Dept. of Computer Science and Engineering
University of Dhaka.
Ph.D Course for 2012-13 and Onward

List of Theoretical Courses

Code	Course Title	Credit
CSE-701	Advanced Computer Networking	3.0
CSE-702	Advanced Algorithm Design and Analysis	3.0
CSE-703	Graph Theory	3.0
CSE-704	Knowledge Engineering	3.0
CSE-705	Information Security and Cryptography	3.0
CSE-706	Simulation and Modeling	3.0
CSE-707	Advanced Computer Graphics	3.0
CSE-708	Advanced Logic Design	3.0
CSE-709	Advanced Database Systems	3.0
CSE-710	Advanced Digital Image Processing	3.0
CSE-711	Pattern Recognition	3.0
CSE-712	VLSI Layout Algorithms	3.0
CSE-713	Introduction to Bioinformatics	3.0
CSE 714	Fiber Optic Communication	3.0
CSE-715	Knowledge Based Systems	3.0
CSE-716	Neural Networks	3.0
CSE-717	E-Commerce System Infrastructure and Implementation	3.0
CSE-718	Principles of GPS/GNSS Positioning	3.0
CSE-719	Machine Learning and Data Mining	3.0
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CSE-721	Mobile Computing	3.0
CSE-722	Computer Vision	3.0
CSE-723	Computational Geometry	3.0
CSE-724	Graph Drawing	3.0
CSE-725	Network Performance Analysis	3.0
CSE-726	Green Networking	3.0

CSE-727	Cloud Computing	3.0
CSE-728	Reversible Logic Synthesis	3.0
CSE-729	Decision Diagram for VLSI design	3.0
CSE-730	Modern Processor Design	3.0
CSE 735	Distributed Artificial Intelligence	3.0
CSE 736	Applied Game Theory and Mechanism Design	3.0
CSE 737	Text Mining	3.0
CSE 738	Mathematical Modeling and Optimization	3.0

Course content (Theoretical Courses)

CSE-701: Advanced Computer Networking

(45 Hour Lectures) 3.0 Credit

High Speed LANs: Emergence of high speed LANs, Fast Ethernet, Gigabit Ethernet and 10 Gigabit Ethernet, topology, implementations and data encoding techniques, Fiber channel. **Spread Spectrum:** Concept, frequency hopping and direct sequence spread spectrum, Code Division Multiplexing. **Wireless LANs**: Wireless LAN technology, IEEE802.11, technology, medium access control, addressing, physical layer implementations, Bluetooth, architecture, layers and data rates, IEEE802.15 and IEEE802.16 standards. **IPv6:** Packet format, extension headers, comparison with IPv4 packet, categories of addresses, transition from IPv4 to IPv6. **Virtual Circuit Networks:** Frame Relay networks, architecture, layers, address formats, virtual circuits switching. ATM networks, architecture, switching, ATM layers, ATM LANs. **Multimedia Networking:** Audio and video compressions, Lossless compression, encoding techniques, Lossy compression, discrete cosine transform, JPEG and MPEG, streaming audio/video, protocol for real-time interactive applications, RTP, RTCP, SIP, H.323, voice over IP. **Congestion Control and Quality of Service:** Congestion control mechanisms, congestion control in TCP and Frame Relay networks, techniques for quality of services, integrated and differentiated services, quality of services in switched networks. **Performance Modeling**: overview of probability and stochastic processes, queuing analysis and queuing models with examples, queues with priorities, networks of queues. **Network Management**: Network management system, structure, management information base, security, SNMP.

CSE-702: Advanced Algorithm Design and Analysis

(45 Hour Lectures) 3.0 Credit

Asymptotic Analysis: Review of Asymptotic Analysis and Growth of Functions; **Recurrence:** Analyze the efficiency of algorithms using recurrences. **Amortized Analysis** – Analyze the efficiency of algorithms using amortized analysis, Binomial Heap, Fibonacci Heap, Splay Tree. **String matching** – KMP (Knuth Moris Pratt) string matching, Boyer Moore string matching, Suffix Tree. **Dynamic Programming –** Basics of dynamic programming, Top down vs. bottom up approach, Memoization, Sum of Subset, 0/1 Knapsack, Sequence Alignment, Edit Distance. **Network Flow** – The Maximum Flow Problem, Applications of Maximum Flow, Maxflow Mincut Theorem, Mincost Flow. **Matching** – Maximum Bipartite Matching, Weighted Bipartite Matching (Hungarian Method). **Sorting** -

Lower bound for comparison based sorting, Non-comparison based sorting: Count sort, bucket sort, radix sort. **NP and Computational Intractability** - NP-Completeness Fundamentals, NP-Complete problems, P versus NP, co-NP, NP Hardness, A Class of problems beyond NP. **Approximation Algorithm:**

Randomized Algorithm: Contention Resolution, Finding the Global Minimum Cut, A Randomized Approximation Algorithm for MAX 3-SAT, Randomized Divide & Conquer. **Linear programming(LP)**: Formulating linear programs, Application of LP, Geometry of LP, simplex algorithm, Duality theory, Sensitivity analysis, Integer Linear Programming

CSE-703: Graph Theory (45 Hour Lectures) 3.0 Credit

Fundamental concepts, varieties of graphs, path, cycles and components, degrees and distances, clique. Trees: Properties, spanning trees, forests, centroids, generation of trees and cycles, independent cycles and co-cycles. Connectivity: Vertex and edge connectivity, blocks, eccentricity, Menge's theorem. Traversability: Eulerian graphs, Hamiltonian graphs, chromatic polynomials. Planarity: Planar and outer planar graphs, Kuratowski's theorem, embedding graphs on surfaces, genus, thickness and crossing number. Graph Coloring: Vertex coloring, edge coloring, chromatic number, five color theorem, four color conjecture, critical graph. Homomorphism Digraph: Different connectedness, oriented graphs-tournaments, network flows and related algorithms. Groups, polynomials and graph enumeration, matching and factorization, perfect graphs, Ramsey number and Ramsey theorem, forbidden graph theory, miscellaneous applications.

CSE-704: Knowledge Engineering (45 Hour Lectures) 3.0 Credit

Introduction to data bases, Artificial Intelligence. Representation of knowledge: Conceptual dependencies, Semantic Networks, Frames, Production Systems. Object oriented Data bases for Knowledge Based Systems. Methods of Inference. Top down and bottom up approaches. Control structures with uncertainty. Certainty factors. Fuzzy theory. Languages and Tools for Knowledge Engineering. Completeness and consistency in Rule-based systems. Expert system development. Expert system support environment. Theory of knowledge sharing and Semantic webs.

CSE-705: Information Security and Cryptography

(45 Hour Lectures) 3.0 Credit

Overview: Security services, mechanisms, threats and attacks, model for network security and access security model. **Classical Encryption Techniques**: Substitution and transposition techniques block ciphers and serial ciphers, steganography. **Symmetric Ciphers:** Data Encryption Standard, Advanced Encryption Standard, contemporary symmetric ciphers, serial encryption and RC4, block cipher modes. **Public Key Cryptography:** RSA algorithm, Diffie-Hellman key exchange, discrete logarithms, elliptic curve arithmetic and elliptic curve cryptography. **Authentication**: Message authentication and entity authentication, message authentication code, hash functions, MD5, Secure Hash Algorithm, RSA digital signature, Digital Signature Standard, biometrics, **Key Management:** Session keys and management of secret keys, key distribution centre, public key distribution and certificate authority, key storage and key revocation, X.509 standard. public key infra structure. **IP Security and Web Security and Application Layer Security:** Overview, IPSec, authentication header and ESP, Secure Socket Layer and Transport Layer Security, security parameters and protocols, email security, PGP5 and secure MIME. **System Security**: Intruders and intrusion detection, password protection and

management, viruses and related threats, virus countermeasures, digital immune systems, firewall design principles, rusted systems.

CSE-706: Simulation and Modeling (45 Hour Lectures) 3.0 Credit

System Models, Statistics and Probability for Simulation, Descriptive Simulation Modeling, Static and Dynamic Modeling, Meta Modeling, Model Validation and Performance Prediction, Continuous and Discrete Event Simulation, Random Number and Random Variety Generation, Input modeling, models of arrival process, Simulation Languages, Queuing Systems and Queuing Networks, Approximation Techniques, Performance Evaluation of Computer Systems.

CSE-707: Advanced Computer Graphics (45 Hour Lectures) 3.0 Credit

Light/object interaction. Geometric object representation; Polygonizing Algorithm: Marching Cubes Algorithm. Subdivision of Surfaces: Basic Ideas, Subdivision for Surfaces. Multi-resolution modeling, Multi-resolution analysis, Normal meshes, Mesh Simplification: Progressive Meshes, Streaming Meshes, Mesh Smoothing and Fairing, Laplacian Mesh Editing. Deformation modeling: Implicit Surfaces, Point-based Models. Computer animation and physically based modeling: Cloth modeling and animation. Texture and environment mapping: Photon mapping. Ray tracing: Monte Carlo path tracing. Radiosity. Global illumination: Introduction to Global Illumination. Advanced real-time rendering: Image based rendering. Virtual reality.

CSE-708: Advanced Logic Design (45 Hour Lectures) 3.0 Credit

Functional decomposition and Symmetric Functions, Graph optimization problems and algorithms, Logic level synthesis and optimization, multi-level logic simplification, sequential logic optimization, Fault-Tolerance and Reliability: Error Detection and Correction. Hamming and CRC codes; two-dimensional (product) codes, Reed Muller expansions and their minimization, Synthesis and verification of Finite State Machine, Review of state machine design, Moore/Mealy machine, finite state machine word problems, Transformation from non-deterministic representations, Look up table (LUT), FPGA, Technology mapping; graph coloring, Choice of base function, creation of the subject graph, the DAG covering problem, delay optimization, Boolean matching, multilevel minimization, PLA reduction regular structure circuits, Synthesis of FSM-ASM chart representation and realization, Layout synthesis, Placement and routing, testing of VLSI, Testing of stuck-at Fault, testing of PLAs RAM, Asynchronous Design: Introduction to Hazard-Free Combinational Logic. Multiple input changes, Hazard free two level logic minimization, Multi-level logic, Design static and dynamic hazard free logic.

CSE-709: Advanced Database Systems (45 Hour Lectures) 3.0 Credit

Object Oriented Database; Data Model, Design, Languages; Object Relational Database: Complex data types, Querying with complex data types, Design; Distributed Database: Levels of distribution transparency, Translation of global queries to fragment queries, Optimization of access strategies, Management of distributed transactions, Concurrency control, Reliability, Administration; Parallel Database: Different types of parallelism, Design of parallel database; Multimedia Database SystemsBasic concepts, Design, Optimization of access strategies,

Management of Multimedia Database Systems, Reliability; Database Wire-housing/Data mining: Basic Concepts and algorithms.

CSE-710: Advanced Digital Image Processing

(45 Hour Lectures) 3.0 Credit

Digital Image Fundamentals: Visual perception and Light, Image Representation and Modeling, Sampling and Quantization, basic relationships between pixels. Image Enhancement: Image Transformation, Histogram Processing, Labeling, Different types of filters, Smoothing Frequency domain Filters, Sharpening Frequency domain Filters, Homomorphic filtering. Color Image Processing: Color Perception, Color coordinate system, Chromaticity Diagram, Color Transformation, Filtering Color images, Color-tone adjustment, Color-based Segmentation. Image Analysis and Segmentation: Line and Edge Detection, Edge linking and Boundary Detection, Region-based Segmentation, Segmentation by Morphological Watersheds, Motion-Based Segmentation. Morphological Image Processing: Dilation and Erosion, Opening and closing, Some Morphological algorithms. Image Restoration: A model of the image restoration process, noise models, periodic noise reduction, linear position-invariant Degradation, Minimum mean square error filtering. Image Compression: Image Compression Models, Error Free Compression, Lossy Compression, Image Compression Standards. Wavelets and Multi Resolution Processing: Multi-resolution Expansions, Wavelet Transforms in One-Dimensions and Two-Dimensions, Wavelet packet. Pattern Recognition: Statistical, Structural, Neural network, PCA, Knowledge-based and Hybrid techniques, Optical Character Recognition, Object Recognition. Applications: Robotic Vision, Medical Image Processing, Satellite Image Processing, etc.

CSE-711: Pattern Recognition (45 Hour Lectures) 3.0 Credit

Introduction and General Pattern Recognition Concerns: Pattern Recognition, Classification and Description, feature extraction with examples, feature extraction from images, training and learning in PR system, pattern recognition approaches. Bayesian Decision Theory: Review of probability theory and some linear algebra, Bayesian Decision making; Bayesian networks, linear discriminants, separability, multi-class discrimination; quadratic classifiers. Bayesian estimation; Random vectors, expectation, correlation, covariance, linear transformations Decision theory, Likelihood ratio test Linear and quadratic discriminants, Fisher discriminants. Sufficient statistics, coping with missing or noisy features. Statistical Pattern Recognition: Introduction to statistical pattern recognition, The Gaussian and Class Dependence, Discriminant Functions, Kalman filtering and smoothing, Classifier performance, risk and Errors. Supervised Learning: Parametric Estimation and Supervise Learning, maximum likelihood Estimation approach, Bayesian parameter estimation approach, Non-parametric approaches, Parzen windows, K-nn Non-parametric estimation, Nearest Neighbor Rule, Mixture modeling, optimization by Expectation-Maximization. Un-supervised learning and Clustering: Formulation of Unsupervised learning Problems, Clustering for unsupervised learning and classification, vector quantization, K-means Feature extraction for representation and classification. Syntactic Pattern Recognition: Syntactic Pattern Recognition overview, Quantifying structure in pattern description and recognition, Grammar-Based approach and Applications, Elements of formal Grammars, Example of string generations as pattern description. Syntactic recognition via parsing and

other grammars, Graphical approaches to syntactic pattern recognition. Classification: Template-based recognition, Eigen vector analysis, PCA Sequence analysis, HMMs, Viterbi algorithm, Baum-Welch algorithm, Maximum likelihood and Bayesian parameter estimation, optimization by gradient descent, SVM, Neural nets, Perceptron learning, Multi-layer Perceptrons, Neural networks for pattern recognition, Decision trees. Applications: Object detection and recognition, Biological object recognition, Tracking, Gesture recognition

CSE-712: VLSI Layout Algorithms (45 Hour Lectures) 3.0 Credit

VLSI design cycle, physical design cycle, design styles; Basic graph algorithms and computational geometry algorithms related to VLSI layout; Partitioning algorithms: group migration algorithms, simulated annealing and evaluation, performance driven partitioning; Floor planning and placement algorithms: constraint based floor planning, rectangular dualization and rectangular drawings, integer programming based floor planning, simulation based placement algorithms, partitioning based placement algorithms; Pin assignment algorithms; Routing algorithms: maze routing algorithms, line prob algorithms, shortest-path based and steiner tree based algorithms, river routing algorithms, orthogonal drawing based algorithms; Compaction algorithms: constraint-graph based compaction, virtual grid based compaction, hierarchical compaction; Algorithms for Multi-Chip Module (MCM) physical design automation.

CSE-713: Introduction to Bioinformatics (45 Hour Lectures) 3.0 Credit

Essentials of Molecular biology: DNA, RNA and Protein, Watson and Crick Model of DNA, DNA replication, transcription, translation, splicing, Central dogma of molecular biology; DNA sequencing technology; Sequence Databases; Sequence Formats; Pairwise sequence alignment: local and global alignment, amino acid substitution scoring matrices; significance of the alignment, Multiple sequence alignment: progressive, iterative, statistical methods for multiple sequence alignment; local multiple alignment - sequence profiles and motifs, EM algorithm, Gibbs Algorithm; Hidden Markov Models: theory; training and applications to sequence alignment. Sequence database search: heuristic methods – FASTA, BLAST; Basic methods in molecular phylogeny: phylogenetic trees; distance matrix methods; maximum parsimony methods; maximum likelihood methods. Proteins: protein classification, structure alignment and prediction; microarrays: design, data acquisition and analysis; gene network modeling; Systems biology.

CSE 714: Fiber Optic Communication (45 Hour Lectures) 3.0 Credit

Introduction to Telecommunication and Fiber Optics: Physics of Light, Electromagnetic waves, Radiation and Absorption, Attenuation, Dispersion of light, Modes, Maxwell's equation, Propagation of EM waves, Total internal reflection. Singlemode fibers: basics, attenuation, dispersion and bandwidth, Multimode fibers. Light source and Transmitter, LED, laser diodes, Receivers, Photodetectors. Introduction of Fiber Optic Networks. Bandwidth of the Fiber: Frequency of different LASER, Relation between laser frequency and Bandwidth.

CSE-715: Knowledge Based Systems (45 Hour Lectures) 3.0 Credit

Representation of Knowledge: Predicate logic, rules, Semantic Networks, Frames; Conceptual graphs, Scripts Fuzziness and uncertainty, Fuzzy logic, Statistical

techniques for determining probability, Methodologies for developing knowledge based systems, The KBS Development Life Cycle: Knowledge acquisition, Prototyping, Implementation, Development environments. Intelligent Database Systems: Decision Support System, OLAP, Data warehouse, Data Mining: rule mining, classification, clustering, regression. Intelligent Information Systems: Neural networks architectures- Hopfield network; Multi-layer perception, Feedforward, Backpropagation; Genetic algorithms- Basic concepts, Population, Chromosomes, Operators, Schemata, Coding, Rule induction, Decision trees/rule sets. Applications: Expert systems, Natural language processing, Machine vision and robotics, Data mining and intelligent business support

CSE-716: Neural Networks (45 Hour Lectures) 3.0 Credit

Introduction and brain physiology, Perceptrons and Backpropagation, Multi-Layer Perceptrons, Learning Theory, Support Vector Machines, Committee Machines, Symbolic vs Non-Symbolic and Connectionist approaches, Recurrent networks, Self-organising Systems, product Networks, Neurodynamics - Hopfield nets, Brain-State-in-a-Box (BSB), Simulated annealing, Boltzmann machine

CSE-717: E-Commerce System Infrastructure and Implementation

(45 Hour Lectures) 3.0 Credit

Introduction to E-commerce, E-Commerce Revolution, Understanding E-commerce Organizing Themes. The Internet and World Wide Web: E-commerce Infrastructure. E-Commerce System Models and Concepts : B2B, B2C, C2C. The Internet: Technology, background. Building an E-Commerce Application: A systematic approach. Choosing server software. Choosing the hardware for an E-commerce site. E-commerce Application Development: XML and XML parsing Methods. Presentation layer Development (Servlet, JSP), Business Logic Layer Development(EJB), Data Layer Development(JDBC), Web Application Design pattern (MVC and other). Personalization, Testing and Debugging, Application to Application communication Protocols: SOAP, WSDL, UDDI, RMI, DCOM, CORBA etc. Security and Encryption: Security, privacy and payment. The E-commerce Security Environment, Security Model. Network-level Security: SSL, Application-level Security. SQL-injection, Form modification, cross site scripting, Privacy: P3P, Policies, Procedures; and Laws. E-commerce Payment Systems. E-Commerce Application infrastructure: J2EE, Net and Web services.

CSE-718: Principles of GPS/GNSS Positioning

(45 Hour Lectures) 3.0 Credit

Introduction to GNSS, Introduction to reference systems, principles of range-based positioning, introduction to orbital motion, Introduction to Matlab & learning resources, Datum definitions & transformations, coordinates, height systems, map projections, height systems, map projections Visualisation of satellite orbits, introduction to GPS, GPS signals & measurements, positioning modes Principles of Least Squares estimation, Mathematical aspects of range-based positioning & LS, Factors affecting GPS/GNSS accuracy, from measurements to position, Differential GPS/GNSS, Introduction to GPS receivers, Introduction to GPS/GNSS, carrier phase-based positioning, Next generation GNSS, trends in technology & applications.

CSE-719: Machine Learning and Data Mining

(45 Hour Lectures) 3.0 Credit

Introduction to machine learning and data mining, Designing a learning system, perspective issues in machine learning, Concept of learning and the general to specific Ordering: induction learning hypothesis, Find-S, version space and candidate elimination algorithms, List-then-elimination algorithms, A biased hypothesis space, unbiased hypothesis space, decision tree, Artificial Neural networks, Multilayer networks and back propagation algorithms, Recurrent network, Evaluation hypothesis, Bayesian learning, Naive bays classifier, Gibbs algorithms, Bayesian belief Networks, EM algorithms, Computational learning theory, probability learning theory, sample complexity finite hypothesis space, sample complexity infinite hypothesis space, Mistake bound model of learning, Instance based learning, K-nearest neighbor learning, Genetic algorithms, Learning sets rules, Analytical learning, Combining inductive and Analytical learning, Reinforcement learning, SVM, Boasting, Clustering, training and testing, cross validation, prediction performance, Data mining tools

CSE-720: Embedded System (45 Hour Lectures) 3.0 Credit

Introduction to the Embedded Systems. Embedded System Design Specifications Embedded System Hardware and Hardware/Software Co-design. The 8051/8052 family of Microcontrollers. C programming for Microcontrollers. I/O ports Programming. Timer/Counter hardware and Its Device Driver. Serial communication interface and Its Device Driver. Interrupts Programming. Embedded Software Development Cycle and the Integrated Development Environment. Debugging Techniques for Embedded Software and the Role of Cross Simulators. Real World Interfacing Case Studies: LCD, Sensors, stepper motor, keyboard, PC. Design of Device Driver for Serial Devices. Concept of Finite State Machines and Examples - Stop Watch, Stepper Motor Control through PC. Remote Control of Systems using IR Remotes Used in Commercial TV Remote Control Modules. Simple Multi Drop Communication Networks with Examples. Simple Wireless Communication with Examples.

CSE-721: Mobile Computing (45 Hour Lectures) 3.0 Credit

Cellular Networks: Channel allocation, Multiple access, Location management, Handoffs. Wireless Networking: MAC protocols, Routing, Transport, Ad-hoc networking, Advantages and disadvantages of wireless networking. Applications: Mobility adaptations, Disconnected operations, Data broadcasting, Mobile agents. Security, Energy efficient computing, Impact of mobility on algorithms. Characteristics of radio propagation: Fading, Multipath propagation. Mobile network layer protocols such as mobile-IP, Dynamic Host Configuration Protocol (DHCP). Mobile transport layer protocols such as mobile-TCP, indirect-TCP. Wireless Application Protocol (WAP). Simplified mobile radio environment: propagation characteristics, signal loss, multipath fading, interference; Design countermeasures: design margins, diversity, coding, equalization, and error correction; Channel concept; Frequency division, time division, spread spectrum; Spectrum efficiency issues; Frequency reuse/cellular/microcellular concepts including sectorization and cell splitting; Cellular telephony as a case study in network support: hand-off, mobility, roaming, billing/ authorization/authentication; Design decisions in European GSM, U.S. Digital TDMA, and U.S. Digital CDMA from the systems perspective; Interplay of channel characteristics (e.g., power vs. bit error rate, multipath fading) and network

protocol design; Media access methods: Aloha network/carrier sense methods, Karn's MACA for packet radio; Packet radio schemes; Survivable network design; Mobile IP proposal and variations; Cellular Digital Packet Data (CDPD) standard; Satellite systems: low-earth orbiting systems; Symmetric vs. asymmetric communications schemes; Broadcast and multicast communications in a wireless context; Direct Broadcast Satellite systems; Description of commercially available wireless local area networking products;

CSE-722: Computer Vision (45 Hour Lectures) 3.0 Credit

Introduction: Human Vision, Computer Vision, and Robots Vision System, Sensing, Seeing, and perceiving, the role of Vision. Image formation: The physics of imaging. Representing, acquiring, and displaying images. Grayscale, color, noise, lens distortion, blurring, and filtering. Image processing, preprocessing, and image correction. Binary image analysis, Enhancing features and correcting imperfections. image understanding, Fourier Transform. Computer Vision Paradigms: Pixels, lines, boundaries, regions, and object representations, "Low-level", "intermediate-level", and "high-level" vision. Image Analysis: Finding edges (low-level), Gradients, zero crossing detectors, line models. Finding and grouping lines (intermediate-level), Boundary tracing, line fitting, Hough transform, Finding and processing regions Finding "elementary regions" (low-level) Merging, splitting, and grouping regions (intermediate-level), Grouping and analyzing lines and regions (high-level). Feature Extraction/Analysis: Feature extraction, shape, histogram, color, spectral, texture, using CVIP tools, Feature analysis, feature vectors, distance /similarity measures, data preprocessing, Segmentation/ Morphological Filtering, texture. Stereo, and Motion: Optical Flow and FOE, motion Understanding. Pattern classification using computer vision Applications in medicine, industry, and survielance.

CSE-723: Computational Geometry (45 Hour Lectures) 3.0 Credit

Algorithms and complexity of fundamental geometric objects: Polygon triangulation and art gallery theorem, Polygon partitioning, Convex-hulls in 2-dimension and 3-dimension, Dynamic convex-hulls; Geometric intersection: Line segment intersection and the plane-sweep algorithm, Intersection of polygons; Proximity: Voronoi diagrams, Delunay triangulations, closest and furthest pair; Visualization: Hidden surface removal and binary space partition (BSP) trees; Graph Drawings: Drawings of rooted trees (Layering, Radial drawings, HV-Drawings, Recursive winding), Drawings of planar graphs (Straight-line drawings, Orthogonal drawings, Visibility drawings); Survey of recent developments in computational geometry.

CSE-724: Graph Drawing (45 Hour Lectures) 3.0 Credit

Introduction to graph drawing: historical background of graph drawing, drawing styles, properties of drawings, applications of graph drawing; Graph theoretic foundations; Straight line drawing: shift method, realizer method, compact grid drawing; Convex drawing: convex drawing and convex testing, convex grid drawing; Rectangular drawing: rectangular drawing and matching, Thomassen's theorem, linear algorithms for rectangular drawing; Box-rectangular drawing; Orthogonal drawing: orthogonal drawing and network flow, linear algorithms for orthogonal drawing; Octagonal drawing; Tree drawing.

CSE-725: Network Performance Analysis (45 Hour Lectures) 3.0 Credit

Overview on probability theory, Poisson processes, Discrete-Time Markov Chain (DTMC), Continuous-Time Markov Chain (CTMC), Queuing Theory – Little's law, M/M/1, M/M/m, M/G/1, G/M/1, G/M/m, G/G/1, Traffic Models – Poisson, On/Off, Markov, Video traffic, Web traffic, Backbone traffic, Multiple Access Techniques – Aloha, CSMA/CD, CSMA/CA, IEEE 802.11 DCF, Delay Analysis, Throughput Analysis, Performance analysis of transport and network layer protocols.

CSE-726: Green Networking (45 Hour Lectures) 3.0 Credit

Green networking is corresponding to the energy-efficient networking. This course explores current perspectives in power consumption for next generation wired and wireless networks, and examines power saving optimization techniques at the levels of the individual networking devices and of the network itself. Re-engineering, dynamic adaptation, sleeping/standby approaches, cooperative communications, energy-aware QoS schemes, transport, routing and MAC protocols are treated in some detail, in order to provide the methodological foundations of the future energy-aware networking.

CSE-727: Cloud Computing (45 Hour Lectures) 3.0 Credit

Defining cloud computing, Delivering services from the cloud, Adopting the Cloud, Key drivers of cloud computing solutions, Evaluating barriers to cloud computing, Exploiting Software as a Service (SaaS), Characterizing SaaS, Comparing service scenarios, Inspecting SaaS technologies, Delivering Platform as a Service (PaaS), Managing cloud storage, Deploying Infrastructure as a Service (IaaS), Accessing IaaS, Building a Business Case, Calculating the financial implications, Preserving business continuity, Migrating to the Cloud, Technical considerations, Planning the migration.

CSE-728: Reversible Logic Synthesis (45 Hour Lectures) 3.0 Credit

Theory of reversibility, Energy and Information loss, Popular Reversible logic gates, Garbage outputs, Delay, Quantum cost, **Reversible Combinational Circuits:** Decoder, Encoder, Multiplexer, Demultiplexer, Adder, BCD Adder, Carry Skip Adder, **Reversible Sequential Circuits:** Flip Flop, Register, Shift Register, Counter, RAM, Turing machine, **Synthesis of Reversible Logic:** Transformation based Synthesis, BDD based Synthesis, Fuzzy Reversible Circuit synthesis, **Reversible Complex Circuits:** PLA, PLD, CPLD, FPGA, **Reversible Fault Tolerant Circuits:** Fault Tolerant gates, Fault Tolerant Decoder, Fault Tolerant Multiplexer, **Reversible Online Testable Circuits:** On line testable gates, On line testable circuits, On line testable adders, On line testable Multiplexer, Ternary Reversible Circuits, Nanotechnology and its' impact, Quantum logic, Qubits, Quantum Circuits.

CSE-729: Decision Diagram for VLSI Design (45 Hour Lectures) 3.0 Credit

Binary Decision Diagram; co-factors, Shannon expansions and their properties; binary decision trees; variable ordering, reduction rules and how they led to reduction, Evolution and Satisfiability, Minimization of Decision Diagrams Classical Methods: exchange of neighbor variables, exact minimization, heuristic Minimization, Reduced Ordered Binary Decision Diagram (ROBDD), canonicity of ROBDDs, If else then operator on ROBDDs, ROBDD implementation concepts,

Solving 8 queens problem using ROBDD, Proof of correctness and equivalence of combinational Circuits using ROBDD, logical operations such as conjunctions, Disjunctions and Negation on ROBDD, Quantified Boolean Formula, Multi rooted BDD, BDD size bounds, dynamic variable re-ordering, SBDD, MTBDD, BDD for Characteristic function, Manipulation of BDD using ITE algorithm, Reversible Decision Diagram, Applications of BDD in formal verification, fault tree analysis and Product Configuration, Shared Decision Diagram, Decision Diagram for Multi valued function.

CSE-730: Modern Processor Design (45 Hour Lectures) 3.0 Credit

The evolution of microprocessors, Instruction set processor design, Digital system design, Architecture, implementation and realization, Instruction set architecture, Dynamic-static interface, Processor performance equation, Processor performance optimizations, Performance evaluation method, Instruction level parallel processing, From scalar to superscalar, Limits of instruction level parallelism, Machines for instruction level parallelism, Pipelined design, Pipelining idealism, Instruction pipelining, Pipeline hazards, Minimizing pipeline stalls, Pipelined processor design, Commercial pipelined processors, RISC pipelined processors, CISC pipelined processors, Scalar pipelined processors, Deeply pipelined processors, Computer system overview, Latency and bandwidth, Components of a modern memory hierarchy, Temporal and spatial locality, Virtual memory systems, Memory hierarchy implementation, Input/output systems, Limitations of scalar pipelines, From scalar to superscalar pipelines, Parallel pipelines, Diversified pipelines, Dynamic pipelines, Superscalar pipeline overview, Instruction fetching, Instruction decoding, Instruction dispatching, Instruction execution.

CSE-735: Distributed Artificial Intelligence (3.0 Credits, 45 Hours Lecture)

Introduction: Introduction to Distributed Artificial Intelligence (DAI), Historical background, Different domains of DAI. **Distributed Problem Solving:** Distributed constraint reasoning, Utility functions, Probabilistic and deterministic graphical models, Constraint graphical representations: Constraint network, DFS-tree, Junction tree, Factor graph. **Consistency-Enforcing Strategies:** Arc-consistency, Path-consistency and higher levels of i-consistency. Constraint propagation. **Constraint Reasoning Frameworks:** Distributed Constraint Satisfaction Problems(DCSPs), Distributed Constraint Optimization Problems (DCOPs) and different families (i.e. optimal and approximate) of constraint reasoning algorithms: search-based optimal algorithms: ABT, ADOPT and OptAPO. Inference-based Optimal algorithms: DPOP, Action-GDL. Local search-based approximate algorithms: DSA, MGM and DBA. Inference-based approximate algorithms: Max-product, Max-Sum. **Multi-Agent Systems (MAS):** Formulation of MAS, Values in MAS (Privacy, Safety, Security, Transparency, etc.), Agent-based Modelling, Coordination strategies, **Multi-Agent planning:** Automated planning, Privacy-preserving planning, Distributed planning and Centralized planning. **Sequential Decision Making:** Markov Decision Process (MDP), Partially Observable Markov Decision Process (POMDP) and their variants.

CSE-736: Applied Game Theory and Mechanism Design (3.0 Credits, 45 Hours Lecture)

Introduction: Introduction to game theory, History, different families of game, strategies, payoffs, rationality, equilibrium **Normal-form games**: simultaneous-move games with pure and mixed strategies, zero-sum game, constant-sum game, rollback, dominance, best-response algorithms, Min-Max methods, Nash equilibrium, price of anarchy; **Extensive-form games** sequential-move games, game trees, strategy, centipede game, combining sequential and

simultaneous moves, two-stage and multi-stage game, sub-game, sub-game perfection, rollback equilibrium; **Uncertainty and Information**: games with perfect and imperfect information (Bayesian game), complete and incomplete information game, cheap talk, conflicting interests, signaling game, Bayes-Nash equilibrium; **Repeated games**: finite and infinite repetition, grims strategy, tit-for-tat, asymmetric information, pooling and separation **Mechanism Design** reverse game theory, incentivecompatibility constraint, participation constraint, social choice and voting theory, social welfare, Groves-Clarke Mechanisms; **Auction**: types, auction rules and design, Dutch and English auctions, bidding strategy, Vickery Auctions.

CSE-737: Text Mining (3.0 Credits, 45 Hours Lecture)

Natural language processing: Basic techniques in natural language processing, including tokenziation, part-of-speech tagging, chunking, syntax parsing and named entity recognition. **Document representation**: How to represent the unstructured text documents with appropriate format and structure to support later automated text mining algorithms. **Text categorization**: Assigning a text document to one or more classes or categories using basic supervised text categorization algorithms, including Naive Bayes, k Nearest Neighbor (kNN) and Logistic Regression, Support Vector Machines and Decision Trees. **Text clustering**: Identifying the clustering structure of a corpus of text documents and assigning documents to the identified cluster(s) using two typical types of clustering algorithms, i.e., connectivity-based clustering (a.k.a., hierarchical clustering) and centroid-based clustering (e.g., k-means clustering). **Topic modeling**: General idea of topic modeling, two basic topic models, i.e., Probabilistic Latent Semantic Indexing (pLSI) and Latent Dirichlet Allocation (LDA), and their variants for different application scenarios, including classification, imagine annotation, collaborative filtering, and hierarchical topical structure modeling. **Document summarization**: Reducing a text document to a summary that retains the most important points of the original document. Extraction-based summarization methods. **Social media and network analysis**: Characteristic of social network: inter-connectivity, the PageRank algorithm. **Sentiment analysis**: It refers to the task of extracting subjective information in source materials. We will discuss several interesting problems in sentiment analysis, including sentiment polarity prediction, review mining, and aspect identification. **Text visualization**: Visual representations of abstract data to reinforce human cognition. Introduce mathematical and programming tools to visualize large collection of text documents.

CSE-738: Mathematical Modeling and Optimization

Linear Programming (LP) as a tool of Operational Research (OP). The history of LP and the contribution of G. Dantzig. Modelling a problem as an LP problem by defining the objective function, the set of linear constraints that determines its feasible solutions. Forms of an LP problem, Unique optimal solution and infinite many optimal solutions. Incompatible constraints, unbounded feasible solution set and unbounded variables; Mathematical Modeling: Linear, nonlinear, and integer programming models;Convex Analysis: Convex sets, polyhedral sets and polyhedral cones, Extreme points and extreme directions, Representation of polyhedral sets, Basic feasible solution and its relation with extreme points. Degenerated basic feasible solutions. The Extreme Point Theorem. Finding the optimal solution by the use of Linear Algebra; Linear Programming: Motivation of the simplex method and the revised simplex method, Farkas' lemma and the Karush-Kuhn-Tucker optimality conditions, Duality and

sensitivity analysis, Interior point methods; The big M method and its application on various problems. The two phase method and its application on various problems. LP Problems with Unbounded variables. The Dual LP problem. Economic Interpretation of the Dual LP problem. Duality theorem. Dual Simplex method and its application on various problems. Computational Complexity Theory: Complexity issues, polynomial-time algorithms, Decision problems and classes NP and P; Network Optimization: Network simplex method, Matching and assignment problems, Min-cost, max-flow problems.