PONDICHERRY UNIVERSITY
(A CENTRAL UNIVERSITY)

SCHOOL OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF COMPUTER SCIENCE

Master of Technology
(Computer Science and Engineering)

(Choice Based Credit System)
(Effective from the academic year 2020-2021)

CURRICULUM & SYLLABUS

PONDICHERRY UNIVERSITY
DEPARTMENT OF COMPUTER SCIENCE
REGULATIONS AND SYLLABUS

Master of Technology
(Computer Science and Engineering)

(For CBCS System in Pondicherry University)
(Effective from the academic year 2020-2021)

Eligibility for Admission

Candidates who have secured 55% of marks or above in the following disciplines are eligible for admission:

B.Tech./ B.E. in Computer Science and Engineering / Information Technology or equivalent

OR

M.Sc.in Computer Science / Information Technology / Software Engineering or equivalent

OR

MCA with Bachelor's in Computer Science / Computer Applications / Information Technology / Mathematics / Statistics/ Physics / Electronics / Applied Sciences

Duration of the Course

The course shall be of two years' duration spread over four consecutive semesters. The maximum duration to acquire prescribed number of credits in order to complete the Programme of Study shall be four years.

Medium

The medium of instruction shall be English.

Passing & Classification

Passing & Classification for the award of the M. Tech (Computer Science & Engineering) Degree shall be as per the norms of CBCS System of Pondicherry University.

Program outcomes of Master of Technology (Computer Science and Engineering)

1. Acquire in-depth knowledge in advanced fields of Computer Science.
2. Apply knowledge, concepts, methods, algorithms and techniques in implementing solutions to the problems that are related to Computer Science and Engineering domain.
3. Extract information pertinent to unfamiliar problems through literature survey and experiments, apply appropriate research methodologies, techniques and tools, design, conduct experiments, analyze and interpret data, demonstrate higher order skill and view things in a broader perspective, contribute individually to the development of scientific/technological knowledge in domains of Computer Science.
4. Usage of modern tools and create, select, learn and apply appropriate techniques, resources, and modern engineering and IT tools, including prediction and modeling, to complex engineering activities with an understanding of the limitations.
5. Communicate with the engineering community, and with society at large, regarding complex engineering activities confidently and effectively, such as, being able to comprehend and write effective reports and design documentation by adhering to appropriate standards, make effective presentations, and give and receive clear instructions.
6. Function effectively as an individual and as a team member to design and develop applications, conduct research and find solutions to the burning problems.
7. Maintain a lifelong interest and aptitude for learning.
8. Acquire professional and intellectual integrity, professional code of conduct, ethics of research, consideration of the impact of research outcomes on professional practices and an understanding of responsibility to contribute to the community for sustainable development of society.

COURSE STRUCTURE

Notation	Course Category	Number of courses	Total Credits
H	Hard Core	13	45
H	Hard core- Lab	4	8
RS	Restricted Soft core (From departments like Computer Science / Electronics / Banking Technology / Mathematics / Statistics)	2	6
SS	Specialisation Soft core	3	9
OS	Open Soft Core (From any Department)	1	3
H	Out Reach Programmes: (Conferences/Symposiums/Technical Meets/Workshops/Etc.,)	1	1
			72

CURRICULUM

FIRST SEMESTER

S.No	Course Code	Course Title	H/S	L	T	P	S	Credits
1.	CSCE 611	Mathematics for Computer Science and Engineering	H	3	0	0	0	3
2.	CSCE 612	Applied Probability and Statistics for Engineers	H	3	0	0	0	3
3.	CSCE 613	Network Configuration and Management	H	3	0	0	0	3
4.	CSCE 614	Advanced Data Structures and Algorithms	H	3	0	0	0	3
5.	CSCE 615	Internet and Web Technologies	H	3	0	0	0	3
6.		Elective - 1	S*	3	0	0	0	3
7.	CSCE 616	Network Management Lab	H	0	0	2	0	2
8.	CSCE 617	Web Technology Lab	H	0	0	2	0	2

SECOND SEMESTER

S.No.	Course Code	Course Title	H/S	L	T	P	S	Credits
1.	CSCE 621	Graph Theory with Applications to Engineering	H	3	0	0	0	3
2.	CSCE 623	Data Mining and Big Data	H	3	0	0	0	3
3.	CSCE 624	Mobile & Pervasive Computing	H	3	0	0	0	3
4.	CSCE 625	Advanced Operating System	H	3	0	0	0	3
5.		Elective-2	S*	3	0	0	0	3
6.		Elective-3	S**	3	0	0	0	3
7.	CSCE 627	Data mining Lab	H	0	0	2	0	2
8.	CSCE 628	Pervasive computing Lab	H	0	0	2	0	2

THIRD SEMESTER

S.No.	Course Code	Course Title	H/S	L	T	P	S	Credits
1.	CSCE 711	Directed Study	H	-	-	-	-	3
2.	CSCE 712	Project Work Phase 1[#]	H	-	-	-	-	3
3		Elective-4	S***	3	0	0	0	3
4.		Elective-5	S**	3	0	0	0	3
5.	CSCE 713	Out Reach Programmes: (Conferences / Symposiums /Technical meets/Workshops/Etc.,)	H	-	-	-	-	1

CSCE 711 -> The Directed Study Area should be chosen from the Courses not offered in the concerned stream

FOURTH SEMESTER

S.No.	Course Code	Course Title	H/S	L	T	P	S	Credits
1.		Elective-6	S**	3	0	0	0	3
2.	CSCE 721	Project work Phase 2[@]	H	-	-	-	-	6
3.	CSCE 722	Project report and Viva voce	H	-	-	-	-	6

***** => RS ; ** => SS ; *** => OS

 # MTech(CSE) Degree by Project Work or Course Work.

- Students are given the option of pursuing the third semester by project work or course work.
- Students choosing the project work option have to follow the prescribed curriculum structure.

  @ In case of failure due to lack of attendance / minimum internal marks/ failure in external examination in CSCE 712, the course has to be repeated in the subsequent semester and only after their successful completion, CSCE 721 and CSCE 722 could be credited.
- Students choosing the course work option instead of project (CSCE 712, CSCE 721 & CSCE 722.) need to compensate the credits by undergoing the following hard core courses from MTech NIS Programme spread across third and fourth semesters.

S.No.	Course Code	Course Title	H/S	L	T	P	S	Credits
1.	CSNS 612	Principles of Modern Cryptography	H	3	0	0	0	3
2.	CSNS 616	Cryptography Lab	H	2	0	0	0	2
3.	CSNS 621	Resource Management Techniques	H	3	0	0	0	3
4	CSNS 624	Network Protocols	H	3	0	0	0	3
5	CSNS 627	Network Protocol Lab	H	2	0	0	0	2
6	CSCE 714	Mini Project on Directed Study	H	2	0	0	0	2

LIST OF ELECTIVES

Sl.No.	Code	Course Title
Research Stream-1 Data Science		
1	CSCE 811	Big Data Technologies
2	CSCE 812	Statistics for Data Analytics
3	CSCE 813	Multivariate Techniques for Data
4	CSCE 814	Data Mining and Data Analysis
5	CSCE 815	Machine Learning
6	CSCE 816	Deep Learning
Research Stream-2 Software Engineering		
7	CSCE 821	Software Testing
8	CSCE 822	Agile Software Process
9	CSCE 823	Software Risk Management and Maintenance
10	CSCE 824	Software Project Management
11	CSCE 825	Software Architecture
12	CSCE 826	Software Quality Assurance
Research Stream-3 Artificial Intelligence		
13	CSCE 831	Cognitive Science
14	CSCE 832	Knowledge Representation and Reasoning
15	CSCE 833	Computational Intelligence
16	CSCE 834	Artificial Intelligence for Automation
17	CSCE 835	Natural Language Processing
18	CSCE 836	Introduction to Robotics
Research Stream-4 Human Computer Interface		
19	CSCE 841	Introduction to Human Computer Interaction
20	CSCE 842	Principles of Interaction Design
21	CSCE 843	Web Accessibility
22	CSCE 844	Context Aware Computing
23	CSCE 845	Data Visualization
24	CSCE 846	Social Computing Systems
Research Stream-5 Theoretical Computer Science		
25	CSCE 851	Automata Computability and Complexity
26	CSCE 852	Mathematical Logic for Computer Science
27	CSCE 853	Complexity Theory
28	CSCE 854	Computability Theory
29	CSCE 855	Advanced Compiler Design
Research Stream-6 Evolutionary Computing		
30	CSCE 861	Design of Modern Heuristics
31	CSCE 862	Evolutionary Algorithms
32	CSCE 863	Linear Optimization
33	CSCE 864	Nature Inspired Algorithms
Research Stream-7 Image Processing		
34	CSCE 871	Advances in Computer Graphics
35	CSCE 872	Digital Image Processing
36	CSCE 873	Pattern Recognition
37	CSCE 874	Steganography and Digital Watermarking
38	CSCE 875	Biometric Security
39	CSCE 876	Content Based Information Retrieval

CSCE 611 MATHEMATICS FOR COMPUTER SCIENCE AND ENGINEERING

L	T	P	C
3	0	0	3

Pre-requisite:

- *Knowledge of functions and basic algebra*

Objectives:

- *To introduce the mathematical concepts fundamental to Computer Science.*
- *To illustrate the applications of mathematical concepts to Computer Science*
- *Learn permutations and combinations*
- *Understand Computer Science applications*

Course Outcome:

- *Capacity to explain mathematical induction and recursive definitions*
- *Analyse basic operations on matrices*
- *List problem solving skill and ability of counting and enumeration*
- *Design Computer Science applications*

Module-I: **9 hrs**

Basic Structures: Sets, Functions, Sequences, Sums, and Matrices: Sets – Set Operations – Functions – Sequences and summation – Matrices .

Module-II: **9 hrs**

Number theory: Divisibility and modular arithmetic – Integer representations and algorithms – Prime and GCD – Congruence and applications.

Module- III: **9 hrs**

Algebraic Structures: Groups – cyclic group - Homomorphism – Cosets and Lagrange's Theorem- Normal Subgroups –Rings and Fields (definition and examples)

Module-IV: **9 hrs**

Counting and Lattices: Basics – Pigeon hole principle – Permutations and combinations – **Lattices –** Partial order relation – Posets- Hasse diagram- Lattices- Boolean Algebra

Module-V: **9 hrs**

Relations and Induction: Relations and Their Properties - *n*-ary Relations and their Applications - Representing Relations – inclusion –exclusion- - Mathematical induction – strong induction and well ordering- applications

Text Book(s):

1. *Kenneth H.Rosen, Discrete Mathematics and its Applications, 2012, Seventh Edition, Jones & Bartlett Learning.*
2. *Trembley. J.P and Manohar .R." Discrete Mathematical Structures with Applications to Computer Science", Tata McGraw Hill Pub. Com. Ltd., New Delhi, Reprinted in 2007*

Reference Book(s):

1. *Norman L Biggs, Discrete Mathematics, Oxford Press, 2nd Edition, 2002*
2. *Kenneth Bogart and Robert L Drysdale, Discrete Mathematics for Computer Science, Addison-Wesley; 1 edition2010*
3. *Thomas Koshy, Discrete Mathematics with Applications, Academic Press Inc, 2004.*

Web resources:

1. *https://www.geeksforgeeks.org/engineering-mathematics-tutorials/*MOOC
2. *NPTEL Course on Discrete Mathematics : https://nptel.ac.in/courses/111107058/#*

E 612 APPLIED PROBABILITY AND STATISTICS FOR ENGINEERS

Pre-requisite:

- *Set Theory and Calculus*

L	T	P	C
3	0	0	3

Objectives:

- *To learn and understand random variables that describes randomness or an uncertainty in certain realistic situation.*
- *To understand the types of sampling distributions and transformations*
- *To understand the framing and testing of hypothesis*
- *To learn and understand probability*

Course Outcome:

- *Describe randomness or an uncertainty in certain realistic situation.*
- *Explain the types of sampling distributions and transformations*
- *Recognize frame and test of hypothesis*
- *Define the rules and theorems of probability*

Module-I: 9 hrs

Probability: Combinatorial methods- Classical, relative frequency and axiomatic definitions of probability, addition rule and conditional probability, multiplication rule, total probability, Bayes' Theorem and independence, problems.

Module-II: 9 hrs

Random Variables: Discrete, continuous random variables, probability mass function, probability density function and cumulative distribution functions - mathematical expectation, moments, moment generating function, Joint, marginal and conditional distributions, product moments, correlation and regression, independence of random variables, Chebyshev's inequality, problems.

Module-III: 9 hrs

Discrete and Continuous Distributions: Bernoulli, Binomial, Poisson, Geometric, Negative binomial, continuous Uniform, Normal, Exponential, Gamma, Pareto, Beta distributions-Reliability and hazard rate, reliability of series and parallel systems, problems. Function of a random variable, problems.

Module-IV: 9 hrs

Sampling Distributions: The Central Limit Theorem, distributions of the sample mean and the sample variance for a normal population, Chi-Square, t and F distributions, problems. **Estimation:** Concepts of Unbiasedness, consistency and sufficiency, Methods of estimation -maximum likelihood estimation, Interval estimation, confidence intervals for mean and variance - problems.

Module-V: **9 hrs**

Testing of Hypotheses: Null and alternative hypotheses, the critical regions, two types of error, level of significance, power of the test, tests for mean for one sample and two sample problems from normal populations, Tests for single mean, difference of means using t, paired t test- tests for proportions - Chi-square goodness of fit test and its applications, Test for independence of attributes, One way ANOVA, simple problems

Text Book :

1. *Irwin Miller and Marlyees Miller (2002): John E Freund's Mathematical Statistics, 9e,2017, PHI,*

Reference Book(s):

1. *Gupta, S.C. and Kapoor, V.K.(2000): Fundamentals of Mathematical Statistics, 10/e, Sultan Chand and Sons*
2. *S.M. Ross, Introduction to Probability and Statistics for Engineers and Scientists,2009, 4th edition, Elsevier.*

CSCE 613 NETWORK CONFIGURATION AND MANAGEMENT

L	T	P	C
3	0	0	3

Pre-requisite:

- *Knowledge in computer networks*

Objectives:

- *To implement and administer common operating systems environments.*
- *To gain experience in systems administration functions and issues as well as network services.*
- *To develop a conceptual understanding of each operating system function and network service*
- *To learn how to plan, implement, and administer each.*

Course Outcome:

- *Identify the common remote monitoring issues.*
- *List systems administration functions and network services.*
- *Perform operating system function and network service and plan, implement, and administer each.*
- *Implement network structure and services*

Module-I: 9 hrs

Introduction: Network Management goals, organization, and functions - Network Management System Platform, Current Status and future of Network Management - Network monitoring - Network control - SNMPv1 Network management organization and communication function models - structure of SNMP management information – standards - SNMPv2 system architecture- protocol - protocol specification - SNMPv3 architecture.

Module-II: 9hrs

Network Configuration: IPv4and IPv6 addressing, Network Interface Configuration, Diagnosing Network start-up issues, Linux and Windows Firewall configuration, Network troubleshooting commands, DNS principles and Operations, Basic Name Server and Client Configuration, Caching Only name server, Primary and Slave Name Server, DNS Zone Transfers, DNS Dynamic Updates, DNS Server Security.

Module-III: 9 hrs

Web, Proxy, Mail Server Configuration and Management: HTTP Server Configuration Basics, Virtual Hosting, HTTP Caching, Proxy Caching Server Configuration, Proxy Access Control List, Proxy-Authentication Mechanisms, Mail Domain Administration, Basic Mail Server Configuration (like Sendmail, qmail), SMTP, POP and IMAP principles, SMTP Relaying Principles, SPAM control and Filtering, Troubleshooting

Module-IV: 9 hrs

Remote Administration and Management: Remote Network monitoring-concepts - group management - RMON alarms and filters - packet capture group - practical issues - RMON2 protocol -practical issues - ATM network management- The ATM Network Reference Model, The Integrated Local Management Interface, The ATM Management Information Base - Telecommunication network management - TMN conceptual model - architecture - Network management applications.

Module-V: **9 hrs**

Techniques for Network Management : Techniques for Network Management – Policy based management– Artificial Intelligence Techniques – Expert systems, Machine Learning - Graph-Theoretic techniques – Causality Graph, Dependency Graph, Decision Trees – Probabilistic Approaches – Fuzzy logic, Bayesian Networks – Web-based Network Management - NMS with Web Interface and Web-Based Management, Web Interface to SNMP Management, Embedded Web-Based Management – Distributed Object Computing - Bio-inspired Approaches.

Text Book(s):

1. *Thomas A. Limoncelli, Christina J. Hogan , Strata R. Chalup. The Practice of System and Network Administration, Third Edition , 2016.*
2. *Mani Subramanian, Network management: Principles and Practice, Addison Wesley, 2000.*
3. *Jianguo Ding, Advances in Network Management, Taylor and Francis Group, LLC, 2010.*

Reference Book(s):

1. *Advanced Linux Networking, Roderick W. Smith, Addison-Wesley Professional (Pearson Education), 2002.*
2. *Linux Network Administrator's Guide, Tony Bautts, Terry Dawson, Gregor N. Purdy, O'Reilly, Third Edition, 2005*
3. *William Stallings, Cryptography and Network Security: Principles and Standards, Prentice Hall India, 4th Edition, 2005.*

CSCE 614 ADVANCED DATA STRUCTURES AND ALGORITHMS

L	T	P	C
3	0	0	3

Pre-requisite:

Basic Knowledge in

- *Algorithm design and analysis techniques*
- *Data Structures*
- *Mathematical techniques*

Objectives:

- *To understand randomized algorithms*
- *To learn Graph algorithms*
- *To study Parallel algorithms*
- *To Learn string matching applications*

Course outcome:

- *Explain Randomized algorithms in problem solving*
- *Implement Graph algorithms in constraint satisfaction problems*
- *Perform Dynamic programming based algorithms*
- *Define Multithreaded algorithms*

Module-I: **9 hrs**

Introduction: Advanced data structures: B-Trees, Fibonacci heaps, data structures for disjoint sets, hash tables Role of Algorithms in Computing - Analyzing Algorithms – Designing Algorithms Growth Functions: Asymptotic Function - Standard Notations and common Functions.

Module II: **9 hrs**

Divide and Conquer: Maximum-subarray problem - Strassen's algorithm for matrix multiplication - Substitution method for solving recurrence - Recursion-tree method for solving recurrences - Master method for solving recurrences. **Randomized Algorithms:** Hiring Problem - Indicator Random Variables.

Module III: **9 hrs**

Advanced Design and Analysis Techniques: Dynamic Programming: Rod Cutting - Matrix-Chain Multiplication - Elements of Dynamic Programming - Longest Common Subsequence - Optimal Binary Search Trees. Greedy Algorithms: Elements of Greedy Strategy - Huffman Codes - Matroids and Greedy Methods Amortized Analysis: Aggregate Analysis - The Accounting Method

Module IV: **9 hrs**

Advanced graph algorithms: Johnsons Algorithm for Sparse Graphs Maximum Flow: Flow Networks - The Ford-Fulkerson Method - Maximum Bipartite Matching. **Multithreaded Algorithms:** Basics of Dynamic Multithreading - Multithreaded Matrix Multiplication - Multithreaded Merge Sort.

Module V: **9 hrs**

String matching and approximation algorithms: String Matching Algorithms: Naïve approach - Rabin-Karp Algorithm - String Matching with Finite Automata -The Knutt-Morris-Pratt Algorithm-NP Completeness.

Text Book(s):

1. *Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest and Clifford Stein, Introduction to Algorithms, MIT Press, 2009.*
2. *Ellis Horowitz , Sartaj Shani, Sanguthevar Rajasekaran, Computer Algorithms, Computer Science Press, 1998.*

Reference Book(s):

1. *S. Dasgupta, C. H. Papadimitriou, and U. V. Vazirani, Algorithms, McGrawHill, 2008.*
2. *G. Brassard and P. Bratley, Algorithmics: Theory and Practice, Prentice -Hall, 1988.*
3. *J. Kleinberg and E. Tardos, Algorithm Design, Pearson Education, 2006.*
4. *Rajeev Motwani and Prabhakar Raghavan, Randomized Algorithms, Cambridge University Press, 1995.*

CSCE 615 INTERNET AND WEB TECHNOLOGIES

L	T	P	C
3	0	0	3

Pre-requisite:

- *Basic Understanding of Computer Programming.*

Objectives:

- *To understand and become familiar with Full Stack of Web development.*
- *To learn the components of Web Design and Development.*
- *To acquire skills on developing effective web applications.*
- *To Learn client side scripting*

Course Outcome:

- *Implement Full Stack of Web development.*
- *Perform the components of Web Design and Development.*
- *Choose effective web applications.*
- *Develop applications securely.*

Module-I: **9 hrs**

The Internet Evolution – Protocols for the Internet – IP Subnetting and addressing - Name resolution – Web Browsers: Features – Comparative analysis; Markup languages – HTML5: Features – Multimedia handling – Canvas; Styling web pages: CSS3 – Types – Benefits – Design considerations.

Module-II: **9 hrs**

Client Side Scripting languages : Features – Comparative analysis; Dynamic pages using client side scripting – Client side storage through Cookies - Client side scripting frameworks : Case study with Jquery – Optimizing web pages for speed.

Module-III: **9 hrs**

Web servers : Features – Comparative analysis; Service side scripting languages: Features – Factors to consider in selecting Web Servers – Server Side Scripting case study with PHP : Introduction - Functions – Object Orientation – Error and Exception Handling – Internationalization and Localization – File Systems and the Server.

Module-IV: **9 hrs**

Databases for web applications : Features – Comparative analysis; Creating the web databases – Accessing databases from server side scripting – Database Administration – Non RDBMS Data Sources for Web applications.

Module-V: **9 hrs**

Web Application Security: risks – Building secure web applications. Rich Internet Applications: Design and Security issues – Mobile Web : Components and Security considerations.

Reference Book(s):

1. *Laura Thomson & Luke Welling :PHP and MySQL Web Development, Pearson Education; Fifth edition (2016)*
2. *Thomas A. Powell:HTML& CSS: The Complete Reference, Fifth Edition, McGraw Hill Education;5th edition (2017)*

Web Resources:

1. *https://github.com/MilanAryal/web-development-resources*
2. *https://github.com/bmorelli25/Become-A-Full-Stack-Web-Developer*
3. *https://github.com/JacobWylie/Web-Dev-Learning-Resources*
4. https://www.w3schools.com/**MOOC***NPTEL Course on Internet Technology : http://nptel.ac.in/courses/106105084/*

CSCE 616 NETWORK MANAGEMENT LAB

L	T	P	C
0	0	2	2

Skills to be acquired:

- *Basics of protocols*

Lab Software Requirements:

- *Open source network management tools*

Course Outcome:

- *Implement System Administration: User/Group management, File System Management*
- *Perform Network Configuration: Start/Stop network Service, network interface configuration*
- *Choose Firewall Configuration*

List of Exercises:

1. Server/Client Installation over VMware Environment
2. Packet Analysis by using TCPDUMP and WIRESHARK
3. Network Practice with Packet Tracer
4. System Administration: User/Group management, File System Management ….
5. Network Configuration: Start/Stop network Service, network interface configuration
6. Firewall Configuration
7. DNS and DHCP Configuration and Troubleshooting
8. Web and Proxy Server Configuration and Troubleshooting
9. Basic Mail Server Configuration and Troubleshooting
10. SAMBA, NFS, CUPS and FTP configuration and Troubleshooting
11. Webmin/ SSH configurations

CSCE 617 WEB TECHNOLOGY LAB

L	T	P	C
0	0	2	2

Skills to be acquired:

- *Designing and developing web pages / applications.*

Lab Software Requirements:

- *Open Source Web Development tools.*

Course Outcome:

- *Perform client side development skills.*
- *Implement server side development skills.*
- *Implement rich internet applications*
- *Develop secure applications*

List of Exercises:

1. Exercises to make the student acquire client side development skills.
2. Exercises to make the student acquire server side development skills.
3. Exercises to make the student acquire Rich Internet Application development skills.
4. Exercises to make the student acquire skills related with making the applications secure.

CSCE 621 GRAPH THEORY WITH APPLICATIONS TO ENGINEERING

L	T	P	C
3	0	0	3

Pre-requisite:

- *Basic knowledge in graphs*

Objectives:

- *To introduce graphs as a powerful modelling tool*
- *To solve practical problems using graph theory*
- *To understand colouring and planar graphs*
- To learn network connectivity using graphs

Course Outcome:

- *Implement graphs as a powerful modelling tool*
- *Explain various algorithms*
- *Implement practical problems in various fields*
- *Perform matching and connectivity in many applications*

Module-I: **9 hrs**

Graph Theory Introduction: Introduction Of Graph and sub graphs - Graph Isomorphism – Representation – Degree- Paths and Connection, Cycles, Trees – Cut Edges – Cut vertices – Gayley's Formula- Connector Problem – Euler's and Hamiltonian Cycles.

Module-II: **9 hrs**

Matching and Connectivity: Matching – Covering in Bipartite graphs – Perfect Matching – Personal Assignment Problem – Optimal Assignment Problem. Connectivity- Blocks – Construction of Reliable communication Networks.

Module-III: **9 hrs**

Planar Graphs and Colouring: Planar Graphs – Dual Graphs - Euler's Formula – Kurotowski's Theorem - Applications. Edge Colouring- Vertex Colouring

Module-IV: **9 hrs**

Directed graphs: Concepts-Directed walks-paths-cycles-orientation of graph-Job Sequencing problem- Applications

Module-V: **9 hrs**

Network: Flows – Cuts- Max-Flow Min Cut Theorem – Feasible Flows.

Textbook(s):

1. *R J Wilson, Introduction to Graph Theory, 2010, 5th Edition, Pearson Education.*
2. *J.A Bondy and U.S.R Murthy, Graph Theory with Applications, Macmillan, 1976.*

Reference Book(s):

1. *Reinhard Diestel, Graph Theory ,2000, 2nd Edition, Springer- Verlag.*
2. *Jay Yellen, Jonathan L.Gross, Graph Theory and Its Applications ,3rd edition, CRC Press LLC.*
3. *NarsinghDeo, Graph Theory: With Application to Engineering and Computer Science,2003, Prentice Hall of India.*

CSCE 623 DATA MINING AND BIG DATA

L	T	P	C
3	0	0	3

Pre-requisite:

- *Knowledge in Artificial Intelligence*

Objectives:

- *To understand the computational approaches to Mining*
- *To understand the need and application of Map Reduce*
- *To understand the various search algorithms applicable to Big Data*
- *To analyse and interpret streaming data*

Course Outcome:

- *Identify the computational approaches to Mining*
- *Identify the need and application of Map Reduce*
- *Explain various search algorithms applicable to Big Data*
- *Analyse and interpret streaming data*

Module-I: **9 hrs**

Introduction to data mining: Data mining-KDD versus data mining, Stages of the Data Mining Process-task primitives, Data Mining Techniques, Data Pre-processing-Data Warehouse and OLAP.

Module-II: **9 hrs**

Association Rule Mining Algorithms and Classification: Basic Concepts- Frequent Itemset Mining Methods and Association Algorithms- Decision Tree Induction - Bayesian Classification – Rule Based Classification. Advanced Methods: Classification by Back propagation- Support Vector Machines – Associative Classification – Lazy Learners.

Module-III: **9 hrs**

Clustering: Clustering techniques, Partitioning methods- k-means- Hierarchical Methods – distance based agglomerative and divisible clustering, Density-Based Methods - Grid Based Methods – Model-Based Clustering Methods – Constraint – Based Cluster Analysis – Outlier Analysis.

Module-IV: **9 hrs**

Introduction to Big Data and Hadoop: Big data Basics-Characteristics-Importance-Processing techniques- Big Data Analytics – computing Technologies-Applications. Hadoop: Analysing data with Hadoop, Hadoop Echo System. HDFS:basics-Architecture--no SQL-data ingest with Flume and Scoop. Mapreduce: Architecture, Anatomy of a map reduce job run, Job Scheduling, Shuffle and sort, Task execution, map reduce Types and Format.

Module-V: **9 hrs**

Applications: Mining complex data objects – Spatial databases – Temporal databases – Multimedia databases – Time series and sequence data – Text mining – Web mining –Case study- Mining social networks.

Text Book(s):

1. *Jure Leskovec, AnandRajaraman, Jeffrey David Ullman, "Mining of Massive Datasets",*
   Cambridge University Press, Second Edition, 2014.
2. *Jiawei Han, MichelineKamber, Jian Pei, "Data Mining Concepts and Techniques", Morgan Kaufman Publications, Third Edition, 2011.*
3. *V.K. Jain, "Big data and Hadoop", Khanna Book Co.(P). LTD.Publishing,2017.*
4. *Tom White "Hadoop: The Definitive Guide" Third Edition, O'reily Media, 2012*
5. *Seema Acharya, Subhasini Chellappan, "Big Data Analytics" First Edition, Wiley 2015.*

CSCE 624 MOBILE AND PERVASIVE COMPUTING

L	T	P	C
3	0	0	3

Pre-requisite:

- *Knowledge of Computer Networks*

Objectives:

- *To Learn the underlying engineering principles*
- *To implement pervasive computing work.*
- *To get an in-depth understanding about the most dynamic technologies*
- *To understand security issues in mobile & pervasive computing.*

Course Outcome:

- *Identify the underlying engineering principles that make pervasive computing work.*
- *Define the most dynamic technologies like mobile computing, service discovery*
- *Explain computing and security issues in mobile & pervasive computing.*
- *Implement and analyse pervasive techniques.*

Module-I: 9 hrs

Introduction to Mobile Computing: Theory of Mobile Computing: Mobile Adaptive Computing – Adaptability – Mechanics of Adaptation – Mobility Management- Data Dissemination and Management – Challenges – Mobile Data Caching – Mobile Cache maintenance schemes – Mobile Web caching

Module-II: 10 hrs

Context Aware Computing: Context aware Computing – Ubiquitous Vs. pervasive Computing – Context aware computing and applications – Middleware support – Mobile middleware – Adaptation – Mobile Agents – Service discovery middleware.

Module-III: 8 hrs

Adhoc& Sensor networks: Introduction to Adhoc& Sensor networks- Properties of adhoc networks – Features of sensor networks – proposed application and challenges.

Module-IV: 9 hrs

Protocols: Protocols – Autoconfiguration – Energy efficient communications – Mobility requirements – Deployment and configuration - Routing – Fault Tolerance and Reliability- Energy efficiency.

Module-V: 9 hrs

Wireless Security: Mobile and Wireless security issues – problems in adhoc networks – additional issues: commerce , Types of attacks - Approaches to security – Limit the signal – encryption – integrity codes – IPSec - Authentication Protocols

Text Book(s):

1. *Frank Adelstein, Sandeep K.S. Gupta, Golden G Richard, Loren schwieber,, Fundamentals of Mobile and Pervasive Computing , Tata McGraw Hill edition , 2005.*

Reference Book(s):

1. *Asoke K. Talukar, Mobile Computing, Second Edition, Tata McGraw-Hill Publication, 2010*

CSCE 625 ADVANCED OPERATIG SYSTEM

L	T	P	C
3	0	0	3

Pre-requisite:

- *Knowledge On Operating System*

Objectives:

- *To study and understand the structure of OS*
- *To understand the design level issues of OS.*
- *To learn the trends in building Distributed and Mobile OS*
- *To understand mobile operating system*

Course Outcome:

- *Analyse the working of operating systems*
- *Explain the process and memory management*
- *Implement applications in mobile operating systems*
- *Define trends in building distributed OS*

Module-I: **9 hrs**

Operating System Architectures - Structures of OS - OS design issues - Process synchronization - Process Scheduling - Memory Management.

Module-II: 9 **hrs**

Distributed Operating Systems: System Architectures - Design issues - Communication models - Clock Synchronization - Mutual Exclusion - Election algorithms - Distributed Deadlock detection

Module-III: **9 hrs**

Distributed scheduling - Distributed shared memory - Distributed File System - Multimedia File Systems - File placement – Caching.

Module-IV: **9 hrs**

Database Operating Systems: Requirements of Database OS - Transaction process model - Synchronization primitives - Concurrency Control Algorithms.

Module-V: **9 hrs**

Mobile Operating Systems: ARM and Intel Architectures - Power Management -Mobile OS Architectures -Underlying OS -Kernel Structure and Native Level Programming -Runtime issues-Approaches to Power Management.

Text Book(s):

1. A.S.Tanenbaum, Distributed Operating Systems, Pearson Education Asia, 2001.
2. Abraham Silberschatz, Peter B. Galvin, Greg Gagne, Operating System Concepts. Sixth edition. Addison-Wesley (2003)
3. Operating System Concepts (8th Edition)bySilberschatz, Peter B. Galvin and Greg Gagne, Wiley-Indian Edition (2010).
4.Modern Operating Systems (Third Edition) by Andrew S Tanenbaum, Prentice Hall India (2008).
5.Principles of Operating Systems by Nareshchauhan, Oxford Press (2014).
6.Operating Systems by D.M. Dhamdhere, Tata McGraw Hill 2nd edition.
7. Operating Systems (5^{th}Ed) –Internals and Design Principles by William Stallings, Prentice Hall India, 2000.

CSCE 627 DATA MINING LAB

L	T	P	C
0	0	2	2

Skills to be acquired:

- *Implementation of data mining algorithms*
- *Implementation of big data mining concepts*

List of S/W requirements:

- *Hadoop, spark*
- *Weka, R language, Python*

Course Outcome:

- *Implement data mining algorithms.*
- *Demonstrate working of clustering*
- *Implement classification algorithms.*

List of exercise:

- *Implementing classification and clustering algorithms*
- *Analysis of the algorithms*
- *Implementing mining algorithms on data streams*

CSCE 628 PERVASIVE COMPUTING LAB

L	T	P	C
0	0	2	2

Skills to be acquired:

- *To understand and use the fundamentals of programming for mobile devices.*
- *To apply event-driven programming and graphical user interfaces for mobile device*

Lab Software Requirements:

- *Open Source Development tools.*
- *J2ME*
- *NS3*

Course Outcome:

- *Explain the fundamentals of programming for mobile devices.*
- *Implement event-driven programming*
- *Implement graphical user interfaces for mobile device*

List of Exercises:

- Study of mobile application development platform and tools.
- Design and develop pervasive applications

CSCE 811 BIG DATA TECHNOLOGIES

L	T	P	C
3	0	0	3

Prerequisite:

- *Basic knowledge in programming concepts*

Objectives:

- *To provide practical foundation level training in big data projects.*
- *To provide grounding in basic big data technology*
- *To learn advanced methods and tool in big data*
- *To understand Hadoop architecture*

Course Outcome:

- *Recognize big data projects.*
- *Implement big data technology and tools*
- *Demonstrate MapReduce and Hadoop and its ecosystem*
- *Implement a sample system using Hadoop.*

Module-I: 9 hrs

Introduction to Big Data: Introduction – distributed file system – Big Data and its importance, Four Vs, Drivers for Big data, Big data analytics, Big data applications. Algorithms using map reduce, Matrix-Vector Multiplication by Map Reduce.

Module-II: 9 hrs

Introduction to Hadoop: Big Data – Apache Hadoop & Hadoop EcoSystem – Moving Data in and out of Hadoop – Understanding inputs and outputs of MapReduce - Data Serialization.

Module-III: 9 hrs

Hadoop Architecture: Hadoop Storage: HDFS, Common Hadoop Shell commands , Anatomy of File Write and Read., NameNode, Secondary NameNode, and DataNode, Hadoop MapReduce paradigm, Map and Reduce tasks, Job, Task trackers - Cluster Setup – SSH & Hadoop Configuration – HDFS Administering –Monitoring & Maintenance.

Module-IV: 9 hrs

Hadoop Ecosystem and Yarn: Hadoop ecosystem components - Schedulers - Fair and Capacity, Hadoop 2.0 New Features Name Node- High Availability, HDFS Federation, MRv2, YARN, Running MRv1 in YARN.

Module-V: 9 hrs

HIVE and HIVEQL, HBASE: Hive Architecture and Installation, Comparison with Traditional Database, HiveQL – Querying- Data - Sorting And Aggregating, Map Reduce Scripts, Joins &Subqueries, HBase concepts Advanced-Usage, Schema Design, Advance Indexing.

Reference(s):

1. *Boris lublinsky, Kevin t. Smith, Alexey Yakubovich, "Professional Hadoop Solutions",First Edition, Wiley, ISBN: 9788126551071, 2015.*
2. Chris Eaton, Dirk derooset al. , "Understanding Big data ", McGraw Hill, 2012.
3. Tom White, "HADOOP: The definitive Guide" , O Reilly 2012.
4. VigneshPrajapati, "Big Data Analytics with R and Haoop", Packet Publishing 2013.
5. Tom Plunkett, Brian Macdonald et al, "Oracle Big Data Handbook", Oracle Press, 2014.
6. http://www.bigdatauniversity.com/
7. JyLiebowitz, "Big Data and Business analytics",CRC press, 2013.

CSCE 812 STATISTICS FOR DATA ANALYTICS

L	T	P	C
3	0	0	3

Prerequisite:

- *Basic Knowledge on probability and statics*

Objectives:

- *To teach fundamental concepts*
- *To tools needed for data analytics*
- *To understand the emerging role of business analytics in organizations.*
- *To Learn predictive analytics*

Course Outcome:

- *Explain hypothesis testing*
- *Define predictive analytics*
- *Implement fundamental concepts and tools*
- *Perform business analytics in organizations.*

Module –I: 9 hrs

Data Analytics Life Cycle: Introduction to Big data Business Analytics - State of the practice in analytics role of data scientists- Key roles for successful analytic project - Main phases of life cycle - Developing core deliverables for stakeholders.

Module –II 9 hrs

Statistics: Sampling Techniques - Data classification, Tabulation, Frequency and Graphic representation -Measures of central value - Arithmetic mean, Geometric mean, Harmonic mean, Mode, Median,Quartiles, Deciles, Percentile - Measures of variation – Range, IQR, Quartile deviation, Mean deviation, standard deviation, coefficient variance, skewness, Moments & Kurtosis.

Module –III 9 hrs

Probability and Hypothesis Testing: Random variable, distributions - Some special probability distribution - Binomial, Poison, Geometric, uniform, exponential, normal and gamma Multivariate normal distribution – Sampling distribuition – Estimation - point, confidence - Test of significance, 1& 2 tailed test, uses of t distribution, F-distribution, $\chi 2$ distribution.

Module –IV 9 hrs

Predictive Analytics: Predictive modeling and Analyisis - Regression Analyisis, Multicollinearity , Correlation analysis, Rank Correlation coefficient, Multiple correlation, Least square, Curve fitting and good ness of fit.

Module –V 9 hrs

Design Of Experiments: one way Classification, two way classification, ANOVA, Latin square, Factorial Design.

Reference book(s):

1. *Chris Eaton, Dirk Deroos, Tom Deutsch et al., "Understanding Big Data", McGrawHIll,2012.*
2. *Alberto Cordoba, "Understanding the Predictive Analytics Lifecycle", Wiley, 2014.*
3. *Eric Siegel, Thomas H. Davenport, "Predictive Analytics: The Power to Predict Who Will Click, Buy, Lie, or Die", Wiley, 2013.*
4. *James R Evans, "Business Analytics – Methods, Models and Decisions", Pearson 2013.*
5. *R. N. Prasad, Seema Acharya, "Fundamentals of Business Analytics", 2nd Edition, Wiley, 2015.*
6. *S M Ross, "Introduction to Probability and Statistics for Engineers and Scientists", Academic Foundation, 2011.*
7. *David Hand, HeikiMannila, Padhria Smyth, "Principles of Data Mining", PHI 2013.*
8. *Spyros Makridakis, Steven C Wheelwright, Rob J Hyndman, "Forecasting methods and applications", Wiley 2013(Reprint).*
9. *David Hand, HeikkiMannila, Padhraic Smyth, "Principles of Data mining", PHI 2013.*

CSCE 813 MULTIVARIATE TECHNIQUES FOR DATA

L	T	P	C
3	0	0	3

Prerequisite:

- *Basic knowledge in optimization techniques*

Objectives:

- *To introduce the students into the field of Multivariate Techniques*
- *To analyse large volumes of data*
- *To take decisions based on inference drawn.*
- *To learn linear programming problem*

Course Outcome:

- *Describe the field of Multivariate Techniques*
- *Explain large volumes of data*
- *Demonstrate decisions based on inference drawn.*
- *Implement linear programming problems*

Module-I: **9 hrs**

Introduction to Multivariate Analysis: Meaning of Multivariate Analysis, Measurements Scales - Metric measurement scales and Nonmetric measurement scales, Classification of multivariate techniques (Dependence Techniques and Inter- dependence Techniques), Applications of Multivariate Techniques in different disciplines.

Module-II: **9 hrs**

Factor Analysis: Meanings, Objectives and Assumptions, designing a factor analysis, deriving factors and assessing overall factors, Interpreting the factors and validation of factor analysis.

Module-III: **9 hrs**

Cluster Analysis: Objectives and Assumptions, Research design in cluster analysis, deriving clusters and assessing overall fit (Hierarchical methods, Non Hierarchical Methods and Combinations), Interpretation of clusters and validation of profiling of the clusters.

Module-IV: **9 hrs**

Linear Programming Problem: Introduction – Formulation of Linear Programming Model- Illustration on Mathematical Formulation of LPP – Graphical Solution – General LPP – Canonical and Standard forms of LPP **Optimization:** Introduction – Classification of Optimization Problems– Mathematical models in Optimization – Types of Optimization Models

Module-V: **9 hrs**

LPP Optimization: Graphical method, simplex method- Problems Applications simplex method, Big M Method, Transportation and Assignment problem. Problems - Applications

Reference(s):

1. Joseph F Hair, William C Black etal , "Multivariate Data Analysis" , Pearson Education, 8th edition, 2018.

2. T. W. Anderson , "An Introduction to Multivariate Statistical Analysis, 3rd Edition", Wiley, 2003.

3. William r Dillon, John Wiley & sons, "Multivariate Analysis methods and applications", First Edition, Wiley, 1984.

4. Naresh K Malhotra, Satyabhusan Dash, "Marketing Research Anapplied Orientation", Pearson, Seventh Edition, 2011.

5. Hamdy A Taha, "Operations Research", Pearson, Tenth Edition, 2012.

6. S R Yaday, A K Malik, "Operations Research", Oxford, 2014.

CSCE 814 DATA MINING AND DATA ANALYSIS

L	T	P	C
3	0	0	3

Prerequisite:

- *Basic knowledge in statistics*

Objectives:

- *To learn data mining techniques.*
- *To understand Data mining techniques and algorithms.*
- *To comprehend the data mining environments and application.*
- *To learn prediction of quantitative variables*

Course Outcome:

- *Define data analysis techniques.*
- *Explain Data mining techniques and algorithms.*
- *Recognize data mining environments and application*.
- *Identify prediction of quantitative variables*

Module-I: 9 hrs

Introduction To Data Mining: Data mining-KDD versus data mining, Stages of the Data Mining Process Task primitives, Data Mining Techniques -Data mining knowledge representation – Data mining query languages- Integration of a Data Mining System with a Data Warehouse – Issues, Data pre-processing – Data cleaning – Data transformation - Feature selection – Dimensionality reduction – Discretization and generating concept hierarchies-Mining frequent pattern association - correlation.

Module-II: 9 hrs

Classification and Clustering: Decision Tree Induction - Bayesian Classification – Rule Based Classification – Classification by Back propagation – Support Vector Machines – Associative Classification – Lazy Learners – Other Classification Methods – Clustering techniques – Partitioning methods- k-means- Hierarchical Methods – Distance based agglomerative and divisible clustering - Density-Based Methods – Expectation maximization -Grid Based Methods – Model-Based Clustering Methods – Constraint – Based Cluster Analysis – Outlier Analysis.

Module-III: 9 hrs

Data Mining Software and Applications: Mining complex data objects - Spatial databases, temporal databases, Multimedia databases- Time series and Sequence data - Text Mining – Graph mining-Web mining-Application and trends in data mining.

Module-IV: 9 hrs

Prediction of Quantitative Variables: Prediction of quantitative variables – Non Parametric estimation – Logical regression – Projection pursuit – Inferential aspects – Regression trees – Neural networks – Case studies.

Module-V: **9 hrs**

Methods of Internal Analysis: Methods of Internal analysis – Cluster analysis – Association among variables – Web mining analysis. Data Analytics – Simulated data – Mathematical statistic analysis – Applications of probability theory – Linear models – Case study.

Reference Book(s):

1. *AdelchiAzzalini, Bruno Scapa, "Data Analysis and Data mining", 2nd Edition, Oxford University Press Inc., 2012.*
2. *Jiawei Han and MichelineKamber, "Data Mining: Concepts and Techniques", 3rd Edition, Morgan Kaufmann Publishers, 2011.*
3. *Alex Berson and Stephen J. Smith, "Data Warehousing, Data Mining & OLAP", 10th Edition, TataMcGraw Hill Edition, 2007.*
4. *G. K. Gupta, "Introduction to Data Mining with Case Studies", 1st Edition, Easter Economy Edition, PHI, 2006.*

CSCE 815 MACHINE LEARNING

Prerequisite:

- *Basic knowledge in AI, algorithm design, basics of probability & statistics*

L	T	P	C
3	0	0	3

Objectives:

- *To understand the machine learning theory*
- *To implement linear and non-linear learning models*
- *To implement distance-based clustering techniques*
- *To build tree and rule based models*

Course Outcome:

- *Evaluate machine learning theory in problem solving*
- *Implement linear and non-linear learning models*
- *Implement distance-based clustering techniques*
- *Demonstrate tree and rule based models*
- *Explain reinforcement learning techniques*

Module-I: **9 hrs**

Introduction – machine learning applications – Basic definitions- types of learning: unsupervised learning – Reinforcement Learning – Supervised Learning – Learning a class from examples – hypothesis space and inductive bias- Vapnik-Chervonenkis (VC) Dimension – Probably Approximately Correct (PAC) Learning – Noise – Learning multiple classes – Model selection and Generalization-Evaluation and Cross validation.

Module-II: **9 hrs**

Linear Regression-Introduction to decision trees-Learning decision trees-Issues-Pruning-Overfitting-k_Nearest neighbour-Feature selection: Metrics-Feature Reduction: Dimensionality reduction – Subset selection – Principal component analysis – Factor analysis – Multidimensional scaling – Linear discriminant analysis.

Module-III: **9 hrs**

Bayesian Learning-Bayes theorem-Maximum Likelihood-Bayes optimal classifier-Gibbs Algorithm-Naïve Bayes Classifier- Bayesian Belief networks-Clustering: Mixture Densities – K Means Clustering – Expectation Maximization – Hierarchical clustering.

Module-IV: **9 hrs**

Linear Discrimination – Linear Model – Geometry of the Linear Discriminant – Pairwise Separation – Gradient Descent – Logistic Discrimination – Discrimination by Regression – Multilayer Perceptrons: Introduction – Perceptron – Training a Perceptron – Learning Boolean Functions – Multilayer Perceptrons – Backpropagation Algorithm.

Module-V: **9 hrs**

Kernel Machines – SVM-Optimal Separating Hyperplane – kernel trick –Hidden Markov Models – Evaluation-Model selection –Introduction to Ensembles- Bagging – Boosting.

Reference Book(s):

1. *Ethem Alpaydin, Introduction to Machine Learning, Third Edition, PHI, 2014.*
2. *Tom M. Mitchell, Machine Learning, Mc Graw Hill, 2003.*

CSCE 816 DEEP LEARNING

L	T	P	C
3	0	0	3

Prerequisite:

- *Basic knowledge in machine learning*

Objectives:

- *To provide knowledge about deep learning based solutions*
- *To introduce major deep learning algorithms*
- *To learn problem settings*
- *To learn deep learning applications to solve real world problems.*

Course Outcome:

- List deep learning based solutions.
- Define major deep learning algorithms
- Recognise the problem settings
- Implement deep learning applications

Module-I: 9 hrs

Building Intelligent Machines: Limitations - Mechanics of Machine Learning - Neuron - Feed-Forward Neural Networks - Linear Neurons and Their Limitations - Sigmoid, Tanh, and ReLU Neurons – Softmax Output Layers. **Training Feed-Forward Neural Networks** - The Fast-Food Problem - Gradient Descent - Delta Rule and Learning Rates - Gradient Descent with Sigmoidal Neurons - Backpropagation Algorithm - Stochastic and Minibatch Gradient Descent - Test Sets, Validation Sets, and Overfitting - Preventing Overfitting in Deep Neural Networks.

Module-II: 9 hrs

Implementing Neural Networks in Tensor Flow: Introduction – installation- creation and manipulation – operations – placeholder tensor – Sessions – Variables – Logistic Regression Model - Visualization – multilayer model. **Beyond Gradient Descent:** Challenges - Local Minima in the Error Surfaces of Deep Networks - Model Identifiability - Flat Regions in the Error Surface- Momentum-Based Optimization - Second-Order Methods - Learning Rate Adaptation – AdaGrad – RMSProp – Adam - Optimizer Selection.

Module-III: 9 hrs

Convolutional Neural Networks: Neurons in Human Vision - The Shortcomings of Feature Selection - Filters and Feature Maps - Convolutional Layer- Max Pooling - Architectural Description - MNIST with Convolutional Networks. **Models for Sequence Analysis:** Recurrent Neural Networks - The Challenges with Vanishing Gradients - Long Short-Term Memory (LSTM) - RNN and GRU Models.

Module-IV: 9 hrs

Deep Generative models: Restrictive Boltzmann Machines (RBMs), Introduction to MCMC and Gibbs Sampling, gradient computations in RBMs, Deep Boltzmann Machines-Adversarial Generative Networks. **Deep Unsupervised Learning:** Autoencoders (standard, sparse, denoising, contractive)-Applications.

Module-V: **9 hrs**

Deep Learning research: Object recognition, sentiment analysis, computer vision, natural language processing. Deep Learning Tools: Caffe, Theano, Torch.

Reference Book(s):

1. *Ian Goodfellow, YoshuaBengio, Aaron Courville, Deep learning, MIT Press, 2016.*
2. *Nikhil Buduma, Fundamentals of Deep Learning, Designing Next Generation Machine Intelligence Algorithms, O'Reilly publications, June 2017.*
3. *EthemAlpaydin, Introduction to Machine Learning,, Second Edition, PHI,2010.*
4. *Bishop, C. M. Neural Networks for Pattern Recognition. Oxford University Press. 1995.*
5. *Bengio, Yoshua. Learning deep architectures for AI. Foundations and trends in Machine Learning, now publishers,2009.*

CSCE 821 SOFTWARE TESTING

L	T	P	C
3	0	0	3

Pre-requisite:

- *Knowledge in Software Engineering*

Objectives:

- *To know the behaviour of the testing techniques to detect the errors in the software.*
- *To understand standard principles to check the occurrence of defects and its removal.*
- *To learn the functionality of automated testing tools.*
- *To understand the models of software reliability.*

Course Outcome:

- *Perform testing techniques to detect the errors in the software.*
- *Choose standard principles to check the occurrence of defects and its removal.*
- *Recognize automated testing tools.*
- *Choose software metrics.*

Module-I: 9 hrs

Testing Environment and Test Processes: World-Class Software Testing Model – Building a Software Testing Environment. **The Seven Step Testing process**: Overview of Software Testing Process – Organizing for Testing – Developing the Test Plan – Verification Testing – Analysing and Reporting Test Results – Acceptance Testing – Operational Testing – Post Implementation Analysis.

Module-II: 9 hrs

Testing Techniques and Levels of testing: Using White Box Approach to Test design - Static Testing Vs. Structural Testing – Code Functional Testing – Coverage and Control Flow Graphs –Using Black Box Approaches to Test Case Design – Random Testing – Requirements based testing –Decision tables –State-based testing – Cause-effect graphing – Error guessing – Compatibility testing – Levels of Testing - Unit Testing - Integration Testing - Defect Bash Elimination. System Testing - Usability and Accessibility Testing – Configuration Testing - Compatibility Testing - Case study for White box testing and Black box testing techniques.

Module-III: 9 hrs

Incorporating Specialized Testing Responsibilities: Testing Client/Server Systems – Rapid Application Development Testing – Testing in a Multiplatform Environment – Testing Software System Security - Testing Object-Oriented Software – Object Oriented Testing – Testing Web based systems – Web based system – Web Technology Evolution – Traditional Software and Web based Software – Challenges in Testing for Web-based Software –Testing a Data Warehouse - Case Study for Web Application Testing.

Module-IV: 9 hrs

Test Automation: Selecting and Installing Software Testing Tools - Software Test Automation – Skills needed for Automation – Scope of Automation – Design and Architecture for Automation – Requirements for a Test Tool – Challenges in Automation – Tracking the Bug – Debugging – Case study using Bug Tracking Tool.

Module-V: **9 hrs**

Software Testing and Quality Metrics: Testing Software System Security - Six-Sigma – TQM - Complexity Metrics and Models – Quality Management Metrics - Availability Metrics - Defect Removal Effectiveness - FMEA - Quality Function Deployment – Taguchi Quality Loss Function – Cost of Quality. Case Study for Complexity and Object Oriented Metrics

Laboratory Components:

Skills to be acquired:

- *Test generation from requirement*
- *Test generation from models.*
- *Test process and continuous quality improvement*

List of Exercises:

1. Cause Effect Graph Testing for a Triangle Program.
2. Boundary Value Analysis for a Software Unit
3. Cyclomatic Complexity for Binary Search
4. Data Flow Testing for Gregorian Calendar
5. State based Testing for an Assembler
6. Stress Testing of a Map-Aided Vehicle Tracking and Scheduling System
7. Model Based Testing
8. Web Application Testing for Student Grade System

Text Book(s):

1. *William Perry, "Effective Methods of Software Testing", Third Edition, Wiley Publishing 2007*
2. *Srinivasan Desikan and Gopalaswamy Ramesh, "Software Testing – Principles and Practices", Pearson Education, 2007.*

Reference Book(s):

1. *NareshChauhan, "Software Testing Principles and Practices" Oxford University Press, New Delhi, 2010.*
2. *Dale H. Besterfiled et al., "Total Quality Management", Pearson Education Asia, Third Edition, Indian Reprint (2006).*
3. *Stephen Kan, "Metrics and Models in Software Quality", Addison – Wesley, Second Edition, 2004*
4. *LleneBurnstein, " Practical Software Testing", Springer International Edition, Chennai, 2003*
5. *RenuRajani,Pradeep Oak, "Software Testing – Effective Methods, Tools and Techniques", Tata McGraw Hill,2004*
6. *Edward Kit, "Software Testing in the Real World – Improving the Process", Pearson Education, 1995.*
7. *Boris Beizer, " Software Testing Techniques" – 2 nd Edition, Van Nostrand Reinhold, New York, 1990*
8. *Adithya P. Mathur, "Foundations of Software Testing – Fundamentals algorithms and techniques", Dorling Kindersley (India) Pvt. Ltd., Pearson Education, 2008.*

CSCE 822 AGILE SOFTWARE PROCESS

L	T	P	C
3	0	0	3

Pre-requisite:

- *Knowledge in Software Engineering*

Objectives:

- *To understand the basic concepts of Agile Software Process*
- *To gain knowledge in the area of various Agile Methodologies.*
- *To develop Agile Software Process*
- *To know the principles of Agile Testing*

Course Outcome:

- *Perform Agile Software Process development*
- *Implement various Agile Methodologies.*
- *List the Agile Software Process*
- *Explain the principles of Agile Testing*

Module-I: 9 hrs

Introduction: Iterative development- Risk-Driven and Client-Driven iterative planning – Time boxed iterative development – During the iteration, No changes from external stakeholders – Evolutionary and adaptive development - Evolutionary requirements analysis – Early "Top Ten" high-level requirements and skillful analysis – Evolutionary and adaptive planning –Incremental delivery – Evolutionary delivery – The most common mistake – Specific iterative and Evolutionary methods.

Module-II: 9 hrs

Agile and Its Significance: Agile development-Classification of methods – The agile manifesto and principles – Agile project management – Embrace communication and feedback –Simple practices and project tools – Empirical Vs defined and prescriptive process – Principle-based versus Rule-Based – Sustainable discipline: The human touch – Team as a complex adaptive system – Agile hype – Specific agile methods. **Motivation:** The facts of change on software projects – Key motivations for iterative development – Meeting the requirements challenge iteratively – Problems with the waterfall. **Evidence:** Research evidence – Early historical project evidence – Standards-Body evidence – Expert and thought leader evidence – A Business case for iterative development – The historical accident of waterfall validity.

Module-III: 9 hrs

Agile Methodology: Scrum-Method overview – Lifecycle – Work products, Roles and Practices values –Common mistakes and misunderstandings – Sample projects – Process mixtures– Adoption strategies – Fact versus fantasy –Strengths versus "Other" history.

Module-IV: 9 hrs

Case Study: Agile – Motivation – Evidence – Scrum – Extreme Programming – Unified Process –Evo– Practice Tips.

Module-V: **9 hrs**

Agile Practice: Project management – Environment – Requirements – Test – The agile alliances –The manifesto – Supporting the values.

Agile testing: Nine principles and sixconcrete/ practices for testing on agile teams.

Text Book(s):

1. *Craig Larman"Agile and Iterative Development – A Manager's Guide"Pearson Education – 2004.*
2. *Elisabeth Hendrickson, "Agile Testing" Quality Tree Software Inc 2008.*

Reference *Book(s):*

1. *Alistair "Agile Software Development series" Cockburn - 2001.*
2. *Robert C. Martin, Agile Software Development, Principles, Patterns, and Practices, Prentice Hall (2002).*

Web *Resources:*

1. ***www.****agileintro.wordpress.com/2008:Agile Introduction For Dummies*
2. *www.serena.com/docs/repository/solutions/intro-to-agile-devel.pdf:An Introduction to Agile Software Development*

CSCE 823 SOFTWARE RISK MANAGEMENT AND MAINTENANCE

L	T	P	C
3	0	0	3

Pre-requisite:

- *Knowledge in Software Engineering*

Objectives:

- *To understand the various risk levels in software development.*
- *To gain expertise in discovering risk and usage of risk assessment tools*
- *To understand the risk plan, implementation and tracking risks*
- *To realize the software maintenance process, measurement and benchmarking*
- *To expertise in the SQA maintenance tools*

Course Outcome:

- *Explain the various risk levels in software development.*
- *Define risk plan*
- *Implement tracking risks.*
- *Demonstrate SQA maintenance tools*

Module-I: 9 hrs

Risk Culture and Management Process: Risk- Basic Terms- Risk Vocabulary – Risk-Driven Project Management- Controlling the Process, Environment and Risk- Maturity in Risk Culture – Risk Scale – Preparing for Risk – Risk Management- Paradigms- Five Models of Risk Management – Thinking about Less Risky alternatives – Risk Management at Different Levels – Risk Escalation – Risk Models- Risk Intelligence - Software Risk Management steps.

Module-II: 9 hrs

Discovering Risk and Assessment: Identifying software risk - Classification of Risks – Risk Taxonomy – Risk Mapping – Statements – Risk Reviews – Risk Ownership and stakeholder management – Risk Assessment Approach – Risk Assessment tools and techniques – Risk Probability, impact, exposure, matrix and Application Problem - Self - assessment checklist.

Module-III: 9 hrs

Responding to Risks and Tracking: Special Treatment for Catastrophic risks- Constraint Risks – Risk Mitigation Plan Case Study – Contingency Plans- Implementing Risk Response- Tracking Risk Response and Hazards – Trigger Levels- Tracking Project Risks and Operational Risks- Learning by Tracking and Risk Tracker Tool.

Module-IV: 9 hrs

Maintenance Process: Software Maintenance- Customer's Viewpoint- Economics of Maintenance- Issues in Maintenance- Software Maintenance Standard, Process, Activities and Categories – Maintenance Measurement – Service Measurement and Benchmarking – Problem Resolution – Reporting – Fix Distribution.

Module-V: **9 hrs**

Activities for Maintenance: Role of SQA for Support and Maintenance – SQA tools for Maintenance- Configuration Management and Maintenance – Maintenance of Mission Critical Systems – Global Maintenance Teams – Foundation of S3m Process Model-Exemplary Practices.

Text Book(s):

1. *C. RavindranathPandian, "Applied Software Risk Management: A guide for Software Project Managers", Auerbach Publications, 2007.*
2. *John Mcmanus, "Risk Management in Software Development Projects", Elsevier Butterworth- Heinemann, First Edition, 2004.*

Reference Book(s):

1. *Alian April and Alain Abran, "Software Maintenance Management: Evaluation and Continuous Improvement", John Wiley & Sons Inc, 2008*
2. *Gopalaswamy Ramesh and Ramesh Bhattiprolu, "Software Maintenance: Effective Practices for Geographically Distributed Environments", Second Reprint, Tata McGrawHill, 2009.*

CSCE 824 SOFTWARE PROJECT MANAGEMENT

L	T	P	C
3	0	0	3

Pre-requisite:

- *Knowledge in Software Engineering*

Objectives:

- *To provide the students with an overall view over Software Engineering*
- *To understand the various methods of Cost Estimation.*
- *To Study about Software Quality Management.*
- *To Study about Software Metrics*

Course Outcome:

- *Describe the various methods of Cost Estimation.*
- *Explain Software Quality Management.*
- *List the use software metrics*
- *Explain software cost estimation*

Module-I: **8 hrs**

Project Concepts and Its Management: Project life cycle models-ISO 9001 model - Capability Maturity Model - Project, Planning-Project tracking-Project closure - Evolution of Software Economics –Software. **Management Process Framework:** Phases, Artifacts, Workflows, Checkpoints – Software Management Disciplines: Planning / Project Organization and Responsibilities / Automation / Project Control – Modern Project.

Module-II: **8 hrs**

Cost Estimation: Problems in Software Estimation – Algorithmic Cost Estimation Process, Function, Points, SLIM (Software Life cycle Management), COCOMO II (Constructive Cost Model) – Estimating Web Application Development – Concepts of Finance, Activity Based Costing and Economic Value Added (EVA) – Balanced Score Card.

Module-III: **10 hrs**

Software Quality Management: Software Quality Factors – Software Quality Components – Software Quality Plan– Software Quality Metrics – Software Quality Costs – Software Quality Assurance-Standard – Certification – Assessment.

Module-IV: **10 hrs**

Software Management and Metrics: Software Configuration Management – Risk Management: Risk Assessment: Identification / Analysis / Prioritization – Risk Control: Planning / Resolution /Monitoring – Failure Mode and Effects Analysis (FMEA) –Defect Management-Cost Management. Software Metrics – Classification of Software Metrics: Product-Metrics: Size Metrics, Complexity Metrics, Halstead's Product Metrics, Quality, Metrics, and Process metrics.

Module-V: **9 hrs**

Project Evaluation and Emerging Trends: Strategic Assessment–Technical Assessment–Cost Benefit Analysis–Cash Flow Forecasting–Cost Benefit Evaluation Technique–Risk Evaluation–Software Effort Estimation. Emerging Trends: Import of the internet on project Management –people Focused Process Models.

Text Book(s):

1. *Ramesh Gopalaswamy,"Managing and global Software Projects", TataMcGraw Hill Tenth Reprint, 2011.*

Reference Book(s):

1. *Demarco, T. and Lister, T. "Peopleware: Productive Projects and Teams, 2ndEd.", Dorset House,1999.*
2. *Royce, W. "Software Project Management: A Unified Framework", Addison-Wesley, 1998. Demarco, T. and Lister, T. "Peopleware: Productive Projects and Teams, 2ndEd.", Dorset House,1999.*
3. *Fenton, N.E., and Pfleeger, S.L."Software Metrics: A Rigorous and PracticalApproach, Revised" Brooks Cole, 1998.*
4. *Kaplan, R.S., Norton, D.P. "The Balanced Scorecard: Translating Strategyinto Action", Harvard Business School Press, 1996.*

CSCE 825 SOFTWARE ARCHITECTURE

L	T	P	C
3	0	0	3

Pre-requisite:

- *Knowledge in Software Engineering.*

Objectives:

- *To understand software architectural requirements and drivers.*
- *To be exposed to architectural styles and views.*
- *To be familiar with architectures for emerging technologies*
- *To understand documenting architecture*

Course Outcome:

- *Describe software architectural requirements and drivers.*
- *Explain architectural styles and views.*
- *Demonstrate emerging technologies*
- *Describe documenting architecture*

Module-I: 9 hrs

Introduction and Architectural Drivers: Introduction – What is software architecture? – Standard Definitions – Architectural structures – Influence of software architecture on organization-both business and technical – Architecture Business Cycle- Introduction – Functional requirements – Technical constraints – Quality Attributes.

Module-II: 9 hrs

Quality Attribute Workshop: Quality Attribute Workshop – Documenting Quality Attributes – Six part scenarios – Case studies.

Module-III: 9 hrs

Architectural Views: Introduction – Standard Definitions for views – Structures and views – Representing views-available notations – Standard views – 4+1 view of RUP, Siemens 4 views, SEI's perspectives and views – Case studies.

Module-IV: 9 hrs

Architectural Styles: Introduction – Data flow styles – Call-return styles – Shared Information styles – Event styles – Case studies for each style.

Module-V: 9 hrs

Documenting The Architecture: Good practices – Documenting the Views using UML – Merits and Demerits of using visual languages – Need for formal languages – Architectural Description Languages – ACME – Case studies. Special topics: SOA and Web services – Cloud Computing – Adaptive structures.

Text Book(s):

1. *Len Bass, Paul Clements, and Rick Kazman, "Software Architectures Principles and Practices", 2nd Edition, Addison-Wesley, 2003.*
2. *Anthony J Lattanze, "Architecting Software Intensive System. A Practitioner's Guide", Auerbach Publications, 2010.*

Reference Book(s):

1. *Paul Clements, Felix Bachmann, Len Bass, David Garlan, James Ivers, Reed Little, Paulo Merson, Robert Nord, and Judith Stafford, "Documenting Software Architectures. Views and Beyond", 2nd Edition, Addison-Wesley, 2010.*
2. *Paul Clements, Rick Kazman, and Mark Klein, "Evaluating software architectures: Methods and case studies. Addison-Wesley, 2001.*
3. *RajkumarBuyya, James Broberg, and Andrzej Goscinski, "Cloud Computing. Principles and Paradigms", John Wiley & Sons, 2011.*

CSCE 826 SOFTWARE QUALITY ASSURANCE

L	T	P	C
3	0	0	3

Pre-requisite:

•Knowledge in Software Engineering

Objectives:

- *To understand the basic tenets of software quality and quality factors.*
- *To expose to the Software Quality Assurance (SQA) architecture*
- *To understand how the SQA components can be integrated.*
- *To be familiar with the software quality infrastructure.*
- *To be exposed to the management components of software quality.*

Course Outcome:

- *Explain the basic tenets of software quality and quality factors.*
- *Demonstrate how the SQA components can be integrated into the project life cycle.*
- *Describe software quality infrastructure*
- *Explain the software quality management concepts*

Module-I: 9 hrs

Introduction to Software Quality & Architecture: Need for Software quality – Quality challenges – Software quality assurance (SQA) – Definition and objectives – Software quality factors- McCall‟s quality model – SQA system and architecture – Software Project life cycle Components – Pre project quality components – Development and quality plans.

Module-II: 9 hrs

Sqa Components and Project Life Cycle:Software Development methodologies – Quality assurance activities in the development process - Verification & Validation – Reviews – Software Testing – Software Testing implementations – Quality of software maintenance – Pre-Maintenance of software quality components – Quality assurance tools – CASE tools for software quality – Software maintenance quality – Project Management

Module-III: 9 hrs

Software Quality Infrastructure: Procedures and work instructions - Templates - Checklists – 3S development team - Staff training and certification Corrective and preventive actions – Configuration management – Software change control – Configuration management audit -Documentation control – Storage and retrieval.

Module-IV: 9 hrs

Software Quality Management & Metrics: Project process control – Computerized tools - Software quality metrics – Objectives of quality measurement – Process metrics – Product metrics – Implementation – Limitations of software metrics – Cost of software quality – Classical quality cost model – Extended model – Application of Cost model

Module-V: **9 hrs**

Standards, Certifications & Assessments: Quality management standards – ISO 9001 and ISO 9000-3 – capability Maturity Models – CMM and CMMI assessment methodologies - Bootstrap methodology – SPICE Project – SQA project process standards – IEEE st 1012 & 1028 – Organization of Quality Assurance – Department management responsibilities – Project management responsibilities – SQA units and other actors in SQA systems

Text Book(s):

1.Daniel Galin, "Software Quality Assurance", Pearson Publication, 2009.

Reference Book(s):

1.Alan C. Gillies, "Software Quality: Theory and Management", International Thomson Computer Press, 1997.

2.Mordechai Ben-Menachem "Software Quality: Producing Practical Consistent Software", International Thompson Computer Press, 1997.

CSCE 831 COGNITIVE SCIENCE

L	S	P	C
3	0	0	3

Pre-requisite:

•Exposure to AI

Objectives:

- *To learn the basics of Cognitive Science with focus on acquisition,*
- *To representation, and use of knowledge by individual minds, brains, and machines*
- *To study the mind and intelligence, embracing psychology, artificial intelligence, neuroscience and linguistics*
- *To understand the role of neuro science in the cognitive field*

Course Outcome:

- *List Cognitive Science with focus on acquisition*
- *Describe the representation, and use of knowledge by individual minds, brains, and machines*
- *Perform neuroscience and linguistics based experiments.*
- *Implement the knowledge of neuro science in the cognitive field*

Module-I: **9 hrs**

Introduction to Cognitive Science: The Cognitive view –Some Fundamental Concepts – Computers in Cognitive Science – Applied Cognitive Science – The Interdisciplinary Nature of Cognitive Science

Module-II: **9 hrs**

Cognitive Psychology: Cognitive Psychology – The Architecture of the Mind - The Nature of Cognitive Psychology- A Global View of The Cognitive Architecture- Propositional Representation- Schematic Representation- Cognitive Processes, Working Memory, and Attention- The Acquisition of Skill- The Connectionist Approach to Cognitive Architecture

Module-III: **9 hrs**

Language Acquisition, Semantics and Processing Model: Milestones in Acquisition – Theoretical Perspectives- Semantics and Cognitive Science – Meaning and Entailment – Reference – Sense – Cognitive and Computational Models of Semantic Processing – Information Processing Models of the Mind- Physical symbol systems and language of thought- Applying the Symbolic Paradigm- Neural networks and distributed information processing- Neural network models of Cognitive Processes

Module-IV: **9 hrs**

Integration Challenge: Cognitive Science and Integration Challenge – Tackling the Integration Challenge.

Module-V: **9 hrs**

Tools: Working with Concept Maps – Scribe Note making tools

Text Book(s):

1.José Luis Bermúdez, "Cognitive Science: An Introduction to the Science of the Mind", 2014, Cambridge University Press, New York.
2.Neil Stillings, Steven E. Weisler, Christopher H. Chase and Mark H. Feinstein, "Cognitive Science: An Introduction", 1995, Second Edition, MIT press.

CSCE 832 KNOWLEDGE REPRESENTATION AND REASONING

L	S	P	C
3	0	0	3

Pre-requisite:

•Exposure to AI and formal languages

Objectives:

- *To explore various representation n and formalisms*
- *To understand algorithms for reasoning.*
- *To understand the problem solving in knowledge engineering tools*
- *To understand protégé tool*

Course Outcome:

- *Explain various knowledge representation formalism in real world problem solving*
- *Describe knowledge engineering tools in problem solving*
- *Implement a knowledge based system using Protégé*.
- *Explain algorithms for reasoning*

Module-I: **9 hrs**

Introduction: Key concepts – Need of knowledge representation and reasoning – Role of Logic – First order Logic – Syntax- Semantics- Pragmatics – Explicit and Implicit Belief – Expressing Knowledge.

Module-II: **9 hrs**

Resolution: Propositional Case – Handling Variables and Quantifiers – Dealing with Computational Intractability – Reasoning with Horn Clauses –Horn Clauses- SLD Resolution – Computing SLD Derivations.

Module-III: **9 hrs**

Reasoning: Procedural control of Reasoning – Facts and Rules – Rule formation and Search Strategy – Algorithm Design – Backtrack control – Negation as Failure – Rules in Production Systems.

Module-IV: **9 hrs**

Representation: Object Oriented Representation – Object and Frames – Frame Formalism – Structured Descriptions – Description Language – Meaning and Entailment – Computing Entailments – Taxonomy and classification.

Module-V: **9 hrs**

Languages and Tools: Working with LISP, Prolog – RDF Tools – Ontology tools.

Text Book:

1. *Ronald J.Brachman and H.J.Levesque, Knowledge Representation and Reasoning, Elsevier, Morgan Kaufman Publishers, 2004.*

Reference Book(s):

1. Deepak Khemani, A First Course in Artificial Intelligence, 2013, First Edition, McGrawHill.

2. Stuart J Russell and Peter Norvig, Artificial Intelligence – A Modern Approach, 2009, Third Edition, PHI.

CSCE 833 COMPUTATIONAL INTELLIGENCE

L	S	P	C
3	0	0	3

Pre-requisite:

- *Knowledge in Algorithms*

Objectives:

- *To understand the fundamentals of key intelligent systems technologies*
- *To understand hybrid intelligent systems*
- *To understand evolutionary computation*
- *To practice in an integration of intelligent systems technologies for engineering applications.*

Course Outcome:

- *Explain the fundamentals of key intelligent systems technologies*
- *Describe neural networks, fuzzy systems, and evolutionary computation.*
- *Explain the hybrid intelligent systems*
- *List the integration of intelligent systems technologies for engineering applications.*

Module-I: 9 hrs

Introduction: Computational Intelligence: Intelligence machines -Computational intelligence paradigms –History- Expert Systems: Rule-based expert systems – Uncertainty management - Fuzzy expert systems: Fuzzy sets and operations of fuzzy sets - Fuzzy rules and fuzzy inference - Fuzzy expert systems

Module-II: 9 hrs

Artificial Neural Networks: Fundamental neurocomputing concepts: artificial neurons, activation functions, neural network architectures, learning rules - Supervised learning neural networks: multi-layer feedforward neural networks, simple recurrent neural networks, time-delay neural networks, supervised learning algorithms - Unsupervised learning neural networks: self-organizing feature maps - Radial basis function networks - Deep neural networks and learning algorithms

Module-III: 9 hrs

Evolutionary computation: Representation: Chromosomes-fitness functions- selection mechanisms -Genetic algorithms: crossover and mutation - Genetic programming

Module-IV: 9 hrs

Hybrid Intelligent Systems: Neural expert systems -Neuro-fuzzy systems -Evolutionary neural networks

Module-V: **9 hrs**

Applications and case studies: Printed Character Recognition – Inverse Kinematics Problems – Automobile Fuel Efficiency Prediction – Soft Computing for Color Recipe Prediction-Case studies

Laboratory Components:
Skills to be acquired:

- *Gain a working knowledge of knowledge-based systems*
- *Understand neural networks, fuzzy systems, and evolutionary computation*
- *Apply intelligent systems technologies in a variety of engineering applications;*

Lab Software Requirements:

- *Implement typical computational intelligence algorithms in MATLAB*

Text Book:

1. *A.P. Engelbrecht, Computational Intelligence: An Introduction, 2012,2nd Edition, John Wiley & Sons.*

Reference Books:

1. *S.Rajasekaran and G.A. Vijayalakshmi Pai, Neural Networks, Fuzzy logic and Genetic Algorithms-Synthesis and Applications, 2003, PHI Learning*
2. *Marsland S, Machine Learning: An Algorithmic Perspective, 2009, CRC Press.*
3. *S. Russell and P. Norvig, Artificial Intelligence – A Modern Approach,2010, Prentice Hall.*
4. *. J.S.R.Jang, C.T.Sun and E.Mizutani, Neuro-Fuzzy and Soft Computing, 2004, PHI, Pearson Education.*

CSCE 834 ARTIFICIAL INTELLIGENCE FOR AUTOMATION

Pre-requisite:

- *Knowledge about data structures and algorithms*

Objective:

- *To understand the various problem solving approaches*
- *To Understand the knowledge representation and reasoning techniques*
- *To Understand the handling of uncertain knowledge*

Outcome:

- *Apply search techniques to solve real world problems*
- *Explain the importance of knowledge representation*

Module-I: **8 hrs**

Introduction To Problem Solving :Problem-Solving Agents, Example Problems, Searching for Solutions, Uninformed Search Strategies, Breadth-first search, Uniform-cost search, Depth-first search, Depth-limited search, Iterative deepening depth-first search, Bidirectional search. Informed (Heuristic) Search Strategies, Greedy best-first search, A* search, Heuristic Functions, The effect of heuristic accuracy on performance.

Module-II: **8 hrs**

Beyond Classical Search: Local Search Algorithms and Optimization Problems, Hillclimbing search, Simulated annealing, Local beam search, Genetic algorithms, Local Search in Continuous Spaces, Searching with Nondeterministic Actions, Searching with Partial Observations, Online Search Agents and Unknown Environments.

Module-III: **8 hrs**

Knowledge Representation: Ontological Engineering, Categories and Objects, Events, Mental Events and Mental Objects, Reasoning Systems for Categories, Semantic networks, Description logics, Reasoning with Default Information, Truth maintenance systems.

Module-IV: **8 hrs**

Uncertain knowledge and reasoning :Quantifying Uncertainty, Acting under Uncertainty, Basic Probability Notation, Inference Using Full Joint Distributions, Bayes' Rule and Its Use, Probabilistic Reasoning, Representing Knowledge in an Uncertain Domain, The Semantics of Bayesian Networks, Exact Inference in Bayesian Networks, Approximate Inference in Bayesian Networks, Inference by Markov chain simulation, Relational and First-Order Probability Models.

Module-V: **8 hrs**

Probabilistic Reasoning over Time: Time and Uncertainty, Inference in Temporal Models, Hidden Markov Models, Kalman Filters, Dynamic Bayesian Networks, Keeping Track of Many Objects, Combining Beliefs and Desires under Uncertainty, The Basis of Utility Theory, Utility Functions, Multiattribute Utility Functions, Decision Networks, The Value of Information, Expert system architecture.

Text Book(s):

1. Stuart Russell and Peter Norvig, "Artificial Intelligence: A Modern Approach", PEARSON 3rd ed,2009.

Reference Book(s):

1. DAN.W.Patterson, "Introduction to Artificial Intelligence and Expert Systems", PHI, 2nd edition, 2009.

2. George.F.Luger, "Artificial Intelligence", Pearson Education, Asia, 3rd Edition,2009.

CSCE 835 NATURAL LANGUAGE PROCESSING

L	S	P	C
3	0	0	3

***Pre-requisite**:*

- *Knowledge of Programming Logic and Proof and Machine Learning*

Objectives:

- *To be able to tag a given word with basic language processing features*
- *To be able to discuss the current and likely future performance of several NLP applications;*
- *To be able to describe briefly a fundamental technique for processing language for several subtasks, such as morphological processing, parsing, word sense disambiguation etc.*
- *To understand how these techniques draw on and relate to other areas of Computer Science.*

Course Outcome:

- *Describe the current and likely future performance of several NLP applications.*
- *Explain how these techniques draw on and relate to other areas of Computer Science.*
- *Describe the processing language for subtasks*
- *List the language processing features*

Module-I: **9hrs**

Introduction to NLP : Knowledge in Speech and Language Processing -–Information Theory- Ambiguity Models and Algorithms, Language : N-gram Language Models - Evaluating Language Models, Thought and Understanding - The State of the Art and the Near term Future

Module-II: **9hrs**

Speech Tagging and Transducers: Part of Speech Tagging, Probability Basics: Hidden Markov - Maximum Entropy Models, Word Transducers: Finite State Transducers - Orthographic Rules - Finite-State Transducers Combining FST Lexicon Rules, Lexicon Free FSTs: The Porter Stemmer Human Morphological Processing.

Module-III: **9 hrs**

Syntax Parsing: Syntax Parsing: Grammar Formalisms - Tree Banks - Parsing with Context Free Grammars - Features and Unification, Statistical parsing: probabilistic CFGs (PCFGs) - Lexicalized PCFG

Module-IV: **9 hrs**

Semantic Analysis: Representing Meaning – Semantic Analysis - Lexical Semantics – Computational Lexical Semantics - Supervised – Dictionary based and Unsupervised Approaches - Compositional Semantics - Semantic Role Labelling - Semantic Parsing – Discourse Analysis.

Module-V: **9 hrs**

Case Studies and Applications: Machine Translation Language Similarities and Differences - Named Entity Recognition and Relation Extraction- IE using sequence labelling-Machine Translation (MT) - Basic issues in MT-Statistical translation - Word Alignment - Phrase-based Translation – Question Answering

Laboratory Components:
Skills to be acquired:

- *Sentence Extraction*
- *Medical Language Extraction*
- *Semantic Tutorial for Languages*

Lab Software Requirements:

- *Any Programming Language*

List of Exercises:

1. *Build language models and generate text from them*
2. *Recognize sentences and separate the words*
3. *Speech tagging*
4. *Identify and find all mentions in unstructured text of named entities*
5. *making a simple supervised WSD classifier*
6. *determining topics from text (Lexical analysis)*

Text Book(s):

1. *Daniel Jurafsky and James H. Martin, Martin Speech and Language Processing, 2008, 2nd Edition, Prentice Hall.*
2. *Christopher D. Manning and HinrichSchuetze, Foundations of Statistical Natural Language Processing, 1999, MIT Press.*

Reference Book(s):

1. *James Allen, Natural Language Understanding, 1994, 2nd Edition, Addison Wesley.*
2. *Steven Bird, Ewan Klein and Edward Loper, Natural Language Processing with Python, O'Reilly Media, 2009, 1st Edition.*

Web Resources:

1. *http://www.nltk.org/*
2. *http://www.ucl.ac.uk/internet-grammar/home.htm*

CSCE 836 INTRODUCTION TO ROBOTICS

L	S	P	C
3	0	0	3

Pre-requisite:

- *Mathematical Foundation of Computer Science and Basics of Machine Learning*

Objectives:

- *To understand agents,*
- *To learn the principles and applications of agents*
- *To design, build and program simple autonomous robots.*
- *To learn the working of robots*

Course Outcome:

- *Perform designing of various robotic arms*
- *Implement robot programs*
- *Apply and design robots*
- *Understand applications of agents*

Module-I: **9 hrs**

Agents, Paradigms, Sensors: Intelligent agents-Search overview-Adversarial search-Constraint satisfaction- Paradigms: Hierarchical, Reactive- Types of Sensors-Vision

Module-II: **9 hrs**

Knowledge representation, reasoning and planning: Predicate logic-Fuzzy logic-Classical planning-Planning and acting in real world-Navigation

Module-III: **9 hrs**

Learning: Decision making-Learning from examples-Knowledge in learning-Learning probabilistic models-Reinforcement learning-Deep learning

Module-IV: **9 hrs**

Robot Programming: Features of various programming methods, Robot Task planning: concept, different methods, robot learning, Mobile Robot: Introduction, obstacle Representatives, Motion Planning in fixed and Changing structure - Simple Programs.

Module-V: **9 hrs**

Industrial Applications and Case Studies: Application of robots: Material handling - Machine loading and unloading – Assembly – Inspection –Recent developments in Robotics- Safety Considerations.

Text Books:

1. *Robin.R.Murphy, Introduction to AI Robotics, MIT press, 2000.*
2. *Stuart J Russell and Peter Norvig, Artificial Intelligence – A Modern Approach, Third Edition, PHI,2010.*

Reference Books:

1. *Kortenkamp, D., Bonasso, R. P., & Murphy, R. (Eds.). Artificial intelligence and mobile robots. Menlo Park, CA: AAAI Press,1998*
2. *Mikell P Groover & Nicholas G Odrey, Mitchel Weiss, Roger N Nagel, Ashish Dutta, Industrial Robotics, Technology programming and Applications, McGraw Hill, 2012.*
3. *M. P. Groover, Mitchell Weis, Roger, N. Nagel, Nicholas G. Odrey, Industrial Robotics Technology, Programming and Applications, McGraw Hill, Int. 2008.*

CSCE 841 INTRODUCTION TO HUMAN COMPUTER INTERACTION

L	S	P	C
3	0	0	3

***Pre-requisites**:*

- *Basic Understanding of Graphical User Interface.*

Course Objectives:

- *To understand the components of Human Computer Interaction*
- *To understand the basics of interaction design*
- *To understand the fundamentals of Universal design*
- *To understand the software process*

Course Outcome:

- *List the components of Human Computer Interaction*
- *Design interactive models*
- *Implement a HCI based system and evaluate it.*
- *Explain the software process involved*

Module I: **9 hrs**

The Components: The Human : Human Memory – Thinking – Emotion – Individual Preferences – Psychology and Design of Interactive Systems. The Computer : Text Entry Devices – Pointing Devices – Display Devices – Devices for Virtual Reality and 3D interaction – Physical Controls, Sensors and Special Devices – Memory – Processing and Networks.

Module II: **9 hrs**

The Interaction: Models of Interaction – Frameworks and HCI- Ergonomics – Interaction Styles – Elements of WIMP interface – Interactivity – Context of interaction – User Experience; Interaction Design Basics : Design Definition – The process of Design – User Focus – Scenarios – Navigation Design – Screen design and Layout – Iteration and prototyping.

Module III: **9 hrs**

Software Process: HCI in the software process: The software life cycle – Iterative design and prototyping – Design rationale. Design Rules: Introduction – Principles to support usability – Standards – Guidelines – Golden rules and heuristics – HCI patterns

Module IV: **9 hrs**

Dialog Notations and design – Dialog semantics – Modeling rich interaction – Cognitive models – Evaluation techniques.

Module V: **9 hrs**

Universal Design: Universal design principles – multimodal interaction – design for diversity; User Support: requirements of user support – approaches to user support – adaptive help systems – designing user support systems.

Text Book:

1. *Alax Dix, Janet Finaly, Gregory D. Abowd, Russell Beale. Human Computer Interaction-Third Edition – Pearson Prentice Hall Publishers*.

Reference Book:

1. *Jonathan Lazar. Research Methods in Human–Computer Interaction - John Wiley &Sons(2009)*

MOOC

1. *NPTEL Course on Human Computer Interaction (HCI) : http://nptel.ac.in/courses/106103115/*

CSCE 842 PRINCIPLES OF INTERACTION DESIGN

L	S	P	C
3	0	0	3

Pre-requisites:

- *Basic Understanding of Human-Computer Interaction methodology and GUI styles*

Course Objectives:

- *To focus on creating interfaces, systems,*
- *To analyse the devices revolving around user behaviour.*
- *To explore the interaction design process*
- *To explain how interaction designers work and the tools used for principles of interaction design*

Course Outcome:

- *Describe creating interfaces and systems*
- *Explain the devices revolving around user behaviour.*
- *List the interaction of design process*
- *Recognize the designers work and the tools they use for interaction design*

Module - I **9 hrs**

Introduction: Goals of System Engineering – Goals of User Interface Design – Motivations of Human factors in Design – High Level Theories –Object-Action Interface Design - Three Principles – Guidelines for Data Display and Data Entry

Module - II **9 hrs**

Managing Design Process: Organizational Design to Support Usability – The Three Pillars of Design Development Methodologies- Ethnographic Observation – Participating Design- Scenario Development- Social Impact Statement for Early Design – Legal Issues- Reviews – Usability Testing and laboratories- Surveys- Acceptance tests – Evaluation during Active use- Specification Methods- Interface – Building Tools- Evaluation and Critiquing tools

Module - III **9 hrs**

Manipulation and Virtual Environments: Introduction-Examples of Direct Manipulation Systems –Explanation of Direct Manipulation-Visual Thinking and Icons – Direct manipulation Programming – Home Automation- Remote Direct Manipulation- Virtual Environments- Task-Related Organization – Item Presentation Sequence- Response Time and Display Rate – Fast Movement Through Menus- Menu Layouts- Form Filling – Dialog Box – Functionality to Support User's Tasks – Command Organization Strategies – Benefits of Structure- Naming and Abbreviations – Command Menus- Natural Language in Computing.

Module- IV **9 hrs**

Interaction Devices: Introduction – Keyboards and Functions – Pointing Devices- Speech recognition ,Digitization and Generation – Image and Video Displays – Printers – Theoretical Foundations –Expectations and Attitudes – User Productivity – Variability – Error messages – Non anthropomorphic Design –Display Design – color-Reading from Paper versus from Displays- Preparation of Printed Manuals- Preparation of Online Facilities.

Module-V **9 hrs**

Windows Strategies and Information Search: Introduction- Individual Window Design- Multiple Window Design- Coordination by Tightly –Coupled Window- Image Browsing- Personal Role Management and Elastic Windows – Goals of Cooperation – Asynchronous Interaction – Synchronous Distributed – Face to Face- Applying Computer Supported Cooperative Work to Education – Database query and phrase search in Textual documents – Multimedia Documents Searches – Information Visualization – Advance Filtering Hypertext and Hypermedia – World Wide Web- Genres and Goals and Designers – Users and their tasks – Object Action Interface Model for Web site Design

Text book:

1. *Ben Shneiderman , " Designing the User Interface", 5th Edition, Addison-Wesley, 2010*

Reference books:

1. *Barfied , Lon , "The User Interface : Concepts and Design", Addison – Wesley.*
2. *Wilbert O. Galiz , "The Essential guide to User Interface Design", Wiley Dreamtech.*
3. *Jacob Nielsen, "Usability Engineering ", Academic Press.*
4. *Alan Dix et al, "Human - Computer Interaction ", Prentice Hall, 2012.*

CSCE 843 WEB ACCESSIBILITY

L	S	P	C
3	0	0	3

Pre-requisites:

- *Basic Understanding of Web Technologies*.

***Course Objectives*:**

- *To understand the components of web accessibility*
- *To understand Accessibility standards and Evaluation Processes.*
- *To acquire skills to evaluate and make the web contents accessible*.
- To understand web content readability

Course Outcome:

- *Describe the components of web accessibility*
- *Explain accessibility standards and evaluation processes.*
- *Perform skills to evaluate and make the web contents accessible.*
- *Explain readability of web contents*

Module I: **9 hrs**

Introduction: The need for Web accessibility – Universal Design – Types of Disabilities and Accessibility Requirements – Introduction to Guidelines and Standards – Accessibility Myths – Assistive Technologies - Benefits of Accessible Design.

Module II: **9 hrs**

Web Content Accessibility Guidelines: Web Contents Accessibility Guidelines – WCAG 1.0 vs WCAG 2.x – Principles: Perceivable – Operable – Understandable – Robust – Levels A, AA, AAA – WCAG standards evaluation tools and Comparative analysis.

Module III: **9 hrs**

Universal Design of Components: Component Specific Requirements : Images – Hyperlinks – Color contrast – Audio and Video components – Tables – Forms – Document Accessibility – Dynamic web contents Accessibility – Mobile Content Accessibility.

Module IV: **9 hrs**

WAI –ARIA and Other Standards: Web Accessibility Initiatives – Accessible Rich Internet Applications – Features. ATAG : Authoring tools accessibility guidelines – UAAG : User Agents Accessibility Guidelines – Accessibility Laws.

ModuleV: **9 hrs**

Readability: Text Readability – Evaluation : Flesch-Kincaid - Gunning Fog - SMOG index – Dale Challe Score – Other Readability Scores – Web Content Readability. Security and Accessibility : Web Security Concerns for Persons with Disabilities – Making Security accessible.

Laboratory Components:

Skills to be acquired:

1. *Evaluating the Web Accessibility*
2. *Designing Accessible Pages*

Lab Software Requirements:

1. *Open Source Web Development tools.*

List of Exercises:

1. *Exercises to make the student to acquire web accessibility evaluation skills.*
2. *Exercises to make the student to acquire accessibility evaluation comparison skills.*
3. *Exercises to make the student to acquire skills related with accessible page design.*
4. *Exercises to make the student to acquire skills related with design accessible mobile web apps.*

Reference Book:

1. *Simon Harper, YelizYesilada (Editors) . Web Accessibility: A Foundation for Research – Springer Publications.*

Web Resources:

1. *W3C Resources on Web Accessibility https://www.w3.org/WAI/intro/accessibility.php*
2. *WebAIM(Web Accessibility in Mind) Resources : http://webaim.org*

Online Courses

1. *Introduction to Web Accessibility by Google : https://webaccessibility.withgoogle.com/course*

CSCE 844 CONTEXT AWARE COMPUTING

L	S	P	C
3	0	0	3

Pre-requisites:

- *Basic Knowledge of mobile computing and distributed systems*

Course Objectives:

- *To be familiar with the components of Context aware computing*
- *To Acquire skills to build context aware applications*
- *To learn Context aware sensor networks*
- *To understand context aware security systems*

Course Outcome:

- *Explain the components of Context aware computing*
- *Design skills to build context aware applications*
- *Explain the context aware sensor networks*
- *Explain context aware security systems*

Module I **9 hrs**

Introduction: Context, Context awareness and Situations – Analogies – Elements of a Context aware System – Architecture – Infrastructure, Middleware and Toolkits.

Module II **9 hrs**

Context aware mobile devices – Location bases serviced – ambient services – e-communities – Interaction in context aware systems.- Enhancing context-aware mobile services.

Module III **9 hrs**

Context aware mobile software agents – Context-aware addressing and communication for people, things and Software agents.

Module IV **9 hrs**

Context aware sensor networks – Context awareness and mirror-world models – Constructing context aware pervasive systems : Declarative approaches and design patterns.

Module V **9 hrs**

Context Aware Security: Traditional Security issues – models – context aware security systems – context aware safety.

References:

1.Seng W. Loke, Context aware pervasive systems-Architecture for a new breed of applications, Auerbach publications, 2006.
2. Context-Aware Mobile and Ubiquitous Computing for Enhanced Usability: Adaptive Technologies and Applications: Dragan Stojanović, IGI Global Snippet, 2009.
3. Rocha, Ricardo CoutoAntunes da, Endler, Markus, Context Management for Distributed and Dynamic Context-Aware Computing, Springer,2012.

CSCE 845 DATA VISUALIZATION

L	S	P	C
3	0	0	3

Pre-requisites:

- *Basic Understanding of Interaction design.*
- *Basic Understanding of Programming*

Course Objectives:

- *To understand the Objectives of Data Visualization*
- *To acquire skills in professional data visualization techniques*
- *To understand the fundamentals of Universal design*
- To understand data abstraction

Course Outcome:

- *Explain the Objectives of Data Visualization*
- *List the skills in professional data visualization techniques*
- *Explain the fundamentals of Universal design*
- *Describe the data abstraction techniques*

Module I*:* **9 hrs**

Introduction: Introduction to Data Visualization – History of Visualization – Need for Visualization - Interactive Visualization – Web Specific Components – Common Types of Data Visualization – Data Visualization and Infographics – Dashboards.

Module II: **9 hrs**

Data Abstraction : Data Set types – Attribute Types – Semantics. Task Abstraction : Actions – Targets. Charts – Data Preprocessing - Choosing the optimal charts – Making charts effective – Context in Visualization - Analyzing Visual Patterns – Beautiful vs Useful Design - Cognitive Load Theory - Responsive Design principles.

Module III: **9 hrs**

Perception and Visualization – Perceptual processing – Metrics - The Visualization Process – Visual Variables – Taxonomies. Visualization validation : Threats to Validity – Validation approaches .

Module IV: **9 hrs**

Visualization Techniques: Spatial Data Visualization - Multivariate Data Visualization Techniques : Point-Based – Line based – Region based – Hybrid Techniques – Visualization techniques for trees, graphs and networks – Text and Document Visualization.

Module V: **Universal Design** **9 hrs**

Interaction concepts – Interaction techniques: screen space – object space – data space – attribute space – Interaction Control – Web specific visualization with the case study of D3.

Laboratory Components:

Skills to be acquired:

1. *Building effective visualization*
2. *Design and development of interactive visualization*

Lab Software Requirements:

1. *Open Source Web Development and visualization tools.*

List of Exercises:

1. *Exercises to make the student to acquire chart building skills with code.*
2. *Exercises to make the student to acquire skills to build effective infographics.*
3. *Exercises to make the student to acquire skills related with web based visualization.*
4. *Exercises to make the student to acquire skills to handle various visualization libraries such as D3*
5. *Exercises to make the student to acquire advanced visuzliation mechanisms such as Dendrogram, Node-link tree etc.*

Text Book:

1. *Matthew O.Ward Interactive Data Visualization: Foundations, Techniques, and Applications AK Peters / CRC Press.*
2. *Mico Yuk. Data Visualization For Dummies*
3. *Tamara Munzner. Visualization Analysis and Design AK Peters Publications.*

Web Resources:

1. http://chimera.labs.oreilly.com/books/1230000000345/ch01.html#_why_write_code (Interactive Data Visualization for the web – Open Book)

CSCE 846 SOCIAL COMPUTING SYSTEMS

L	S	P	C
3	0	0	3

Pre-requisites:

- Basic Understanding of HCI Concepts

Course Objectives:

- To understand the components of Social computing systems.
- To acquire skills to analyse the social network data.
- To understand embedding concept
- To understand statistical tools

Course Outcome:

- Understanding the components of Social computing systems.
- Acquiring skills to analyse the social network data.
- Describe embedding needs
- Perform statistical analysis

Module I: **9 hrs**

Introduction: Introduction to Social computing – Human centred computing: Methods – benefits – incentives – computer supported cooperative work – collaboration platforms- Introduction to Crowd sourcing: Components – activities.

Module II: **Social Network methods** **9 hrs**

Social Network methods: Social network data – Graphs to represent social relations – Matrices to represent social relations – working with network data – Connection: Networks and actors – basic demographics – density – reachability – connectivity – distance.

Module III: **9 hrs**

Embedding: Introduction – density – reciprocity – transitivity – clustering – Group external and internal ties – Krackhardt's graph theoretical dimensions of hierarchy - Ego networks.

Module IV: **9 hrs**

Opinion Formation: Opinion Formation Models – Cultural and language dynamics – crowd behavior patterns – Hierarchies formation – Propagation models in social networks; Advertisements and social network systems.

Module V: **9 hrs**

Statistical tools: Statistical tools to analyze social network data – Sentiment analysis – Recommendation systems – Link prediction in social networks.

Ref Books:

1. *Cioffi-Revilla, Claudio. Introduction to Computational Social Science, Springer, 2014.*
2. *Robert Hanneman and Mark Riddle. Introduction to social network methods. Online Open Book.*
3. *Matthew A. Russell. Mining the Social Web: Data Mining Facebook, Twitter, Linkedin, Google+, Github, and More, 2nd Edition, O'Reilly Media, 2013.*
4. *Jennifer Golbeck, Analyzing the social web, Morgan Kaufmann, 2013.*

MOOC:

https://www.coursera.org/learn/social-computing

CSCE 851 AUTOMATA, COMPUTATBILITY AND COMPLEXITY

L	S	P	C
3	0	0	3

Pre-requisite:

- *Knowledge of discrete mathematics, proofs, data structures and algorithms*

Objectives:

- *To introduce concepts in automata theory*
- *To design recognizers for different formal languages*
- *To determine decidability*
- *To determine complexity of computational problems.*

Course Outcome:

- *Use regular language and grammar for designing real world problems*
- *Perform computational complexity analysis*
- *Define Turing machines performing simple tasks*.
- *Understand formal languages*

Module-I: **9 hrs**

Introduction to theory of computation and Finite Automata: Mathematical preliminaries – Basic concepts – Applications – DFA – NFA – Equivalence – Reduction of states.

Module-II: **9 hrs**

Regular Language (RL) , Regular Grammar, Properties of RL: Regular Expressions (RE) – Relation between RE and RL – Regular Grammars – Properties – Context Free Grammars (CFG)

Module-III: **9 hrs**

Simplification of Context Free Grammars & Normal Forms: Methods for transforming Grammars – Chomsky and Greibach Normal Forms Push Down Automata (PDA)Non-deterministic PDA – PDA and Context Free Languages (CFL) – Deterministic PDA and CFL

Module-IV: **9 hrs**

Properties of CFL and Turing Machines: Pumping lemma –closure properties Turing machines (TM) – the standard TM – Turings' thesis – Linear Bounded Automata

Module-V: **9 hrs**

Algorithmic computation: Poblems that cannot be solved by TM – Undecidable problems for recursively enumerable and context-free languages- Post correspondence problem

Text Book:

1. *Peter Linz, An introduction to Formal Languages and Automata, 2012, Fifth Edition, Jones & Bartlett Learning.*

Reference Books

1. *Automata, Computability and Complexity: Theory and Applications, Pearson Education India; 1 edition 2012.*
2. *Moore, Cristopher, and Stephan Mertens.* The Nature of Computation. *Oxford University Press, 2011.*
3. *Arora, Sanjeev, and Boaz Barak. Computational Complexity: A Modern Approach. Cambridge University Press, 2009*

Web resources

1. www.Automatatutor.com

MOOC

1. NPTEL COURSE ON Formal languages and Automata Theory - https://nptel.ac.in/courses/111103016/

CSCE 852 MATHEMATICAL LOGIC FOR COMPUTER SCIENCE

L	S	P	C
3	0	0	3

Pre-requisite:

- *Exposure to Automata Theory*

Objectives:

- *To learn the basics of mathematical logic*
- *To apply those concepts in various Computer Science domain*
- *To learn knowledge based applications*
- *To learn logics based reasoning*

Course Outcome:

- *Describe the mathematical logic for knowledge representation*
- *Analyse problems in various Computer Science fields*
- *Implement knowledge based applications*
- *Explain logics based reasoning*

Module-I: **9 hrs**

Introduction: Objective – History – Terminology – Propositions, Beliefs and declarative sentences – Contradictions - Formalization – Formalizing the language – Extending the language

Module-II: **9 hrs**

Propositional Logic: Formulas, Models, Tableaux – Deductive systems – Resolution – Binary Decision Diagrams -

Module-III: **9 hrs**

First order Logic: Formulas, Models, Tableaux – Deductive systems - Gentzen system – Hilbert system – C- Rule - Formulas to Logic, Horn clauses in SLD resolution – Search Rules

Module-IV: **9 hrs**

Temporal Logic: Introduction – Syntax and semantics – Models of Time – Linear Temporal Logic – Binary temporal operators and its Axioms

Module-V: **9 hrs**

Tools: Working with Prolog programs – Standard ML programs

Text Books:

1. *Steve Reeves and Michael Clarke, "Logic for Computer Science", 2003, Addison – Wesley.*
2. *M Ben Ari," Mathematical Logic for Computer Science", 3rd Edition, 2015, Prentice Hall.*

CSCE 853 COMPLEXITY THEORY

L	S	P	C
3	0	0	3

Course Pre-requisite:

Prior knowledge of following materials is assumed. A brief overview of basics will be given in the first lecture. Other than this, the course should be self-contained.

- *Computation Theory*
- *Automata Theory*
- *Linear Algebra, Algorithms*

Course Objectives:

- *To understand the fundamental concepts of Complexity theory*
- *To provide the concepts of complexity classes and reduction problems*
- *To enumerate NP-complete and NP-equivalent problems*
- *To discuss complexity of approximation problems and black box problems*
- *To describe communication complexity*

Course Outcome:

- *Explain the fundamental concepts of Complexity theory*
- *Explain the concepts of complexity classes*
- *Describe the reduction problems*
- *Explain the NP complete and equivalent problems*

Module-I: **9 hrs**

Introduction: Complexity Theory – Algorithmic Problems and Their Complexity – Algorithmic Problems – Some Important Algorithmic Problems – Measuring Computation Time

Module- II: **9 hrs**

Complexity classes: Randomized Algorithms – The Fundamental Complexity Classes for Algorithmic Problems – The Fundamental Complexity Classes for Decision Problems Reductions: Algorithmic Relationships between Problems

Module-III: **9 hrs**

NP-Completeness: Theory of NP-Completeness – Fundamental Considerations Problems in NP – Alternative Characterizations of NP – NP-complete and NP-equivalent Problems – Traveling Salesperson Problems – Knapsack Problems – Scheduling Problems

Module- IV: **9 hrs**

Complexity of Approximation Problems: Complexity Classes – Approximation Algorithms – Approximation-Preserving Reductions. Black Box Problems: Black Box Optimization

Module-V: **9 hrs**

Communication Complexity: The Communication Game – Nondeterministic Communication Protocols– Communication Complexity and Computation Time

Text Book(s):

1. *Ingo Wegener, "Complexity Theory: Exploring the limits of efficient algorithms", Springer-Verlag Berlin Heidelberg, 2005.*
2. *Sanjeev Arora, "Computational Complexity - A Modern Approach", Cambridge University Press, 2009.*

Reference Book(s):

1. *Neil F.Johnson, "Simply Complexity: A Clear Guide to Complexity Theory", Oneworld Publications, 2007.*
2. *OdedGoldreich, "Computational Complexity: A Conceptual Perspective", Cambridge University Press, 2008.*

CSCE 854 COMPUTABILITY THEORY

L	S	P	C
3	0	0	3

Pre-requisite:

- *Exposure to Automata Theory and basic logic*

Objectives:

- *To learn the basics of mathematical logic*
- *To understand the computability theory*
- *To apply those concepts in various Computer Science domain*
- *To understand MOLTAP tool*

Course Outcome:

- *Explain the basics of mathematical logic*
- *Evaluate those concepts in various Computer Science domain*
- *Explain the computability theory*
- *Demonstrate MOLTAP tool*

Module-I: 9 hrs

Computability Theory: Enumerability – Diagonalization – Uncomputability – Abacus Computability – Recursive functions – Recursive sets and relations – Equivalent definitions of computability

Module-II: 9 hrs

Logic: First order Logic – Syntax and Semantics – Undecidability of First Order Logic – Monadic and Dyadic Logic – Second order Logic- Modal Logic and Provability

Module-III: 9hrs

Logic Proofs: Models - The Existence of models – Proofs and completeness – Indefinitability, undecidability, Imcompleteness – Unprovability of consistencey

Module-IV: 9hrs

Logic Theorems: Normal Forms – Disjunctive and Prenex Normal forms – Skolem Normal Form - Herbrand's Theorem - Craig Interpolation Theorem – Ramsey's Theorem

Module-V**: 9hrs**

Tools: Working with Prolog –FLORID - MOLTAP

Text Book:

1. George S Boolos, John P Burgess and Richard C Jeffrey, "Computability and Logic", Fifth Edition, 2007, Cambridge University Press, New York.

Reference Book:

1. *Martin Davis, "Engines of Logic: Mathematicians and the origin of computers", 2001, Norton*

CSCE 855-ADVANCED COMPILER DESIGN

L	S	P	C
3	0	0	3

Pre-requisite:

- *Knowledge of data structures, algorithms, compilers, architecture, assembly language programming*

Objectives:

- *To learn the advanced issues in the design of complier*
- *To learn implementation of compilers*
- *To understand the intermediate representation and optimization*
- *To understand the data flow analysis and scalar optimization*

Course Outcome:

- *Explain the advanced issues in the design of compliers*
- *Describe the implementation of compilers*
- *Implement the intermediate representation and optimization*
- *Explain the data flow analysis and scalar optimization*

Module-I: 9 hrs

Compilers and Scanner: Overview of compilation –compiler structure – Translation - Introduction to Scanners – Regular expressions – Scanner – Implementing scanners

Module-II: 9 hrs

Parser and Context sensitive analysis: Expressing syntax – top down parsing – Bottom Up Parsing – Practical issues. Type systems – attribute grammar framework – Adhoc SDT

Module-III: 9 hrs

Intermediate Representation and Optimization: Graphical IR – Linear IR – Mapping values to names – Symbol Table Scope of optimization – Local – Regional – global – Interprocedural optimization

Module-IV: 9 hrs

Data flow analysis and Scalar optimization: Iterative data flow analysis – Single static assignment - Interprocedural analysis Useless code elimination - code motion – specialization – redundancy elimination – other transformations

Module-V: 9 hrs

Instruction selection, scheduling and register allocation: Code generation – tree pattern matching – peephole optimization -Instruction scheduling – local list – Regional scheduling- Register allocation – issues – local allocation – global allocation

Text Book:

1. *Keith D Cooper and Linda Torczon, Engineering a Compiler, Morgan Kaufmann, 2 edition, 2011*

Reference Book:

1. *Advanced Compiler Design and implementation, Steven Muchnick, .Morgan Kaufmann Publishers , 1997*

MOOC: *https://in.udacity.com/course/compilers-theory-and-practice--ud168*

CSCE 861 DESIGN OF MODERN HEURISTICS

L	S	P	C
3	0	0	3

Pre-requisite:

- *Knowledge of fundamental concepts of Designing Strategies*

Objectives:

- *To enable the students to understand the optimisation methods*
- *To design application of optimization techniques*
- *To practise the optimization techniques using search strategies*
- *To learn heuristics algorithms*

Course Outcome:

- *Identify the importance of optimisation methods*
- *Design optimisation techniques for real world problems*
- *List the results obtained through optimisation*
- *Describe heuristics algorithms*

Module-I: **9 hrs**

Optimization Problems: Introduction - Solution Process – RecognizingProblems, Defining Problems, Constructing Models, Solving Models Validating Solutions, Implementing Solutions - Problem Instances- Search Spaces - Metrics, Neighborhoods, Fitness Landscapes, Optimal Solutions - Properties of Optimization Problems - Problem Difficulty, Locality, Decomposability

Module-II: **9 hrs**

Optimization Methods: Analytical and Numerical Optimization Methods- Optimization Methods for Linear, Continuous Problems - Linear Optimization Problems, Simplex Method Optimization Methods for Linear, Discrete Problems

Module-III: **9 hrs**

Heuristics: Introduction-Heuristics – Applications- Heuristic Optimization Methods - Heuristics, Approximation Algorithms, Modern Heuristics

Module-IV: **9 hrs**

Search Strategies: Local Search Methods - Recombination-Based Search - Genetic Algorithms, Estimation of Distribution Algorithms, Genetic Programming

Module-V: **9 hrs**

Case Study: The Optimal Communication Spanning Tree Problem - Biasing Modern Heuristics for OCST Problems - Search Operator - Representation - Initialization - Using an MST as Initial Solution

Text Book(s):

1. *Rothlauf, Franz, Design of Modern Heuristics - Principles and Application, Nature Computing Series, Springer 2011.*

Reference Books:

1. *Xiaopeng Fang, Engineering Design Using Genetic Algorithms, Iowa State University 2007.*
2. *David E. Goldberg, Genetic Algorithms in Search, Optimization, and Machine Learning, Addison -Wesley publishing company, Inc., 1st Edition, 1989.*

CSCE 862 EVOLUTIONARY ALGORITHMS

L	*S*	*P*	*C*
3	*0*	*0*	*3*

Pre-requisite:

- *Basic knowledge in programming competence.*

Objectives:

- *To master the basics of EA*
- *To learn the techniques for solving optimization problems through EA*
- *To learn genetic programming*
- *To learn multi objective optimization*

Course Outcome:

- *Design an evolutionary technique to a real problem by choosing the parameters for optimal performance*
- *Evaluate the job shop scheduling and routing problems using genetic algorithms*
- *Implement genetic programming and solve classic GP problems*
- *Explain multi objective optimization*

Module-I: **9 hrs**

Introduction to EA: EA Basics: Introduction to Evolutionary Computation: Biological evolution and genetics- artificial evolution, Basics of optimization and search space , evolutionary computation and AI, lasses of EA- Structure of EA - Advantages of Evolutionary Computation -.Hybridization with Other Methods - Parallelism - Applications of Evolutionary Computation - computational time complexity of the algorithms.

Module-II: **9 hrs**

Genetic Algorithm: A simple genetic algorithm- Biological background - Encoding- Fitness Evaluation techniques - Search Operators: Crossover, mutation- Selection Schemes: Fitness proportional selection and fitness scaling, ranking, tournament selection, Selection pressure and its impact on evolutionary search. The Schema Theorem in GA- Building Block Hypothesis - Applications of GA in Engineering problems, job shop scheduling and routing problems

Module-III: **9 hrs**

Advanced operators and techniques in Genetic Algorithm: Inversion and reordering operators – Micro operators- Population sizing - Advanced selection schemes- Types of GA- Parallel & Distributed GA- Hybrid GA- Adaptive GA – Genetic algorithm implementation using MATLAB.

Module-IV: **9 hrs**

Genetic Programming: Genetic programming and how it differs from GA., The creation and regeneration of populations: crossover, mating, and reproduction Classic GP problems and their solutions:

Module-V: **9 hrs**

Multi-objective Optimization: Linear and nonlinear multi-objective problems, convex and non – convex problems, dominance – concepts and properties, Pareto – optimality, Use of Evolutionary Computations to solve multi objective optimization. NSGA, SPEA ,etc. for multi-objective optimization.

Text Book(s):

1. *Sivanandam, S.N., Deepa, S. N ,Introduction to Genetic Algorithms, Springer, 2011*
2. *Deb, K.: Multi-Objective Optimization using Evolutionary Algorithms, John Wiley and Son, 2002.*
3. *John Koza, Genetic Programming, MIT Press, 2005*

Reference Book(s):

1. *D. E. Goldberg, Genetic Algorithm In Search, Optimization And Machine Learning, New York: Addison _ Wesley (1989)*

CSCE 863 LINEAR OPTIMIZATION

L	*S*	*P*	*C*
3	*0*	*0*	*3*

Pre-requisite:

- *Fundamental knowledge of calculus and linear programming problem*

Course Objectives:

- *To understand the fundamental concepts of Operation Research and Optimization*
- *To Provide the concepts of various LPP methods and duality*
- *To Enumerate transportation and assignment problem*
- *To Discuss sequencing theory*
- *To Describe network routing and scheduling*

Course Outcome:

- *Explain the fundamental concepts of Operation Research and Optimization*
- *Evaluate transportation and assignment problem*
- *Explain network routing*
- *Implement sequencing theory*

Module-I: 9 hrs

Operations Research: Introduction – Applications of OR – Linear Programming Problem: Introduction – Formulation of Linear Programming Model- Illustration on Mathematical Formulation of LPP – Graphical Solution – General LPP – Canonical and Standard forms of LPP Optimization**:** Introduction – Classification of Optimization Problems– Mathematical models in Optimization – Types of Optimization Models

Module-II 9 hrs

LPP Methods: Introduction –Simplex method- Fundamental Properties of Solution – The Computational Procedure – Use of Artificial Variables – Degeneracy in LPP – Big M Method – Applications of Simplex Method Duality**:** Duality LPP – General Prime-Dual Pair – Formulating a Dual Problem – Primal-Dual Pair in Matrix Form – Two-Phase Method

Module-III: 9 hrs

Transportation Problem: Introduction – Mathematical Model for Transportation Problem – Types: Balanced Transportation Problem – Unbalanced Transportation Problem – Transportation algorithm: MODI Method – Applications of TP Assignment Problem**:** Introduction – Mathematical Formulation of the Problem – Types of Assignment Problem – Hungerian Method – Applications of AP

Module-IV: 9 hrs

Sequencing Problem: Introduction – Problem of Sequencing – Basic Terms used in Sequencing – Processing *n* Jobs through Two Machines – Processing *n* Jobs through *k* Machines

Module-V: **9 hrs**

Network Routing: Network Flow Problems – Minimal Spanning Tree Problem – Shortest Route Problems – Applications of Shortest Route Problem Network Scheduling**:** Introduction– Logical Sequencing – Concurrent Activities – Critical Path Analysis – PERT – CPM

Text Book(s):

1. *R.Panneerselvam, "Operations Research", PHI, 2006.*
2. *Kanti Swaroop, Man Mohan and P.K. Gupta, "Operations Research", Sultan Chand and Sons, 2005.*
3. *Hamdy A Taha, "Operations Research –An Introduction", 10th Edition, Prentice Hall India, 2017.*

Reference Book(s):

1. *Philips, Ravindran and Solberg, "Operations Research", John Wiley, 2002.*

CSCE 864 NATURE INSPIRED ALGORITHMS

L	*S*	*P*	*C*
3	*0*	*0*	*3*

Pre-requisite:

- *Basic Knowledge of optimization theory*

Objectives:

- *To enable the students to understand the design of nature inspired algorithms*
- *To explore the* Meta-heuristic *techniques.*
- *To understand swarm intelligence algorithms*
- *To understand physics chemistry based algorithms*

Course Outcome:

- *Explain the design of nature inspired algorithms*
- *Implement the Meta-heuristic techniques.*
- *Explain swarm intelligence algorithms*
- *Describe physics chemistry based algorithms*

Module-I: **9 hrs**

Single solution based Meta-heuristics: Introduction-Newton's Method – Optimization: Gradient-Based Algorithms, Hill Climbing with Random Restart - Search for Optimality - Nature Inspired Meta heuristics - A Brief History of Metaheuristics

Module-II: **9 hrs**

Evolutionary Algorithm: Analysis of Optimization Algorithms - Nature-Inspired Algorithms – Cultural Algorithm- Co Evolutionary Algorithm - Simulated Annealing

Module-III: **9 hrs**

Swarm Intelligence: Swarm Intelligence – ACO Algorithm - PCO Algorithm– Ant and Bee Colony Optimization based Algorithm – Accelerated PSO - Convergence Analysis

Module-IV: **9 hrs**

Physics and Chemistry based Algorithms: Quantum computational complexity and chemistry - Digital quantum simulation - Hybrid Algorithm – Krill Herd (KH) algorithm

Module-V: **9 hrs**

Case studies: Simulated annealing – Particle swarm Optimization – Differential Evolution - Firefly algorithm - Cuckoo search – Bat algorithm – Flower pollination algorithm

Reference Books:

1. Xin-She Yang, Nature-Inspired Optimization Algorithms, 2nd Edition, Elsevier, 2016.
2. Nazmul H. Siddique, HojjatAdeli, Nature-Inspired Computing: Physics and Chemistry-Based Algorithms, Taylor & Francis, 2016.
3. Omid Bozorg-Haddad, Advanced Optimization by Nature-Inspired Algorithms, Studies in Computational Intelligence, Springer, 2017.

Web Resources:

1. http://www.academia.edu/7395054/Nature-Inspired_Optimization_Algorithms
2. http://www.cleveralgorithms.com/nature-inspired/index.html
3. http://onlinelibrary.wiley.com/doi/10.1002/adma.201002689/full

CSCE 871 ADVANCES IN COMPUTER GRAPHICS

L	*S*	*P*	*C*
3	*0*	*0*	*3*

Pre-requisite:

- *Fundamental Knowledge in Mathematics, Computer Science and Computer Graphics*

Objectives:

- *Learn image synthesis techniques;*
- *Examine applications of modelling, design and visualization.*
- *Learn different color modelling and computer animation*
- *Learn hierarchical modelling and graphing file formats.*

Course Outcome:

- *Describe image synthesis techniques*
- *Implement color modelling*
- *Design computer animation techniques*
- *Implement hierarchical modelling techniques*

Module-I: **9 hrs**

Three-Dimensional Concepts - Three-Dimensional Display Methods - Parallel Projection - Perspective Projection-Depth Cueing - Visible Line and Surface – Identification - Surface Rendering - Exploded and Cutaway Views - Three-Dimensional and Stereoscopic Views- Three-Dimensional Graphics - Three-Dimensional - Polygon Surfaces - Curved Lines and Surfaces - Quadric Sutiaces – Superquadrics - Blobby Objects - Spline Representations - Interpolation and Approximation Splines - Cubic Spline Interpolation Methods - Bezier Curves and Surfaces - B-Spline Curves and Surfaces - Beta-Spline Continuity - Rational Splines - Conversion Between Spline Representations - Displaying Spline Curves and Surfaces - Sweep Representations - Constructive Solid-Geometry Methods – Octrees - BSP Trees - Fractal-Geometry Methods

Module-II: **9 hrs**

Three-Dimensional Geometric and Modeling Transformations: Translation - Rotation - Scaling - Other Transformations - Composite Transformations -Three-Dimensional Transformation Functions - Modeling and Coordinate Transformations - Three-Dimensional Viewing - Viewing Pipeline - Viewing Coordinates – Projections - View Volumes and General Projection Transformations – Clipping - Hardware Implementations - Three-Dimensional Viewing Functions

Module-III: **9 hrs**

Visible-Surface Detection Methods: Visible-Surface Detection Methods: Classification Of Visible –Surface Detection Algorithms, Back-Face Method, Depth-Buffer Method, A-Buffer Method, Scan-Line Method, BSP-Tree Method, Area-Subdivision Method, Octree Methods, Ray-Casting Method, Comparison of Visibility –Detection Methods, Curved Surfaces, Wire-Frame Visibility –Detection Functions

Module-IV **9 hrs**

Illumination Models and Surface : Illumination Models and Surface- Rendering Methods: Light Sources, Surface Lighting Effects, Basic Illumination Models, Transparent Surfaces, Atmospheric Effects, Shadows, Camera parameters, Displaying light intensities, Halftone patterns and dithering techniques, polygon rendering methods, ray-tracing methods, Radiosity lighting model, Environment mapping, Photon mapping, Adding surface details, Modeling surface details with polygons, Texture mapping, Bump mapping.

Module-V: **9 hrs**

Color models :Color models, color applications and Computer animation: Properties of light, Color models, Standard primaries and the chromaticity diagram, The RGB color model, The YIQ and related color models, The CMY and CMYK color models, The HSV color model, The HLS color model, Color Selection and applications.

Text Book(s):

1. *Hearn Baker, Computer Graphics with openGL, 4rd edition, Pearson publication.2010*
2. *James D Foley,Andries van dam,Steven K Feiner,John F Hughes, Computer graphics, Pearson Education 3rd edition, 2013*

Reference Book(s):

1. *Edward Angel: Interactive Computer graphics a top-down approach with openGL, Addison Wesley, 6th edition 2012*
2. *Advanced graphics programming using openGL: TomMcReynolds-David Blythe. Elesvier.MK, 2005*

CSCE 872 DIGITAL IMAGE PROCESSING

L	*S*	*P*	*C*
3	*0*	*0*	*3*

Pre-requisite:

- *Knowledge in Mathematics and computer graphics*

Objectives:

- *To understand the image fundamentals*
- *To understand the mathematical transforms necessary for image processing*
- *To study the image enhancement techniques.*
- *To understand the image segmentation and representation techniques.*
- *To understand how image are analyzed to extract features of interest.*

Course Outcome:

- *Implement image enhancement techniques*
- *Analyse images and extract features of interest*
- *Perform image processing using various techniques*
- *Perform image segmentation and tranforms*

Module-I: **9 hrs**

Introduction: What is Digital Image Processing, Origins of Digital Image Processing, Examples of fields that use DIP, Fundamental Steps in Digital Image Processing, Components of an Image Processing System. Introduction to Digital Image Fundamentals : Elements of Visual Perception, A Simple Image Formation Model, Basic Concepts in Sampling and Quantization, Representing Digital Images, Spatial and Gray-level Resolution, Zooming and Shrinking Digital Images, Some Basic Relationships Between Pixels, Linear and Nonlinear Operations.

Module-II: **9 hrs**

Image Enhancement in the Spatial Domain : Some Basic Gray Level Transformations, Histogram Processing, Enhancement Using Arithmetic/Logic Operations, Basics of Spatial Filtering, Smoothing Spatial Filters, Sharpening Spatial Filters, Combining Spatial Enhancement Methods. Image Enhancement in the Frequency Domain: Introduction to the Fourier Transform and the Frequency Domain, Smoothing Frequency-Domain Filters, Sharpening Frequency-Domain Filters, Homomorphic Filtering.

Module-III: **9 hrs**

Image Restoration: A Model of the Image degradation/Restoration process, Noise Models, Restoration in the Presence of Noise Only–Spatial Filtering, Periodic Noise Reduction by Frequency Domain Filtering, Linear, Position-Invariant Degradations, Estimating the Degradation Function, Inverse Filtering, Minimum Mean Square Error (Wiener) Filtering, Constrained Least Square Filtering, Geometric Mean Filter.

Module-IV: **9 hrs**

Color Fundamentals: Color Models, Pseudocolor Image Processing, Basics of Full-Color Image Processing, Color Transformations, Smoothing and Sharpening, Color Segmentation, Noise in Color Images, Color Image Compression. Wavelets and Multiresolution Processing**:** Image Pyramids, Subband coding, The Haar Transform, Multiresolution Expansions, Wavelet Transforms in one Dimension, Fast Wavelet Transform, Wavelet Transforms in Two Dimensions, Wavelet Packets. Image Compression**:** Fundamentals, Image Compression Models, Error-free (Lossless) compression, Lossy Compression.

Module-V: **9 hrs**

Morphological Image Processing: Preliminaries, Dilation and Erosion, Opening and Closing, the Hit-or-Miss Transformation, Some Basic Morphological Algorithms. Image Segmentation**:** Detection of Discontinuities, Edge Linking and Boundary Detection, Thresholding, Region-Based Segmentation.

Text Book(s):

1. *Rafael C Gonzalez and Richard E. Woods: Digital Image Processing, PHI 3rd Edition 2007.*

Reference Book(s):

1. *A. K. Jain: Fundamentals of Digital Image Processing, Pearson, 2004.*
2. *Scott.E.Umbaugh: Digital Image Processing and Analysis, CRC Press, 2014.*
3. *S.Jayaraman, S.Esakkirajan, T.Veerakumar: Digital Image Procesing, McGraw Hill Ed. (India) Pvt. Ltd., 2013*

CSCE 873 PATTERN RECOGNITION

L	*S*	*P*	*C*
3	*0*	*0*	*3*

Pre-requisite:

- *Fundamental Knowledge in Mathematics and Digital Image Processing*

Objectives:

- *To study the mathematical morphology necessary for Pattern recognition.*
- *To introduce the student to various Pattern recognition techniques.*
- *To study the Representation and description of feature extraction.*
- *To study the principles of decision trees and clustering in pattern recognition.*

Course Outcome:

- *Explain the mathematical morphology necessary for Pattern recognition.*
- *Explain the Representation and description of feature extraction.*
- *List the principles of decision trees*
- *Describe clustering in pattern recognition*

Module-I: **9 hrs**

Introduction:Introduction: Definition of PR, Applications, Datasets for PR, Different paradigms for PR, Introduction to probability, events, random variables, Joint distributions and densities, moments. Estimation minimum risk estimators, problems.

Module-II: **9 hrs**

Representation: Data structures for PR, Representation of clusters, proximity measures, size of patterns, Abstraction of Data set, Feature extraction, Feature selection, Evaluation.

Module-III: **9 hrs**

Nearest Neighbor based classifiers & Bayes classifier :Nearest Neighbor based classifiers & Bayes classifier: Nearest neighbor algorithm, variants of NN algorithms, use of NN for transaction databases, efficient algorithms, Data reduction, prototype selection, Bayes theorem, minimum error rate classifier, estimation of probabilities, estimation of probabilities, comparison with NNC, Naive Bayes classifier, Basyessian belief network.

Module-IV: **9 hrs**

Decision Trees : Introduction, DT for PR, Construction of DT, Splitting at the nodes, Over-fitting & Pruning, Examples.

Module-V: **9 hrs**

Clustering: Hierarchical (Agglomerative, single/complete/average linkage, wards, Partitional (Forgy's, k-means, Isodata), clustering large data sets, examples.

Text Book(s):

1. V Susheela Devi, M Narsimha Murthy, Pattern Recognition (An Introduction), Universities Press, ISBN 978-81-7371-725-3,2014.

2. Earl Gose, Richard Johnsonbaugh, Steve Jost Pattern Recognition & Image Analysis,. PHI ISBN-81-203-1484-0, 1996.

Reference Book(s):

1. Duda R. O., P.E. Hart, D.G. Stork., Pattern Classification, John Wiley and sons, 2000.

CSCE 874 STEGANOGRAPHY AND DIGITAL WATERMARKING

L	*S*	*P*	*C*
3	*0*	*0*	*3*

Pre-requisite:

- *Basic knowledge of security*

Objectives:

To make the student

- *To understand the importance of information hiding*
- *To analyse various steganography techniques*
- *To learn the various watermarking techniques*
- *To analyse study on finger prints*

Course Outcome:

- *Understand the importance of information hiding*
- *Analyse various stenographic techniques*
- *Learn the various watermarking techniques*
- *Learn various fingerprint techniques*

Module-I: **9 hrs**

Introduction to Information hiding : Introduction to Information hiding – Brief history and applications of information hiding – Principles of Steganography – Frameworks for secret communication – Security of Steganography systems –Information hiding in noisy data – Adaptive versus non adaptive algorithms – Laplace filtering – Using cover models – Active and malicious attackers – Information hiding in written text – Examples of invisible communications.

Module-II: **9 hrs**

Survey of steganographic techniques : Survey of steganographic techniques – Substitution system and bitplane tools – Transform domain techniques – Spread spectrum and information hiding – Statistical Steganography - Distortion and code generation techniques – Automated generation of English text.

Module-III: **9 hrs**

Steganalysis: – Detecting hidden information – Extracting hidden information - Disabling hidden information – Watermarking techniques – History – Basic Principles – applications – Requirements of algorithmic design issues – Evaluation and benchmarking of watermarking system.

Module-IV: **9 hrs**

Survey of current watermarking techniques : Survey of current watermarking techniques – Cryptographic and psycho visual aspects – Choice of a workspace – Formatting the watermark bets - Merging the watermark and the cover – Optimization of the watermark receiver – Extension from still images to video – Robustness of copyright making systems.

Module-V **9 hrs**

Fingerprints : Fingerprints – Examples – Classification – Research history – Schemes – Digital copyright and watermarking – Conflict of copyright laws on the internet.

Text Book(s):

1. *Stefan Katzenbelsser and Fabien A. P. Petitcolas, "Information hiding techniques for Steganography and Digital Watermarking", ARTECH House Publishers, January 2004.*

Reference Book(s):

1. *Jessica Fridrich, "Steganography in Digital Media: Principles, Algorithms, and Applications", Cambridge university press, 2010.*
2. *Ingemar Cox, Matthew Miller,JeffreyBloom,JessicaFridrich and TonKalker, "Digital Watermarking And Steganography", Morgan Kaufmann Publishers, Nov 2007.*

CSCE 875 BIOMETRIC SECURITY

L	*S*	*P*	*C*
3	*0*	*0*	*3*

Pre-requisite:

- *Basic knowledge of security*

Objectives:

- *To review image processing techniques for biometric security*
- *To understand Face, Fingerprint, Palmprint, Iris biometric technologies*
- *To understand three-dimensional image analysis techniques*
- *To study some applications of biometric security algorithms*

Course Outcome:

- *List image processing techniques for biometric security*
- *Describe Use Face, Fingerprint, Palmprint, Iris biometric technologies*
- *Perform biometric security algorithms*
- *Implement three-dimensional image analysis techniques*

Module-I: **9 hrs**

Introduction - What Is a Biometric? - Enrollment, Template, Algorithm, and Verification - FAR, FRR, and FTE - Authentication Technologies - The Need for Strong Authentication - Network Convergence Role in Password Proliferation - Mitigating Public Risk through Government Regulation - Mitigating the Risks from an Inside Threat - The Role of Strong Authentication with Single Sign-On (SSO) - Biometric Technologies: An Intelligent Solution - Protecting Privacy with Biometrics and Policy - Employer's Right to Privacy - Employee's Right to Privacy - Protection of Personal Data Collected by the Employer - Creating a Positive Biometric Policy

Module-II: **9 hrs**

Finger Biometric Technologies - General Description of Fingerprints - Macro Fingerprint Features - Micro Fingerprint Features - How Is the Finger Imaged? - Types of Algorithms Used for Interpretation - How Can this Biometric be Spoofed?

Module-III: **9 hrs**

Face Biometric Technologies - General Description of Face Biometrics - How Is the Face Imaged? - What Types of Algorithms Are Used for Facial Interpretation? - Eigenface - Local Feature Analysis - Neural Network - Automatic Face Processing - Which Algorithm Is Best? - How Can This Biometric Be Spoofed?

Module-IV: **9 hrs**

Voice Biometric Technologies - General Description of Voice Biometrics - How Is the Voice Captured? - Types of Algorithms Used for Voice Interpretation - How Can This Biometric Be Spoofed? - Attacking the Physical Voice - Iris Biometric Technology - General Description of Iris Biometrics - How Is the Iris Captured? - Description of the Iris Algorithm - How Can This Biometric Be Spoofed?

Module-V: **9 hrs**

Implementing Biometrics for Network Security - Finger Biometrics - Face Biometrics - Voice Biometrics - Iris Biometrics - The Choice of a Biometric for Network Access - EER - What Measure Is Most Important? - The Biometric Transaction - Securing and Trusting a Biometric Transaction - Matching Location.

Text Book(s):

1. *Paul Reid, "Biometrics for Network Security", Pearson Education, 2004.*
2. *NaliniK.Ratha,RundBolle,"Automatic fingerprint recognition system, Springer", 2003.*

Reference Book(s):

1. *L C Jain, I Hayashi, S B Lee, U Haleci, "Intelligent Biometric Techniques in Fingerprint and Face Recognition".*
2. *S.Y.Kung,S.H.Lin,M.W.,"Mak Biometric Authentication: A Machine Learning Approach".*
3. *John Chirillo, Scott Blaul, "Implementing Biometric Security", John Wile, 2003.*
4. *IEEE – T- PAMI (IEEE transaction on Pattern Analysis and Machine Intelligence) International journal of computer vision, Springer.*

CSCE 876 CONTENT BASED INFORMATION RETRIEVAL

L	*S*	*P*	*C*
3	*0*	*0*	*3*

Pre-requisite:

- *Basic knowledge about information retrieval*

Objectives:

To make the student understand

- *To learn the various techniques used in image enhancement*
- *To learn the image retrieval techniques*
- *To understand colour feature extraction*
- *To understand multimedia databases*

Course Outcome:

- *Explain the various techniques used in image enhancement*
- *Describe various image retrieval techniques*
- *List colour feature extraction*
- *Explain multimedia databases*

Module-I: **9 hrs**

Introduction - Content-Based Retrieval - Challenges and solutions - Formalism of Content-based Multimedia Systems - The System Must be User-centered - Content-based Multimedia Information System - Object Recall - A New Formalism for Content-Based Retrieval - Need for formalism of content-based retrieval - A Content-Based Similarity Retrieval Formalism - Learning of Similarity Function - Experimental Results

Module-II: **9 hrs**

Color Feature Extraction - Color Spaces Selection - Color Measures - Reference Color Table Method -Texture Feature Extraction - Discrete Cosine Transformed Texture - Discrete cosine transform - Feature vector formation - Wavelet Transformed Texture Feature - Wavelet Transform - Feature measures and similarity functions - Learning of multi-level similarity functions - Texture feature based on discrete cosine transform - Texture Features Based on Second Moment Matrix

Module-III: **9 hrs**

Multimedia Databases: Video Processing - Review of Video Processing Techniques - Video features - Video applications - Research areas - State of the art review - Content-Based Representative Frame Extraction and Video Summary - Definition -Related work - Extraction of representative frames - Application of representative frame extraction technique - Object Segmentation - Edge-preserved smoothing of features - Principle of edge-preserved smoothing - EPSM for 2D signal - Application in color feature - Application in texture feature - Clustering in the feature space - Region analysis and region merging.

Module-IV: **9 hrs**

Image Retrieval: Human Face Detection - Color Segmentation of Faces - Chromaticity diagrams -Effects of the projection of 3-D color spaces on chromaticity diagrams - Method for face detection using chromaticity diagrams - Shape Information As a Cue - Geometric characteristic of face - Shape descriptors - Face Feature Detection Using DOG Operators - The DOG (Difference of Gaussians) operator - Face feature detection by DOG operator -

Template-based Human Face Detection - Normalized “face space” - Dimensionality reduction - Clustering and face template generation Template matching - Visual Keywords - Related Works - Methodology - Typification - Description scheme - Selection - Coding scheme - Image Retrieval - Unsupervised learning - Learning by instruction - Image Categorization

Module-V: **9 hrs**

Content Based Image Retrieval: Face Retrieval - CAFIIR system - Content Based Indexing of Multimedia Object - ContIndex Creation by Self-organization Neural Networks - LEP neural network architecture - Fusion of multi-modal feature measures - Spatial self-organization - Bi-directional learning on experiences - Visual Retrieval of Facial Images - Descriptive Queries - Further Improvement of Queries - System for Trademark Archival and Retrieval - Representation of Trademarks - Segmentation of Trademarks - Color segmentation - Capturing Visual Features of Trademark Images - Composite Similarity Measures - Evaluation and Learning of Similarity Measures - Selection of training and test data sets

Text Book(s):

1. *J.K.Wu, M.S.Kankanhalli, J.H.Lim, D.Z.Hong “Perspectives on Content Based Multimedia Systems”, Kluwer Academic publishers,Boston,2000.*
2. *Rafael C.Gonzalez and Richard E.Woods, “Digital Image Processing” Fourth Edition, Pearson Education, 2017.*

Reference Book(s):

1. *Anil K.Jain, “Fundamentals of Digital Image Processing”, Person Education, 2003.*
2. *Michael S.Lew “Image and Video Retrieval”, Springer – Verlag, 2002.*