MTECH SYLLABUS – COMPUTER AND INFORMATION SCIENCE

M.Tech. Computer and Information Science (2015)

Sl. No.	Course code	Course Title	Core/Elective	Credits	Lec.	Lab	Marks
		Semester - I					
1	CSC3101	Mathematical concepts for computer science	C	4	4	2	100
2	CSC3102	Statistical Machine Learning	C	4	4	2	100
3	CSC3103	Algorithms for Modern Data Models	C	4	4	2	100
4		Elective I	E	3	4	0	100
5		Elective II	E	3	4	0	100
			Total for Semester I	18	20	6	500

Electives

CSC 3104: Wireless Communications & Networking

CSC 3105: Virtualized Systems

CSC 3106: Computational Linguistics

CSC 3107: Digital Image Processing

CSC 3108: Fundamentals of Bioinformatics

Sl. No.	Course code	Course Title	Core/Elective	Credits	Lec.	Lab	Marks
		Semester - II					
1	CSC3201	Massive Dataset Mining	C	4	4	2	100
2	CSC3202	Computer Vision	C	4	4	2	100
3	CSC3203	Seminar	C	1	0	2	50
3		Elective III	E	3	4	0	100
4		Elective IV	E	3	4	0	100
5		Elective V	E	3	4	0	100
			Total for Semester II	18	20	6	550

Electives

CSC 3204: Bioinformatics

CSC 3205: Parallel Computer Architecture

CSC 3206: Adhoc Networks

CSC 3207: Modelling Cyber Physical Systems

CSC 3208: Number Theory and Cryptography

CSC 3209: Algorithmic Game Theory

Sl. No.	Course code	Course Title	Core/Elective	Credits	Lec.	Lab	Marks
		Semester - III					
1	CSC3301	Project & Viva Voce	C	18	0	15	400
		Semester - IV					
1	CSC3302	Project & Viva Voce	C	18	0	25	500

Total credits for Degree: **72**

CSC3101: MATHEMATICAL CONCEPTS FOR COMPUTER SCIENCE

Core/Elective: **Core** Semester: **1** Credits: **4**

Course Description

This course introduces the study of mathematical structures that are fundamentally discrete in nature. It introduces linear algebra, graph theory and probability. The course is intended to cover the main aspects which are useful in studying, describing and modelling of objects and problems in the context of computer algorithms and programming languages.

Course Objectives

To understand Linear systems using Linear Algebra
To get deep understanding of stochastic processes and their applications
To study graph theory and its applications using matrix formulation

Course Content

1. Linear Systems: Vector Spaces, Linear Independence and Rank, Basis, Quadratic forms and Semi Definite matrices, Eigen values and Eigen Vectors, LU Decomposition, Orthogonality, Least squares problem, QR decomposition, SVD, Basic Tensor Concepts

2. Probability axioms, Bayes theorem, Random variables and distributions, Expectation and Variance, Covariance and correlation, Moment generating functions, Inequalities: Markov, Chebyshev, Chernoff bound, Laws of large numbers, Central limit theorem

3. Multivariate Distribution, Point estimation: EM algorithm, Mean-square Error, Sufficiency-Completeness, Testing hypotheses, Stochastic Processes and Markov Chains: Markov process, Kolmogorov-Chapman equations, Parameter Estimation

4. Matrix representation of graphs, Hypergraphs, Bipartite graphs, Components, Independent paths, connectivity and cut sets, Graph Laplacian - Random walks - Measures and metrics on graphs

5. Random Graphs : Models, Ramsey theory, Random graphs with general degree distributions Connectivity and Matchings, Diameter of Random Graphs

REFERNCES

1. Fundamentals of Matrix Computations, David S. Watkins, 3rd Edn, John Wiley, (2010)
2. Introduction to Linear Algebra, Gilbert Strang, 4th Edn, Wellesley-Cambridge Press, (2009)
3. Matrix Methods in Data Mining and Pattern Recognition, Lars Elden, SIAM, (2007)
4. Probability and Computing: Randomized Algorithms and Probabilistic Analysis, Michael Mitzenmacher & Eli Upfal, Cambridge University Press, (2005)
5. Networks: An Introduction, Mark Newman, OUP Oxford, (2010)
6. Random Graphs, Bela Bollobas, 2nd Edition, Cambridge University Press, (2001)

CSC3102: STATISTICAL MACHINE LEARNING

Core/Elective: **Core** Semester: **1** Credits: **4**

Course Description

This course introduces fundamental set of techniques for machine learning. This includes topics in statistical theory that are now becoming important for researchers in machine learning. While giving strong foundations on theoretical aspects, emphasis is given on applying many techniques to real data in various application scenarios.

Course Objectives

To understand probabilistic approaches to modelling
To apply the models for machine learning problems
To understand learning structures

Course Content

1. Inference in Probabilistic Models: Generative models for discrete data, Bayesian concept learning, Beta-binomial, Dirchlet multinomial models, Navie Bayes classifiers, Gaussian Models

2. Bayesian statistics: MAP estimation, Model selection, Hierarchical and Empirical Bayes, Bayesian decision theory, Bayes risk, Admissible estimators and properties, Empirical risk minimization, Logistic regression: Model specification and fitting, Bayesian logistic regression, Fishers LDA, Generalized linear models

3. Graphical models, Examples of learning and inference, Mixture models and EM algorithm, latent linear models, PCA and ICA, Sparse linear models, Regularization and sparse coding, Kernels, SVM

4. Adaptive basis function models, CART, Boosting, Multilayer perceptrons, Ensemble learning, Markov Random Fields and examples, Conditional Random Fields, Graphical model structure learning, Learning tree structures, Learning DAGs

5. Dynamical Models: HMM and learning for HMMs, Deep Learning: Deep generative models, Boltzman models, Belief networks, Multilayer perceptrons, Applications of deep networks

REFERNCES

1. Machine Learning: A Probabilistic Perspective, Kevin P Murphy, MIT Press (2012)
2. Bayesian Reasoning and Machine Learning, David Barber,Cambridge University Press, (2012)
3. The Elements of Statistical Learning: Data mining, Inference, and Prediction, Trevor Hastie et. al., 2nd Edn, Springer, (2009)
4. Pattern Recognition and Machine Learning, Christopher M Bishop, Springer, (2006)
5. Information Theory, Inference, and Learning Algorithms, David MacKay, Cambridge University Press (2003)

CSC3103: ALGORITHMS FOR MODERN DATA MODELS

Core/Elective: **Core** Semester: **1** Credits: **4**

Course Description

This course describes the techniques for the design and analysis of efficient algorithms, giving emphasis on methods useful in practice. Topics include graph algorithms; divide-and-conquer algorithms and recurrences; dynamic programming; greedy algorithms; amortized analysis; network flow; randomized and approximation algorithms.

Course Objectives

To know problem solving techniques
To understand techniques for the design and analysis of efficient algorithms
To be able to design algorithms for new problems with volume of data

Course Content

1. Algorithms – Complexity – Recurrences - Algorithmic Techniques: Backtracking – Branchand bound - Divide-and-Conquer – Dynamic Programming – Greedy strategy

2. Probability – Expectations - Tail Bounds, Chernoff Bound, Markov Chains and Random Walks – Applications of randomized algorithms

3.Graph models and algorithms– Random graph Models,Algorithms for graph generation - Random graphs as models of networks, Power laws, Small world Phenomena

4.Components of evolutionary algorithms – Example applications – Genetic algorithms – Evolution strategies – Evolutionary programming

5.Sampling, sketching, data stream models, read-write streams, stream-sort, map-reduce - Algorithms in evolving data streams

REFERNCES

1. Introduction to Algorithms (3rd Ed):Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest and Clifford Stein, MIT Press (2009)
2. Algorithm Design: Jon Kleinberg and Eva Tardos,AW (2005)
3. Anany V. Levitin. Introduction to the Design & Analysis of Algorithms (2nd Ed): A W(2006)
4. Randomized Algorithms: Rajeev Motwani and Prabhakar Raghavan, Cambridge University Press; Reprint edition (2010)
5. Data Streams: Algorithms and Applications: S. Muthukrishnan, Now Publishers (2005)
6. Data Streams: Models and Algorithms: Charu C. Aggarwal, Springer (2006)
7. Introduction to evolutionary computing: Agoston E. Eiben, J.E. Smith, Springer (2010)

CSC3104: WIRELESS COMMUNICATIONS & NETWORKING

Core/Elective:**Elective** Semester: **1** Credits: **3**

COURSE DESCRIPTION

This course focuses on imparting knowledge about the practical aspects of wireless network systems with the required basic principles behind them, along with some practical assignments. The course examines the conceptual framework for specifying a wireless network and the related protocols.

COURSE OBJECTIVES

Comprehend and demonstrate command in the principles of wireless networking.
Describe the networking technologies including Cellular networks, WLANs andWWANs.
Understand the functions of TCP/IP and the organization of the Internet.
Design and evaluate a wireless network in terms of cost, performance, privacy and security.
Plan and design a small and practical network for home or small business applications under a specified set of constraints

To understand new trends and emerging technologies

COURSE CONTENT

1. Overview of wireless systems – Tele traffic engineering – Radio propagation – Path loss models – Digital communication over radio channels – Modelling of a Wireless Channel - Capacity of wireless channels – AWGN channel -Fading channels

2. Cellular concepts – Multiple access and interference management- Narrowband and Wideband systems- GSM, CDMA and OFDM - Channel reuse analysis- spread spectrum and CDMA systems – Random access and Wireless LANs – Data and voice sessions over 802.11 – Association in WLANs

3. Wide-Area Wireless Networks – GSM evolution for data – UMTS architecture – QoS in UMTS – HSDPA – FOMA - CDMA evolution

4. Design of a wireless network – radio design for a cellular network – Link budget for GSM and CDMA

5. Beyond 3G – HSPA+, WiMAX and LTE – Cognitive radio networks

REFERNCES

1. Wireless Communication Networks and Systems (1st Ed): Cory Beard and William Stallings, Pearson (2015)
2. Wireless Communications & Networking (1st Ed): Vijay K Garg, Morgan Kaufmann (2007)
3. Wireless Networks: Anurag Kumar, D. Manjunath, Joy Kuri, (1st Ed.), Morgan Kaufman (2008)
4. An Introduction to LTE: LTE, LTE-Advanced, SAE and 4G Mobile Communications (2nd Ed): Christopher Cox, Wiley (2012)
5. Web Resources: http://standards.ieee.org

CSC3105: VIRTUALIZED SYSTEMS

Core/Elective:**Elective** Semester: **1** Credits: **3**

COURSE DESCRIPTION

Virtualization provides the benefit of reducing the total cost of ownership and improving the business agility. This course systematically introduces the concepts and techniques used to implement the major components of virtual servers behind the scene. It discusses the details on hypervisor, CPU scheduling, memory management, virtual I/O devices, mobility, and etc.

COURSE OBJECTIVES

The course introduces the concepts and principles of virtualization, the mechanisms and techniques of building virtualized systems, as well as the various virtualization-enabled computing paradigms.

COURSE CONTENT

1. Overview: Why server virtualization –History and re-emergence –General structures. Architectures comparison. Commercial solutions –VMWare, Xen.

2. Virtual machines: CPU virtualization -Privileged instructions handling -Hypervisor -Paravirtualization. Hardware-assisted virtualization. Booting up. Time keeping. CPU scheduling. Commercial examples.

3. Memory management in virtualization: partitioning –reclamation –ballooning. Memory sharing. OS-level virtualization –VMWare –Red Hat Enterprise Virtualization.

4. I/O virtualization: Virtualizing I/O devices -monolithic model -virtual I/O server. Virtual networking –tunneling –overlay networks. Commercial examples. Virtual storage: Granularity -file system level –blocks level.

5. Virtualized computing: Virtual machine based distributed computing, elastic cloud computing, clustering, cold and hot migration. Commercial examples. Challenges and future trends.

REFERNCES

1. Virtual Machines: Versatile Platforms for Systems and Processes (1st Ed): Jim Smith, Ravi Nair; Morgan Kaufmann (2005)
2. Applied Virtualization Technology -Usage models for IT professionals and Software Developers (1st Ed): Sean Campbell Intel Press (2006).
3. Virtualization Essentials (1st edition): Matthew Portnoy, JW(2012)
4. Virtualizing Hadoop: George Trujillo, Charles Kim, Steve Johnes, Rommel Gracia, Justin Murray: VM Press (2015)

CSC3106: COMPUTATIONAL LINGUISTICS

Core/Elective:**Elective** Semester: **1** Credits: **3**

COURSE DESCRIPTION

Computational Linguistics deals with statistical and rule based modelling of natural languages from a computational point of view. This course is intended to give a comprehensive coverage of language processing fundamentals likemorphology, Syntax, Semantics and pragmatics. Application of various computational models in application domains like Machine translation, information retrieval etc. is also dealt with.

COURSE OBJECTIVES

To familiarise the fundamentals of speech and written language processing
To study the applications of these techniques in real world problems like spell-checking, Parts-of Speech Tagging, Corpus development, Wordnet, speech recognition, pronunciation modelling, dialogue agents, document retrieval etc
To gather information about widely used language processing resources

COURSE CONTENT

1. Words- Regular Expressions and Finite Automata-Morphology and Finite State Transducers-Probabilistic Models of Pronunciation and Spelling -N grams

2. Word Classes and Part-of-Speech Tagging-MM Taggers- probabilistic Context Free Grammars for English Syntax-Parsing with Context Free Grammars- probabilistic parsing-Features and Unification-Language and Complexity

3. Semantics-Representing Meaning-canonical forms-FOPC-ambiguity resolution-scoping phenomena-Semantic Analysis-syntax driven semantic analysis-Lexical Semantics-Word Sense Disambiguation and Information Retrieval

4. Discourse-Reference Resolution -Text Coherence -Dialog and Conversational Agents-Dialogue acts-dialogue structure

5. Statistical alignment and machine translation-clustering- text categorization

REFERNCES

1. Natural language annotation for machine learning : james Pustejovsky, Amber Stubbs, O'Reilly(2012)
2. The hand book of Computational linguistics and natural language processin : Alexander Clark and Chris Fox: Willey-Blackwill (2012)
3. Taming Text : Grant S Ingersoll, Thomas Morton, Andrew L Farris: Manning Publications (2013)
4. Speech and Language Processing (2nd Ed): Daniel Jurafsky and James Martin, PH (2008)
5. Foundations of statistical natural language processing (1st Ed): Christopher D. Manning and HinRich Schutze, MIT press (1999)

CSC3107: DIGITAL IMAGE PROCESSING

Core/Elective:**Elective** Semester: **1** Credits: **3**

COURSE DESCRIPTION

This course introduces the basic theories and methodologies of digital image processing. This includes techniques such as image enhancement, restoration, segmentation and compression. These techniques can be used to solve many of the real time challenges in the field of remote sensing, medical imaging, and scientific visualization and so on. Digital Image Processing also takes tremendous advances in technology such as mining, neural network etc., and combines them with the powerful human ability to visualize and interpret data, thereby offering creative solutions to complex and challenging problems.

COURSE OBJECTIVES

To understand the basic principles and methods of digital image processing
To expose students to current technologies and issues that are specific to image processing systems
To develop hands-on experience by making use of Image Processing Tools
To be able to formulate solutions to general image processing problems

COURSE CONTENT

1. Digital image fundamentalsIntroduction: Digital Image - Steps in Digital Image Processing - Elements of Visual Perception Image Sampling and Quantization - Relationship between Pixels - Simple Operations- Arithmetic. Logical. Geometric Operations. Mathematical Preliminaries - Convolution , Correlation

2. Image EnhancementSpatial Domain - Histogram Processing - Spatial Filtering- Smoothing spatial filters. Sharpening Spatial filters. Frequency Domain - Fourier Transform- Frequency domain Filtering- Smoothening filters. Sharpening filters

3. Image restoration and construction Image Restoration: Image Degradation/ Restoration Model - Noise Models - Mean filters-Order Statistic-Filters- Adaptive Filters- Band reject Filters- Bandpass filters -Notch Filters- Optimum Notch Filters-Estimating Degradation Function - Wiener Filtering-Inverse Filtering- Constrained Eeast Squares Filtering

4. Image compression Fundamentals of Image Compression - Image Compression Models - Compression Methods- Run Length Coding, Huffman Coding , Arithmetic Coding , LZW coding, Bit-Plane Coding, Block Transform Coding. Predictive Coding- JPEG Standard- Digital Image Watermarking

5. Image SegmentationImage Segmentation: Point Detection -Edge Detection - Eine Detection - Thresholding -Region based Segmentation - Region Growing, Region Splitting and Merging - Morphological Image Processing -Dilation. Erosion, Opening And Closing, Hit And Miss Transformations-Morphological Algorithms

REFERNCES

1. 1.Digital Image Processing, Rafael C. Gonzalez, Richard E. Woods., 3/e, Pearson Education, 2014.
2. Digital Image Procesing, S. Jayaraman, S. Esakkirajan. T. Veerakumar, McGraw Hill Education , 2011. Pvt Ltd, NewDelhi
3. Digital Image Processing. Kenneth R Castleman, Pearson Education,2007.

CSC3108: FUNDAMENTALS OF BIOINFORMATICS

Core/Elective:**Elective** Semester: **1** Credits: **3**

COURSE DESCRIPTION

This course is an introduction to fundamental concepts of molecular biology, Biological data bases and programming in bioinformatics. This includes computational problems in molecular biology and some basic algorithms to solve them.

COURSE OBJECTIVES

To study fundamentals of bioinformatics
To understand computational problems in molecular biology

COURSE CONTENT

1. Introduction to molecular biology – Nucleic acids – DNA – RNA – Proteins – Gene –Genome – Genetic synthesis – Translation – Transcription – Protein synthesis –Chromosomes – Maps and sequences – Human genome project.

2. Perl for bioinformatics: sequences and strings – concatenating DNA fragments – transcription and translation using Perl – reverse complement in Perl – proteins,files and arrays – Motifs and loops – Nucleotides – Scoping and subroutines – Mutations and randomizations – Genetic code.

3. Biological data bases: Features – Classifications – Sequence and Molecular file formats – Sequence conversion tools – Content, structure and annotation – Sequence databases – Primary and secondary databases, composite databases, annotated databases, genomes and organism specific databases, protein databases, disease databases, other data bases – NCBI, Entrez, database management systems, file formats for sequence databases – Retrieval of biological data Structural databases: Protein databank, PIR, SCOP and CATH, FSSP, 3Dee, MMDB / Small

molecule databases

4. Sequence alignment and database search: Pair-wise sequence alignment – Substitution matrixes – PAM and BLOSSUM matrices, Dot plots – Local and global alignment theory – Dynamic programming methods – FASTA and BLAST algorithms – database search using BLAST and FASTA – Similarity & distance – Similarity scores – Weight matrices – Heuristic method – Hidden Markov Models and their application in sequence analysis

5. Phylogenetic trees: Introduction – Dendrogram construction – Molecular Phylogenetics – Tree definitions – Optimality criteria – Distance matrix methods and maximum parsimony – Multiple sequence alignments – tree alignments, star alignments, pattern in pair wise alignment – Genetic algorithm

REFERNCES

1. Zhumar Ghosh and Bibekanand Mallick. Bioinformatics: Principles and Applications.,Oxford University Press; 1 edition , March 1, 2015
2. James Tisdall, Beginning Perl for Bioinformatics; O'Reilly; 1 edition ; 2 November 2001
3. Rastogi, S. C., Parag Rastogi, and Namita Mendiratta. Bioinformatics Methods and Applications: Genomics Proteomics and Drug Discovery 4th Ed. PHI Learning Pvt. Ltd., 2013.

CSC3201: MINING ALGORITHMS FOR MASSIVE DATASETS

Core/Elective: **Core** Semester: **2** Credits: **4**

Course Description

Big Data concerns large-volume, complex, growing data sets with multiple, autonomous sources. With the fast development of networking, data storage, and the data collection capacity, Big Data is now rapidly expanding in all science and engineering domains. The traditional data mining algorithms also need to be adapted for dealing with the ever-expanding datasets of tremendous volume.

Course Objectives

To learn algorithms and techniques for mining very large amounts of data
To understand emphasis on the algorithms to be applied on data
To develop hands-on experience on the distributed file systems and MapReduce as a tool for creating parallel algorithms
To explore streaming data and some of the techniques and algorithms specifically extended for mining on stream data

Course Content

1. Introduction to MapReduce – the map and reduce tasks, MapReduce workflow, fault tolerance. - Algorithms for MapReduce – matrix multiplication, relational algebra operations- Complexity theory for MapReduce

2. Locality-Sensitive Hashing - shingling of documents, min-hashing. Distance measures, nearest neighbors, frequent itemsets- LSH families for distance measures, Applications of LSH- Challenges when sampling from massive data

3. Mining data streams – stream model, stream data sampling, filtering streams – bloom filters,

counting distinct elements in a stream - Flajolet-Martin algorithm. Moment estimates - Alon-Matias-Szegedy algorithm, counting problems for streams, decaying windows

4. MapReduce and link analysis- PageRank iteration using MapReduce, topic-sensitive PageRank - On-line algorithms – Greedy algorithms, matching problem, the adwords problem – the balance algorithm

5. Computational model for data mining – storage, cost model, and main memory bottleneck. Hash based algorithm for mining association rule – improvements to a-priori, park-chen-yu algorithm, multistage algorithm, approximate algorithm, limited-pass algorithms – simple randomized algorithm, Savasere, Omiecinski, and Navathe algorithm, Toivonen algorithm

REFERNCES

1. Mining of Massive Datasets:Jure Leskovec, Rajaraman, A., & Ullman, J. D., Cambridge University Press (2014)
2. Data Streams: Models and Algorithms: Charu C. Aggarwal, Springer (2007)
3. Frontiers in Massive Data analysis : Michael I Jordan et.al:National Academies Press (2013)
4. Big Data: Principles and best practices of scalable realtime data systems, Nathan Marz & James Warren, Manning Publications (2015)

CSC3202: COMPUTER VISION

Core/Elective: **Core** Semester: **2** Credits: **4**

Course Description

This course introduces concepts and applications in computer vision. Starting with image formation the course covers image processing methods such as filtering and edge detection, segmentation and classification. It includes vision tasks like; object detection, recognition and human motion detection. The content of the course also includes practical exercises to help the students formulating and solving computer vision problems.

Course Objectives

To understandprocessing of digital images
To familiarise different mathematical structures
To study detailed models of image formation
To study image feature detection, matching, segmentation and recognition
To understand classification and recognition of objects.
To familiarize state-of-the-art problems in computer vision

Course Content

1. Image formation –Geometric primitives and transformations – singular value decomposition – Harr,Walsh and Hadamard transforms – Discrete Fourier Transform - Photometric image formation – Statistical description of images.

2. Feature detection and matching – Digital morphology - Segmentation – Mean shift and mode finding – K-means and mixture of Gaussians – Graph cuts and energy-based methods – feature based alignment

3. Image restoration – Inverse filtering – Classification – Minimum distance classifiers –Cross

validation – SVM – Ensembles – Bagging and boosting

4. Recognition – Object classification and detection – Face recognition – Instance recognition – Category recognition – Context and scene understanding – Human motion recognition

5. State-of-the-art and the future - Content based Search – Computation Photography - Image & video annotation

REFERNCES

1. Computer vision: Algorithms and Applications (1st Ed): Richard Szeliski , Springer (2010)
2. Computer Vision: A Modern Approach (2nd Ed): Ponce Jean & Forsyth David, Pearson Prentice Hall (2014)
3. Algorithms for Image Processing and Computer Vision (2nd Ed): J. R. Parker, Wiley (2010)
4. Learning OpenCV: Computer Vision with the OpenCV Library (1st Ed): Gary Bradski, O'Reilly (2008)
5. Image Processing: The Fundamentals (2 edition): Maria Petrou and Costas Petrou, Wiley (2010)

CSC3203: SEMINAR

Core/Elective: **Core** Semester: **2** Credits: **1**

Course Description

The student has to prepare and deliver a presentation on a research topic suggested by faculty member before the peer students and staff. They also have to prepare a comprehensive report of the seminar presented

Course Objectives

Review and increase their understanding of the specific topics tested.
Inculcating presentation and leadership skills among students
Offering the presenter student an opportunity of interaction with peer students and staff

CSC3204: BIOINFORMATICS

Core/Elective: **Elective** Semester: **2** Credits: **3**

Course Description

Present fundamental concepts from molecular biology, computational problems in molecular biology and some efficient algorithms that have been proposed to solve them.

Course Objectives

To familiarize computational problems in biology
To understand models of DNA and DNA mapping
To study structure prediction

Course Content

1. Basic concepts of molecular Biology-Proteins-Nucleic acids– genes and genetic synthesis – translation- transcription- protein Synthesis- Chromosomes- Maps and sequences- human genome project- sequence data bases

2. Strings-Graphs-Algorithms- Comparing 2 sequences- Global & Local comparison-General Gap Penalty Function-Affix gap penalty function-comparing multiple sequences-Star alignments-Tree alignments-Database Search-PAM matrices BLAST-FAST –Issues

3. Fragment Assembly of DNA-Biological Background –Models-Algorithms-Heuristics-Physical Mapping of DNA-Restriction site Mapping-site models-Internal Graph Models –Hybridization Mapping-Heuristics

4. Phylogenic Trees –Binary Character States-Parsimony and Compatibility in Phylogenies-Algorithm for Distance Matrices-Additive Trees- Genome rearrangements-Oriented Blocks-unoriented Blocks

5. Molecular Structure Prediction- RNA secondary structure prediction-Protein Folding problems-Protein threading-Computing with DNA-Hamilton Path Problems. –Satisfiability

REFERNCES

1. An introduction to Bioinformatics Algorithms4tht Ed): Neil James and Pavel A Pevzner, OUPress (2014)
2. Bioinformatics : Principles and Applications: Zhumur Ghosh, Bibekanand Mallick: OUPress(2015)
3. Building Bioinformatics Solutions: Concord Bessant, Darren Oakley, Ian Shadforth : OU press(2014)
4. Computational Molecular Biology-An introduction (1st Ed): Peter Clote and Rolf Backofen, Wiley Series (2000)

CSC3205: COMPUTATIONAL LINGUISTICS

Core/Elective: **Elective** Semester: **2** Credits: **3**

Course Description

The key objective of this course is to provide fundamental knowledge in the design principles for general-purpose parallel computers. Students will gain fknowledge and understanding of principles and practice in parallel computer architecture and computing, emphasizing both hardware and software challenges and the interactions between them.

Course Objectives

Get a broad understanding of parallel computer architecture and different models for parallel computing
To understand concepts related to memory consistency models, cache coherence, interconnection networks, and latency tolerating techniques.
To learn about strategies for how algorithms that were originally developed for single-processor systems can be converted to run efficiently on parallel computers
To know about current practical implementations of parallel architectures

Course Content

1. Introduction to digital computers – processor design principles - Advanced Processor Technology – Memory and I/O organization- Cache organization – Introduction to parallel processing

2. Parallel processing terminology – Flynn’s &Handler’s Classification - Pipelining and

Superscalar Techniques: Linear & Nonlinear Pipeline Processors – Instruction and Arithmetic Pipeline design – Superscalar and super pipeline design

3. Parallel and scalable architectures: Multiprocessor System Interconnect – Cache coherence – Uniform and non-uniform memory access multiprocessors - Synchronization - Message passing systems

4. Distributed systems – Message passing model – Programming model – Parallel Virtual Machine – Architecture of PVM – Programming model of PVM - Comparison

5. Connectivity: System interconnect architectures – Networks – Routing – Clusters, Linux Clusters – Case studies on Parallel Architectures developed in India like PARAM

REFERNCES

1. Computer Architecture –a quantitative approach ; John L. Hennessy, David A Patterson (2011)
2. Computer Architecture (5th Ed): John L. Hennessy & David A. Patterson, Elsevier (2013)
3. Parallel Computer Organization &design: Michel Dubois, Murali Annavaram, Per Stenstorm Cambridge University Press (2012)
4. Computer Architecture and Parallel Processing, Kai Hwang, McGraw Hill (2012)
5. Advanced Computer Architecture& parallel Processing : Hesham El_Rewin, Mostafa Abd-El-Baer: Wiley Series(2005)

CSC3206: ADHOC NETWORKS

Core/Elective: **Elective** Semester: **2** Credits: **3**

Course Description

The course examines wireless cellular, ad hoc and sensor networks, covering topics such as wireless communication fundamentals, medium access control, network and transport protocols, unicast and multicast routing algorithms, mobility and its impact on routing protocols, application performance, quality of service guarantees, and security. Energy efficiency and the role of hardware and software architectures may also be presented for sensor networks

Course Objectives

To know the constraints of the wireless physical layer that affect the design and performance of ad hoc and sensor networks, protocols, and applications;
To understand MAC, Routing protocols that have been proposed for ad hoc and sensor networks
To understand the energy issues in sensor networks and how they can be addressed using scheduling, media access control, and special hardware;
To explain various security threats to ad hoc networks and describe proposed solutions

Course Content

1. Overview of Wireless LAN, PAN - IEEE 802.11- Bluetooth - Wireless WANs and MANs - Cellular Architecture- WLL - IEEE 802.16 - Wireless Internet - IP and TCP in Wireless domain

2. AD HOC Wireless Networks - Cellular and Ad hoc networks - Applications of Ad hoc networks - Issues in Ad hoc networks - MAC protocols for Ad hoc networks

3. Routing Protocols for Ad hoc Networks - Classification - Table driven, On demand, Hierarchical Routing Protocols- Energy Management in Ad hoc Networks

4. Wireless Sensor Networks - Architecture - Data Dissemination and Gathering - Location Discovery - Applications of WSNs – Operating system and programming for Sensor Network

5. Emerging trends in Ad hoc Networks - Mobility modelsfor Ad hoc Networks - Security - Ultra Wideband Systems - Hybrid Wireless Networks

REFERNCES

1. Wireless Networks: Anurag Kumar, D. Manjunath, Joy Kuri, (1st Ed.), Morgan Kaufman (2008)
2. Ad Hoc Wireless Networks: Architectures and Protocols, C. Siva Ram Murthy and B. S. Manoj, (2nd Ed.), Pearson Education (2005)
3. Ad Hoc & Sensor Networks: Theory and Applications, Carlos de Morais Cordeiro and Dharma Prakash Agrawal, (1st Ed.), World Scientific (2007)
4. Algorithms and Protocols for Wireless Sensor Networks: Azzedine Boukerche (Edited volume), Wiley-IEEE press (2008)
5. Recent developments in Wireless Sensor & Adhock Networks : Srikante Patnaiik, Xiaolang Li, Yeon_Mo Yang: Springer (2014)

CSC3207: MODELLING CYBER PHYSICAL SYSTEMS

Core/Elective: **Elective** Semester: **2** Credits: **3**

Course Description

The course examines wireless cellular, ad hoc and sensor networks, covering topics such as wireless communication fundamentals, medium access control, network and transport protocols, unicast and multicast routing algorithms, mobility and its impact on routing protocols, application performance, quality of service guarantees, and security. Energy efficiency and the role of hardware and software architectures may also be presented for sensor networks.

Course Objectives

To know problem solving techniques
To understand techniques for the design and analysis of efficient algorithms
To be able to design algorithms for new problems with volume of data

Course Content

1. Introduction to Cyber Physical System :Cyber physical system : Definition Applications, Design Process for Cyber Physical System :Modeling, Design, Analysis: Modelling continuous dynamics ,Newtonian Mechanics, Actor models, Properties that actors and the systems :Causal Systems, Memoryless Systems, Linearity and Time Invariance, Stability. Feedback control

2. Modeling Discrete Systems :Discrete Systems ,State, Finite-State Machines: Transitions, The occurrence of reaction, Update functions, Determinacy and Receptiveness, Extended State Machines, Nondeterministic Finite State Machines , Behaviors and Traces

3. Hybrid Systems :Actor Model for State Machines, Continuous Inputs, State Refinements, Classes of Hybrid Systems: Timed Automata, Higher-Order Dynamics, Supervisory control

4. Composition of State Machines: Concurrent Composition: Side-by-Side Synchronous Composition, Side-by-Side Asynchronous Composition, Shared Variables, Cascade Composition, General Composition, Hierarchical state machines

5. Concurrent Models of Computation : Structure of Models, Synchronous-Reactive Models: Feedback Models, Well-Formed and ill-Formed Models, Constructing a Fixed Point, Dataflow Models of Computation: Dataflow Principles, Synchronous Dataflow ,Dynamic Dataflow, Structured Dataflow, Process Networks, Timed Models of Computation: Time-Triggered Models, Discrete Event Systems, Continuous-Time Systems

REFERNCES

1. Principles of Cyber-Physical Systems: Rajeev Alur, MIT Press (2015)
2. Introduction to Embedded Systems - A Cyber-Physical Systems Approach: Edward A. Lee, Sanjit A. Seshia, Lulu.com (2011)
3. Applied Cyber-Physical Systems, Suh, S.C et.al (Edited), Springer (2014)
4. Cyber-Physical Systems: Integrated Computing and Engineering Design: Fei Hu, CRC Press (2013)
5. Embedded System Design-Embedded Systems Foundations of Cyber-Physical Systems: Marwedel & Peter, SIE (2013)

CSC3208: NUMBER THEORY AND CRYPTOGRAPHY

Core/Elective: **Elective** Semester: **2** Credits: **3**

Course Description

The course provides an introduction to basic number theory, where the focus is on computational aspects with applications in cryptography. Applications to cryptography are explored including symmetric and public-key cryptosystems. Modern cryptographic methods are also discussed.

Course Objectives

To understand the number theoretic foundations of modern cryptography
To implement and analyze cryptographic and number theoretic algorithms
To understand public key cryptosystems
To understand modern cryptographic techniques

Course Content

1. Divisibility, Division Algorithm, Euclidean Algorithm, Congruences, Complete Residue systems, Reduced Residue systems, Fermat’s little theorem, Euler’s Generalization, Wilson's Theorem, Chinese Remainder Theorem, Euler Phi-function, multiplicative property, Finite Fields, Primitive Roots, Quadratic Residues, Legendre Symbol, Jacobi Symbol, Gauss's lemma, Quadratic Reciprocity Law

2. Primality Tests, Pseudoprimes, Carmichael Numbers, Fermat’s pseudoprimes, Euler pseudoprimes, Factorization by Pollard’s Rho method, Simple Continued Fraction, simple infinite continued fractions, Approximation to irrational numbers using continued fractions, Continued Fraction method for factorization.

3. Traditional Cryptosystem, limitations, Public Key Cryptography Diffie-Hellmann key exchange, Discrete Logarithm problem, One-way functions, Trapdoor functions, RSA cryptosystem, Digital signature schemes, Digital signature standards, RSA signature schemes,

Knapsack problem, ElGamal Public Key Cryptosystem, Attacks on RSA Cryptosystem: Common modulus attack, Homomorphism attack, timing attack, Forging of digital signatures, Strong primes, Safe primes, Gordon's algorithm for generating strong primes.

4. Cubic Curves, Singular points, Discriminant, Introduction to Elliptic Curves, Geometry of elliptic curves over reals, Weierstrass normal form, point at infinity, Addition of two points, Bezout's theorem, associativity, Group structure, Points of finite order

5. Elliptic Curves over finite fields, Discrete Log problem for Elliptic curves, Elliptic Curve Cryptography, Factorization using Elliptic Curve, Lenstra's algorithm, ElGamal Public Key Cryptosystem for elliptic curves

REFERNCES

1. A Course in Number Theory and Cryptography,Â Neal Koblitz, (Springer 2012).
2. An Introduction to Mathematical Cryptography, Jill Pipher, Jeffrey Hoffstein, Joseph H. Silverman (Springer, 2008)
3. An Introduction to theory of numbers, G.H.Hardy and Edward M Wright (Oxford 2008)
4. Computational Number Theory & Modern Cryptography: Song Y.Yan : Wiley(2013)

CSC3209: ALGORITHMIC GAME THEORY

Core/Elective: **Elective** Semester: **2** Credits: **3**

Course Description

Game theory is a branch of mathematics and economics which models interactions of agents as games. Algorithmic game theory is the intersection of game theory and computer science. This course introduces algorithmic game theory in an application-oriented manner.

Course Objectives

1. To get a practical understanding of game theory.
2. To be able to solve computer science problems using the concepts of game theory.

Course Content

1. Introduction to game theory – strategies, costs, payoffs – solution concepts – finding equilibria – games with sequential moves – games with simultaneous moves – discrete strategies, continuous strategies – mixed strategies – games with incomplete information – expected payoffs – Prisoner’s dilemma and repeated games – Nash equlibrium – Computational complexity of Nash equilibrium

2. Games on networks – congestion games – selfish routing – Nash and wardrop equilibria for networks – price of anarchy – pricing network edges – network design with selfish agents – economic aspects of internet routing

3.Epistemic game theory – Modeling knowledge – rationality and belief – common belief in rationality – game strategies and perfect recall – cryptography and game theory – modeling cryptographic algorithms as games – multi-party computations – MPC and games

4. Mechanism design – general principles – social choice – incentives – algorithms mechanism design – dis- tributed aspects – cost-sharing mechanisms – mechanism design without money –

house allocation problem – stable matchings

5. Voting – evaluation of voting systems – strategic manipulation of votes – auctions – types of auctions – winner’s curse – bidding strategies – fairness in auctions

REFERNCES

[1] Avinash K. Dixit et al., Games of Strategy, W. W. Norton & Company, 4th edition, 2014.
[2] Noam Nisan et al. Algorithmic Game Theory, Cambridge University Press 1st edition, 2007
[3] Steven Tadelis, Game Theory: An Introduction 1st Edition, Princeton University Press, 2013.
[4] Michael Maschler, et al. Game Theory 1st Edition, Cambridge University Press, 2013.
[5] Andr´es Perea Epistemic Game Theory: Reasoning and Choice 1st Edition, Cambridge University Press, 2012.