M.TECH. COMPUTER SCIENCE AND ENGINEERING

Department of Computer Science

The M. Tech. programme in Computer Science & Engineering aims at preparing the students to take up applications, research and development activities in core and some emerging areas in Computer Science with a provision for specializing in any one of the following streams: Machine Learning and Data Science, Architectures and Systems, Networks and Intelligent Systems, and Computer Vision. The core subjects cover advanced level courses in Computer Architecture, Algorithms, System Security, Distributed Systems and Machine Learning. This programme will provide a strong basis in Computer Science & Engineering for those who opt for a serious career in industry.

The purpose of the programme is to generate trained professionals capable of supporting R & D activities in critical areas like automated, secured, monitoring and surveillance systems, medical diagnostics, intelligent monitoring systems etc. The diversity of platforms available for implementation and the huge volume of data available for analysis and knowledge mining activities in various domains attract employment opportunities.

CURRICULUM

First Semester

Course Code	Type	Course	L T P	Cr
16CS601	FC	Foundations of Computer Science	2 0 1	3
16CS602	FC	Advanced Algorithms and Analysis	3 0 1	4
16MA604	FC	Mathematical Foundations for Computer Science	3 0 0	3
16CS621	SC	System Security	3 0 1	4
16CS624	SC	Modern Computer Architecture	3 0 1	4
16HU601	HU	Cultural Education*		P/F
				Credits 18

*Non-Credit Course

Second Semester

Course Code	Type	Course	L T P	Cr
16CS622	SC	Distributed Systems	3 0 1	4
16CS623	SC	Machine Learning	3 0 1	4
	E	Mathematics Elective	3 0 0	3
	E	Elective–I (GENERAL)	3 0 0	3
	E	Elective–II	3 0 0	3
16CS625	SC	Research Methodologies and Seminar	1 0 1	2
16EN600	HU	Technical Writing*		P/F
				Credits 19

*Non-Credit Course

Third Semester

Course Code	Type	Course	L T P	Cr
	E	Elective –III	3 0 0	3
	E	Elective –IV	3 0 0	3
16CS798	P	Dissertation		10
				Credits 16

Fourth Semester

Course Code	Type	Course	L T P	Cr
16CS799	P	Dissertation		12
				Credits 12

Total Credits: 65

List of Courses

Foundation Core

Course Code	Course	L T P	Cr
16CS601	Foundations of Computer Science	2 0 1	3
16CS602	Advanced Algorithms and Analysis	3 0 1	4
16MA604	Mathematical Foundations for Computer Science	3 0 0	3

Subject Core

Course Code	Course	L T P	Cr
16CS621	System Security	3 0 1	4
16CS622	Distributed Systems	3 0 1	4
16CS623	Machine Learning	3 0 1	4
16CS624	Modern Computer Architecture	3 0 1	4
16CS625	Research Methodologies and Seminar	1 0 1	2

GENERAL ELECTIVES

Course Code	Course	L T P	Cr
16CS701	Computational Intelligence	3 0 0	3
16CS702	Advanced Database	3 0 0	3
16CS703	Object Oriented Design	3 0 0	3
16CS704	Computational Statistics	3 0 0	3
16CS705	Advanced Computer Networks	3 0 0	3

16CS706	Compiler Design	3 0 0	3
16CS707	Enterprise Architecture	3 0 0	3
16CS708	Foundations for Signal and Image Processing	3 0 0	3
16CS709	Formal Methods	3 0 0	3
16CS710	Programme Analysis and Optimization	3 0 0	3
16CS711	Data Visualization	3 0 0	3

Mathematics Electives

(Fractal options to be provided)

Course Code	Course	L T P	Cr
16MA701	Random Process and Optimization theory	3 0 0	3
16MA702	Optimization Theory	3 0 0	3
16MA703	Advanced Linear Algebra	3 0 0	3
16CS712	Randomized Algorithms	3 0 0	3
16CS713	Networks and Spectral Graph Theory	3 0 0	3

Electives II, III, IV, (Stream based electives)

	Stream –I Machine Learning	**L T P**	**Cr**
16CS714	Machine Learning for Big Data	3 0 0	3
16CS715	Foundations of Data Science	3 0 0	3
16CS716	Applications of Machine Learning	3 0 0	3
16CS717	Statistical Learning Theory	3 0 0	3
16CS718	Natural Language Processing	3 0 0	3
16CS719	Information Retrieval	3 0 0	3
16CS720	Data Mining and Business Intelligence	3 0 0	3
16CS721	Semantic Web	3 0 0	3

	Stream –II Architecture and Systems		
16CS722	Hardware Software Co-Design	3 0 0	3
16CS723	Parallel Computer Architecture	3 0 0	3
16CS724	Reconfigurable Computing	3 0 0	3
16CS725	Advanced Operating Systems	3 0 0	3
16CS726	Critical Systems and Verification	3 0 0	3
16CS727	Compiler Optimization Techniques and Design	3 0 0	3
16CS728	Computer Systems' Performance Analysis	3 0 0	3
16CS729	Parallel Programming	3 0 0	3
16CS730	High Performance Computing	3 0 0	3

	Stream –III Networks and Intelligent Systems		
16CS731	Mobile Networks	3 0 0	3
16CS732	Principles of Software Defined Networks	3 0 0	3
16CS733	Wireless Sensor Networks	3 0 0	3
16CS734	Wireless Networks	3 0 0	3
16CS735	Pervasive Computing	3 0 0	3
16CS736	Agent Based Intelligent Systems	3 0 0	3

	Stream –IV Computer Vision		
16CS737	Principles of Digital Image Processing	3 0 0	3
16CV702	Video Analytics	3 0 0	3
16CV705	Medical Image Analysis	3 0 0	3
16CV706	Content Based Image and Video Retrieval	3 0 0	3

16CS738	Pattern Recognition	3 0 0	3
16CS739	Data Compression	3 0 0	3

Project Work

Course Code	Course	L T P	Cr
16CS798	Dissertation		10
16CS799	Dissertation		12

16CS601 FOUNDATIONS OF COMPUTER SCIENCE 2-0-1 -3

Note: The course will be evaluated internally by the Department.

Review of Data Structures: Linear Data Structures – Linked Lists: - Singly LL, Doubly LL, Circular LL – Implementation – Applications. Stacks: - Implementation using Arrays and Linked Lists – Applications in Recursion. Queues - Implementation and Applications. Binary Trees - Basic tree traversals - Binary tree - Priority queues - Binary search tree. AVL trees.

Review of matrices, sets and relations.

Review of Algorithms: Algorithm Analysis- Methodologies for Analyzing Algorithms, Asymptotic growth rates, Amortized Analysis. Divide and Conquer technique, Greedy techniques and Dynamic Programming. Graphs - Data Structures for Graphs, Graph Traversal – Directed Graphs, Weighted Graphs, Single- Source Shortest Paths, All pairs Shortest Paths, Depth First Search, Breadth First Search and their applications, Minimum Spanning Trees.

Computation – Limits of Computation – Algorithm for Finding Prime Numbers – Sieve Algorithm - Iteration for Solving Computational Problems. Problem Solving using Data Structures and Algorithms

Course will focus on Implementation of common Algorithms and Data Structures, Problem Solving using Data Structures and Algorithms, and simple competitive programming exercises

TEXT BOOKS/ REFERENCES

1. *Michael T Goodrich, Roberto Tamassia and Michael H Goldwsasser, "Data Structures and Algorithms in Java", Fifth edition, John Wiley publication, 2010.*
2. *Clifford A. Shaffer, "Data Structures and Algorithm Analysis", Third Edition, Dover Publications, 2012.*
3. *Kenneth H. Rosen, "Application of Discrete Mathematics", Seventh Edition, McGraw Hill Publications, 2012.*
4. *John S. Conery, "Explorations in Computing: An Introduction to Computer Science", CRC Press, 2010*

16CS602 ADVANCED ALGORITHMS AND ANALYSIS 3-0-1-4

Algorithm Analysis: Asymptotic Notation-Standard - Recurrences - Solution to Recurrences Divide and Conquer - Sorting, Matrix Multiplication and Binary Search. Dynamic Programming- Longest common sustring/subsequence - Matrix Chain Multiplication - 0-1 Knapsack problem - Coin Change problem. Greedy algorithms: Fractional knapsack, job scheduling, matroids. Graph Algorithms - Graph Traversal, Single- Source Shortest Paths, All pairs Shortest Paths, Depth First Search, Breadth First Search and their applications, Minimum Spanning Trees. Network Flow and Matching: Flow Algorithms - Maximum Flow – Cuts - Maximum Bipartite Matching -Graph partitioning via multi-commodity flow**,** Karger'r Min Cut Algorithm. Amortized Analysis - Aggregate Method - Accounting Method - Potential Method. String Matching Algorithms: KMP, Aho-Korasik algorithm, Z-algorithm. NP Completeness: Overview - Class P - Class NP - NP Hardness - NP Completeness - Cook Levine Theorem - Important NP Complete Problems - Reduction of standard NP Complete Problems (SAT, 3SAT, Clique, Vertex Cover, Set Cover, Hamiltonian

Cycle). Approximation Algorithms: Approximation algorithms for known NP hard problems - Inapproximability - Analysis of Approximation Algorithms -

TEXT BOOKS/ REFERENCES

1. *Michael T Goodric and Roberto Tamassia, "Algorithm Design: Foundations, Analysis and Internet Examples", John Wiley and Sons, 2002.*
2. *Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest and Clifford Stein, "Introduction to Algorithms", Third Edition, The MIT Press, 2009.*
3. *Sanjoy Dasgupta, Christos Papadimitriou and Umesh Vazirani, "Algorithms", Tata McGraw-Hill, 2009.*
4. *RK Ahuja, TL Magnanti and JB Orlin, "Network flows: Theory, Algorithms, and Applications", Prentice Hall Englewood Cliffs, NJ 1993.*
5. *Rajeev Motwani and Prabhakar Raghavan, "Randomized Algorithms", Cambridge University Press, 1995.*

16MA604 MATHEMATICAL FOUNDATIONS FOR COMPUTER SCIENCE 3-0-0-3

Logic: Propositional Calculus, Resolution in the propositional calculus, Predicate calculus, Resolution in the predicate calculus. Linear Algebra: Review of Matrices: Geometry of linear equations, Vector spaces and subspaces, linear independence, basis and dimensions, linear transformations, orthogonality, projections and least square applications. Probability and Advanced Statistics: Introduction to probability concepts, Bayesian approach to distributions, two dimensional random variables and joint probability distributions, stochastic independence of random variables, stochastic convergence and limit theorems, stopping rules for simulation experiments, multivariate probability distributions, variance and covariance matrices, regression models using matrices. Theory of estimation, Bayesian methods of estimation, construction of test statistics, critical region, p value.

TEXTBOOKS/ REFERENCES:

1. *Gilbert Strang, "Introduction to Linear Algebra", Fourth Edition, Wellelsley- Cambridge Press, 2009.*
2. *Nils Nilsson, "Artificial Intelligence, A New Synthesis", PHI, 2000*
3. *Douglas C. Montgomery and George C. Runger, "Applied Statistics and Probability for Engineers", Third Edition, John Wiley & Sons Inc., 2003.*
4. *Ronald E. Walpole, Raymond H Myres, Sharon.L.Myres and Kying Ye, "Probability and Statistics for Engineers and Scientists", Seventh Edition, Pearson Education, 2002.*
5. *A. Papoulis and Unnikrishna Pillai, "Probability, Random Variables and Stochastic Processes", Fourth Edition, McGraw Hill, 2002.*

16CS621 SYSTEM SECURITY 3-0-1- 4

Security Overview: Computer Security Concepts - Threats, Attacks, and Assets - Security Functional Requirements - security Architecture for Open Systems. Cryptographic Tools:

Confidentiality with Symmetric Encryption - Message Authentication and Hash Functions - Public-Key Encryption - Digital Signatures and Key Management - Random and Pseudorandom Numbers - Practical Application: Encryption of Stored Data. User Authentication: Means of Authentication - Password-Based Authentication - Token-Based Authentication - Biometric Authentication - Remote User Authentication - Security Issues for User Authentication - Practical Application: An Iris Biometric System Access Control Principles - Example: UNIX File Access Control. Database Security: The Need for Database Security - Database Access Control - Statistical Databases - Database Encryption - Cloud Security Software Security - Software Security Issues - Handling Program Input - Writing Safe Program Code - Interacting with the Operating System and Other Programs - Handling Program Output. Operating System Security: Introduction to Operating System Security - System Security Planning - Operating Systems Hardening - Application Security -Security Maintenance - Linux/Unix Security - Windows Security - Virtualization Security. Trusted Computing and Multilevel Security: The Bell-LaPadula Model for Computer Security - Other Formal Models for Computer Security - The Concept of Trusted Systems - Application of Multilevel Security - Trusted Computing and the Trusted Platform Module . Legal and Ethical Aspects: Cybercrime and Computer Crime - Intellectual Property - Privacy - Ethical Issues.

TEXTBOOKS/ REFERENCES:

1. *W. Stallings, "Computer Security: Principles and Practice," Second Edition, Prentice Hall, ISBN: 0132775069, 2011.*
2. *M. Stamp, "Information Security: Principles and Practice", Second Edition, Wiley, ISBN: 0470626399, 2011.*
3. *M. E. Whitman and H. J. Mattord, "Principles of Information Security," Fourth Edition, Course Technology, ISBN: 1111138214, 2011.*
4. *M. Bishop, "Computer Security: Art and Science", Addison Wesley, ISBN: 0-201-44099-7, 2002.*
5. *G. McGraw, "Software Security: Building Security In", Addison Wesley, ISBN: 0321356705, 2006.*

16CS622 DISTRIBUTED SYSTEMS 3-0-1- 4

A Taxonomy of Distributed Systems - Models of computation: shared memory and message passing systems, synchronous and asynchronous systems Global state and snapshot algorithms. Logical time and event ordering, clock synchronization, Distributed mutual exclusion, Group based Mutual Exclusion, leader election, deadlock detection, termination detection, spanning tree construction. Fault tolerance and recovery: basic concepts, fault models, agreement problems and its applications, commit protocols, voting protocols, check pointing and recovery, reliable communication.

Distributed file systems: Dropbox, Google FS (GFS)/ Hadoop Distributed FS (HDFS) , Bigtable /HBase MapReduce, RDDs, Apache Spark ,Clustering: scalable performance, load balancing, and availability.

TEXTBOOKS/ REFERENCES:

1. *Andrew S. Tannenbaum and Maarten van Steen "Distributed Systems: Principles and Paradigms", Second Edition, Prentice Hall, October 2006.*
2. *Ajay D. Kshemkalyani and Mukesh Singhal, "Distributed Computing: Principles, Algorithms, and Systems", Cambridge University Press, 2011.*
3. *Vijay K Garg, "Elements of Distributed Computing", Wiley-IEEE Press, , May 2002*
4. *George Coulouris, Jean Dollimore, Tim Kindberg and Gordon Blair, "Distributed Systems: Concepts and Design", Fifth Edition, Addison Wesley, 2012.*
5. *Mukesh Singhal and Niranjan Shivaratri, "Advanced Concepts in Operating Systems, McGraw-Hill.*
6. *Mahmoud Parsian, "Data Algorithms: Recipes for Scaling Up with Hadoop and Spark", O'Reilly Media. 2012.*

16CS623 MACHINE LEARNING 3 -0-1- 4

Introduction: Machine learning: Types of machine learning, Supervised learning, Unsupervised learning, Some basic concepts in machine learning, Review of probability, Computational Learning theory.

Support Vector Machines, SMO algorithm. Dimensionality reduction PCA

Generative models for discrete data: Bayesian concept learning Likelihood, Posterior predictive distribution, The beta-binomial model , Naive Bayes classifiers , The log-sum-exp trick , Feature selection using mutual information, Classifying documents using bag of words,

Gaussian models: Basics, Gaussian discriminant analysis, Inference in jointly Gaussian distributions, Linear Gaussian systems, Digression: Inferring the parameters of an MVN, Baysian Statistics, Linear Regression, Logistic regression.

Directed graphical models (Bayes nets), Conditional independence, Inference, Learning Learning from complete data, Learning with missing and/or latent variables, Conditional independence properties of DGMs, Mixture models and EM algorithm, Kernels, Adaptive basis function models, Clustering, Graphical model structure learning

TEXTBOOKS/REFERENCES:

1. *E. Alpaydin, "Introduction to Machine Learning", PHI, 2005.*
2. *Tom Mitchael, "Machine Learning", McGraw Hill, 1997.*
3. *Stanford lecture notes*
4. *Kevin P. Murphey, "Machine Learning, a Probabilistic Perspective", The MIT Press Cambridge, Massachusetts, 2012.*
5. *Alex Smola and SVN. Viswanathan, "Introduction to Machine Learning", Cambridge University Press, 2008.*

16CS624 MODERN COMPUTER ARCHITECTURE 3-0-1-4

MIPS architecture – Basic concepts Instruction level parallelism – Concepts and challenges – Hardware and software approaches – Dynamic scheduling – Speculation - Compiler

techniques for exposing ILP – Branch prediction. Multiple issue processors – Advanced compiler support – Hardware support for exposing parallelism – Hardware versus software speculation mechanisms- Multiprocessors and thread level parallelism- Symmetric and distributed shared memory architectures – Performance issues – Synchronization – Models of memory consistency, Introduction to Multithreading. Types of Memory, Cache performance – Reducing cache miss penalty and miss rate – Reducing hit time – Main memory and performance. Types of storage devices– RAID – Reliability, availability and dependability – I/O performance measures Multi-core Processors-General-Purpose Multi-core Processors- GPU-GPU architecture-memory architecture-Thread modeling, GPU Computing, CUDA architecture, CUDA Threads, Programming & Performance.

TEXTBOOKS/ REFERENCES:

1. *John L Hennessy and David A Patterson, "Computer Architecture, A Quantitative Approach", Fourth Edition, ELSEVIER, 2003.*
2. *David B. Kirk and Wen-mei W. Hwu "Programmimg Massively Parallel Processors: A Hands-on Approach", Morgan Kaufmann, 2010.*
3. *Keckler, Stephen W., Olukotun, Kunle, Hofstee and H. Peter (Eds.), "Multi-core Processors and Systems", Springer, 2009*
4. *David E. Culler and Jaswinder Pal Singh, "Parallel Computing Architecture: A Hardware/software Approach", Morgan Kaufmann /Elsevier, 2010.*

16CS625 RESEARCH METHODOLOGIES AND SEMINAR 1-0-1-2

Note: The course will be evaluated internally by the Department.

This course is intended to be a self study course. Each student can select an area of self study in consultation with the Faculty, collect and study basic and recent research articles (project reports, review articles, published articles in journals and book chapters.) on the topic. Students will be required to make two in-class presentations. The Seminars will be evaluated for grading purpose. The evaluation will be done by a panel of (at least) two Faculty members.

Topics to be covered:

Selection of project domain ;Publication ethics, Tools and evaluation. Selection of tentative project area and process of literature survey – Literature survey components and procedures Basic components of a research paper – procedures and processes, Journal types, Scopus, web of science, Thomson Reuters, Science Citation Index, H-index, Google citations,
Presentation of selected project proposal – Oral presentation.
Preparation of a report on the selected project proposal in LaTeX format
Attending special invited lectures, practical orientation in searching and collecting literature through library, online tools, presenting a seminar on selected project proposal and submitting project report prepared using LaTeX.

Note: Evaluation components will be Campus specific; Allotment / Selection of Mentor/Supervisor will be done at Department,

16EN600 **TECHNICAL WRITING**

P/F

(Non-credit Course)

Technical terms – Definitions – extended definitions – grammar checks – error detection – punctuation – spelling and number rules – tone and style – pre-writing techniques – Online and offline library resources – citing references – plagiarism – Graphical representation – documentation styles – instruction manuals – information brochures – research papers – proposals – reports (dissertation, project reports etc.)

TEXTBOOKS/REFERENCES:

1. H.L. Hirsch, *Essential Communication Strategies for Scientists, Engineers and Technology Professionals*, Second Edition, New York: IEEE Press, 2002.
2. P.V. Anderson, *Technical Communication: A Reader-Centered Approach*, Sixth Edition, Cengage Learning India Pvt. Ltd., New Delhi, 2008, (Reprint 2010).
3. W.Jr. Strunk and E.B.White, *The Elements of Style*, New York. Alliyan & Bacon, 1999.

ELECTIVE-I (GENERAL)

16CS701 **COMPUTATIONAL INTELLIGENCE** **3-0-0-3**

Computational intelligence (CI): Adaptation, Self-organization and Evolution, Biological and artificial neuron, Neural Networks Basic Concepts,- Single Layer perceptron- Multilayer perceptron- Supervised and unsupervised learning- Back propagation networks- Kohnen's self-organizing networks-Hopfield networks- Implementations.

Evolutionary computing: Basic Concepts- survival of the fittest- Fitness computation- Crossover- Mutation- reproduction- Rank method- Rank space method, Implementations.

Fuzzy systems: Basic Concepts, Fuzzy sets- properties- membership functions- fuzzy operations, Applications, Implementation, Hybrid systems

CI application: case studies may include sensor networks, digital systems, control, forecasting and time-series predictions.

TEXTBOOKS/ REFERENCES:

1. *R.C. Eberhart, "Computational Intelligence: Concept to Implementations", Morgan Kaufmann Publishers, 2007.*
2. *Laurence Fausett, "Fundamentals of Neural Networks",*
3. *Timothy J Rose, "Fuzzy Logic with Engineering Applications", Third Edition, Wiley, 1995.*
4. *A Konar, "Computational Intelligence: Principles, Techniques and Applications", Springer -Verlag, 2005.*

16CS702 **ADVANCED DATABASE** **3-0-0-3**

Overview of DBMS – Database design – Query processing and optimization. Data modeling – ER – EER – Relational – Object Relational – Semistructure. XML document – Structure of XML Data – XML Document Schema – Querying and Transformation – API – Storage of XML Data – XML Applications. Temporal and Spatial Databases – Multidimensional Indexes - Data Cubes, Grid Files, R-trees. Distributed Databases – Data Distribution – Distributed Transactions. Parallel Databases – Performance measure - Parallel operations for relational operations. Document oriented Databases – Background of NoSQL - Information Retrieval Systems.
Lab : Postgresql, DB2(for XML),MongoDB.

TEXTBOOKS/ REFERENCES:

1. *Silberschatz, Korth and Sudarshan, "Database Concepts", Sixth Edition, Tata McGraw Hill, 2010.*
2. *Hector Garcia-Molina, Jeff Ullman and Jennifer Widom, "Database Systems: The Complete Book", Pearson, 2011.*
3. *Niall O'Higgins, "MongoDB and Python", O'Reilly, 2011.*

16CS703 OBJECT ORIENTED DESIGN 3-0-0-3

Object oriented analysis and Design: Iterative development, Case studies, Inception, Understanding evolution of requirements, Use cases, Identifying other requirements, Domain models, System sequence diagrams, Local architecture and UML package diagrams, Object design, Interaction diagrams, Class diagrams, Objects and responsibilities, Mapping design to code, Test driven development and refactoring, UML tools, GRASP, GoF patterns, Activity diagrams, and modeling, State Machine diagrams and modeling, relating Use cases, Domain Model Refinement, Architectural analysis.

TEXTBOOKS/ REFERENCES:

1. *Craig Larman, "Applying UML and Patterns: An Introduction to Object Oriented Analysis", Third Edition, Pearson, 2004.*
2. *Brown, D.W., "An Introduction to Objected Oriented Analysis: Objects and UML in Plain English", Second Edition, John Wiley & Sons, 2002.*
3. *Michael Bleha and JamesRambaugh, "Object Oriented Modelling and Design with UML", Second Edition, Pearson, 2005.*
4. *Bend Bruegge and Allen H. Dutoit, "Object Oriented Software Engineering: Using UML, Patterns and Java",Third Edition, PHI, 2000.*
5. *Len Bass, Paul Clements and Rick Kazman, "Software Architecture in Practice" Addison Wesley Professional, 2012.*

16CS704 COMPUTATIONAL STATISTICS 3-0-0-3

Computational Statistics- Probability concepts, Sampling Concepts, Generating Random Variables, Exploratory Data Analysis, Monte Carlo Methods for Inferential Statistics, Data Partitioning, Probability Density Estimation, Statistical Pattern Recognition, Nonparametric

Regression. Data Mining- data mining algorithms-Instance and Features, Types of Features(data), Concept Learning and Concept Description, Output of data mining-Knowledge Representation; Decision Trees- Classification and Regression trees-Constructing. Classification trees, Algorithm for Normal Attributes, Information Theory and Information. Entropy, Building tree, Highly-Branching Attributes, ID3 to c4.5, CHAID, CART, Regression Trees, Model Trees, Pruning. Preprocessing and Post processing in data mining – Steps in Preprocessing, Discretization, Manual Approach, Binning, Entropy- based Discretization, Gaussian Approximation, K-tile method, Chi Merge, Feature extraction, selection and construction, Feature extraction, Algorithms, Feature selection, Feature construction, Missing Data, Post processing. Association Rule Mining- The *Apriori* Algorithm. Multiple Regression Analysis, Logistic Regression, k- Nearest Neighbor Classification, Constructing new attributes for algorithms of decision trees. Induction, Quick, Unbiased and Efficient Statistical tree.

TEXTBOOKS/ REFERENCES:

1. *Wendy L. Martinez and Angel R, "Martinez Computational Statistics," Chapman & Hall/CRC, 2002.*
2. *Ian H. Witten, "Data Mining: Practical Machine Learning Tools and Techniques with Java Implementations", Morgan Kaufmann, 2000.*
3. *Jiawei Han and Micheline Kamber, "Data Mining: Concepts and Techniques," Morgan Kaufmann Publishers, 2001.*
4. *K. P. Soman, V. Ajay and Diwakar Shyam, "Insight into Data Mining: Theory and Practice", Prentice Hall India, 2005.*

16CS705 ADVANCED COMPUTER NETWORKS 3-0-0-3

Review of Computer Networks and Internet: Layered communication architecture: layers, services, protocols, layer entities, service access points, protocol function.

Application layer protocols – World Wide Web: HTTP – File transfer: FTP – Electronic Mail – DNS – SNMP, Internet Applications:- Web Cache, P2P Systems, CDN. Network layer – Review of Internet Addresses, ARP, RARP, IP, Routing algorithm – Routing in the Internet: Intra and inter domain routing; Unicast Routing Protocols: RIP, OSPF, BGP; Multicast Routing Protocols: MOSPF, DVMRP. Drawbacks of traditional routing methods, Idea of TE, TE and Different Traffic classes. IP over ATM, Multi protocol Label switching (MPLS) , Storage Area Networks (SAN). IPv6 – the new version of IP. IP Telephony VoIP – Basics- IP telephone system-protocols and layering-H.323 characteristics and layering, SIP. – Multimedia networking - Quality of Service. Transport layer services and principles – Principles of congestion control. Socket Introduction-address structures-Value-Result Arguments, Byte Ordering function, Byte manipulation functions. Elementary TCP sockets. TCP Client/ Server Model of Interaction and examples. Denial-of-service (DOS) attacks. Impact of wireless technology on transport protocols. Socket Level programming, RPC, High level networking using Java/Python.

TEXTBOOKS/ REFERENCES:

1. *Andrew S. Tanenbaum, "Computer Networks", Fourth Edition, Pearson Education Asia, 2002.*

2. *Douglas E. Comer, "Internetworking with TCP/IP Volume – I", Fifth Edition, Prentice Hall, 2008.*
3. *W. Richard Stevens, Bill Fenner and Andrew M. Rudoff, "Unix Network Programming, Vol.1: The Sockets Networking API", Third Edition, Addison-Wesley Professional, 2003.*
4. *James F. Kurose and Keith W. Ross. "Computer Networking: A Top-Down Approach". Sixth Edition, Addison-Wesley, 2013.*
5. *Huitema, C, Routing in the Internet, Second Edition,, Prentice-Hall, 2000.*

16CS706 COMPILER DESIGN 3-0-0-3

Analysis: Overview of compilation, Scanning: Recognizing words – Regular expressions – From regular expressions to scanner and back – Implementing scanners. Parsing: Expressing syntax – Top-Down parsing - Bottom-up parsing – Building LR(1) tables – Practical Issues – Optimizing a Grammar – Reducing the size of LR(1) tables. Context-Sensitive Analysis: Type systems – Attribute grammar framework – Syntax directed translation – Type inference – Changing associativity. Synthesis: Intermediate Representation: Graphical IRs – Linear IRs- Symbol tables. Procedure Abstraction: Control abstraction – Name spaces – Passing parameters – Returning values – Addressability – Managing memory. Code Shape: Assigning Storage locations – Arithmetic, relational and Boolean operators – Arrays, Strings and Structures – Control flow constructs – Procedure calls. Advanced topics: Code Optimization – Data flow analysis – Scalar optimizations- Instruction selection – Instruction scheduling – Register allocation.

TEXTBOOKS/ REFERENCES:

1. *Keith D. Cooper and Linda Torczon, "Engineering A Compiler", Elsevier, 2004.*
2. *Aho, A.V, Senthil. R and Ullman. J.D. "Compilers: Principles, Techniques and Tools", Addison Wesley, 1986.*
3. *Steven Muchnick. "Advanced Compiler Design Implementation", Morgan Kaufmann, 1997.*
4. *Appel, A. W. "Modern Compiler Implementation in Java", Cambridge University Press,2000.*
5. *Kenneth. C. Louden, "Compiler Construction Principles and Practice", Thomson, 2003.*

16CS707 ENTERPRISE ARCHITECTURE 3-0-0-3

Cloud Computing: The internet as a platform, Software as a service and cloud computing, cloud computing platforms, Cloud Technologies- Virtualization and cloud, Mutitenant Software. Data in the cloud and cloud file systems. Big Data: Map Reduce,Key-value stores, Time & Ordering, HDFS & Hadoop.Classical Distributed algorithms -Leader Election- Bully Algorithm, Mututual Exclusion, Concurrency and Replication Control, Scheduling, Stream Processing, Distributed Graph Processing. Cloud Backbone Systems2P Systems- Resource discovery, Napster, Gnutella & Bitorrent, Multicast, Paxos, Gossip, Membership, Grids, CDN systems.

TEXTBOOKS/REFERENCES:

1.*Gautam Shroff, "Enterprise Cloud Computing: Technology, Architecture, Applications"*, *Cambridge University Press, 2010.*

2.Dan C Marinescu ,"Cloud Computing: Theory and Practice", *Morgan Kaufmann, 2013*

3.Sitaram and Manjunath , "Moving to the Cloud", *Elsevier, 2012.*

4.Tom White , "Hadoop: The Definitive Guide", *O'Reilly Media.2012*

5. http://www.coursera.org/course/cloudcomputing.

16CS708 FOUNDATIONS FOR SIGNAL AND IMAGE PROCESSING 3-0-0- 3

Two-Dimensional Signals and Systems, Separable Signals, Periodic Signals, General Periodicity, 2-D Discrete-Space Systems, 2-D Convolution, Stability in 2-D Systems, 2-D Discrete Space Fourier Transform, Properties, Continuous-Space Fourier Transform, Rotational invariance, Projection-Slice Theorem, Radon Transform. Sampling in Two Dimensions, Nonisotropic Signal Spectra, , General sampling.- 2-D Discrete-Space Transforms, Discrete Fourier Series, Properties, Periodic Convolution, Shifting Property, DFT, Circular Convolution and Shift, Interpolating DFT- 1D and 2D Discrete Cosine Transform, Sub-bands and Discrete Wavelet Transform and relation to filter banks, Ideal and Finite order Filters, Haar Pair, Comparison, FFT, Computation, Sectioned Convolution. Sparse representations - Solving sparse representation problem.-Uniqueness and uncertainty of solutions for sparse representation-compressive sensing theory - Greedy pursuit algorithms. Orthogonal-matching-pursuit. Convex relaxation techniques.- Sparse representation in image processing

TEXTBOOKS/ REFERENCES:

1. *John W. Woods, "Multidimensional Signal, Image, and Video Processing and Coding", Second Edition, , Academic Press, Elsevier Inc. 2012.*
2. *K.P Soman and K I Ramachandran "Insight into Wavelets from Theory to Practice", Third Edition, Prentice Hall of India, 2005.*
3. *J.Mairal, F. Bach and J. Ponce "Sparse Modeling for Image and Vision Processing", , Foundations and Trends R in Computer Graphics and Vision Vol. 8, No. 2-3 (2012) 85–283*
4. *Relevent papers from IEEE Transactions on Signal Processing.*

16CS709 FORMAL METHODS 3-0-0 3

Introduction:

Formal Methods: Specification, Analysis, Verification, Importance for Safety Critical Systems, Propositional and Predicate Logic Specification Languages - Axiomatic Specifications, Algebraic Specifications, Model-based Specifications - Program Verification:- Floyd-Hoare logic and Dijkstra's Weakest Pre-conditions, Partial Correctness and Termination, Structural induction for Recursive Procedures, Data refinement in Z Abstract Data Types, Software Tools: PVS, Isabelle, …-Temporal Logics: - Specifying Concurrent Systems: Safety, Liveness, Fairness, Linear (LTL) and Branching Time (CTL) Logics, Translation from LTL-to-Buchi automata - Fixed Point Characterization of

Temporal Operators - Model Checking:- LTL and CTL model-checking. Analysis of model-checking algorithms - Symbolic model checking; overview of state-space reduction methods, Case study and practical verification of properties, Software Tools: SPIN/Promela Other Topics:- Process Algebras: CCS and Pi-calculus, Simulation and Bisimulation
Timed Automata for Real-time Systems (UPPAAL).

TEXTBOOKS/REFERENCES:

1. *Michael Huth and Mark Ryan, "Logic in Computer Science: Modelling and Reasoning about Systems, Cambridge University Press, 2004.*
2. *E.M. Clarke, O. Grumberg, and D. Peled, "Model Checking", MIT Press, 2000.*
3. *Christel Baier and Joost-Pieter Katoen, "Principles of Model Checking", The MIT Press, 2008.*
4. *J. Woodcock and J. Davies, "Using Z: Specification, Refinement and Proof", Prentice Hall, 1994*.

16CS710 PROGRAM ANALYSIS AND OPTIMIZATION 3-0-0 3

Introduction: compiler structure, architecture and compilation, sources of improvement. Control flow analysis: basic blocks & loops, dominators, control dependence Data flow analysis and optimizations: bit vectors, iterative frameworks, interval analysis, reaching definitions, liveness, common sub expression elimination, constant propagation. Static-single assignment: static-single assignment, constant propagation. Scalar optimization:- loop invariant code motion, common sub expression elimination, strength reduction, dead code elimination, loop optimizations, etc. Instruction scheduling:- pipelined architectures, delayed-load architectures, list scheduling. Register allocation:- coloring, allocation, live range splitting. Inter-procedural analysis: side effects, flow-insensitive, flow-sensitive, constants, in-lining. Alias analysis:- alias analysis, method resolution, Data dependence analysis: dependence testing, dependence graphs. Loop transformation:- interchange, tiling, fusion, distribution, splitting. Advanced topics:- Just-in-time compilation, fast global optimization, Garbage collection, automatic memory management and data locality.

TEXTBOOKS/ REFERENCES:

1. *Steven Muchnick, "Advanced Compiler Design Implementation", Morgan Kaufmann.*
2. *Keith D Cooper and Linda Torczon, "Engineering a Compiler", Morgan Kaufmann.*
3. *Aho, Lam, Sethi and Ullman, "Compilers: Principles, Techniques and Tools", Second Edition, Addison-Wesley, 2007.*
4. *Flemming Nielson, Hanne R. Nielson and Chris Hankin, "Principles of Program Analysis", Springer, 2004*.

16CS711 DATA VISUALIZATION 3-0-0-3

The Computer and the Human Introduction to Visualization-Using computer graphics to display data: 2D Graphics, 2D Drawing, 3D Graphics, photorealism, non-photorealism-The model human processor and Fitts's law: The Human, Memory, Reasoning, The Human Retina-Human visual perception and cognition: Perceiving two dimensions, Perceiving Perspective. Visualization of Numerical Data Different kinds of visualizations: Data, Mapping- Basic charts-More advanced visualization techniques: stream graphs parallel coordinates, Glyphs, stacked graphs-Design and color usage: Tufte's Design Rules, Color. Visualization of Non-Numerical Data Graphs, networks, and hierarchies-Layout of relational and hierarchical data: tree maps, Graph Visualization-Methods for visualizing high-dimensional data: Principal component analysis and multidimensional scaling, Packing. The Visualization Dashboard Visualizing large datasets-Visualization of databases and data mining results-Visual analytics for decision support-Task analysis-Visualization dashboards.

TEXTBOOKS/ REFERENCES:

1. *Tamara Munzner, "Visualization Analysis and Design", AK Peters Visualization series, CRC Press, 2014.*
2. *Colin Ware, "Information Visualization: Perception for Design", Second Edition, Elsevier. The Morgan Kaufmann Publishers, 2004.*

MATHEMATICS ELECTIVES

16MA701 RANDOM PROCESS AND OPTIMIZATION THEORY 3-0-0-3

Review of Probability Concepts and Random Variables - Random Processes: General concepts and definitions-Stationarity in random process- autocorrelation and properties-Poisson points, Poisson and Gaussian processes-Spectrum estimation- Ergodicity and mean Ergodic theorem-Power spectral density and properties. Markov processes –Markov Chains – Transition Probability matrix – Classification of states – Limiting Distributions. Optimization Techniques: Single variable optimization: Optimality criteria – bracketing methods – region elimination methods – point estimation method – gradient based methods. Multivariable optimization: Optimality criteria – unidirectional search – direct search methods – gradient based methods. Lagrangian and Kuhn-Tucker conditions.

TEXTBOOKS/ REFERENCES:

1. *Douglas C. Montgomery and George C. Runger, "Applied Statistics and Probability for Engineers", Third Edition, John-Wiley & Sons Inc., 2003.*
2. *A. Papoulis and Unnikrishna Pillai, "Probability, Random Variables and Stochastic Processes", Fourth Edition, McGraw Hill, 2002.*
3. *J Ravichandran, "Probability and Statistics for Engineers", First edition, Wiley, 2012.*
4. *Scott L. Miller and Donald G. Childers, "Probability and Random Processes", Academic Press, 2012.*

5. *Justin Solomon, "Mathematical Methods for Computer Vision, Robotics, and Graphics", Stanford University, 2013.*

16MA702 OPTIMIZATION THEORY 3-0-0- 3

Mathematical optimization, Linear programming, Least squares, convex and non-linear optimization, Convex sets, Convex optimization Problems, Optimization problem in standard form, Quasi-convex optimization, linear optimization, quadratic optimization, inequality constraints, Semi definite programming, vector optimization. Duality, approximation and fitting, statistical estimation, geometric problems, Unconstrained minimization, gradient descent method, steepest descent method, Newton's method, Equality constrained minimization, eliminating equality constraints, Newton's method with equality constraints, Interior point method,L1 norm optimization methods.

TEXTBOOKS/ REFERENCES:

1 *S.S. Rao, "Optimization Theory and Applications", Second Edition, New Age International (P) Limited,1995.*
2 *Kalynmoy Deb, "Optimization for Engineering Design Algorithms and Examples", PHI, New Delhi, 2004.*
3 *Edwin, K.P., Chong and Stanislaw H. Zak, "An introduction to Optimization", Second Edition, Wiley-Interscience in Discrete Mathematics and Optimization, 2004.*

16MA703 ADVANCED LINEAR ALGEBRA 3-0-0-3

Vector Spaces, Norms, Orthogonality, Matrix Multiplication Problems, Matrix Analysis, Linear Systems, Orthogonalizations and Least squares, Parallel Matrix Computations,The unsymmetric Eigenvalue problem, Symmetric eigen value problem, Iterative methods for linear systems, Lanczos methods.

TEXTBOOKS/ REFERENCES:

1. *Golub and Loan, "Matrix Computations", Third Edition, John Hopkins University Press, 1996.*
2. *Carl. D. Meyer, "Matrix Analysis and Applied Linear Algebra", SIAM.,2000.*

16CS712 RANDOMIZED ALGORITHMS 3-0-0 3

Introduction – Min-Cut algorithm, Las Vegas and Monte Carlo, Binary Planar partitions, A probabilistic recurrence, Computational Model and Complexity Classes. Game Theoretic Techniques – Game tree evaluation, Mini-Max pr inciple, Randomness and Non-uniformity. Moments and Deviations – Occupancy problems, Markov and Chebyshev inequalities, Randomized selection, two-point sampling, stable marriage problem, coupon collector's problem.Probabilistic method – Overview, Maximum satisfiability, oblivious routing.Markov chains and random walks – 2-SAT, Markov chains, Random walks on graphs. Algebraic techniques – Fingerprinting and Freivalds' techniques, Verifying

polynomial identities and equality of strings, perfect matchings in graphs, pattern matching, PCP and efficient proof verification. Applications: Brief introduction to: data structures, geometric algorithms, linear programming, graph algorithms, approximate counting, parallel and distributed computing, online algorithms, number theory and algebra.

TEXTBOOKS/ REFERENCES:

1. *Rajeev Motwani and Prabhakar Raghavan. "Randomized Algorithms", First Edition, Cambridge University Press India, 1995.*
2. *Cormen T H, Leiserson C E, Rivest R L and Stein C, "Introduction to Algorithms", Third Edition, Prentice Hall of India Private Limited, 2011.*

16CS713 NETWORKS AND SPECTRAL GRAPH THEORY 3-0-0-3

Graphs and Networks: Review of basic Graph Theory - Digraphs-Maximal flow and minicut Algorithm. Matching and Assignments. Social networks: the web graph, the internet graph, citation graphs, planar graphs. Graph based network topologies-diameter and girth. The structure of complex networks- Definitions - Clustering -Motifs - Community structures -. Graph spectra. Networks models - Random graphs , Generalized random graphs ,Weighted networks - The Internet and the World Wide Web - Structure of the Internet – Structure of the World Wide Web- Metabolic, protein, and genetic networks - Brain networks -- Algorithms for finding community structures - Spectral graph partitioning – Hierarchical clustering -- The algorithm by Girvan and Newman -- Fast methods based on the modularity- Methods based on spectral analysis -Navigation and searching - Searching with local information - Network navigability. Spectral Graph theory.

TEXTBOOKS/ REFERENCES:

1. *Dougles West, "Introduction to Graph Theory", Second Edition, PHI Learning Private Limited, 2011.*
2. *Guido Caldarelli, "Scale-Free Networks", Oxford University Press, 2007.*
3. *Alain Barrat, Marc Barthelemy and Alessandro Vespignani, "Dynamical Processes on Complex Networks", Cambridge University Press, 2008.*
4. *Reuven Cohen and Shlomo Havlin, "Complex Networks: Structure, Robustness and Function", Cambridge University Press, 2010.*
5. *M.E.J. Newman, "Networks: An Introduction", Oxford University Press, 2010.*

STREAM BASED ELECTIVES

ELECTIVES-II, III and IV

STREAM-I MACHINE LEARNING AND DATA SCIENCE

16CS714 MACHINE LEARNING FOR BIG DATA 3-0-0- 3

Concept of Machine learning, , MapReduce and the New Software Stack, Finding similar items, Mining Data Streams, Review of Graphical model structure learning, Link Analysis, Frequent Itemsets, Sparse Linear models, Gaussian processes, Markov and HMMs, Clustering, Inference for graphical models, Variational Inference, Monte Carlo Inference, Latent variable models for discrete data, Deep Learning.

TEXT BOOKS/ REFERENCES:

1. *Anand Rajaraman, Jure Leskovec and J.D. Ullman, "Mining of Massive Data Sets", e-book, Cambridge University Press, 2014.*
2. *Kevin P. Murphey, "Machine Learning, a Probabilistic Perspective", The MIT Press Cambridge, Massachusetts, 2012,*
3. *Tom Mitchael, "Machine Learning", McGraw Hill, 1997.*

16CS715 FOUNDATIONS OF DATA SCIENCE 3-0-0-3

Introduction, High dimensional space, Random Graphs, Singular Value Decomposition, Random walks and Markov Chains, Learning and VC dimensions, Algorithms for Massive data problems, Clustering ,CURE algorithm – ROCK algorithm - The Chameleon Algorithm –DBSCAN Algorithm - DBCLASD Algorithm - DENCLUE Algorithm – Clustering algorithms for high dimensional data ,Topic model, Hidden Markov process,, Graphical models, Belief propagation, Sparse models.

TEXT BOOKS/ REFERENCES:

1. *John Hopcroft and Ravi Kannan, "Foundations of Data Science", e-book, Publisher, 2013.*
2. *Kevin P. Murphey, "Machine Learning, a Probabilistic Perspective", The MIT Press, Cambridge, Massachusetts, 2012.*
3. *Wes McKinney, "Python for Data Analysis: Data Wrangling with Pandas, NumPy, and IPython", O'Reilly Media, 2012.*
4. *Vignesh Prajapati "Big Data Analytics with R and Hadoop", Publisher: Packt Publishing (November 25, 2013), Language: English, ISBN-10: 178216328X, ISBN-13: 978-1782163282.*
5. *Chris Eaton, Et.al. , "Understanding Big Data", McGraw-Hill 2012, ISBN/ASIN: 071790535, ISBN-13: 9780071790536.*

16CS716 APPLICATIONS OF MACHINE LEARNING 3-0-0-3

Review of machine learning Concepts, Advertising on the Web, Recommendation Systems, Mining Social network graphs, Dimensionality reduction, Large scale Machine learning, Sparse models, State space models, Markov random Fields, Review of Inference for

graphical models, Latent Linear and Variable models for discrete data, random algorithms in Computational Linear algebra. Applications/case study in Image processing.

TEXTBOOKS/ REFERENCES:

1. *Anand Rajaraman, Jure Leskovec and J.D. Ullman, "Mining of Massive Data sets", e-book, Publisher, 2014.*
2. *Kevin P. Murphey, "Machine Learning, a Probabilistic Perspective", The MIT Press Cambridge, Massachusetts, 2012,*
3. *Selected papers.*

16CS717 STATISTICAL LEARNING THEORY 3-0-0-3

Overview of Supervised Learning, Basis Expansions and Regularization, Kernel smoothing, Model assessment and Selection, Model Inference, Additive Models, Trees & Related Methods, Boosting and Additive Trees, Support Vector Machines and Flexibilities, Prototype methods and Nearest Neighbors, Unsupervised Learning, Ensemble Learning, Undirected graphical Models, High dimensional Problems.

TEXTBOOKS/ REFERENCES:

1. *Trevor Hastie, Robert Tibshirani and Jerome Friedman, "Elements of Statistical Learning" Second Edition, Springer, 2008.*

16CS718 NATURAL LANGUAGE PROCESSING 3-0-0-3

Introduction and Mathematical foundations: Elementary probability theory – Essential information theory. Linguistic essentials: Part of speech and morphology – Phrase structure. Corpus based work: Looking up text - Marked-up data. Statistical inference: Bins: Forming equivalence classes - Statistical Estimators – Combining Estimators. Word Sense Disambiguation: Supervised and Dictionary based Disambiguation. Markov Models: Hidden Markov Models – Implementation - Properties and Variants. Part of Speech Tagging: Hidden Markov Model Taggers - Transformation based Learning of Tags - Tagging accuracy and use of Taggers. Probabilistic Context free grammars and Probabilistic parsing. Statistical alignment and Machine translation: Text alignment – Word alignment – Statistical Machine Translation.

TEXTBOOKS/ REFERENCES:

1. *Christopher D. Manning and Hinrich Schutze, "Foundations of Statistical Natural Language Processing", MIT Press, 1999.*
2. *Daniel and James H. Martin "Speech and Language Processing: An Introduction to Natural Language Processing, Computational Linguistics and Speech Recognition", Second Edition, Prentice Hall of India, 2008.*
3. *James Allen, "Natural Language Processing with Python", First Edition, O'Reilly Media, 2009.*

16CS719 INFORMATION RETRIEVAL 3-0-0- 3

Introduction to IR: Space Retrieval Models - Ranked Retrieval - Text Similarity Metrics - Tokenizing- stemming-Evaluations on benchmark text collections - Components of an information retrieval system. Indexing for IR: Inverted Indices - Postings lists - Optimizing indices with skip lists - Proximity and phrase queries - Positional indices - Dictionaries and tolerant retrieval - Dictionary data structures - Wild-card queries- n-gram indices - Spelling correction and synonyms - Edit distance - Index construction - Dynamic indexing - Distributed indexing - real-world issues. Relevance in IR: Parametric or fielded search - Document zones - Vector space retrieval model - tf.idf weighting - queries as vectors - Computing scores in a complete search system - Efficient scoring and ranking - Evaluation in information retrieval : User happiness- Creating test collections: kappa measure- interjudge agreement - Relevance feedback and query expansion: Query expansion - Automatic thesaurus generation - Sense-based retrieval -. Document Classification and Clustering: Introduction to text classification -Latent Semantic Indexing.

TEXTBOOKS/ REFERENCES:

1. *C. Manning, P. Raghavan, and H. Schütze, "Introduction to Information Retrieval", Cambridge University Press, 2008.*
2. *R. Baeza-Yates and B. Ribeiro Neto,"Modern Information Retrieval: The Concepts and Technology behind Search", Second Edition, Addison Wesley, 2011.*
3. *David A. Grossman and Ophir Frieder "Information Retrieval: Algorithms and Heuristics", Second Edition, Springer 2004.*

16CS720 DATA MINING AND BUSINESS INTELLIGENCE 3-0-0-3

Introduction: Evolution and importance of Data Mining-Types of Data and Patterns mined-Technologies-Applications-Major issues in Data Mining. Knowing about Data- Data Preprocessing: Cleaning– Integration–Reduction–Data transformation and Discretization. Data Warehousing: Basic Concepts-Data Warehouse Modeling- OLAP and OLTP systems - Data Cube and OLAP operations–Data Warehouse Design and Usage-Business Analysis Framework for Data Warehouse Design- OLAP to Multidimensional Data Mining. Mining Frequent Patterns: Basic Concept – Frequent Item Set Mining Methods - Mining Association Rules – Association to Correlation Analysis. Classification and Predication: Issues - Decision Tree Induction - Bayesian Classification – Rule Based Classification – k-Nearest mining Classification. Prediction –Accuracy and Error measures. Clustering: Overview of Clustering – Types of Data in Cluster Analysis – Major Clustering Methods. Introduction to BI -BI definitions and concepts- BI Frame work-Basics of Data integration-Introduction to Business Metrics and KPI - Concept of dash board and balance score card. Tool for BI: Microsoft SQL server: Introduction to Data Analysis using SSAS tools-Introduction to data Analysis using SSIS tools- Introduction to Reporting Services using SSRS tools- Data Mining Implementation Methods.

TEXTBOOKS/ REFERENCES:

1. *Jiawei Han, Micheline Kamber and Jian Pei, "Data Mining Concepts and Techniques", Third Edition, Elsevier Publisher, 2006.*
2. *K.P.Soman, Shyam Diwakar and V.Ajay, "Insight into Data Mining Theory and*

Practice", PHI of India, 2006.
3. *Loshin D, "Business Intelligence", First Edition, Elsevier Science, 2003.*
4. *Darren Herbold, Sivakumar Harinath, Matt Carroll, Sethu Meenakshisundaram, Robert Zare and Denny Guang-Yeu Lee, "Professional Microsoft SQL Server Analysis Services 2008 with MDX", Wrox, 2008.*
5. *Brian Knight and Erik Veerman, Grant Dickinson and Douglas Hinson, "Professional SQL Server 2008 Integration Services", Wiley Publishing, Inc, 2008.*

16CS721 SEMANTIC WEB 3-0-0-3

Introduction to Semantic Web: Semantic Web Concepts- Need for the Semantic Web- Information Overload - Stovepipe Systems - Poor Content Aggregation - XML and the Semantic Web - Web Services and the Semantic Web - Current Applications of the Semantic Web - Business Case for the Semantic Web Decision Support - Business Development-Information Sharing and Knowledge. XML and Web Services: XML Basics - Well-Formed and Valid Documents - XML Schema - XML Namespaces - Document Object Model (DOM) - Use of Web Services - Basics of Web Services - SOAP – UDDI. Understanding the Resource Description Framework: - Capturing Knowledge with RDF - Other RDF Features - RDF Schema – Non-contextual Modeling. Taxonomies: Overview of Taxonomies - Use of Taxonomies - Defining the Ontology Spectrum - Thesaurus, Logical Theory - Ontology - Topic Maps Standards and Concepts – Occurrence – Association - Subject Descriptor – Scope. Ontologies: Overview of Ontologies - Ontology Example – Definitions – Syntax – Structure – Semantics - and Pragmatics - Expressing Ontologies Logically - Ontology and Semantic Mapping Problem. Knowledge Representation: Languages - Formalisms, Logics - Semantic Networks, Frame-Based KR, and Description Logics - Ontology Design and Management using the Protege editor - Ontology Reasoning with Pellet, Ontology Querying with SPARQL - Ontology Programming with the Jena API - Emerging Semantic Web Ontology Languages using Protégé tool.

TEXTBOOKS/ REFERENCES:

1. *Michael C. Daconta, Leo J. Obrst, and Kevin T. Smith, "The Semantic Web: A Guide to the Future of XML, Web Services, and Knowledge Management", Fourth Edition, Wiley Publishing, 2003.*
2. *John Davies, Rudi Studer, and Paul Warren John, "Semantic Web Technologies: Trends and Research in Ontology-based Systems", Wiley and Son's, 2006.*
3. *John Davies, Dieter Fensel and Frank Van Harmelen, "Towards the Semantic Web: Ontology-Driven Knowledge Management", John Wiley and Sons, 2003.*

STREAM-II ARCHITECTURE AND SYSTEMS

16CS722 HARDWARE SOFTWARE CO-DESIGN 3-0-0-3

Introduction to system level design, Models of computation, Architectural selection, Partitioning, scheduling and communication, Simulation, synthesis and verification,

Implementation case studies, Performance analysis and Optimization retargetable code generation, FPGAs.

TEXTBOOKS/ REFERENCES:

1. *Patrick R. Schaumont, "A Practical Introduction to Hardware / Software Co-design", Springer India, 2010.*
2. *Jorgen Stanstrup and Wayne Wolf, "Hardware / Software Co-design: Principle and Practice", Kluwer Academic, 1997.*
3. *Giovanni De Micheli, "Readings in Hardware Software Co-design", Morgan Kaufmann, 2002.*
4. *Sao-Jie Chen, Guang-Huei Lin, Pao-Ann Hsiung and Yu-Hen Hu, "Hardware Software Co-Design of a Multimedia SOC Platform", Springer, 2010.*
5. *Joris van den Hurk and Jochen A.G. Jess, "System Level Hardware/Software Co-Design: An Industrial Approach", Springer, 1998.*

16CS723 PARALLEL COMPUTER ARCHITECTURE 3-0-0-3

Models of parallel computation. Superscalar architecture. Shared memory parallel machines. Interconnection networks and their topological properties. Massively parallel computers. Hypercube architectures. Performance measurement for parallel algorithms. Parallel evaluation of expressions. Parallel searching and data structures. Parallel algebraic and geometric processing.

TEXTBOOKS/ REFERENCES:

1. *David Culler, J.P. Singh and Anoop Gupta, "Parallel Computer Architecture: A Hardware Software Approach", First Edition, Morgan Kaufmann; 1998.*
2. *John P. Shen and Mikko Lipasti, "Modern Processor Design: Fundamentals of Superscalar Processors", McGraw Hill, 2004.*
3. *Muhammad Yasir Qadri and Stephen J. Sangwine (Eds), "Multicore Technology: Architecture, Reconfiguration and Modelling", CRC Press, 2013.*
4. *Stephen W., Keckler, Kunle Olukotun, and H. Peter Hofstee, (Eds), "Multicore Processors and Systems", Springer, 2009.*

16CS724 RECONFIGURABLE COMPUTING 3-0-0-3

General overview of computing models, Basic RC concepts, Performance, power, size, and other metrics, RC devices and architecture: FPGA computing platforms, Design tools and languages: HDLs, Synthesis, PAR, HLL and HLS, RC application development, domains and case studies, Special topics in RC: Middleware, Fault tolerance, Partial reconfiguration, device characterization.

TEXTBOOKS/ REFERENCES:

1. *Scott Hauck and Andre DeHon, "Reconfigurable Computing: The Theory and Practice of FPGA-Based Computation", Morgan Kaufmann (Elsevier), 2008.*
2. *M. Gokhale and P. Graham, "Reconfigurable Computing: Accelerating Computation with Field-Programmable Gate Arrays", Springer, 2005.*

3. C. Maxfield, "The Design Warrior's Guide to FPGAs", Newnes, 2004.

16CS725 ADVANCED OPERATING SYSTEMS 3-0-0-3

Review of OS, Design approaches, Types, Issues, Communication Networks, Communication Primitives, Limitations; Distributed Mutual Exclusion: Lamport, Recart-agrawala, and Maekawa's algorithms; Suzuki-kasami broadcast algorithm, and Raymond's tree based algorithm; Distributed Deadlock Detection: Resource Vs. Communication deadlock, Strategies to handle deadlock, Ho-Ramamoorthy, Path-Pushing, Edge-Chasing, Diffusion Computation-based algorithms; Agreement Protocols: Classification of agreement problems, Solutions to Byzantine agreement problems; Distributed File Systems: Design Issues, Sun DFS, and Sprite DFS; Distributed Scheduling: Issues in Load Distribution, Load Distribution Algorithms, V-system, Sprite, and Condor; Distributed Shared Memory: Algorithms for implementing DSMs, Memory Coherence, and Coherence Protocols; Classification of failures, Synchronous and Asynchronous Check pointing and Recovery; Fault Tolerance: Commit Protocols, Voting Protocols, Failure Resilient Processes; Protection and Security: Access Matrix Model, Implementation of access matrix, Unix, and Amoeba, Introduction to Data Security.

TEXTBOOKS/ REFERENCES:

1. *M. Singhal and N. Shivaratri, "Advanced Concepts in Operating Systems: Distributed, Database and Multiprocessor Operating Systems", Tata McGraw Hill, 2011.*
2. *George Coulouris, Jean Dollimore, Tim Kindberg and Gordon Blair, "Distributed Systems: Concepts and Design",Fifth Edition, Addison Wesley, 2011.*
3. *Andrew S Tanenbaum, "Distributed Operating Systems", Pearson Education, 2009.*
4. *Pradeep K Sinha, "Distributed Operating Systems: Concepts and Design", PHI Learning, 2009.*
5. *Jie Wu, "Distributed System Design", CRC Press, 1998.*

16CS726 CRITICAL SYSTEMS AND VERIFICATION 3-0-0-3

The course will cover the following concepts: Computers in critical application, safety criteria, Hazard Analysis, Risk analysis, Developing safety-critical systems, Fault Tolerance, System reliability, Safety-critical hardware, Safety-critical software, Programmable logic controllers, Formal methods, Verification, validation, and testing, Quality management, case study.

Faculty will assign state of the art reading material/reference books at the beginning of the semester.

16CS727 COMPILER OPTIMIZATION TECHNIQUES AND DESIGN 3-0-0-3

Overview of optimizing compilers, Graph structures for control flow analysis of programs, Data flow analysis of programs, Static Single Assignment form, Data Dependence of programs, Program Dependence Graph, Scalar Optimizations, Optimization based on Static

Single Assignment, Loop Optimizations, Register Allocation, Instruction Scheduling, Case studies of compilers and future trends.

TEXTBOOKS/ REFERENCES:

1. *Steven S. Muchnick, "Advanced Compiler Design & Implementation", Morgan Kaufmann (Elsevier India), 1997.*
2. *Randy Allen and Ken Kennedy, "Optimizing Compilers for Modern Architectures", Morgan Kaufmann, 2001.*
3. *Michael Wolfe, "High Performance Compilers for Parallel Computing" , Addison-Wesley, 1995.*
4. *Y.N. Srikant and Priti Shankar, "The Compiler Design Handbook: Optimizations & Machine Code Generation", CRC Press, 2002.*

16CS728 COMPUTER SYSTEMS' PERFORMANCE ANALYSIS 3-0-0-3

Computer Processing and Architecture, Performance Measurement techniques, Workload Selection and Characterization, Fundamentals of Probability Theory and Statistics, Analysis of Sample Data including Regression Analysis, Performance Modeling, Experimental Design and Analysis, Simulation, Queuing Theory, Test beds and study of evaluation tools.

TEXTBOOKS/ REFERENCES:

1. *Paul J. Fortier and Howard E. Michel, "Computer Systems Performance Evaluation and Prediction", Elsevier, 2003.*
2. *Raj Jain, "The Art of Computer Systems Performance Analysis," John Wiley and Sons, 2007.*

16CS729 PARALLEL PROGRAMMING 3-0-0-3

Parallel computer architecture concepts, Produce-consumer problem, Principles of parallel programming: Mutual Exclusion, Concurrency, principles of parallel Algorithms, PRAM model, Parallel time-cost-speedup. Amdahl's law- Gustaffson Law. Brent's Theorem, Scalability, NC, Basic data –parallel algorithmic building blocks, Parallel divide and conquer, Shared memory programming, Programming with P-threads and OpenMP, Memory system performance, Cache coherency and synchronization, Spin locks, Contention issues, Transactional memory, Message passing and MPI, parallel sorting, GPU architecture and programming

TEXTBOOKS/ REFERENCES:

1. *Ananth Grama, George Karypis, Vipin Kumar, and Anshul Gupta, "Introduction to Parallel Computing", Second Edition, Addison-Wesley, 2003.*
2. *Barry Wilkinson and Michael Allen, "Parallel Programming Techniques and Applications Using Networked Workstations, and Parallel Computers", Second Edition, Prentice Hall, 2004.*

3. Timothy G. Mattson, Beverly A. Sanders and Berna L. Massingill, "Patterns for Parallel Programming", Addison-Wesley, 2004.

16CS730 HIGH PERFORMANCE COMPUTING 3-0-0-3

The following concepts/ topics will be covered in this course:
Hadoop, CUDA. Cloud Computing, Parallel Programming, include (OPENCL), Autonomic Computing, Green Computing, Pervasive Computing, Virtualization, Smart Grids.

NOTE: The course will be based on project reports, review articles, published articles in journals and book chapters. It will also involve semester long mini projects involving programming, implementation, testing performance analysis etc. in different application specific contexts. The group projects will be closely guided by instructor on a weekly basis. . Students will use simulations tools as well. Students will be required to make one in-class presentation at the end of the semester. Lectures will be reinforced with lab exercises.

STREAM-III NETWORKS AND INTELLIGENT SYSTEMS

16CS731 MOBILE NETWORKS 3-0-0-3

Cellular Networks – First and Second Generation Cellular Systems – Cellular communications from 1G to 3G - Roadmap for higher data capability in 3G. 4G networks - Future of Wireless Networks – Standardization.
Teletraffic Engineering – Traffic Usage – Data Collection – Traffic Types – Blocking formulas - Radio Propagation –Characteristics of Wireless Channels – Signal Finding Statistics - Propagation Path Models – Digital Communication and Transmission – Baseband Systems – Sampling Process – Voice Communication – Pulse Code Modulation – Shannon Limit – Nyquist Bandwidth – OSI Model.
Cellular Communications – Multi Access Techniques – Architecture of wireless wide-area network – Speech coding and channel coding – Modulation schemes – Antennas, Diversity, and Link Analysis – Spread Spectrum and CDMA Systems.
Mobility Management in Wireless Networks – Security in Wireless Networks – Mobile Network and mobile Transport Layer – Wireless Area networks (GSM) – Wide area Wireless Netowrks (CDMAOne) – Planning and Design of wireless area networks – Wireless Application Protocol (WAP), Wireless Application Architecture – Wireless Personal Area Network (Bluetooth) – Wireless Local Area Networks – IEEE 802.11 WLAN

TEXTBOOKS/ REFERENCES:

1. Vijay.K.Garg, "Wireless Communications and Networking", Morgan Kaufmann 2010.
2. Jochen Schiller, "Mobile Communications", Second Edition, Pearson Education, 2008.
3. Raj Kamal, "Mobile Computing", Oxford University Press.,2007.

CS732 PRINCIPLES OF SOFTWARE DEFINED NETWORKS 3-0-0-3

Introduction: Networking Basics - Naming and Addressing - Distributed and centralized Control Plane and Data Plane. SDN software stack- Open Flow Architectures - Open Flow Switches - NOX/ POX controllers - Flow Visor. SDN Languages like Pyretic - Frentic and Maple. Applications like Data centers - Migration/Network virtualization - WAN Engineering. Abstractions: Distributed Protocols - Routing - Traffic Engineering - Declarative Networking. Updates - Verification-Static and Run-time Analysis like Veriflow - header space - verified compilers. Synthesis - Certified Programming. Advanced Topics: Middle boxes- SIMPLE - ClickOS - Slick - FlowTags - OpenMB. Security - FortNOX - FRESCO - AvantGuard. Wireless Networks – OpenRadio - SoftRAN - SoftCell.

TEXTBOOK/ REFERENCES:

1. *Thomas D. Nadeau and Ken Gray, "SDN: Software Defined Networks", O'Reilly Media, August, 2013. ISBN: 978-1-4493-4230-2.*
2. *Siamak Azodolmolky, "Software Defined Networking with Open Flow", Packt Publishing, 2013.*
3. *Vishal Shukla, "Introduction to Software Defined Networking - OpenFlow & VxL", Create Space Independent Publishing Platform, 2013.*

16CS733 WIRELESS SENSOR NETWORKS 3-0-0-3

Introduction: Single node Architecture- Network Architecture - Layered and clustered Architecture - Sensor network scenarios - design principles and service interfaces - Overview of areas in Sensor networks – Localization and tracking - topology control - MAC protocols - Routing - data dissemination - clock synchronization - lifetime maximization and resource management. Physical Layer: Channel and transceiver design principles - MAC Layer: Low duty cycle protocols and wakeup concepts – STEM - S-MAC - T-MAC - B-MAC - Mediation device protocol - Wake concepts. Contention-based protocols – CSMA - PAMAS. Schedule based protocols - SMACS - LEACH - TRAMA - EAR - Hybrid TDMA / FDMA. IEEE 802.15.4 MAC. Link Layer. Naming and Addressing - Topology control: Flat network topologies - Hierarchical networks by dominating sets and clustering - Combining hierarchical topologies and power control - Adaptive node activity. Data Dissemination: Flat – Flooding - Gossiping - Rumor routing - nsor protocols for information via negotiation - Directed diffusion. QoS based - Sequential assignment routing. Location based - Geographic hash table - Unicast routing: greedy distance routing. Hierarchical – LEACH. Data-centric and content-based networking - Transport protocols: QoS in wireless sensor networks - Coverage and deployment - Reliable data transport - Block delivery - Congestion control and rate control.

TEXTBOOKS/ REFERENCES:

1. *Holger Karl and Andreas Willig, "Protocols and Architectures for Wireless Sensor Networks", John Wiley & Sons Ltd., 2005.*
2. *Feng Zhao and Leonidas J. Guibas, "Wireless Sensor Networks: An Information Processing Approach", Morgan Kaufmann, 2004.*
3. *C S Ragavendra, KM Shivalingam and T Zanti, "Wireless Sensor Networks", Springer, New York, 2004.*

16CS734 WIRELESS NETWORKS 3-0-0-3

Mobile vs Wireless. Issues and Trends: History - Hype cycle of the year - Market scenario - latest technologies. Wireless Physical Layer: Electromagnetic Spectrum - Time and Frequency Domain - Decibels - Coding Terminology - Phase-Shift Keying (PSK) - QAM - Antenna - Reflection - Diffraction - Scattering - Multipath Propagation - Doppler Shift - Channel Capacity - Shannon's Theorem - Error correction - CDMA - Spread spectrum - Wireless Radio Channel Model - Path Loss - d^{-4} Power Law - Small Scale Fading - Large Scale Fading - Shadowing - Path Loss - Noise - Interference Limited Systems - Fresnel Zones - Link Budget - Multipath Power Delay Profile - Tapped Delay Line Model - Doppler Spread - Empirical Channel Models - Multi-Antenna Systems - OFDM Wireless Local Area Networks: WiFi - IEEE 802.11 Features - IEEE 802.11 Physical Layers - IEEE 802.11 MAC - IEEE 802.11 Priorities - Time Critical Services - synchronization - power management - roaming - various 802.11 standards and significance. Ad-hoc Networks: Characteristics - Applications - Issues - Media Access Control - Requirements - Classification of Routing Protocols - Dynamic Source Routing - Ad -hoc On-Demand Distance Vector. Wireless Personal Area Networks: IEEE 802.15 standard - Bluetooth-operational states - packet format - Piconet - protocol stack - profile. Ultra-Wideband. Introduction to Sensor Networks and mesh networks – ZigBee - RFID and NFC

TEXTBOOKS/ REFERENCES

1. *Jochen Schiller, "Mobile Communications", Second Edition, Pearson Education, 2008.*
2. *Dr. Sunilkumar, et.al "Wireless and Mobile Networks: Concepts and Protocols", Wiley India, 2010.*
3. *Vijay.K.Garg, "Wireless Communications and Networking", Morgan Kaufmann, 2010.*
4. *Matthew S.Gast, "802.11 Wireless Networks", SPD O'REILLY.*
5. *Ivan Stojmenovic, "Handbook of Wireless Networks and Mobile Computing", Wiley, 2007.*

16CS735 PERVASIVE COMPUTING 3-0-0-3

Basics: Some Computer Science Issues in Ubiquitous Computing, Pervasive Computing: Vision and Challenges, Naming and Service Discovery: The Design and Implementation of an Intentional Naming System. Dealing with Location: Providing Location Information in a Ubiquitous Computing Environment, The Cricket Compass for Context-Aware Mobile

Applications. Mobile Data Access: Balancing Push and Pull for Data Broadcast, Rover: A Toolkit for Mobile Information Access, Agile Application-Aware Adaptation for Mobile Computing, the Roma Personal Metadata Service.
Consistency Management, Mobile Networking: Scalable Support for Transparent Host Internetworking, A Comparison of Mechanisms for Improving TCP Performance over Wireless Networks, An End-to-End Approach to Host Mobility, Reliable Network Connections Distributed File Systems: Exploiting Weak Connectivity for Mobile File Access, Automated Hoarding for Mobile Computers, Personal RAID: Mobile Storage for Distributed and Disconnected Computers Energy Management, Sensor Networks: Mobile Networking for "Smart Dust", Building Efficient Wireless Sensor Networks with Low-Level Naming, Fine-Grained Network Time Synchronization Using Reference Broadcasts Security: The Resurrecting Duckling: Security Issues for Ad-Hoc Wireless Networks, Zero-Interaction Authentication, SPINS: Security Protocols for Sensor Networks, Toward Speech-Generated Cryptographic Keys on Resource-Constrained Devices

TEXTBOOKS/ REFERENCES:

1. *Jochen Burkhardt , Dr Horst Henn ,Stefan Hepper ,Klaus Rindtorff and Thomas Schaeck "Pervasive Computing: Technology and Architecture of Mobile Internet Applications" Addison Wesley Publisher, 2002.*
2. *Sumi Helal "The Landscape of Pervasive Computing Standards", ISBN 1598299263, Morgan and Claypool Publishers, 2010.*
3. *Selected Papers.*

16CS736 AGENT BASED INTELLIGENT SYSTEMS 3-0-0-3

Artificial Intelligence: Introduction - Intelligent Agents. Problem Solving: Solving Problems by Searching – Beyond Classical Search – Adversarial Search – Constraint Satisfaction Problems. Knowledge, Reasoning and Planning: Logical Agents – First Order Logic – Inference in First Order Logic – Classical Planning – Planning and Acting in the Real World –Knowledge Representation. Uncertain Knowledge and Reasoning: Quantifying Uncertainty – Probabilistic Reasoning - Making Simple Decisions. Learning: Learning from Examples – Knowledge in Learning – Reinforcement Learning. Communicating, Perceiving and Acting: Introduction - Types. AI the Present and Future. Case Study: Web based agents – Negotiating agents - Artificial Intelligence Applications and Programming - Agents in Google Search Engine - Agent implementation in Prolog / LISP.

TEXTBOOKS/ REFERENCES:

1. *Stuart Russell and Peter Norvig, "Artificial Intelligence – A Modern Approach", Third Edition, Prentice Hall, 2009.*
2. *Nils J. Nilsson, "The Quest for Artificial Intelligence", Second Edition, Cambridge University Press, 2009.*

STREAM IV COMPUTER VISION

16CS737 PRINCIPLES OF DIGITAL IMAGE PROCESSING 3-0-0-3

Image enhancement in spatial domain-basic gray level transforms, Histogram, histogram processing- equalization, Matching & color histogram. Enhancement using arithmetic/logic operations, spatial filtering, smoothing spatial filtering, Sharpening spatial filtering Smoothing frequency domain filtering, sharpening frequency domain Image Transforms -- Linear Discrete Image Transforms- The Fourier transforms, Discrete cosine transform, Wavelet transform -Morphological Image processing- restoration- Color Image Processing: Segmentation - Thresholding – Edge-Based Segmentation – Region Based Segmentation Mean Shift – Active Contour Models – Geometric Deformable Models – Fuzzy Connectivity – 3D Graph Based Image Segmentation – Graph Cut Segmentation - Optimal Surface segmentation-Shape Representation and Description: Hough Transform – Feature Detection and matching -Contour Based and Region Based Shape representation and Description – Feature descriptors-SIFT,SURF,GLOH-matching and tracking Motion Estimation Optical Flow Segmentation -Recognition(Applications as Case studies).

TEXTBOOKS/ REFERENCES:

1. *Richard Szeliski, "Computer Vision: Algorithms and Applications", Springer, 2011.*
2. *Milan Sonka, Vaclav Hlavac and Roger Boyle, "Image Processing, Analysis and Machine Vision", Third Edition, Cengage Learning, 2007.*
3. *Rafael C. Gonzalez and Richard E. Woods, "Digital Image Processing", Third Edition, Pearson Education, 2009.*
4. *William K. Pratt, "Digital Image Processing", Fourth Edition, Wiley Interscience, 2007.*

16CV702 VIDEO ANALYTICS 3-0-0-3

Introduction: Video Analytics. Computer Vision: Challenges- Spatial Domain Processing – Frequency Domain Processing-Background Modeling-Shadow Detection-Eigen Faces - Object Detection-Local Features-Mean Shift: Clustering, Tracking - Object Tracking using Active Contours – Tracking & Video Analysis: Tracking and Motion Understanding – Kalman filters, condensation, particle, Bayesian filters, hidden Markov models, change detection and model based tracking- Motion estimation and Compensation-Block Matching Method, Hierarchical Block Matching, Overlapped Block Motion and compensation,Pel-Recursive Motion Estimation, -Mesh Based Method, Optical Flow Method - Motion Segmentation-Thresholding for Change Detection, Estimation of Model parameters - Optical Flow Segmentation-Modified Hough Transform Method- Segmentation for Layered Video Representation-Bayesian Segmentation-Simultaneous Estimation and Segmentation-Motion Field Model - Action Recognition - Low Level Image Processing for Action Recognition: Segmentation and Extraction, Local Binary Pattern, Structure from Motion - Action Representation Approaches: Classification of Various Dimension of Representation, View Invariant Methods, Gesture Recognition and Analysis, Action Segmentation. **Case Study:** Face Detection and Recognition, Natural Scene Videos, Crowd Analysis, Video Surveillance, Traffic Monitoring, Intelligent Transport System

TEXTBOOKS/ REFERENCES:

1. *Richard Szeliski, "Computer Vision: Algorithms and Applications", Springer, 2011*
2. *Yao Wang, Jorn Ostermann and Ya-Qin Zhang, "Video Processing and Communications", Prentice Hall, 2001.*
3. *A.Murat Tekalp, "Digital Video Processing", Pearson, 1995.*
4. *Thierry Bouwmans, Fatih Porikli, Benjamin Höferlin and Antoine Vacavant ,"Background Modeling and Foreground Detection for Video Surveillance: Traditional and Recent Approaches, Implementations, Benchmarking and Evaluation", CRC Press, Taylor and Francis Group, 2014.*
5. *Md. Atiqur Rahman Ahad, "Computer Vision and Action Recognition-A Guide for Image Processing and Computer Vision Community for Action Understanding", Atlantis Press, 2011.*

16CV705 MEDICAL IMAGE ANALYSIS 3-0-0-3

Medical imaging modalities: Planaer X-Ray imaging- X-Ray Computed Tomography – Magnetic Resonance Imaging – Nuclear Imaging – Ultrasonography – other modalities. Image file formats: DICOM. Image Enhancement: Fundamental enhancement techniques- Adaptive image filtering – Enhancements by multi-scale non linear operators – Case Study. Image segmentation: Overview and fundamentals of medical image segmentation – Segmentation using fuzzy clustering – Neural networks – Deformable models - Case study. Medical image registration: Rigid body transformation – Non rigid body transformation – Pixel based registration – Surface based registration – Intensity based registration. Medical image fusion: Linear and non linear methods – Wavelet based fusion – Pyramidal fusion schemes. Validation of medical image analysis techniques. Case Study: Tissue characterization and classification – Brain image analysis and atlas construction – Tumour image analysis and treatment planning – Microscopic Image analysis- Tongue and abdominal imaging.

TEXTBOOKS/ REFERENCES:

1. *Geoff Dougherty, "Medical Image Processing Techniques and Applications", Springer, New York: Dordrecht Heidelberg, London, 2011.*
2. *Thomas M Deserno, "Biomedical Image Processing", Springer-Verlag Berlin Hiedelberg, 2011.*
3. *A Ardheshir Goshtasby, "2-D and 3-D Image Registration for Medical, Remote Sensing, and Industrial Applications", John Wiley and Sons, 2005.*
4. *Tania Sthathaki, "Image Fusion: Algorithms and Applications", Academic Press, 2008.*
5. *James T. Dobbins III, Sean M . Hames, Bruce H . Hasegawa, Timothy R. DeGrado, James A. Zagzebski and Richard Frane, "Measurement, Instrumentation, and Sensors Handbook", Second Edition, Electromagnetic, Optical, Radiation, Chemical, and Biomedical Measurement, CRC Press, 2014.*

16CV706 CONTENT BASED IMAGE AND VIDEO RETRIEVAL 3-0-0-3

Architecture and Design: Introduction - Architecture of content-based image and video retrieval - Designing an image retrieval system - Designing a video retrieval system.

Feature extraction and similarity measure: Color - Texture - Shape - Spatial relationships - MPEG 7 features. Modeling and analysis of images: Classification and clustering - Annotation and semantic based retrieval of visual data - Probabilistic models - Relevance feedback.
Standards for image data management: Standards relevant to Content based image retrieval- Image compression- Query Specification- Metadata description. Analysis of video: Feature extraction - Semantics understanding - Summarization - Indexing and retrieval of video - Mining large databases. Applications: Architectural and engineering design- Fashion and interior design-Journalism and advertising-Medical Diagnosis- Geographical Information Systems and Remote Sensing-Education and Training- Web Searching. –Survey of Content .Based Image Retrieval Systems.

TEXTBOOKS/ REFERENCES:

1. *Oge Marques and Borko Furht, "Content Based Image and Video Retrieval", Multimedia Systems and Applications, Springer, 2002.*
2. *Oge Marques, "Practical Image and Video Processing", Wiley IEEE Press, 2011.*
3. *Borko Furht and Oge Marques, "Hand Book of Video Databases Design and Applications", CRC Press, 2003.*

16CS738 PATTERN RECOGNITION 3-0-0-3

Introduction to Pattern Recognition,Tree Classifiers -Decision Trees: CART, C4.5, ID3., Random Forests. Bayesian Decision Theory. Linear Discriminants. Discriminative Classifiers: the Decision Boundary- Separability, Perceptrons, Support Vector Machines. Parametric Techniques- Maximum Likelihood Estimation, Bayesian Parameter Estimation, Sufficient Statistics. Non-Parametric Techniques-Kernel Density Estimators, Parzen Window, Nearest Neighbor Methods. Feature Selection- Data Preprocessing, ROC Curves, Class Separability Measures,Feature Subset Selection,Bayesian Information Criterion. The Curse of Dimensionality-Principal Component Analysis. Fisher Linear Discriminant, Singular Value Decomposition, Independent Component Analysis, Kernel PCA Locally Linear Embedding.Clustering-. Sequential Algorithms, Hierarchical Algorithms,Functional Optimization-Based Clustering,Graph Clustering, Learning Clustering, Clustering High Dimensional Data, Subspace Clustering,Cluster Validity Measures, Expectation Maximization, Mean Shift. Classifier Ensembles-Bagging, Boosting / AdaBoost. Graphical Models-Bayesian Networks, Sequential Models- State-Space Models, Hidden Markov Models, Context Dependent Classification. Dynamic Bayesian Networks.

TEXTBOOKS/ REFERENCES:

1. *Duda, R.O., Hart, P.E., and Stork, D.G. "Pattern Classification". Second Edition, Wiley-Interscience. 2003.*
2. *Theodoridis, S. and K. Koutroumbas, "Pattern Recognition", Fourth Edition, San Diego, CA: Academic Press, 2009.*
3. *Christopher M. Bishop, "Pattern Recognition and Machine Learning", Springer, 2006.*
4. *Earl Gose, Richard Johnsonbaugh and Steve Jost, "Pattern Recognition and Image Analysis", Prentice Hall of India, 2002.*

5. *Nanning Zeng and Jianru Xue, "Statistical Learning and Pattern Analysis for Image and Video Processing", Springer, 2009.*

16CS739 DATA COMPRESSION 3-0-0-3

Information Theory Foundation: Entropy, its properties, conditional entropy, mutual information, Types of codes, Krafts McMillan Inequality theorem, Source coding theorem. Introduction to Compression Techniques: Introduction, Types of compression - Lossy, lossless. Performance measures, Modeling, Coding. Text Compression: Huffmann - static and dynamic, application in text compression, Shannon Fano Elias Coding, Arithmetic coding, Dictionary based coding-static, adaptive, UNIX compress.

Scalar and Vector Quantization: Scalar Quantization – Introduction, Uniform and Adaptive quantization. Vector Quantization- Introduction, Advantages, LBG, Tree vector quantization, Trellis coded quantization
Audio Compression: Distortion criteria- Auditory perception, PCM, DPCM, ADPCM, Predictive coding- basic algorithm, Basic sub-band coding, MPEG Audio Coding
Image Compression: Distortion criteria- The human visual system, Transform coding- DCT, JPEG, JBIG II, GIF, Wavelet based compression- wavelets, the scaling function, Haar Transforms, JPEG-2000. Video Compression: Motion Estimation and Compensation- Full search and Fast search algorithms, H.261, MPEG-1, MPEG-2, MPEG-4, MPEG -7.

TEXTBOOKS/ REFERENCES:

1. *Sayood and Khalid, "Introduction to Data Compression", Third Edition, Morgan Kaufmann, 2006.*
2. *Richardson I E G, "Video Codec Design: Developing Image and Video Compression Techniques", John Wiley and Sons, 2002.*
3. *Salomon D, "Data Compression: The Complete Reference", Fourth Edition, Springer, 2007.*
4. *Gersho A and Kluwer R M G, "Vector Quantization and Signal Compression", Academic Press, 1992.*