: Introduction to Network Simulator 3 (ns-3), Description of the ns-3 core module and simulation example.

**Module II**

Medium Access Control Protocol design: Fixed Access, Random Access, WSN protocols: synchronized, duty- cycled

Introduction to Markov Chain: Discrete time Markov Chain definition, properties, classification and analysis

MAC Protocol Analysis: Asynchronous duty-cycled. X-MAC Analysis (Markov Chain)

**Module III**

Security: Possible attacks, countermeasures, SPINS, Static and dynamic key distribution

Routing protocols: Introduction, MANET protocols

Routing protocols for WSN: Resource-aware routing, Data-centric, Geographic Routing, Broadcast, Multicast Opportunistic Routing Analysis: Analysis of opportunistic routing (Markov Chain) Advanced topics in wireless sensor networks.

Advanced Topics: Recent development in WSN standards, software applications.

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**Text Books:**

1. W. Dargie and C. Poellabauer, “Fundamentals of Wireless Sensor Networks –Theory and Practice”, Wiley 2010
2. Kazem Sohraby, Daniel Minoli and Taieb Znati, “wireless sensor networks -Technology, Protocols, and Applications”, Wiley Interscience 2007

**Reference Book:**

1. Takahiro Hara, Vladimir I. Zadorozhny, and Erik Buchmann, “Wireless Sensor Network Technologies for the Information Explosion Era”, springer 2010

**Mini Project with Seminar (PPRIE201)**

**[To be decided by the Department]**

**Lab 3: Advanced Digital Signal Processing Lab II (PLCIE203)**

**Prerequisite:**

Basic knowledge of MATLAB, DSP

**Course Outcomes:**

At the end of this course, students will be able to

1. Apply various transforms in time and frequency
2. Perform decimation and interpolation
3. Simulate signals and noise
4. Detect signals in the presence of noise
5. Compare various estimation techniques

**List of Experiments:**

1. State Space Matrix from Differential Equation
2. Normal Equation Using Levinson Durbin
3. Decimation and Interpolation Using Rationale Factors
4. Convolution and M Fold Decimation & PSD Estimator
5. Simulate signal and noise models
6. Simulate spatially separated target Signal in the presence of Additive Correlated White Noise
7. Simulate spatially separated target Signal in the presence of Additive Uncorrelated White Noise
8. Using AWGN, Detect Constant Amplitude Signal, Time varying Known Signals, Unknown Signals.
9. Compare performance comparison of the Estimation techniques - MLE, MMSE, Bayes Estimator, MAP Estimator, Expectation Maximization (EM) algorithm
10. Performance comparison of conventional Energy Detectors and Coherent Matched Filter Techniques
11. Program for coding & decoding of Linear block codes.
12. Simulation program to implement source coding and channel coding for transmitting a text file.

**Text Book:**

1. John G. Proakis, Dimitris G. Manolakis, Digital Signal Processing: Principles, Algorithms, and Applications, 4/e.

**Lab 4: Machine Learning Laboratory (PLCIE204)**

**Prerequisite:**

Basic knowledge of Python, soft computing

**Course Outcomes:**

At the end of this course, students will be able to

1. Perform different kind of optimization algorithms
2. Solve and implement classification problem
3. Solve and implement Regression problem
4. Implement the knowledge of Machine Learning in real time applications
* The programs can be implemented using Python.
* For experiment 2 to 7 and 11, programs are to be developed without using the built-in classes or APIs of Python.
* Data sets can be taken from standard repositories (https://archive.ics.uci.edu/ml/datasets.html) or constructed by the students.

**Lab Experiments:**

1. Introduction to Basic python tools.
2. Implement and demonstrate the FIND-S algorithm for finding the most specific hypothesis based on a given set of training data samples. Read the training data from a .CSV file.
3. For a given set of training data examples stored in a .CSV file, implement and demonstrate the Candidate- Elimination algorithm to output a description of the set of all hypotheses consistent with the training examples.
4. Write a program to demonstrate the working of the decision tree based ID3 algorithm. Use an appropriate data set for building the decision tree and apply this knowledge to classify a new sample.
5. Build an Artificial Neural Network by implementing the Back-propagation algorithm and test the same using appropriate data sets.
6. Write a program to implement the Naive Bayesian classifier for a sample training data set stored as a .CSV file. Compute the accuracy of the classifier, considering few test data sets.
7. Assuming a set of documents that need to be classified, use the NaiveBayesian Classifier model to perform this task. API can be used to write the program. Calculate the accuracy, precision, and recall for your data set.
8. Write a program to construct a Bayesian network considering medical data. Use this model to demonstrate the diagnosis of heart patients using standard Heart Disease Data Set. You can use Python ML library classes/API.
9. Apply EMalgorithm (Expectation–maximization algorithm) to cluster a set of data stored in a .CSV file. Use the same data set for clustering using K-Means algorithm. Compare the results of these two algorithms and comment on the quality of clustering. You can use Python ML library classes/API in the program.
10. Write a program to implement K- Nearest Neighbor algorithm to classify the iris data set. Print both correct and wrong predictions. Python ML library classes can be used for this problem.
11. Implement the non-parametric Locally Weighted Regression algorithm in order to fit data points. Select appropriate data set for your experiment and draw graphs.
12. Mini project based on any problem set using python

**Text Book:**

1. Michael Bowles, Machine learning in Python essential techniques for predictive analysis.

**Audit-2**

**[To be decided by the Department]: Refer Appendix-II**

**Semester-3**

**PE 5: Biomedical Signal Processing (PPEIE304)**

**Pre-requisite:**

Analog Signal Processing Signal and Systems Digital Signal Processing

**Course Outcomes:**

At the end of this course, students will be able to

* 1. Analyze different types of biomedical signal.
	2. Identify and analyze different biomedical signals.
	3. Implement applications related to biomedical signal processing
	4. Demonstrate problem solving using different mathematical models.

**Module I**

Nature of Biomedical signals, Origin of biomedical signals, Objective of Biomedical Signal Analysis, Issues in signal acquisition and analysis, filtering for removal of artifacts, Event Detection in ECG and EEG.

**Module II**

Biomedical signal processing by Fourier analysis, Biomedical signal processing by wavelet (time frequency) analysis, Classification of signals and noise, Examples of biomedical signal classification, Spectral analysis of deterministic, stationary random signals and non-stationary signals, Coherent treatment of various biomedical signal processing methods and applications.

**Module III**

Introduction to Correlation and regression, Analysis of chaotic signals, Basics of Multi resolution analysis (MRA), Principal component analysis (PCA), Independent component analysis (ICA).

Introduction to Pattern classification–supervised and unsupervised classification, Brief idea on Neural networks, Support vector Machines, Hidden Markov models, Sparse Matrices etc.

**Text Books:**

1. R M Rangayyan “Biomedical Signal Analysis: A case Based Approach”, IEEE Press, John Wiley & Sons. Inc, 2002
2. Willis J. Tompkins “Biomedical Digital Signal Processing”, EEE, PHI, 2004
3. D C Reddy “Biomedical Signal Processing: Principles and Techniques”, Tata McGraw-Hill Publishing Co. Ltd, 2005
4. J G Webster “Medical Instrumentation: Application & Design”, John Wiley & Sons Inc., 2001

**Reference Books**

1. C Raja Rao, S K Guha “Principles of Medical Electronics and Biomedical Instrumentation”, Universities Press, 2001
2. Myer Kutz, “Biomedical Engineering and Design Handbook, Volume I”, McGraw Hill,2009.
3. Katarzyn J. Blinowska, Jaroslaw Zygierewicz, “Practical Biomedical Signal Analysis Using MATLAB”, 1st Edition, CRC Press, 2011

**PE 5: Internet of Things (PPEIE305)**

**Prerequisites:**

Basic Knowledge in Computer Networks, OSI Model, Programming Skills

**Course Outcomes:**

At the end of this course, students will be able to

* 1. Interpret and apply the concept of IOT and M2M
	2. Apply IoT architecture and applications in various fields
	3. Apply the security and privacy issues in IOT.
	4. Implement IoT Applications

**Module I**

IoT& Web Technology the Internet of Things Today, Time for Convergence, Towards the IoT Universe, Internet of Things Vision, IoT Strategic Research and Innovation Directions, IoT Applications, Future Internet Technologies, Infrastructure, Networks and Communication, Processes, Data Management, Security, Privacy & Trust, Device Level Energy Issues, IoT Related Standardization.

M2M to IoT – A Basic Perspective– Introduction, Some Definitions, M2M Value Chains, IoT Value Chains, an emerging industrial structure for IoT, the international driven global value chain and global information monopolies. M2M to IoT-An Architectural Overview– Building an architecture, Main design principles and needed capabilities, An IoT architecture outline, standards considerations.

**Module II**

IoT Architecture -State of the Art – Introduction, State of the art, Architecture Reference Model- Introduction, Reference Model and architecture, IoT reference Model, IoT Reference.

Architecture- Introduction, Functional View, Information View, Deployment and Operational View, Other Relevant architectural views.

IoT Applications for Value Creations Introduction, IoT applications for industry: Future Factory Concepts, Brownfield IoT, Smart Objects, Smart Applications, Four Aspects in your Business to Master IoT, Value Creation from Big Data and Serialization, IoT for Retailing Industry, IoT for Oil and Gas Industry, Opinions on IoT Application and Value for Industry, Home Management, eHealth.

**Module III**

Internet of Things Privacy, Security and Governance Introduction, Overview of Governance, Privacy and Security Issues.

Security, Privacy and Trust in IoT-Data-Platforms for Smart Cities, First Steps Towards a Secure Platform, Smartie Approach. Data Aggregation for the IoT in Smart Cities, Security.

Introduction to Python

**Text Books:**

1. Vijay Madisetti and Arshdeep Bahga, “Internet of Things (A Hands-on-Approach)”, 1st Edition, VPT, 2014.
2. Francis da Costa, “Rethinking the Internet of Things: A Scalable Approach to Connecting Everything”, 1st Edition, A press Publications, 2013.

**Reference Book:**

1. Cuno Pfister, “Getting Started with the Internet of Things”, O. Reilly Media, 2011.

**PE 5: Multimedia Signals Processing (PPEIE306)**

**Pre-Requisite**

Digital image processing, Digital Signal Processing

**Course Outcome**

At the end of the course, students will be able to:

1. Demonstrate the fundamentals of fourier transform, wavelet transform, Haar transform and multi-resolution analysis
2. Implement speech and Music Decomposition Algorithm
3. Identify different audio and video compression techniques
4. Illustrate classification and requirement of watermarking
5. Incorporate compressive sensing and its applications

**Module I**

Basic Signal transform: Fourier Transform, Short-Time Fourier Transform, Wavelet Transform-Continuous Wavelet Transform, Wavelet Transform with Discrete Wavelet Functions, Haar Wavelet, Multi-resolution Analysis, Filter Banks, Digital Audio signal: Effects of Sampling and Quantization on the Quality of Audio Signal, Speech and Music Decomposition Algorithm, Audio Compression-Lossless Compressions, Lossy Compressions, MPEG Compression

**Module II**

Digital Video Processing: Digital Video Standards, Motion Estimation, Digital Video Compression-MPEG-1, MPEG- 2, MPEG-4.

Digital Watermarking: Classification of Digital Watermarking Techniques Common Requirements Considered in Watermarking, Watermark Embedding, Watermark Detection

**Module III**

Compressive Sensing

The Compressive Sensing Requirements Signal Reconstruction Approaches, Algorithms for Signal Reconstruction, Analysis of Missing Samples in the Fourier Transform Domain Relationship Between the Robust Estimation Theory and Compressive Sensing, Applications of Compressive Sensing Approach

**Text Books:**

1. Srdjan Stankovic, Irena Orovic Ervin Sejdic, Multimedia Signals and Systems Basic and Advanced Algorithms for Signal Processing, Second Edition, Springer International Publishing Switzerland 2016

**Reference Books:**

1. R. C. Gonzalez, R. E. Woods, Digital Image Processing, Pearson Education. 3rd Edition,2016.
2. A. Bovik, Handbook of Image & Video Processing, 2nd edition, Academic Press, 2005
3. A. M. Tekalp, Digital Video Processing, Prentice-Hall, 2nd edition, 2015
4. A. K. Jain, “Fundamentals of Digital Image Processing”, Prentice Hall,2015

**PE 5: Audio Signal Processing (PPEIE307)**

**Prerequisites:**

Basic knowledge in Digital Signal Processing

**Course Outcomes:**

At the end of this course, students will be able to

1. Analyze and design algorithms for extracting parameters from the speech signal.
2. Analyze and design algorithms for speech and audio coding.
3. Identify and analyze different speech analysis system.
4. Write algorithms for Recognition of speech.

**Module I**

Principle Characteristics of Speech: Linguistic information, Speech and Hearing, Speech production mechanism, Acoustic characteristic of speech Statistical Characteristics of speech. Speech production models, Linear Separable equivalent circuit model, Vocal Tract and Vocal Cord Model.

Speech Analysis and Synthesis Systems: Digitization, Sampling, Quantization and coding, Spectral Analysis, Spectral structure of speech, Autocorrelation and Short Time Fourier transform, Window function, Sound Spectrogram, Mel frequency Cepstral Coefficients, Filter bank and Zero Crossing Analysis, Analysis –by-Synthesis, Pitch Extraction.

**Module II**

Linear Predictive Coding Analysis: Principle of LPC analysis, Maximum likelihood spectral estimation, Source parameter estimation from residual signals, LPC Encoder and Decoder, PARCOR analysis and Synthesis, Line Spectral Pairs, LSP analysis and Synthesis.

Speech Coding: Reversible coding, Irreversible coding and Information rate distortion theory, coding in time domain: PCM, ADPCM, Adaptive Predictive coding, coding in Frequency domain: Sub band coding, Adaptive transform coding, Vector Quantization, Code Excited Linear Predictive Coding (CELP).

**Module III**

Speech Recognition: Principles of speech recognition, Speech period detection, Spectral distance measure, Structure of word recognition system, Dynamic Time Warping (DTW), Theory and implementation of Hidden Markov Model (HMM).

Speaker recognition: Human and Computer speaker recognition Principles Text dependent and Text Independent speaker recognition systems. Applications of speech Processing.

**Text Books:**

1. Sadaoki Furui, “Digital Speech Processing, Synthesis and Recognition” 2nd Edition, Taylor & Francis, 2000.
2. Rabiner and Schafer, “Digital Processing of Speech Signals”, Pearson Education, 1979.

**Reference Books:**

1. Thomas F. Quatieri, “Discrete-time Speech Signal Processing: Principles and Practice” Prentice Hall, Signal Processing Series.
2. Ben Gold & Nelson Morgan, “Speech and Audio Signal Processing”, John Wiley & Sons, Inc.

**Open Elective**

**[To be decided by the Department]: Refer Appendix-III**

**Project 1: (PPRIE301)**

**[To be decided by the Department]: Dissertation (Phase-I)**

**Semester-4**

**Project 2: (PPRIE401)**

**[To be decided by the Department]: Dissertation (Phase-II)**