M.Tech. Programme in 'Mathematics & Computing'

School of Basic Science and School of Engg. & Tech, IIT Patna

1. Introduction to the programme:

This course is intended to fill an existing gap in industry and research institutions of a type of trained professionals who would be well trained in Mathematics and Computing both. It has been observed that professionals involved in work involving engineering and technology applications lack a strong background in Mathematics and those professional whose basic training is in Mathematics lack strong computing background skills. This course aspires to fill this gap and at the same time impart rigorous training in fundamental areas of Computer Sciences and Mathematics. There is high demand and need of professional with these skills and hence after completion of this course the candidate are expected to be placed in industry, r & d organization or they may even pursue higher studies.

2. Course structure and Syllabus

2.1 Name of the courses:

- **Core Courses**
  1. MA501: Probability, Statistics & Stochastic Processes (3-0-0-6)
  2. CS501: Database Systems and Data mining (3-0-0-6)
  3. MA502: Numerical Optimization (3-0-0-6)
  4. MA504: Computational Differential Equations (3-0-0-6)

- **Elective Courses (Elective I –III)**
  1. MA503: Discrete structures (3-0-0-6)
  2. CS505: Software Engineering (3-0-0-6)
  3. MA505: Number Theory and Cryptography (3-0-0-6)
  4. CS 507: Cyber Security (3-0-0-6)
  5. MA511: Large Scale Scientific Computation(3-0-0-6)
  6. MA509: Graph Theory (3-0-0-6)

- **Elective Courses (Elective IV –VI)**
  1. CS502: Pattern Recognition (3-0-0-6)
  2. CS504**:** Computer Networks and Distributed systems (3-0-0-6)
  3. MA508: Fuzzy Sets and Artificial intelligence (3-0-0-6)
  4. MA510: Advanced Multivariate Statistical Technique (3-0-0-6)
  5. MA512: Mathematical Modeling (3-0-0-6)
  6. MA514: Design of Experiments (3-0-0-6)

- **Lab Courses**
  1. MC501: Data Structures & Algorithms Lab (0-0-6-6)
  2. MC502: Simulation Lab (0-0-6-6)

2.2 Course Curriculum :

1ST SEMESTER

Sl. no.	Course Number	Course Title	L	T	P	C
1	MA501	Probability, Statistics & Stochastic Processes	3	0	0	6
2	CS501	Database Systems and Data mining	3	0	0	6
3		Elective-I	3	0	0	6
4		Elective-II	3	0	0	6
5		Elective - III	3	0	0	6
6	MC501	Data Structures & Algorithms Lab*	0	0	6	6
7	MC591	Seminar-I	0	0	4	4
		TOTAL	**15**	**0**	**10**	**40**

2ND SEMESTER

Sl. No	Course Number	Course Title	L	T	P	C
1	MA502	Numerical Optimization	3	0	0	6
2	MA504	Computational Differential Equations	3	0	0	6
3		Elective-IV	3	0	0	6
4		Elective-V	3	0	0	6
5		Elective - VI	3	0	0	6
6	MC502	Simulation Lab	0	0	6	6
7	MC592	Seminar-II	0	0	4	4

TOTAL	**15**	**0**	**10**	**40**

3RD SEMESTER

Sl. No	Course Number	Course Title	L	T	P	C
1	MA600	Comprehensive Viva				**10**
2	MA601	Project–Phase I				**40**
		TOTAL				**50**

4TH SEMESTER

Sl. No	Course Number	Course Title	L	T	P	C
1	MA602	Project–Phase II				**45**
		TOTAL				**45**

TOTAL CREDITS: 40+40+50+45 = 175

2.3 Detailed syllabus:

MA 501 : Probability, Statistics and Stochastic Processes

Probability : algebra of sets, monotone class, sigma fields, Borel sigma fields, set function, product spaces, measurable transformations, probability measure, notions of probability space and some consequences, Borel-Cantelli Lemma

Discrete, continuous and mixed type probability spaces, cumulative distribution functions, probability mass (density) functions, mathematical expectations, general concepts of conditional probability and expectation, conditional expectation given a sigma field, properties of conditional expectation, moments, moment and probability generating functions, moment inequalities: Markov, Chebyshev-Bienayme, Lyapunov.

Special Probability Distributions : Discrete and continuous uniform, binomial, beta, Cauchy, Negative Binomial, Hypergeometric, Gamma, Normal, Lognormal, Weibull, Pareto distributions, generalized distributions, Approximation properties of discrete distributions, Beta-Binomial and Poisson-Gamma relationship.

Function of a random variable, random vectors and their distributions, convolutions, Joint, marginal and conditional distributions, product moments, correlation, independence of random variables, bivariate distributions and properties, order statistics and their distributions, further properties.

Sampling Distributions: The Central Limit Theorem, Demoivre theorem, uniform convergence in CLT, characteristics functions, continuity theorems, strong law of large numbers, Sequence of random variables, modes of convergence and some results, Slutsky theorem, distributions of the sample mean and the sample variance for a normal population, Chi - Square, t and F distributions and their distributional properties

Point and Interval Estimation : The method of moments and the method of maximum likelihood estimation, large sample properties, concepts of unbiasedness, criteria for choosing estimators, consistency and efficiency of estimates, confidence intervals for the parameters of common distributions, pivotal quantities, confidence intervals for proportions (one and two samples problems) .

Testing of Hypotheses : simple and composite hypothesis, Null and alternative hypotheses, critical and acceptance regions, two types of error, level and size of test, error probabilities of a test, the most powerful test and Neyman - Pearson Fundamental Lemma, tests for one sample and two sample problems for normal populations, tests for one sample and two sample proportions, Likelihood ratio tests, Chi-sqaure test for goodness of fit.

Stochastic Processes: illustrations of stochastic processes, stochastic matrices, Markov chains: finite and countably infinite state spaces, Classification of states, strong markov property, stationary distributions, time reversible markov chains, Branching processes, ergodic and nonergodic markov chains, recurrent and transient random walk, General Markov processes in discrete and continuous state spaces. Poisson process: homogeneous and nonhomogeneous, pure birth process, birth and death process, regenerative processes, notions of queuing models

References:

(1) Rohatgi, V.K., and Saleh, A.K.Md. Ehsanes (2009). An introduction to probability and statistics. Second Edition, Wiley India.
(2) Introduction to the Theory of Statistics; Alexander M. Mood, Franklin A. Graybill, Duane C. Boes, Tata McGraw Hill.
(3) Milton, J.S. and Arnold, J.C. (2009) Introduction to Probability and Statistics, Fourth Edition, Tata Mcgraw-Hill.
(4) Ross, S.M.(2008) Introduction to Probability Models, Ninth edition, Academis Press.
(5) Statistical Inference (2007), G. Casella and R.L. Berger, Duxbury Advanced Series
(6) Ash, Robert B. (2009), Probability & Measure Theory, Academic Press

CS 501 Database Systems & Data Mining

Data models: entity-relationship, relational, network, hierarchical, and logic data models, with the emphasis on the relational model. Query languages: relational algebra, relational calculus, SQL, QBE. Theory of database design: functional dependencies; normal forms: 1NF, 2NF, 3NF, Boyce-Codd NF; decompositions; normalization; multivalued dependencies, join dependencies, 4NF, 5NF. Data storage and indexing: disks, files, file organizations, indexes; tree structured indexing (ISAM, B-trees), hash based indexing. Query processing: evaluation of relational operators, query optimization; transcation management, Concurrency control; error recovery; security. Case studies: ORACLE, Microsoft access

etc. Introduction to Open Database Connectivity, Client-Server environment etc.

Types of data mining problems. The process of data mining. Statistical evaluation of big data: statistical prediction, performance measures, pitfalls in data-mining evaluation. Data preparation: data models, data transformations, handling of missing data, time-dependent data, textual data. Data reduction: feature selection, principal components, smoothing data, case subsampling. Predictive modeling: mathematical models, linear models, neural nets, advanced statistical models, distance solutions, logic solutions, decision trees, decision rules, model combination. Solution analyses: graphical trend analyses, comparison of methods. Case studies. Future trends: text mining, visualization, distributed data. Practical sessions using open-source software.

Texts :

- R. Ramakrishnan and J. Gehrke, Database Management Systems, 3rd Ed, McGraw Hill, 2002.
- S. Weiss and N. Indurkhya, Predictive Data-Mining: A Practical Guide, Morgan Kaufmann, 1998.

References:

- A. Silberschatz, H. F. Korth and S. Sudarshan, Database System Concepts, 4th Ed, McGraw Hill, 2001.
- T. Connolly and C. Begg, Database Systems, 3rd Ed, Pearson Education, 2002.
- R. Elmasri, S. B. Navathe and R. Sunderraman, Fundamentals of Database Systems / Oracle 9i Programming, 4th Ed, Benjamin Cummings Publishing Company, 2004.
- H. Garcia-Molina, J. D. Ullman and J. D. Widom, Database Systems: The Complete Book, Prentice Hall, 2002.
- C. J. Date, An Introduction to Database Systems, 6th Ed, Addison Wesley, 1995.
- J. Melton, Understanding the New SQL: A Complete Guide, 2nd Ed, Morgan Kaufmann Publishers, 2000.
- 1. S. Weiss, N. Indurkhya, T. Zhang and F. Damerau, Text Mining: Predictive Methods for Analyzing Unstructured Information, Springer, 2004.

MA 502 : **Numerical Optimization**

Introduction to optimization problems, Convex sets and convex funcions, their properties, convex programming problems, Lagranges Multiplier mehtod, Optimality conditions for unconstrained minimization and constrained minimization problems, KKT conditions.

Unimodal functions, Fibonnacci search, Linesearch methods, Convergence of generic line search methods, Method of steepest descent, more general descent methods, Conjugate gradient methods, Fletcher Reeves methods for nonlinear functions, Interior point methods for inequality constrained optimization, Merit functions for constrained minimization, logarithmic barrier function for inequality constraints, A basic barrier-function algorithm, perturbed optimality conditions, A practical primal-dual method

Newton's method for first-order optimality, The Sequential Quadratic Programming iteration, Line search SQP methods, Trust-region SQP methods

Mulitobjective programming, Efficient solutions, Dominated cones, Formulation of Goal programming problems and solution methodologies for linear Goal programming problem.

Introduction to Evolutionary methods and global optimization.

Texts/References

1. J. Nocedal and S. Wright, Numerical Optimization, Springer Verlag 1999
2. P. Gill, W. Murray and M. Wright, Practical Optimization, Academic Press 1981
3. R. Fletcher, Practical Methods of Optimization, 2nd edition Wiley 1987, (republished in paperback 2000)
4. A. Conn, N. Gould and Ph. Toint, Trust-Region Methods, SIAM 2000

MA 504 Computational Differential equations

Introduction to Scientific Computing

Problem Classification, Linear Systems of ODEs with Constant Coefficients, Some Stability Concepts for ODEs, Stability for a Solution Trajectory of an ODE System, Stability for Critical Points of ODE Systems, Some ODE Models in Science and Engineering
Basic Principles of Numerical Approximation of ODEs, Numerical Solution of IVPs with Euler's Explicit and Implicit Method , Trapezoidal Method, Higher-Order Methods for the IVP, Runge-Kutta Methods, Linear Multistep Methods, Accuracy, Stability
Difference Methods for BVPs, Accuracy, Spurious Oscillations, Linear Two-Point BVPs, Nonlinear Two-Point BVPs, The Shooting Method, Ansatz Methods for BVPs.

Classical PDE Problems, Differential Operators Used for PDEs, Some PDEs in Science and Engineering, Initial and Boundary Conditions for PDEs, The Finite Difference Method, Discretization of a Problem with Different BCs, The Method of Lines for Parabolic PDEs, Generalizations of the Heat Equation, The Convection-Diffusion-Reaction PDE, The General Nonlinear Parabolic PDE, Ansatz Methods for the Model Equation, The Finite Difference Method, Discretization of a Problem with Different BCs, Introduction to Finite Element Method, The Finite Difference Method, Discretization of a Problem with Different BCs, Numerical Stability for Hyperbolic PDEs , Nature Laws, Constitutive Equations, Equations in Heat Transfer Problems, Equations in Mass Diffusion Problems, Equations in Mechanical Moment Diffusion Problems, Equations in Elastic Solid Mechanics Problems, Equations in Chemical Reaction Engineering Problems, Equations in Electrical Engineering Problems, Conservative Equations, Equations in Financial Engineering.

References/Text

- J.C. Butcher, Numerical methods for ordinary differential equations, John Wiley and Sons, 2008
- K. E. Atkinson, W. Han, D. Stewart, Numerical solution of ordinary differential equations, John Wiley and Sons, 2009
- D. F. Griffiths, D.J. Higham, Numerical Methods for Ordinary Differential Equations: Initial Value Problems, Springer, 2010
- Tveito, R. Winther, Introduction to partial differential equations: a computational approach, Springer, 2005
- R.M. M. Mattheij, S. W. Rienstra, J. H. M. ten Thije Boonkkamp, Partial differential equations: modeling, analysis, computation, SIAM, 2005

- G. D. Smith, Numerical solution of partial differential equations: finite difference methods, Oxford University Press, 1985
- J. A. Trangenstein, Numerical solution of hyperbolic partial differential equations, Cambridge University Press, 2009

MA 503. Discrete Structures

Mathematical Logics, Sets, Relations and Mappings: Statements, Logical connectives, Truth tables, Equivalence, Inference and deduction, Predicates, Quantifiers. Relations, Equivalence relations, Partial Order relations and lattices, Chains, Antichains, Dilworth's Theorem, Composition of mappings, one-one and onto mappings, Pigeonhole Principle, Counting techniques, Countable and Uncountable sets.

Semigroups and Monoids: Semigroups, Monoids, Subsemigroups/monoids, Congruence and quotient semigroups/monoids, Homomorphism, isomorphism and the basic isomorphism theorem.

Graph Theory: Basic concepts of graphs, directed graphs and trees, Adjacency and incidence matrices, Spanning trees, Matchings and Coverings, Hall's condition, Graph Coloring, Planar Graphs, Eulerian and Hamiltonian graphs.

Combinatorics: Permutation, Combination, Principle of inclusion and exclusion, Recurrence relations, Generating functions

Number Theory: Divisibility, Congruences, The Chinese Remainder Theorem, Some Diophantine Equations.

Boolean Algebra: Boolean algebra and their various identities, Homomorphisms and isomorphisms, Atoms and the Stone's theorem (finite case), Boolean functions, their simplification and their applications to combinational circuits.

References:

1. C.L. Liu, Elements of Discrete Mathematics, McGraw-Hill, 1985
2. D.B. West, Introduction to Graph Theory, 2nd ed., 2001, PHI Learning
3. P.J. Cameron, Combinatorics: Topics, Techniques, Algorithms, First Ed. 1994, Cambridge University Press
4. I. Niven, H.S. Zuckerman, H.L. Montgomery, An Introduction to the Theory of Numbers, 1991, John Wiley and sons.
5. P.R. Halmos, Naive Set Theory, UTM, Springer, 1974

CS505 Software Engineering

The software life cycle, nature and qualities of software, software engineering principles. Software project management: planning, scheduling, monitoring, control, risk management. Requirements specification: specification styles (informal, formal), operational and descriptive specifications. Software Design: function-oriented and object-oriented approaches; architectural, component-level and user-Interfaces design; structured programming and implementation. Verification: testing (strategies and techniques), formal methods, validation. Advanced topics: maintenance, product
metrics, Software engg tools

Texts:

- R. S. Pressman, Software Engineering: A Practioner's Approach, 5th Ed, McGraw-Hill, 2001.

References:

- I. Sommerville, Software Engineering, 7th Ed, Addison-Wesley, 2005.
- C. Ghezzi, M. Jazayeri and D. Mandrioli, Fundamentals of Software Engineering, 2nd Ed, Prentice Hall of India, 2003.

MA505 Number Theory & Cryptography

- Divisibility in integers, Division Algorithm in integers, Well ordering property in the set of positive integers, Greatest common divisor and least common multiple and algorithms to find them. Primes, Fundamental Theorem of Arithmetic, Euclid's theorem, Fermat and Mersenne primes, Infinitude of primes of certain types. Congruences, Euler's phi function, Euler-Fermat theorem, Wilson's theorem. Linear congruence equations, Chinese Remainder theorem, Multiplicativity and expression for $\varphi(n)$, Congruence equations of higher degree.
- Quadratic Residues, Legendre symbols, Gauss' lemma, Quadratic Reciprocity Law and applications, Jacobi symbol, Tests of primality. Multiplicative functions, Functions τ, σ, and μ and their multiplicativity, Moebius inversion formula and its converse, Diophantine equations: $ax + by = c$, $x^2 + y^2 = z^2$, $x^4 + y^4 = z^2$, Sums of squares, Waring's problem, Binary quadratic forms over integers. Farey sequences.
- Simple continued fractions, Infinite continued fractions and irrational numbers, Periodicity, Pell's equation. Distribution of primes, Function $\pi(x)$, Partition function, Ferrer's Graph, Formal power series, Euler's identity, Euler's formula for $\varphi(n)$.
- Review of finite fields, Divisibility and Euclidean algorithm, congruences, Gauss Algorithm for computing primitive elements, Primitive root theorem and algorithm to find primitive elements in case it exists. Power residues, Algorithm to determine irreducible polynomials of degree n over $\mathbf{Z}_p$. Higher power residues and reciprocity theorems, Algorithm to solve quadratic equations in $\mathbf{Z}_m$. Factorizations of polynomials over finite fields.
- Cryptosystems (definition illustrations and classical examples), the idea od public key cryptography, RSA Public Cryptosystems, RSA key generation and algorithm, the RSA conjecture, Attack on RSA crypto systems, El Gamal Public Key Cryptosystems and algorithm, Digital signature algorithm (DSA).
- Elliptic curves - basic facts, Elliptic curves over **R, C, Q,** finite fields, Group Law, Elliptic curve cryptosystems, analogue of El Gamal on elliptic curves, Primality testing and factorizations.
- **References:**

1. I. Niven and T. Zuckermann, An Introduction to the Theory of Numbers, Wiley Eastern.
2. G.H. Hardy and E.M. Wright, Theory of Numbers, Oxford University Press & E.L.B.S.
3. D.E. Burton, Elementary Number Theory, Tata McGraw-Hill.
4. S.G. Telang, M.Nadkarni & J.Dani, Number Theory, Tata McGraw-Hill.
5. Neal Koblitz, A Course in Number Theory and Cryptology, Graduate Texts in Mathematics, Springer, 1987.
6. M. Rosen and K. Ireland, A Classical Introduction to Number Theory, Graduate Texts in Mathematics, Springer, 1982.
7. D. Bressoud, Factorization and Primality Testing, Undergraduate Texts in Mathematics, Springer (1989).
8. W. Trappe and L. Washington, Introduction to Cryptography and coding theory, Pearson International Edition, 2006.
9. R. A. Mollin, An introduction to cryptography**,** 2nd edition, Chapman and Hall/CRC Edition, 2007.
10. A. J. Menezes et al., Handbook of Applied Cryptography, CRC Press, 1997.

CS507 Cyber Security

Overview, vulnerabilities, risk assessment, incidents. Cryptography: Classical Cryptography, Symmetric Cryptography, Public Key (Asymmetric cryptography), Modern Cryptography, Hash Functions, Key Exchange. Review: Installing Unix and common service daemons (Unix Security, Windows NT Security, Ping, traceroute, TCP Dump, sniffer etc.), Networking. Security issues: Terminology (Integrity, Availability, Confidentiality, Non-repudiation, Authentication, Authorization/Access Control, accounting, auditing, Passive and Active Attacker, Interruption, Interception, Modification, Fabrication, Social Engineering), Vulnerabilities and Counter Measures (Viruses, worms, Trojan horses, backdoors, unused services, buffer overflows, RPC), Exploits (Buffer overflow, Port Scanning etc). Applications Security (System Security, Audit Logs Intrusion Detection, Wrappers, Password and remote authorization tools e.g. PGP, S/MIME, SSH, Netscape/SSL, SET, IPsec, Kerberos, Firewalls, VPN etc, Secure (commerce) Transaction over a network, Network Anonymity.

Texts :

1. W. Stallings, Cryptography and Network Security: Principles and Practice, 3rd Ed, Prentice Hall, 2003.

References :

1. B. Schneier, Applied Cryptography, 2nd Ed, John Wiley & Sons, Inc., 1996.
2. A. Menezes, P. van Oorshot and S. Vanstone, Handbook of Applied Cryptogrphy, CRC Press, 1997.
3. C. Kauffman, R. Perham and M. Speciner, Network Security: Private Communication in a Public World, Prentice-Hall, 1994.
4. H. C. A. van Tilborg, Fundamentals of Cryptology, Kluwer Academic Publishers, 2000.
5. P. Garrett, Making and Breaking Codes: An Introduction to Cryptology, Prentice-Hall, 2001.
6. P. Wayner, Disappearing Cryptography, 2nd Ed, Morgan Kaufmann, 2002.
7. W. Cheswick, S. Bellovin and A. Rubin, Firewalls and Internet Security. Repelling the Wiley Hacker, 2nd Ed, Addison-Wesley, 2003.
8. Related publications in Journals/Conferences.

MA 511 : Large Scale Scientific Computation

Introduction to sparse matrices, Storage Schemes, Permutations and Reorderings, , Sparse Direct Solution Methods. Iterative methos and Preconditioning Convergence Krylov Subspaces, Arnoldi's Method, GMRES, Symmetric Lanczos Algorithm, Conjugate Gradient Algorithm, Convergence Analysis, Block Krylov Methods, Preconditioned Conjugate Gradient, Preconditioned GMRES, Jacobi, SOR, and SSOR Preconditioners, ILU Factorization Preconditioners, Block Preconditioners, Types of Partitionings, Techniques, Direct Solution and the Schur Complement, Schur Complement Approaches, Full Matrix Methods, Graph Partitioning: Geometric Approach, Spectral Techniques.

Newton's method and some of its variations, Newton method in several dimension, continuation methods, conjugate direction method and Davidon-Fletcher-Powell Algorithms, Introduction to Non-linear Multigrid with applications.

HPC kernels (BLAS, multicore and GPU computing)

Texts / References

- O. Axelsson, Iterative Solution Methods Cambridge Univ. Press, 1994.
- W. Hackbusch, Multigrid Methods and Applications. Springer-Verlag, 1985.

- J.M. Ortega and W.C. Rheinboldt, Iterative Solution of Nonlinear Equations in Several Variables. Academic Press, NY, 1970.
- C.W. Ueberrhuber, Numerical Computation : Methods, Software and Analysis. Springer-Verlag, Berlin, 1997.
- P. Wesseling, An Introduction to Multigrid Methods. John Wiley & Sons, 1992.
- Yousef Saad, Iterative Methods for Sparse Linear Systems, SIAM 2003.

MA 509 Graph Theory

Basic notions of Graph theory: Subgraphs, Factors, Paths, Cycles, Connectedness, Eulerian graph, Bipartite graph, Adjacency and Incidence matrices, Graph isomorphism, Bipartite graph and matrices, Diameter and eigenvalues,

Trees, Leaves, Forests, Counting labelled trees, Spanning subgraphs, Minimum spanning trees and algorithms of Kruskal, Prim and Boruvka, Colouring Graphs, Colouring Trees and Cycles, Polya Theory,

Flows, Complexity of Algorithms

The Marriage theorem, Weighted Bipartite matching, Matching in general graph, Connectivity, Planer graphs, Euler's formula, The five colour theorem, Edges and cycles, Edge colouring, Hamiltonian cycles, Regular graphs, Eigen values of regular graphs, Diameter of regular graphs, Ramanujan graphs.

References:

1. S.M. Cioaba, M. Ram Murty, A first Course in Graph Theory and Combinatorics, TRIM, Hindustan Book Agency, 2009.
2. J A Bondy and USR Murty : Graph Theory, GTM 244, Springer, 2008
3. D. Jungnickel, Graphs, Networks and Algorithms, Springer, 2005.
4. Reinhard Diestel, Graph Theory, Graduate Texts in Mathematics, Springer, 1997.
3. B. Bollobas, Graph theory an introductory course, GTM 63, Springer-Verlag, New york, 1979.
4. J.H. van Lint and R.M. Wilson, A course in combinatorics, Cambridge University press, 1992.

CS502 Pattern Recognition

Introduction to Pattern Recognition: Learning paradigms, Supervised and unsupervised learning; Bayesian decision theory: Minimum error rate classifier; Parameter estimation: Maximum likelihood and Bayesian Estimation; Hidden Markov models; Nonparametric techniques: Nearest neighbor rules, Parzen windows; Decision trees: Axis-parallel, Oblique, Impurity measures; Feature selection: Forward, backward search; Component analysis and discriminant functions: Principal component analysis, Fisher linear discriminant, Perceptron, Support vector machines; Generalization ability of learning methods: Bias and variance, Regularization; Bootstrapping, Boosting, Bagging; Unsupervised learning and clustering: k-Means methods.

Texts :

1. R. O. Duda, P. E. Hart and D. G. Stork, Pattern classification, John Wiley & Sons, 2002.

References :

1. C. M. Bishop, Neural Networks for Pattern Recognition, Oxford University Press, 1995.

2. V. N. Vapnik, The Nature of Statistical Learning Theory, Springer, 2000.
3. N. Cristianini and J. Shawe-Taylor, An Introduction to Support Vector Machines, Cambridge University Press, 2000.
4. Selected Research Papers.

CS504 Computer Networks & Distributed Systems

7 layer OSI/ISO model; evolution of computer networks. Data Link Layer: HDLC, PPP, sliding window protocols. Network Layer: IP, ICMP, X.25, Frame Relay, ATM, routing algorithms (EGP, RIP, OSPF etc.); Transport Layer: TCP, UDP, congestion control, flow control; Sockets interface, sockets programming; Application Layer: SNMP, Authentication, Encryption, electronic mail. WWW basics: http, html, CGI, Java, Firewalls.

Introduction to distributed computing models. Issues in distribution of data and control: Clock synchronization, agreement, deadlock detection, termination detection etc. Distributed file servers: Concurrency control and recovery, resiliency etc. Distributed programming environments: Communication primitives, selected case studies.

(Note: Some topics may be added/deleted to suit specific offerings of the course)

Texts:

- G. F. Coulouris, J. Dollimore and T. Kindberg, Distributed Systems: Concepts and Design, 4th Ed, Addison-Wesley, 2005.
- Tanenbaum A.S., Computer Networks, 3rd Edition, Prentice Hall of India, 1996.

References:

- S. Mullender (Ed), Distributed Systems, 2nd Ed, Addison-Wesley, 1994.
- M. Singhal and N. Shivratri, Advanced Concepts in Operating Systems, McGraw Hill, 1994.
- Selected research papers
- Stallings, W., Data and Computer Communications, 4/e, Prentice Hall of India,1996.
- Stevens, D.L. et al., TCP/IP Illustrated, Volumes I, II and III, Addison Wesley, 1996.

MA508 Fuzzy sets and Artificial Intelligence

Basic Concepts of Fuzzy Sets, Fuzzy Logic, Zadeh's Extension Principle, Operations on Fuzzy Sets, Fuzzy Measures, Probability and Possibility Measures, Fuzzy Inference Methodologies, Fuzzy Relations, Applications of Fuzzy Sets in Management, Decision Making, Medicine and Computer Science.

Introduction to Artificial Intelligence, Production System and Artificial Intelligence, Problem Solving by Search, Predicate Calculus, Knowledge Representation, Semantics Nets, Frames, Conceptual Dependencies, Knowledge Bases and Expert Systems, Fuzzy Rule, Neuro Fuzzy Approaches, Case Studies in Various Domain.

Texts:

- S. Russell and P. Norvig, Artificial Intelligence: A Modern Approach, 2nd Ed, Prentice Hall, 2003.
- H.J.Zimmermann, Fuzzy Set Theory and Its Applications, 2nd Ed., Kluwer Academic Publishers, 1996.
- D.Dubois and H. Prade, Fuzzy Sets and Systems: Theory and Applications, Academic Press, 1980.

References:

- E. Charniak and D. McDermott, Introduction to Artificial Intelligence, Addison-Wesley, 1985.
- E. Rich, Artificial Intelligence, McGraw-Hill, 1983.
- P. H. Winston, Artificial Intelligence, Addison Wesley, 1993.
- J.Yen and R.Langari, Fuzzy Logic Intelligence, Control, and Information, Pearson Education, 2005.
- T.J.Ross, Fuzzy Logic with Engineering Applications, McGraw-Hill, 1997.
- J.Kacprzyk, Multistage Fuzzy Control, Wiley, 1997.

MA510 Advanced Multivariate Statistical Techniques

Multiple linear regression, multicollinearity, outliers, heteroscedasticity, autocorrelation and model validation, polynomial regression and the method of orthogonal polynomials, nonlinear regression, multivariate regression model, testing and estimation, Ridge regression, multivariate analysis of variance and covariance, Test of linear hypothesis, likelihood ratio criteria, test of equality of means of several normal distributions, testing independence of a set of variates, factor analysis, extracting common factors, factor scores and estimation, cluster analysis, correlations and distances, methods of clustering: hierarchical clustering, nonhierarchical clustering, partitioning methods, overlapping clustering

References:

1. Johnson, R. A. and Wichern, D. W. (2002). Applied multivariate Statistical Analysis, PHI learning pvt ltd.
2. Anderson, T.W (2010), An introduction to Multivariate Statistical Analysis, Wiley- India
3. Srivastava, M. S. (2002), Methods of multivariate statistics, Wiley-Interscience
4. Jobson, D. B. (1991), Applied Multivariate Analysis, Vol 1, Springer
5. Neil, H. Tim (2002), Applied Multivariate Analysis, Springer
6. B. Everitt, Landau, S., Leese, M., Stahl D., (2011), Cluster Analysis, Wiley

MA512 Mathematical Modeling

Introduction to modeling; Elementary mathematical models and General modeling ideas; General utility of Mathematical models

Stability theory of system of differential equations; Linear and nonlinear stability; Lyapanov's second method; Basic idea of bifurcation; Illustrations with help of computer programming

Role of mathematics in problem solving; Concepts of mathematical modeling; System approach; formulation, Analyses of models; Pitfalls in modeling;

Illustrations models such as Population dynamics, Traffic Flow, Social interactions, Viral infections, Epidemics, Finance, Economics, etc. (The choice and nature of models selected may be changed with mutual interest of lecturer and students.)

Introduction to probabilistic models; Simulation approach.

Orthogonal projections, Singular Value Decomposition, Principal Component Analysis, Fourier and Wavelet Transformation and Applications, Kernel Methods

References:

1. D. N. P. Murthy, N. W. Page, Ervin Y. Rodin, Mathematical modelling: a tool for problem solving in engineering, physical, biological, and social sciences, Pergamon Press, 1990.
2. W.E. Boyce and R.C. DiPrima, Elementary Differential Equations and Boundary Value Problems, 7th Edition, Wiley, 2001.
3. J. D. Murray, Mathematical Biology Volume I,3rd Ed, 2003.
4. J.P. Pinasco and L. Romanelli, Coexistence of Languages is possible, Physica A 361, 355-360 (2006).

MA514 Design of Experiments

Basic design concepts, Selection of factors and levels, Different types of design, Simple comparative experiments, single factor experiments, Random effect model, Completely randomized design, Randomized block design, Incomplete block design, recovery of interblock information, Balanced incomplete block design and their (nonparmetric) analysis, symmetric BIBD, resolvable design, Partially balanced incomplete block designs, Latin square designs and their efficiency, Graeco-Latin square design, missing plot technique, Factorial designs - 2^k designs, confounding in factorial design, blocking in 2^k designs, fractional replications in 2^k designs, 3-level and mixed-level factorials and fractional factorials. Response surface designs and their analysis, central composite designs, hybrid and uniform cell design, Nested designs, staggered nested designs with factorial structure, split plot designs, blocking and efficiency

References:

(1) Montgomery, D. C. (2006), Design and Analysis of Experiments, Wiley

(2) Dean, A., and Voss, D. (1998), Design and Analysis of Experiments, Springer

(3) Cochran, W. G. and Cox, G. M. (1992), Experimental Designs, Wiley
(4) G. Casella (2008), Statistical Design, Springer

MC501: Data Structures & Algorithms Lab

Fundamental Data structures: linked lists, arrays, matrices, stacks, queues, binary trees, tree traversals. Algorithms for sorting and searching: linear search, binary search, insertion-sort, bubble-sort, quicksort. Priority Queues: lists, heaps. Graphs: representations, depth first search, breadth first search. Hashing: separate chaining, linear probing, quadratic probing. Search Trees: binary search trees, red-black trees, AVL trees, splay trees, B-trees. The disjoint set union problem; String matching; Strings: suffix arrays, tries; Randomized data structures: skip lists; A selection of advanced topics.

Experiments would be designed to provide hands-on experience in programming data structures and algorithms, to learn a few systems programming tools, and scripting.

References :

1. T H Cormen, C E Leiserson, R L Rivest and C Stein, Introduction to Algorithms, MIT Press, 2001.
2. Jon Kleinberg and Eva Tardos, Algorithm Design, Addison Wesley, 2005.
3. M. A. Weiss, Data Structures and Algorithm Analysis in C++, Addison-Wesley, 2007.

MC502 : Simulation Lab

Random number and generators, Testing of random number generators and analysis, Empirical tests, Theoretical tests

Algorithms for generation of random variables: Inverse transform method, convolution methods, Acceptance-Rejection method, Ratio of uniforms method

Generation of continuous random variates: Uniform, generalized (Exponential), Gamma, Inverse Gamma, Weibull, Gaussian, Lognormal, Pareto, Inverse Gaussian, Half logistics, Pearson Type, Multivariate distributions, Empirical distributions

Generation of discrete random variates: Discrete uniform, Binomial, Geometric, Negative Binomial, Poisson

Analysis of generated data: Estimation of different measures: mean, variance, quantiles, Variance reduction techniques, conditioning, importance sampling

References:

(1) Ross, S. M. (2011), Simulation, Academic Press

(2) Law, A. M. (2008), Simulation Modelling and Analysis, Tata McGraw Hill

(3) Givens, G. H. and Hoeting, J. A. (2005), Computational Statistics, Wiley