MAHATMA GANDHI UNIVERSITY

SCHEME AND SYLLABI

FOR

M. Tech. DEGREE PROGRAMME

IN

SIGNAL PROCESSING

(2013 ADMISSION ONWARDS)
# SCHEME AND SYLLABI FOR M. Tech. DEGREE
## PROGRAMME IN SIGNAL PROCESSING
### SEMESTER – II

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Course No.</th>
<th>Subject</th>
<th>Hrs / Week</th>
<th>Evaluation Scheme (Marks)</th>
<th>Credits</th>
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<td>Adaptive &amp; Non Linear Signal Processing</td>
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<td>Estimation &amp; Detection Theory</td>
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<td>Signal Processing Lab – II</td>
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**Electives:**

- **Elective – IV (MAESP 206):** Array Signal Processing, Spread Spectrum and CDMA Systems, Spectrum Analysis, Pattern Recognition & Analysis

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**L** – Lecture, **T** – Tutorial, **P** – Practical

**TA** – Teacher’s Assessment (Assignments, attendance, group discussion, tutorials, seminars, etc.)

**CT** – Class Test (Minimum of two tests to be conducted by the Institute)

**ESE** – End Semester Examination to be conducted by the University

**Electives:** New Electives may be added by the department according to the needs of emerging fields of technology. The name of the elective and its syllabus should be submitted to the University before the course is offered.

*Common with MECCE, **- Common with MECCI, # - Common with MECAE*
Module 1:


Module 2:

Filters with recursions based on the steepest descent and Newton's method, criteria for the convergence, rate of convergence. LMS filter, mean and variance of LMS, the MSE of LMS and misadjustment, Convergence of LMS.

Module 3:

RLS recursions, assumptions for RLS, convergence of RLS coefficients and MSE. Filter based on innovations, generation of forward and backward innovations, forward and reverse error recursions. Implementation of Weiner, LMS and RLS filters using lattice filters, Linear Prediction, Levinson Durbin algorithm, reverse Levinson Durbin algorithm.

Module 4:

Non-linear signal processing: Non-linear filters, Non-gaussian models, Generalized Gaussian and stable distributions, Median smoothers, Rank/order filters, Weighted median smoother.

References:

Module 1: Fundamentals of Detection Theory

**Hypothesis Testing:** Bayes’ Detection, MAP Detection, ML Detection, Minimum Probability of Error Criterion, Min-Max Criterion, Neyman-Pearson Criterion, Multiple Hypothesis, Composite Hypothesis Testing: Generalized likelihood ratio test (GLRT), Receiver Operating Characteristic Curves.

Module 2: Fundamentals of Estimation Theory


Module 3: Estimation Techniques

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

Module 4: Estimation Techniques (contd)

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

References:

Module 1
Functionals - Norm, Convergence - Cauchy sequence, Completeness of vector spaces; Infinite dimensional vector spaces - Normed linear spaces; Banach Spaces, Inner product spaces, Hilbert spaces; Continuous linear operators. **Bounded Linear Operators and Spectral Theory** Bounded linear operators in finite dimensional inner product spaces - Adjoint of an operator, Norm of an operator; Self-adjoint operators - Spectral analysis of self-adjoint operators; Bessel’s inequality, Parseval’s identity; Reisz Representation Theorem, Compact linear operators

Module 2
Generalized functions and the Dirac’s delta; Differential operators - Green’s function and the inverse linear operators. **The Making of Integral Transforms** The making of Fourier transform, Self-reciprocal functions and operators under Fourier transform - The construction of Fractional Fourier transform

Module 3

Module 4
Reisz basis, Resolution of unity, Definition of frames (**introduction only**), Geometrical considerations and the general notion of a frame, Frame projector, Example - windowed Fourier frames; Continuous wavelet transform, Introduction to DWT.

References:

3. Athanasios Papoulis, “Systems and Transforms with Applications in Optics,”


Module 1:
Image representation: Gray scale and colour Images, image sampling and quantization. Two dimensional orthogonal transforms: DFT, WHT, Haar transform, KLT, DCT. Image enhancement - filters in spatial and frequency domains, histogram-based processing, homomorphic filtering. Edge detection, LOG filters.

Module 2:

Module 3:

Module 4:
Video Processing: Representation of Digital Video, Spatio-temporal sampling; Motion Estimation; Video Filtering; Video Compression, Video coding standards- H.264

References:

Module 1: Fading and Diversity

Module 2: Cellular Communication
Cellular Networks; Multiple Access: FDMA, TDMA, Spatial Reuse, Co-Channel Interference Analysis, Hand-off, Erlang Capacity Analysis, Spectral Efficiency and Grade of Service, Improving Capacity: Cell Splitting and Sectorization.

Module 3: Spread spectrum and CDMA

Module 4:

References:
Module 1: Multidimensional systems


Module 2: Sampling continuous 2D signals

Periodic sampling with rectangular geometry- sampling density, Aliasing effects created by sampling - Periodic sampling with hexagonal geometry.

Module 3: Multidimensional Discrete Fourier Transform

Multidimensional discrete Fourier transform- Properties of DFT, Circular convolution- Calculation of DFT- DFT for periodically sampled signals - Fast Fourier transform for periodically sampled signals.

Module 4: Multidimensional Digital Filter Design

Separable Filters- Linear phase filters- FIR Filters- Implementation of FIR filters - design of FIR filters using windows- Two dimensional window functions, IIR Filters

References :

Module I


Module II

Retiming – definitions and properties, solving system of inequalities, retiming techniques, Unfolding – algorithm for unfolding, properties of unfolding, critical path, unfolding and retiming, applications of unfolding, Folding – folding transformation, register minimization techniques, register minimization in folded architectures, folding of multirate systems

Module III

Parallel FIR filters – discrete time cosine transform – implementation of DCT based on algorithm – architecture transformations – parallel architectures for rank order filters.

Module IV

Scaling and round off noise – round off noise in pipelined IIR filters – round off noise in lattice filters – pipelining of lattice IIR digital filters – low power CMOS lattice IIR filters.

Reference:

Module 1:

**Introduction to Cryptography** OSI Security Architecture, Classical Encryption techniques, Cipher Principles, Data Encryption Standard, Block Cipher Design Principles and Modes of Operation, Evaluation criteria for AES, AES Cipher, Triple DES, Placement of Encryption Function, Traffic Confidentiality

Module 2:

**Public Key Cryptography** Key Management, Diffie-Hellman key Exchange, Elliptic Curve Architecture and Cryptography, Introduction to Number Theory, Confidentiality using Symmetric Encryption, Public Key Cryptography and RSA. Practical implementation of Cryptography

Module 3:

**Information Hiding**: Principle and Objectives of Watermarking and Steganography. Mathematical formulations, Public - Private Key Steganography, Information hiding in noisy data (adaptive and nonadaptive) and written texts.

Module 4:


References:

8. Branislav Kisacanin, “Mathematical Problems and Proofs, Combinatorics, Number theory and Geometry”.
Module 1:

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

Module 2:


Module 3:


Module 4:


References:

Module 1: Fundamentals of Spread Spectrum

Introduction to spread spectrum communication, direct sequence spread spectrum, frequency-hop spread spectrum system. Spreading sequences- maximal-length sequences, gold codes, Walsh orthogonal codes- properties and generation of sequences. Synchronization and Tracking: delay lock and tau-dither loops, coarse synchronization-principles of serial search and match filter techniques.

Module 2: Performance Analysis of SS system

Performance of spread spectrum system in jamming environments- Barrage noise jamming, partial band jamming, pulsed noise jamming and single tone jamming. Error probability of DS-CDMA system under AWGN and fading channels, RAKE receiver

Module 3: Capacity, Coverage and multiuser detection

Basics of spread spectrum multiple access in cellular environments, reverse Link power control, multiple cell pilot tracking, soft and hard handoffs, cell coverage issues with hard and soft handoff, spread spectrum multiple access outage, outage with imperfect power control, Erlang capacity of forward and reverse links. Multi-user Detection -MF detector, decorrelating detector, MMSE detector. Interference Cancellation: successive, Parallel Interference Cancellation, performance analysis of multiuser detectors and interference cancellers.

Module 4: CDMA Systems

General aspects of CDMA cellular systems, IS-95 standard, Downlink and uplink, Evolution to Third Generation systems, WCDMA and CDMA-2000 standards, Principles of Multicarrier communication, MCCDMA and MC-DS-CDMA.

References:

Module 1:
Power Spectral Density: Energy spectral density of deterministic signals, Power spectral density of random signals, Properties of PSD.

Module 2:
PSD Estimation - Non-parametric methods Estimation of PSD from finite data, Non-parametric methods: Periodogram properties, bias and variance analysis, Blackman-Tuckey method, Window design considerations, time-bandwidth product and resolution-variance trade-offs in window design, Refined periodogram methods: Bartlet method, Welch method.

Module 3:

Module 4:
Filterbank methods: Filterbank interpretation of periodogram, Slepia base-band filters, refined filterbank method for higher resolution spectral analysis, Capon method, Introduction to higher order spectra.

References:
Module I

Module II
Non-Linear classifiers - Two layer and three layer perceptrons, Back propagation algorithm, Networks with Weight sharing, Polynomial classifiers, Radial Basis function networks.

Module III

Module IV

References:
4. Robert Schalkoff, “Pattern Recognition – Statistical, Structural and Neural Approaches”, Wiley India
MAESP 207       SIGNAL PROCESSING LAB -II

Tools- Matlab, DSP Kits – TMS320C6XX

Multirate Signal Processing – Decimation and Interpolation, Noble Identities, Polyphase Decomposition.

Speech processing

Image Processing
Reading, display, and saving of different image file formats using Matlab
Implementation of 2-D transforms- (DFT/ DCT/ Walsh Transform/Wavelets)

Adaptive Filter Implementation

LMS Algorithm, Wiener Filter.

FIR and IIR Filter design using TMS 320 DSK
Each student shall present a seminar on any topic of interest related to the core / elective courses offered in the second semester of the M. Tech. Programme. He / she shall select the topic based on the references from international journals of repute, preferably IEEE journals. They should get the paper approved by the Programme Co-ordinator / Faculty member in charge of the seminar and shall present it in the class. Every student shall participate in the seminar. The students should undertake a detailed study on the topic and submit a report at the end of the semester. Marks will be awarded based on the topic, presentation, participation in the seminar and the report submitted.