National Institute of Technology Silchar

Department of Computer Science & Engineering

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M.Tech. – Computer Science and Engineering
Course Structure and Syllabus

Semester 1						Semester 2					
Course Code	Course Name	L	T	P	C	Course Code	Course Name	L	T	P	C
CS5101	Foundations of Computing Science	3	0	0	3	CS5106	Advanced Database Management System	3	0	0	3
CS5102	Advanced Algorithms & Data Structure	3	0	0	3	CS5107	High Performance Computing	3	0	0	3
CS5103	Linear Optimization	3	0	0	3	CS5108	Internet Protocol	3	0	2	4
CS5104	Computer Systems Lab-I	0	0	3	2	CS5109	Artificial Intelligence	3	0	0	3
CS5105	Seminar-I	0	0	3	2	CS5110	Computer Systems Lab-II	0	0	3	2
CS51XX	Elective I	3	0	0	3	CS51XX	Elective II	3	0	0	3
Total					16	Total					18
Semester 3						Semester 4					
CS6101	Seminar-II	0	0	3	2	CS6099	Project Phase-II	0	0	16	8
CS 6098	Project Phase-I	0	0	12	6						
Total					8	Total					8
Total Credit = 50 Credits											

Elective I			Elective II	
Course Code	Course Name		Course Code	Course Name
CS5131	Game Theory		CS5141	Complex Networks
CS5132	Logic for Computer Science		CS5142	Foundation of Cryptography
CS5133	Distributed Systems		CS5143	Quantum Computing
CS5134	Information Retrieval		CS5144	Kernel Methods
CS5135	Wireless Network		CS5145	Cloud Computing
CS5136	Graph Theory		CS5146	Cyber Physical Systems
CS5137	Machine Learning		CS5147	Reinforcement Learning
CS5138	Information Theory and Coding		CS5148	Searching in Big Data
CS5139	Digital Image Processing and its Applications		CS5149	Machine Translation
CS5140	Natural Language Processing			

CS 5101 **Foundations of Computing Science** **3-0-0-3**

Discrete Structures - Sets, Relations and Functions; Proof Techniques, Algebraic Structures, Morphisms, Posets, Lattices and Boolean Algebras.

Logic - Propositional calculus and Predicate Calculus, Satisfiabiliy and validity, Notions of soundness and completeness

Languages & Automata Theory - Chomsky Hierarchy of Grammars and the corresponding acceptors, Turing Machines, Recursive and Recursively Enumerable Languages; Operations on Languages, closures with respect to the operations.

Computability - Church-Turing Thesis, Decision Problems, Decidability and Undecidability, Halting Problem of Turing Machines; Problem reduction (Turing and mapping reduction).

Computational Complexity -- Time Complexity -- Measuring Complexity, The class P, The class NP, NP-Completeness, Reduction, co-NP, Polynomial Hierarchy. Space Complexity -- Savich's Theorem, The class PSPACE.

Text Books:

1. J.P. Trembley and R. Manohar -- Discrete Mathematical Structures with Applications to Computer Science, McGraw Hill Book Co.,
2. Michael Sipser -- Introduction to the Theory of Computation, Thomson Course Technology.
3. John E. Hopcroft and J. D. Ullman -- Introduction to Automata Theory, Languages and Computation, Narosa Pub. House, N. Delhi.
4. H.R. Lewis and C. H. Papadimitrou -- Elements of the Theory of Computation, Prentice Hall, International, Inc.

CS 5102 **Advanced Algorithms & Data Structure** **3-0-0-3**

Priority queue, Binomial, Fibonacci, and Pairing Heaps, Double-Ended Priority Queues, Hash tables, Balanced Binary Search trees, Splay trees, Randomized Dictionary Structures Multidimensional Spatial Data Structures, Quad trees and Octrees, Binary Space Partitioning Trees, R-trees, Tries, Suffix Trees and Suffix Arrays, PQ Trees, Application of data structure in Information retrieval, data mining, image processing.

Text Books:

1. Handbook of Data Structures and Applications – Sahni S. (CRC Press)
2. Introduction to Algorithms – Cormen T. H., Leiserson C. E., Rivest R. L., Stein C. (MIT Press)
3. Algorithm Design – Kleinberg J., Tardos E. (Addison Wesley)

CS 5103 **Linear Optimization** **3-0-0-3**

Vector Spaces: bases, echelon forms, rank and determinants. Gauss elimination and its complexity, Inner products, Gram- Schmidt orthogonalization. Linear transformations. Optimization: Modeling and formulation of optimization problems. Linear costs and convex domains. Mean-square (distance) minimizations. Linear programming and the Simplex algorithm. Duality and the primal dual method. Examples from combinatorial optimization. Shortest paths, network flows and matchings. Approximation and randomized algorithms. Matrix Games.

Text Books:

1. Combinatiorial Optimization – C. Papadimitriou and K. Steiglitz (PHI)
2. Linear Algebra and its Applications – Gibert Strang. (Harcourt Brace)
3. Linear Programming and Applications – V. Chvatal

CS 5104 **Computer Systems Lab - I** **0-0-3-2**

Object-oriented programming concepts and implementation of abstract data types. Implementation of graph algorithms. Linear programming with applications. Basics of OS programming - process creation and synchronization, shared memory and semaphore, shell programming.

CS 5131 **Game Theory** **3-0-0-3**

Games and equilibria, two player Zero-Sum Games, proof of Nash Equilibria, complexity of finding Nash equilibria, information, strategies, dynamic and repeated games, bargaining, auctions, market equilibria, algorithmic mechanism design, inefficiency of equilibria, routing games, load balancing games.

Text Books:

1. Algorithmic Game Theory – N. Nisan, T. Roughgarden, V. Vazirani and E. Tardos (Cambridge University Press)
2. Games and Information: An Introduction to Game Theory– E. Rasmusen (Wiley)
3. A Course in Gam Theory– M. J. Osborne and A. Rubinstein (MIT Press)
4. Auction theory - V. Krishna (Elsevier)

CS 5132 **Logic for Computer Science** **3-0-0-3**

Axiomatic Theory: Propositional Calculus, Predicate Calculus, First Order Theories,Peano Arithmetic. Decision Procedures in First Order Logic: Resolution TheoremProvers: some theoretical issues. Modal Logic, Temporal Logic: their applications,Model Checking. Model Theory, Proof Theory. mu Calculus, Lambda Calculus, Non-monotonic Reasoning, Intuitionistic First Order Logic, Fuzzy Logic.

Text Books:

1. Logic for Applications– N. Nisan, A. Nerode and R. A. Shore (Springer)
2. First-order Logic and Automated Theorem Proving– M. Fitting (Springer)
3. Mathematical Logic for Computer Science – Ben-Ari M. (Springer)
4. Logic for Computer Science: Foundations of Automatic Theorem Proving- J. H. Gallier (Willey)

CS 5133 **Distributed Systems** **3-0-0-3**

Introduction: Concepts of distributed system and its general architecture, basic design issues in distributed system

Naming: Naming of entities and concept of name space, name space implementation, locating mobile entities

Process Management: Basic concepts of process and thread, threads in distributed system, code migration and its models, migration in heterogeneous environment, Introduction to RPC and RMI

Synchronization: Basic synchronization techniques, physical and logical clocks, clock synchronization algorithms, global state, election algorithms

Distributed mutual exclusion: Requirements, types and models of mutual Exclusion algorithms, discussion on mutual exclusion algorithms

Distributed deadlock handling: Introduction to deadlock, deadlock prevention and avoidance techniques, deadlock detection/ resolution algorithms

Agreement protocols: Basic concept of agreement protocols, different agreement problems, Byzantine agreement problem, Consensus problem, relations among agreement problems, solution to Byzantine agreement problem, application of agreement algorithm

Text Books:

1. Distributed Systems: Concepts and Design – Coulouris G., Dollimore J., Kindberg T. (Pearson)
2. Advanced Concepts in Operating System – Singhal M., Shivaratri N. G. (TMH)
3. Distributed Systems: Principles and Paradigms – Tanenbaum A. S., Steen M. V. (Pearson Ed)
4. Distributed Operating System – Sinha P. K. (PHI)
5. Distributed Operating Systems – Tanenbaum A. S. (Pearson Ed)

CS 5134 **Information Retrieval** **3-0-0-3**

Introduction: Principles of Information Retrieval, Indexing, Zipfs Law, Search. Vector space model, cosine similarity. Scoring techniques. Stemming, Stop words, Query expansion, Rochhio. Probabilistic models language. Relevance feedback. Evaluation: Precision, recall, f-measure. TREC Text classification, clustering, query routing. Advanced topics like summarization and question answering.

Text Books:

1. Introduction to Information Retrieval – P Raghavan, M Manning and P Schutze (Kluwer)

CS 5135 **Wireless Network** **3-0-0-3**

Introduction to wireless communication systems and networks

Wireless technologies: Cellular wireless networks and systems principles, antennas and radio propagation, signal encoding and modulation techniques, spread spectrum, coding and error control

Wireless Networking: Multiple access techniques, Mobile IP and WAP, Wireless systems and standards

Wireless LANs: Wireless LAN technology, Wireless standard (IEEE 802.11 etc.), Ad-hoc Networks, Bluetooth.

Text Books:

1. Wireless Communications: Principles & Practice – Rappaport T. S. (Pearson Ed)
2. Wireless Communications and Networks – Stallings W. (Pearson Ed)

CS 5136 **Graph Theory** **3-0-0-3**

Introduction to graphs and their representation, finite and infinite graphs, incidence and degree, path

Directed graph, single source shortest path, all pair shortest path, directed acyclic graph, Euler's graphs, Hamiltonian paths and circuits

Basic results of trees, minimum cost spanning tree

Introduction to cut-sets and cut-vertices, connectivity and separability

Basic concepts of vector space of graph, sets with one or two operations, basis vector, circuit and cut-set subspaces, orthogonal vectors and spaces

Matrix representation of graph, incidence matrix, circuit matrix, path matrix, cut-set matrix and adjacency matrix.

Text Books:

1. Graph theory with applications to engineering and computer science – Deo N. (PHI)
2. Introduction to Algorithms – Cormen T. H., Leiserson C. E., Rivest R. L., Stein C. (PHI)
3. Algorithmic graph theory – Gibbons A. (Cambridge Univ. Press)
4. Schaum's outline of theory and problems of Graph theory – Balakrishnan V.K. (TMH)
5. Fundamentals of Data Structures – Horowitz E., Sahni S. (Galgotia Pub.)
6. Handbook of Graph Theory – Gross J. L., Yellen J. (CRC Press)

CS 5137 **Machine Learning** **3-0-0-3**

Introduction, Decision Trees, Probability Primer, Bayes Decision Theory, Maximum-likelihood and Bayesian Parameter Estimation, Non-parametric Techniques, Bayes Networks, Optimization Primer, Linear Discriminant Functions, Support Vector Machines, Unsupervised Learning, Semi Supervised Learning, Reinforcement Learning.

Text Books:

1. Machine Learning – Mitchell T. M. (McGraw Hill)
2. Pattern Classification – Duda R. O., Hart P. E., Strok D. G. (Wiley Interscience)

CS 5138 **Information Theory and Coding** **3-0-0-3**

Introduction: Concept of entropy and mutual information, application of entropy in feature extraction

Entropy in stochastic processes: Entropy rates, markov chains, Hidden Markov models

Data Compression: Kraft inequality and optimal coding, Huffman codes and optimality, Shanon-Fano-Elias coding, Arithmetic codes

Channel capacity and Coding: Different channel models, concept of channel capacity, channel coding theorem, Fano's inequality, Huffman codes, channel capacity theorem, Shanon's limit, Random selection of codes, noiseless coding

Error control codes: Concept of Linear block codes, cyclic codes, BCH codes, RS codes, Convolution codes

Error correcting techniques: Short-random-error correction by error-trapping, burst-error correction for block codes

Coding and Digital Modulation: Trellis coded modulation.

Text Books:

1. Elements of Information Theory – Cover T. M., Thomas J. A. (Wiley)
2. Information Theory, Coding and Cryptography – Bose R. (TMH)
3. Introduction to Coding and Information Theory – Roman S. (Springer)
4. Error Control Coding for Data Network – Reed I. S., Chen X. (Kluwer)
5. The Mathematics of Coding Theory – Garret P. (Pearson)

CS 5139 **Digital Image Processing and Its Applications** **3-0-0-3**

Introduction: Steps in Digital Image Processing – Image sampling and Quantization – Basic relationships between pixels – Color Fundamentals – File Formats – Image Transforms: DFT, DCT, Haar, SVD and KL- Introduction to Matlab Toolbox

Image Enhancement: Spatial Domain: Gray level transformations – Histogram processing – Basics of Spatial Filtering–Smoothing and Sharpening Spatial Filtering – Fuzzy set for spatial filters - Frequency Domain: convolution and correlation - Introduction to Fourier Transform - Other Separable Image Transforms, Walsh-Hadamard and K-L transform– Smoothing and Sharpening frequency domain filters – Ideal, Butterworth and Gaussian filters, Enhancement by point processing, Generation of Spatial Masks from Frequency Domain Specifications.

Image Restoring and segmentation: Noise models – Mean Filters – Order Statistics – Adaptive filters – Band reject Filters – Band pass Filters – Notch Filters – Optimum Notch Filtering – Inverse Filtering – Formulation, Removal of Blur Caused by Uniform Linear Motion - Wiener filtering Segmentation: Detection of Discontinuities–Edge Linking and Boundary detection – Region based segmentation-Morphological processing- erosion and dilation – Morphological Water sheds – Description: Boundary descriptors, Regional Descriptors.

Wavelets and Image compression: Wavelets – Sub-band coding – Multiresolution expansions – Fast Wavelet Transforms – lifting scheme– Compression: Fundamentals – Image Compression models – Error Free Compression – Variable Length Coding – Bit-Plane Coding – Lossless Predictive Coding – Lossy Compression – Lossy Predictive Coding – Compression Standards.

Applications: Image classification, Object recognition, Image fusion, Steganography – Current Trends: Color Image Processing, Wavelets in Image Processing, Medical Image Processing – Case studies

Text Books:

1. Digital Image Processing – R. C. Gonzalez, R. E. Woods. (Pearson Education)
2. Fundamentals of Digital Image Processing – Anil K. Jain (Prentice-Hall India)

CS 5140 **Natural Language Processing** **3-0-0-3**

Introduction, Regular Expressions, Text Normalization, Edit Distance, N-gram Language Models, Ambiguity, Naive Bayes and Sentiment Classification, Vector Semantics, Neural Networks and Neural Language Models, RNN, LSTM, GRU, Part-of-Speech Tagging, HMM, Maximum Entropy, CRF, Sequence Processing with Recurrent Networks, Formal Grammars of English, Treebanks as Grammars, Syntactic Parsing, Statistical Parsing, PCFG, Dependency Parsing, The Representation of Sentence Meaning, WSD, Information Extraction, Semantic Role Labeling, Lexicons for Sentiment, Discourse Coherence, Machine Translation, Question Answering, Dialog Systems and Chatbots, Speech Recognition and Synthesis

Text Books:

1. Speech and Language Processing – Jurafsky D., Martin J. H. (Prentice Hall)
2. Foundations of Statistical Natural Language Processing – Manning C., Schütze H. (MIT Press)

CS 5106 **Advanced Database Management System** **3-0-0-3**

M.Tech. (CSE), second semester (core)

Prerequisites, if any:

Measures of query costs, selection operation, sorting, join operation, evaluation of expressions

Query optimization: Translation of SQL queries to relational algebra, heuristic approach and cost based optimization, Serializibility, locking, system log, undoing and redoing, Extended entity relationship model and object model, object oriented databases, Object relational and extended relational databases, Parallel and distributed databases, XML and Internet database, Active database.

Text Books:

1. Database Management Systems – Ramakrishnan R., Gehrke J. (McGraw-Hill)
2. Database Management Systems – Silberschatz, A., Korth H. F., Sudarshan S. (McGraw)
3. Fundamentals of Database Systems – Elmasri R., Navathe S. B. (Addison-Wesley)
4. Database : Principles, Programming, Performance – ONeil P. (Morgan Kaufmann)
5. Database Modeling & Design – Theorey T. J. (Morgan Kaufmann)

CS 5107 **High Performance Computing** **3-0-0-3**

M.Tech. (CSE), second semester (core)

Prerequisites, if any:

Introduction: review of basic computer architecture, quantitative techniques in computer design, measuring and reporting performance. CISC and RISC processors. Pipelining: Basic concepts, instruction and arithmetic pipeline, data hazards, control hazards, and structural hazards, techniques for handling hazards. Exception handling. Pipeline optimization techniques. Compiler techniques for improving performance. Hierarchical memory technology: Inclusion, Coherence and locality properties; Cache memory organizations, Techniques for reducing cache misses; Virtual memory organization, mapping and management techniques, memory replacement policies. Instruction-level parallelism: basic concepts, techniques for increasing ILP, superscalar, super-pipelined and VLIW processor architectures. Array and vector processors. Multiprocessor architecture: taxonomy of parallel architectures. Centralized shared-memory architecture: synchronization, memory consistency, interconnection networks. Distributed shared-memory architecture. Cluster computers. Non von Neumann architectures: data flow computers, reduction computer architectures, systolic architectures.

Text Books:

1. Database Management Systems – Ramakrishnan R., Gehrke J. (McGraw-Hill)
2. Database Management Systems – Silberschatz, A., Korth H. F., Sudarshan S. (McGraw)
3. Fundamentals of Database Systems – Elmasri R., Navathe S. B. (Addison-Wesley)
4. Database : Principles, Programming, Performance – ONeil P. (Morgan Kaufmann)
5. Database Modeling & Design – Theorey T. J. (Morgan Kaufmann)

CS 5108 **Internet Protocol** **3-0-2-4**

M.Tech. (CSE), second semester (core)

Overview of IPv4, TCP, IPv6, ICMP, ARP, DHCP; Routing Protocols: OSPF, RIP, BGP, Ad hoc network routing (AODV, DSR); IP Security: NAT, IPSEC, Socks, SSL; Quality of Service related protocols: Intserv, Diffserv, Queuing techniques (WFQ, RED, etc.); Multi-Protocol Label Switching (MPLS) and GMPLS; Virtual Private Network (VPN) Protocols: L2TP, PPTP; Overview of Application Layer Protocols: DNS, LDAP, SMTP, POP3, IMAP4, SNMP; Voice over IP Protocols (VOIP) and videoconferencing: SIP, H323. Server Load Balancing Techniques.

Text Books:

1. TCP/IP Guide – Charles. M. Kozierek (Shroff Publishers)
2. MPLS and Label Switching Networks – Uyless Black (Pearson Education)
3. Adolfo Rodriguez et. al, TCP/IP Tutorial and Technical Overview, IBM Redbook

CS 5109 **Artificial Intelligence** **3-0-0-3**

M.Tech. (CSE), second semester (core)

Prerequisites, if any:

Introduction, problems and techniques related to artificial intelligence, Problem spaces and search, state space graph, production systems BFS and DFS, Introduction to heuristic search, hill climbing, best first search, A* algorithm, admissibility, AND/OR graph – AO*, Predicate logic, rule-based systems, forward vs backward reasoning, non-monotonic reasoning, statistical reasoning, Dempster Shafer theory, Min-Max search, Alpha-Beta cut-offs, Case studies: MYCIN, R1

Text Books:

1. Artificial Intelligence – Rich, Knight (TMH)
2. Principles of Artificial Intelligence – Nilson N. J. (Narosa)
3. Paradigms of AI programming – Norvig P. (Elsevier)
4. Introduction to Expert System – Jackson P. (Addison-Wesley)

CS 5110 **Computer Systems Lab - II** **0-0-3-2**

M.Tech. (CSE), second semester (core)

Prerequisites, if any:

Socket programming, database creation and update, building large client server applications. Basics of compiler writing using *lex* and *yacc*.

CS 5141 **Complex Networks** **3-0-0-3**

M.Tech. (CSE), second semester (elective)

Prerequisites, if any:

Types of network: Social networks, Information networks, Technological networks, Biological networks.

Properties of network: Small world effect, transitivity and clustering, degree distribution, scale free networks, maximum degree; network resilience; mixing patterns; degree correlations; community structures; network navigation.

Random Graphs: Poisson random graphs, generalized random graphs, the configuration model, power-law degree distribution, directed graph, bipartite graph, degree correlations.

Models of network growth: Price's model, Barabasi and Albert's model, other growth models, vertex copying models.

Processes taking place on networks: Percolation theory and network resilience, Epidemiological processes.

Applications: Search on networks, exhaustive network search, guided network search, network navigation; network visualization.

Text Books:

1. Evolution of Networks – S. N. Dorogovtsev and J. F. F. Mendes (Oxford Press)
2. The structure and dynamics of networks – M. Newman, A-L Barabasi, D. J. Watts (Princeton)

CS 5142 **Foundation of Cryptography** **3-0-0-3**

M.Tech. (CSE), second semester (elective)

Prerequisites, if any:

Introduction to Cryptography: Basics of Symmetric Key Cryptography, Basics of Asymmetric Key Cryptography, Hardness of Functions

Notions of Semantic Security (SS) and Message Indistinguishability (MI): Proof of Equivalence of SS and MI, Hard Core Predicate, Trap-door permutation, Goldwasser-Micali Encryption

Goldreich-Levin Theorem: Relation between Hardcore Predicates and Trap-door permutations

Formal Notions of Attacks: Attacks under Message Indistinguishability: Chosen Plaintext Attack (IND-CPA), Chosen Ciphertext Attacks (IND-CCA1 and IND-CCA2), Attacks under Message Non-malleability: NM-CPA and NM-CCA2, Inter-relations among the attack model

Random Oracles: Provable Security and asymmetric cryptography, hash functions, Weak and Strong one way functions

Pseudo-random Generators (PRG): Blum-Micali-Yao Construction, Constructionof more powerful PRG, Relation between One-way functions and PRG, Pseudo-random Functions (PRF)

Building a Pseudorandom Permutation: The Luby Rackoff Construction: Formal Definition, Application of the Luby Rackoff Construction to the construction of Block Ciphers, The DES in the light of Luby Rackoff Construction

Message Authentication Codes (MACs): Formal Definition of Weak and Strong MACs, Using a PRF as a MAC, Variable length MAC

Public Key Signature Schemes: Formal Definitions, Signing and Verification, Formal Proofs of Security of Full Domain Hashing

Assumptions for Public Key Signature Schemes: One way functions Imply Secure One-time Signatures

Shamir's Secret Sharing Scheme, Formally Analyzing Cryptographic Protocols, Zero Knowledge Proofs and Protocols.

Text Books:

1. Introduction to Cryptography: Principles and Applications – Hans Delfs and Helmut Knebl (Springer)
2. Modern Cryptography, Theory and Practice – Wenbo Mao (Pearson Ed)
3. Foundations of Cryptography, Part 1 & 2 – Oded Goldreich (CRC)

CS 5143 **Quantum Computing** **3-0-0-3**

M.Tech. (CSE), second semester (elective)

Prerequisites, if any:

Introduction to Quantum Computation: Quantum bits, Bloch sphere representation of a qubit, multiple qubits.

Background Mathematics and Physics: Hilber space, Probabilities and measurements, entanglement, density operators and correlation, basics of quantum mechanics, Measurements in bases other than computational basis.

Quantum Circuits: single qubit gates, multiple qubit gates, design of quantum circuits

Quantum Information and Cryptography: Comparison between classical and quantum information theory. Bell states. Quantum teleportation. Quantum Cryptography, no cloning theorem

Quantum Algorithms: Classical computation on quantum computers. Relationship between quantum and classical complexity classes. Deutsch's algorithm, Deutsch's-Jozsa algorithm, Shor factorization, Grover search

Noise and error correction: Graph states and codes, Quantum error correction, fault-tolerant computation

Text Books:

1. Quantum Computation and Quantum Information – M. A. Nielsen & I. L. Chiang (Cambridge)
2. Explorations in Quantum Computing – Colin P. Williams (Springer)
3. Quantum Computing: A Gentle Introduction – Eleanor G. Rieffel and Wolfgang H. Polak (MIT)
4. An Introduction to Quantum Computing Algorithms – A. O. Pittenger (Springer)

CS 5144 **Kernel Methods** **3-0-0-3**

M.Tech. (CSE), second semester (elective)

Prerequisites, if any:

Introduction: Data representation, similarity, statistical learning theory, hyper-plane classifiers, support vector classification, support vector regression, kernel principal component analysis

Kernels: Product features, representation of similarities in linear spaces, examples and properties of kernels

Risk and loss functions: Loss functions, test error, expected risk, statistical perspective, robust estimators

Regularization: Regularized risk functional, representer theorem, regularization operators, translation invariant kernels, dot product kernels

Support vector machines: Separating hyper-planes, role of margin, optimal margin hyper-planes, nonlinear support vector classifiers, soft margin hyperplanes, multi-class hyper-planes

Single class problems: introduction, algorithms, optimization, theory

Regression estimation: Linear regression with insensitive loss function, dual problems, ν-SV regression

Implementation: Tricks of the trade, sparse greedy matrix approximation, subset selection methods, sequential minimal optimization, iterative methods

Designing kernels: Tricks for constructing kernels, string kernels, natural kernels.

Text Books:

1. Learning with Kernels - support vector machines, regularization, optimization and beyond – B. SchÖlkopf and A. J. Smola (MIT Press)
2. Kernel Methods for Pattern Analysis – J. Shawe-Taylor and N. Cristianini (Cambridge)
3. Introduction to Support Vector Machines – N. Cristianini and J. Shawe-Taylor (Cambridge)

CS 5145 **Cloud Computing** **3-0-0-3**

M.Tech. (CSE), second semester (elective)

Prerequisites, if any:

Introduction: Definition, Characteristics, Components, Cloud provider, SAAS, PAAS, IAAS and Others, Organizational scenarios of clouds, Administering & Monitoring cloud services, benefits and limitations, Deploy application over cloud, Comparison among SAAS, PAAS, IAAS

Cloud computing platforms: Infrastructure as service: Amazon EC2, Platform as Service: Google App Engine, Microsoft Azure, Utility Computing, Elastic Computing

Cloud Technologies: Study of Hypervisors, Compare SOAP and REST

Web services: SOAP and REST, SOAP versus REST, AJAX - asynchronous 'rich' interfaces, Mashups - user interface services

Virtualization: Virtual machine technology, virtualization applications in enterprises, Pitfalls of virtualization

Multitenant software: Multi-entity support, Multi-schema approach, Multi-tenancy using cloud data stores, Data access control for enterprise applications

Data in the cloud: Relational databases, Cloud filesystems - GFS and HDFS, Big Table, HBase and Dynamo

Map-Reduce and extensions: Parallel computing, The map-Reduce model, Parallel efficiency of Map-Reduce, Relational operations using Map-Reduce, Enterprise batch processing using Map-Reduce, Introduction to cloud development, Example/Application of Map reduce, Features and comparisons among GFS, HDFS etc,

Map-Reduce model Cloud security: Vulnerability assessment tool for cloud, Privacy and Security in cloud, Architectural Considerations - General Issues, Trusted Cloud computing, Secure Execution Environments and Communications, Security challenges - Virtualization security management- virtual threats, VM Security Recommendations, VM-Specific Security techniques, Secure Execution Environments and Communications in cloud

Issues: Implementing real time application over cloud platform Issues in Inter-cloud environments, QoS Issues in Cloud, Dependability, data migration, streaming in Cloud. QoS monitoring in a Cloud computing environment

Text Books:

1. Cloud Computing for Dummies – Hurwitz J., Bloor R., Kanfman M., Halper F. (Wiley India)
2. Enterprise Cloud Computing – Shroff G. (Cambridge)
3. Cloud Security – Krutz R., Vines R. D. (Wiley India)

CS 5146 **Cyber Physical Systems** **3-0-0-3**

M.Tech. (CSE), second semester (elective)

Prerequisites, if any:

Introduction: Cyber-Physical Systems (CPS) in the real world, Basic principles of design and validation of CPS, Industry 4.0, AutoSAR, IIOT implications

Components: CPS HW platforms - Processors, Sensors, Actuators, CPS Network – Wireless Hart, CAN, Automotive Ethernet, CPS Sw stack – RTOS, Scheduling Real Time control tasks

Automated Control Design: Dynamical Systems and Stability, Controller Design Techniques, Stability Analysis: CLFs, MLFs, stability under slow switching, Performance under Packet drop and Noise

Implementation: Features to software components, mapping software components to ECUs, Performance Analysis - effect of scheduling, bus latency, sense and actuation faults on control performance, network congestion, Control, Bus and Network Scheduling using Truetime

Safety Assurance: Automata based modeling and analysis – Introduction, Timed and Hybrid Automata, Flowpipe construction, reachability analysis

Security: Secure Task mapping and Partitioning, State estimation for attack detection, Case study - Vehicle ABS hacking, SmartGrids attack

Text Books:

1. Introduction to Embedded Systems – A Cyber Physical Systems Approach – E. A. Lee, Sanjit Seshia (MIT)
2. Principles of Cyber-Physical Systems – Rajeev Alur (MIT)
3. Logical Foundations of Cyber-Physical Systems – André Platzer (Springer)
4. High-Performance Embedded Computing: Applications in Cyber-Physical Systems and Mobile Computing – Marilyn Wolf (Elsevier)

CS 5147 **Reinforcement Learning** **3-0-0-3**

M.Tech. (CSE), second semester (elective)

Prerequisites, if any:

The Reinforcement Learning problem: evaluative feedback, non-associative learning, Rewards and returns, Markov Decision Processes, Value functions, optimality and approximation.

Dynamic programming: value iteration, policy iteration, asynchronous DP, generalized policy iteration.

Monte-Carlo methods: policy evaluation, roll outs, on policy and off policy learning, importance sampling.

Temporal Difference learning: TD prediction, Optimality of TD(0), SARSA, Q-learning, R-learning, Games and after states.

Eligibility traces: n-step TD prediction, TD (lambda), forward and backward views, Q (lambda), SARSA (lambda), replacing traces and accumulating traces

Function Approximation: Value prediction, gradient descent methods, linear function approximation, ANN based function approximation, lazy learning, instability issues

Policy Gradient methods: non-associative learning – REINFORCE algorithm, exact gradient methods, estimating gradients, approximate policy gradient algorithms, actor-critic methods

Text Books:

1. Reinforcement Learning: An Introduction – Sutton R S, Barto A G (MIT)
2. Reinforcement Learning: State-of-the-Art – Marco Wiering and Martijn van Otterlo (Springer)
3. Artificial Intelligence: A Modern Approach – Peter Norvig, Stuart J. Russell (Pearson Ed)
4. Deep Learning – Ian Goodfellow, Yoshua Bengio, Aaron Courville (MIT)

CS 5148 **Searching in Big Data** **3-0-0-3**

M.Tech. (CSE), second semester (elective)

Prerequisites, if any:

Queries: range queries, top-k queries, reverse top-k queries, multi-attribute top-k queries, top-k diversity queries, skyline queries.

Distance measures: LP norm, normalized Euclidean distance, Mahalanobis distance, KL-divergence, earth movers distance.

Memory, disk and SSD access: the dynamics of data reads based on the underlying storage architecture and how that affects the index performance. Single-dimensional index structures: B+-tree. Memory-based index structures: kd-tree, quad trees, interval trees, trie, Voronoi diagrams

Disk-based structures: R-tree, R-tree variants R+-tree and R*-tree, X-tree, SS-tree, VA-files, M-tree Index structure Vs Hashing in high-dimensional spaces

Hashing: extensible hashing, linear hashing, bloom filters, locality sensitive hashing.

Indexing and Searching non-traditional queries: multi-attribute top-k queries (Fagins algorithm, threshold algorithm, Onion), indexing skyline queries, indexing diversity queries

Dimensionality reduction: SVD, PCA, Fastmap, Lipschitz embedding Index structures and distance functions for Non-vector datasets: text Corpus, time-series datasets, graph datasets

Text Books:

1. Foundations of Multidimensional and Metric Data Structures – H Samet (Morgan Kaufmann)
2. Computational Geometry: Algorithms and Applications – de Berg, Cheong, van Krefeld, Overmars (Springer)
3. Introduction to Algorithms – Cormen T. H., Leiserson C. E., Rivest R. L., Stein C. (MIT Press)

CS 5149 **Machine Translation** **3-0-0-3**

M.Tech. (CSE), second semester (elective)

Introduction: Why MT is hard? Ambiguity, Language Divergence and Typology: Word Order Typology, Lexical Divergences, Morphological Typology, Referential density. Classical MT and the Vauquois Triangle: Direct Translation, Transfer, Combined Direct and Tranfer Approaches in Classic MT, The Interlingua Idea: Using Meaning

Basic concept of Language modeling: n-gram, smoothing techniques, P($F|E$): the Phrase-Based Translation Model, Alignment in MT, IBM Model 1, HMM Alignment, Training Alignment Models, EM for Training Alignment Models, Symmetrizing Alignments for Phrase-Based MT, Decoding for Phrase-Based Statistical MT, IBM Model 3 and Fertitlity, Training for Model 3, Re-Odering Models, Log-linearModels for MT

Intuition of NMT, Neural Networks, The Encoder-Decoder Modeling: Sequence to Sequence with RNN, Encode-Decoder with RNNs, Training the Encoder-Decoder Model, Attention Mechanism, Beam Search, Encode-Decider with Transformers

Tokenization, MT Corpora, Backtranslation, Introduction to Supervised, Unsupervised, Self-Supervised MT approaches, Standard Toolkits: SRILM, KenLM, Moses, OpenNMT

MT Evaluation: Quality Estimation, Using Human Raters to Evaluate MT, Automatic Evaluation: BLEU, METEOR, Automatic Evaluation: Embedding-Based Methods

References

1. Speech and Language Processing: An Introduction to Natural Language Processing, Computational Linguistics and Speech Recognition by Daniel Jurafsky and James H. Martin, 2e, Pearson Edition and 3rd Edition (Online)
2. Statistical Machine Translation by Philipp Koehn, Cambridge University Press
3. Neural Machine Translation by Philipp Koehn, Cambridge University Press
4. Machine Translation by Pushpak Bhattacharyya, Chapman and Hall/CRC; 1st edition
5. Foundations of Statistical Natural Language Processing by Christopher D. Manning and Hinrich Schütze, The MIT Press