School of Computer & Systems Sciences

M. Tech Programme in Statistical Computing

Course Structure

A student shall have to earn a minimum of 50 credits at the end of II year in order to be eligible for the award of M. Tech degree

Semester I

S.No.	Course Name	Credits
1	*Data Structure & Algorithms	3
2	Optimization Techniques	3
3	Probability& Stochastic Processes	3
4	Big Data Systems (Compulsory for Data Science Stream) Data Communication & Computer Networks (Compulsory for Data Communication Stream)	3
5	Statistical Computing Lab	3

*For students from non-computer science background, Data Structure & Algorithms is compulsory course. Students from Computer science background may opt for Linear algebra instead of Data Structure & Algorithms

Semester II

S.No.	Course Name	Credits
1	Statistical Inference & Multivariate Techniques	3
2	Big Data Algorithms (Compulsory for Data Science Stream) Information Theory (Compulsory for Data Communication Stream)	3
3	Elective I	3
4	Elective II	3
5	Elective III	3

Semester III

S.No.	Course Name	Credits
1	Elective IV	3
2	Elective V	3
3	Seminar Course	2
4	Dissertation	

Semester IV

S.No.	Course Name	Credits
1	Dissertation (in continuation from semester III)	12

Elective courses Elective I, Elective II, Elective III, Elective IV and Elective V would be chosen from the stream in which the student has taken admission to the M.Tech. programme. The students from a given stream can opt at most two courses from Elective courses which are common elective courses to both streams. The elective courses in Data Science stream and Data Communication stream are given below:

Data Science Stream	**Data Communication Stream**
Design Of Experiments	Design Of Experiments
Stochastic Modeling And Applications	Stochastic Modeling And Applications
Regression & Time Series Analysis	Regression & Time Series Analysis
Computational Intelligence & Applications	Computational Intelligence & Applications
Speech & Natural Language Processing	Speech & Natural Language Processing
Cloud Computing	Cloud Computing
Internet of Things	Internet of Things
Nature Inspired Algorithms	Nature Inspired Algorithms
Social Network Analytics	Social Network Analytics
Machine Learning	Statistical Signal Processing
Computational Finance	Wireless Sensor Networks
Bioinformatics	Multimedia Communication
Data Mining & Pattern Recognition	Parallel & Distributed Systems
Econometrics	Wireless Communication & Mobile Computing
Spatial Data Analysis &GIS	Game Theory & Mechanism Design
Data Visualization Techniques	Vehicular Communication Networks
Big Data Analytics	Adhoc Networks
Data Stream Management	Data Compression
Multimedia and Video Analytics	Network Simulation
Web Mining	Network Security
Probabilistic Graphical Models	Multicast Communication
Probabilistic Risk Assessment	Performance Modeling of Computer Communication Networks
Data Security	Brain Theory & Neural Networks
Smart Camera & Visual Sensor Networks	

Semester: I

Data Structures and Algorithms

Introduction to C programming, Complexity of Algorithms: Worst case, Average case and Amortized Complexity, Algorithm Analysis, Lists, Stacks and Queues, Trees: Binary Search Trees, AVL Trees, Red-Black Trees, M-way and B Trees, Splay Trees, Hash Tables, Priority Queues: Binary Heap, D-Heaps, Skew Heaps, Binomial Queues, Sorting: Quick sort, Heap Sort, Merge Sort and External Sorting, Bin and Radix Sort, Graphs: Topological Sort, Shortest Path, Network Flow Problem, Minimum Spanning Tree, Algorithm Design Techniques: Greedy Algorithms, Divide and Conquer, Dynamic Programming, Randomized Algorithms, Back Tracking, NP Completeness

Suggested Readings:

1. A. V. Aho, J. E. Hopcraft and J. D. Ullman. “Data Structures and Algorithms", Addison Wesley, 1983
2. M. A. Weiss, “Data Structures and Algorithm Analysis in C", Addison Wesley 2002
3. T. Cormen, C. Leiserson, R. Rivest and C. Stein, ”Introduction to Algorithms", Prentice Hall, 2010
4. D. Knuth, “The Art of Computer Programming", Vol I and Vol III, Addison Wesley, 2011

Optimization Techniques

Linear programming–Formulation, Simplex Method, Interior Point Methods, Duality and Sensitivity Analysis, Constrained Non-linear programming – Lagrange Multiplier Methods, Karush-Kuhn-Tucker Optimality Conditions, Quadratic and Separable Programming Methods, Unconstrained Non-linear Programming–Gradient Search, Newton Method

Suggested Readings:

1. R. A. Thisted, “Elements of Statistical Computing: Numerical Computation", Chapman and Hall, New York, 1988
2. C. S. Beightler , D. T. Phillips and D. J. Wilde,”Foundations of Optimization", Prentice Hall, 1979
3. R. L. Rardin, “Optimization in Operations Research", Pearson Education, 1997
4. E. K. P. Chong and S. H. Zak, “An Introduction to Optimization", John Wiley and Sons, 2013
5. K. Lange, “Optimization", Springer-Verlag, 2004

Probability and Stochastic Processes

Introduction to Probability Theory, Bayes Formulae, Random Variables, Expectation, Moment Generating Function, Characteristic Function, Jointly Distributed Random Variables, Weak Law and Strong Law of Large Numbers, Modes of Convergence, Limit Theorems. Sample Moments and Their Distributions; Introduction to Stochastic

Processes, Markov Chains, Chapman- Kolmogorov Equations, Classification of States, Time Reversible Markov Chains, Random Walk and Gambler's ruin Problem; Poisson Processes, Continuous-time Markov Chains, Birth-Death Processes, Uniformization, Renewal Theory, Limit Theorem, Semi-Markov Processes, Queuing Theory, M/M/1, M/G/1 Systems, Network of Queues, Reliability Theory, Martingales, Stopping Times, Brownian Motion, Using Martingales to Analyze Brownian Motion Process

Suggested Readings:

1. S. M. Ross, "Probability Models", 8th Edition, Academic Press, 2003
2. S. M. Ross, "Stochastic Processes", 2nd Edition, John Wiley, 1996
3. K. S. Trivedi, "Probability and Statistics with Reliability, Queuing and Computer Science Applications", 2nd Edition, Wiley, 2004
4. R. Nelson, "Probability, Stochastic Processes and Queuing Theory", Springer, 1995
5. D. Williams, "Weighing the Odds: A Course in Probability and Statistics", Cambridge University Press, 2001
6. M. F. Neuts, "Algorithmic Probability", Chapman and Hall, 1995

Big Data Systems (for Data Science Stream)

Introduction to Big Data: Big Data characteristics, types of Big Data, Traditional vs. Big Data business approach; Big Data Architecture: Tradition Information Architecture, Big Data Architecture Capabilities: Storage, Management, Database, Processing, Data Integration; Introduction to MapReduce and Hadoop: Core Hadoop Components; Hadoop Ecosystem; Physical Architecture; Hadoop limitations; Distributed File System, HDFS; Data Management Techniques to Store Data Locally and in Cloud Infrastructures; Data-Intensive Computations on Cluster and Cloud Infrastructures using MapReduce; NoSQL: introduction, architectural patterns; Challenges and Opportunities in Big Data Management

Suggested Readings:

1. Rajaraman, A., Ullman, J. D., Mining of Massive Datasets, Cambridge University Press, United Kingdom, 2012
2. Berman, J.J., Principles of Big Data: Preparing, Sharing and Analyzing Complex Information, Morgan Kaufmann, 2014
3. Barlow, M., Real-Time Big Data Analytics: Emerging Architecture, O Reilly, 2013
4. Schonberger, V.M. , Kenneth Cukier, K., Big Data, John Murray Publishers, 2013

Data Communication and Computer Networks (for Data Communications Stream)

Data Communication – Analog and digital communications, Channel characteristics, modulation, encoding schemes; Error Detection and correction, Flow control, multiplexing switching, Multiple access techniques, Routing– shortest path algorithms, routing protocols, virtual path routing, Network Protocols – IP, TCP, UDP, FTP, SMTP,

etc, Performance Evaluation – Queuing models, Traffic model – deterministic and stochastic .

Suggested Readings:

1. Leon Garcia and IndraWidjaja, Communication Networks: Fundamental Concepts and Key Architecture, 2nd ed., Tata McGraw-Hill, 2004
2. Anurag Kumar, D. Manjunath and Joy Kuri, Communication Networking: An analytical approach, Elsevier, 2004.
3. Dimitri Bertsekas and Robert Gallager, Data Networks, 2nd ed., PHI, 2001.
4. Thomas G. Roberttazzi, Computer Networks and Systems, 3rd ed. Springer, 2002.

Semester II

Statistical Inference and Multivariate Techniques

Statistical Inference: Parametric Point Estimation Method of Moments, Maximum Likelihood, Minimum-Chi Square, Properties of Estimators, MVUE, CR Inequality, Consistent Asymptotic Normal Estimator, Extension to Multi Parameter Exponential Family, Solution of Likelihood Equations, Bayesian Estimation, Quadratic and other Loss Functions, Testing of Hypothesis- Neyman-Pearson Lemma, Generalized Likelihood Ratio Test, Parametric Interval Estimation, Confidence Estimation Methods, General Linear Hypothesis, Nonparametric Statistical Inference, U Statistics, Some Applications of Ordered Statistics, Some Single Sample and Two Sample Problem; Multivariate Techniques: Exploratory Data Analysis: Graphical Examination of the Data. Approaches to Dealing with Missing Data and Outliers, Testing the Assumptions of Multivariate Analysis like Normality, Homoscedasticity, Linearity and Absence of Correlated Errors, Factor Analysis and Principal Component Analysis, Basic Multiple Regression Analysis and Multivariate Analysis of Variance (ANOVA & MANOVA), Multiple Discriminant Analysis, Cluster Analysis, Multidimensional scaling, Conjoint Analysis Structural Equation Modeling and its Applications – Path Diagram, Lisrel Notation, Canonical Correlation Analysis

Suggested Readings:

1. E. L. Lehmann, "Testing Statistical Hypothesis", John Wiley, New York, 1986
2. J. F. Hair, R. E. Anderson, R. L. Tatham and W. C. Black, "Multivariate Data Analysis", 5th Edition, Pearson Education., 2003
3. T. W. Anderson, "Introduction to Multivariate Statistical Analysis", 3rd Edition, John Wiley, New York, 2004
4. P. E. Green, "Analyzing Multivariate Data", Hinsdale, Illinois: Dryden Press, 1978
5. A. Gelman, J. B. Carlin, H. S. Stern and D. B. Rubin, "Bayesian Data Analysis", Chapman and Hall, 1995
6. P. J. J. Bickel and K. A. Doksum, "Mathematical Statistics: Basic Ideas and Selected Topics", Vol. I, Prentice Hall, 2000
7. G. Casella, R. L. Berger, “Statistical Inference", 2nd edition Brooks/Cole, 1999

8. R. A. Johnson and D. W. Wichern, “Applied Multivariate Statistical Analysis", 5th Edition, Prentice Hall, 2001
9. W. Hardle and L. Simar, “Applied Multivariate Statistical Analysis", Springer-Verlag, 2003

Big Data Algorithms (for Data Science Stream)

Introduction to Probability Theory, Tail bounds with Applications, Markov Chains and Random Walks, Randomized Algorithms against an Oblivious Adversary, Pairwise Independence and Universal Hashing, The Streaming Model, Approximate Counting, Approximate Median, Flajolet Martin -- Distinct Sampling, Alon-Mattias-Szegedy Sketch, Bloom Filters, Count-min Sketch, Property Testing Model, Local search and testing connectivity, Enforce and Test Techique: Biclique and Bipartiteness Testing, Random Walks and Testing Bipartiteness& Expansion, Regularity Lemma and Testing Triangle Freeness, Boolean Functions, BLR test for Linearity.

Suggested Readings:

1. Mitzenmacher and Upfal, Probability and Computing: Randomized Algorithms and Probabilistic Analysis, Cambridge University Press, 2005.
2. Dana Ron, Algorithmic and Analysis Techniques in Property Testing, Now Publishers Inc, 2010 .
3. Graham Cormode, Minos Garofalakis, Peter J. Haas and Chris Jermaine, Synopses for Massive Data: Samples, Histograms, Wavelets, Sketches, Now Publishers, 2012.

Information Theory (for Data Communications Stream)

Uncertainty, Probablilty, Entropy, Shannon's Measure, Joint Entropy, Mutual Information, Differential Entropy, AEP, Entropy Rates of a Stochastic Process, Markov Chains, Hidden Markov Models, Data Compression, Kraft Inequality, Entropy of English Language, Inference, Sufficient Statistics, Maximum Likelihood and Clustering, Marginalization, Laplaces Method, Model Comparison and Occam's Razor; Maximum Entropy Principle, Maximum Entropy Probability Distributions, Jaynes Concentration Theorem, Applications-Physics, Economics, Statistics. Information in Contingency Tables, Comparison and Fisher's and Maxent Methods of Estimation; Further Applications of Maxent Principle: Pattern Recognition as a Quest for Minimum Entropy, Non-Linear Spectral Analysis, Parametric Entropy Measures: Renyi, Tsallis, Power Laws

Suggested Readings:

1. A. Golan, G. Judge and D. Miller, "Maximum Entropy Econometrics", John Wiley, 1996
2. J. N. Kapur and H. K. Kesavan, "Entropy Optimization Principles with Applications", Academic Press, 1992
3. J. van der Lubbe, “Information Theory", Cambridge University, 1997
4. T. M. Cove and J. A. Thomas, "Elements of Information Theory", Wiley, 1991
5. R. F. Blahut, "Principles and Practice of Information Theory", Addison Wesley, 1988

6. R. G. Gallager, "Information Theory and Reliable Communication", Tata McGraw Hill, 1968

Design of Experiments

Introduction: Guidelines for Designing Experiments, Experiments with a Single Factor, Analysis of Variance, Randomized Blocks, Latin Squares and Related Designs, Factorial Designs: 2^K factorial design, Fractional Factorial Designs- Two level, Three level and Mixed Level Designs, Response Surface Methods: Process Optimization, Response Surface, Mixture Experiments, Robust Designs, Nested and Split plot Designs, Non-normal Responses and Transformations, Analysis of Covariance, Computer Solutions, Factorial Experiments with Covariates (Emphasis will be placed on computational methods in the design of experiments)

Suggested Readings:

1. D. C. Montogomery, "Design and Analysis of Experiments", 5th Edition, John Wiley, 2001
2. T. J. Santner, B. J. Williams and W. I. Notz, "Design and Analysis of Computer Experiments", Springer, 2003
3. G. Taguchi, "System of Expermental Design", Volumes I and II, White Plains, New York, 1987
4. B. P. Zeigler, K. Praehofer and T. G. Kim, "Theory of Modeling and Simulation", 2nd Edition, Academic Press, 2000
5. J. D. Jobson, "Applied Multivariate Data Analysis, Regression and Experimental Design", Springer, 1991
6. Y. Dodge, "Analysis of Experiments with missing data", Wiley, 1985

Stochastic Modeling and Applications

Purposes of Stochastic Models: Review of Stochastic Processes, Discrete and Continuous time Markov Chains; Continuous Time Markov Chains: The Kolmogorov equations, Queueing systems, Modeling Neural Activity; Markov Random Fields: Ising Model of Ferromagnetism, Phase Transitions in Markov Random Fields, Likelihood Analysis of the Ising model, Image Analysis; Point Processes: Model of Traffic Patterns, Estimating Second Order Parameters for Stationary Point Processes, Mixed Point Processes, Spatial Point Processes; Brownian Motion and Diffusion: Second Order Processes, A More Realistic Model of Brownian Motion, Introduction to SDE, Likelihood inference for SDE, Wright- Fisher Model and Diffusion; Fractional Brownian Motion: Modeling Internet Traffic, 1/f Noise.

Suggested Readings:

1. P. Guttorp, "Stochastic Modeling of Scientific data", Chapman & Hall, 1995
2. V. G. Kulkarni, "Modeling and Analysis of Stochastic Systems", Chapman & Hall, 1995
3. M. Mitzenmacher, "Eliupfal, Probability and Computing", Cambridge, 2005

4. H. C. Tijms, "Stochastic Modeling and Analysis", Wiley, 1986
5. K. Borovkov, “Elements of Stochastic Modeling", World Scietific, 2003
6. H. Haken, "Synergetics : An Introduction", 3rd Edition, Springer-Verlag, 1993
7. D. J. Bartholomew, "Stochastic Models for Social Processes", 3rd Edition, Wiley, 1982
8. J. Beran, "Statistics for long memory processes", Chapman & Hall, 1994

Regression and Time Series Analysis

Basic Regression Model: Computational Techniques for Variable Selection, Regression Models with Multicollinearity and Autocorrelated Errors, ARIMA, ARCH and GARCH Models, VAR Models, Autocorrelation Function and Spectrum of Stationary Processses, White Noise and Colored Noise, Linear Stationary Models, Linear Nonstationary Models Forecasting: Forecast Function and Forecast Weights, Forecasting Autoregressive Processes, Error of Forecast. Seasonal Models, Stochastic Model Building – Model Diagnostics, Transfer Function Models: Identification, Fitting and Checking, Intervention Analysis of Models and Outlier Detection, Aspects of Process Control

Suggested Readings:

1. D. C. Montgomery, E. A. Peck and G. G. Vining, “Introduction to Linear Regression Analysis", 3rd Edition, John Wiley, 2003
2. S. Makridakis, S. C. Wheelwright and R. J. Hyndman, "Forecasting Methods and Application", 3rd edition. John Wiley and Sons, 1998
3. G. E. P. Box, G. M. Jenkins and G. C. Reinsel, "Time Series Analysis - Forecasting and Control", 3rd Edition, Pearson Education, 2004
4. N. R. Draper and H. Smith, “Applied Regression Analysis", 3rd Edition, John Wiley, 2003
5. J. D. Hamilton, “Times Series Analysis", Princeton University Press, 1994
6. C. Chatfield, “The analysis of Time Series", CRC, Chapman and Hall, 2003
7. H. Kantz and T. Schreiber, “Nonlinear Time Series Analysis", 2nd Edition, Cambridge, 2004
8. M. West and J. Harrison, “Bayesian Forecasting", Springer, 1989

Computational Intelligence and Applications

Neural Networks: Biological Neuron, Artificial Neuron, General Attributes of Biological Neural Networks and Artificial Neural Networks, Different Learning Paradigms, Specific Models like MLP, SOFM, ART, LVQ, Hopfield Net, Boltzman Machine, Simulated Annealing and Applications; Fuzzy Logic: Motivation, Linguistic Variables and Linguistic Values, Fuzzy Set, Membership Functions, Fuzzy Relation, Operations on Fuzzy Sets and Relations, Approximate Reasoning, Fuzzification, Defuzzification, Fuzzy Rule based Systems, Fuzzy and Possibilistic Clustering and Fuzzy Classification and Applications

Suggested Readings:

1. C. M Bishop, “Neural Network for Pattern Recognition", Oxford University Press, 2014
2. S. Kumar, “Neural Networks", Tata McGraw Hill, 2004
3. H. T. Nguye and E. Walker, “A First Course in Fuzzy Logic", 3rd Edition, 2005
4. George J. Klir, “Fuzzy Sets and Fuzzy Logic: Theory and Applications”, Ist Edition, PHI, 2015

Speech and Natural Language Processing

Biology of Speech Processing; Place and Manner of Articulation; Word Boundary Detection; Argmax based computations; HMM and Speech Recognition. Morphological Diversity of Languages; Morphology Paradigms; Finite State Machine Based Morphology; Automatic Morphology Learning; Shallow Parsing; Named Entities; Maximum Entropy Models; Random Fields. Theories of Parsing, Parsing Algorithms; Robust and Scalable Parsing on Noisy Text as in Web documents; Hybrid of Rule Based and Probabilistic Parsing; Scope Ambiguity and Attachment Ambiguity resolution. Lexical Knowledge Networks, Wordnet Theory; Indian Language Wordnets and Multilingual Dictionaries; Semantic Roles; Word Sense Disambiguation; WSD and Multilinguality; Metaphors; Coreferences. Sentiment Analysis; Text Entailment; Robust and Scalable Machine Translation; Question Answering in Multilingual Setting; Cross Lingual Information Retrieval (CLIR).

Suggested Readings:

1. D. Manning, “Statistical Foundation of Natural language Processing", MIT Press, 1999
2. A. James, “Introduction to Natural Language Understanding", Addison Wesley, 1991
3. E. Charnaik, “Statitistical Natural Learning", MIT Press, Cambridge, 1993
4. Jurafsky, Dan and Martin, James, Speech and Language Processing, Second Edition, Prentice Hall, 2008.

Cloud Computing

Over view of Distributed Computing: Trends of computing, Introduction to Parallel/distributed computing, Grid Computing, Cloud computing, Introduction to Cloud Computing: What’s cloud computing, Properties and Characteristics, Service models, Deployment models Components of a computing cloud, Different types of clouds: public, private, hybrid, Delivering services from the cloud, Categorizing service types, Comparing vendor cloud products: Amazon, Google, Microsoft and others, Infrastructure as a Service (IaaS): Introduction to IaaS, Resource Virtualization, Server, Storage, Network, Case studies, Platform as a Service (PaaS): Introduction to PaaS, Cloud platforms and Management, Computation, Storage, Case studies, Software as a Service (SaaS): Introduction to SaaS, Web services, Web 2.0, Web OS, Case studies, Cloud Issues and Challenges: Cloud provider Lock-in, Security.

Suggested Readings:

1. Kai Hwang, Geoffrey Fox, Jack Dongarra, Distributed and Cloud Computing, Elsevier, 2012.
2. Rajkumar Buyya, Christian Vecchiola, and Thamarai Selvi, Mastering Cloud Computing, TMH, 2013.
3. Dan C. Marinescu, Cloud Computing: Theory and Practice, Elsevier, 2013.
4. Barrie Sosinsky, Cloud Computing Bible, Wiley, 2011.

Internet of Things

Introduction to the Internet of Things (IoT), Technology and Business drivers for IoT, IoT Architectures and design considerations; IoT paradigms and frameworks; semantics, security, privacy, network and standardisation issues; IoT Integration with Cloud technologies, big data, cyber-physical systems, components, network technologies; IoT application and device programming; Data analytics for IoT; Typical IoT applications, Trends and implications; Challenges and Opportunities with IoT.

Suggested Readings:

1. Samuel Greengard, The Internet of Things, MIT Press, 2015
2. Robert Stackowiak , Art Licht , Venu Mantha , Louis Nagode, Big Data and The Internet of Things: Enterprise Information Architecture for A New Age, APress, 2015
3. Peter Waher, Learning Internet of Things, Packt Publishing, 2015
4. Dirk Slama, Frank Puhlmann, Jim Morrish , Enterprise IOT, O'Reilly Publishers, 2015
5. Adrian McEwen, Hakim Cassimally, Designing the Internet of Things, John Wiley and Sons, 2014
6. Vijay Madisetti and Arshdeep Bahga, "Internet of Things (A Hands-on-Approach)", VPT, 2014.
7. Francis daCosta, "Rethinking the Internet of Things: A Scalable Approach to Connecting Everything", 1st Edition, Apress Publications, 2013

Nature Inspired Algorithms

Introduction to metaheuritsics, fundamentals of Evolutionary Computation, Genetic Algorithms, Genetic Programming; Evolution Strategies, Components of Evolutionary Computation: Framework, Populations, Selection Operators, Genetic Operators; Introduction to swarm intelligence, Social Behavior as Optimization: Discrete and Continuous Optimization Problems, Swarm Intelligence Techniques: Particle Swarm Optimization, Ant Colony Optimization, Artificial Bees, cuckoo search algorithm etc., Bio-inspired algorithms, modeling and computation with cellular systems, artificial immune system. Introduction to physical algorithms, simulated annealing.

Suggested Readings:

1. De Jong, K.A., Evolutionary Computation – A Unified Approach, Prentice Hall of India, 2006

2. Eiben, A.E., Smith, J.E., Introduction to Evolutionary Computing, Springer-Verlag, 2003
3. Kennedy, J. and Eberhart, R.C., Swarm Intelligence, Morgan Kaufmann Publishers, 2001
4. Bonabeau, E., Dorigo, M. and Theraulaz, G., Swarm Intelligence: From Natural to Artifical Systems, Oxford University Press, 1999
5. Dorigo, M., Stutzle, T., Ant Colony Optimization, MIT Press, 2004
6. Clerc, M., Particle Swarm Optimization, ISTE, 2006
7. Yang, X.S., Nature Inspired Metaheuristic Algorithms, Luniver Press, 2010
8. de Castro, L. N., Timmis, J., Artificial Immune Systems: A New Computational Intelligence Approach, Springer, 2002

Social Network Analytics

Background: Review of graph theory, graph isomorphism, types of graph, connectivity, paths and cycles, trees, graph representation, spectral properties of graphs; Introduction: Real world complex networks – technological networks, information networks and social networks, topological properties of networks, network data sets; Social Networks: Strong and weak ties, strength and network structure in large scale data, homophily, tracking link formation in online data; Structure of the web: Hypertext and associative memory, web as a directed graph, link analysis and web search; Network effects: Information cascades, stability, instability and tipping points, power laws and rich – get richer phenomenon; Network dynamics: Modeling diffusion through a network small world phenomenon, epidemics; Case studies: Facebook, LinkedIn, Google Plus and Twitter

Suggested Readings

1. David Easley and Jon Kleinberg, “Networks, Crowds and Markets”, Cambridge University Press, 2010
2. Kayhan Erciyes, “Complex Networks : An Algorithmic Perspective”, CRC Press, 2015
3. Matthew A. Russell, “Mining the Social Web: Analyzing Data from Facebook, Twitter, LinkedIn and other social media sites”, O'Reilly Media, 2011, ISBN: 978-1-449-38834-8
4. Reza Zafarni, Mohammad Ali Abbasi,Huan Liu, “Social Media Minning”, Cambridge University Press, 2014

Machine Learning (Data Science Stream)

Overview of Machine Learning; Concept Learning and the General - to - Specific Ordering, Decision Tree Learning, Neural Networks, Evaluating Hypothesis, Bayesian Learning, Computational Learning Theory; Instance Based Learning, Genetic Algorithms, Learning Sets of Rules, Analytical Learning, Combining Inductive and Analytical Learning, Reinforcement Learning, Markov and Hidden Markov Model

Suggested Readings:

1. T. M. Mitchell, "Machine Learning", Mcgraw Hill, 1997
2. R. S. Mitchalski, J. G. Carhonell and T. M. Mitchell, "Machine Learning- An Artificial Intelligence Approach", Vol I - IV, Springer-Verlag, 1980
3. H. Adeli and S. L. Hung,"Machine Learning- Neural Networks, Genetic algorithms and Fuzzy Systems", John Wiley and Sons, 1995
4. T. Hastie, J. Friedman and R. Tibshirani, "Elements of Statistical Learning", Springer, 2000

Computational Finance (Data Science Stream)

Basic Functional Mathematics- Time Value of Money, Annuities, Yields, Bonds, Bond Price Volatility, Term Structure of Interest rates; Option Basics, Exchange Traded Options, Arbitrage in Option Pricing, Relative Option Prices, Put-Call Parity and its Consequences; Option Pricing Models- Binomial Option Pricing Model, Black- Scholes Formula; Forwards, Futures, Future Options, Forward Contracts; Continuous Time Functional Mathematics- Stochastic Integrals, Black- Scholes Differential Equation, Hedging and Futures, Hedging and Options.

Suggested Readings:

1. Y. D. Lyuu,"Financial Engineering and Computation", Cambridge university, 2002
2. S. M. Ross,"An elementary introduction to mathematical finance", 2nd Edition Cambridge University
3. S. N. Neftci, "Principles of Financial Engineering, Elseveir, 2004
4. P. Wilmont, S. Howison and J. Dewynne, "The Mathematics of Financial Derivatives", Cambridge University, 1995
5. J. Stampfli and V. Goodman, "The Mathematics of Finance: Modeling and Simulation", Thompson, 2001
6. M. J. Miranda and P. L. Fackler, "Applied Computational Economics and Finance", The MIT Press / Pearson Education, 2002
7. R. Bhart and S. Hamori, "Hidden markov models: Application to financial economy", Kluwer, 2004

Bioinformatics (Data Science Stream)

Review of Basic Biology (includes Biomolecules, DNA, Protein, Structure of Amino acids), Basic Concepts of Molecular Biology, Sequence Comparison: Comparing Two Sequences, Global Pair wise Sequence Alignment, Multiple Sequence Alignment, Database Search: PAM Matrices, BLAST, FAST, Markov Chain, Hidden Markov Models, Pair wise Alignment, Likelihood and Scoring a Model; Phylogenetic Trees, Probabilistic Approaches, Algorithms for Distance Matrices, Transformational Grammars, RNA Structure Analysis, RNA Secondary Structure Predictions, System Biology Concepts, Computational Models of Regularity Networks, The Search for General Principles

Suggested Readings:

1. W. J. Ewens and G. R. Grant, "Statistical Methods in Bio-Informatics- An Introduction", Springerm, 2004
2. J. Setubal and J. Meidaris, “Introduction to Computational Molecular Biology", Thomson, 2003
3. R. Durbin, S. Eddy, A. Krogh and G. Mitchison, “Biological Sequence Analysis: Probabilistic Models of Proteins and Nueclic Acids”Cambridge University Press, 1998
4. P. Clote and R. Backofen, “Computational Molecular Biology", John Wiley, 2002
5. T. Jiang, Y. Xu and M. Q. Zhang,”Current Topics in Computational Molecular Biology", MIT, 2002
6. J. K. Percus, “Mathematics of Genome Analysis", Cambridge University Press, 2002
7. R. Durrett, “Probability Models for DNA Sequence Evolution", Springer, 2002

Data Mining & Pattern Recognition (Data Science Stream)

Statistical Pattern Recognition: Introduction to Statistical Pattern Recognition, The Gaussian Case and Class Dependence, Discriminant Functions, Classifier Performance, Risk, and Errors, Supervised Learning Using Parametric and Nonparametric Approaches: Parametric Estimation and Supervised Learning, Maximum Likelihood Estimation, Bayesian Parameter Estimation Approach, Parzen Windows, Linear Discriminant Functions: Linear Discriminant Functions and Decision Surfaces, Generalized Linear Discriminant Functions, Linearly Separable Case, Minimizing the Perceptron Criterion Function, Relaxation Procedures, Minimum Square Error Procedures, Linear Programming Algorithms, Support Vector Machines, Unsupervised Learning and Clustering: Formulation of Unsupervised Learning Problems, Hierarchical Clustering, Partitional Clustering, Density Based Clustering, Learning Vector Quantization, Syntactic Pattern Recognition: Quantifying Structure in Pattern Description and Recognition, Grammar Based Approach and Applications, Elements of Formal Grammar, Recognition of Syntactic Descriptions, Parsing, Graph Based Structural Representations, Neural Pattern Recognition: Neural Network Structures for Pattern
Recognition Applications, Single Layer Perceptron, Multilayer Back propogation Algorithm, Radial Basis Function Network, Hopfield Nets, Kohonen Network

Suggested Readings:

1. R. Schalkoff, "Pattern Recognition Statistical, Structural and Neural Approaches", R. Wiley, 2007
2. R. O. Duda, P. E. Hart and D. G. Stork, “Pattern Classification", 2nd Edition, Wiley
3. E. Gose, R. Johnsonbaugh and S. Jost, "Pattern Recognition and Image Analysis", Prentice Hall, 1996
4. B. D. Ripley and N. L. Hjort, "Pattern Recognition and Neural Networks", Cambridge University Press, 1995

5. C. H. Chen and P. S. Pwang, "Pattern Recognition and Computer Vision", World Scientific, 2005
6. S. Theodoridis and K. Koutroumbas, "Pattern Recognition", 2nd Edition, Academic Press
7. J. Han and M. Kamber, “Data Mining: Concepts and Techniques", Morgan Kaufmann, 2001
8. I. H. Witten and E. Frank, “Data Mining: Practical Machine Learning Tools and Techniques with Java Implementations”Morgan Kaufmann, 1999

Econometrics (Data Science Stream)

Pre-requisite: Probability Theory and Statistical Inference (Multivariate), Linear Algebra, Quadratic Forms, Definite Matrices and Classical Regression Models); Data problems in the classical regression Model – Missing observations, Multicollinearity, Measurment Error and Proxy Variables, Regression Diagnostics and Influential Data Points; Nonlinear Regression Models - Loglinear, Logistic and others. Nonlinear Least Squares. Maximum Likelihood Estimation. Asymptotic distribution theory. Parametric Transormations of the Dependent variable - Box-Cox Transformations; Models with Heteroscedasticity and General covariance matrix of error terms with non-zero off diagonal terms- Tests, Estimation and Inference with Generalised Least Squares; Autocorrelated Disturbances: ARIMA, ARCH and GARCH Models; Longitudinal Data and Panel Data Models, Regressions with lagged variables, Logit and Probit Models, Simultaneous Equation Models ; Identification Problem, Estimation Methods - 2SLS, 3SLS, LIML and FIML methods. Forecasting., Structural Equation Models with Latent variables. Censored Regression Models; Bayesian Model Averaging, Flexible Models, Nonparametric and Semi- Parametric Methods

Suggested Readings:

1. W. Greene, “Econometric Analysis", 4th Edition, Prentice Hall, 2000
2. R. S. Pindyck and D. L. Rubinfeld, "Econometric Models and Economic Forecasts", 4th Edition, McGraw-Hill, 1998
3. J. H. Dorfman, "Bayesian Economics through numerical methods", Springer, 1997
4. G. Koop, “Bayesian Econometrics", Wiley, 2003
5. R. Marimon and A. Scott, “Computational methods for the study of dynamic economics", Oxford University Press, 1999
6. K. A. Lawler and A. V. Katos, "Econometrics- A practical approach", Routledge, 2000

Spatial Data Analysis and GIS (Data Science Stream)

Introduction review of non-spatial statistics, overview of different types of spatial data
Geostatistics: Variograms and covariance functions, fitting variogram functions, kriging, spatial regression
Areal data: Neighborhoods, testing for spatial association, Global and local tests of association, CAR and SAR models, inference, phenomena mapping

Point process data: types of spatial pattern, spatial clustering
GIS conceptual framework, Database, Visualization, Modelling and Analysis
Special topics: Non-stationary Covariance, Bayesian methods, Spatio-temporal modelling, Current Topics

Suggested Readings:

1. O. Schabenberger and C.A. Gotway, "Statistical Methods for Spatial Data Analysis", CRC, 2005
2. T. C. Bailey and A. Gatrell, "Interactive Data Analysis", Longman, 1995
3. S. Fotheringham, A. Stewart, C. Brunsdon and C. Martin, "Quantitative Geography: Perspectives on Spatial Data Analysis", SAGE publication, 2000
4. N. Cressie, "Statistics for Spatial Data", Revised Edition, John Wiley, 1993
5. Manfred M. Fischer and Arthur Getis, "Handbook for Applied Spatial Statistics: Software Tools and Methods, Springer, 2010
6. Alan E. Gelfand, Peter Diggle, Peter Guttorp, and Montserrat Fuentes "Handbook of Spatial Statistics", CRC Press, 2010

Data Visualization Techniques (Data Science Stream)

Interactive and Dynamic Graphics: Scatter Plots; Brushing and Linked Brushing; Focussing, Zooming; Rotations and Projections; Parallel Coordinate Plots, Andrews Plots; Density Plots; Catagorical Data; Virtual Reality, Interactive 3D Graphics, 3d Representation of Statistical Data; Exploratory Spatial Data Analysis, Application of Interactive and Dynamic Graphics. Applications from Geography, Medicine and Environmental Sciences, Interactive Micromaps, Choropleth maps; Graphical Software; Limitations of Graphics

Suggested Readings:

1. W. S. Cleveland and M. E. McGill, "Dynamic Graphics for Statistics", Woodsworth, 1998
2. J. Blasius and M. Greenacre M, "Visualization of Categorical Data",1998
3. A. P. Buja and P. A. Tukey, Computing and Graphics in Statistics, Springer, 1991
4. J. Symanzik, "Interactive and Dynamic Graphics in Handbook of Computational Statistics (ed) J.E. Gentle, W. Havdle, Y. Mori", Springer, 2004
5. E. R. Tufte, "The Visual Display of Quantitative Information", The Graphics Press, 2001

Big Data Analytics (Data Science Stream)

Introduction to Data Mining, Data Analytics, Predictive Analysis and Business Intelligence, Large Scale File System, Mining Big Data, Advanced Data Analytics and Machine Learning, Big Data Streams and Real Time Predictive Analysis, Tools and Visualization, Link Analysis, Web Analytics, Collaborative Filtering, Social Network Analysis, Issues, Challenges and Opportunities with Big Data and its Analytics

Suggested Readings:

1. Rajaraman, A., Ullman, J. D., Mining of Massive Datasets, Cambridge University Press, United Kingdom, 2012
2. Barlow, M., Real-Time Big Data Analytics: Emerging Architecture, O Reilly, 2013
3. Baesens, B., Analytics in a Big Data World, Wiley, 2016
4. Bell, J., Machine Learning for Big Data, Wiley, 2016

Data Stream Management (Data Science Stream)

Introduction to data streams, overview of streaming applications, architecture of Data Stream Management Systems, issues in data stream management, data models and query semantics for streams, streaming operators and languages, query processing and optimization, algorithmic issues, resource management, multiple and distributed streams, mining and analysis of data streams, streaming applications and systems, security and privacy, stream reduction, data stream management in mobile environments

Suggested Readings:

1. Charu C. Aggarwal, "Data Streams: Models and Algorithms", Springer Verlag, 2007.
2. Joao Gama, "Knowledge Discovery from Data Streams", CRC Press, Taylor and Francis Group, 2010
3. Minos Garofalakis, Johannes Gehrke, Rajeev Rastogi, "Data Stream Management: Processing High-speed Data Streams", Springer Verlag, 2007.
4. Sharma Chakravarthy, Qing Chun Jiang, "Stream Data Processing: Issues and Solutions", Springer Verlag, 2007.
5. Chaudhry Nauman, Shaw Kevin, Abdelguerfi Mahdi, "Stream Data Management", Kluwer Academic Publishers, 2005.

Multimedia and Video Analytics (Data Science Stream)

Introduction to multimedia systems. Multimedia compression including fundamentals of compression, text compression, image compression, audio and speech compression, video compression. Multimedia information storage and retrieval including text. Audio, image and video storage and retrieval methods multimedia programming multimedia security. Usability of multimedia.

Basics of image processing, computer vision and machine learning (assuming background in these areas). Video content analysis including: moving object detection and tracking algorithms. Image/video features for human activity detection and recognition in images and video image/video event classification and recognition objects in video counting approaches. Anomaly detection in images and videos multi-camera video analysis. Analyzing videos for video analytics applications such as retail analytics, healthcare, traffic analytics.

Suggested Readings:

1. Richard Szeliski, Computer Vision: Algorithms and Applications, 2010
2. Forsyth & Ponce, Computer Vision: A Modern Approach, Pearson, 2002
3. Rafael C. Gonzalez, Richard Eugene Woods, Digital Image Processing Pearson Education India, 2009.
4. Li , Ze - Nian, Fundamentals of Multimedia, ISBN: 0130618721, Prentice-Hall, 2004.
5. Ramesh Yerraballi, Multimedia Systems Concepts Standards and Practice, PHI, 2004.

Web Mining (Data Science Stream)

Data Mining Foundations : Basic concepts in data Mining, Web mining versus Data mining, Discovering knowledge from Hypertext data; An overview of web mining : What is Web mining, Web mining taxonomy, Web mining subtasks, issues, challenges; Web Search and Information Retrieval : Information Retrieval Models, Web Search and IR, Text Mining, , Latent Semantic Indexing, Web Spamming, Clustering and Classification of Web Pages, Information Extraction , Web Content Mining; Web Structure mining: Web as social network , Graph based analysis of web structure, link based ranking of web pages : Page rank and HIT, Short comings of coarse grained models, Enhanced models and techniques; Web usage mining : An introduction to web usage mining, Steps in web usage mining, Web usage mining process, Applications of Web usage mining, Clustering of web pages based on usage; Future of Web mining : Information Extraction, Web mining and Natural Language Processing, Ontology and Semantic Web

Suggested Readings:

1.Bing Liu, Web Data Mining, Springer Publication
2.Somen Chakrabarti, Web mining, Elsevier Publication
3.Grossman, Information Retrieval : Algorithm and Heuristics, Springer
4.Witton Frank, Data Mining , Morgan Kauffan Publishers

Probabilistic Graphical Models (Data Science Stream)

Introduction, Probability Theory, Bayesian Networks, Undirected Graphical Models, Local Probabilistic Models, Template-Based Representations, Gaussian Network Models, The Exponential Family, Exact Inference, Inference as Optimization, Particle-Based Approximate Inference, MAP Inference, Inference in Hybrid Networks, Inference in Temporal Models, Learning Graphical Models, Parameter Estimation, Structure Learning in Bayesian Networks, Partially Observed Data, Learning Undirected Models, Causality, Utilities and Decisions, Structured Decision Problems

Suggested Readings:

1. Daphne Koller and Nir Friedman, “Probabilistic Graphical Models: Principles and Techniques”, MIT Press.
2. Adnan Darwiche, “Modeling and Reasoning with Bayesian networks”.
3. Kevin P. Murp Mhy, “Machine Learning: a Probabilistic Perspective”.
4. David J. C. Mackay, “Information Theory, Inference, and Learning Algorithms”

5. Martin J. Wainwright and Michael I. Jordan, “Graphical models, exponential families, and variational inference”.

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Probabilistic Risk Assessment (Data Science Stream)

Concept of risk, objective and scope of risk assessment, probabilistic risk, risk perception and acceptability, Quantitative aspects of risk. Three levels of risk quantification, PRA management, preliminary hazard analysis, HAZOP and HAZAN, FMEA and FMECA analysis, Fault tree Analysis. Digraph and other approaches. Computation of Hazard probability, unavailability and other parameters using fault tree methodology. Monte Carlo Simulation technique, Event tree analysis, identification of initiating events, sequence and scenario development, system analysis, external events and dependent failures and quantification, Accident-consequence Analysis, uncertainty analysis, sensitivity analysis and importance measures, Bayesian approaches. Human Reliability analysis.

Suggested Readings:

1. Mohammad Modarres, “Probabilistic Risk Assessment”, Springer
2. Ernest J. Henley and Hiromitsu Kumamoto, Probabilistic Risk Assessment: Reliability Engineering, Design, and Analysis (Henley, Ernest J. Reliability Engineering and Risk Assessment, IEEE Press.
3. M. Stewart and Robert E. Melchers, Probabilistic Risk Assessment of Engineering Systems (Systems Effectiveness), Springer
4. Tim Bedford, Probabilistic Risk Analysis - Foundations and Methods, Cambridge University Press

Data Security (Data Science Stream)

Introduction and Objectives, Cryptographic Techniques, Threats, Vulnerabilities, Protection, Access Control, Data Security: Disk Encryption, Mechanisms in Data Security, Authentication, Backup Solutions, Data Masking, Data Erasure, Internal Laws and Standards, Data Breach, Data Theft, Privacy-Preserving Data Mining, information flow control, Wireless Identity Theft.

Suggested Readings:

1. Stinson D., Cryptography, Theory and practice, CRC Press, Boca Raton.
2. Dorothy Elizabeth Robling Denning, Cryptography and Data Security, publisher Addison-Wesley, 1982
3. Brent Mullins, Data Security Complete Certification Kit, Publisher Emereo Publishing company, May 2016
4. Stallings, William, Computer Security: Principles and Practices, Pearson Education Limited, 2015.

Smart Camera & Visual Sensor Networks (Data Science Stream)

Basics of image sensors and processing, computer vision and visual sensor networks, Calibration of smart camera networks, Camera network tracking and re-identification, Visual analytics in a smart camera network, Data association in visual sensor network, Distributed camera networks, Collaborative sensing and analysis in visual sensor networks.

Suggested Readings:

1. Richard Szeliski, Computer Vision: Algorithms and Applications , 2010, Springer,
2.Forsyth & Ponce, Computer Vision: A Modern Approach, Pearson, 2002
3. Rafael C. Gonzalez, Richard Eugene Woods, Digital Image Processing Pearson Education India,2009
4. B. Bhanu, C. Ravishankar, A. Roy-Chowdhury, H., Distributed Video Sensor Networks

Statistical Signal Processing (Data Communication Stream)

Discrete-Time Processing, Random Variables, Stochastic Signals, Estimation Theory, Signal Models, Autocorrelation, Spectral Estimation, Joint Signal Analysis, Coherence Analysis, Time-Frequency Analysis, Linear Estimation, Optimum FIR Filters, Linear Prediction, Optimum IIR Filters, Optimum Linear Filter Applications, State Space Models, Kalman Filter, Extended Kalman Filter, Least-Squares Estimation, Practical Modeling, Autoregressive Models.

Suggested Readings:

1. Robert M. Gray and Lee D. Davisson, An Introduction to Statistical Signal Processing, 2004 ,Cambridge University Press.
2. Mandyam D. Srinath, P.K. Rajasekaran, R. Viswanathan, Introduction to Statistical Signal Processing with Applications, Prentice Hall, 1995

Wireless Sensor Networks (Data Communication Stream)

Background of sensor network technologies and its applications, Keys definitions of sensor networks, Sensor Node, sensor taxonomy, sensor networks operation environments.Deployment methods: deterministic and random sensor deployment, Localization, Coverage and connectivity. MAC Protocols: Classification of MAC Protocols, S-MAC,T-MAC,B-MAC and Zig Bee, Disseminationprotocol, routing protocols: Issues in designing routing protocols, Classification of routing protocols, Hierarchical routing, position-based routing, Energy-efficientrouting, Unicast, Broadcast and multicast, Geographic routing, Data centric and content based routing, Data fusion technique, Load/energy balancing and lifetime maximization algorithms and simulation. Simulationusing ns-2, Qualnet and MATLAB.

Suggested Readings:

1. Feng Zhao, Leonidas Guibas, “Wireless Sensor Network”,Elsevier,

2. Kazem, Sohraby, Daniel Minoli, TaiebZanti, "Wireless Sensor Network: Technology, Protocols and Application", John Wiley and Sons.
3. B. Krishnamachari, "Networking Wireless Sensors", Cambridge University Press.
4. Carlos d. M and D P Agrawal, "Ad Hoc and Sensor networks: Theory and Applications", Worldscientific.

Multimedia Communications (Data Communication Stream)

Introduction to Multimedia, Fundamental Concepts of Multimedia Data types : Image, Audio, Video and Animation; Compression Technology, Multimedia Communication and delivery, Content management and retrieval, Distributed multimedia Systems.

Suggested Readings:

1. Ze-Nian Li and M. S. Drew, Fundamentals of Multimedia, Pearson Education, 2004.
2. K. R. Rao, Z. S. Bojkovic and Dragorad A. Milovanovi, Multimedia Communication Systems: Techniques, Standards, and Networks, Prentice Hall

Parallel and Distributed Systems (Data Communication Stream)

Parallel processing concept, Parallelism in conventional machine, Pipelining, Flynn's classification, Feng's classification, Array processor, Amdahl's law, Minsky's conjecture.Static and dynamic networks, Single stage and multistage interconnection network, Blocking and nonblocking network, Star, Ring, Mesh, Torus, Pyramid etc. topology, Elementary permutations used in Interconnection network, Crossbar, Clos, Benes network, Shuffle exchange, Hypercube, PM21 network.Simple addition on various network topologies, Recurrence computation, Matrix multiplication, Sorting networks0-1 Principle, Bitonic sorter, Merger, SorterPRAM Model, EREW, ERCW, CREW, CRCW algorithms. Distributed computation, characteristics of distributed systems, overview of related networking, operating systems and programming language concepts. Interprocess communication, message passing communication, remote procedure call (RPC), atomic transactions. Distributed coordination, physical and logical clocks, synchronization, mutual exclusion, leader election

Suggested Readings:

1. Kai Hwang , Advanced Computer Architecture, TMH, 2011
2. M.R. Bhujade, Parallel Computing, New Age International Publications, 2011
3. Andrew S. Tanenbaum Tanenbaum, Distributed System, Pearson Education, 2002
4. Nancy A. Bynch, Distributed Algorithms, Morgan Kaufmann, 1996.

Wireless Communication and Mobile Computing (Data Communication Stream)

Mobile radio systems-, Paging systems, cordless telephone system, cellular telephone system, Cellular Concept: Frequency reuse, channel assignment, hand off, Interference and cell splitting, sectoring, Improving Coverage and capacity in Cellular systems. Propagation modeling: Outdoor/Indoor Propagation models, Small scale Multipath

propagation- Rayleigh fading, Ricean Fading, Nakagami fading, Shadowing, lognormal shadowing fading model, outage probability, coverage estimation under shadowing, and multipath fading. Wireless Networks 802.11, frequency-hopping, encoding and modulation, MAC Layer Protocol Architecture Multiple access with collision avoidance protocol, Virtual Carrier-Sensing, DCF Protocol, PCF Operation. Mobility: challenges, limits and connectivity, mobile TCP, mobile IP and cellular IP in mobile computing.

Suggested Readings:

1. Rappaport, "Wireless communications : principal and practice", Pearson ed.
2. Matthews. Gast, 802.11 wireless networks, o'reilly
3. Andrea Goldsmith ,Wireless communication , cambridge university press ed .
4. Jochen Schiller, Mobile communications, phi/person edu., 2nd ed.

Game Theory and Mechanism Design (Data Communication Stream)

Introduction: What is Game Theory good for? Experimental regularity and Behavioral Game Theory. Basic Game Theory. Experimental design. Science of strategic interaction.
Non-cooperative Game Theory: Strategic forms of games, preferences, utilities, rationality, Intelligence, classification of games, dominant strategy equilibria, pure strategy Nash equilibria, existence of Nash equilibrium, Bayesian games.
Learning: Theories of learning, reinforcement learning, belief learning, Bayesian learning.
Introduction to mechanism design: Social choice functions, compatibility and revelation theorem, Vickery-Clarke-Groves (VCG) mechanisms, and individual rationality.
Auctions: Types and desirable properties, combinatorial auctions, optimal mechanisms, and Myerson auction.
Cooperative Game theory: Two person bargaining problem, the Shapley value.

Suggested Readings:

1. Y Narahari, Game Theory and Mechanism Design, IISc Lecture Notes Series, Vol.4
2. M. J. Osborne, An Introduction to Game Theory, MIT Press, 2003.
3. Colin Camerer, Behavioral Game Theory, Princeton University Press, 2010.

Vehicular Communication Networks (Data Communication Stream)

Vehicular Network- Definition, Architecture, Characteristics and Evolution; MAC layer Protocols – IEEE 802.11p, DSRC; Vehicular Mobility models – Flow models Traffic models behavioral models, Trace and survey based models; Routing Protocols – Position based, geocasting, other routing protocols; Traffic Engineering – Traffic Monitoring, Traffic flow models; Vehicular Safety Applications, Localization.

Suggested Readings:

1. Hassnaa Muoustafa and Yan Zhang (edited), "Vehicular Networks Techniques, Standards and Applications", CRC Press, 2009

2. Hannes Hartenstein and Kenneth P. Laberteaux (edited), "VANET Vehicular Applications and Inter-Networking Technologies", Wiley, 2010
3. Stephan Olariu and Michele C. Weigle (edited), Vehicular Networks from Theory to Practice, CRC Press, 2009.

Ad Hoc Networks (Data Communication Stream)

Fundamentals of Wireless Communication Technology – Radio Propagation Mechanisms, Multiple Access Techniques, Characteristics of wireless Channel. Ad Hoc Networks – Definition, Application, challenges, Traffic profile, and challenges, Media Access protocols Topology-based routing; Position-based routing, Mobility and location Management, Transport Protocols, Energy Conservation Issues QoS, Security issue, Simulation of protocols.

Suggested Readings:

1.C. Siva Ram Murthy and B.S. Manoj, Ad Hoc Wireless Networks – Architecture and Protocols, Pearson Education, 2004 (Low price edition)
2.C.K. Toh, Ad hoc Mobile Wireless Networks – Protocols and Systems, Prentice Hall, 2002
3.Ivan Stojmenovic (ed), Handbook of Wireless Networks and Mobile Computing, John Wiley, 2002

Data Compression (Data Communication Stream)

Compression Techniques, Lossless Compression,Lossy Compression, Mathematical Preliminaries for Lossless Compression, Huffman Coding, Arithmetic Coding, Dictionary Techniques, The Shannon–Fano and Huffman coding techniques, The JPEG compression algorithm, Fractal compression techniques, Mathematical Preliminaries for Lossy Coding, Scalar, Vector, Quantization, Differential Encoding, video compression.

Suggested Readings:

1. Khalid Sayood, Introduction to Data Compression, Morgan Kaufmann Publishers, 3ed, 2006
2. Wade, Graham, "Signal coding and processing", 2nd edition. Cambridge University Press, 1994

Network Simulation (Data Communication Stream)

Tools for computer network simulation. Simulation of queuing models in communication networks. Simulation of functions and performance of protocols and data traffic on the data link, network, transport, and application levels in data communications.Evaluation and improvement of models in network and data communications.

Suggested Readings:

1. Knuth, D.E. The art of computer programming: seminumerical algorithms (Vol. 2). 3rd ed. Reading, Mass.: Addison-Wesley, 1998.
2. Ross, S.M. Simulation. 4th ed. San Diego: Academic Press, 2006.

Network Security (Data Communication Stream)

Introduction, Security goals, attacks, services and mechanisms, cryptography and steganography, Symmetric Key cipher-substitution ciphers, Transposition ciphers, stream and block ciphers, Modern block ciphers, Modern stream ciphers, DES and AES, Elliptic curve cryptosystems, RSA, Message integrity, Digital signature, Public key distribution, IPSec, SET, ESP, PGP, SSL, Security in wireless.

Suggested Readings:

1. Stallings,Cryptography and Network Security: Theory and practice, JohnWiley, 2013.
2. Behrouz A. Forouzan, Cryptography and Network security, Tata Mcgraw Hill, 2010.
3. Bible Eric Cole, Ronald L.Krutz, Network security, Welley, 2009.
4. Stinson D., Cryptography, Theory and Practice, CRC Press, Boca Raton, FA, 2005.

Multicast Communication (Data Communication Stream)

Introduction, Application, Characteristics, Multicast Backbone Architecture, Multicast Routing, Basic Routing Algorithm, Group Dynamics, Multicast routing between domains, Ip multicast, Multicast in transport protocols, address allocation, Multicast LANs, Reliable Multicast, Congestion control, Security issues.

Suggested Readings:

1. Morgan Kaufmann, Ralph Wittmann, Martina Zitterbart,Multicast Communication: Protocols, Programming and Applications, Edition, 2000, Academic Press, USA.
2. Kennet Miller, Multicast Networking and Application,AW publication,2008.
3. David Makofske, Kevin Almeroth,Multicast sockets: Practical Guide for Programmers, Edition, 2003, Elsevier, USA.

Performance Modeling of Computer Communication Networks (Data Communication Stream)

Role of Modeling and Analysis, Examples of Performance Modeling, Analytic Models, Elements of Stochastic process, Poisson Process, Basic Queuing models, M/M/1; M/M/∞; M/G/ ∞; M/M/m; M/M/m/m Queues with Product formula. Cell and Burst scale Traffic Models: Round trip time distribution, PING data, Markov modulated Poisson Process, Long Range Dependence, Heavy Tail Distribution. Traffic Control: Admission Control, Effective Bandwidth, Statistical Multiplexing gain, Access Control: Leaky bucket System. Multi access Modelling: Slotted ALOHA Markov chain, Diffusion

Approximation Approach, CSMA, Congestion Control, Window Control, Modelling TCP, Window Size, TCP Window Dynamics.

Suggested Readings:

1. M. N. O. Sadiku, S. M. Musa, 2013, Performance Analysis of Computer Networks, Springer.
2. I. Kaj, 2002, Stochastic Modeling in Broadband Communications Systems, SIAM .
3. H. Kobayashi, B. L. Mark, 2009, System Modeling and Analysis, Foundations of System Performance Evaluation, Pearson Prentice Hall.
4. M.H. Balter, 2013, Performance Modeling and Design of Computer Systems, Cambridge Univ. Press.

Brain Theory and Neural Networks (Data Communication Stream)

Introducing the Neuron, Basic properties of Neurons, receptors and effectors, Neural models
Dynamics and adaptation: Neural networks, Dynamic systems, Self-organization and co-operativity, Learning in artificial neural networks, computability and complexity, Connectionism, Psychology, Linguistics, and Artificial Intelligence.

Biological neurons and networks, detection and classification of extracellular action-potential recordings, information theoretic analysis of neural data, identification of non-linear dynamics in neural population activity.

State-space modeling of neural spike train and behavioral data, neural decoding, statistical pattern recognition and machine learning in brain-computer interfaces.

Suggested Readings:

1.Theoretical Neuroscience: Computational and Mathematical Modeling of Neural Systems, P. Dayan and L. F. Abott, MIT Press, 2001.
2.Statistical Signal Processing for Neuroscience and Neurotechnology, Edited K. G. Oweiss, Elsevier 2010.
3.The handbook of Brain Theory and Neural Networks, Edited M.A. Arbib, MIT Press, 2006.
4.Dynamical Systems in Neuroscience: The Geometry of Excitability and Bursting, E. M. Izhikevich, MIT Press, 2010.