Course Structure & Syllabus of Ph.D. CSE
Applicable for Batch: 2021 Onwards

DIT UNIVERSITY
Dehradun

Detailed Course Structure & Syllabus
of
Ph.D. in Computer Science & Engineering

Approved by the Academic Council at its 14th Meeting held on 20.04.2020

Course Structure & Syllabus of Ph.D. CSE
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Course Category	Course Code	Course Title	L	T	P	Credit
UC	MB901	Research Methodology	4	0	0	4
	CPE-RPE	Research and Publication Ethics	2	0	0	2
DE		Elective I	4	0	0	4
DE		Elective II	4	0	0	4
DIS	CS901	Seminar	0	0	2	1
		Total				**15**

List of Electives for 1st Semester

Elective – I& Elective II		Credit	Elective Category
CS981	Advanced Concept in Image Processing	4	Elective I
CS982	Advanced Digital Cryptography	4	
CS983	Neural Networks & Neuro Fuzzy Applications	4	
CS984	Mobile And Ad-Hoc Wireless Networks	4	
noc19_CS 972	An Introduction to Machine Learning& Applications	0	
noc19_CS 973	Virtual Reality Development	0	
CS985	I o T & Its Security	4	
CS986	Advanced Data Warehousing, Mining & OLAP	4	Elective II
CS987	Designing Distributed Systems	4	
CS988	Advanced Algorithm Design & Analysis	4	
CS989	Fuzzy Logic & Genetic Algorithms: Synthesis & Applications	4	
CS990	Information Retrieval& Extraction	4	
CS991	Nature Inspired Computing	4	

Note: Apart from above listed Elective courses, Research Scholar may choose any course across departments being offered at PG level, if it is required/suggested by the Research Committee.

Course Structure & Syllabus of Ph.D. CSE
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Subject Code	MB901	Subject Title	Research Methodology					
LTP	4 0 0	Credit	4	Subject Category	UC	Year	1st	Semester	I

UNIT – I

Fundamentals of Research: Defining research, Objectives of research, types, research process, deductive and inductive reasoning;

Identifying and formulating a research problem, Literature review: Search for existing literature (World Wide Web, Online data bases), Review the literature selected (Case studies, review articles and Meta-analysis), Develop a theoretical and conceptual framework, Writing up the review,

Definition of variables: Concepts, indicators and variables, Types of variables, Types of measurement scales, Constructing the Hypothesis- Null(Research) and alternative, one-tailed and two-tailed testing, errors in testing. Ethical and Moral Issues in Research, Plagiarism, tools to avoid plagiarism – Intellectual Property Rights – Copy right laws – Patent rights

UNIT – II

Research Design: Design of Experiments: Research Designs -Exploratory, Descriptive and Experimental, Experimental designs- Types of Experimental Designs

UNIT – III

Sampling, Sampling distribution, and Data Collection: Sampling distribution, Normal and binomial distribution, Reasons for sampling, sampling technique, sampling errors.Sources of Data-Primary Data, Secondary Data, Data Collection methods

UNIT – IV

Statistical Data Analysis: Descriptive and inferential statistical analysis. Testing of hypothesis with Z-test, T-test and its variants, Chi-square test, ANOVA, Correlation, Regression Analysis, Introduction to data analysis data using SPSS20.0

UNIT – V

Research Report: Writing a research report**-** Developing an outline, Formats of Report writing, Key elements- Objective, Introduction, Design or Rationale of work, Experimental Methods, Procedures, Measurements, Results, Discussion, Conclusion, Referencing and various formats for reference writing of books and research papers, Writing a Research Proposal.

Books Recommended:

1. Ganesan R, Research Methodology for Engineers , MJP Publishers, Chennai. 2011
2. C.R.Kothari, "Research Methodology", 5th edition, New Age Publication,
3. Cooper, "Business Research Methods", 9th edition, Tata McGraw hills publication
4. Walpole R.A., Myers R.H., Myers S.L. and Ye, King: Probability & Statistics for Engineers and Scientists, Pearson Prentice Hall, Pearson Education, Inc. 2007.
5. Anderson B.H., Dursaton, and Poole M.: Thesis and assignment writing, Wiley Eastern 1997.
6. Bordens K.S. and Abbott, B.b.: Research Design and Methods, McGraw Hill, 2008.
7. Morris R Cohen: An Introduction to logic and Scientific Method (Allied Publishers) – P 197-222; 391–403

Course Structure & Syllabus of Ph.D. CSE
Applicable for Batch: 2021 Onwards

Subject Code	CS981	Subject Title	ADVANCED CONCEPT IN IMAGE PROCESSING						
LTP	4 0 0	Credit	4	Subject Category	DE	Year	1st	Semester	I / II

OBJECTIVE

To expose students to advanced concepts of digital image processing.Understand basic concepts of morphological image processing. Enable students to implement techniques in practical image processing problems. Understand pattern recognition theories such as Bayes classifier, Syntactic Recognitionofstrings.Design, analyze and implement algorithms for advanced image analysis like imagecompression, image segmentation etc.

Unit 1: **12Hrs**

Introduction: Digital Image- Steps of Digital Image Processing Systems-Elements of Visual Perception - Connectivity and Relations between Pixels. Simple Operations- Arithmetic, Logical, Geometric Operations. Mathematical Preliminaries - 2D Linear Space Invariant Systems - 2D Convolution - Correlation 2D Random Sequence - 2D Spectrum.

Unit 2: **10Hrs**

Image transforms and enhancement Image Transforms: Fourier transform, Haar Transform - Slant Transform - KL Transform –Wavelet Transform. Image Enhancement: - Histogram Equalization Technique- Point Processing-Spatial Filtering-In Space and Frequency - Nonlinear Filtering-Use of Different Masks. Image Restoration: Image Observation and Degradation Model, Algebraic Approach to Restoration- Inverse by Wiener Filtering – Generalized Inverse-SVD and Interactive Methods - Blind Deconvolution-Image Reconstruction from Projections

Unit 3: **10Hrs**

Image Compression: Redundancy And Compression Models -Loss Less And Lossy. Loss Less- Variable-Length, Huffman, Arithmetic Coding - Bit-Plane Coding, Loss Less Predictive Coding, Lossy Transform (DCT) Based Coding, JPEG Standard - Sub Band Coding. Image Segmentation: Edge Detection - Line Detection - Curve Detection - Edge Linking And Boundary Extraction, Boundary Representation, Region Representation And Segmentation, Morphology-Dilation, Erosion, Opening And Closing. Hit And Miss Algorithms Feature Analysis

Unit-4: **10Hrs**

Object recognition: patterns and pattern classes. Recognition Based on decision-theoreticmethods: Matching: minimum distance classifier, matching by correlation, optimum statisticalclassifiers: Bayes classifier for Gaussian pattern classes, neural networks: perception for twopattern classes, multilayer neural networks. Structural methods: matching shape numbers, stringmatching. Syntactic Recognition of Strings, Syntactic Recognition of Tree.

Unit-5: **10 Hrs**

Advanced topics: Image Fusion, Filters for SAR processing, Fuzzy classification and accuracy analysis, Spatial classification: Texture, Context. Segment/Object-based classification, ANN classification, Classification of hyper-spectral data: Characteristics, Feature selection, Independent component analysis, Support vector machines, 3D Image Reconstruction, Image rendering, image inpainting.

COURSE OUTCOME:

At the end of the coursethe student will learn:

CO1. Toimplement simple pattern classifiers, classifier combinations, and structural pattern recognizers.

CO2. Apply pattern recognition techniques to image processing, document analysis etc.

CO3. Differentiate Spatial and Frequency domain concepts for image enhancement.

CO4. Apply restoration process of degraded image and Multi resolution processing.

TEXT BOOKS

1. Rafael C. Gonzalvez and Richard E.Woods,Digital Image Processing 3rd Edition , PearsonEducation,2016.

2. Digital Image Processing Wiley student edition by W. K Pratt.

REFERENCES

1. Fundamentals of Electronics Image Processing by Arthur R. Weeks, jr.- PHI

2. Digital Image Processing and analysis by B. Chanda and D. DuttMajumdar, PHI

Course Structure & Syllabus of Ph.D. CSE
Applicable for Batch: 2021 Onwards

Subject Code	CS982	Subject Title	ADVANCED DIGITAL CRYPTOGRAPHY						
LTP	4 0 0	Credit	4	Subject Category	DE	Year	1st	Semester	I / II

OBJECTIVE

The aim of this course is to introduce the areas of cryptography and cryptanalysis to the participants. This course develops a basic understanding of the algorithms used to protect users online and addresses some of the design choices behind these algorithms. One of the major focus in this course is to build a workable knowledge of mathematics used in cryptology. The course emphasizes to provide a basic understanding of previous attacks on cryptosystems with the aim of preventing future attacks.

Unit 1: **12 Hrs**

Introduction to Cryptography: Basics of Symmetric Key Cryptography, Basics of Assymetric Key Cryptography, Hardness of Functions.Notions of Semantic Security (SS) and Message Indistinguishability (MI): Proof of Equivalence of SS and MI, Hard Core Predicate, Trap-door permutation, Goldwasser-Micali Encryption. Goldreich-Levin Theorem: Relation between Hardcore Predicates and Trap-door permutations.

Unit 2: **10 Hrs**

Formal Notions of Attacks: Attacks under Message Indistinguishability: – Chosen Plaintext Attack(IND-CPA), – Chosen Ciphertext Attacks (IND-CCA1 and IND-CCA2), – Attacks under Message Non-malleability: NMCPA and NM-CCA2, – Inter-relations among the attack model.

Unit 3: **10 Hrs**

Random Oracles: Provable Security and asymmetric cryptography, hash functions.One-way functions: Weak and Strong one way functions.Pseudo-random Generators (PRG): – Blum-Micali-Yao Construction, – Construction of more powerful PRG, – Relation between One-way functions and PRG, Pseudo-random Functions (PRF).

Unit-4: **10 Hrs**

Building a Pseudorandom Permutation: – The LubyRackoff Construction: Formal Definition, – Application of the LubyRackoff Construction to the construction of Block Ciphers, The DES in the light of LubyRackoff Construction.

Unit-5: **10 Hrs**

Left or Right Security (LOR). Message Authentication Codes (MACs): Formal Definition of Weak and Strong MACs, Using a PRF as a MAC, Variable length MAC. Public Key Signature Schemes: Formal Definitions, Signing and Verification, Formal Proofs of Security of Full Domain Hashing. Assumptions for Public Key Signature Schemes: One way functions Imply Secure One-time Signatures.Shamir's Secret Sharing Scheme. Formally Analyzing Cryptographic Protocols .Zero Knowledge Proofs and Protocols

COURSE OUTCOME:

At the end of the coursethe student will learn:

CO1. Students start learning how to think from an adversarial viewpoint.

CO2. The goal is to become familiar with basic techniques to protect data in computer and communication environments against several different varieties of fraud.

CO3. Understand the working of authentication functions.

CO4. Apply public key encryption and key distribution techniques.

TEXT BOOKS

1. William Stallings, “Cryptography and Network Security: Principles and Standards”,
2. Prentice Hall India, 3rd Edition, 2003.
3. Jonathan Katz and Yehuda Lindell, Introduction to Modern Cryptography, CRC Press.
4. Hans Delfs, Helmut Knebl, "Introduction to Cryptography, Principles and Applications", Springer Verlag.
5. Wenbo Mao, "Modern Cryptography, Theory and Practice", Pearson Education (Low Priced Edition)
6. ShaffiGoldwasser and MihirBellare, Lecture Notes on Cryptography, Available in http://citeseerx.ist.psu.ed

REFERENCES

1. Charles P. Pleeger, “Security in Computing”, Pearson Education Asia, 5th Edition, 2001.
2. Wenbo Mao: Modern Cryptography: Theory and Practice, Pearson Education, 2004.

3. O. Goldreich, Foundations of Cryptography, CRC Press (Low Priced Edition Available), Part 1 and Part 2

Subject Code	CS983	Subject Title	NEURAL NETWORKS & NEURO FUZZY APPLICATIONS						
LTP	4 0 0	Credit	4	Subject Category	DE	Year	1st	Semester	I / II

OBJECTIVE

It deals with the knowledge of Neural Networks and Fuzzy Logic Control and uses these for controlling real-time systems, it also provides the Application of Neural Networks.

Unit 1: INTRODUCTION & BASIC CONCEPTS **12 Hrs**

Introduction: Humans and Computers, Biological neural system, the structure of the brain, learning in machines, the differences. The basic neuron- Introduction, modelling the single neuron, learning in simple neurons, Artificial Intelligent Systems, Modeling human performance.Uncertain& incomplete knowledge, Expert Systems Vs Neural Networks.

Unit 2: MULTILAYER NETWORKS **10 Hrs**

Foundations for connectionist networks. Architecture, Activation functions, Characteristics of Neural Networks, The multi-layer perceptron: Introduction, altering the perception model, the new model, the new learning rule, multi-layer perception algorithm, XOR problem. Multi-layer feed forward networks, error back propagation training algorithm: Problems with back propagation, Boltzmann training,

Unit 3: SUPERVISED & UNSUPERVISED LEARNING **10 Hrs**

Perceptron learning, Pattern Classification. Hebb Rule. Adaline.Madaline, Delta Rule.Back propagation learning, Competitive learning, Hebbian learning, BAMs.

Supervised and Unsupervised learning. Reinforcement learning, Kohonen Self Organizing Maps,

Unit-4:FUZZY LOGIC CONTROL & APPLICATION OF NN **10 Hrs**

Membership function – Knowledge baseDecisionmakinglogic. Optimizations of membership function using neural networks. Adaptive fuzzy systems, Introduction to generate genetic algorithm.Applications of SOMs, Adaptive Resonance Theory, Neural Network Applications.

Unit-5:APPLICATION OF SVM & FLC **10 Hrs**

Neuro-Fuzzy Systems: Types of Fuzzy Neural Nets, Neural components in a Fuzzy System
Fuzzy-ANN Controller, Support Vector Machines, Applications of SVMs.

Fuzzy logic control: Inverted pendulum, Image processing, Home heating system, Blood pressure during anaesthesia. Introduction to neuron fuzzy controller.

COURSE OUTCOME:

At the end of the coursethe student will learn:

- **CO1.** The student will be able to obtain the fundamentals and types of neural networks
- **CO2.** The student will have a broad knowledge in developing the different algorithms for neural networks.
- **CO3.** Student will be able to analyze neural controllers & Fuzzy Logic
- **CO4.** Student will be able to determine the different methods of Defuzzification.

TEXT BOOKS

1. Simon Haykin, “Neural Networks: A Comprehensive Foundation”, Prentice Hall (2nd edition) 2002.
2. Timothy J Ross, “Fuzzy Logic with Engineering Applications”, John Willey and Sons, West Sussex, England, (fourth edition 2016)
3. Kosko, B, “Neural Networks and Fuzzy Systems: A Dynamical Approach to Machine Intelligence”, PrenticeHall, New Delhi, 2009.
4. Nils J. Nilsson,“Artificial Intelligence - A New Synthesis”, Morgan Kaufmann Publishers (1st edition) 1998
5. Robert J. Scholkoof“ Artifical Neural Networks”; McGraw Hill Education, 2011

REFERENCES

1. Stuart Russel, Peter Norvig,”Artificial Intelligence A Modern Approach” , Pearson (3rd edition)
2. Jack M. Zurada, “Introduction to Artificial Neural Systems”,PWS Publishing Co., Boston, 2002.

3. Klir G.J. &Folger T.A., "Fuzzy sets, Uncertainty and Information", Prentice –Hall of India Pvt. Ltd., New Delhi, 2008.
4. Rao V.B and Rao H.V., "C++, Neural Networks and Fuzzy Logic", BPB Publications, 2003.

Subject Code	CS984	**Subject Title**	**MOBILE AND AD-HOC WIRELWSS NETWORKS**					
LTP	4 0 0	**Credit**	4	**Subject Category**	DE	**Year**	1st	**Semester**	I / II

OBJECTIVE

This course covers major aspects of mobile and ad hoc networks, from design through performance issues to application requirements. It starts with mobile computing conceptual issues with its characteristics features. Applications of ad hoc networks, Modulation techniques and voice coding. It also covers the IEEE 802.11 Wireless LAN and Bluetooth standards.

Unit 1: **12 Hrs**

Mobile Computing issues, Mobile IP &its working, Issues in Mobile IP. TCP over Wireless, Wireless Access Protocol (WAP): Architecture & Protocol Stack. Security in Wireless Systems- WEP and Virtual Private Networks, Mobile Agents Computing, Transaction Processing in Mobile Computing Environment

Wireless Telephony: Frequency Reuse, Cell Design, Cellular Architecture. Second Generation Cellular System- IS-95, GSM, IS-41, Data Operations- CDPD, HCSD, & GPRS. Third Generation Cellular System- 3G Concept, 3G Spectrum Allocation, 3G Service Classes & Application, UMTS, Introduction to Future Trends- 4G and Beyond.

Unit 2: **10 Hrs**

Wireless Networks: WLAN Overview, Infrared LAN, Spread-Spectrum LAN, Narrowband Microwave LAN, Wireless Multiple Access Protocols- MACA & MACAW, IEEE 802.11 variants, HIPERLAN, PAN Technologies- Bluetooth and HomeRF, Wireless Metropolitan Area Networks (Wireless Local Loop).

Routing in Wireless Networks: hybrid routing, Energy-aware routing, Geographic routing, attribute based -routing

Unit 3: **10 Hrs**

Ad Hoc Networks: Ad Hoc Networks vs. Cellular Networks, Design Issues & challenges in Ad Hoc Wireless Networks.

Routing Protocols for Ad Hoc Wireless Networks:: proactive routing, reactive routing (on-demand), hybrid routing.

Unit-4: **10 Hrs**

Quality of Service (QoS) in Ad Hoc Networks: Introduction to QoS, Issues and Challenges Involved in Providing QoS, Medium Access Control (MAC) Layer, QoS Solutions, Network, Layer QoS Solutions, QoS Model, QoS, Frameworks

Security Issues in Mobile Ad Hoc Networks: Various Attacks on MANET, Security Mechanisms in the Network Layer, Security Mechanisms in the Data Link Layer, Key Management.

Unit-5: **10 Hrs**

Wireless Sensor Networks: Characteristics and Applications of Wireless Sensor Networks,WSN Operating Environment, WSN Trends, Sensor Nodes' Architecture,Data Aggregation, Routing, and Query Processing in WSN.

Commercially available sensor nodes- Imote, IRIS, Mica Mote, EYES nodes, BTnodes, TelosB, Sunspo-Physical layer and transceiver design considerations in WSNs,

Network simulators (OPNET, NS2, etc.)

COURSE OUTCOME:

At the end of the course, the student can :

CO1. Have an understanding of mobile computing, wireless telephony & networks, Routing in Wireless Networks both from an industry and research point of views.
CO2. Have an understanding of Ad Hoc Networks, Quality of Service (QoS) in Ad Hoc Networks.
CO3. Have an understanding of security Issues for Ad Hoc Wireless Networks.
CO4. Have an understanding of WSN and hands on learning of use of OPNET and NS2.

TEXT BOOKS

1. Jochen H. Schiller, "Mobile Communication", Addison-Wesley, Pearson Education, latest Edison.
3. PrasantMohapatra, Prasant, Krishnamurthy, Srikanth (Eds.)," AD HOC NETWORKS Technologies and Protocols, Springer, Springer International edition, 2009
4. Stefano Basagni, Marco Conti, Silvia Giordano, Ivan Stojmenovic "Mobile Ad Hoc Networking", Wiley IEEE Press.
5. Anna Hác, "Wireless Sensor Network Designs", John Wiley & Sons Ltd.

REFERENCES

1.Subir K Sarkar, T G Basavaraju, C Puttamadappa, Ad Hoc Mobile Wireless Networks, Auerbach Publication 2007.
2.A. Ananda, MunChoon Chan, Mobile, Wireless & Sensor Networks,Wei Tsang Ooi , IEEE press, Willy Intersciences.

Course Structure & Syllabus of Ph.D. CSE
Applicable for Batch: 2021 Onwards

Subject Code	CS985	Subject Title	IOT AND ITS SECURITY					
LTP	4 0 0	Credit	4	Subject Category	DE	Year	1st	Semester	I / II

OBJECTIVE

- To Understand the Architectural Overview of IoT
- To Understand the IoT Reference Architecture and RealWorld Design Constraints
- To Understand the various IoT Protocols (Datalink, Network, Transport, Session, Service)
- To get a flavor of security issues in IoT

Unit 1: OVERVIEW **12 Hrs**

IoT-An Architectural Overview– Building an architecture, Main design principles and needed capabilities, An IoT architecture outline, standards considerations. M2M and IoT Technology Fundamentals- Devices and gateways, Local and wide area networking, Data management, Business processes in IoT, Everything as a Service(XaaS), M2M and IoT Analytics, Knowledge Management

Unit 2: REFERENCE ARCHITECTURE **10 Hrs**

IoT Architecture-State of the Art – Introduction, State of the art, Reference Model and architecture, IoT reference Model - IoT Reference Architecture- Introduction, Functional View, Information View, Deployment and Operational View, Other Relevant architectural views. Real-World Design Constraints- Introduction, Technical Design constraints-hardware is popular again, Data representation and visualization, Interaction and remote control.

Unit 3: IOT DATA LINK LAYER & NETWORK LAYER PROTOCOLS **10 Hrs**

PHY/MAC Layer(3GPP MTC, IEEE 802.11, IEEE 802.15), WirelessHART,Z-Wave,Bluetooth Low Energy, Zigbee Smart Energy, DASH7 - Network Layer-IPv4, IPv6, 6LoWPAN, 6TiSCH,ND, DHCP, ICMP, RPL, CORPL, CARP

Unit-4:TRANSPORT,SESSION& SERVICE LAYER PROTOCOLS **10 Hrs**

Transport Layer (TCP, MPTCP, UDP, DCCP, SCTP)-(TLS, DTLS) – Session Layer-HTTP, CoAP, XMPP, AMQP, MQTT. Service Layer -oneM2M, ETSI M2M, OMA, BBF

Unit-5: **10 Hrs**

IoT Security Requirements, IoT Privacy Preservation Issues, Attack Models - Attacks to Sensors in IoTs, Attacks to RFIDs in IoTs,Attacks to Network Functions in IoTs,Attacks to Back-end Systems,Security in Front-end Sensors and Equipment,Prevent Unauthorized Access to Sensor Data,M2M Security,RFIDSecurity,Cyber-Physical Object Security,HardwareSecurity,Front-end System Privacy Protection,Networking Function Security-IoT Networking Protocols,SecureIoT Lower Layers,SecureIoT Higher Layers,Secure Communication Links in IoTs,Back-end Security -Secure Resource Management,SecureIoTDatabases,Security Products-Existing Testbed on Security and Privacy of IoTs,Commercialized Products.

COURSE OUTCOME:

At the end of the coursethe student will learn:

CO1. The fundamentals of Internet of Things

CO2. Work in an environment that requires nuances of IoT

CO3. Identify and solve different security issues involved with IoT

TEXT BOOKS

1. 1.Jan Holler, VlasiosTsiatsis, Catherine Mulligan, Stefan Avesand, StamatisKarnouskos, David Boyle, **"**From Machine-to-Machine to the Internet of Things: Introduction to a New Age of Intelligence**",** 1st Edition, Academic Press, 2014.
2. Peter Waher**, "**Learning Internet of Things", PACKT publishing, BIRMINGHAM – MUMBAI
3. Bernd Scholz-Reiter, Florian Michahelles, "Architecting the Internet of Things", ISBN 978-3-642-19156-5 e-ISBN 978-3-642-19157-2, Springer
4. Daniel Minoli, "Building the Internet of Things with IPv6 and MIPv6: The Evolving World of M2M Communications", ISBN: 978-1-118-47347-4, Willy Publications
5. Fei HU, "Security and Privacy in Internet of Things (IoTs): Models, Algorithms, andImplementations", CRC Press,2016
6. Russell, Brian and Drew Van Duren, "Practical Internet of Things Security", Packt Publishing, 2016.
7. Ollie Whitehouse, "Security of Things: An Implementers' Guide to Cyber-Security forInternet of Things Devices and Beyond", NCC Group, 2014

REFERENCES

1. Vijay Madisetti and ArshdeepBahga, **"**Internet of Things (A Hands-on-Approach)**",** 1st Edition, VPT, 2014.
2. http://www.cse.wustl.edu/~jain/cse570-15/ftp/iot_prot/index.html

Course Structure & Syllabus of Ph.D. CSE
Applicable for Batch: 2021 Onwards

Subject Code	CS986	Subject Title	ADVANCED DATA WAREHOUSING, MINING& OLAP					
LTP	4 0 0	Credit	4	Subject Category	DE	Year	1st	Semester	I / II

OBJECTIVE

To introduce the basic concepts of Data Warehouse and Data Mining techniques. Examine the types of the data to be mined and apply preprocessing methods on raw data. Discover interesting patterns, analyze supervised and unsupervised models and estimate the accuracy of the algorithms.

Unit 1: **12 Hrs**

Evolution of Database System Technology, Architecture of Data Mining System, Data Warehouse, Advanced Data and Information Systems and Advanced Applications, Data Mining Functionalities, Comparison of OLTP and Data Warehousing.

Unit 2: **10 Hrs**

Data Preprocessing, Descriptive Data Summarization, Data Cleaning, Data Integration and Transformation, Data Reduction, Data Discretization and Concept Hierarchy Generation

Unit 3: **10 Hrs**

Data Warehouse Architecture, Data Warehouse Schemas, Multidimensional Data Model, OLTP, OLAP, OLAP operations, ROLAP, MOLAP, HOLAP,DOLAP, Indexing OLAP Data, Efficient Processing of OLAP Queries, OLAP Implementation, OLAP Tools.

Unit-4: **10 Hrs**

Market Basket Analysis, Apriori Algorithm, Mining Multilevel Association Rules, Classification and Prediction, Classification by Decision Tree Induction, Bayesian Classification, and Classification by Back propagation

Unit-5: **10 Hrs**

Cluster Analysis, Types of Data in Cluster Analysis, Partitioning Methods, K-Means Method, K-Medoids Method, DBSCAN, OPTICS. Mining Sequence pattern in Biological Data, Mining Multidimensional, Multilevel Sequential Pattern

COURSE OUTCOME:

At the end of the course, the student will learn:

CO1. Process raw data to make it suitable for various data mining algorithms.
CO2. Discover and measure interesting patterns from different kinds of databases.
CO3. Apply the techniques of clustering, classification, association finding, feature selection and visualization to real world data.
CO4. Apply OLAP methodology in the data mining process.

TEXT BOOKS

1. Jiawei Han and MichelineKamber, “Data Mining: Concepts and Techniques”.

REFERENCES

1. M.H.Dunham, ”Data Mining: Introductory and Advanced Topics” , Pearson Education,1st ed.

2. Mallach ,Data Warehousing System McGraw –Hill,2002.

3. Alex Berson and Stephen J. Smith, “Data Warehousing, Data mining and OLAP”, Tata McGraw-Hill,13thed, 2008.

Course Structure & Syllabus of Ph.D. CSE
Applicable for Batch: 2021 Onwards

Subject Code	CS987	Subject Title	DESIGNING DISTRIBUTED SYSTEMS						
LTP	4 0 0	Credit	4	Subject Category	DE	Year	1st	Semester	I / II

OBJECTIVE

This course provides an introduction to the fundamentals of distributed systems for design the distributed system.

Unit 1: **12 Hrs**

Fundamentals: What Is a Distributed Computing System? Evolution of Distributed Computing Systems.Distributed Computing System Models. Why Are Distributed Computing Systems Gaining Popularity? What Is a Distributed Operating System? Issues in Designing a Distributed System.Distributed Computing Environment (DCE).

Message Passing: Desirable Features of a Good Message-Passing System. Issues in IPC by Message Passing. Synchronization, Buffering. Multi-datagram Messages. Encoding and Decoding of Message Data. Process Addressing.FailureHandling.Group Communication. Case Study: 4.3 BSD UNIX IPC Mechanism.

Unit 2: **10 Hrs**

Remote Procedure Calls:

The RPC Model.Transparency of RPC.Implementing RPC Mechanism. Stub Generation. RPC Messages.Marshaling Arguments and Results.ServerManagement.Parameter-Passing Semantics. Call Semantics. Communication Protocols for RPCs. Complicated RPCs. Client-Server Binding Exception Handling. RPC in Heterogeneous Environments.LightweightRPC.Optimizations for Better Performance.

Unit 3: **10 Hrs**

Distributed Shared Memory:

General Architecture of DSM Systems.Design and Implementation issues of DSM.Granularity.Structure of Shared Memory Space.ConsistencyModels.ReplacementStrategy.Thrashing.

Synchronization:

Clock Synchronization.EventOrdering.MutualExclusion.Deadlock.Election Algorithms.

Unit-4: **10 Hrs**

Resource Management:

Desirable Features of a Good Global Scheduling Algorithm.Task Assignment Approach.Load-Balancing Approach.Load-Sharing Approach.

Process Management:

Process Migration.Threads.

Unit-5: **10 Hrs**

Distributed File Systems:

Desirable Features of a Good Distributed File System. File Models. File-Accessing Models.File-Sharing Semantics.File-Caching Schemes. File Replication. Fault Tolerance. Atomic Transactions. Design Principles. Case Study: DEC Distributed File Service.

COURSE OUTCOME:

At the end of the coursethe student can:

CO1. The student will understand the various architectures used to design the distributed systems, such as client-server paradigm and peer-to-peer connection, files handling, implementation of distributed shared memory.

CO2. The student will have the knowledge about distributed systems using various interposes communication techniques, such as remote method invocation, remote events, and tuple spaces.

TEXT BOOKS

1. Pradip K Sinha, Distributed operating system Concept and design, Prentice Hall India,2ND ed, 2006
2. Tannenbaum, A, Van Steen, Distributed Systems, Principles and Paradigm,. Prentice Hall India,2ND ed, 2006
3. Tannenbaum,Distributed Operating Systems, A. Pearson Education. 2006
4. S Ghosh, Distributed Systems An algorithmic Approach- 2nd Edition CRC Press

REFERENCES

1. Singhal and Shivaratri, "Advanced Concepts in Operating Systems", McGraw Hill, 2017

2. Attiya, Welch, Distributed Computing, Wiley India 2006

Course Structure & Syllabus of Ph.D. CSE
Applicable for Batch: 2021 Onwards

Subject Code	CS988	Subject Title	ADVANCED ALGORITHM DESIGN & ANALYSIS						
LTP	4 0 0	Credit	4	Subject Category	DE	Year	1st	Semester	I / II

OBJECTIVE

- The fundamental design, analysis, and implementation of basic data structures.
- Basic concepts in the specification and analysis of programs.
- Principles for good program design, especially the uses of data abstraction.
- Significance of algorithms in the computer field
- Various aspects of algorithm development
- Qualities of a good solution

Unit 1: Introduction: **12 Hrs**

Role of algorithms in computing, Analyzing algorithms, Designing Algorithms, Growth of Functions, Divide and Conquer- The maximum-subarray problem, Strassen's algorithms for matrix multiplication, The substitution method for solving recurrences, The recurrence-tree method for solving recurrence, The master method for solving recursions, Probabilistic analysis and random analysis.

Unit 2: AdvancedData Structures **10 Hrs**

Elementary Data Structures, Hash Tables, Binary Search Trees, Red-Black Trees, Number–Theoretic Algorithm.

Unit 3: Dynamic Programming **10 Hrs**

Matrix-chain multiplication, Elements of dynamic programming, Longest common subsequence, Greedy Algorithms – Elements of the greedy strategy, Huffman codes, Amortized Analysis – Aggregate analysis, The accounting method, The potential method, Dynamic tables.

Unit-4:Graph Algorithms **10 Hrs**

Elementary Graph Algorithms, Minimal spanning trees, Single-Source Shortest Paths, Maximum flow.

Unit-5:NP **10 Hrs**

Complete & Approximate Algorithms-Polynomial time, Polynomial-time verification, NP-completeness and reducibility, NP-complete & approximation problems – Clique problem, Vertex cover problem, formula satisfiability, 3 CNF Satisfiability, The vertex-cover problem, The traveling salesman problem, The subset-sum problem.

COURSE OUTCOME:

At the end of the coursethe student will learn:

CO1. Define basic static and dynamic data structures and relevant standard algorithms for them: stack, queue, dynamically linked lists, trees, graphs, heap, priority queue, hash tables, sorting algorithms, min-max algorithm,

CO2. Demonstrate advantages and disadvantages of specific algorithms and data structures,

CO3. Select basic data structures and algorithms for autonomous realization of simple programs or program parts

CO4. Determine and demonstrate bugs in program, recognize needed basic operations with data structures

TEXT BOOKS

1. "Introduction to Algorithms", Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest, Clifford Stein, Third Edition, PHI Publication.
2. "Data Structures and Algorithms in C++", M.T. Goodrich, R. Tamassia and D.Mount, Wiley India.

REFERENCES

1. Fundamentals of Computer Algorithms, Ellis Horowitz, SartajSahni, SanguthevarRajasekaran, Second Edition, Galgotia Publication
2. Data structures with C++, J. Hubbard, Schaum's outlines, TMH.
3. Data structures and Algorithm Analysis in C++, 3rd edition, M. A. Weiss, Pearson.
4. Classic Data Structures, D. Samanta, 2nd edition, PHI.

Course Structure & Syllabus of Ph.D. CSE
Applicable for Batch: 2021 Onwards

Subject Code	CS989	Subject Title	FUZZY LOGIC AND GENETIC ALGORITHM:SYNTHESIS & APPLICATIONS						
LTP	4 0 0	Credit	4	Subject Category	DE	Year	1st	Semester	I / II

OBJECTIVE

The course has been designed with the purpose to teach the students the fundamentals of Reasoning under uncertain circumstances (covered through Probabilistic Reasoning) and the Reasoning with imprecise knowledge (covered through Fuzzy Sets and Fuzzy Logic). The objective of the course is also to teach the fundamentals and applications of Genetic Algorithms. How to Synthesize the problems to find their solutions by the application of these three techniques shall also be taught.

Unit 1: **12 Hrs**

Fuzzy Sets (Introduction)

Basic concepts of fuzzy logic, Fuzzy sets and Crisp sets, Fuzzy set theory, Basic operations, Properties of fuzzy sets, Fuzzy and Crisp relations, Fuzzy to Crisp conversion.

Unit 2: **10 Hrs**

Fuzzy Logic (Fuzzy Membership, Rules)

Membership functions, Propositional logic and predicate logic, Inference in fuzzy logic, Fuzzy if-then rules, Fuzzy mapping rules, Fuzzy implications, Min-Max Theorem, Resolution Rule under Fuzzy environment, Refutation method for theorem proving, Defuzzifications, Fuzzy classification.

Unit 3: **10 Hrs**

Review of Probability theory, and Numericals based upon the Conditional Probability and Bayes Theorem, Bayesian Networks, Bayesian reasoning. Decision Making, Joint Probabilities Relationships, Chain Rule, Polytrees.,Dempster-Shafer theory of evidence, Certainty theory, Non-monotonic systems.

Unit-4: **10 Hrs**

Theoretical Foundation of Genetic Algorithms

Introduction: Basic Operators: Reproduction, Crossover & Mutation. Fitness function. Search Space, Schemas & Two-Armed and k-armed problem, Exact mathematical models,

Unit-5: **10 Hrs**

Applications of Genetic Algorithms: Optimization of Travelling Salesman Problem using Genetic Algorithms, Application of Genetic Algorithms for Internet Searching

COURSE OUTCOME:

At the end of the course, the students shall have learnt the fundamentals and gained the requisite knowledge on the following:

CO1: The Fuzzy Sets Fuzzy Systems and the reasoning using the Fuzzy Logic
CO2: How to develop a decision support system using the fuzzy knowledge
CO3: The Reasoning Techniques under uncertain circumstances
CO4: The Bayesian Networks and the Bayesian Reasoning
CO5: Dempsters- Shafers theory and Certainty theory as alternative to Bayesian reasoning uncer uncertain circumstances.
CO6: Genetic Algorithms provide one of the best optimization techniques when the serch space is large. Starting from the very fundamentals the students shall learn as to how to find solutions to problems using Genetic Algorithms.

TEXT BOOKS

1. Timothy J Ross, “Fuzzy Logic with Engineering Applications”, 2nd Edition, John Wiley, 2004.

2. David E. Goldberg, “Genetic algorithms in search, optimization & Machine Learning” Pearson Education, 2006

3. Stuart Russel, Peter Norvig, ”Artificial Intelligence A Modern Approach” Pearson, 2014 (3rd Ed.)

REFERENCES

1. John Yen, Reza Langari, “Fuzzy Logic Intelligence, Control and Information”, Pearson Education, 2006.

2. G.J.Klir ,Yuan,“Fuzzy Sets and fuzzy logic, Theory and applications”, Prentice Hall India, 1995.

3. H. Zimmermann, “Fuzzy Set Theory and its applications”, 2nd Edition, Allied Publishers, 1996.

4. Melanle Mitchell, “An introduction to genetic algorithms”, Prentice Hall India, 2002.

5. SN Sivanandam, SN Deepa, Principals of Soft Computing, Wiley India, 2008.

Course Structure & Syllabus of Ph.D. CSE
Applicable for Batch: 2021 Onwards

Subject Code	CS990	Subject Title	INFORMATION RETRIVAL & EXTRACTION						
LTP	4 0 0	Credit	4	Subject Category	DE	Year	1st	Semester	I / II

OBJECTIVE

- To Understand the Overview of Information Retrieval System
- To learn different indexing techniques
- To learn the fundamental IR models and performance evaluation techniques
- To know about different clustering techniques
- To get an idea about advanced topics in Information retrieval system

Unit 1:Introduction **12Hrs**

Concepts and terminology of information retrieval systems, Significance of information retrieval and storage, Information Retrieval Vs Information Extraction

Unit 2:Indexing **10Hrs**

Inverted files, encoding, Zipf's Law, compression, boolean queries, tokenization, stemming and stop words.

Unit 3: Fundamental IR modelsand Performance Evaluation **10 Hrs**

Boolean, Vector Space, binary independence, probabilistic, TFIDF, Okapi, language modeling, latent semantic indexing, query processing and refinement techniques. Performance Evaluation: precision, recall, F-measure

Unit-4:DataMining,Classification and Clustering **10 Hrs**

Study basic techniques, algorithms, and systems of data mining and analytics, including frequentpattern and correlation and association analysis, anomaly detection, and click-through modelling.

Classification: Rocchio, Naive Bayes, k-nearest neighbors, support vector machine; Clustering:partitioning methods, k-means clustering, hierarchical

Unit-5:Introduction to advanced topics **10 Hrs**

Search, relevance feedback, ranking, query expansion.MapReduce and Sparck; Learning to Rank; Portfolio retrieval and Risk Management; Deep Learning

COURSE OUTCOME:

At the end of the course the student will learn:

CO1. The fundamentals of Data mining

CO2. Different data retrieval techniques used

CO3. To evaluate performance of different fundamental models used for information retrieval

CO4. To work in an environment that uses advanced concepts of information retrieval

TEXT BOOKS

1. Christopher D. Manning, PrabhakarRaghavan and HinrichSchtze, Introduction to Information Retrieval, Cambridge University Press. 2008

2. Ricardo Baeza-Yates and BerthierRibeiro-Neto, Modern Information Retrieval, Addison Wesley, 1st edition, 1999.

REFERENCES

1. SoumenChakrabarti, Mining the Web, Morgan-Kaufmann Publishers, 2002.

2. Bing Liu, Web Data Mining: Exploring Hyperlinks, Contents, and Usage Data, Springer, Corr. 2nd printing edition, 2009.

3. David A. Grossman, OphirFrieder, Information Retrieval: Algorithms and Heuristics, Springer, 2nd edition, 2004.

4. William B. Frakes, Ricardo Baeza-Yates, Information Retrieval Data Structures and Algorithms, Prentice Hall, 1992.

5. G. Salton, M. J. McGill, Introduction to Modern Information Retrieval, McGraw-Hill, 1986. 6. C. J. Van Rijsbergen, Information Retrieval, Butterworth-Heinemann; 2nd edition, 1979.

Course Structure & Syllabus of Ph.D. CSE
Applicable for Batch: 2021 Onwards

Subject Code	CS991	Subject Title	NATURE INSPIRED COMPUTING					
LTP	4 0 0	Credit	4	Subject Category	DE	Year	1st	Semester	I / II

OBJECTIVE

To understand the fundamentals of nature inspired techniques which influence computing, studythe Swarm Intelligence and Immuno computing techniques and familiarize the DNA Computing.

Unit 1: **12Hrs**

INTRODUCTION: From Nature to Nature Computing , Philosophy , Three Branches: A BriefOverview, Individuals, Entities and agents - Parallelism and Distributivity Interactivity , AdaptationFeedback-Self-Organization-Complexity, Emergence and ,Bottom-up Vs Top-Down-Determination,Chaos and Fractals.

Unit 2: **10Hrs**

Computing Inspired by Nature: Evolutionary Computing, Hill Climbing and Simulated Annealing, Darwin's Dangerous Idea, Genetics Principles, Standard Evolutionary Algorithm –Genetic Algorithms , Reproduction-Crossover, Mutation, Evolutionary Programming, Genetic Programming

Unit 3: **10 Hrs**

SWARM INTELLIGENCE: Introduction - Ant Colonies, Ant Foraging Behavior, Ant Colony Optimization, SACO and scope of ACO algorithms, Ant Colony Algorithm (ACA), Swarm Robotics, Foraging for food, Social Adaptation of Knowledge, Particle Swarm Optimization (PSO)

Unit-4: **10 Hrs**

IMMUNOCOMPUTING: Introduction- Immune System, Physiology and main components, Pattern Recognition and Binding , Immune Network Theory- Danger Theory, Evaluation InteractionImmune Algorithms , Introduction – Genetic algorithms , Bone Marrow Models , Forest's Algorithm**,** Artificial Immune Networks

Unit-5: **10 Hrs**

COMPUTING WITH NEW NATURAL MATERIALS: DNA Computing: Motivation, DNAMolecule , Adleman's experiment , Test tube programming language, Universal DNA Computers , PAMModel , Splicing Systems , Lipton's Solution to SAT Problem , Scope of DNA Computing , From Classicalto DNA Computing.

COURSE OUTCOME:

At the end of the coursethe student will learn:

CO1. The basics Natural systems
CO2. The concepts of Natural systems and its applications
CO3. Integration of Hardware and software in Natural applications.
CO4. Natural design considerations

TEXT BOOKS

1. Leandro Nunes de Castro, “Fundamentals of Natural Computing, Basic C Applications", Chapman & Hall/ CRC, Taylor and Francis Group, 2007

REFERENCES

1. Floreano D. and Mattiussi C., "Bio-Inspired Artificial Intelligence: Theories, Methods, and Technologies",MIT Press, Cambridge, MA, 2008.
2. Albert Y.Zomaya, "Handbook of Nature-Inspired and Innovative Computing", Springer, 2006.
3. Marco Dorrigo, Thomas Stutzle,” Ant Colony Optimization”, PHI,2005