University of Gour Banga

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Department of Computer Science

N.H.-34 (Near Rabindra Bhawan), P.O.: Mokdumpur
Dist.: Malda, West Bengal, Pin: 732103

M.Sc. in Computer Science

Two Years (Four Semesters) Syllabus
(In CBCS Format from 2018)

Semester	Paper	Paper Code	Paper Name	Credit	Total Credits	Equivalent Marks /Paper	Total marks
I	Core 1	*COMP 101*	Design and Analysis of Algorithms	4	**24**	50	300
	Core 2	*COMP 102*	Computer Networks and Wireless Communications	4		50	
	Core 3	*COMP 103*	Business English and Communication Lab.	4		50	
	Core 4	*COMP 104*	Algorithms Lab.	4		50	
	Elective Core	*COMP 105*	Advanced DBMS	4		50	
	Elective	*COMP 106*	Programming with Python	4		50	
II	Core 1	*COMP 201*	Object Oriented Programming with JAVA	4	**24**	50	300
	Core 2	*COMP 202*	Advanced Software Engineering	4		50	
	Core 3	*COMP 203*	Advanced Discrete Mathematics & Graph Theory	4		50	
	Core 4	*COMP 204*	Object Oriented Programming with Java Lab.	4		50	
	Elective Core	*COMP 205*	Advanced Compiler Design	4		50	
	Elective	*COMP 206*	Information Security	4		50	
III	Core 1	*COMP 301*	Pattern Recognition	4	**24**	50	300
	Core 2	*COMP 302*	Pattern Recognition Lab.	4		50	
	Core 3	*COMP 303*	Seminar	4		50	
	Core 4	*COMP 304*	Minor Project	4		50	
	Elective Core	*COMP 305*	Artificial Intelligence	4		50	
	Elective	*COMP 306*	Data Mining and Data Warehousing	4		50	
IV	Core 1	*COMP 401*	Elective	4	**24**	50	300
	Core 2	*COMP 402*	Elective Lab.	4		50	
	Core 3	*COMP 403*	Major Project	4		50	
	Core 4	*COMP 404*	Project Presentation	4		50	
	Elective Core	*COMP 405*	Computational Intelligence	4		50	
	Elective	*COMP 406*	Image Processing	4		50	
TOTAL					**96**		1200

N.B:- Alternative elective core papers mentioned in the third page can be taught as elective core for more choices.

List of alternative elective core papers

1. Machine Learning
2. Advanced Operating System
3. Parallel Computing
4. Cryptography
5. Wireless Communication & Mobile Computing
6. Advanced Theory of Computing
7. Modelling and simulation
8. Natural Language Processing
9. Big Data Analytics
10. Human Computer Interaction
11. Bioinformatics
12. Computational Geometry
13. Distributed Computing
14. Biometric system
15. Cloud Computing

Details Syllabus

Paper *COMP 101*: Design and Analysis of algorithms

Brief Review of Data structures: Stack, Queue, Hashing, Heap, Fundamental of trees, Binary Search Tree, AVL tree, 2-3 Tree, Red Black Tree, B- tree, Splay Tree, Graph-basic terminology & representations

Basic algorithmic analysis: Asymptotic analysis of upper and average complexity bounds; best, average, and worst case behaviors; big-Oh, big-Omega and big-Theta; standard complexity classes; empirical measurements of performance; time and space trade-offs in algorithms; solving technique of recurrence relations.

Divide and Conquer: Merge Sort**,** Quick Sort, Strassen's Matrix Multiplication, Multiplication of large integers

Greedy Algorithm: Prim's and Kruskal's Algorithm, Dijkstra's Algorithm, Huffman Codes

Dynamic Programming: Chained matrix multiplication, Knapsack algorithm, Warshall's and Floyd's Algorithms,

Backtracking Algorithms: 8 queens problem

Graph Searching Algorithms: BFS, DFS, Topological Sort, Minimum Spanning Tree, Bipartite Graphs.

Miscellaneous Theory: Amortized Analysis. Bellman Ford Algorithm, Travelling Salesman problem, Tractable and intractable problems, Introductions to NP-completeness,

Books and References:

1. Introduction to Algorithms: Cormen, Leiserson, Rivest and Stein: Prentice Hall of India
2. Fundamentals of Computer Algorithms: Sahni , Horowitz: Universites Press
3. Introduction to the Design and Analysis of Algorithms: AnanyLevitin
4. Data Structures and Algorithms: Aho, Hopcroft and Ullmann: Addison Wesley.
5. Data Structures and Algorithms in Java b: Michael T. Goodrich , Roberto Tamassia
6. Data Structures and Algorithms in C++ : Adam Drozdek
7. Teofilo F. Gonzalez, Handbook of NP-Completeness: Theory and Applications

Paper *COMP 102*: Computer Networks and Wireless Communications

Overview of Data Communication and Networking: Introduction; Data communications: components, direction of data flow (simplex, half duplex, full duplex); Networks: distributed processing, network criteria, physical structure (type of connection, topology), categories of network (LAN,MAN,WAN);OSI reference model, TCP/IP reference model, their comparative study.

Physical level: Overview of data (analog & digital), transmission (analog & digital) & transmission media (guided & non-guided); TDM, FDM, Circuit switching: time division &space division switch.

Data link layer: Types of errors, framing (character and bit stuffing), error detection & correction methods; Flow control ; Protocols:Stop & wait ARQ,Go-Back-NARQ, Selective repeat ARQ, HDLC;

Medium access sublayer: Point to point protocol, LCP, NCP, FDDI, token bus, token ring; Reservation, polling, concentration; Multiple access protocols: Pure ALOHA, Slotted ALOHA, CSMA, CSMA/CD, Traditional Ethernet, fast Ethernet;

Network layer: Internetworking & devices - Repeaters, Hubs, Bridges, Switches, Router, Gateway; Addressing: Internet address, classification, subnetting; Routing: techniques, static vs. dynamic routing, Routing algorithms - shortest path algorithm, flooding, distance vector routing, link state routing; Protocols: ARP, RARP, IP, ICMP, IPV6; Unicast and multicast routing protocols.

Transport layer: Process to process delivery; UDP; TCP; Congestion control algorithm: Leaky bucket algorithm,Token bucket algorithm,

Application Layer: DNS, SMTP, SNMP, FTP, HTTP & WWW; Network Security and Cryptography **.**

Modern Topics : ISDN services & ATM; DSL Technology, Cable Modem, Sonet.

Wireless LAN: IEEE802.11, Introduction to blue-tooth, VLAN's, Cellular & Satellite Networks

BooksandReferences:

1. B.A.Forouzan:DataCommunicationsandNetworking(3rdEd.),TMH
2. A.S.Tanenbaum:ComputerNetworks(4thEd.),PearsonEducation/PHI

3. W.Stallings:DataandComputerCommunications(5thEd.),PHI/PearsonEducation

Paper *COMP 103*: Business English and Communication Lab.

Expression: Practical communication skill development, business presentation with Multimedia, speaking skill, prepared speech, extempore speech, group discussion, debate
Reading skill: comprehension test.

Writing: precise, technical/business letter, Resume/CV, organisation of writing material, poster presentation, writing technical document, preparing software user manual, preparing project documentation.

Books:
1. Business Correspondence & Report Writing, Sharma, TMH
2. Business Communication Strategies, Monipally, TMH
3. English for Technical communication,Laxminarayanan,Scitech
4. Business Communication, Kaul,PHI
5. Communication Skill for Effective Mgmt., Ghanekar,EPH

Paper *COMP 104*: Design and Analysis of Algorithms Lab.

Programming with Python or any suitable language, Assignments on developing programs and functions related to the theoretical paper coverage on Design and Analysis of algorithms.

Paper *COMP 105*: Advanced DBMS

Relational Database Management Issues: Transaction Processing, Concurrency, Recovery, Security and Integrity.

Distributed Databases: Storage structures for distributed data, data fragmentation, Transparency of distributed architecture, Distributed query processing, Query optimization, Transaction management in distributed environment, Recovery and Concurrency control, Locking protocols, Deadlock handling, Dynamic modeling of distributed databases, Client - Server Databases. Performance Tuning, Advanced Transaction Processing.

Object-oriented Databases: Objects and Types, Specifying the behavior of objects, Implementing Relationships, Inheritance. Sample Systems. New Database Applications.

Multimedia Database: Multimedia and Object Oriented Databases, Basic features of Multimedia data management, Data Compression Techniques, Integrating conventional DBMSs with IR and Hierarchical Storage Systems, Graph Oriented Data Model, Management of Hypertext Data, Client Server Architectures for Multimedia Databases.

Books and References:
1. H. F. Korth & A. Silverschatz: Database Systems Concepts, McGraw Hill.
2. Bindu R. Rao: Object Oriented Databases, McGraw Hill, 1994.
3. Gray, Kulkarni, Paton: Object Oriented Databases, Prentice Hall International, 1992.
4. Khoshafian: Object Oriented Databases, John Wiley & Sons, 1993.

5. S. Khoshafian& A.B. Baker, Multimedia and Imaging Databases, Morgan Kaufmann Publishers, 1996.
6. Kemper & Moerkoette: Object-Oriented Database Management, PH, 1994.
7. Alex Berson: Client/Server Architecture, McGraw Hill.
8. R.Elmasri, S.B. Navate: Fundamentals of Database System, Pearson.

Paper *COMP 106*: Programming with Python

1: Introduction To Python

2: Python Data Types

3: Python Program Flow Control

4: Python Functions, Modules and Packages

5: Python String, List And Dictionary Manipulations

6: Python File Operation

7: Python Object Oriented Programming – Oops

8: Python Regular Expression

9: Python Exception Handling

10: Python Database Interaction

11: Python Multithreading

12: Contacting User Through Emails Using Python

13: Python CGI Introduction

Books and References:

1. Python Crash Course: A Hands-On, Project-Based Introduction to Programming, by Eric Matthes.
2. Learning Python, by Mark Lutz,.
3. Fluent Python: Clear, Concise, and Effective Programming, by Luciano Ramalho.
4. Python Programming: An Introduction to Computer Science, by John Zelle.

Paper *COMP 201*: Object Oriented Programming with JAVA

Java Fundamentals: Features of Java, OOPs concepts, Java virtual machine, Reflection byte codes, Byte code interpretation, Data types, variable, arrays, expressions, operators, and control structures, Objects and classes

Java Classes: Abstract classes, Static classes, Inner classes, Packages, Wrapper classes, Interfaces, This, Super, Access control

Exception handling: Exception as objects, Exception hierarchy, Try-catch, finally, Throw, Throws

IO package: Input streams, Output streams, Object serialization, Deserialization, Sample programs on IO files, Filter and pipe streams

Multi-threading: Thread Life cycle, Multi-threading advantages and issues, Simple thread program, Thread synchronization

GUI: Introduction to AWT programming, Layout and component managers, Event handling, Applet class, Applet life-cycle, Passing parameters embedding in HTML, Swing components – JApplet, JButton, JFrame, etc. Sample swing programs

Database Connectivity: JDBC architecture, Establishing connectivity and working with connection interface, Working with statements, Creating and executing SQL statements, Working with Result Set

Books and References:

1. Bruce Eckel: Thinking in Java 3rd Edition, Prentice Hall
2. Herbert Schildt: Java: The Complete Reference, 9th Edition, Tata Mcgraw Hill Education Private Limited
3. Deitel and Dietel: Java How to Program 9th Edition, PHI Learning
4. Cay S. Horstmann: Core Java, Volume I : Fundamentals (English) 9th Edition, Pearson India
5. Bert Bates, Kathy Sierra: SCJP Sun Certified Programmer for Java 6, Tata Mcgraw Hill Education Private Limited.

Paper *COMP 202*: Advanced Software Engineering

Review of Software Engineering Fundamentals.

System Requirement Specification : DFD, DataDictionary, ERdiagram, Process Organization & Interactions.

System Design: Problem Partitioning,Top-Downand, Bottom-Updesign; Decision tree, decision table and structured English; Functional vs. Object-Oriented approach.

Coding & Documentation: Structured Programming, OO Programming, Information Hiding, Reuse, System Documentation.

Testing: Levels of Testing, Integration Testing, Test case Specification, Reliability Assessment, Validation & Verification Metrics, and Monitoring & Control.

Software Project Management: Project Scheduling, Staffing, Software Configuration Management, Quality Assurance, Project Monitoring.

CASE TOOLS: Concepts, use and application.

Books and References:

1. R. G. Pressman: Software Engineering, TMH
2. Behforooz: Software Engineering Fundamentals, OUP
3. Ghezzi: Software Engineering, PHI
4. Sommerville, Ian: Software Engineering, Pearson Education

Paper *COMP 203*: Advanced Discrete Mathematics & Graph Theory

Basic Structures: Sets representations, Set operations, Functions, Relations, Mapping, Groups.

Mathematical Logic: propositional logic, propositional equivalences, predicates & quantifiers, rule of inference, Boolean algebra.

Graphs: Graphs definitions, graph terminology, types of graphs, representing graphs, graph isomorphism, connectivity of graphs, Euler and Hamilton paths and circuits, planar graphs–Euler's formula and its applications, graph colouring and its applications

Books and References:

1. Discrete Mathematics and its Applications : Text Kenneth H. Rosen
2. Elements of discrete Mathematics:C.L Liu, McGraw Hill
3. Discrete and Combinatorial Mathematics:Ralph P. Grimaldi
4. Discrete Mathematics for Computer Scientists: Stein, Drysdale, Bogart
5. Graph theory:N. Deo, phi
6. Graph Theory:R. Diestel,Springer-Verlag

Paper *COMP 204*: Object Oriented Programming with JAVA Lab.

1. Programs using constructor and destructor.
2. Creation of classes and use of different types of functions.
3. Count the number of objects created for a class using static member function.
4. Write programs on interfaces.
5. Write programs on packages.
6. Write programs using function overloading.
7. Programs using inheritance.
8. Programs using IO streams.
9. Programs using files.
10. Write programs using exception handling mechanism.
11. Programs using AWT
12. Programs on swing.
13. Programs using JDBC

Paper *COMP 205*: Advanced Compiler Design

Introduction to Compiling: Compilers, Analysis of the source program, The phases of the compiler, Cousins of the compiler.

Lexical Analysis: The role of the lexical analyzer, Tokens, Patterns, Lexemes, Input buffering, Specifications of a token, Recognition of a tokens, Finite automata, From a regular expression to DFA, Design of a lexical analyzer generator (Lex).

Syntax Analysis : The role of a parser, Context free grammars, Writing a grammar, Top down Parsing, Non-recursive Predictive parsing (LL), Bottom up parsing, Handles, Viable prefixes, Operator precedence parsing, LR parsers (SLR, LALR)

Syntax directed translation: Syntax director definitions, Construction of syntax trees, Bottom-up evaluation of S attributed definitions, L attributed definitions, Bottom-up evaluation of inherited attributes.

Type checking: Type systems, Specification of a simple type checker, Equivalence of type expressions, Type
conversions

Code optimization: Introduction, Basic blocks & flow graphs, Transformation of basic blocks, Dag representation of basic b locks, The principle sources of optimization, Loops in flow graph, Peephol e optimization.

Code generations: Issues in the design of code generator, a simple code generator, Register allocation & assignment.

Books and References:

1. Aho, Sethi, Ullman: Compiler Principles, Techniques and Tools, Pearson Education.
2. Kain: Theory of Automata & Formal Language, McGraw Hill.

Paper *COMP 206*: Information Security

Overview of Security: Protection versus security; aspects of security–data integrity, data availability, privacy; security problems, user authentication, Orange Book.

Security Threats: Program threats, worms, viruses, Trojan horse, trap door, stack and buffer overflow; system threats- intruders; communication threats- tapping and piracy.

Cryptography: Substitution, transposition ciphers, symmetric-key algorithms-Data Encryption Standard, advanced encryption standards, public key encryption - RSA; Diffie-Hellman key exchange, ECC cryptography, Message Authentication- MAC, hash functions.

Digital signatures: Symmetric key signatures, public key signatures, message digests, public key infrastructures.

Security Mechanisms: Intrusion detection, auditing and logging, tripwire, system-call monitoring;

Books and References:

1. W. Stalling, Cryptography and Network Security Principles and Practices (4th ed.), Prentice-Hall of India, 2006.
2. C. Pfleeger and SL Pfleeger, Security in Computing (3rd ed.), Prentice-Hall of India, 2007.
3. D. Gollmann, Computer Security, John Wiley and Sons, NY, 2002.
4. J. Piwprzyk, T. Hardjono and J. Seberry, Fundamentals of Computer Security, Springer-Verlag Berlin, 2003.
5. J.M. Kizza, Computer Network Security, Springer, 2007.
6.M. Merkow and J. Breithaupt, Information Security: Principles and Practices, Pearson Education, 2006

Paper *COMP 301*: Pattern Recognition

Introduction to pattern recognition and learning: Supervised, Unsupervised, training and test sets, feature selection.

Mathematical Background: Revision of basic probability & statistics: joint probabilities, central limit theorem, Bayes' theorem, covariance, independence and correlation, Lagrange multipliers.
Feature Selection: Search algorithms, branch & bound, scatter matrices, criteria functions. Feature selection by global optimization: (meta)-heuristic methods: genetic algorithms, simulated annealing.

Feature Extraction: Linear feature extraction: PCA, LDA-Fisher mapping. Nonlinear feature extraction: overview, multidimensional scaling, dissimilarity-based classifiers & embedding

Supervised learning and classification:
Bayesian Classifiers: Bayes decision theory, Bayes classifier, Bayes error & risk, logistic classifier. Parzen classifier, k-NN classifier, proportional classifier.
Linear Regression: Bayesian regression. MMSE estimator, MAP estimator, ML estimator, Model evaluation, Quality of regression.
Nonlinear & Multidimensional Regression: Nonlinear regression, kernel smoothing, local regression, backfitting algorithm.
Multidimensional regression: confidence bounds, model regularization: ridge regression, Least-Absolute-Shrinkage-&-Selection-Operator.
Artificial Neural Networks: Perceptron, multi-layer Perceptron, Backpropagation training, decision functions. Autoregressive ANN, radial basis function. Use in regression & feature extraction.

Unsupervised learning and clustering
Clustering: Unsupervised learning, hierarchical clustering, k-means, fuzzy c-means, mean shift algorithm. Gaussian mixture model, expectation-maximization algorithm, self-organizing maps
Cluster Validation: Cluster validation, number of clusters, distortion measures, Davies-Bouldinindex, other assessment criteria. Novelty detection, ROC curve.

Books and References:
1. Richard Duda Peter Hart David Stork: Pattern Classification, 2nd ed., Wiley.
2. J. T. Tou and R. C. Gonzalez: Pattern Recognition Principles, Addison-Wesley, London.
3. Christopher Bishop: Pattern Recognition and Machine Learning, Springer.
4. Fukunaga: Introduction to Statistical Pattern Recognition, Second Edition, Academic Press.

Paper *COMP 302*: Pattern Recognition Lab.

Programming in one of the following languages:
a. Matlab
b. Octave
c. Python
d. R
Data visualization, central limit theorem, multivariate normal distribution
Implementation of Hierarchical clustering, k-means
Implementation of Gaussian mixture model, expectation-maximization, Davies-Bouldin index, self organizing map algorithms.
Implementation of Bayesian classifier, k-NN classifier
Implementation of Linear regression, MMSE, MAP, MLE, quality measures.
Implementation of Nonlinear regression
Image processing using MATLAB

Paper *COMP 305*: Artificial Intelligence

Introduction: Various definition of Artificial Intelligence. Introduction to AI applications and AI techniques, AI Problems. Importance of AI.

Intelligent Agents: Definitions of a rational agent, reflex, model-based, goal-based, and utility-based agents, the environment in which a particular agent operates.

Solving problems by Searching:
State Space search: State Space Graphs, Implicit and explicit graphs, Production Systems, formulating the State-space, Uninformed search: breadth first search, depth first search, iterative deepening; Uniform cost algorithm, Informed search: use of heuristics, Greedy, A* algorithm, IDA* algorithm, AO* algorithm, Best first search, hill climbing, simulated annealing, genetic algorithm. Adversarial Search: Two agent games, AND/OR graphs, Minimax procedure, and game trees, Alpha – Beta pruning procedure, learning evaluation functions. Game Playing. Constrained Satisfaction Search.

Knowledge Representation: Representation of facts in propositional logic and predicate logic, Resolution, Unification, Natural deduction system, Refutation, logic programming, PROLOG, Semantic networks, Frame system, Value inheritance, Conceptual dependency, Ontology.

Experts System: Introduction, its applications, various expert system shells with one frame work, knowledge acquisition, Case study.

Uncertainty: different types of uncertainty - degree of belief and degree of truth, various probability constructs - prior probability, conditional probability, probability axioms, probability distributions, and joint probability distributions, Bayes' rule, other approaches to modeling uncertainty such as Dempster-Shafer theory and fuzzy sets/logic.

Books and References:

1. Elaine Rich and Kelvin Knight: Artificial Intelligence, Tata McGraw Hill, 2002
2. Stuart Russell and Peter Norvig: Artificial Intelligence: A Modern Approach (2nd ed.), Pearson Education,2006.
3. Dan W. Patterson, Introduction to Artificial Intelligence and Expert Systems: Prentice Hall of India, 2006.
4. Nils J Nilson, Artificial Intelligence: A New Synthesis, Morgan Kaufmann Publishers, Inc., San Francisco, California, 2000.
5. R. Akerkar: Introduction to Artificial Intelligence, Prentice-Hall of India, 2005
6. Nils J. Nilson: Principles of Artificial Intelligence, Narosa Publishing House, 2001
7. W.F. Clocksin and C.S. Mellish: Programming in PROLOG, Narosa Publishing House, 2002.
8. SarojKaushik: Logic and Prolog Programming, New Age International Publisher, 2006

Paper *COMP 306*: Data Mining and Data Warehousing

Data Mining: Introduction, Relational Databases, Data Warehouses, Transactional databases, Advanced database Systems and Application, Data Mining Functionalities, Classification of Data Mining Systems, Major Issues in Data Mining, Architectures of Data Mining Systems.

Data Warehouse : Introduction, A Multidimensional data Model, Data Warehouse Architecture, Data Warehouse Implementation, Data Cube Technology, From Data warehousing to Data Mining.

Data Processing: Data Cleaning, Data Integration and Transformation, Data Reduction, Discretization and concept Hierarchy Generation.

Concept Description: Data Generalization & Summarization – Based Characterization, Analytical Characterization, Mining class Comparisons, Mining Descriptive Statistical Measures in Large Databases.

Mining Association Rules in Large Databases: Association Rule Mining, Single –Dimensional Boolean Association Rules, Multilevel Association Rules from Transaction Databases, Multi-Dimensional Association Rules from Relational Databases.

Classification and Prediction: Classification & Prediction, Issues Regarding Classification & Prediction, Classification by decision Tree Induction, Bayesian Classification, Classification by Back propagation, Prediction, Classification Accuracy.

Cluster Analysis: Types of Data in Cluster Analysis, Partitioning methods, Hierarchical methods, Density–Based Methods, Grid–Based Methods, Model–Based Clustering Methods, Outlier Analysis.

Web Mining: Web data: collection and interpretation, analyzing user browsing behavior learning from click-through data, predictive modeling and online advertising, link analysis and the Page Rank algorithm
Social Network Analysis: descriptive analysis of social networks, network embedding and latent space models, network data overtime: dynamics and event-based networks, link prediction

Books and References:

1. J. Hanand & M. Kamber: Data Mining: Concepts and Techniques, 2nd Ed. Morgan Kaufman. 2006.
2. M. H. Dunham: Data Mining: Introductory and Advanced Topics. Pearson Education. 2001.
3. I. H. Witten & E. Frank: Data Mining: Practical Machine Learning Tools and Technique, Morgan Kaufmann.2000.
4. D. H, H. Mannila & P. Smyth: Principles of Data Mining. Prentice-Hall.2001.
5. Data warehousing: OLAP & data mining, S. Nagabhushan, New age publications.
6. Introduction to data mining by Tan, Steinbach, Kumar, Pearson Education
7. Data mining: A tutorial based primer by Roiger, Geatz,, Pearson Educatio1.

Paper *COMP 405*: Computational Intelligence

Introduction to Computational Intelligence, Computational Intelligence vs Artificial Intelligence.

Rough Sets: Introduction, Set Approximation, Decision Tables.

Fuzzy Logic Systems: Notion of fuzziness, fuzzy modeling, operations on fuzzy sets, T-norms and other aggregation operators, basics of approximate reasoning, compositional rule of inference, fuzzy rule based systems, (Takagi-Sugeno and Mamdani-Assilianmodels), schemes of fuzzification, inferencing, defuzzificatin, fuzzy clustering, fuzzy rule based classifier.

Artificial Neural Networks: The neuron as a simple computing element the Perceptron, Multilayer Neural Networks, Supervised Learning Neural Networks, Unsupervised Learning Neural Networks, Radial Basis Function Networks, Reinforcement Learning

Evolutionary Computation: Genetic operators, building block hypothesis, evolution of structure, genetic algorithms based on tree and linear graphs, applications in science and engineering.

Books and References:

1. Leszek Rutkowski, Computational Intelligence: Methods andTechniques,Springer,2008.
2. Andries P.Engelbrecht, ComputationalIntelligence: An Introduction, John Wiley and Sons, 2007.
3. K. H. Lee, First Course on Fuzzy Theory and Applications, Springer, 2005
4. D. E. Goldberg, Genetic Algorithms in Search, Optimization, and Machine Learning, Addison-Wesley, Reading, 1989
5. E. Alpaydin, Introduction to Machine Learning, Prentice-Hall of India, 2004
6. Amit Konar, Computational Intelligence: Principles, Techniques and Applications, Springer, 2005.

Paper *COMP 406*: Image Processing

Introduction: Introduction of Image Processing with its applications, Fundamental steps in digital Image Processing, Components of Image processing system.

Digital Image Fundamentals:
Element of visual perception, a simple image formation model, Image digitization process, sampling and quantization, some basic relationships between pixel, Linear and Non linear operations.

Image Enhancement:
Image enhancement in Spatial domain: Basic gray level transformations, Histogram Processing, enhancement using arithmetic and logical operations, Spatial filtering. Image enhancement Frequency domain: Fourier Transform, Frequency domain filters.

Colour Image Processing:
Colour Models: RGB, CMY, HSI, Pseudo colour and Full colour Image processing , Colour transformation, Image fusion.
Image Restoration: Noise models, Noise reduction filtering, Degredations.

Morphological Image Processing: Dilation and erosion, opening and closing, hit-or-miss transformation, morphological algorithms.

Image Compression:Image compression model, Lossy Compression techniques and Lossless image compression techniques, Huffman coding, Run Length Encoding, Block Truncation compression, JPEG, MPEG, Wavelets, Image compression standards

Image Segmentation: Characteristics of segmentation, detection of discontinuities, edge linking and boundary detection thresholding, pixel and region based segmentation methods,use of motion in segmentation.

Object Recognition: Recognition and interpretation patterns and pattern classes, decision-theoretic methods, introduction to neural network.

Books and References:

1. Gonzalez, R. C. and Woods, R. E.: Digital Image Processing, 3rd ed., Prentice Hall
2. Sonka, M., Hlavac, V., Boyle, R.: Image Processing, Analysis and Machine Vision (2nd edition), PWS Publishing, or (3rd edition) Thompson Engineering, 2007
3. Gonzalez, R. C., Woods, R. E., and Eddins, S. L.: Digital Image Processing Using MATLAB, 2nd ed.,Gatesmark Publishing, Knoxville, TN.
4. Anil K. Jain: Fundamentals of digital image processing (2nd Edition), Prentice-Hall, NJ
5. Willian K. Pratt: Digital Image Processing (3rd Edition), John Wiley & Sons, NY
6. Burger, Willhelm and Burge, Mark J.: Digital Image Processing: An Algorithmic Introduction Using Java, Springer

Detailed Syllabus of (alternative) elective core

1. Machine Learning

Introduction: Basic Concepts

Supervised learning: Supervised learning setup. LMS; Logistic regression. Perceptron. Exponential family; Generative learning algorithms. Gaussian discriminant analysis. Naive Bayes; Support vector machines; Models election and feature selection; Ensemble methods: Bagging, boosting; evaluating and debugging learning algorithms.

Learning theory: Bias/variance trade off. Union and Chernoff /Hoeffding bounds; VC dimension. Worst case (online) learning; Practical advice on how to use learning algorithms.

Unsupervised learning: Clustering. K-means; EM. Mixture of Gaussians; Factor analysis; PCA (Principal components analysis); ICA (Independent components analysis).

Reinforcement learning and control: MDPs. Bellman equations; Value iteration and policy iteration; Linear quadratic regulation (LQR). LQG; Q-learning. Value function approximation; Policy search. Reinforce. POMDPs.

Books and References:

1. Tom Mitchell: Machine Learning, McGraw-Hill
2. E. Alpaydin, Introduction toMachine Learning, Prentice Hall of India, 2006.
3. C. M. Bishop, Pattern Recognition and Machine Learning, Springer, 2006.
4. R. O. Duda, P. E. Hart, and D. G. Stork, Pattern Classification, John Wiley and Sons, 2001.
5. Vladimir N. Vapnik, Statistical Learning Theory, John Wiley and Sons, 1998.
6. Shawe-Taylor J. and Cristianini N.,Cambridge, Introduction to Support Vector Machines, University Press, 2000.

2. Advanced Operating System

Review of operating system, classification of operating system Introduction to Parallel and Distributed Systems. State recovery and clock models for distributed systems. Classification of control, algorithms for distributed and parallel systems, process and mode synchronization, Process Migration, Termination detection, Remote Procedure Call.
Introduction to UNIX/Linux Kernel: System Structure, User Perspective, Assumptions about Hardware, Architecture of UNIX Operating Systems, Concepts of Linux Programming- Files and the File system, Processes, Users and Groups, Permissions, Signals, Inter process Communication Case study on various operating systems.

Books and References:

1. Distributed Operating Systems: Tanenbum, A.S. ,Pearson Education
2. Linux System Programming: Robert Love, O'Reilly.
3. Advanced Concepts in Operating System Singhal, Shivaratri, TMH
4. Distributed Systems Concepts And Design: G. Coulouris, J. Dollimore, T. Kindberg, G. Blair,

5. Operating Systems & Systems Programming: Balakrishna Prasad, Scitec

3. Parallel Computing

Overview, need for parallel computing, basic concepts and terminology- Flynn's classical taxonomy, general parallel terminologies, issues in high performance computing Architecture and interconnection of parallel computers: Memory architectures -shared memory, distributed memory, hybrid distributed-shared memory. Interconnection networks, Parallel Programming Models: Overview, shared memory model, threads model, message passing model, data parallel model, advanced Models Designing Paralle lAlgorithms: Automatics. Manual parallelization. Partitioning, communications, synchronization, data dependencies, load balancing, granularity, limits and costs of parallel programming, performance analysis and tuning, Processes and processors, Shared memory, Fork, Join constructs, Basic parallel programming techniques-loop splitting, spin locks, contention barriers and row conditions.

Variations in splitting, self and indirect scheduling. Data dependency-forward and backward, block scheduling. Parallel computing examples: array processing, PI calculation, simpleheat equation, matrix vector multiplication, matrix-matrix multiplication, combinational search

Books and References:

1. Vipin Kumar,Ananth Gramar, Anshul Gupta, George Kayrips: An Introduction to Parallel Computing :Design and Analysis of Algorithms
2. Brawer, S: Introduction to parallel programming". Academic Press, NewYork, 1989.
3. Hawang Kaiand Briggs F.A.: Computer Architecture and Parallel Processing, McGrawHill
4. Jorden H. F. and Alaghaband G.: Fundamentals of Parallel Processing.
5. M.J.Quinn: Parallel Programming, TMH

4. Cryptography

Introduction: History and overview of cryptography

Identification protocols: Password protocols, salts, PBKDF2; one time passwords (S/Key and Secure ID); Challenge response authentication.

Basic symmetric-key encryption:

One time pad and stream ciphers: perfect secrecy and the one time pad, semantic security and stream ciphers.

Block ciphers: Case studies: Feistel networks, DES, 3DES, and AES; basic modes of operation: CBC and counter mode.

Block cipher abstractions: Pseudo Random Permutations (PRP); Pseudo Random Functions (PRF); security against chosen plain text attacks (CPA); nonce-based CBC encryption and nonce-based counter mode.

Attacks on block ciphers: exhaustive search, time-space trade offs, differential & linear crypt analysis, meet in the middle, side channels.

Message integrity: CBC-MAC and PMAC.

Collision resistant hashing: Merkle-Damgard and Davies-Meyer. MACs from collision resistance. Case studies: SHA and HMAC.

Authenticated encryption: intro to session set up using a key distribution center (KDC).

Public Key cryptography:

Arithmetic modulo primes.
Cryptography using arithmetic modulo primes: vanilla key exchange (Diffie-Hellman); the CDH and discrete-log assumptions

Public key encryption: semantically secure ElGamal encryption; CCA security

Arithmetic modulo composites: RSA and Rabin functions, how to encrypt with trapdoor permutations.

Digital signatures:
Digital signatures: How to sign using RSA.

More signature schemes: Lamport and Merkle schemes, overview of signatures based on discrete-log, certificates and trust management.

Final topics: Real world crypto: SSL/TLS and IPsec, The EMV payment protocol

Books and References:
1. J. Katz and Y. Lindell: Introduction to Modern Cryptography, Chapman & Hall/CRC Press
2. A. Menezes, P. Van Oorschot, S. Vanstone: Handbook of Applied Cryptography
3. J. Pieprzyk, T. Hardjono and J. Seberry: Fundamentals of Computer Security, Springer
4. D. Stinson: Cryptography: Theory and Practice, CRC Press
5. B. Schneier: Applied Cryptography: Protocols, Algorithms, and Source Code in C, Wiley

5. Wireless Communication & Mobile Computing

Wireless Communication - Wired and wireless, Mobility of users and equipment
Overview of Electro magnetic Spectrum, Radio and Microwave communication, Infrared and Mille meter waves, Light wave Transmission.
Overview of Satellite Networks. Concepts of Spread Spectrum, CDMA System.
Medium Access Control (MAC): MAC protocols for digital cellular systems such as GSM. MAC protocols for wireless LANs such as IEEE802.11 and HIPERLAN I and II. The near far effect. Hidden and exposed terminals. Collision Avoidance (RTS-CTS) protocols.

Mobile Computing – Characteristics, Infrastructure vs Infrastructure less Networks, Routing Protocols in Mobile Ad-hoc Network (MANET), Overview of Bluetooth Technology. Overview of Sensor Networks. Concepts of Mobile IP, Overview of Vehicular Ad-hoc Networks(VANETs)
Wireless Application Protocols and others. Overall security requirements and considerations in wireless and mobile computing systems. Concepts of fault tolerance.

Books and References:
1. T. S. Rappaport, B. D. Woerner and J.H. Reed: Wireless Personal Communications: The Evolution of PCS, Dkyener Academic
2. G.I. Stuber: Principles of Mobile Communication, Kluener Academic
3. U.Black: Mobile and Wireless Networks, Prentice Hall PTR
4. Charles Parkins – Mobile Adhoc Networks
5. W. Stallings: Wireless- Communication
6. J. Schiller: – Mobile Communication
7. C. Siva Ram Murthy and B. S. Manoj: Ad Hoc Wireless Networks: Architectures and Protocols

6. Advanced Theory of Computing

Grammars: Production systems , Chomskian Hierarchy , Right linear grammar and Finite state automata , Context free grammars , Normal forms , uvwxy theorem , Parikh mapping , Self embedding property , Subfamilies of CFL - Derivation trees and ambiguity.

Finite state Automata: Non deterministic and deterministic FSA, NFSA with ε- moves, Regular Expressions, Equivalence of regular expression and FSA . Pumping lemma , closure properties and decidability. Myhill - Nerode theorem and minimization ,Finite automata with output.

Pushdown automata: Acceptance by empty store and final state , Equivalence between pushdown automata and context-free grammars , Closure properties of CFL , Deterministic pushdown automata.

Turing Machines: Techniques for Turing machine construction - Generalized and restricted versions equivalent to the basic model, Godel numbering, Universal Turing Machine - Recursively enumerable sets and recursive sets - Computable functions - time space complexity measures - context sensitive languages and linear bound automata.

Decidability: Post's correspondence problem; Rice's theorem; decidability of membership, emptiness and equivalence problems of languages.

Time and tape complexity measures of Turing machines; Random access machines; the classes P and NP; NP-Completeness; satisfiability and Cook's theorem; Polynomial reduction and some NP-complete problems.

Advanced topics; Regulated rewriting L systems; Grammar systems.

New paradigms of computing; DNA computing; Membrane computing.

Books and References:

1. Introduction to Computer Theory Author: Daniel I. A. Cohen Publisher: Prentice-Hall, Second Edition, 1997.
2. K. Krithivasan and R. Rama; Introduction to Formal Languages, Automata Theory and Computation; Pearson Education, 2009.
3. J. E. Hopcroft, R. Motwani and J. D. Ullman , "Introduction to Automata Theory Languages and computation", Pearson Education Asia , 2001.
4. Peter Linz, "An Introduction to Formal Language and Automata", 4th Edition, Narosa Publishing house , 2006.
5. M. Sipser; Introduction to the Theory of Computation; Singapore: Brooks/Cole, Thomson Learning, 1997.
6. John. C. martin, "Introduction to the Languages and the Theory of Computation", Third edition, Tata McGrawHill, 2003.

7. Modelling and simulation

Systems and environment: Concept of model and model building, model classification and representation, Use of simulation as a tool, steps in simulation study.

Continuous-time and Discrete-time systems: Laplace transform, transfer functions, state space models, order of systems, z-transform, feed back systems, stability, observability, and controlability.

Statistical Models in Simulation: Common discrete and continuous distributions, Poisson process, and empirical distributions.

Random Numbers: Properties of random numbers, generation of pseudo random numbers, techniques of random number generation, tests for randomness, random variate generation using inverse transformation, direct transformation, convolution method, acceptance-rejection.

Design and Analysis of simulation experiments: Data collection, identifying distributions with data, parameter estimation, goodness of fit tests, selecting input models with out data, multivariate and time series input models, verification and validation of models, static and dynamic simulation out put analysis, steady-state simulation, terminating simulation, confidence interval estimation, Output analysis for steady state simulation, variance reduction techniques.

Queuing Models: Characteristics of queuing systems, notation, transient and steady-state behavior, performance, network of queues.

Large Scale systems: Modelreduction, hierarchicalcontrol, decentralizedcontrol, structural properties of large scale systems.

Books and References:

1. Jerry Banks, John Carson, Barry Nelson, David Nicol: Discrete Event System Simulation
2. Averill Law, W. David Kelton: Simulation Modeling and Analysis, McGRAWHILL
3. Geffery Gordon: System Simulation, PHI
4. Bernard Zeigler, Herbert Praehofer, Tag Gon Kim: Theory of Modeling and Simulation, Academic Press
5. Narsing Deo: System Simulation with Digital Computer, PHI
6. Donald W. Body: System Analysis and Modeling, Academic Press Harcourt India
7. W David Kelton, Randall Sadowski, Deborah Sadowski: Simulation with Arena, McGRAW-HILL.

8. Natural Language Processing

Regular Expressions and Automata: Introduction to NLP, Regular Expression, Finite State Automata

Tokenization: Word Tokenization, Normalization, Sentence Segmentation, Named Entity Recognition, Multi Word Extraction, Spell Checking –Bayesian Approach, Minimum Edit Distance

Morphology: Morphology – Inflectional and Derivational Morphology, Finite State Morphological Parsing, The Lexicon and Morphotactics, Morphological Parsing with Finite State Transducers, Orthographic Rules and Finite State Transducers, Porter Stemmer

Language Modeling: Introduction to N-grams, ChainRule, Smoothing–Add-One Smoothing, Witten-Bell Discounting; Backoff, Deleted Interpolation, N-grams for Spelling and Word Prediction, Evaluation of language models.

Hidden Markov Models and POS Tagging: Markov Chain, Hidden Markov Models, Forward Algorithm, Viterbi Algorithm, Part of Speech Tagging – Rule based and Machine Learning based approaches, Evaluation

Text Classification: Text Classification, Naïve Bayes' Text Classification, Evaluation, Sentiment Analysis– Opinion Mining and Emotion Analysis ,Resources and Techniques

Context Free Grammar: Context Free Grammar and Constituency, Some common CFG phenomena for English, Top-Down and Bottom-up parsing, Probabilistic Context Free Grammar, Dependency Parsing

Computational Lexical Semantics: Introduction to Lexical Semantics–Homonymy, Polysemy, Synonymy, Thesaurus –Word Net, Computational Lexical Semantics – Thesaurus based and Distributional Word Similarity

Information Retrieval: Boolean Retrieval, Term-document incidence, The Inverted Index, Query Optimization, Phrase Queries, Ranked Retrieval–Term Frequency–Inverse Document Frequency based ranking, Zone Indexing, Query term proximity, Cosine ranking, Combining different features for ranking, Search Engine Evaluation, Relevance Feedback

Books and References:

1. Jurafsky and Martin, Speech and Language Processing, Pearson Education
2. Manning and Schutze, Foundation of Statistical Natural Language Processing, MIT Press Steven Bird, Ewan Klein and Edward Loper, Natural Language Processing with Python, O'Reilly Media

9. Big Data Analytics

Introduction to Big Data Analytics: Big Data Overview, State of the Practice in Analytics, Big Data Analytics in Industry Verticals, Data Analytics Lifecycle

Review of the Basic Data Analytic Methods using R: Introduction to R–look at the data, Analyzing and Exploring the Data, Statistics for Model Building and Evaluation

Analytics: K-means clustering, Association rules, Linear Regression, Logistic Regression, Naïve Bayes, Decision Trees, Time Series Analysis, Text Analysis

Advanced Analytics: Analytics for Unstructured Data (MapReduce and Hadoop),The Hadoop Ecosystem, In-database Analytics–SQL Essentials, Advanced SQL and MAD lib for in-database Analytics

Putting All Together: Operationalizing an Analytics Project, Creating the Final Deliverables, Data Visualization Techniques

Books and References:

1. Viktor Mayer-Schönberger, Kenneth Cukier: BigData, Hodder & Stoughton
2. O'Reilly Media Inc: Big Data Now, Shroff And O'Reilly
3. Bill Schmarzo:BigData:Understanding How Data Powers Big Business (English)1st Edition,Wiley
4. Vignesh Prajapati: Big Data Analytics with R and Hadoop (English)1stEdition, Shroff/ Pack

10. Human Computer Interaction

Introduction: Introduction to Human Computer Interaction, The power of Prototyping, Evaluating Designs, The Birth of HCI

Need finding: Participant Observation, Interviewing, Additional Need finding strategies, Creating Design Goals

Rapid Prototyping: Story boards, Paper Prototypes, and Mockups, Faking it—Wizard of Oz, Faking it Video
Prototyping**,** Creating and Comparing Alternatives

Heuristic Evaluation: Heuristic Evaluation— Why and How? Design Heuristics.

Direct Manipulation and Representations: Direct Manipulation, Mental Models, Representations Matters,Distributing Cognition

Visual Design and Information Design: Visual Design, Typography, Grids and Alignment, Reading and Navigating

Designing experiments: Designing Studies That You Can Learn From, Assigning Participants to Conditions, In-Person Experiments, Running Web Experiments, Comparing Rates

Books and References:

1. Alan Dix: Human-Computer Interaction, Pearson Education
2. Yvonne Rogers, Helen Sharp, Jenny Preece: Interaction Design: Beyond Human-Computer Interaction, Wiley India Pvt Ltd
3. Donald A. Norman: The Design of Everyday Things, PERSEUS BOOKS GROUP

11. Bioinformatics

Introduction to molecular biology, The Central Dogma of Molecular Biology, Physical mapping

Protein sequence data bank. NBFR-PIR, SWISSPROT, GenBank, EMBL nucleotide sequence data bank, Protein Data Bank (PDB) etc.

Motif finding in DNA and proteins

Sequence alignment for DNA and protein sequences, Concepts: homology, sequence similarity and sequence alignment; dynamic programming algorithms, Pairwise alignment, Global and local alignment using dynamic programming, Heuristic alignment methods: BLAST/FASTA and the statistics of local alignments, Multiple sequence alignment: Definition, scoring, techniques, Aligners for proteins sequences, Spliced alignment.

Gene ontology, Annotation and Metadata

Secondary and Tertiary Structure predictions; Chao-Fasman algorithms; The basic HMM algorithms: forward, backward, Viterbi, Baum-Welch; Neural Networking

Phylogenetic analysis, Neighbor joining, parsimony, and maximum likelihood methods, Gene expression analysis and clustering methods .

Comparative genomics: gene regulation, gene finding, genome rearrangements

Protein folding, protein-protein interactions, Molecular Modeling & Dynamics, Drug Designing.

Books and References:

1. M. Lesk, "Introduction to Bio Informatics," Oxford University Press
2. Hooman Rashidi, Lukas K. Buehler, "Bioinformatics Basics: Applications in Biological Science and Medicine," CRC Press/Taylor & Francis Group, 2nd edition, May 2005
3. Jeffrey Augen, "Bioinformatics in the Post-Genomic Era: Genome, Transcriptome, Proteome, and Information-Based Medicine," Addison-Wesley
4. Stephen A. Krawetz, David D. Womble, "Introduction to Bioinformatics: A Theoretical and Practical Approach," Humana Press
5. Bryan Bergeron, "Bioinformatics Computing," Prentice Hall PTR
6. Malcolm Campbell, Laurie J. Heyer, "Discovering Genomics, Proteomics, and Bioinformatics," Benjamin/Cummings
7. Teresa K. Attwood, David Parry-Smith, "Introduction to Bioinformatics," Pearson Education
8. Gusfield, Dan, "Algorithms on Strings, Trees and Sequences: Computer Science and Computational Biology," Cambridge, UK: Cambridge University Press, 1997.
9. Waterman, Michael, "Introduction to Computational Biology: Maps, Sequences, and Genomes," Boca Raton, FL: CRC Press, 1995.
10. Durbin, Richard, Graeme Mitchison, S. Eddy, A. Krogh, and G. Mitchison, "Biological Sequence Analysis: Probabilistic Models of Proteins and Nucleic Acids," Cambridge, UK: Cambridge University Press, 1997.

12. Computational Geometry

Geometric Objects – Points, Lines, Planes, Polygons, 3D Objects – Geometric Algorithms – Degeneracies and Robustness – Application Domains 3L Convex Hull in 2D – Incremental Algorithm

Line Segment Intersection Algorithms – Doubly Connected Edge List – Map Overlays – Boolean operations

Polygon Triangulation – Partitioning Polygons into Monotone Pieces – Triangulation of Monotone Polygons – Art Gallery Problem

Half Plane Intersections – Use of Linear Programming Techniques – Manufacturing with Moulds

Orthogonal Range Searching – Kd Trees – Range Trees – Higher Dimensional Range Trees – Database Searching – Point Location

Voronoi Diagrams – VD of Line Segments – Farthest Point VDs – Post Office Problem 6L Convex Hulls in 3-space

Robot Motion Planning – Work Space and Configuration Space – Translational Motion Planning

Books and References:

1. Computational Geometry – Algorithms and Applications by Berg, Cheong, Kreveld and Overmars 3e, Springer
2. Computational Geometry – An Introduction by Preparata and Shamos, Springer
3. Computational Geometry in C – Joseph O'Rourke, 2e, Cambridge Univ Press.

13. Distributed Computing

Introduction to distributed environment: Goals, hardware & software concepts, P2P, Cluster, Grid, Cloud, the client-server model, Strengths and weakness of distributed computing, forms of computing

Communication: Layered protocols, RPC, remote object invocation, message-oriented communication

Distributed computing paradigms: Message passing, client server, P2P, remote procedure call model, distributed objects, object space, collaborative application (groupware)

Socket: Socket metaphor, datagram socket API, stream mode socket API, sockets with non blocking I/O, secure socket API

Java RMI: Client side, Server Side, object registry, Remote Interface, Server side software, client side software, RMI vs Socket

Advanced RMI: Client callback, stub downloading, RMI security manager

Group Communication: Unicasting, multicasting, connection oriented & connectionless, reliable and unreliable multicast, Java basic multicast API

Internet Applications: HTML, XML, HTTP, Applets, Servlets, Web services, SOAP

Mobile Agents: Basic architecture, advantages, mobile agent framework systems, design, implementation using Java RMI

Distributed coordination-based systems JINI: Runtime environment, architecture, discovery protocol, join protocol, lookup service, distributed event, distributed leasing, transactions, surrogate architecture

New paradigms of distributed computing environment

Books and References:

1. Distributed Computing: Principles and Applications, M. L. Liu, Pearson/AddisonWesley.
2. A Programmer's Guide to Jini Technology, Jan Newmarch, Apress
3. A. Taunenbaum, Distributed Systems: Principles and Paradigms, PHI
4. G. Coulouris, J. Dollimore, and T. Kindberg, Distributed Systems: Concepts and Design, Pearson Education 5. Core Jini, W. Kieth Edwards, Apress.

14. Biometric Systems

Introduction to Biometric Systems: History, Definition, Characteristics, Systems model, Identification, Verification/Authentication, Applications.

Image processing and Pattern recognition Fundamentals: Introduction to biometric samples, Representation, Biometrics as pattern recognition systems, Preprocessing, Segmentation, Noise removal techniques, etc.

Biometric Traits: Fundamentals of acquisition sensors and techniques, Characteristics of Biometric traits: Face, Gait, Iris, Fingerprint, Signature, etc.

Biometric Systems Performance Terminology: Performance assessment terminology – Estimation of errors, FAR, FRR, ROC, Ranking; Testing methods used in biometrics, Graphical analysis of system performance.

Biometric Feature Extraction: Subspace-based approaches: Principal Component Analysis (PCA), Fisher's Linear Discriminant Analysis (FLDA), Independent Component Analysis (ICA), Variants of PCA, FLDA and ICA, Kernel version of subspace-based approaches; Geometric-feature-based approaches; Hybrid approaches. Invariant features, etc.

Biometric Classification & Recognition: Design of classifiers: Neural networks-based classifiers, Probabilistic classifiers, Neuro-Fuzzy classifiers; Template matching, etc.

Multi-biometric Systems: Introduction to multi-biometric systems, Types of multibiometric systems, levels of fusion in multi-biometric systems: Image fusion, Feature level fusion, Dimension reduction, Decision level fusion, Demster Shafer (DS) Theory, Multi-level fusion.

Video-based Person Identification: Acquisition, Generic systems model, Face detection and recognition from video, Tracking.

3D face recognition systems: 3D face model – Reconstruction, feature extraction and recognition; Expression and Action recognition; Multi-view 3D reconstruction.

Biometric Standards & Privacy: Introduction to biometric standards, importance of biometric standards, privacy, Biometric attacks, interoperability of data, systems and applications.

Books and References:

1. Introduction to Biometrics, A. K. Jain and A. Ross, Springer
2. Biometrics: Theory, Methods & Applications, N. V. Boulgouris, K. N. Plataniotis, E. Micheli-Tzanakou, IEEE Press, 2009.
3. A. Ross, K. Nandakumar and A. K. Jain, "Handbook of Multibiometrics", Springer Publishers. 4. Guide to Biometrics, Ruud Bolle, J. Connell, S Pankanti, N Ratha, A Senior, Springer.
4. Biometric Technologies and Verification Systems, J R Vacca, Elsevier.
5. Biometric Systems: Technology, Design & Performance Evaluation, J. Wayman, A. K. Jain, D. Maltoni, D. Maio, Springer Verlag, 2004.
6. Handbook of Biometrics, Springer Verlag, 2008, A. K. Jain, P. Flynn and A. A. Ross.

15. Cloud Computing

Cloud computing fundamentals: Cloud Computing definition, private, public and hybrid cloud. Cloud types; IaaS, PaaS, SaaS. Benefits and challenges of cloud computing, public vs private clouds, role of virtualization in enabling the cloud; Business Agility: Benefits and challenges to Cloud architecture. Application availability, performance, security and disaster recovery; next generation Cloud Applications.

Cloud applications: Technologies and the processes required when deploying web services; Deploying a web service from inside and outside a cloud architecture, advantages and disadvantages

Management of cloud services: Reliability, availability and security of services deployed from the cloud. Performance and scalability of services, tools and technologies used to manage cloud services deployment; Cloud Economics: Cloud Computing infrastructures available for implementing cloud based services. Economics of choosing a Cloud platform for an organization, based on application requirements, economic constraints and business needs (e.g Amazon, Microsoft and Google, Salesforce.com, Ubuntu and Redhat)

Application development: Service creation environments to develop cloud based applications. Development environments for service development; Amazon, Azure, Google App.

Cloud it model: Analysis of Case Studies when deciding to adopt cloud computing architecture. How to decide if the cloud is right for your requirements. Cloud based service, applications and development platform deployment so as to improve the total cost of ownership (TCO)

Books and References:

1. Gautam Shroff, "Enterprise Cloud Computing Technology Architecture Applications",Cambridge University Press; 1 edition,
2. Toby Velte, Anthony Velte, Robert Elsenpeter, "Cloud Computing, A Practical Approach"McGraw-Hill Osborne Media
3. Dimitris N. Chorafas, "Cloud Computing Strategies" CRC Press; 1 edition