

Revised Curriculum Structure for AY 2025-26 Onwards
M.Tech. in Communication Systems
(previously M.Tech. in Intelligent Communication Systems)



Department of Electronics Engineering
Indian Institute of Technology Jodhpur

Introduction

During the past few years, there has been an exponential growth in the usage of internet. The fast development of economy and society requires modern and high-performance communications systems that can cater for massive deployment of Internet of Things, while still offering acceptable levels of energy consumption, equipment cost and network deployment and operation cost. It needs to support a wide variety of applications and services requiring increased spectral efficiency, higher data rates, low latency and high reliability. Communication technologies need to meet the growing connectivity requirements for new use cases (e.g. for ultra-low latency or high reliability cases) and new applications for industry, opening new revenue streams also for operators. The M. Tech. program in Communication Systems prepares students for an advanced engineering career by in-depth understanding of modern communication systems at all layers and their associated signal processing methods. The program provides students with an opportunity to learn the specialization in depth by updating and renewing their technical knowledge in a rapidly changing telecommunication industry.

Objective of the Program

Graduates from the program will have in-depth knowledge and critical awareness of theoretical and practical solutions to problems at the forefront of communications and the processing of signals. They would be ready for careers in fields such as development, research, operations and management of next-generation telecommunication networks and information processing systems.

Graduate Attributes

The graduates of this program will have

- Strong fundamentals in modern communications technology and signal processing methods.
- Understanding of cutting-edge research on future generations of wireless communication.
- Analytical and experimental skills required to design and implement next-generation communication systems for various applications like Internet-of-Things, smart health, Smart City, Intelligent Transportation Systems
- Ability to do critical and creative thinking, and to conduct independent and original research and scholarship
- Ability to apply existing skills and knowledge to identify and formulate new problems, produce new ideas, approaches or actions
- Ability to teach and express ideas in both written and oral formats

Learning outcome

- Ability to statistically characterize and evaluate the performance of communication systems.
- Ability to apply the different methods for signal detection and estimation to real world engineering problems and advanced research
- Develop understanding of cutting-edge research on future generations of wireless communication.
- Analyze multi-user networks and understanding of techniques like opportunistic communication, multiuser diversity, superposition coding and successive interference cancellation
- Implement end-to-end wireless communication systems with various MIMO technologies like maximal ratio combining, OFDM, interleaving/ de-interleaving, and Alamouti codes
- Ability to master a specific set of methods appropriate to their dissertation, with the depth needed to produce methodologically rigorous research.
- Carry out research work demonstrating scientific problem solving and generate IPR

Program Structure

Overall Structure (M. Tech. Degree Requirements for Communication Systems)

Cat.	Course Number, Course Title	L-T-P	Credits		Cat.	Course Number, Course Title	L-T-P	Credits	
Semester I					Semester II				
C	EEL7XX0	Applied Linear Algebra	3-0-0	3	C	EEL7XX0	Wireless Communications	3-0-0	3
C	EEL7XX0	Statistical Signal Analysis	3-0-0	3	E	EEL7XX0	<i>Elective</i>	3-0-0	3
C	EEL7XX0	Digital Communications	3-0-0	3	E	EEL7XX0	<i>Elective</i>	3-0-0	3
E	EEL7XX0	<i>Elective</i>	3-0-0	3	E	EEL7XX0	<i>Elective</i>	3-0-0	3
NG1	HSN7XX0	Non-Graded I	1-0-0	S/X	NG2	HSN7XX0	Non-Graded II	1-0-0	S/X
				<i>Total</i>					<i>Total</i>
				12					12
III Semester					IV Semester				
T	EET8XX0	Thesis		16	T	EET8XX0	Thesis		16
				<i>Total</i>					<i>Total</i>
				16					16

Topic Clouds

<i>Applied Linear Algebra</i>	<i>Statistical Signal Analysis</i>	<i>Digital Communications</i>	<i>Wireless Communications</i>
<ul style="list-style-type: none"> • Fundamental Concepts of Linear Algebra • Eigenvalues, Eigenvectors, and Diagonalization • Matrix Theory & Factorization • Matrix Computations in Signal Processing & Communications 	<ul style="list-style-type: none"> • Random Processes • Stationarity and Ergodicity • Random parameter estimation • Non-random parameter estimation • Multiple parameter estimation 	<ul style="list-style-type: none"> • Signal Representation and Digital Modulation Schemes • Receiver Design, Sufficient Statistics and Performance Analysis • Carrier and Symbol Synchronization • Introduction to Coding and design tradeoffs 	<ul style="list-style-type: none"> • Fading channel models • Error performance in AWGN and fading channels • Diversity Techniques • Capacity of fading channels • Multiuser systems- multiple and random access techniques • Multiuser diversity • Ad-Hoc Networks

List of Program Electives

S. No.	Course Number	Course Title	L-T-P	Credits
1	EEL7240	Cellular Communication Networks	3-0-0	3
2	EEL7200	Data Communication and Networking	2-0-2	3
3	EEL7110	MIMO Wireless Communications	3-0-0	3
4	EEL7990	RF system design for Communications	3-0-0	3
5	EEL7630	Coding Theory	3-0-0	3
6	EEL71320	Network Information Theory	3-0-0	3
7	EEL7760	Design and Analysis of Communication Networks	3-0-0	3
8	EEL7030	Advanced Digital Signal Processing	3-0-0	3
9	EEL7930	Optical Communication Systems	3-0-0	3
10	CSL7620	Machine Learning	3-0-0	3
11	CSL7590	Deep Learning	3-0-0	3
12	EEL7480	Machine Learning for Communications	3-0-0	3
13	EEL7xx0	Optimization Techniques for Signal Representation and Processing	3-0-0	3

Curriculum of Core Courses

Title:	Applied Linear Algebra	Number	EEL7XX0
Department:	Electrical Engineering	L-T-P [C]	3-0-0 [3]
Offered for:	M. Tech. and Ph.D.	Type	Core Course for Communication and Signal Processing groups

Objectives:

The instructor will:

1. introduce fundamental definitions and concepts of Linear Algebra
2. introduce matrix computations required for signal processing and communication

Learning Outcomes:

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

1. Analyze vector spaces, orthogonality, and linear transformations to establish mathematical foundations for signal processing and communication
2. Apply matrix computations and factorizations to solve problems in signal processing and communication.

Contents:

Fundamental Concepts of Linear Algebra (12 Lectures)

Algebra of Matrices, Systems of Linear Equations, Vector Spaces & Subspaces, Linear Dependence and Independence, Inner Product Spaces, Norms, orthogonality, Gram-Schmidt process, Linear Transformations & Change of Basis

Eigenvalues, Eigenvectors, and Diagonalization (9 Lectures)

Eigenvalues & Eigenvectors, Diagonalization & Spectral Theorem, Jordan Canonical Form – Generalized eigenvectors and applications, Singular Value Decomposition (SVD), Pseudoinverse & Moore-Penrose Inverse

Matrix Theory & Factorization (12 Lectures)

Matrix Operations – Rank, inverse, determinant, trace, Special Matrices – Symmetric, skew-symmetric, Hermitian, Toeplitz, circulant matrices, LU Decomposition, QR Factorization, Cholesky Decomposition

Matrix Computations in Signal Processing & Communications (9 Lectures)

Fourier & Wavelet Transforms in Matrix Form, Fast Algorithms in Signal Processing, Compressive Sensing & Sparse Signal Recovery, Signal Subspace Estimation and Array Processing, Linear and Quadratic programming

Textbook:

1. Strang, Gilbert. Linear Algebra and Its Applications 4th ed. 2012.
2. Meyer, Carl D. Matrix analysis and applied linear algebra. Society for Industrial and Applied Mathematics, 2023.

Self-learning Material:

1. Strang, Gilbert., Linear Algebra, Spring 2010, MIT OpenCourseWare, Massachusetts Institute of Technology: <https://ocw.mit.edu/courses/18-06-linear-algebra-spring-2010/> Rao, Vittal., Advanced Matrix Theory and Linear Algebra for Engineers, NPTEL Course ID 111108066: <https://nptel.ac.in/courses/111108066>

Title:	Statistical Signal Analysis	Number:	EEL7XX0
Department:	Electrical Engineering	L-T-P [C]	3-0-0 [3]
Offered for:	M. Tech. and Ph.D.	Type	Core Course for Communication and Signal Processing groups

Objectives:

The instructor will:

1. introduce fundamental definitions and concepts of Probability, Random Variables and Random Processes
2. provide background to understand the fundamental aspects of parameter estimation and hypothesis testing

Learning Outcomes:

The students will be able to:

1. perform filtering, parameter estimation, and hypothesis testing concepts of signal detection and estimation for deterministic and random signals
2. apply the theoretical knowledge to applications in communication, machine learning, optimization, and signal processing

Contents:

Review of Probability Theory (8 Lectures)

Introduction to Probability Theory, Conditional Probability & Bayes' Theorem, Independence, Conditional independence, Markov property, Discrete Random Variables, Continuous Random Variables, Expectation, Characteristic and Moment-Generating Functions, Joint Distributions of Multiple Random Variables, Functions of Random Variables, Conditional Expectation, Law of Large Numbers and Central Limit Theorems

Stochastic Processes and Linear Filtering (14 Lectures)

Stochastic Processes, Classification and characterization, Stationarity & Ergodicity, Gaussian and Poisson Processes, Markov Chains and Markov Processes, Spectral Representation of Stochastic Processes, Power Spectral Density (PSD), Linear Systems with Random Inputs, White Noise & Colored Noise Models, Wiener Filter, Least Squares Estimation and Linear Prediction, Kalman Filtering

Parameter Estimation (10 Lectures)

Parameter Estimation: Introduction to Statistical Estimation: Bias, Variance, MSE, Maximum Likelihood Estimation (MLE), Cramér-Rao Bound (CRB) and Efficiency of Estimators, Bayesian Estimation: MMSE, MAP, and Posterior Distributions

Hypothesis Testing and Detection (10 Lectures):

Likelihood Ratio Test (LRT), Neyman-Pearson Theorem, Bayesian Hypothesis Testing, Minimum Probability of Error Criterion, Matched Filter, Energy Detector (6 Lectures)

Textbook:

Papoulis, Athanasios, and S. Unnikrishna Pillai. 2002. Probability, Random Variables, and Stochastic Processes. 4th ed. New York: McGraw-Hill.

Kay, S.M., (1998), Fundamentals of Statistical Signal Processing: Vol. 1 Estimation Theory, 1st Edition, Prentice Hall

Kay, S.M., (1998), Fundamentals of Statistical Signal Processing: Vol. 2 Detection Theory, 1st Edition, Prentice Hall

Self-learning Material:

Chakraborty, Mrityunjay. *Probability and Random Processes*, NPTEL Course ID 117105085:

<https://nptel.ac.in/courses/117105085>

Sinha, Rohit, *Signal Detection and Estimation Theory*, NPTEL Course ID 117103018:

<https://nptel.ac.in/courses/117103018>

Title	Digital Communication	Number	EEL7XX0
Department	Electrical Engineering	L-T-P [C]	3-0-0 [3]
Offered for	M. Tech. and PhD	Type	Compulsory
Prerequisite	Knowledge of Probability Theory and Fundamentals of Communications		

Objectives

The instructor will:

1. Provide strong theoretical foundation of digital communication modulation schemes and performance evaluation.
2. Help students understand the fundamentals of communication through band limited channels and synchronization.

Learning Outcomes

The students will be able to:

1. Design receivers for optimum performance.
2. Analyze communication systems for their bit error performance.

Contents

Signal Representation and Digital Modulation Schemes (8 Lectures)

Complex baseband representation of signals, Gram-Schmidt orthogonalization procedure, M-ary orthogonal signals, bi-orthogonal signals, simplex signal waveforms, Memoryless modulation schemes, signaling schemes with memory, power spectral density of digitally modulated signals

Receiver Design, Sufficient Statistics and Performance Analysis (14 Lectures)

Coherent and non-coherent demodulation: Matched filter, Correlator demodulator, square-law, and envelope detection; Detector: Optimum rule for ML and MAP detection Performance: Bit-error-rate, symbol error rate for coherent and non-coherent schemes, Recurrent Neural Networks and their use for robust and adaptive receiver design

Carrier and Symbol Synchronization (4 Lectures)

carrier recovery and symbol synchronization in demodulation, carrier phase estimation, symbol timing estimation

Introduction to Coding (12 Lectures)

Linear block codes, properties and examples, soft decision decoding, hard decision decoding, convolutional codes, Viterbi decoding

Design Tradeoffs (4 Lectures)

Rate, bandwidth efficiency, power efficiency, modulation and coding tradeoffs

Textbook

1. Proakis, J. G. and Salehi, M., (2007), *Digital Communications*, 5th Edition, McGraw-Hill
2. Madhow, U., (2008), *Fundamentals of Digital Communication*, 1st Edition, Cambridge University Press
3. Barry, J. R., Lee, E. A., and Messerschmitt, D. G., (2004), *Digital Communications*, 3rd Edition, Springer

Preparatory Course Material

Jagannatham, A. K., *Principles of Communication II*, Department of Electrical Engineering, Indian Institute of Technology Kanpur, <https://nptel.ac.in/courses/108104098/>

Title	Wireless Communications	Number	EEL7XX0
Department	Electrical Engineering	L-T-P [C]	3-0-0 [3]
Offered for	M.Tech.-Ph.D. Dual Degree (Comm. Engg.)	Type	Compulsory
Prerequisite	Fundamentals of Communications		

Objectives

The instructor will:

1. Provide students with an understanding of the concepts related to communication over wireless fading channel.
2. Expose students to concepts and techniques for exploiting fading and application of these concepts in multiuser communication systems context.

Learning Outcomes

The students will be able to:

1. Interpret and apply core principles of deep fading, diversity strategies, and channel capacity in the context of point-to-point wireless communication systems.
2. Analyze multi-user networks and understanding techniques like opportunistic communication, multiuser diversity, superposition coding and successive interference cancellation.
3. Analyze and design wireless ad-hoc networks with special emphasis on energy constrained networks

Contents

Wireless Channels [10 Lectures]:

Review of signal detection over AWGN channels and M-ary Modulation (5L)

Modelling of wireless channels; space, time and frequency channel coherence; input/output channel models for single and multi-antenna systems - SIMO, MISO, and MIMO (5L)

Diversity Techniques [14 Lectures]:

Digital modulation and its performance in fading (4L) Deep fade and diversity (3L)

Realizing diversity: time diversity (1L), frequency diversity (3L), antenna diversity - SIMO, MISO, and MIMO (3L)

Wireless Channel Capacity [11 Lectures]:

Capacity of the Gaussian channels -SISO, SIMO, MISO and MIMO (4L) Outage limited and ergodic capacity of fading channels (4L)

Water filling algorithm and opportunistic communication (3L)

Multiuser system design [7 Lectures]:

Multiple access techniques (2L)

Multiuser channel capacity and multiuser diversity (5L)

Textbook

1. Tse, D. and Viswanath, P., (2005), *Fundamentals of wireless communication*, Cambridge University Press.
2. Goldsmith, A., (2005), *Wireless Communications*, Cambridge University Press.
3. Simon, M. K. and Alouini, M. S., (2004), *Digital communication over fading channels*, John Wiley and Sons.

Self-Learning Material

1. Zheng, L., Principles of Wireless Communications, MIT OpenCourseWare, Electrical Engineering & Computer Science, Massachusetts Institute of Technology, <https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-452-principles-of-wireless-communications-spring-2006/index.htm>

Preparatory Course Material

1. Jagannatham, A. K., *Principles of Communication II*, NPTEL Course Material, Department of Electrical Engineering, Indian Institute of Technology Kanpur, <https://nptel.ac.in/courses/108104098/>

2. Zheng, L. and Gallager, R., *Principles of Digital Communications I*, MIT OpenCourseWare, Electrical Engineering & Computer Science, Massachusetts Institute of Technology, <https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-450-principles-of-digital-communications-i-fall-2006/>

Elective Courses

Title	Advanced Digital Signal Processing	Number	EEL7XX0
Department	Electrical Engineering	L-T-P [C]	3-0-0 [3]
Offered for	B.Tech., M.Tech., Ph.D.	Type	Core
Prerequisite	Signals and Systems		

Objectives

The Instructor will:

1. Provide students an understanding of analysis and synthesis of algorithms and systems that process discrete time signals, with emphasis on realization and implementation

Learning Outcomes

The students are expected to have the ability to:

1. Interpret and process discrete/digital signal and systems
2. Analyze and provide solutions to practical implementation issues of DSP systems

Contents

Review of Fourier analysis Discrete time systems, DTFT, Z-transform, Analysis of LSI systems, DFT and FFT (9 lectures)

Time-frequency representation; frequency scale and resolution; uncertainty principle, short-time Fourier transform (5 lectures)

Multi-resolution concept and analysis, Wavelet transforms (CWT, DWT) (4 lectures)

Families of wavelets: Orthogonal and bi orthogonal wavelets Daubechies' family of orthogonal wavelets, elements of multi-rate systems and two band filter bank design for dyadic wavelets (10 lectures)

Multirate systems: sampling rate conversion, implementation of Multirate systems, filter design for Multirate systems, two channel filter banks and multi-channel filter banks. (5 lectures) *Finite wordlength*

effects: Number representation, statistical analysis of quantization error, quantization of Fixed-point and Floating point numbers, A/D and D/A conversion, A/D conversion noise analysis, quantization of filter coefficients, Effects of finite wordlength on digital filters. (6 lectures)

Applications of ADSP (3 lectures)

Textbook

1. Proakis, J. G. and Manolakis, D.G., (2007), *Digital Signal Processing*, 4th Edition, Prentice Hall
2. Mitra, S. K., (2008), *Digital Signal Processing*, 3rd Edition, McGraw Hill
3. Manolakis, D.G., and Ingle, V., (2011), *Applied Digital Signal Processing*, 1st Edition, Cambridge University Press

Self-Learning Material

1. Basu, T. K., *Digital Signal Processing*, NPTEL Course Material, Department of Electrical Engineering, Indian Institute of Technology Kharagpur, <https://nptel.ac.in/courses/108105055/>

Preparatory Course Material

1. Jagannatham, A. K., *Principles of Signals and Systems*, NPTEL Course Material, Department of Electrical Engineering, Indian Institute of Technology Kanpur, <https://nptel.ac.in/courses/108104100/>

Title	Data Communication and Networking	Number	EEL7XX0
Department	Electrical Engineering	L-T-P [C]	3-0-0 [3]
Offered for	B. Tech (IV Year), M. Tech., PhD.	Type	Compulsory
Prerequisite	Fundamentals of Wireless Communications		

Objectives

The Instructor will: expose the students to distinguishing features of wireless networks

Learning Outcomes

The students are expected to have the ability to:

1. Design and optimize wireless network architectures.
2. Implement security techniques for wireless networks.

Contents

Fundamentals: Layered architecture overview, data communication techniques, motivations for cross-layer protocol design, motivations for performance analysis, forward error correction and re-transmission performances (7 Lectures)

Network layer and topology design: Markov and semi-Markov processes, Little's theorem, M/M/m/k, M/G/1 systems, priority queueing, network of queues, network traffic behavior, routing algorithms and analysis, distributed networks, design constraints, bounded latency networks, optimization, cognitive networks (10 Lectures)

Network Management: Power management, time synchronization, localization, energy-efficient protocols for sensor networks (7 Lectures)

Mechanisms to improve performance: Self-Organizing Network, Software-Defined Networking (7 Lectures)

Transport and Application Layers: congestion control and quality of service, scheduling, multimedia, key aspects and design issues (7 Lectures)

Reliability and security: Security requirement and attacks, Encryption techniques, reliable and secure communication protocols (4 Lectures)

Textbook

1. Dargie, W., and Poellabauer, C., (2010), *Fundamentals of Wireless Sensor Networks: Theory and Practice*, Wiley
2. Stallings, W., (2007), *Data and Computer Communications*, 8th Edition, Pearson
3. Bertsekas, D. P. and Gallager, R. G., (1992), *Data Networks*, 2nd Edition, Prentice Hall

Self-Learning Material

1. Mishra, S., *Wireless Adhoc and Sensors Networks*, NPTEL Course Material, Department of Electrical and Electronics Communication Engineering, Indian Institute of Technology Kharagpur, <https://nptel.ac.in/courses/106105160/>
2. Zou, Y., Zhu, J., Wang, X., and Hanzo, L., "A Survey on Wireless Security: Technical Challenges, Recent Advances, and Future Trends," in *Proceedings of the IEEE*, vol. 104, no. 9, pp. 1727-1765, Sept. 2016.
3. W. Xia, Y. Wen, C. H. Foh, D. Niyato and H. Xie, "A Survey on Software-Defined Networking," in *IEEE Communications Surveys & Tutorials*, vol. 17, no. 1, pp. 27-51, First quarter 2015.

Preparatory Course Material

1. Zheng, L., *Principles of Wireless Communications*, MIT OpenCourseWare, Electrical Engineering & Computer Science, Massachusetts Institute of Technology, <https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-452-principles-of-wireless-communications-spring-2006/index.htm>

Title	MIMO Wireless Communications	Number	EEL7XX0
Department	Electrical Engineering	L-T-P [C]	3-0-0 [3]
Offered for	M.Tech.-Ph.D. Dual Degree (Comm. Engg.)	Type	Compulsory
Prerequisite	Wireless Communications		

Objectives

The Instructor will:

1. Provide exposure to the fundamental concepts and techniques of multiple-input multiple-output (MIMO) communications over wireless communication channels.
2. Expose students to the massive MIMO theory that gives rise to improved reliability and increased data rates.

Learning Outcomes

The students are expected to have the ability to:

1. Understand the concepts and mathematical tools related to MIMO architecture like V-BLAST, D-BLAST, beamforming and diversity multiplexing gain tradeoff.
2. Analyze, design, and simulate MIMO communication systems with a special emphasis on space-time codes and signaling techniques for massive MIMO.

Contents

Channel Modeling and Spatial Multiplexing: Multiplexing Capability of Deterministic MIMO Channels, Physical Modeling of MIMO Channels, Modeling of MIMO Fading Channels (7 Lectures)

Capacity and Multiplexing Architectures: The V-BLAST Architecture, Fast Fading MIMO Channel, Receiver Architectures, Slow Fading MIMO Channel, D-BLAST: An Outage-Optimal Architecture (7 Lectures)

Diversity-Multiplexing Tradeoff and Space-Time Codes: Diversity-Multiplexing Tradeoff, Space-time Code Design for Optimal Diversity-Multiplexing Tradeoff (7 Lectures)

MIMO Multiuser Communication: Uplink with Multiple Receive Antennas, MIMO Uplink, Downlink with Multiple Transmit Antennas, MIMO Downlink, Multiple Antennas in Cellular Networks: A System View (9 Lectures)

Massive MIMO networks: Large MIMO systems- Channel hardening and favorable propagation, channel estimation, precoding in large MIMO systems (12 Lectures)

Textbook

1. Tse, D. and Viswanath, P., (2005), *Fundamentals of wireless communication*, Cambridge University Press.
2. Chockalingam A. and Rajan B. S., (2014), *Large MIMO Systems*, Cambridge University Press.
3. Biglieri E., Calderbank R., Constantinides A., Paulraj A. and Poor H. V., (2007), *MIMO Wireless Communications*, Cambridge University Press.

Self-Learning Material

1. Zheng K., Zhao L., Mei J., Shao B., Xiang W. and Hanzo L., "Survey of Large-Scale MIMO Systems," in *IEEE Communications Surveys & Tutorials*, vol. 17, no. 3, pp. 1738-1760, 2015.
2. Wu Y., Xiao C., Ding Z., Gao X. and Jin S., "A Survey on MIMO Transmission With Finite Input Signals: Technical Challenges, Advances, and Future Trends," in *Proceedings of the IEEE*, vol. 106, no. 10, pp. 1779-1833, Oct. 2018.

Title	Coding Theory	Number	EEL7XX0
Department	Electrical Engineering	L-T-P [C]	3-0-0 [3]
Offered for	B.Tech. IV Year, M. Tech., Ph.D.	Type	Elective
Prerequisite	Knowledge of Probability Theory and Fundamentals of Communications		

Objectives

The Instructor will:

1. Provide an introduction to different types of channel codes.
2. Familiarize students with the fundamentals of error detection and correction.

Learning Outcomes

The students are expected to have the ability to:

1. Design channel codes for error detection and correction.
2. Analyze and compare the performance of uncoded and coded communication systems.

Contents

Introduction: Review of information theory, motivation for channel coding (3 Lectures)

Bounds on Codes: Hamming Bound, Asymptotic Hamming bound, Gilbert-Varshamov bound, Singleton bound, Plotkin bound (7 Lectures)

RS and BCH Codes: RS) Polynomial representations over finite fields, MDS property, Unique decoding via Welch-Berlekamp algorithm, List decoding of RS codes; BCH) Code construction, dual codes and trace function, Berlekamp-Massey algorithm (8 Lectures)

Convolutional Codes: Structure of convolutional codes, distance bounds for convolutional codes, punctured convolutional codes, Soft-Decision Decoding and Viterbi Algorithm, BCJR algorithm (8 Lectures)

LDPC codes: Tanner graphs, Gallager's construction and modern random ensembles, Iterative Decoding Algorithms, Message passing principles, EXIT charts, Sum-product algorithm, Min-sum algorithm (8 Lectures)

Polar codes: Polarization phenomenon, Arikan's construction using kernel transformations, Encoding of polar codes, Successive cancellation decoding, Speed of Polarization, Modern capacity-achieving constructions (8 Lectures)

Textbook

1. Lin, S. and Costello, D. J., (2004), *Error Control Coding*, 2nd Edition, Prentice Hall
2. Proakis, J. G. and Salehi, M., (2007), *Digital Communications*, 5th Edition, McGraw-Hill
3. Bose, R., (2017), *Information Theory, Coding and Cryptography*, 3rd Edition, McGraw-Hill
4. Guruswami, Venkatesan, Atri Rudra, and Madhu Sudan. "Essential coding theory." *Draft available at <http://www.cse.buffalo.edu/atri/courses/coding-theory/book 2.1>* (2012).

Self-Learning Material

1. Thangaraj, A., *Coding Theory*, NPTEL Course Material, Department of Electrical Engineering, Indian Institute of Technology Madras, <https://nptel.ac.in/courses/117106031/>

Preparatory Course Material

1. Jagannatham, A. K., *Principles of Communication II*, Department of Electrical Engineering, Indian Institute of Technology Kanpur, <https://nptel.ac.in/courses/108104098/>

Title	Optimal Filtering	Number	EEL7XX0
Department	Electrical Engineering	L-T-P [C]	3-0-0 [3]
Offered for	B.Tech. IV Year, M. Tech., Ph.D.	Type	Elective
Prerequisite	Knowledge of Probability Theory and Fundamentals of Communications		

Objectives

The Instructor will:

1. Help students understand the relationship between optimal filtering, linear estimation, and Wiener/Kalman filtering

Learning Outcomes

The students are expected to have the ability to:

1. Derive and manipulate the time discrete and time continuous Wiener and Kalman filter equations and compute the Wiener and Kalman filter for a given estimation problem.
2. Design optimal filters in the case of non-Gaussian noise or non-linear models.

Contents

Weiner Theory for scalar processes: continuous time Weiner smoothing, solution to Weiner Hopf equation, discrete time Weiner Hopf technique, recursive Weiner filtering, time-invariant state space models, recursive estimation given state-space models (14 Lectures)

Kalman Filter: Derivation of the Kalman filter, Filter properties, Steady-state Kalman filter, Prediction and smoothing, Kalman filter recursions, recursion for predicted and filtered state estimators (14 Lectures)

Nonlinear Filtering: The extended Kalman filter, The Levenberg-Marquardt measurement update, Applications in navigation and signal processing (14 Lectures)

Textbook

1. Kamen and Su, J. K., (1999), *Introduction to Optimal Estimation*, Springer Verlag
2. Kailath, T., Sayed, A., and Hassibi, B., (2000), *Linear Estimation*, Prentice Hall

Title	Optical Fiber Communications	Number	EEL7XX0
Department	Electrical Engineering	L-T-P [C]	3-0-0 [3]
Offered for	B.Tech. (IV Year), M.Tech., Ph.D.	Type	Elective
Prerequisite	EM Theory		

Objectives

The Instructor will:

1. Provide the fundamental principles and the practices followed in the area of optical communications.
2. Enable the appreciation of the global connectivity achieved via optical fiber technology.

Learning Outcomes

The students are expected to have the ability to:

1. Design and implement an end-to-end fiber optic communication link using commercially available LASERS, LEDs and Photodetectors.

Contents

EE7XX1: Optical Fiber Waveguide [1-0-0]

Vector Nature of Light, Optical Fiber – Single and Multimode, Step index and Graded Index Fibers, Ray and Wave picture of propagation, Cut-off, mode field diameter, group delay, Gaussian field approximation. (8 Lectures)

Transmission Characteristics: The consequences of attenuation and dispersion in Optical Fibers: Material, Waveguide, Polarization, Intermodal and Intramodal Dispersion, Group velocity Dispersion, Dispersion modified single mode fibers. Fiber Fabrication Methods. (6 Lectures)

EE7XX2: Optical Sources and Receivers [1-0-0]

Optical Sources: LASERS: Population inversion and feedback, Spontaneous and Stimulated emission, Injection LASERS, Gain and Index Guided LASERS, VCSELs, LASER Characteristics and Driver Circuits, Fiber Coupling. LED: Structure, Characteristics and Driver Circuits. (7 Lectures)

Optical Receivers: Photo-detectors – PN, P-I-N, Avalanche Photodiodes, Phototransistors, Responsivity, Quantum Efficiency, Noise, Optical Receiver structures: Low, high and transimpedance front end, Low noise Preamplifiers. (7 Lectures)

EE7XX3: Optical Fiber Link Design [1-0-0]

Fiber joints, connectors, couplers and isolators, Splicing operation, System Planning considerations, quantum limit, SNR, BER calculation, Rise time budgeting, Power budgeting, Choice of components, Principles of Coherent and Incoherent Optical communication systems. (8 Lectures)

Introduction to Nonlinear effects: Impact of SPM, XPM, FWM on communication systems, Raman and Brillouin Scattering and soliton based communication. (4 Lectures)

Miscellaneous: EDFA, Raman amplifier, and WDM and SDM systems. (2 Lectures)

Textbooks

1. J. M. Senior, Optical Fiber Communications: Principles and Practice, Prentice Hall, 3rd Edition, 2010.
2. G. Keiser, Fibre Optic Communication McGraw-Hill, 5th Edition, 2013.
3. G. Agrawal, Fiber optic Communication Systems, John Wiley and sons, 4th Edition 2010.

Self Learning Material

1. NPTEL Lectures on Advanced Optical Communication by Prof. R.K. Shevgaonkar, IIT Bombay(<https://nptel.ac.in/courses/117101002/>)
2. The RP Photonics Encyclopedia (<https://www.rp-photonics.com/encyclopedia.html>)

Preparatory Course Material

1. (Fractal 1) Some concepts from “M.O. Sadiku and S.V. Kulkarni, Principles of Electromagnetics”, Oxford University Press, 6th edition, 2015.
2. (Fractal 2) Some Concepts from “Jacob Millman *et.al.*, Integrated Electronics”, McGraw Hill Education, 2nd Edition, 2017.
3. (Fractal 3) Some concepts from “B.P. Lathi and Z. Ding, Modern Digital and Analog Communication Systems”, Oxford University Press, 4th Edition, 2011

Title	Multirate Digital Signal Processing	Number	EEL7XX0
Department	Electrical Engineering	L-T-P [C]	2-0-0 [2]
Offered for	B.Tech. IV Year, M. Tech., Ph.D.	Type	Elective
Prerequisite	Digital Signal Processing		

Objectives

The Instructor will:

1. Provide the concept of multirate signal processing and demonstrate the ability to solve the problems in sample rate conversion, filter banks and Transmultiplexers

Learning Outcomes

The students are expected to have the ability to:

1. Understand the basic concepts of multirate systems; understanding of decimation, interpolation and filterbanks
2. Understand the realizations for upsampling and downsampling of signals using polyphaser decomposition
3. design the filter banks based on the techniques discussed in the class

Contents

Review of Digital Filters, Multirate Systems (3 Lectures)

Interconnection of Multirate DSP blocks, Multiplexer and demultiplexer functionality (4 Lectures)

Application of Multirate DSP: DFT- based filterbanks, Transmultiplexer, Filterbank Interpretation of Spectral Analysis using DFT, Two channel maximally decimated filter banks (6 Lectures)

Introduction to OFDM (5 lectures)

Multicarrier modulation, Block transceivers with redundancy, Zero-padding, cyclic prefix, OFDM, extensions of OFDM including Filterbank Multicarrier (FBMC) (6 lectures)

Application of Multirate DSP: Delta Sigma A/D conversion (4 lectures)

Textbook

1. Vaidyanathan, P. P., (2008), *Multirate Systems and Filter Banks*, Pearson Education
2. Harris, F. J., (2007), *Multirate Signal Processing for Communication Systems*, 1st Edition, Pearson Education

Self-Learning Material

1. Kovilpillai D., *Multirate Digital Signal Processing*, NPTEL Course Material, Department of Electrical Engineering, Indian Institute of Technology Chennai, <https://nptel.ac.in/courses/108106136/>

Preparatory Course Material

1. Dutta, S. C. R., *Digital Signal Processing*, NPTEL Course Material, Department of Electrical Engineering, Indian Institute of Technology Delhi, <https://nptel.ac.in/courses/117102060/>

Title	Network Information Theory	Number	EEL7XX0
Department	Electrical Engineering	L-T-P [C]	3-0-0 [3]
Offered for	M.Tech.-Ph.D. Dual Degree (Comm. Engg.)	Type	Elective
Prerequisite	Wireless Communications		

Objectives

The Instructor will:

1. Provide fundamental concepts in multi-user and network information theory with applications in communications
2. Expose students to the fundamentals of the multiple access channel, broadcast channel, channels with state, interference channel, relay channel, network coding and MIMO multiuser channels.

Learning Outcomes

The students are expected to have the ability to:

1. the core ideas of network information theory, including key multi-user coding techniques, proof ideas and performance analysis in modern communications networks

Contents

Review of basic information theory concepts: entropy, mutual information (3 lectures)

Multiple access channel: capacity, successive interference cancellation (4 lectures)

Gaussian Degraded Broadcast Channels: Discrete Memoryless Broadcast Channel, Simple Bounds on the Capacity Region, Superposition Coding Inner Bound, Degraded DM-BC, Gaussian Broadcast Channel (7 lectures)

Channels with state: DMC with state, Compound Channel, Arbitrarily Varying Channel, Channels with Random State, Causal State Information Available at the Encoder, Non-causal State Information Available at the Encoder, dirty-paper coding (7 lectures)

Interference channel: Discrete Memoryless Interference Channel, Simple Coding Schemes, Strong Interference, Gaussian Interference Channel, Han-Kobayashi Inner Bound, Capacity Region of the Gaussian IC within Half a Bit (7 lectures)

Relay channel: Cut-set Upper Bound on the Capacity, Direct-Transmission Lower Bound, Decode-Forward Lower Bound, Gaussian Relay Channel, Compress-Forward Lower Bound, Receiver Frequency Division Gaussian Relay Channel, Look-ahead Relay Channels (7 lectures)

Multicast and interference networks: network coding, noisy network coding, interference alignment. (7 lectures)

Textbook

1. Gamal A. E. and Kim Y. H., (2012), *Network Information Theory*, Cambridge University Press.
2. Kramer G., (2008), *Topics in multi-user information theory*, now Publishers Inc.
3. Cover T. and Thomas J., (2006), *Element of Information Theory*, Wiley-Interscience.

Self-Learning Material

1. Avestimehr A. S., Diggavi S.N. and Tse D. N. C., "Wireless Network Information Flow: A Deterministic Approach," *IEEE Transactions on Information Theory*, Vol. 57, No. 4, pp.1872-1905, 2011.
2. Dimakis A. G., Godfrey P. B., Wu Y., Wainwright M. J. and Ramchandran K., "Network Coding for Distributed Storage Systems," *IEEE Transactions on Information Theory*, Vol. 56, No. 9, pp. 4539 - 4551, 2010.

Title	Adaptive Signal Processing	Number	EEL7XX0
Department	Electrical Engineering	L-T-P [C]	3-0-0 [3]
Offered for	B.Tech. (IV Year), M.Tech., Ph.D	Type	Elective
Prerequisite	Digital Signal Processing		

Objectives

The Instructor will:

1. Provide students an understanding of fundamental issues related to adjustment of weights of processing filters based on requirement and signal characteristics.

Learning Outcomes

The students are expected to have the ability to:

1. Design various optimal filters such as Least Squares filters and its variants.
2. Apply the adaptive filtering techniques in various application areas such as speech, image, and video processing.

Contents

Introduction: Applications of Adaptive Signal Processing (1 Lecture)

Review of linear and non-linear estimation theory: Properties of estimators, estimators of mean and variance, least square estimation, loss function, weighted least squares (6 lectures) Signal modelling, Optimal filtering, Adaptive filtering as an extension of the optimal least mean square error case Adaptive algorithms: Linear non-parametric signal models, parametric pole-zero signal models, optimum signal estimation, linear mean square error estimation, optimum FIR and IIR response filters, derivation of LMS algorithm, convergence of weight vector, recursive least square adaptive filters, RLS algorithm (15 lectures)

Adaptive equalization and echo cancellation: structures and adaptive algorithms, double talk detection, Howling suppression, stereophonic acoustic echo cancellation (5 lectures)

Adaptive lattice filters: Forward and backward linear prediction, derivation of lattice structure, lattice joint process estimator, autoregressive modeling, gradient adaptive lattice, RLS adaptive lattice, RLS lattice recursions (10 lectures)

Application to image processing, video processing, and communications (spread spectrum techniques) (5 lectures)

Textbook

1. Haykin, S., (1986), *Adaptive filter theory*, Prentice Hall
2. Widrow, B. and Stearns, S. D., (1984), *Adaptive Signal Processing*, Prentice Hall

Self-Learning Material

1. Chakraborty M., *Adaptive Signal Processing*, NPTEL Course Material, Department of Electrical and Electronics Engineering, Indian Institute of Technology Kharagpur, <https://nptel.ac.in/courses/117105075/>

Preparatory Course Material

1. Dutta Roy, S. C., *Digital Signal Processing*, NPTEL Course Material, Department of Electrical Engineering, Indian Institute of Technology Delhi, <https://nptel.ac.in/courses/117102060/>

Title	Machine Learning for Communications	Number	EEL7XX0
Department	Electrical Engineering	L-T-P [C]	3-0-0 [3]
Offered for	B.Tech. IV Year, M. Tech., Ph.D.	Type	Elective
Prerequisite	Fundamentals of communication systems, machine learning 1		

Objectives

The Instructor will:

1. Introduce the area of machine learning in the context of communications
2. Discuss scenarios in the domain of communications where machine learning can be a viable alternative to traditional approaches

Learning Outcomes

The students are expected to have the ability to:

1. Apply machine learning techniques (supervised/unsupervised classification and regression) for specific problems in the domain of communications

Contents

Review of machine learning techniques as applicable in the area of communications (3 lectures)

Why and when machine learning can be useful in communication? (2 lectures) Overview of machine learning in communications (2 lectures)

Machine learning for physical layer design: Adaptive modulation and coding (AMC), classical AMC, AMC using support vector machines, k-nearest neighbors, reinforcement learning (5 lectures)

Channel prediction: prediction of wireless channel features via neural networks, channel prediction using Recurrent neural networks (3 lectures)

Video communication: introduction to video coding standards (MPEG, H.26x), discussion of traditional algorithms (motion compensation, linear prediction etc.), modern approaches for video compression using machine learning (8 lectures)

Machine learning for mobile network design: network state prediction, traffic prediction and interference management, small cell clustering in Hetnet, user grouping/clustering in D2D, HetNets for offloading, modeling spatio-temporal correlations in geographical mobile traffic measurements using CNNs/RNNs (10 lectures)

User mobility analysis: modeling spatial dependencies in sequential data (3 lectures) Learning based automatic modulation recognition in cognitive radios (2 lectures) Possible limitations of machine learning methods in communication systems (3 lectures)

Textbook

1. Bishop, C. M., (2007), *Pattern Recognition and Machine Learning*, Springer
2. MacKay, D.J.C., (2005), *Information Theory, Inference, and Learning Algorithms*, Cambridge University Press

Self-Learning Material

Machine Learning For Communications Emerging Technologies Initiative, IEEE

<https://mlc.committees.comsoc.org/research-library/>

Title	GNSS Signal Processing	Number	EEL7XX0
Department	Electrical Engineering	L-T-P [C]	3-0-0 [3]
Offered for	B. Tech., M. Tech., Ph. D.	Type	Elective
Prerequisite	Fundamentals of Communications and Signals and Systems		

Objectives

The Instructor will:

1. Describe and analyze the signal processing of a GNSS receiver, including signal acquisition, tracking and navigation.
2. Expose students to the main vulnerabilities and limitations of GNSS technology, including interference sources such as jamming, unintentional interferences, spoofing and ionospheric scintillation.

Learning Outcomes

The students are expected to have the ability to:

1. Understand the basic principles and signal processing tools that are used in satellite-based navigation for signal acquisition and computation of positioning solutions.
2. Analyze the state of the art signal acquisition methods and countermeasures strategies for interference and spoofing. Interpret anti-jamming techniques in the context of robust signal processing theory.

Contents

Course introduction: positioning is everywhere; GNSS is a key technology; main GNSS components; GNSS limitations; review of mathematical tools. (3 lectures)

Fundamentals of satellite-based navigation: historical remarks on navigation; positioning concepts; system segments; space segment; ground segment; user segment. (4 lectures) *GNSS signals in space:* overview of the main signal characteristics: GPS, Galileo, GLONASS, Beidou, IRNSS; focus on IRNSS SPS and RS signal; BPSK vs BOC modulations. (3 lectures) *GNSS channel model:* propagation delay; Doppler effect; multipath and non-line-of-sight; ionospheric and tropospheric delays. (4 lectures)

GNSS receiver: antenna and RF front-end; signal sampling; signal acquisition as a detection problem; signal tracking as a filtering problem; observables' computation. (7 lectures) *Navigation solution:* Code-based positioning; Code and carrier-based positioning; least squares solution; weighted least squares solution; Kalman filtering solution; basic schemes for GNSS/inertial hybridization. (7 lectures)

Vulnerabilities of GNSS: intentional interferences and jammers; unintentional interferences; spoofing attacks; ionospheric scintillation; detection and mitigation techniques. (7 lectures) *Indoor positioning:* basic measurements; positioning approaches: model-based versus model-free methods; hybridization and data fusion; main technologies. (7 lectures)

Textbook

1. Betz J. W., (2015), *Engineering Satellite-Based Navigation and Timing: Global Navigation Satellite Systems, Signals, and Receivers*, Wiley-IEEE Press.
2. Kaplan E. and Hegarty C. J., (2017), *Understanding GPS/GNSS: Principles and Applications*, Artech House.
3. Misra P. and Enge P., (2011), *Global Positioning System: Signals, Measurements, and Performance*, Ganga-Jamuna Press.

Preparatory Course Material

1. Zheng, L. and Gallager, R., *Principles of Digital Communications I*, MIT OpenCourseWare, Electrical Engineering & Computer Science, Massachusetts Institute of Technology, <https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-450-principles-of-digital-communications-i-fall-2006/>

Title	Applied Optimization for Wireless Communication	Number	EEL7XX0
Department	Electrical Engineering	L-T-P [C]	3-0-0 [3]
Offered for	B. Tech., M. Tech. and Ph. D.	Type	Elective
Prerequisite	Basic knowledge of - Calculus, Probability, Matrices		

Objectives

The Instructor will expose students to the fundamental tools and techniques in modern optimization.

Learning Outcomes

The students are expected to have the ability to apply Convex Optimization techniques to various aspects of wireless communication systems.

Contents

Introduction to properties of Vectors, Norms, Positive Semi-Definite, matrices, Gaussian Random Vectors (6 Lectures)

Introduction to Convex Optimization, Convex sets, Hyperplanes Half-spaces etc. Application: Power constraints in Wireless Systems (6 Lectures)

Convex Concave Functions, Examples, Conditions for Convexity. Application: Beamforming in Wireless Systems, Multi-User Wireless, Cognitive Radio Systems (6 Lectures)

Convex Optimization problems, Linear Program, Application: Power allocation in Multi-cell cooperative OFDM

QCQP, SOCP Problems, Application: Channel shortening for Wireless Equalization, Robust Beamforming in Wireless Systems (8 Lectures)

Duality Principle and KKT Framework for Optimization. Application: Water-filling power allocation, Optimization for MIMO Systems, OFDM Systems and MIMO-OFDM systems (7 Lectures)

Optimization for signal estimation, LS, WLS, Regularization. Application: Wireless channel estimation (2 Lectures)

Application: Cooperative Communication, Optimal Power Allocation for cooperative, Communication (2 Lectures)

Application: Radar for target detection, Array Processing, MUSIC, MIMO-Radar Schemes for Enhanced Target Detection (2 Lectures)

Application: Autonomous self-organization in dynamic wireless networks (3 Lectures)

Textbook

1. Boyd S. P. and Vandenberghe L., (2004), *Convex Optimization*, Cambridge University Press.

Self-Learning Material

1. Jagannatham A., *Applied Optimization for Wireless, Machine Learning, Big Data*, NPTEL Course Material, Department of Electrical Engineering, Indian Institute of Technology Kanpur, https://nptel.ac.in/noc/individual_course.php?id=noc18-ee31
2. Llorca J., Milner S. D. and Davis C. C., "A convex optimization method for autonomous self-organization in dynamic wireless networks," MILCOM 2008 - 2008 IEEE Military Communications Conference, San Diego, CA, pp. 1-8, 2008.

Title	Selected Topics in Communication	Number	EEL7XX0
Department	Electrical Engineering	L-T-P [C]	3-0-0 [3]
Offered for	M.Tech., PhD	Type	Elective
Prerequisite	Fundamentals of Wireless Communications		

Objectives

The Instructor will expose the students to the latest upcoming fields in the area of communications

Learning Outcomes

The students are expected to have the ability to: apply the knowledge of recent topics in the field of communications to specific areas of research

Contents

The topic clouds for the course include some contemporary topics in communications (but not restricted to) mm-Wave wireless communications, wireless networks, quantum information processing, molecular communications. The topics may be further updated according to the instructor.

Textbook

Relevant Textbook and/or research papers to be announced by the instructor.

Self-Learning Material

Relevant Textbook and/or research papers to be announced by the instructor.

Preparatory Course Material

Relevant Textbook and/or research papers to be announced by the instructor.

Title	Physical Layer Security	Number	EEL7XX0
Department	Electrical Engineering	L-T-P [C]	3-0-0 [3]
Offered for	B. Tech. (IV Year), M. Tech., Ph. D.	Type	Elective
Prerequisite	Fundamentals of Information Theory		

Objectives

The Instructor will:

1. Familiarize the students with the fundamental concepts of information theoretic security such as perfect secrecy, wiretap channels, secrecy capacity etc.
2. Help students understand the proofs of fundamental theorems in information theoretic secrecy

Learning Outcomes

The students are expected to have the ability to:

1. Acquire the current state of research on physical layer security
2. Apply the physical layer security techniques learnt to formulate a problem for research and solve them in a comprehensive manner

Contents

Fundamentals of Physical Layer Security: Information-theoretic secrecy, secret communication over noisy channels, Secret-key generation from noisy channels

Coding for secrecy: Coding for wiretap channels, Polar wiretap codes, LDPC codes for the Gaussian wiretap channel

Physical Layer Security Techniques: Cooperative jamming, MIMO signal processing algorithms for enhanced physical layer security, secrecy through intentional uncertainty, secure modulation schemes, secure

Applications to Contemporary Communication Systems: secure waveforms for 5G, security of massive MIMO and mm-Wave cellular systems, security in IoT and massive machine type communications: issues and challenges

Textbook

1. Bloch, M. and Barros, J., (2011), *Physical-Layer Security: From Information Theory to Security Engineering*, 1st Edition, Cambridge University Press.
2. Zhou, X., Song, L., and Zhang, Y., (2013), *Physical Layer Security in Wireless Communications*, 1st Edition, CRC Press.
3. Duong, T. Q., Zhou, X., and Poor, H. V., (2016), *Trusted Communications with Physical Layer Security for 5G and Beyond*, 1st Edition, IET.

Self Learning Material

1. Liu, R. and Trappe, W., (2010), *Securing Wireless Communications at the Physical Layer*, 1st Edition, Springer.

Title	Compressive Sensing	Number	EEL7XX0
Department	Electrical Engineering	L-T-P [C]	3-0-0 [3]
Offered for	B. Tech., M. Tech. and Ph. D.	Type	Elective
Prerequisite	Signals and Systems, Random Signal Analysis		

Objectives

The Instructor will:

1. Introduce development of compressed sensing and matrix completion, focusing on the design and analysis of algorithms to recover data from its compressed and/or incomplete measurements.

Learning Outcomes

The students are expected to have the ability to:

1. use signal processing techniques to solve undetermined linear systems.

Contents

Sparse representation: Sparse representation in over-complete basis, Uniqueness and uncertainty principles, l_0 minimization and l_1 minimization (7 Lectures)

Model selection in linear regression: Prediction risk, l_0 -penalized regression and Lasso, Risk inflation, Minimax risk for sparse vectors (7 Lectures)

Lasso algorithms and extensions: Proximal gradient methods, Nesterov accelerated methods, Group lasso and elastic net (7 Lectures)

Compressed sensing and sparse recovery: Restricted isometry property (RIP), A RIPless theory, Golfing scheme, Phase transition and convex geometry (7 Lectures)

Low-rank matrix recovery: Spectral method, Nuclear norm minimization (4 Lectures)

Super-resolution and spectral estimation: Model mismatch issue in compressed sensing, Matrix pencil approach, Atomic norm minimization, Connection to low-rank matrix completion (10 Lectures)

Textbook

1. Hastie T., Tibshirani R. and Wainwright M., (2015), Statistical learning with sparsity: the Lasso and generalizations, CRC.
2. Foucart S. and Rauhut H., (2013), A mathematical introduction to compressive sensing, Springer.

Self-Learning Material

1. Compressive Sensing resources, Rice University, <http://dsp.rice.edu/cs/>

Title	Selected Topics in Signal Processing	Number	EEL7XX0
Department	Electrical Engineering	L-T-P [C]	3-0-0 [3]
Offered for	M.Tech., PhD	Type	Elective
Prerequisite			

Objectives

The Instructor will:

1. Expose the students to the latest upcoming fields in the area of signal processing

Learning Outcomes

The students are expected to have the ability to:

1. Apply the knowledge of recent topics in the field of signal processing to specific areas of research

Contents

The topics may be further updated according to the instructor.

Textbook

Relevant Textbook and/or research papers to be announced by the instructor.

Self-Learning Material

Relevant Textbook and/or research papers to be announced by the instructor.

Preparatory Course Material

Relevant Textbook and/or research papers to be announced by the instructor.