DELHI TECHNOLOGICAL UNIVERSITY
SCHEME OF TEACHING AND EVALUATION
MASTER OF TECHNOLOGY IN COMPUTER SCIENCE & ENGINEERING(CSE)

The following alphanumeric coding scheme has been adopted
Core Courses XXXYMN
Elective Courses XXXYCMN
XXX abbreviates a particular M. Tech. program, Y – (5 for M. Tech. 1 st year, 6 for M. Tech. 2 nd year),
C – credit of the course (4/3/2),
MN – Subject code (Odd number for odd semester and even number for even semester courses

Semester-I

	S. No.	Course Code	Course Name	Type/Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE	Total Credits
Group A	1	CSE501	Advanced Database Management Systems	Core	4	3	0	2	15	25	20	40	-	
	2	CSE503	Advanced Algorithms and Data Structures	Core	4	3	0	2	15	25	20	40	-	
Group B	3	CSE5401/5403/…………	Elective 1	Elective	4	3/2	0	2/4	15	25	20	40	-	**17**
	4	CSE5301/5303/…………	Elective 2	Elective	3	3/2	0	0/2	20/15	0/25	30/20	50/40	-	
	5	CSE5201/5203/…………/ UEC5201/5203/…………	Elective 3/ University Elective I	Elective	2	2/1	0	0/2	20/15	0/25	30/20	5040	-	

Semester-II

	S. No.	Course Code	Course Name	Type/Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE	Total Credits
Group C	1	CSE502	Distributed Systems	Core	4	3	0	2	15	25	20	40	-	**17**
	2	CSE504	Advanced Computer Networks	Core	4	3	0	2	15	25	20	40	-	

	S.No.	Course Code	Course Name	Type/Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE	Total Credits
Group D	3	CSE5402/5404/…………	Elective 4	Elective	4	3/2	0	2/4	15	25	20	40	-	
	4	CSE5302/5304/…………	Elective 5	Elective	3	3/2	0	0/2	20/15	0/25	30/20	50/40	-	
	5	CSE5202/5204/…………/ UEC5202/5204/…………	Elective 6/ University Elective II	Elective	2	2	0	0	20	-	30	50	-	

Semester-III

	S.No.	Course Code	Course Name	Type/Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE	Total Credits
				Track 1										
Group E	1	CSE651	Research Project	Core	12	0	0	12	0	-	0	100	0	**12**
				Track 2										
	1	CSE601	Major Project I	Core	3						40	60		**12**
	2	CSE6401/6403/…………	Elective 7	Elective	4	3/2	0	2/4	15	25	20	40	-	
	3	CSE6301/6303/…………	Elective 8	Elective	3	3/2	0	0/2	20/15	0/25	30/20	50/40	-	
	4	CSE6201/6203/…………	Elective 9	Elective	2	2/1	0	0/2	20/15	0/25	30/20	50/40	-	

Semester-IV

	S.No.	Course Code	Course Name	Type/Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE	Total Credits
				Track 1										
Group F	1	CSE652	Research Project	Core	12	0	0	12	0	-	0	100	0	**12**
				Track 2										
	1	CSE602	Major Project II	Core	12						40	60		**12**

	S. No.	Course Code	Course Name	Type/Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 1	1	CSE5401	Artificial Intelligence and Expert Systems	Elective	4	3	0	2	15	25	20	40	-
	2	CSE5403	Data warehousing and Data Mining		4	3	0	2	15	25	20	40	-
	3	CSE5405	Design of Embedded Systems		4	2	0	4	15	25	20	40	-
	4	CSE5407	Information Retrieval		4	3	0	2	15	25	20	40	-
	5	CSE5409	Soft Computing		4	3	0	2	15	25	20	40	-
	6	CSE5411	Semantic Web		4	3	0	2	15	25	20	40	-
	7	CSE5413	Machine Learning		4	3	0	2	15	25	20	40	-
		Course Code	Course Name	Type/Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 2	1	CSE5301	Advanced Computer Graphics	Elective	3	2	0	2	15	25	20	40	-
	2	CSE5303	Fault Tolerant and testable Systems		3	3	0	0	20	-	30	50	-
	3	CSE5305	VLSI Design		3	2	0	2	15	25	20	40	-
	4	CSE5307	Parallel Computer Architecture		3	3	0	0	20	-	30	50	-
	5	CSE5309	Social Media and Online Marketing		3	3	0	0	20	-	30	50	-
	6	CSE5311	Reliable System Design		3	3	0	0	20	-	30	50	-
	7	CSE5313	Robotics Engineering		3	2	0	2	15	25	20	40	-
		Course Code	Course Name	Type/Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 3	1	CSE5201	SEMINAR	Elective	2	0	0	2	-	100	-	-	-
	2	CSE5203	Distributed Algorithms		2	2	0	0	20	-	30	50	
	3	CSE5205	Modeling& Simulation		2	1	0	2	15	25	20	40	-
	4	CSE5207	Multivariate Calculus		2	2	0	0	20	-	30	50	-
	5	CSE5209	Ethical Hacking		2	2	0	0	20	-	30	50	-
	6	CSE5211	Software Lab		2	1	0	2	15	25	20	40	-
		Course Code	Course Name	Type/Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 4	1	CSE5402	Wireless & Mobile Communication	Elective	4	3	0	2	15	25	20	40	-
	2	CSE5404	Digital Image Processing		4	3	0	2	15	25	20	40	-
	3	CSE5406	Software Testing		4	3	0	2	15	25	20	40	-

		Course Code	Course Name	Type/Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
	4	CSE5408	Computer Vision		4	2	0	4	15	25	20	40	-
	5	CSE5410	Applied Cryptography		4	3	0	2	15	25	20	40	-
	6	CSE5412	Optical Networks		4	3	0	2	15	25	20	40	-
		Course Code	**Course Name**	**Type/Area**	**Cr**	**L**	**T**	**P**	**CWS**	**PRS**	**MTE**	**ETE**	**PRE**
Elective 5	1	CSE5302	MINOR PROJECT	Elective	3	-	-	-	-	40	-	-	60
	2	CSE5304	Information and Network Security		3	2	0	2	15	25	20	40	-
	3	CSE5306	Bioinformatics		3	3	0	0	20	-	30	50	-
	4	CSE5308	Big Data Analytics		3	2	0	2	15	25	20	40	-
	5	CSE5310	Security and Privacy in Social Networks		3	3	0	0	20	-	30	50	-
	6	CSE5312	Probability and Statistical Theory		3	3	0	0	20	-	30	50	-
	7	CSE5314	Business Intelligence		3	3	0	0	20	-	30	50	-
	8	CSE5316	Mobile and Cellular Network Security		3	3	0	0	20	-	30	50	-
		Course Code	**Course Name**	**Type/Area**	**Cr**	**L**	**T**	**P**	**CWS**	**PRS**	**MTE**	**ETE**	**PRE**
Elective 6	1	CSE5202	Optimization Tools	Elective	2	2	0	0	20	-	30	50	-
	2	CSE5204	Statistical Tools		2	2	0	0	20	-	30	50	-
	3	CSE5206	Geo-Informatics		2	2	0	0	20	-	30	50	-
	4	CSE5208	Security Tools and Applications		2	2	0	0	20	-	30	50	-
	5	CSE5210	Secure Coding		2	2	0	0	20	-	30	50	-
	6	CSE5212	Linear Optimization		2	2	0	0	20	-	30	50	-
	7	CSE5214	Advances in Multimedia Technology		2	2	0	0	20	-	30	50	-
		Course Code	**Course Name**	**Type/Area**	**Cr**	**L**	**T**	**P**	**CWS**	**PRS**	**MTE**	**ETE**	**PRE**
Elective 7	1	CSE6401	Pattern Recognition	Elective	4	3	0	2	15	25	20	40	-
	2	CSE6403	Software Project Management		4	3	0	2	15	25	20	40	-
	3	CSE6405	Cluster & Grid Computing		4	3	0	2	15	25	20	40	-
	4	CSE6407	Internet of Things		4	3	0	2	15	25	20	40	-
	5	CSE6409	Nanotechnology		4	2	0	4	15	25	20	40	-
		Course Code	**Course Name**	**Type/Area**	**Cr**	**L**	**T**	**P**	**CWS**	**PRS**	**MTE**	**ETE**	**PRE**

		Course Code	Course Name	Type/Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 8	1	CSE6301	Natural Language Processing	Elective	3	3	0	0	20	-	30	50	-
	2	CSE6303	Digital Forensics		3	3	0	0	20	-	30	50	-
	3	CSE6305	Game Theory		3	3	0	0	20	-	30	50	-
	4	CSE6307	Deep Learning		3	3	0	0	20	-	30	50	-
	5	CSE6309	Blockchain and applications		3	3	0	0	20	-	30	50	-
	6	CSE6311	Real Time Systems		3	2	0	2	15	25	20	40	-
	7	CSE6313	Quantum Computing		3	2	0	2	15	25	20	40	-
		Course Code	**Course Name**	**Type/Area**	**Cr**	**L**	**T**	**P**	**CWS**	**PRS**	**MTE**	**ETE**	**PRE**
Elective 9	1	CSE6201	Research Methodology		2	2	0	0	20	-	30	50	-
	2	CSE6203	Enterprise Computing in JAVA		2	1	0	2	15	25	20	40	-
	3	CSE6205	Advances in Internet & Web Technology		2	2	0	0	20	-	30	50	-

SEMESTER I

Courses

CSE501   Advanced Database Management System

Relational Databases: Integrity Constraints revisited, Extended ER diagram, Relational Algebra & Calculus, Functional, Muiltivalued and Join Dependency, Normal Forms, Rules about functional dependencies .**Advanced Transaction Processing:** Nested and Multilevel Transactions, Compensating Transactions and Saga, Long Duration Transactions, Weak Levels of Consistency, Transaction Work Flows, Transaction Processing Monitors, Schedules, Serializability- conflict and view. **Query Processing:** General strategies for query processing, transformations, expected size, statistics in estimation, query improvement, view processing, query processor. **Query Optimization:** Indexing and Query Optimization, Limitations of Relational Data Model, Null Values and Partial Information. **Parallel and Distributed Databases:** Distributed Data Storage – Fragmentation & Replication, Location and Fragment Transparency Distributed Query Processing and Optimization, Distributed Transaction Modeling and concurrency Control, Distributed Deadlock, Commit Protocols, Design of Parallel Databases, Parallel Query Evaluation**Active Database and Real Time Databases:** Triggers in SQL, Event Constraint and Action: ECA Rules, Query Processing and Concurrency Control, Compensation and Databases Recovery.

Suggested Books:

1. Elmarsi, Navathe, Somayajulu and Gupta, Fundamentals of Database Systems", 4th Edition, Pearson Education, 2007.
2. Garcia, Ullman and Widom, "Database Systems, The complete book", Pearson,2007
3. Date, Kannan andSwaminathan, "An Introduction to Database Systems", 8th Edition Pearson Education, 2007.
4. Silberscatz, Korth and Sudarshan, "Database System Concepts", Mcgraw Hill, 6th Edition, 2006

CSE503Advanced Algorithms and Data Structures

Review of Elementary data structures: Binary Trees, Binary heap, Sorting and Searching techniques, Sparse matrices: Properties of sparse matrices, linked list representation of sparse matrices, analyzing algorithms. , Hashing, universal hashing, perfect hashing. **Advanced Data Structures**: data structures for combinatorial optimization - Binomial heaps, Fibonacci heaps. Red-Black Trees. Augmenting Red-Black Trees to Dynamic Order Statics and Interval Tree Applications. Operations on Disjoint sets - find union problem, Implementing Sets. Dictionaries, self-adjusting trees, skip lists. **Divide and Conquer approach-** Application of divide and Conquer-Finding Maximum and Minimum, Finding K-th smallest element Order Statistics, Finding K-th smallest element, Merge Sort, Randomized quick sort. **Graph Algorithms**: Definitions for Graphs, Algorithms for Connectedness, Finding all Spanning Trees in a Weighted Graph and Planarity Testing Breadth First and Depth First Search, Articulation Point, Cut edge, Topological Sort, Strongly Connected Components and. Single source shortest path and all pair

shortest path algorithms, Planer graphs**Greedy Method and Dynamic Programming:** General Method, Knapsack problem, Single source shortest path. Job Sequencing with deadline, Scheduling problems. Dynamic Programming: General method, 0/1 Knapsack problem, All pair shortest path. Backtracking: Sum of subsets, 8-queens problem, and Hamiltonian cycles.**Advanced Algorithms**: NP Complete problems, Approximation algorithms for NP complete problem (Vertex cover, traveling salesman), , Algorithms for matching, Flow and circular problems, Bio Inspired Algorithm- Genetic Algorithm, Particle Swam, Artificial Bee Colony, Firefly Algorithm, Bat Algorithm.

Suggested Books:

1. T.H. Cormen, C. E. Leiserson, R.L. Rivest, Introduction to Algorithms, MIT Press,2013
2. Aho, Hopcraft&Ulman, The Design and Analysis of Computer algorithms", Addison Wesley,1974
3. S. Dasgupta, C. H. Papadimitriou, and UV Azirani, Algorithms,2006
4. Tannenbaum, Data Structures, PHI,2004
5. R.E. Trajan,,Data Structures and Network algorithms, SIAM Regional Conference series in applied mathemetics,1983
6. E. Horowitz, S.Sahni and S. Rajasekaran The Design and Analysis of Computer Algorithms, Universities Press2003
7. R. Motwani and P. Raghavan, Randomized Algorithms, Cambridge University Press,1995
8. D. C. Kozan, The Design & Analysis of Algorithms, Springer,1992
9. N. Deo,Graph Theory with Application to Engineering and Computer Science, Prentice Hall of India,1979

CSE5401Artificial Intelligence and Expert Systems

Introduction: AI Problems, Task Domains of AI, Introduction to Intelligent program and Intelligent methodologies.
AI Techniques: search knowledge, abstraction. **Problem Solving**: Basic Problem solving Method: state space search, problem characteristics, Production systems characteristics, issues in design of Intelligent search algorithm**Heuristic search Techniques**: Hill climbing techniques, Best Firstsearch, A* Search,: AO* Search, Constraint Satisfaction, Means-End Analysis.**Game Playing**: Game Tree, Searching procedure Minimax, alpha-beta pruning**Knowledge Representation**: Knowledge Representation issues.**Knowledge Representation:** usingPredicate Logic: Unification, resolution.Natural deduction, using Rules: Forward versus backward reasoning, conflict resolution. **Structured Knowledge Representation**: Semantic Nets, Frames, conceptual dependency, scripts.**Programming Languages:**Prolog or Lisp implementation of inferences for above knowledge representation methods**Symbolic Reasoning under uncertainty**: Introduction to Non-Monotonic Reasoning, Logics for non monotonic reasoning such as Default reasoning; Minimalist reasoning; implementation issues.**Statistical Reasoning**: Probabilistic Reasoning, CertaintyFactors and Rule Based Reasoning, Bayesian Network, Dempster Shafer Theory, Fuzzy logic**Learning**. Concept of learning, learning in problem solving, learning by inductions, genetic algorithm, **Learning:** Neural Network, Genetic theorem**Introduction to machine LearningApplications: Expert Systems**: Architecture, Domain Knowledge, Knowledge Acquisition, Case Studies: MYCIN, RI,**Natural language Processing**: Syntactic, Semantic and Pragmatic Analysis.**Research issues** in different domains

Suggested Books:

1. E. Rich and K. Knight, Artificial Intelligence, TMH, 2nd ed,1992
2. N.J. Nilsson, Narosa Publication. House, Principles of AI, 1990
3. M.Negnevitsky, Artificial Intelligence: A Guide to Intelligent Systems (2nd Edition) Addison-Wesley,2005.
4. D.W. Patterson, "Introduction to AI and Expert Systems", PHI, 1992.

CSE5403Data Warehousing and Data Mining

Data Warehousing: - Basic concepts in data warehousing, Collecting the requirements of data warehouse, Data Warehouse Architecture, Design, Implementation & Maintenance, OLAP in data warehouse, Data warehousing and the web, Data Cube Technology, From Data Warehousing to Data Mining. **Data Mining Concepts:** Data mining primitives, Basics of data mining, Query language, Architectures of data mining systems. **Mining Association Rules in Large Databases:**Association Rule Mining, Mining Single Dimensional Boolean Association Rules from Transactional Databases, Mining Multilevel Association Rules from Transaction Databases, Mining Multidimensional Association Rules from Relational Databases and Data Warehouses, From Association Mining to Correlation Analysis, Constraint Based Association Mining. **Classification and Prediction:** Issues Regarding Classification and Prediction, Classification by Decision Tree Induction, Bayesian Classification, Classification by Back propagation, Classification Based on Concepts from Association Rule Mining, Other Classification Methods, Prediction, Classifier Accuracy. **Cluster Analysis in Data Mining:** Types of Data in Cluster Analysis. A Categorization of Major Clustering Methods, Partitioning Methods, Density Based Methods, Grid Based Methods; Model Based Clustering Methods, Outlier Analysis. **Mining Complex Types of Data:** Multidimensional Analysis and Descriptive Mining of Complex Data Objects, Mining Spatial Databases, Mining Multimedia Databases, Mining Time Series and Sequence Data, Mining Text Databases. **Applications and trends in Data Mining: -** Applications, Systems products and research prototypes, Additional themes in data mining, Trends in Data mining, spatial mining, and Web Mining.

Suggested Books:

1. P. Ponnian,Data Warehousing Fundamentals, John Wiley

2. M.H. Dunham, Pearson Education,Data Mining Introductory & Advanced Topics, 2011.

3. H. Kamber, M. Kaufman, Data Mining Concepts & Techniques, Elsevier, 2011.

4. R. Kimball,The Data Warehouse Lifecycle Tool Kit, John Wiley, 2012.

5. M. Berry , G. Linoff,Master in Data Mining, John Wiley, 1996.

CSE5405Design Of Embedded Systems

Introduction to Embedded Real time Systems: Fundamental components of ESD, Preprocessing, Compiling, crosscompiling,

Linking, Locating, compiler driver, Linker script, Program segmentsType of memory, Memory Management in Embedded real time systems, Interrupt and ISR, Introduction to Real-time theory: Scheduling theory, Rate Monotonic Scheduling, Utilization bound theorem, RTOSTask Management, Task management, Race condition, Priority inversion, ISRs and scheduling, Inter-Task communication, TimersMicrocontrollers: Role of processor selection in Embedded System (microprocessor vs microcontroller), 8051 microcontroller: architecture, assembly language programming, instruction set, addressing mode, logical operation, arithmetic operation, interrupt handling, Timing subroutinesSerial data communication, RS-232, USB, I2C, Interfacing with ADC & sensors, Interfacing with DAC, Interfacing with external ROM, Interfacing with 8255 IEEE 1149.1 (JTAG) testability: Boundary Scan Architecture.

Suggested Books:

1. S. V Iyer and P. Gupta, Embedded Real-time Systems Programming, TMH,2003
2. Mazidi and Mazidi, The 8051 Microcontroller, PHI. 2007
3. R. Kamal ,Embedded System , TMH,2017
4. K. J. Ayala, T. DelMar ,The 8051 Microcontroller,1996
5. A. Deshmukh, Microcontrollers, TMH, 2017.
6. R. Kapadia, 8051 Microcontroller & Embedded systems,Jacio publishing house,2004
7. wayne wolf, Computer as components, Harcourt India Pvt. Ltd., 2008.
8. Philip A. Laplante,Real time System and Analysis,Wiley; 3rd edition (11 May 2004)

CSE5407Information Retrieval

Introduction and Search engine architecture:We will highlight the basic structure and major topics of this course, and go over some logistic issues and course requirements.Search engine architecture): We will briefly discuss the basic building blocks of a modern search engine system, including web crawler, basic text analysis techniques, invertedindex, query processing, search result interface**. Retrieval models**:Retrieval model, a.k.a., ranking algorithm, is arguably the most important component of a retrieval system, and it directly determines search effectiveness. We will discuss classical retrieval models, including Boolean, vector space, probabilistic and language models. We will also introduce the most recent development of learning-based ranking algorithms, i.e.,learning-to-rank. **Retrieval evaluation**:Assessing the quality of deployed system is essential for retrieval system development. Many different measures for evaluating the performance of information retrieval systems have been proposed. We will discuss both the classical evaluation metrics, e.g., Mean Average Precision, and modern advance, e.g., interleaving. **Relevance feedback**:User feedback is important for retrieval systems to evaluate the performance and improve the effectiveness of their service strategies. However, in most practical system, only implicit feedback can be collected from users, e.g., clicks, which are known to be noisy and biased. We will discuss how to properly model implicit user feedback, and enhance retrieval performance via such feedbac. **Link analysis and Search applications**: We will discuss the unique characteristic of web: inter-connection, and introduce Google's winning algorithm PageRank. We will also introduce the application of link analysis techniques in a similar domain: social network analysis.Search applications: We will introduce modern applications in search

systems, including recommendation, personalization, and online advertising, if time allows.

Suggested Books:

1. C. D. Manning, P. Raghavan and H. Schutze. Introduction to Information Retrieval, Cambridge University Press, 2008.

CSE5409   Soft Computing

Soft Computing & Artificial Intelligence: Soft Computing Introduction, Hard Computing, Types of Soft Computing Techniques, Applications of Soft Computing, AI Search Algorithm, Predicate Calculus, Rules of Interference, Semantic Networks, Frames, Objects, Hybrid Models **Artificial Neural Networks :** History, overview of biological Neuro-system, Neuron Model, Neural Network Architecture, Learning Rules, Perceptrons, Single Layer Perceptrons, Multilayer Perceptrons, Back propagation Networks: Kohnen'sself organizing networks, Hopfield network, Applications of NN **Fuzzy Logic and Fuzzy Sets :** Introduction to Fuzzy Logic, Classical and Fuzzy Sets: Compliment, Intersections, Unions, Combinations of Operations, Aggregation Operations, Overview of Classical Sets, Membership Function, Fuzzy rule generation **Fuzzy Arithmetic:** Fuzzy Numbers, Linguistic Variables, Arithmetic Operations on Intervals & Numbers, Lattice of Fuzzy Numbers, Fuzzy Equations. **Neuro - Fuzzy Modeling** : Neuro Fuzzy Controls ,Adaptive Networks Based Fuzzy Interface Systems, Classification and Regression Trees, Data Clustering Algorithms, Rule Based Structure Identification, Evolutionary Computation **Genetic Algorithms and Swarm Optimizations:** Introduction to Genetic Algorithm, Fitness Computations, Evolutionary Programming, Genetic Programming Parse Trees, Variants of GA, Applications, Ant Colony Optimization, Particle Swarm Optimization, Artificial Bee Colony Optimization.

Suggested Books:

1. Anderson J.A., An Introduction to Neural Network, PHI, 1995.
2. S.Patnaik, B.Zhong, Soft Computing Techniques in Engineering Applications,Springer 2014
3. Hertz J. Krogh, R.G. Palmer, Introduction to the Theory of Neural Computation, Addison-Wesley, 1991.
4. G.J. Klir& B. Yuan, Fuzzy Sets & Fuzzy Logic, PHI, 1995.
5. M. Mitchell, An Introduction to Genetic Algorithm, PHI, 1998.
6. S. Kaushik, Artificial Intelligence, Cengage Learning, 2007..

CSE5411Semantic Web

Semantic Web Vision: Todays' web, Examples of semantic web from today's web, Semantic web technologies, layered approach. **Structured web documents in XML**: The XML language, Structuring, Namespaces, Querying and Addressing XML documents, Processing. **Describing Web Resources**: Introduction, RDF , RDF Schema syntax and language, Direct Inference System, Querying RQL. **Web Ontology Language**: Introduction, OWL language, Examples, OWL in OWL, Future

extensions. **Logic and Inference**: Rules: Introduction, Monotonic Rules syntax, semantics & examples, Nonmonotonic rules – syntax & examples, Encoding in XML. **Ontology Engineering**: Introduction, Manual construction of Ontology, Reusing existing ontology, using Semi-automatic methods, Knowledge semantic web architecture. **Applications & Future trends:** Various applications, Issues and future trends.

Suggested Books:
1. P. Hitzler, M. Krötzsch, Foundations of Semantic Web Technologies, CRC Press,2009
2. G.Antoniou and F.Hermelen ,A Semantic web Primer, MIT Press,2004
3. John Hebler ,Semantic Web programming, Wiley,2009

CSE5413   Machine Learning

Introduction to Machine Learning: Introduction, Types of Machine Learning :Supervised, Unsupervised Learning, Reinforcement Learning, Categories of Supervised Learning; Predictive Modeling, Steps in Model Prediction: Metric Data Analysis, Attribute Reduction, Hypothesis Testing, Performance Evaluation Measures, Model Development, Model Development, Model Validation, Model Comparison Tests. **Supervised Learning:** Decision Trees: Introduction, Basic Methodology, Basic Terminologies, ID3 Algorithm, Splitting Based on Nominal Attributes, Splitting Based on Ordinal Attributes, Splitting Based on Continuous Attributes, Entropy, Infogain, Inductive Bias, Occam's Razor, Issues in Decision Tree, Overfitting, Pruning, Problem with Information Gain Approach, Gain ratio, Decision Trees using Gain Ratio, Gini Index, Decision trees using Gini Index, Advantages and Disadvantages of Decision Trees, Handling Training Examples with Missing Attribute Values, Handling Attributes with Differing Costs, Comparison of ID3, C4.5 and CART. Artificial Neural Networks (Single-Layer Networks): Introduction, Characteristics of ANN, Topologies, Neuron and its terminologies, Transfer Functions (Sign, Step, Log Sigmoid, Tan Sigmoid, Unipolar and Bipolar), Perceptron, Perceptron Convergence Theorem, Perceptron Learning Algorithm.Multi-layer Perceptron: Introduction, Implementation of Logical XOR with a Hidden Layer, Delta Rule and Gradient Descent, Back Propagation Learning Algorithm, Learning and Generalization, Bias and Variance, Bias/Variance Trade-off, Preventing Over-fitting and Under-fitting, Applications of Neural Networks. Nearest Neighbor: Nearest Neighbor Classifier Introduction, Characteristics of K-Nearest Neighbor, Nearest Neighbor Algorithm, Computing Distance: Euclidean measure, Feature Weighting in KNN, Feature Weighting according to Distance, Classification, Characteristics of Nearest Neighbor Classifiers. **Unsupervised Learning:** Unsupervised Learning Introduction, Clustering Introduction and its applications, Partitional Clustering vs Hierarchical Clustering, Partial vs Complete Clustering, Hard Clustering vs Soft Clustering, K-means Clustering, Proximity Measures: Euclidean Distance, Minkowski Distance, Manhattan Distance , K-means Algorithm with example, Hierarchical Clustering, Types of Hierarchical Clustering, Agglomerative Clustering Algorithm,.Dimensionality Reduction:- Why Dimensionality Reduction is needed?, Classification of Dimensionality Reduction Methods, Feature Selection Methods, Wrapper, Filter, Univariate Analysis, Correlation-Based Feature Selection (CFS), Feature Extraction, Principal Component Analysis, Principal Component Method, Standard Deviation, Variance, Covariance, Covariance Matrix, Eigenvectors, Eigenvalues, Computing Eigenvalues and Eigenvectors, PCA Steps (Data, Subtract the mean, Compute Covariance Matrix, Computing Eigenvalues and Eigenvectors, Choosing components & forming a feature vector, Deriving the new data set). Euclidean Distance. **Ensemble Learning**: Introduction, Basic Methodology, Bagging: Basic Algorithm and Classification, Boosting: Introduction,

Decision Stump, Adaptive Boosting AdaBoost: Model Generation and Classification, Random Forests: Introduction, Algorithm, Classification through Random Forests, Uses of ensemble learners in predictive modeling, advantages and disadvantages. **Other Topics:** Bayesian learning, online learning. Learning theory, Bias Variance trade-offs. **Recent applications & Research Topics:** Applications in the fields of software engineering.

Suggested Books:
1. T. Mitchell,Machine Learning, McGraw Hill,1997
2. S.S Shwartz and S,B. David, Understanding Machine Learning: From Theory to Algorithm**,**2014
3. J, D. Kelleher, B.C. Namee, and Aoife D'Arcy, Fundamentals of Machine Learning for Predictive Data Analytics: Algorithms, Worked Examples, and Case Studies,2015

CSE5301   Advanced Computer Graphics

Line Drawing and transformation: Basic raster graphical algorithm for 2D primitives, Line drawing algorithm, 2D and 3D transformation**Clipping:** Window, View port, clipping algorithm. **Curves and Surfaces:** Circle drawing algorithm, Ellipse drawing algorithm, Bezier curve, b-spline curve, surfaces, Solid modelling. **Projection:** Parallel projection, Perspective projection, Computation of vanishing point. **Visible surface determination:** Z-buffer algorithm, Scan line algorithm, Area subdivision algorithm, Raytracing algorithm. **Shading:** Illumination mode, Specular reflection model, Shading models for curve surfaces, Radiosity method, Rendering, Recursive ray tracing, Texture mapping Advanced Modelling Techniques Procedural Models,FractalModels,Grammar based models,particle systems. **Animation:** 3D animation, morphing, simulation of key frames.

Suggested Books:

1. Foley,Computer Graphics Principles & Practice, 2nd ed. Pearson Education,2014
2. Hearn &Baker , Computer Graphics C version, 2nd ed. Pearson Education,2002
3. Ro and Adams , Mathematical Element for Computer Graphics, 2nd ed., Tata McGraw Hill,1984
4. D. F. Rogers, Procedural Element for computer graphics, McGraw Hill Book Company,2016
5. W. A. and M. Watt, Advanced Animation and Rendering Techniques Theory and Practice, Addison-Wesley,1992
6. A. K. Peters, P. Shirley, Fundamentals of Computer Graphics, 3rd ed. CRC Press,2009

CSE5303   Fault Tolerant and Testable Systems

Fundamental Concepts: Definitions of fault tolerance, fault classification, fault tolerant attributes and system structure. Faults and their causes Common Fault Models, Common Error Models. **Fault-Tolerant Design Techniques:** Information redundancy, hardware redundancy, and time redundancy. **Architecture of Fault-Tolerant Computers (case study):** General-purpose systems, high-availability systems, long-life systems, critical systems. **Software Fault Tolerance:** Software faults and their manifestation, design techniques, reliability models..**Fault Tolerant Parallel/Distributed Architectures:** Shared bus and shared

memory architectures, fault tolerant networks. **Recent topics in fault tolerant systems:** Security, fault tolerance in wireless/mobile networks..

Suggested Books:

1. D.K. Pradhan,Fault-Tolerant Computer System Design, Prentice Hall, 1996.
2. B.W.Johnson, Design and Analysis of Fault Tolerant Digital System, Addison-Wesley, 1989.
3. D.K. Pradhan, Fault-Tolerant Computing: Theory and Techniques Vol. I,II, Prentice-Hall, 1986.
4. D.P. Siewiorek and R.S. Swarz , Reliable Computer Systems Design and Evaluation, AK Peters Ltd,1998.
5. K.S.Trivedi, Probability and Statistics with Reliability, Queueing and Computer Science Application, Prentice Hall, 2001.

CSE5305   VLSI Design

Introduction to CMOS circuits: MOS Transistors, MOS transistor switches, CMOS Logic, The inverter, Combinational Logic, NAND gate, NOT Gate, Compound Gates, Multiplexers, Memory-Latches and RegistersProcessing Technology: Silicon Semiconductor Technology- An Overview, wafer processing, oxidation, epitaxy deposition, Ion-implantation and diffusion, The Silicon Gate Process- Basic CMOS Technology, basic n-well CMOS process, p-well CMOS process, Twin tub process, Silicon on insulator, CMOS process enhancement-Interconnect, circuit elements, 3-D CMOS. Layout Design Rule: Layer Representations, CMOS n-well Rules, Design Rule of background scribe line, Layer Assignment, SOI RulePower Dissipation: Static dissipation, Dynamic dissipation, short-circuit dissipation, total power dissipation. Programmable Logic, Programmable Logic structure, Programmable interconnect, and Reprogrammable Gate Array: Xilinx Programmable Gate Array, Design Methods: Behavioral Synthesis, RTL synthesisPlacement: placement: Mincut based placement – Iterative improvement placement simulated annealing. Routing: Segmented channel routing – maze routing – routability and routing resources – net delaysVerification and Testing: Verification Versus Testing, Verification: logic simulation design validation – timing verification – Testing concepts: failures – mechanisms and faults – fault coverage – ATPG methods – types of tests – FPGAs – programmability failures – design for testability.Overview of VHDL

Suggested Books:
1. J.M. Rabaey, A.P. Chadrakasan and B. Nikolic, Digital integrated circuits a design perspective, Pearson Education, 2012.
2. S.M.O. Kang and Y. Leblebici, CMOS digital integrated circuits, Tata McGraw Hill Publication, 2014.
3. Wayne Wolf "Modern VLSI Design", Prentice Hall, 2002.
4. N. Sherwani, "Algorithm for VLSI Design & Automation", Springer, 1998
5. Bhaskar, "VHDL", PHI, 1999.

CSE5307   Parallel Computer Architecture

Parallel computer models: The state of computing, Classification of parallel computers, Multiprocessors and multicomputers, Multivector and SIMD computers. **Program and network properties:** Conditions of parallelism, Data and resource

Dependences, Hardware and software parallelism, Program partitioning and scheduling, Grain Size and latency, Program flow mechanisms, Control flow versus data flow, Data flow Architecture, Demand driven mechanisms, Comparisons of flow mechanisms. **System Interconnect Architectures:** Network properties and routing, Static interconnection Networks, Dynamic interconnection Networks, Multiprocessor system Interconnects, Hierarchical bus systems, Crossbar switch and multiport memory, Multistage and combining network. **Advanced processors:** Advanced processor technology, Instruction-set Architectures, CISC Scalar Processors, RISC Scalar Processors, Superscalar Processors, VLIW Architectures, Vector and Symbolic processors. **Pipelining:** Linear pipeline processor, nonlinear pipeline processor, Instruction pipeline Design, Mechanisms for instruction pipelining, Dynamic instruction scheduling, Branch Handling techniques, branch prediction, Arithmetic Pipeline Design, Computer arithmetic principles, Static Arithmetic pipeline, Multifunctional arithmetic pipelines. **Memory Hierarchy Design:** Cache basics & cache performance, reducing miss rate and miss penalty, multilevel cache hierarchies, main memory organizations, design of memory hierarchies. **Multiprocessor architectures:** Symmetric shared memory architectures, distributed shared memory architectures, models of memory consistency, cache coherence protocols (MSI, MESI, MOESI), scalable cache coherence, overview of directory based approaches, design challenges of directory protocols, memory based directory protocols, cache based directory protocols, protocol design tradeoffs, synchronization. **Scalable point – point interfaces:** Alpha364 and HT protocols, high performance signaling layer.

Suggested Books:
1. Kai Hwang, Advanced computer architecture; TMH,2010.
2. D. A. Patterson and J. L. Hennessey, Computer organization and design,2010
3. J.P.Hayes,Computer Architecture and organization; T.MH,2012
4. Harvey G.Cragon, Memory System and Pipelined processors, Narosa Publication,1996
5. V.Rajaranam&C.S.R.Murthy, Parallel computer"; PHI. ,2000
6. R.K.Ghose, R Moona& P. Gupta, Foundation of Parallel Processing, Narosa Publications,1996
7. K. Hwang and Zu, Scalable Parallel Computers Architecture, MGH. ,2000
8. Stalling W, Computer Organisation & Architecture, and PHI,2004

CSE5309   Social Media and Online Marketing

Social media marketing ,platforms and strategies, active and passive approach,purpose and tactics,marketing techniques, implications on traditional advertising,leaks and mishapsDigitaladvertising,Displayadvertising,web banner advertising,mobileadvertising, email advertising,classifiedadvertising,affiliatemarketing,content marketing, benefits of online advertising,security concerns and technological concerns,regulatoryactsMarketingmanagement,brandauditing,marketing planning and implementation strategy, Social media in business,importance of social media in entreprenurship and business success,businessmanagement,social media and business management strategiesWebsites and its levels, difference between blogs, portals, and websites. Static and dynamic websites, News Writing and SEO-onpage and off page optimizationsSocial Media Optimizations, SMM:An Overview, Theoretical Concepts Guiding Social Media, Social Media Strategy and Planning, Social Media Measurement.Content Strategy, Blogging and Microblogging, Social Bookmarking, Social Media Sites(SNS): LinkedIn & Twitter, SNS: Photosharing Sites(Instagram,Snapchat, Pinterest), SNS: Facebook for business, SNS:Youtube and Live Streaming

Suggested Books:

1. "Social Media Marketing: Principles and Strategies", Stephen, A. & Bart, Y. (2017)
2. "Social PR Secrets: How to Optimize, Socialize, and Publicize Your Brand." 3rd edition, Buyer, (2016)
3. Digital and social media marketing-A result driven approach by Heinzei,Rashid and Cruz 1st edition
4. The New Rules of Marketing & PR-David scott 5th edition
5. The New Rules of Marketing & PR: How to Use Social Media, Online Video, Mobile Applications, Blogs, News Releases, and Viral Marketing to Reach Buyers Directly

CSE5311Reliable System Design

Fundamental Concepts Definitions of fault tolerance, fault classification, fault tolerant attributes and system structure**. Fault-Tolerant Design Techniques** Information redundancy, hardware redundancy, and time redundancy. **Dependability Evaluation Techniques**.Reliability and availability models: (Combinatorial techniques, Fault-Tree models, Markov models), Performance Models.**Architecture of Fault-Tolerant Computers (case study)** General-purpose systems, high-availability systems, long-life systems, critical systems. **Software Fault Tolerance**.Software faults and their manifestation, design techniques, reliability models.**Fault Tolerant Parallel/Distributed Architectures**Shared bus and shared memory architectures, fault tolerant networks. Recent topics in fault tolerant systems:Security, fault tolerance in wireless/mobile networks.

Suggested Books:

1. D.K. Pradhan, Fault, Tolerant Computer System Design ,Prentice-Hall2003
2. B.W. Johnson, Design and Analysis of Fault-Tolerant Digital Systems, Addison-Wesley
3. D.K. Pradhan, Fault, Tolerant Computing, Theory and Techniques, Volumes I and II, Prentice Hall,2003
4. D.P.Siewiorek and R.S.Swartz ,Reliable Computer Systems: Design and Evaluation, Digital Press, 1992.
5. K.S.Trivedi, Probability and Statistics with Reliability, Queueing and Computer Science Application , Prentice Hall, 1982

CSE5313   Robotics Engineering

Introduction to Robotics Engineering: History of robots, Classification of robots, Present status and future trends,Basic components of robotic system, Basic terminology- Accuracy, Repeatability, Resolution, Degree of freedom, Mechanisms and transmission, End effectors: Grippers-different methods of gripping, Mechanical and other types of grippers, Tools as end effectors, Robot and effector interface, Gripper selection and design, Specifications of robot. **Drive systems and Sensors:** Drive system- hydraulic, pneumatic and electric systems Sensors in robot – Touch sensors, Tactile sensor, Proximity and range sensors, Robotic vision sensor, Force sensor, Light sensors, Pressure sensors. **Kinematics and Dynamics of Robots:** 2D, 3D Transformation, Scaling, Rotation, Translation, Homogeneous coordinates, multiple transformation, Simple problem, Matrix representation, Forward and Reverse Kinematics Of Three Degree of Freedom, Homogeneious Transformations, Inverse

kinematics of Robot, Robot Arm dynamics, D-H representation of robots, Basics of Trajectory Planning,Robot Dynamics: Lagrangian Mechanics, Lagrangian Formulation and numericals, Dynamics, Newton-Euler Recursive Algorithm, Simulation, Euler-Lagrange Equations of motion/Any one other formulation like using Decoupled Natural Orthogonal Complements (DeNOC).**Robot Controls and Programming:** Robot controls-Point to point control, Continuous path control, Intelligent robot, Control system for robot joint, Control actions, Feedback devices, Encoder, Resolver, LVDT, Motion Interpolations, Adaptive control,Introduction to Robotic Programming, On-line and off-line programming, programming examples. **Applications for Manufacturing:** Flexible automation, Robot cell layouts, Machine interference, Other considerations in work cell design, Work cell control, interlocks, Robot cycle time analysis, Mechanical design of robot links,Typical applications of robots in material transfer, machine loading/unloading; processing operations; assembly and inspection.

Suggested Books:

1. M. P Groover, N.G Odrey, M. Weiss, R.N Nagel, Technology programming and Applications, McGraw Hill, 2012.
2. Craig. J. J., Introduction to Robotics- mechanics and control, Addison- Wesley, 1999.
3. Saha, S.K., Introduction to Robotics, 2nd Edition, McGraw-Hill Education, New Delhi, 2014
4. S.R. Deb, Robotics Technology and flexible automation, Tata McGraw-Hill Education., 2009..
5. R. D. Klafter, Thomas. A, C.Elewski, M. Negin, Robotics Engineering an Integrated Approach, PHI Learning., 2009
6. R. Asfahl. C, Robots and Manufacturing Automation, John Wiley & Sons Inc.,1985.
7. Fu. K. S., Gonzalez. R. C. & Lee C.S.G, Robotics control, sensing, vision and intelligence, McGraw Hill Book co, 1987

CSE5201   SEMINAR

CSE5203   Distributed Algorithms

Introduction: Algorithmic challenges of distributed algorithms) ; Basic definitions (System models, distributed computation, local/global states, consistency, complexity measures) .Time in distributed computing (logical clocks, vector clocks, virtual time) ; Distributed graph algorithms   (Spanning trees, broadcast & converge cast, shortest path)Distributed mutual exclusion algorithms ; Global state and snapshot recording algorithmsMonitoring global states (Necessary & sufficient conditions for consistent global states, zig-zag paths) ; Termination Detection (Based on snapshots computations, weight throwing, spanning trees)

Suggested Books:

1. A. Kshenkalyani/ M.Singhal: Distributed Computing, Cambridge University Press, 2008
2. Wan Fokkink: Distributed Algorithms: an Intuitive Approach, MIT Press, 2013
3. David Peled: Distributed Computing: a Locality Sensitive Approach, SIAM Monograph, 2000
4. Nancy Lynch: Distributed Algorithms, Morgan Kaufmann, 1996

5. M. Raynals: Distributed Algorithms for Message-Passing Systems, Springer, 2013.

CSE5205   Modeling& Simulation

System definition and components: stochastic activities, continuous and discrete systems, system modeling, types of models, static and dynamic physical models.Types of system simulation: Real time simulation, Hybrid simulation, simulation of pure-pursuit problem, single-server queuing systemIntroduction to SIMSCRIPT: Program, system concepts, origination, and statements, defining the telephone system model.Simulation of PERT Networks: critical path computation, uncertainties in activity duration, resource allocation and consideration.Simulation languages and software**.**

Suggested Books:

1. Geoffrey Gordon, System Simulation, PHI,2011
2. J. Banks, John S. C Barry L. Nelson David M. Nicol, "Discrete Event System Simulation", Pearson Education,2010
3. V P Singh, System Modelling and simulation, New Age International,2009
4. Averill M. Law, W. David Kelton, System Modelling and simulation and Analysis, TMH

CSE5207   Multivariate Calculus

Functions, Gradients and derivatives, product rule, chain rule, variables, constants and context, differentiation with respect to different variables.Vectors of derivatives: Jacobian, calculation and applications of Jacobian, Hessian, calculation and applications of HessianMultivariate chain rule, Application in neural network: neuron, simple neural network, training neural network,backpropagation.Taylor Series for approximation: Building approximate functions, power series, visualization of Taylor series, power series derivative and details, applications of Taylor series, Linearization, Multivariate Taylor series.Fitting as minimization problem: Newton-Raphson in one dimension, Gradient descent, constraint optimization, Lagrange multipliers

Suggested Books:
1. Roger A. Horn, Charles R. Johnson, Matrix Analysis (2nd ed.), Cambridge University Press, 2013.
2. Dimitri P. Bertsekas, John N. Tsitsiklis,Introduction to Probability (2nd ed.). Athena Scientific, 2008.
3. Trevor Hastie, Robert Tibshirani, Jerome Friedman,The Elements of Statistical Learning (2nd ed.), Springer, 2008

CSE5209Ethical Hacking

Introduction to ethical hacking:-Introduction-Ethical hacking Terminology-types of hacking technologies-phases of ethical hacking-Footprinting-Social Engineering-Scanning and enumeration. **System hacking:-** Understanding the password hacking techniques-Rootkits-Trojans- Backdoors-Viruses and worms-sniffers-denial of service-Session hijacking. **Web server hacking:-** Hacking web servers-web application vulnerabilities –Buffer overflow-Wireless hacking Physical Security. **Wireless hacking**:- WEP, WPA Authentication mechanism-wireless sniffers-Physical Security-factors affecting physical security-honey pots-Firewall types. **Penetration testing:-**Cryptography-overview of MD5, SHA, RC4-penetration testing methodologies- steps-pen test legal

framework-penetration testing tools.

Suggested Books:

1. P. Engebretson, The Basics of Hacking and Penetration Testing, Elsevier, 2013
2. R. Khare, Network Security and Ethical Hacking, Luniver Press, 2006
3. Michael T. Simpson, K. Backman, J Corley, Hands-On Ethical Hacking and Network Defence
4. S. DeFino, B. Kaufman, N Valenteen, Official Certified Ethical Hacker Review Guide
5. The Basics of Hacking and Penetration Testing: Ethical Hacking and Penetration Testing Made Easy Syngress Basics Series
6. Hands-On Ethical Hacking and Network Defence.

CSE5211   Software Lab

SEMESTER II

CSE502   Distributed Systems

Introduction:Distributed System Models, Transparency, Scalability, Inter-process Communication, Middleware, issues in design of Distributed systems: current &future.Communications: Layered Protocol, Distributed Objects & Remote Method Invocation, Remote Procedure Call, Synchronization in communication, sockets, MPI, Message brokers, Data Streams.Process and Synchronization: Processes, Threads, Code Migration, Logical clocks, vector clocks, direct dependency clocks, matrix clocks, Serializability.Resource Allocation: Distributed Shared Memory, Process Scheduling, Load Balancing & Load Sharing, Mutual Exclusion, Election algorithms.Distributed File Systems: Coordination & Agreement, Distributed Transaction, Consistency & Replication: Consistency Models, Distribution &Consistency Protocols. Distributed Systems: Google Case Study with Map ReduceDistributed Systems: Security:Overview of security techniques, Cryptographic algorithms , Digital signatures, Cryptography pragmatics, Case studies: Needham–Schroeder, Kerberos, TLS, 802.11

Suggested Books:

1. A.S. Taenbaum and M. Van Steen, "Distributed Systems: Principles and Paradigms", Prentice Hall, 2016.
2. G. Coulouris and J. Dollimore, Distributed Systems Concepts and Design, Addison Wesley,2006.
3. A. Kshenkalyani and M.Singhal, Distributed Computing, Cambridge University Press, 2008.

CSE504   Advanced Computer Networks

Basic networking concepts : introduction to networks, layering and link layer, network layer, routing, end-to-end layer, congestion control. **Modeling and measurement**: network traffic modeling, network measurement, simulation issues, network coding techniques.Routing and router design, scheduling and QoS, integrated and differentiated services, RSVP.Wireless networks and mobility supports, MAC protocol, routing, AODV, group communication, multicast Flow and congestion control,

TCP variants, TCP modeling, active queue management. **Overlay networks**: RON, P2P, CDN, Web caching, cross-layer optimizations, Emerging network types: data center, DTN, 4G mobile networks (LTE, Wi-Max), Online social networks (OSN), wireless sensor networks (WSN) – cross-layer sensor data dissemination. .**Emerging applications :** VoIP, SIP, video over P2P.

Suggested Books:
1. J.F. Kurose and K.W. Ross, Computer networking: A top-down approach, 6th edition,Adison Wesley, 2012.
2. L.L. Peterson and B.S. Davie, Computer Networks ISE: A System Approach, 5th edition,Morgan Kaufman, 2007.
3. B.A. Forouzan, Data communication & networking, 5th Edition, Tata Mc-Graw Hills, 2000.

CSE5402   Wireless & Mobile Communication

Introduction: Network Technologies and Cellular Communications, Discussion on Bluetooth & GSM. Introduction to Mobile Computing: novel applications, limitations, and architecture. **(Wireless) Medium Access Control**: Motivation for a specialized MAC (Hidden and exposed terminals, Near and far terminals), SDMA, FDMA, TDMA, CDMA.Bluetooth (User scenarios, physical layer, MAC layer, networking, security, link management) **Mobile Architecture:** Mobile Network Layer: Mobile IP (Goals, assumptions, entities and terminology, IP packet delivery, agent advertisement and discovery, registration, tunneling and encapsulation, optimizations), Dynamic Host Configuration Protocol (DHCP). **Mobile Transport Layer:** Traditional TCP, Indirect TCP, Snooping TCP, Mobile TCP, Fast retransmit/fast recovery, Transmission /time out freezing, Selective retransmission, Transaction oriented TCP .**Mobile Ad hoc Networks (MANETs):** Overview, Properties of a MANET, spectrum of MANET applications, routing and various routing algorithms, security in MANETs. Wireless Sensor Networks- Basic Characteristics of WSNs- Operating Systems for WSNs. **Protocols and Tools:** Wireless Application Protocol WAP. (Introduction, protocol architecture, and treatment of protocols of all layers) ,J2ME and Latest Technologies

Suggested Books:

1. R. Kamal, Mobile Computing,Oxford Higher education, Second Edition, 2002.
2. W. Stallings,Wireless Communication and Networks, Pearson Education, 2003.
3. V. Garg and J. Wilkes, Wireless and Personal Communications Systems, Prentice-Hall, Englewood Cliffs, NJ, 1996.
4. L. Merk, M.S. Nicklaus and T. Stober, Principle of Mobile Computing, Second Edition, Springer, 2003.
5. D. Tse and P. Viswanath, Fundamentals of Wireless Communication, Cambridge University Press, 2005.
6. J. Schiller, Mobile Communication, Addison Wesley, 2000.

CSE5404   Digital Image Processing

The origins of Digital Image Processing. Examples of Fields that Use Digital Image Processing, Fundamentals Steps in Image Processing, Elements of Digital Image Processing Systems, Image Sampling and Quantization, Some basic relationships like Neighbors, Connectivity, Distance Measures between pixels, Linear and Non Linear Operations. **Image Enhancement in the Spatial Domain.** Some basic Gray Level Transformations, Histogram Processing, Enhancement Using Arithmetic and Logic operations, Basics of Spatial Filters, Smoothening and Sharpening Spatial Filters, Combining Spatial Enhancement Methods.

Image Enhancement in the Frequency Domain. Introduction to Fourier Transform and the frequency Domain, Smoothing and Sharpening Frequency Domain Filters, Homomorphic Filtering. **Image Restoration.** A model of The Image Degradation / Restoration Process, Noise Models, Restoration in the presence of Noise Only Spatial Filtering, Periodic Noise Reduction by Frequency Domain Filtering, Linear Position-Invariant Degradations, Estimation of Degradation Function, Inverse filtering, Wiener filtering, Constrained Least Square Filtering, Geometric Mean Filter, Geometric Transformations. **Image Compression.** Coding, Interpixel and Psychovisual Redundancy, Image Compression models, Elements of Information Theory, Error free comparison, Lossy compression, Image compression standards. **Image Segmentation.** Detection of Discontinuities, Edge linking and boundary detection, Thresholding, Region Oriented Segmentation, Motion based segmentation. Representation, Boundary Descriptors, Regional Descriptors, Use of Principal Components for Description, Introduction to Morphology, Some basic Morphological Algorithms.

Suggested Books:

1. Jayaraman, Digital image processing, Tata Mcgraw Hill, 2011
2. R.C. Gonzalez and R.E. Woods, Digital Image Processoing (3rd Edition), 2007.

CSE5406   Software Testing

Introduction: Software Failures, Testing Process, Some Terminologies, Limitations of Testing, The V Shaped Software Life Cycle Model. **Functional Testing:** Boundary Value Analysis, Equivalence Class Testing,Decision Table Based Testing, Cause Effect Graphing Technique.Essentials of Graph Theory :- Graph introduction, Matrix Representation of Graphs, Paths and Independent Paths, Generation of a Graph from Program, Identification of Independent Paths. **Structural Testing:** Control Flow Testing, Data Flow Testing, Slice Based Testing, Mutation testing. **Software Verification:** Verification Methods, Software Requirements Specification (SRS) Document, Software Design Description (SDD) Document, Source Code Reviews, User Documentation Verification. **Selection, Minimization and Prioritization of Test Cases for Regression Testing:** Regression Testing, Regression Test Cases Selection, Reducing the Number of Test Cases, Risk Analysis, Code Coverage Prioritization Technique. **Software Testing Activities:** Levels of Testing, Debugging, Software Testing Tools, Software Test Plan. **Metrics and Models in Software Testing:** Software Metrics, Categories of Metrics, Object Oriented Metrics Used in Testing, Measures during testing, Software Quality Attributes Prediction Models**.**

Suggested Books:
1. Y. Singh, "Software Testing", 1st Ed., Cambridge University Press,2012.
2. P.C. Jorgenson, Software Testing A Craftsman's approach, CRC Press,1997.
3. B. Beizer, "Software Testing Techniques", Second Volume, Second Edition, Van Nostrand Reinhold, 1990.
4. B. Beizer, "Software System Testing and Quality Assurance", Van Nostrandeinhold, New York,1984.
5. G. Myers, "The Art of Software Testing", John Wiley & Sons Inc., New York,1979.
6. L. Tamres, "Software Testing", Pearson Education Asia,2002.

CSE5408   Computer Vision

Introduction to Computer Vision: Role of Artificial Intelligence and Image processing in Computer Vision, Industrial Machine Vision Applications, System Architecture, Stages of Computer Vision, State of the art. **Visual Sensors:** Camera sensors, Fundamentals of Image Formation, Transformation: Orthogonal, Euclidean, Affine, Projective, etc; Fourier Transform, Convolution and Filtering, Image Enhancement, Restoration, Histogram Processing, 2D/3D Geometric transformations, Homography, Feature descriptors- SIFT, Ransac, Camera Calibration: Interior and Exterior Calibration. **Feature Extraction:** Edges - Canny, LOG, DOG; Line detectors (Hough Transform), Corners - Harris and Hessian Affine, Orientation Histogram, SIFT, SURF, HOG, GLOH, Scale-Space Analysis- Image Pyramids and Gaussian derivative filters, Gabor Filters and DWT. **Image Representation:** Adaptive basis- Principal Component Analysis (PCA) and Independent Component Analysis (ICA), **Image Segmentation:** Region Growing, Edge Based approaches to segmentation, Graph-Cut, Mean-Shift, MRFs, Texture Segmentation; Object detection. **Pattern Analysis:** Clustering: K-Means, K-Medoids, Mixture of Gaussians, Classification:Discriminant Function, Supervised, Un-supervised, Semi-supervised; Classifiers: Bayes, KNN, ANN models; Dimensionality Reduction: PCA, LDA, ICA; Non-parametric methods. **Motion and Tracking:** Detection and tracking of point features, Optical flow, Tracking-Lucas Kanade&Tomasi method (LK Tracker), **Motion Analysis:** Background Subtraction and Modeling, Optical Flow, KLT, Spatio-Temporal Analysis, Dynamic Stereo; Motion parameter estimation.

Suggested Books:
1. Forsyth and J. Ponce, Computer Vision: A Modern Approach, D. A. Pearson Education, 2003.
2. M. Sonka, V. Hlavac and R. Boyle, "Image Processing, Analysis, and Machine Vision" 3rd Edition, Cengage Learning, 2008.
3. R. Hartley and A. Zisserman, Multiple View Geometry in Computer Vision, Second Edition, Cambridge University Press, 2004.
4. R.Szeliski, Computer Vision: Algorithms and Applications, Springer Verlag London Limited 2011.
5. K. Fukunaga, Introduction to Statistical Pattern Recognition, Second Edition, Academic Press, Morgan Kaufmann, 1990.

CSE5410   Applied Cryptography

Cryptography Theory, Foundations and applications of modern cryptography. Steganography, One-way functions.Number Theory Basics: Modular arithmetic, primes, GCD and Chinese remainder theorems.   Encryption;   authentication;   Stream Ciphers: Encryption and decryption with Stream ciphers; Block Ciphers: DES, AES, Double and triple encryptions.Symmetric cryptography, asymmetric cryptography; Public Key Cryptography: RSA, Diffe-Hellman Key exchange, digital signatures, Hash functions, Message Authentication Codes.Remote user authentication, notions of security; zero knowledge/ interactive proofs, multi-party cryptographic protocols, key exchange and applications.Crypotanalysis of cryptographic primitives and protocols, such as by side-channel attacks, differential cryptanalysis, or replay attacks; and cryptanalytic techniques on deployed systems etc.

Suggested Readings:
1. Kahate and Atul,"Cryptography and Network Security." Tata McGraw Hill, 2007.
2. W. Stalling, Cryptography and Network Security, PHI, 2013.

3. B.A. Forouzan, Cryptography,TMH
4. Mogollon and Manuel, Cryptography & security services, Mechanism & application, Cyber tech. Pub, 2008.
5. Delfs and Hans, "Introduction to cryptography." Springer, 2004.
6. Stalling, Cryptography and hardware security, W PHI,

CSE5412   Optical Networks

Optical fiber fundamentals: Solution to Maxwell's equation in a circularly symmetric step index optical fiber, linearly polarized modes, single mode and multimode fibers, concept of V number, graded index fiber.Total number of guided modes (no derivation), polarization maintaining fibers, attenuation mechanisms in fibers, dispersion in single mode and multimode fibers, dispersion shifted and dispersion flattened fibers, attenuation and dispersion limits in fibers, Kerr nonlinearity, self phase modulation, combined effect of dispersion and self phase modulation, nonlinear Schrodinger equation (no derivation), fundamental soliton solution.**Optical sources:** LED and laser diode, principles of operation, concepts of line width, phase noise, switching and modulation characteristics – typical LED and LD structures.**Optical detectors:** P-N detector, pin detector, avalanche photodiode – Principles of operation, concepts of responsivity, sensitivity and quantum efficiency, noise in detection, typical receiver configurations (high impedance and transimpedance receivers).**Optical amplifiers:** Semiconductor amplifier, rare earth doped fiber amplifier (with special reference to erbium doped fibers), Raman amplifier, Brillouin amplifier – principles of operation, amplifier noise, signal to noise ratio, gain, gain bandwidth, gain and noise dependencies, intermodulation effects, saturation induced crosstalk, wavelength range of operation.

Suggested Books:
1. L. Kazovsky, S. Benedetto and A.Willner,Optical Fiber Communication Systems', Artech House, 1996.
2. J. Senior,Optical Fiber Communications, PHI, 2009.
3. SilvelloBetti, G. De Marchis and E. Iannone, `Coherent Optical Communications Systems', John Wiley, 1995.

CSE5302   MINOR PROJECT

CSE5304   Information and Network Security

Introduction to Data Security: General Security Principles, Communication Security, Design of Secure System. classical encryption techniques substitution ciphers and transposition ciphers, cryptanalysis, stereography, stream and block ciphers, Intruders, Viruses and related threads. **Conventional Encryption Principles:** Conventional encryption algorithms, cipher block modes of operation, location of encryption devices, key distribution Approaches of Message Authentication, Secure Hash Function and HMAC. **Modern Block Ciphers:** Block ciphers principals, Shannon's theory of confusion and diffusion, fiestal structure, data encryption standard(DES), strength of DES, cryptanalysis of DES, block cipher modes of operations, triple DES, IDEA encryption and decryption, strength of IDEA, key distribution. **Public-key cryptography Principles**: Recent Public key cryptography algorithms such as RSA, DSS etc., digital signatures, digital Certificates, Certificate Authority and key management Kerberos, X.509 Directory Authentication Service. **Latest Trends and solutions in Information Security:** Web Security, Firewall Design Principles, Trusted Systems, Intrusion Detection System. Recent trends in cryptosystem. **IP Security:**

Architecture, Authentication header, Encapsulating security payloads, combining security associations, key management. **Web Security:** Secure Socket Layer(SSL) and transport layer security, TSP, Secure Electronic Transaction (SET), Electronic money, WAP security, firewall design principals, Virtual Private Network (VPN) security.

Suggested Books:
1. W. Stallings, "Cryptography and Network Security", Third Edition, Prentice Hall International, 2013.
2. Jan C A, "Basic Methods of Cryptography", Cambridge University Press. 1998.
3. Thomas Calabrese, "Information Security Intelligence: Cryptographic Principles & Applications", Thomson Learning, 2003.
4. W. Mao, "Modern Cryptography: Theory and Practice", Pearson Education, 2003.

CSE5306   Bio-Informatics

Algorithms For Bioinformatics: Sequence Alignment: Edit distance, LCS. PAM and BLOSUM Scoring Matrices. Global alignments. **Pattern Matching And Clustering**: Exact Pattern Matching: KMP Algorithm, Keyword Trees, Aho-Corasick Algorithm. Clustering Basics: Hierarchical Clustering, Multiple Sequence Alignment: CLUSTAL. **Bioinformatics – Techniques AndApplications**: Methods of sequence alignment. Pair wise alignment- Global, local, dot plot and its applications. Words method of alignment- FASTA. **Macromolecular Structure Analysis** : Gene prediction, Conserved domain analysis, Protein visualization, Prediction of protein secondary structure, Tertiary struct. **Numerical AndBiostatistical Methods**: Distributions – Binomial, Poisson and Normal, Handling Univariate, Bivariate and Multivariate data- Introduction to Probabilities, Interval Estimation.

Suggested Books:

1. N.C. Jones and P.A. Pevzner, "An Introduction to Bioinformatics Algorithms", MIT Press, 2005.
2. C. Gibas and P.Jambeck, "Developing Bioinformatics Computer Skills", O'Reilly Media,Inc., 2001.
3. S.S. Kremer, "Molecular Bioinformatics: Algorithms and Applications", Walter de Gruyter, 1996.
4. G.W. Collins, "Fundamental Numerical Methods and data analysis", George W. Collins, II Press, 2003.

CSE5306   Big Data Analytics

Introduction to Big Data: Evolution of Big data, Best Practices for Big data Analytics – Big data characteristics, Validating, The Promotion of the Value of Big Data, Big Data Use Cases- Characteristics of Big Data Applications, Perception and Quantification of Value, Understanding Big Data Storage, A General Overview of High-Performance Architecture, HDFS – MapReduce and YARN, Map Reduce Programming Model. **Clustering and Classification:** Advanced Analytical Theory and Methods: Overview of Clustering ,K-means, Use Cases – Overview of the Method, Determining the Number of Clusters, Diagnostics, Reasons to Choose and Cautions, Classification: Decision Trees Overview of a Decision Tree, The General Algorithm, Decision Tree Algorithms Evaluating a Decision Tree, Decision Trees in R, Naïve Bayes, Bayes' Theorem, Naïve Bayes Classifier. **Association**

and Recommendation System: Advanced Analytical Theory and Methods-Association Rules, Overview – Apriori Algorithm, Evaluation of Candidate Rules, Applications of Association Rules, Finding Association& finding similarity, Recommendation System: Collaborative Recommendation- Content Based Recommendation, Knowledge Based Recommendation, Hybrid Recommendation Approaches. **Classification :**Classification: Decision Trees, Overview of a Decision Tree, The General Algorithm, Decision Tree Algorithms, Evaluating a Decision Tree, Decision Trees in R, Naïve Bayes, Bayes' Theorem, Naïve Bayes Classifier. **Stream Memory:** Introduction to Streams Concepts, Stream Data Model and Architecture, Stream Computing, Sampling Data in a Stream, Filtering Streams, Counting Distinct Elements in a Stream, Estimating moments, Counting oneness in a Window, Decaying Window, Real time Analytics Platform(RTAP) applications, Case Studies, Real Time Sentiment Analysis, Stock Market Predictions. Using Graph Analytics for Big Data: Graph Analytics. **NoSQL Data Management For Big Data And Visualization:** NoSQL Databases: Schema-less Models: Increasing Flexibility for Data Manipulation-Key Value Stores-Document Stores, Tabular Stores, Object Data Stores, Graph Databases Hive, Sharding, Hbase, Analyzing big data with twitter, Big data for E-Commerce Big data for blogs, Review of Basic Data Analytic Methods using R.

Suggested Books:
1. C. Eaton and D.deroos et al., "Understanding Big data ", McGraw Hill, 2012
2. A. Rajaraman and J.D. Ullman, "Mining of Massive Datasets", Cambridge University Press, 2012
3. B. lublinsky, K. t. Smith and A.Yakubovich, "Professional Hadoop Solutions", Wiley, ISBN: 9788126551071, 2015.
4. T. White, "HADOOP: The definitive Guide" , O Reilly 2012

CSE5310   Security and Privacy in Social Networks

What is Online Social Networks, data collection from social networks, challenges, opportunities, and pitfalls in online social networks, APIs.Collecting data from Online Social Media.Trust, credibility, and reputations in social systems. Online social Media and Policing.Information privacy disclosure, revelation and its effects in OSM and online social networks.Phishing in OSM & Identifying fraudulent entities in online social networks

Suggested Books:
1. T.Segaran, Programming Collective Intelligence: Building Smart Web 2.0 Applications, O'reilly Media,2007.
2. Q.Zervaas, Practical Web 2.0 Applications with PHP, 3rd ed., APRESS, 2008.
3. G. Bell, Building Social Web Applications, Oreilly,2009.
4. D. Stuttard and M. Pinto, The Web Application Hacker's Handbook: Finding and Exploiting Security Flaws, 2nd ed., Wiley, 2007.

CSE5312   Probability and Statistical Theory

Introduction to Probability theory: Through set and Relative Frequency: Experiments and Sample Spaces, Discrete and Continuous Sample Spaces, Events, Probability and Axioms, Probability as a Relative Frequency, Joint and Conditional Probability: Joint Probability, Conditional Probability, Total Probability, Bayes' Theorem. Independent Events: Two Events,

Multiple Events, Properties of Independent Events. Random Variables: Random Variable.Concept, Definition of a Random Variable, Conditions for a Function to Be a Random Variable, Discrete and Continuous Random Variables, Mixed Random Variable. Distribution Function, Density Function: Existence, Properties of Density Functions. Gaussian Random Variable: Other Distribution and Density Examples: Binomial, Poisson, Uniform, Exponential, Rayleigh. Conditional Distribution and Density Functions: Conditional Distribution, Properties of Conditional Distribution, Conditional Density, Properties of Conditional Density.Operations on Random Variables: Expectation, Expected Value of a Random Variable, Expected Value of a Function of a Random Variable, Conditional Expected Value, Moments, Moments about the Origin, Central Moments, Variance and Skew / Chebychev's Inequality / Markov's Inequality, Chernoff's Inequality and Bound. Multiple Random Variables, Vector Random Variables, Joint Distribution and Its Properties, Joint Distribution Function, Properties of the Joint Distribution, Marginal Distribution Functions, Joint Density and Its Properties, Joint Density Function, Properties of the Joint Density, Marginal Density Functions, Conditional Distribution and Density, Statistical Independence, Distribution and Density of a Sum of Random Variables Sampling Distributions: The Central Limit Theorem, distributions of the sample mean and the sample variance for a normal population, Chi-Square, t and F distributions. Descriptive Statistics: Graphical representation, measures of locations and variability.Estimation: Unbiasedness, consistency, the method of moments and the method of maximum likelihood estimation, confidence intervals for parameters in one sample and two sample problems of normal populations, confidence intervals for proportions, problems. Testing of Hypotheses: Null and alternative hypotheses, the critical and 8 acceptance regions, two types of error, power of the test, the most powerful test and Neyman-Pearson Fundamental Lemma, tests for one sample and two sample problems for normal populations, tests for proportions, Chi-square goodness of fit test and its applications, problems.

Suggested Books:
1. Peebles, Probability random variables and random signal principles,4Th Ed. MacGrawHil, 2013.
2. Poupolis and Pillai , Random Processes and Probability, 4th Ed., TMH, 2002.
3. D. A. Lind, W. G. Marchal and S. A. Wathen, Statistical Technics in Business and Economics, 13th Ed., THM, 2007.

CSE5314   Business Intelligence

Business Intelligence: Effective And Timely Decisions – Data, Information And Knowledge, Role Of Mathematical Models, Business Intelligence Architectures: Cycle Of A Business Intelligence Analysis – Enabling Factors In Business Intelligence Projects, Development of a Business Intelligence System – Ethics And Business Intelligence. **Knowledge Delivery:** The Business Intelligence User Types, Standard Reports, Interactive Analysis And Ad Hoc Querying, Parameterized Reports And Self-Service Reporting, Dimensional Analysis, Alerts/Notifications, Visualization: Charts, Graphs, Widgets, Scorecards And Dashboards, Geographic Visualization, Integrated Analytics, Considerations: Optimizing The Presentation For The Right Message. **Efficiency:** Efficiency Measures, The CCR Model: Definition Of Target Objectives, Peer Groups, Identification Of Good Operating Practices, Cross Efficiency Analysis, Virtual Inputs And Outputs, Other Models. Pattern Matching, Cluster Analysis, Outlier Analysis. **Business Intelligence Applications:** Marketing Models – McKinsey 7S model, The 7Ps of the Marketing Mix, AIDA, The Ansoff Matrix, The BCG Matrix, Diffusion of Innovation, DRIP Porter's Five Forces. Logistic And Production Models – Case Studies.**Future of Business Intelligence:** Future Of Business Intelligence, Emerging Technologies, Machine Learning, Predicting The Future, BI Search & Text Analytics, Advanced Visualization, Rich Report, Future Beyond Technology. **Future Of Business**

Intelligence: Future Of Business Intelligence – Emerging Technologies, Machine Learning, Predicting The Future, BI Search & Text Analytics – Advanced Visualization – Rich Report, Future Beyond Technology.

Suggested Books:
1. E. Turban, R. Sharda and D.Delen, "Decision Support And Business Intelligence Systems", 9th Edition, Pearson 2013.
2. C.Vercellis, "Business Intelligence: Data Mining And Optimization For Decision Making", Wiley Publications, 2009.
3. C. Howson, "Successful Business Intelligence: Secrets To Making BI A Killer App", McGraw-Hill, 2007
4. L.T. Moss and S. Atre, "Business Intelligence Roadmap: The Complete Project Lifecycle Of Decision Making", Addison Wesley, 2003
5. R. Kimball , M. Ross, W. Thornthwaite, J. Mundy and B. Becker, "The Data Warehouse Lifecycle Toolkit", Wiley Publication Inc.,2007.

CSE5202   Optimization Tools

Introduction to Linear Programming: Prototype Example, the Linear Programming Model, Assumptions of Linear Programming, Additional Examples, Some Classic Case Studies. Graphical method, The Simplex Method: The Essence of the Simplex Method, Setting up the Simplex Method, The Algebra of the Simplex Method, The Simplex Method in Tabular Form, Tie Breaking in the Simplex Method, Adapting to Other Model Forms, Post optimality Analysis. **Duality Theory And Sensitivity Analysis:** The Essence of Duality Theory, Economic. Interpretation of Duality, Primal-Dual relationships, Adapting to Other Primal Forms, The Role of Duality Theory in Sensitivity Analysis. Other Algorithms for Linear Programming:The Dual Simplex Method, Parametric Linear Programming, the Upper Bound Techniques, An Interior-Point Algorithm. **Dynamic Programming:** A prototype example for Dynamic Programming, Characteristics of Dynamic Programming Problems, Deterministic Dynamic Programming, Probabilistic Dynamic Programming. **Integer Programming:** Prototype Example, Some BIP Applications, Innovative Uses of Binary Variables in Model Formulation, Some Formulation examples, Some Perspectives on Solving Integer Programming Problems, The Branch-and-Bound Technique and Its application to Binary Integer Programming, A Branch-and-Bound Algorithm for Mixed Integer. **Nonlinear Programming:** Sample Applications, Graphical Illustration of Nonlinear Programming Problems, Types of Nonlinear Programming Problems, One-Variable Unconstrained Optimization, Multivariable Unconstrained Optimization, The Karush-Kuhn-Tucker (KKT) Conditions for Constrained Optimization, Quadratic Programming, Separable Programming , Convex Programming. **Queuing Theory:** Prototype Example, Basic Structure of queuing Models, Examples of Real Queuing Systems, The role of the Exponential Distribution, The Birth-and-Death Process, Queuing Models Based on the Birth-and Death Process, Queuing Models involving non exponential distributions

Suggested Books:
1. H.A.Taha, Operations Research, 8/e , Pearson Education, 2013.
2. J.K. Sharma, Operations Research, 3/e, Mcmillan , India Ltd, 2007
3. S. Hiller and G.J. Lieberman – Operations Research, 8th Edn, TMH, New Delhi, 2011.
4. K. Swarup, P.K. Gupta and M. Mohan, Operations Research, Sultan Chand & Sons, 2010.

CSE5204   Statistical Tools

Review of Probability and Distributions: Rules for probability, random variables and their distributions, moments, special discrete and continuous distributions, laws of large numbers and central limit theorem, sampling distributions. **Parametric Methods:** Point estimation – unbiasedness, consistency, UMVUE, sufficiency and completeness, method of moments, maximum likelihood estimation and method of scoring. Bayes, minimax and admissible estimators. Interval estimation - confidence intervals for means, variances and proportions. Testing of Hypotheses - tests for parameters of normal populations and for proportions, goodness of fit test and its applications. **Multivariate Analysis:** Multivariate normal, Wishart and Hotelling's T^2 distributions and their applications in testing of hypotheses problems. Classification of observations, principal component analysis, canonical correlations and canonical variables. **Nonparametric Methods:** Empirical distribution function, asymptotic distributions of order statistics, single sample problems, problems of location, prediction intervals,KolmogorovSmirnov one sample statistics, sign test, Wilcoxon signed rank statistics, two sample problems, Mann-Whitney-Wilcoxon tests, scale problems,KolmogorovSmirnov two sample criterion, Hoeffding's U-statistics

Suggested Books:
1. V.K. Rohatgi and A.K. Md.E.Saleh, An Introduction to Probability and Statistics, Wiley,2008.
2. E.J. Dudewicz and S.N. Mishra, Modern Mathematical Statistics, wiley, 1988.
3. S.M. Ross, Introduction to Probability and Statistics for Engineers and Scientists, 2009.
4. T. W. Anderson, An Introduction to Multivariate Analysis, 2009.
5. J.D. Gibbons and S. Chakraborti, Nonparametric Statistical Inference, Chapman and Hall, 2010.

CSE5206   Geo-Informatics

Fundamentals Of Gis Introduction to GIS ;Basic spatial concepts ;Coordinate Systems; GIS and Information Systems History of GIS ;Components of a GIS: Hardware, Software, Data, People and Methods; Proprietary and open source Software; Types of data: Spatial, Attribute data; types of attributes ; scales/ levels of measurements. **Spatial Data Models** Database Structures: Relational, Object Oriented ; Entities; ER diagram ; data models: conceptual, logical and physical models; spatial data models ; Raster Data Structures ; Raster Data Compression; Vector Data Structures;Raster vs Vector Models; TIN and GRID data models. **Data Acquisition** Acquisition and storage of Numeric data,Textual data , image data , Audio data ,Animation and Video data ;Data formats; fundamentals of image and video compression ; introduction to geospatial data; remote sensing sensors, data organization. **Data Quality And Standards** Data quality ; Basic aspects - completeness, logical consistency, positional accuracy, temporal accuracy, thematic accuracy and lineage ; Metadata; GIS Standards; Interoperability; OGC; Spatial Data Infrastructure. **Data Management And Output** Import / Export; Data Management functions; Raster to Vector and Vector to Raster Conversion; Data Output; Map Compilation; Chart/Graphs; Enterprise Vs. Desktop GIS; Distributed GIS. **Geoinformation**Information System ;GIS ;GPS ;Information retrieval system ; Geo-database ; interactive applications ; Multimedia applications ; Earth resource platform ; Google maps and Google earth ; LBS; Introduction to Integration of Geo-database and Social networking applications.

Suggested Books:
1. K.T. Chang, " Introduction to Geographic Information Systems", 2nd Edition, McGraw Hill Publishing, 2011.
2. I. Heywood, S. Cornelius, S. Carver and S. Raju, "An Introduction Geographical Information Systems, 2nd Edition, Pearson Education, 2007
3. Lo Albert C.P. Yeung K.W. Concepts and Techniques of Geographic Information Systems, Prentice Hall of India Publishers, 2006.

CSE5208   Security Tools and Applications

Network Security tool taxonomy:Reconnaissance tools, attack and penetration tools, defensive tools.High, Medium, Low and Virtual honeypots, NMAP, TCPDUMP, Wireshark, Reverse firewalling, securing honeypots, sebek, Argos, Honeywall.Hybrid systems, client honeypots, Botnets, tracking botnets, analysing malware.Capturing malware using honeypots, implementing honeypots, medium interaction and high interaction honeypots.Security metrics: What is a security metric? Metric and measurement, Designing effective security metrics, Data sources for security metrics, Analysis of security metrics data, Designing the security measurement project, Measuring security cost and value, Different context for security process management.

Suggested Books:
1. G.M. Jackson, Predicting Malicious Behavior, John Wiley & Sons, 2012.
2. N. Provos and Thorsten Holz, Virtual Honeypots: From Botnet Tracking to Intrusion Detection, Addison Wesley, 2007.
3. L. Hayden, IT Security Metrics, Tata McGraw Hill, 2010.
4. L.Spitzner, Know Your Enemy: Learning about Security Threats (2nd Edition), 2004.
5. M. Schiffman, Building Open Source Network Security Tools: Components and Techniques, Wiley, 2002.

CSE5210   Secure Coding

Introduction: Security, CIA Triad, Viruses, Trojans, and malware The need for secure system, proactive security development process, Threat modelling process and its benefits, Identifying the Threats by Using Attack Trees and rating threats using DREAD, cross-site scripting, Cryptographic foibles, Weak random numbers, improper use of cryptography.Access control, protecting secret data, Format String Problems, Integer Overflow, and Software Security Fundamentals, Buffer Overrun- Stack overrun, Heap Overrun, Array Indexing Errors, Format String Bugs. Security Issues in C Language: String Handling, Avoiding Integer Overflows and Underflows and Type Conversion Issues, Memory Management Issues, Code Injection Attacks, Canary based countermeasures using Stack Guard and Propolice.Socket security, Avoiding Server Hijacking, Securing RPC, ActiveX and DCOM, secure .NET code, Command Injection, Failure to Handle Errors, and Security Touchpoints, Java Programming with Crypto API.Proactive Security development process, Secure Software Development Cycle (S-SDLC) , Security issues while writing SRS, Design phase security, Development Phase, Test Phase, Maintenance Phase, Writing Secure Code – Best Practices SD3 (Secure by design, default and deployment), Security principles and Secure Product Development Timeline, Writing Secure SoftwareDatabase and Web-specific issues: SQL Injection Techniques and Remedies, Race conditions, Time of Check Versus Time of Use and its protection mechanisms. Validating Input and Page 21 of 46 Interposes Communication, Securing Signal

Handlers and File Operations. XSS scripting attack and its types – Persistent and Non persistent attack XSS Countermeasures and Bypassing the XSS Filters.Secure Coding Techniques: Protection against DoS attacks, Application Failure Attacks, CPU Starvation Attacks, Insecure Coding Practices In Java Technology. ARP Spoofing and its countermeasures. Secure programming in Java and mobile code securityTesting Secure Applications: Security code overview, secure software installation. The Role of the Security Tester, Building the Security Test Plan. Testing HTTP-Based Applications, Testing File-Based Applications, Testing Clients with Rogue Servers.

Suggested Books:
1. M. Howard and D. LeBlanc, Writing Secure Code, Microsoft Press, 2nd Edition, 2004.
2. J. Deckar, Buffer Overflow Attacks: Detect, Exploit, Prevent, 1st Edition, Syngress, 2005.
3. F.Swiderski and W. Snyder, Threat Modeling, Microsoft Professional, 1st Edition, 2004

CSE5212   Linear Optimization

Linear models such as; Product mix problem, Nutrition Problem, a Blending Problem, Formulation of these problems as Linear Programming problems (LLP). Axioms of linearity, General form of LPP, Slack and Surplus Variables. Standard Form of LPP. Basic concepts of rank of a matrix, Solution of a system of linear equations, Examples. Basic feasible solution (bf s), degenerate and non-degenrate, examples of basic solutions which are not feasible. Upper bound on the number of bf s. Upper bound on the absolute value of the basic variables.Existence of bf s, Moving from one bfs to another and improving the value of the objective function. Optimality Criteria. Optimal solution is a bfs. Simplex algorithm through a simple example.Simplex algorithm - geometrically interpretation. Definition of an affine space, Polyhedron P, faces of a polyhedron – facets, edges and vertices. Representation of a polyhedron in terms of extreme points and extreme rays. A basic feasible solution is an extreme point of the corresponding Polyhedron. More about degeneracy. Supporting hyperplane of a polyhedron. Characterisation of an optimal solution in terms of supporting hyperplane. Graphical illustrations. Simplex Algorithm- Tableau format. Simplex algorithm – Starting feasible solution, Artificial variables, Phase I and Phase II methods. Bounded variables case; modification of the Simplex algorithm. Revised Simplex algorithm. Define the Dual problem and its various forms.Fundamental Theorem of Duality. Farka's theorem. Complementary Slackness theorem. Dual Simplex algorithm; Motivation , theory and a numerical example. Primal Dual algorithm: Motivation , theory and a numerical example. Sensitivity Analysis of the objective function coefficient, right hand side components and elements of the matrix A. Adding of constraints and activities. A comprehensive numerical example. Parametric analysis. Min-cost flow problem- formulation and derivation of special cases such as Transportation problem, Assignment problem, Max-flow problem and the shortest path problem. Integer bfs property of Transportation problem.Simplified Simplex algorithm for Transportation problem. Sensitivity Analysis and Bounded Variable case. Formulation of Shortest Path Problem, Dijkstra's algorithm. More general shortest Path algorithms, Sensitivity analysis. Applications of Max-flow problem. Applications of Max-flow problem. Network Simplex Algorithm for Min – cost flow problem. Project Planning Control with PERT / CPM, linear programming formulations.

Suggested Books:
1. K.G. Murty, Linear and Combinatorial Programming, Wiley 1976, Revised in 2007

2. F.S. Hillier and G.J. Lieberman, Introduction to Operations Research, McGraw Hill International Edition, (Eigth edition), 2005.
3. M.S. Bazara, J.J. Jarvis and H.D. Sherali, Linear Programming and Network flows, John Wiley and Sons, New York, 1990.
4. N.S. Kambo, Mathematical Programming Techniques, Affiliated East-West Press, New Delhi.2008.

CSE5214   Advances in Multimedia Technology

Introduction to Multimedia Systems Architecture and Components, Multimedia Distributed Processing Model, Synchronization, Orchestration and Quality of Service Architecture. Usage of Text in Multimedia, Families and Faces of Fonts, Outline Fonts, Bitmap Fonts International Character Sets and Hypertext, Digital Fonts Techniques. **Audio and Speech** Data Acquisition, Sampling and Quantization, Human Speech Production Mechanism, Digital Model of Speech Production, Analysis and Synthesis, Psycho-Acoustics, Low Bit Rate Speech Compression, MPEG Audio Compression. Compression and Transmission of Audio on Internet, Adding Sound to your Multimedia Project, Audio Software and Hardware. **Images and Video** Colour Science, Colour, Colour Models, Colour palettes, Dithering, 2D Graphics, Image Compression and File Formats: GIF, JPEG, JPEG 2000, PNG, TIFF, EXIF, PS, PDF, Basic Image Processing [Can Use Photoshop], Image acquisition and representation, composite video signal, NTSC, PAL and SECAM video standards. Video compression based on motion compensation, MPEG-1, MPEG-2, MPEG-4, MPEG-7, MPEG-21. **Multimedia and Hypermedia** Communication: Fundamentals of Data Communication and Networking, Bandwidth Requirements of Different Media; Real Time Constraints: Audio Latency, Video Data Rate; Multimedia over LAN and WAN, Multimedia Conferencing. Hypermedia Presentation: Authoring and Publishing, Linear and Nonlinear Presentation, Structuring Information, Different Approaches of Authoring Hypermedia Documents, Hypermedia Data Models and Standards. Data Models for Multimedia and Hypermedia information.

Suggested Books:
1. T. Vaughan's "Multimedia: Making it work", Tata McGraw-Hill, 2017
2. R. Aggarwal and B.B Tiwari, "Multimedia Systems", Excel Publication, New Delhi, 2007.
3. Li and Drew, "Fundamentals of Multimedia", Pearson Education, 2009.
4. D. Hillman, "Multimedia Technology and Application", Galgotia Publication, 1998.

SEMESTER III

CSE651   Research Project

CSE601   Major Project I

CSE6401   Pattern Recognition

Introduction to Pattern Recognition, Feature Detection, Classification, Review of Probability Theory, Conditional Probability and Bayes Rule, Random Vectors, Expectation, Correlation, Covariance, Review of Linear Algebra, Linear Transformations. Decision Theory, ROC Curves, Likelihood Ratio Test, Linear and Quadratic Discriminants, Fisher Discriminant, Sufficient

Statistics, Coping with Missing or Noisy Features. Template-based Recognition, Feature Extraction, Eigenvector and Multilinear Analysis, Training Methods, Maximum Likelihood and Bayesian Parameter Estimation, Linear Discriminant/Perceptron Learning, Optimization by Gradient Descent. Support Vector Machines, K-Nearest-Neighbor Classification, Non-parametric Classification, Density Estimation, Parzen Estimation. Unsupervised Learning, Clustering, Vector Quantization, K-means, Mixture Modelling, Expectation-Maximization. Hidden Markov Models, Viterbi Algorithm, Baum-Welch Algorithm, Linear Dynamical Systems, Kalman Filtering, Bayesian Networks.

Suggested Books:
1. R. O. Duda, P. Hart, D. Stork, Pattern Classification, 2nd Ed. Wiley, 2000.
2. C.M. Bishop, Pattern Recognition and Machine Learning. Springer, 2007.
3. C.M. Bishop, Neural Networks for Pattern Recognition, Oxford University Press, 1995.
4. S. Theodoridisand K. Koutroumbas, Pattern Recognition, 4th Ed. Academic Press, 2008.
5. T. Hastie, R. Tibshirani and J. Friedman, The Elements of Statistical Learning, Springer, 2009.

CSE6403   Software Project Management

Introduction: Project Management concepts, Process Framework, Project Planning Software Life Cycle Models, Artifacts of the Project Management Process. **Cost and Scheduling Estimation Models**: Various Levels of COCOMO for Cost, Effort, Schedule and Productivity Estimation. Approaches to Effort, Cost Estimation, and Schedule Estimation factors through COCOMO II, Putnam Estimation Model, Algorithmic models. **Project Management Techniques**: Project Organizations and Responsibilities, Establishing Project Environment, Risk Management Process, Project Tracking and Control Defect Tracking Concepts such as Process monitoring and audit, Reviews, Inspections and Walkthroughs. **Project Closure**: Project Closure Analysis, Role of Closure Analysis in a project, Performing Closure Analysis, Closure Analysis Report. **Software Project Management Renaissance**: Conventional Software Management, Evolution of Software Economics, Improving Software Economics, The old way and the new way. **Advance Topics in Software Project Management**: Discussion on future Software Project Management Practices & Modern Project Profiles, Next Generation Software Economics, Modern Process Transitions.

Suggested Books:
1. W.S. Humphrey, "Managing the Software Process", Pearson Education, 1989.
2. W. Royce, "Software Project Management", Pearson Education.1998.
3. P. Jalote, "Software Project Management in Practice", Pearson Education, 2002.
4. B. Hughes, "Software Project Management", TMH, 1968.
5. C.F.Kemerer, "Software Project Management Readings and Cases", TMH, 7996.

CSE6405   Cluster & Grid Computing

Introduction: Cluster and Grid computing, Meta-computing, Web services and Grid Computing, e-Governance and the Grid Technologies and Architectures for Grid Computing: Issues in Data Grids, Functional requirements in Grid Computing, Standards for Grid Computing, Recent technologies trends in Large Data Grids. **Web Services and the Service Oriented Architecture**: Service Oriented Architecture, SOAP and WSDL, Creating Web Services, Server Side. **OGSA and WSRF**: OGSA for Resource Distribution, Stateful Web Services in OGSA, WSRF, WSRF Specification. **Globus Toolkit**: History, version, Applications, Approaches and Benefits, Infrastructure Management, Monitoring and Discovery, Security, Data Choreography and Coordination, GT4 Architecture, GT4 Containers. **The Grid and Databases**: Requirements, Storage Request Broker, Integration of Databases with the Grid, Architecture of OGSA-DAI for offering Grid Database services. **Cluster**

Computing: Approaches to Parallel Computing, Definition and Architecture of a Cluster, Categories of clusters. **Cluster Middleware**: Levels and Layers of Single System Image, Design objectives, Resource Management and Scheduling, Cluster programming Environment and Tools. **Networking, Protocols and I/O for clusters**: Networking and Interconnection/Switching Devices, Design Issues, Design Architecture, HiPPI, ATM, Myrinet, Memory Channel. **Setting Up and Administering a Cluster**: Setup of simple cluster, setting up nodes, clusters of clusters, System monitoring, Global Clocks Sync. **Cluster Technology for High Availability**: High availability clusters, high availability parallel computing, types of failures and errors, cluster architectures and configurations for high availability, Failure/Recovery clusters. **Process Scheduling**: Job management System, Resource management system, policies of resource utilization, Scheduling policies. **Load Sharing and Load Balancing**: Introduction, Strategies for load balancing, Modelling parameters.

Suggested Books:
1. W. Gropp, E. Lusk and T. Sterling, Beowulf Cluster Computing with Linux, 2nd edition, MIT Press,2003.
2. B. Jacob and M. Brown, Introduction to grid computing, Vervante, 2005.
3. G.F. Pfister, In Search of Clusters: The ongoing battle in lowly parallel computing, Second Edition, Prentice Hall Publishing Company, 1998.
4. C.S.R. Prabhu, Grid and Cluster Computing, PHI,2008
5. R. Buyya, High Performance Cluster Computing: Architectures and Systems, Volume 1, Pearson Education,2008.
6. D. Janakiram, Grid Computing, Tata McGraw-Hill,2005.

CSE6407   Internet of Things

Introduction to Internet of Things: Definition and Characteristics of IoT, Physical Design of IoT – IoT Protocols, IoT communication models, Iot Communication APIs IoTenabaled Technologies – Wireless Sensor Networks, Cloud Computing, Big data analytics, Communication protocols, Embedded Systems, IoT Levels and Templates Domain Specific IoTs – Home, City, Environment, Energy, Retail, Logistics, Agriculture, Industry, health and Lifestyle. **IoT and M2M:** Software defined networks, network function virtualization, difference between SDN and NFV for IoT Basics of IoT System Management with NETCOZF, YANG- NETCONF, YANG, SNMP NETOPEER. **Introduction to Python:** Language features of Python, Data types, data structures, Control of flow, functions, modules, packaging, file handling, data/time operations, classes, Exception handling Python packages – JSON, XML, HTTPLib, URLLib, SMTPLib. **IoT Physical Devices and Endpoints:** Introduction to Raspberry PI-Interfaces (serial, SPI, I2C) Programming – Python program with Raspberry PI with focus of interfacing external gadgets, controlling output, and reading input from pins. **IoT Physical Servers and Cloud Offerings:** Introduction to Cloud Storage models and communication APIs Webserver – Web server for IoT, Cloud for IoT, Python web application framework designing a RESTful web API.

Suggested Books:
1. A. Bahga and V. Madisetti, Internet of Things – A Hands-on Approach, Universities Press, 2015.
2. M. Richardson and S. Wallace, Getting Started with Raspberry Pi, O'Reilly (SPD), 2014.
3. J. Holler, V. Tsiatsis, C. Mulligan, S. Avesand, S. Karnouskos and D. Boyle, "From Machine-to-Machine to the Internet of Things: Introduction to a New Age of Intelligence", 1st Edition, Academic Press, 2014.
4. B.S. Reiter and F.Michahelles, "Architecting the Internet of Things", Springer, 2011.
5. W. Stallings, "Foundations of modern networking: SDN, NFV, QOE, IOT, and cloud" publisher: Addison-Wesley 2015

CSE6409   Nanotechnology

Introduction to nanoscale systems. Length, energy, and time scales. Top-down approach to nanolithography. Spatial resolution of optical, deep-ultraviolet, x-ray, electron beam, and ion beam lithography. Single electron transistors, coulomb blockade effects in ultra-small metallic tunnel junctions. Quantum confinement of electrons in semiconductor nanostructures: two-dimensional confinement (quantum wells). Band gap engineering. Epitaxy. Landauer-Buttiker formalism for conduction in confined geometries. One-dimensional confinement: quantum point contacts, quantum dots. Bottom-up approach. Chemical self-assembly, carbon nanotubes. Molecular electronics. Self-assembled monolayers. Electrochemical techniques; applications in biological and chemical detection. Atomic scale characterization techniques: scanning tunneling microscopy, atomic force microscopy. Introduction to quantum methods of information processing.

Suggested Books:
1. D. Ferry, Transport in Nanostructures, Cambridge University Press, 2000.
2. Y. Imry, Introduction to Mesoscopic Physics, Oxford University Press, 1997.
3. S.Datta, Electron Transport in Mesoscopic Systems, Cambridge University Press, 1995.
4. H. Grabert and M. Devoret, Single Charge Tunneling, Plenum Press, 1992.
5. Beenaker and V. Houten, Quantum Transport in Semiconductor Nanostructures, in Solid State Physics v. 44, eds. Ehernreich and Turnbull, Academic Press, 1991.
6. P.R. Choudhury, Handbook of Microlithography, Micromachining & Microfabrication, SPIE, 1997.

CSE6301   Natural Language Processing

Introduction- Human languages, models, ambiguity, processing paradigms; Phases in natural language processing, applications. **Words and Word Forms** : Morphology fundamentals; Morphological Diversity of Indian Languages; Morphology Paradigms; Finite State Machine Based Morphology; Automatic Morphology Learning; Shallow Parsing; Named Entities; Maximum Entropy Models; Random Fields. Morphology, acquisition models, Finite State Transducer. N-grams, smoothing, entropy, HMM, ME, SVM, CRF. **Structures** : Theories of Parsing, Parsing Algorithms; Robust and Scalable Parsing on Noisy Text as in Web documents; Hybrid of Rule Based and Probabilistic Parsing; Scope Ambiguity and Attachment Ambiguity resolution. **Meaning** : Lexical Knowledge Networks, Wordnet Theory; Indian Language Wordnets and Multilingual Dictionaries; Semantic Roles; Word Sense Disambiguation; WSD and Multilinguality; Metaphors; Coreferences. **Web 2.0 Applications** : Sentiment Analysis; Text Entailment; Robust and Scalable Machine Translation; Question Answering in Multilingual Setting; Cross Lingual Information Retrieval (CLIR).

Suggested Books:
1. D. Jurafsky and J.H. Martin, Speech and Language Processing, 2e, Pearson Education, 2009.
2. A. James, Natural language Understanding 2e, Pearson Education, 1994 .
3. A. Bharati, R. Sangal, V. Chaitanya, Natural language processing: a Paninian perspective, PHI, 2000.

CSE6303   Digital Forensics

Computer Forensics Fundamentals: What is Computer Forensics, Use of Computer Forensics in Law Enforcement, Computer Forensics Assistance to Human Resources, Computer Forensics Services, Benefits of Professional Forensics Methodology. Computer Forensics Technology- Military Computer Forensic Technology, Law Enforcement, Computer Forensic Technology, Business Computer Forensic Technology. **Computer Forensics Evidence and Capture:** Data Recovery Defined, Data Back-up and Recovery, The Role of Back-up in Data Recovery, The Data-Recovery Solution. Evidence Collection and Data Seizure - Collect Evidence, Collection Options, Obstacles, Evidence, The Rules of Evidence, Volatile Evidence, General Procedure, Collection and Archiving, Methods of Collection, Artifacts, Collection Steps, Controlling Contamination: The Chain of Custody. **Duplication and Preservation of Digital Evidence:** Preserving the Digital Crime Scene, Computer Evidence Processing Steps, Legal Aspects of Collecting and Preserving Computer Forensic Evidence. Computer Image Verification and Authentication - Special Needs of Evidential Authentication, Practical Consideration, Practical Implementation. **Computer Forensics analysis and validation:** Data collection and analyzing, validating forensic data, addressing data-hiding techniques, performing remote acquisitions. Network Forensics - performing live acquisitions, developing standard procedures for network forensics. Processing Crime and Incident Scenes - digital evidence, collecting evidence in private-sector incident scenes, processing law enforcement crime scenes, seizing digital evidence at the scene, storing digital evidence, obtaining a digital hash. **Working with Windows and DOS Systems:** Understanding file systems, exploring Microsoft File Structures, NTFS disks, Understanding whole disk encryption, windows registry, Microsoft startup tasks, MS-DOS startup tasks, virtual machines. **Current research trends and Forensic tools:** Research trend in digital forensics- Digital forensics tools, network analysis, computer forensics, cloud forensics. Evaluating computer forensic software and hardware tools, validating and testing forensics software.

Suggested Books:
1. B. Nelson, A. Phillips, C. Steuart, Computer Forensics and Investigations,CENGAGE Learning, 2015.

CSE6305   Game Theory

Introduction to Game Theory: What is game theory. Theory of rational choice, Interacting decision makers. **Strategic Games and Nash Equilibrium:** Strategic games: examples, Nash equilibrium: concept and examples, Best response functions, Dominated Actions, Symmetric games and symmetric equilibria. **Illustrations of Nash Equilibrium and Extensive Games:** Cournot's model of duopoly market, Bertrand's model of duopoly market, Electoral Competition, War of Attrition, Auctions, Accident Laws. Stackelberg model of duopoly markets, Ultimatum game.**Mixed Strategy Nash Equilibrium:** Introduction, Strategic games with randomisation, Mixed strategy Nash equilibrium: concept and examples, Dominated Actions, Formation of Players' beliefs.**Extensive Games and Nash Equilibrium:** Introduction to extensive games, Strategies and outcomes, Nash equilibrium, Subgame perfect Nash equilibrium, Backward induction. **Research Trends in Game Theory:** Research trends include dynamic games, games of incomplete information, and evolutionary games, applications in the fields of voting, bargaining, lobbying and violent conflict

Suggested Books:
1. Nisan, Roughgarden, Tardos, Vazirani, Algorithmic Game Theory, Cambridge University Press, 2007

2. M. Osborne, An Introduction to Game Theory, Oxford University Press, 2003
3. A. MacKenzie, Game Theory for Wireless Engineers, Synthesis lectures on Communications, 2006
4. R. Gibbons, A Primer in Game Theory, Pearson Education, 1992

CSE6307   Deep Learning

Introduction: Introduction to K-Nearest Neighbors, Deep Feedforward Networks, Regularization of deep learning, Optimization for training deep models, convolutional networks, recurrent networks, Applications. **Convolutional Neural Networks:** Invariance, stability Properties of CNN representations: invertibility, stability, invariance. Variantsof the Basic Convolution Function ,history of CNN and deep learning **Recurrent and Recursive Nets:** Recurrent and Recursive Nets, Unfolding Computational Graphs, Recurrent Neural Network, Bidirectional RNNs, Deep Recurrent Networks , Recursive Neural Networks , The Challenge of Long-Term Dependencies , Echo State Networks, Leaky Units and Other Strategies for Multiple, Time Scales , The Long Short-Term Memory and Other Gated RNNs, optimization for Long-Term Dependencies, Explicit Memory. **Linear Factor Model and Autoencoder:** Linear Factor Models ,Probabilistic PCA and Factor Analysis Independent Component Analysis (ICA) ,Slow Feature Analysis, Sparse Coding, Autoencoders ,UndercompleteAutoencoders ,Regularized Autoencoders, Stochastic   Encoders   and   Decoders   ,   Applications   of   Autoencoders. **Deep Supervised Learning:** Introduction to Deep Supervised Learning, Convolution & Pooling, Dropout, Transfer Learning Transfer Learning Scenarios, Applications of Transfer Learning, transfer Learning Methods, Fine Tuning and Data Augmentation, Related Research Areas. **Review of Other Neural Networks**: Introduction other Deep Neural Networks , Recursive Neural Networks, Boltzmann and Restricted Boltzmann Machine , Case Studies :Various Frameworks such as DIGITS, Tensorflow, Caffe and Theano

Suggested Books:

1. I. Goodfellow, Y. Bengio and A.Courville, Deep Learning, MIT Press, 2015.
2. A. Gibson and J Patterson, Deep Learning, O'Reilly Media, Inc., 2017.
3. S.J. Russell and P. Norvig, Artificial Intelligence: A Modern Approach. Prentice Hall, 1994.
4. R.O. Duda, P.E. Hart, and D.G. Stork, Pattern Classification, Wiley, 1973.
5. C. M. Bishop, Neural Networks for Pattern Recognition. Oxford University Press**, 1995.**

CSE6309   Blockchain and Applications

Need for Distributed Record Keeping, Modeling faults and adversaries Byzantine Generals problem,Consensus algorithms and their scalability problems. Why Nakamoto Came up with Blockchain based cryptocurrency? Technologies Borrowed in Blockchain – hash pointers, consensus, byzantine fault-tolerant distributed computing, digital cash etc. Atomic Broadcast, Consensus, Byzantine Models of fault tolerance. Hash functions, Puzzle friendly Hash, Collison resistant hash, digital signatures,

public key crypto, verifiable random functions, Zero-knowledge system. **Bitcoin blockchain, the challenges, and solutions, proof of work, Proof of stake, alternatives to Bitcoin consensus, Bitcoin scripting language and their use.** Ethereum and Smart Contracts, The Turing Completeness of Smart Contract Languages and verification challenges, Using smart contracts to enforce legal contracts, comparing Bitcoin scripting vs. Ethereum Smart Contracts. Hyperledger fabric, the plug and play platform and mechanisms in permissioned blockchain, pseudo-anonymity vs. anonymity, Zcash and Zk-SNARKS for anonymity preservation, attacks on Blockchains such as Sybil attacks, selfish mining, 51% attacks - -advent of algorand, and Sharding based consensus algorithms to prevent these.

Suggested Books:
1. M. Swan, "Blockchain: Blueprint for a New Economy", O'Reilly Media, 2015.
2. J. Thompsons,Blockchain: The blockchain for beginners guide to blockchain technology and leveraging blockchain programming", 2017

CSE6311   Real Time Systems

Real-time systems: Real-time systems models, Types of real-time systems, Internal structure of real-time systems, Performance measures, Examples of real-time systems and real-world applications, Modeling& Designing real-time systems. **Real-Time Process Management:** Task scheduling for Uniprocessor systems, handling priorities with critical section, interrupts, task allocation & scheduling for multiprocessor systems, adaptive scheduling. **Programming Environment:** In depth Knowledge of RTOS programming languages, tools & techniques. **Real-Time System Design:** Design techniques for Reliability, Fault Tolerance & other application specific quality considerations. **Trends in Real-Time System** Design & Development in fields such as Robotics. **Case Studies of RTOS:** RT Linux, Micro C/OS-II, Vx Works, Embedded Linux, and Tiny OS

Suggested Books:

1. A.C. Shaw, Real-Time Systems and Software, Wiley, 2001.
2. J.E. Cooling, Real-Time Software Systems, International Thompson Computer Press, 1997.
3. W.A. Halang and K.M. Sacha, Real-Time Systems, World Scientific, 1992.
4. P.H. Laplante, Real-Time Systems Design and Analysis, IEEE Press.1992.
5. J. Liu, Real-Time Systems, Prentice-Hall, 2000.
6. S. Bennett, Real-Time Computer Control, Prentice-Hall, 1984.
7. C.M. Krishna and K.G. Shin, Real-Time Systems, McGraw-Hill, 1997.

CSE6313   Quantum Computing

Introduction to Quantum Computers: Qubits & their representation, multiple qubits, Bloch sphere representation of a qubit. **Quantum Elements:** Logic Gates, Circuits, Architectures, design of quantum circuits. **Quantum Information and Cryptography** : Quantum Key Distribution, teleportation, Single photons, EPR pairs, Bell states. Quantum Cryptography, no

cloning theorem. **Quantum Algorithms:** Introduction to quantum algorithms,Deutsch's algorithm, Deutsch's-Jozsa algorithm, Shor factorization, Grover search. **Error correction:** Graph states and codes, Quantum error correction, fault-tolerant computation. **Implementations:** Different implementations of quantum computers. NMR and ensemble quantum computing, Ion trap implementations. Optical implementations.

Suggested Books:
1. P. Kaye etal., Introduction to Quantum Computing, Oxford University Press, 2006.
2. G.P. Berman, Introduction to Quantum Computers, World Scientific, 1998.
3. M. Nielsen and I. Chuang, Quantum Computation and Quantum Information, Cambridge University Press, Cambridge, 2000.
4. A. Yu. Kitaev, A.H. Shen, and M.N. Vyalyi, Classical and Quantum Computation,American Mathematical Society, Providence, 2002.
5. W.H. Steeb and Y. Hardy, Problems & Solutions in Quantum Computing & Information, World Scientific, River Edge, NJ, 2004.

CSE6201   Research Methodology

Foundation of Research and Problem Definition Meaning, Objective and Importance of research, Types of research, steps involved in research, identification of research problem and its formulation. **Research Design** Research design, Methods of research design, research process and steps involved, Literature Survey. **Data Collection and Analysis** Classification of Data, Methods of Data Collection, Sampling techniques, Ethical considerations in research. Data analysis, Statistical techniques, Hypothesis, Hypothesis testing, Data processing software (e.g. SPSS etc.), Interpretation of results. **Reporting of Research** Types of research report, Referencing and referencing styles, Indexing and citation of Journals, Reference management software like Mendeley, Intellectual property, Plagiarism.

Suggested Books:
1. C. R. Kothari and G. Garg, Research Methodology Methods and Techniques, New Age International publishers, Third Edition, 2019
2. Donald Cooper and Pamela Schindler, Business Research Methods, TMGH, 9th edition, 2013
3. Creswell and W. John, Research design: Qualitative, quantitative, and mixed methods approaches. Sage publications, 2013

CSE6203   Enterprise Computing in JAVA

Introduction to J2EE and building J2EE applications, MVC architecture, Introduction to servlets and its life cycle , problems with cgi-perl interface , generic and http servlet , servlet configuration, various session tracking techniques, servlet context, servlet

configuration, servlet collaboration. **JSP Basics and Architecture**: JSP directives, Scripting elements, standard actions, implicit objects, JSP design strategies. **Struts**: Introduction of Struts and its architecture, advantages and application of Struts.

EJB Fundamentals: Motivation for EJB, EJB Echo system, J2EE technologies, Enterprise beans and types, distributed objects and middleware, developing EJB components, remote local and home interface, bean class and deployment descriptor.

Introducing session beans: Session beans life time, statefull and Stateless session beans, lifecycle of session beans.

Introducing Entity beans: Persistence concepts, features of entity beans, entity context. Introduction to JMS & Message driven beans. Web-enabled EJBs with JAX-RS, Web-UI integration, EP Drop/Audit Deadline , EJB/JavaEE Security, JavaEE Interceptors, JMS, Asynchronous Methods, EJB Timers.

Suggested Books:
1. E.D. Roman, S.W. Ambler and T. Jewell, "Mastering Enterprise Java Beans", Wiley, 2nd Ed., 2005.
2. G.Sesadri , "Enterprise Java Computing: Application and Architectures", Cambridge University Publications, 1999.
3. T.Neward, "Effective Enterprise Java", Eddison -Wesley, 2004.
4. J. Farley and W. Crawford, " Java Enterprise in a Nutshell", O'Reilly and Associates, 2005.
5. A. Sincock , "Enterprise Java for SAP" , A Press Publications, 2003.
6. J. Wigglesworth and M. Paula, "Java Programming: Advanced Topic", Thomson, 3rd Ed., 2003.
7. S. Allamaraju and C.Buest, "Professional Java Server Programming, J2EE, Apress, 1.3 Ed., 2005.
8. I. Bayross and S. Shah, "Java Server Programming", Shroff, 2008.

CSE6205   Advances in Internet & Web Technology

Internet Computing: Internet: The Giant WAN; Communicating over the Internet (Protocol Layering, Internet Addressing); Accessing the Internet (Internet Configuration, Web Browser); Internet Organizations; Cyber Ethics; Internet Services (Electronic Mail, File Transfer, Real-time User Communication , Remote Login, Usenet, World Wide Web. **Web Theory:**
The World Wide Web; The Working of Web; Web Terminology (Web page, Website, Web Apps, Web Service); Web Architecture; World Wide Web Challenges; Hypertext Transfer Protocol (HTTP); HTTP Version; HTTP Connections (Non-Persistent HTTP, Persistent HTTP); HTTP Communication (Handshaking ; Request Message; Response Message); Hypertext Transfer Protocol Secure (HTTPS); HTTP State Retention: Cookies; HTTP Cache (Cache Consistency); Evolution of Web (Web 1.0, Web 2.0, Web 3.0); Web Information Retrieval (Web IR); Web IR Tool; Web IR Architecture (Search Engine Architecture); Web IR Performance Metrics. **Web Development:** Elements of Web Development; Client Side and Server-side scripting; Model-View-Controller (MVC) Architecture; Client-side Technologies(HTML, CSS, JavaScript); Server-side Technologies (PHP); Web Databases. **Web Research:** Research Trends in Web; Contextual Information Retrieval; Web Mining; Social media analytics, Sentiment Analysis, Recommender systems.

Suggested Books:
1. Web Technology: Theory and Practice by Akshi Kumar, CRC Press, Taylor and Francis Group, A Chapman & Hall Book, 2018.

2. Internet and Web Technologies by Raj Kamal, Tata McGraw Hill edition, 2017.
3. Web Technologies by Uttam K. Roy, Oxford University Press, 2010.
4. HTML: A Beginner's Guide by Wendy Willard, Tata McGraw-Hill, 2013.
5. R.W. Sebesta, Programming World Wide Web, Pearson, 2001
6. The World Wide Web Consortium: w3c.org

SEMESTER IV

CSE652   **Research Project**

CSE602   **Major Project II**