FIRST SEMESTER

MAT 5134 MATHEMATICAL FOUNDATIONS OF COMPUTER NETWORKING[3 1 0 4]

Abstract
Probability Theory, Statistics, Linear Algebra, Optimization Theory, Stochastics Process and Queueing Theory, Fundamental Concepts of Game Theory, Basics of Information Theory

Self-Directed Learning: Vectors and Matrices, Vector and Matrix Algebra, Linear Combinations, Independence

Course Outcomes
At the end of this course, students will be able to:

1. Apply the concepts of probability and statistics to model and quantify uncertainty
2. Apply the concepts of linear algebra to solve real world problems
3. Apply different optimization techniques to solve complex engineering problem.
4. Use different queueing systems to model traffic in data networks
5. Use game-theoretic approach to develop routing strategies

References

1. Srinivasan Keshav, *Mathematical Foundations of Computer Networking*, Addison-Wesley, 2012
2. John F. Shortle, James M. Thompson, Donald Gross, and Carl M. Harris, *Fundamentals of Queueing Theory*, Wiley, 2018
3. T. Veerarajan, *Probability and Statistics, Random Processes and Queueing Theory*, McGraw Hill Education, 2018

ICT 5114 ADVANCED DATA STRUCTURES & ALGORITHMS [4 0 0 4]

Abstract

Performance analysis of algorithms, Advanced data structures- Trees, Binary trees, Balanced trees, Hashing, Priority queues, Searching and sorting, The disjoint set ADT, Path compression algorithms, Algorithm design techniques-Greedy, divide and conquer, Backtracking, dynamic programming, Branch and bound, randomized algorithms, Evolutionary algorithms, NP-completeness.

Self-Directed Learning: Binary Trees, The Search Tree ADT- Binary Search Trees, AVL Trees

Course Outcomes:

By the end of the course, student should be able to

1. Comprehend and select appropriate data structures and algorithms and use it to solve problems.
2. Analyse and compare the various searching and sorting algorithms for their efficiency.
3. Design and analyse programming problem statements.
4. Comprehend and select algorithm design techniques for solving a programming problem.

References:

1. Mark Allen Weiss, *Data Structures and Algorithm Analysis in C++*, Pearson Education 2014
2. Sahni, *Data structures, Algorithms and Applications in C++* (2e), Silicon Press, 2009.

3. Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest, and Clifford Stein., *Introduction to Algorithms* (3e), PHI Learning Pvt. Ltd., Eastern Economy Edition, PHI, 2010
4. Xinije Yu, Mitsuo Gen ,Introduction to Evolutionary algorithms, Springer publishers, 2010
5. Dasimon, Evolutionary optimization Algorithms John, Wiley and sons publishers, 2013

ICT 5115 ADVANCED OPERATING SYSTEMS [4 0 0 4]

Abstract

Review of the basic operating system concepts, distributed operating system architecture, issues and communication mechanisms, logical clocks, vector clocks, mutual exclusion and deadlock detection in distributed environment, distributed file systems and shared memory concepts, failure recovery and fault tolerance concepts, resource security and protection, scheduling algorithms in real time operating system, database and multiprocessor system concepts.

Self-Directed Learning: Issues in load distribution, Load distribution algorithms, task migration

Course Outcomes:

At the end of this course the student will be able to

1. Understand the functionalities of a basic Operating systems and distributed OS concepts
2. Interpret the concepts of Mutual Exclusion, Deadlocks, File Systems, Scheduling, Failure recovery, Fault Tolerance with respect to Distributed Operating Systems.
3. Understand resource security and protection, Multiprocessor Operating Systems, Concurrency control mechanisms of database Operating System.
4. Apply the real time scheduling algorithms to solve a given problem.

References:

1. M. Singhal and N.G. Shivaratri, *Advanced concepts in operating systems*, TMH (1e), 2017.
2. S. Tanenbaum, *Modern Operating Systems*, 4th Edition, Pearson, 2016.
3. L. Jane W. S., *Real time systems*, Pearson, 2018

ICT 5116 COMMUNICATION NETWORK PROTOCOLS [4 0 0 4]

Abstract

Introduction, Connectionless and connection-oriented service, circuit and packet switching, packet forwarding in computer networks, network access and physical media, ISPs and Internet backbones, delay and loss in packet-switched networks, protocol layers and their service models. Queuing Models, LANs, Network service models, routing principles, hierarchical routing, the Internet Protocol (IP), Routing in the internet, Multicasting and Multicast Routing, Introduction to transport layer services, TCP, UDP and SCTP, Principles of congestion control, TCP Congestion control, Client–Server Model, Socket programming with TCP, socket programming with UDP

Self-Directed Learning: TCP, UDP and SCTP **-** Introduction to transport layer services

Course Outcomes
By the end of this course the student should be able to

1. Apply concepts and principles to solve problems
2. Identify protocols, network elements to design a network for a given scenario
3. Write simple network debugging software applications using socket system calls.

References:

1. Behrouz A. Forouzan, *TCP/IP Protocol Suite*, 4th Edition, McGraw Hill, 2017.
2. Leon-Garcia and Widjaja, *Communication Networks*, 2nd Edition, McGraw Hill, 2017.
3. Behrouz A Forouzan, *Data Communications and Networking with TCP/P Protocol Suite*, 6th Edition, McGraw Hill, 2022
4. Jean Walrand and Pravin Varayya, *High Performance Communication Networks*, Harcourt Asia Pvt Ltd., 2010.
5. Andrew S. Tanenbaum, , Nick Feamster, and David J.Wetherall, *Computer Networks*, 6th Edition, Pearson, 2022.
6. Richard W Stevens, *Unix Network Programming*, Vol. – I, Pearson Education 2004.

ICT 5117 MOBILE COMPUTING AND COMMUNICATION [3 0 0 3]

Abstract

Cellular network OFDM frequency selective channels, Multiple access OFDMA, Channel coding, Spreading and modulation, LTE, NOMA, 5G, beamforming. Mobile computing models, Wireless location services, Mobile agents

Self-Directed Learning: Evolution of cellular network (1G to 6G), Evolution of LTE Technology to Beyond 4G

Course outcomes

At the end of this course, students will be able to:

1. Realize the working principles of mobile agents for wireless communication
2. Analyze the functionalities of networking technologies
3. Identify the technologies to be used based on the given scenario.
4. Analyze and evaluate the different features evolved in mobile computing.
5. Develop and evaluate the networking framework for 5G scenario.

References:

1. Jiannong Cao, Sajal K. Das, *Mobile Agents in Networking and Distributed Computing* (1e), Wiley-Interscience, July 2012.
2. Zach Shelby, Carsten Bormann, *6LoWPAN: The Wireless Embedded Internet*, John Wiley Publications, 2011.
3. Andrea Molisch, *Wireless Communications* (2e), Wiley Publications, 2012.
4. Frank Adelstein, Sandeep K.S. Gupta, Golden Richard, Loren S, *Fundamentals of Mobile and Pervasive Computing* (1e), Mc-Graw Hill Companies, 2005.
5. Saad Z. Asif, *Next Generation Mobile Communications Ecosystem: Technology Management for Mobile Communications*, Wiley Publications, 2011.
6. Upena Dalal, Wireless communication (1e), Oxford 2014.
7. Jonathan Rodriguez, *Fundamentals of 5G Mobile Networks*, John Wiley & Sons, Ltd, 2015.

HUM 5051 RESEARCH METHODOLOGY AND TECHNICAL COMMUNICATION

[1 0 3 -]

Abstract

Mechanics of Research Methodology: Basic concepts: Types of research, Significance of research, Research framework, Case study method, Experimental method, Sources of data, Data collection using questionnaire, Interviewing, and experimentation. Research formulation: Components, selection and formulation of a research problem, Objectives of formulation, and Criteria of a good

research problem. Research hypothesis: Criterion for hypothesis construction, Nature of hypothesis, need for having a working hypothesis, Characteristics and Types of hypothesis, Procedure for hypothesis testing, Sampling methods- Introduction to various sampling methods and their applications. Data Analysis: Sources of data, Collection of data, Measurement and scaling technique, and Different techniques of Data analysis. Thesis Writing and Journal Publication: thesis writing, journal and conference papers writing, IEEE and Harvard styles of referencing, Effective Presentation, Copyrights, and avoiding plagiarism.

Self-Directed Learning: IEEE and Harvard styles of referencing

References :

1. Ranjit Kumar, Research Methodology: *A Step-by-Step Guide for Beginners*, SAGE, 2005.
2. Geoffrey R. Marczyk, David DeMatteo & David Festinger, *Essentials of Research Design and Methodology*, John Wiley & Sons, 2004.
3. John W. Creswel , *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches*, SAGE, 2004
4. Suresh C. Sinha and Anil K. Dhiman, *Research Methodology (2 Vols-Set)*, Vedam Books, 2006.
5. C. R. Kothari, *Research Methodology: Methods and Techniques*, New Age International Publisher, 2008.
6. Donald R Cooper & Pamela S Schindler, *Business Research Methods*, McGraw Hill International, 2007.
7. R. Pannershelvam, *Research Methodology*, Prentice Hall, India, 2006
8. Manfred Max Bergman, *Mixed Methods Research*, SAGE Books, 2006.
9. Paul S. Gray, John B. Williamson, David A. Karp, John R. Dalphin, *The Research Imagination*, Cambridge University press, 2007.
10. Cochrain & Cox, *Experimental Designs*, II Edn. Wiley Publishers, 2006.

ICT 5141 ALGORITHMS AND OPERATING SYSTEMS LAB [0 0 3 2]

Abstract

The algorithms part covers Binary trees, Binary Search Trees, AVL trees, and B-trees, algorithm design techniques such as greedy, divide-and-conquer, dynamic programing, and backtracking. Searching and sorting, graph algorithms.

The operating systems part deals with the implementation of various algorithms related to the topics such as process synchronization (producer-consumer), deadlock detection, remote method invocation, Lamport's logical clock, token based and non-token based mutual exclusion algorithms.

Course Outcomes

At the end of this course, students will be able to:

Write programs to implement various trees and hashing techniques

1. Device programs to solve given problems using algorithm design techniques
2. Implement programs based on searching and sorting
3. Write programs for graph-based algorithms
4. Solve problems on OS process deadlock prevention schemes, avoidance and detection schemes
5. Implements programs for remote method invocation
6. Write programs for implementing mutual exclusion

References

1. Mark Allen Weiss, *Data Structures and Algorithm Analysis in C++*, Pearson Education 2014

2. Sartaj Sahni, *Data structures, Algorithms and Applications in C++*, 2nd Edition, Silicon Press, 2017.
3. M. Singhal and N.G. Shivaratri, *Advanced concepts in operating systems*, McGraw-Hill Education, 2017.

ICT 5142 NETWORK MODELING AND PERFORMANCE LAB [0 0 3 2]

Abstract
Introduction to network modeling and simulation, Protocols and Services in Computer Networks and Systems, Approaches in Performance Evaluation, Modeling Approaches for Computer Networks and Systems, Simulation Methodologies in Computer Networks and Systems, Tools-NS2/3, Cisco Packet Tracer, Wireshark, Project Work

Self-Directed Learning: Cisco Packet Tracer, Wireshark

Course Outcomes
At the end of this course, students will be able to:

1. Identify a suitable network simulation approach for a given problem
2. Use network modelling tools to model a given network
3. Identify a suitable approach for performance evaluation for the designed network

References

1. Mohsen Guizani, Ammar Rayes, Bilal Khan, and Ala Al-Fuqaha, *Network Modeling and Simulation: A Practical Perspective*, Wiley, 2010
2. James Gross, Klaus Wehrle, and Mesut Gunes (Editors), *Modeling and Tools for Network Simulation*, Springer, 2010
3. Faouzi Zarai, Mohammad S. Obaidat, and Petros Nicopolitidis (Editors), *Modeling and Simulation of Computer Networks and Systems*, Morgan Kaufmann Publishers, 2015
4. George Zobrist, Jean Walrand, and Kallol Bagchi (Editors), *Network Performance Modeling and Simulation*, CRC, 2019
5. Nejat Ince, and Ercan Topuz (Editors), *Modeling and Simulation Tools for Emerging Telecommunication Networks: Needs, Trends, Challenges and Solutions*, Springer, 2014

SECOND SEMESTERS

ICT 5213 ADVANCED COMMUNICATON NETWORK TECHNOLOGIES [4 0 0 4]

Abstract

Adhoc Networks, Inter-vehicular communications and GPS, Switch performance measures, Time and space switches, Modular switch design Packet switch and distributed BufferOptical N/W, DWDM, High-speed Networks, Circuits switched N/W: SONET and SDH. IP forwarding Architectures, RSVP ,ATM, MPLS, Network Management: Organisation and Information Models, Communication and functional models, SNMPv2, SDN Background and Motivation, SDN Data Plane, SDN Control Plane, Controllers, OpenFlow: OpenFlow Logical Network Device -Flow Table Structure , Flow Table Pipeline, The Use of Multiple Tables , Group Table, OpenFlow Protocol, Program a SDN enabled switch as hub, learning switch Software Defined Networks

Self-Directed Learning: SDN Background and Motivation

Course Outcomes
By the end of this course the student should be able to

1. Demonstrate the Understanding of the principles of Inter-vehicular Communications including GPS principles for developing Adhoc network applications
2. Develop network monitoring solutions for the network managed devices using network management principles
3. Identify different wired communication network technologies developed for real life scenarios
4. Develop skill sets to design and implement wired/wireless networks using current technologies
5. Demonstrate the understanding of various protocols supporting QOS for high speed communication Networks
6. Demonstrate the understanding of Software Defined Networks

References

1. Mani Subramanian, Timothy A. Gonsalves, N Usha Rani, *Network Management, Principles and Practice* (2e), Pearson Education India, 2010.
2. Jean Walrand and Praveen Varaiya, *High-Performance Communication NetWorks* (2e), Morgan Kaufmann 2000.
3. Albert Leon-Garcia, and Indra Widjaja, *Communication Networks*, 2nd Edition, McGraw Hill, 2017.
4. William Stallings, *Foundations of Modern Networking: SDN, NFV, QoE, IoT, and Cloud*, 1st Edition, Pearson, 2016.
5. Oswald Coker, and Siamak Azodolmilky, *Software-Defined Networking with OpenFlow*, 2nd Edition, Packt Publishing, 2017.

ICT 5214 SYSTEMS AND NETWORK SECURITY [4 0 0 4]

Abstract
Network security principles, types of attacks, cryptography, mathematics of cryptography, private key and public key cryptography, operating system security, protected objects and methods of protection, File protection mechanisms, database security, reliability and integrity, sensitive data, multilevel database, security in networks, IPSec, email security, SSL/TLS, Web security, SET protocol, Intruder Detection Systems, Public Key Infrastructure, X.509, digital certificates, trust models, Transport-level security, E-mail security, IoT security, Blockchain technology.

Self-Directed Learning: Web Security Consideration, Transport Layer Security

Course Outcomes
By the end of this course the student should be able to

1. Understand cybercrime and various threats to information systems
2. Comprehend the fundamental mathematics required to understand cryptographic algorithms and apply them to cryptographic algorithms
3. Understand the principles of operating system security , databases security and network security
4. Understand intrusion detection system and firewall
5. Comprehend security issues in IoT and blockchain technology

References:

1. Stallings W., *Cryptography and Network Security: Principles and Practice (8e),* Pearson Publications, 2022.
2. Pfleeger C. P., Pfleeger S.L., Margulies J., *Security in Computing (5e),* Prentice Hall, 2015

3. F. Hu. “Security and Privacy in Internet of Things (IoTs): Models, Algorithms, and Implementations”, (1e), CRC press, 2016.
4. Brenn Hill, Samanyu Chopra, and Paul Valencourt, *Blockchain Quick Reference: A guide to exploring decentralized blockchain application development*, Packt Publishing, 2018

PROGRAM ELECTIVE I **[3 0 0 3]**

PROGRAM ELECTIVE II **[3 0 0 3]**

PROGRAM ELECTIVE III **[4 0 0 4]**

OPEN ELECTIVE **[3 0 0 3]**

ICT 5242 NETWORK SECURITY LAB [0 1 3 2]

Abstract

Students will explore vulnerabilities of Windows, and Linux, Installation and maintenance of firewalls, Network-based and host-based intrusion detection systems (IDS) and prevention, developing a security policy for an enterprise network to enable students to acquire the experience of starting from scratch and designing a functioning security
system for an enterprise.

Course Outcomes

By the end of this course the student should be able to

1. Analyse the security of major operating systems
2. Evaluate the suitability of firewalls for a given networking scenario for an enterprise
3. Produce security policy for an enterprise network
4. Implement and install intrusion detection sytems

References:

1. Joseph Migga, *Guide to Computer Network Security*, 5th Edition, Springer, 2020
2. Arthur Salmon, Warun Levesque, and Michael McLafferty, *Applied Network Security*, Packt, 2017
3. Andrew Green, Michael Whitman, and Herbert Mattord, *Hands-On Information Security Lab Manual*, 4th Edition, Cengage, 2014

ICT 5244 NETWORK ENGINEERING CAPSTONE PROJECT [0 0 3 2]

Abstract

Capstone project in Network Engineering will skill up the student to take up computer network design scenario, model, simulate and evaluate the performance. The projects will be across three research axes: network modeling, network simulation, and performance evaluation. The duration of capstone project will be of 12 weeks. As a part of this, student will submit detailed problem statement explicitly specifying the objectives (3rd week). A mid-term evaluation of the capstone project work will be done in 6th week. Students will submit the synopsis in 11th week. The final evaluation will be conducted in 12th week. The evaluation is based on demo and final report submission followed by viva-voce.

Depending on the domain students will use tools like, NS2/3, Cisco Packet Tracer, and Wireshark.

Course Outcomes

At the end of this course, students will be able to

1. Define the problem statement explicitly specifying objectives.
2. Demonstrate the methodology followed for the given problem statement
3. Implementation of the capstone project.

References

1. Mohsen Guizani, Ammar Rayes, Bilal Khan, and Ala Al-Fuqaha, *Network Modeling and Simulation: A Practical Perspective*, Wiley, 2010
2. James Gross, Klaus Wehrle, and Mesut Gunes (Editors), *Modeling and Tools for Network Simulation*, Springer, 2010
3. Faouzi Zarai, Mohammad S. Obaidat, and Petros Nicopolitidis (Editors), *Modeling and Simulation of Computer Networks and Systems*, Morgan Kaufmann Publishers, 2015
4. George Zobrist, Jean Walrand, and Kallol Bagchi (Editors), *Network Performance Modeling and Simulation*, CRC, 2019
5. Nejat Ince, and Ercan Topuz (Editors), *Modeling and Simulation Tools for Emerging Telecommunication Networks: Needs, Trends, Challenges and Solutions*, Springer, 2014.

PROGRAM ELECTIVES

ICT 5401 APPLIED DEEP LEARNING [3 0 0 3]

Abstract

Introduction, Mathematical Preliminaries, Machine Learning Basics, Deep Feedforward Networks, Regularization for Deep Learning, Optimization for Training Deep Models, Convolutional Networks, Recurrent and Recursive Networks, Practical Methodology

Self-Directed Learning: Python basics, Linear Algebra, Probability and Information Theory

Course Outcomes

By the end of this course a student must be able to:

1. Choose the right deep learning model for a given learning problem.
2. Select the suitable deep learning layers for a given learning problem.
3. Implement deep learning architectures using Python frameworks.
4. Analyze the effect of hyperparameters on the performance of deep learning architectures
5. Comprehend and communicate the content of a research paper in the area of deep learning.

References:

1 Ian Goodfellow and Yoshua Bengio and Aaron Courville, *Deep Learning*, MIT Press 2016
2 Umberto Michelucci, *Advanced Applied Deep Learning*, Springer, 2022
3 Simon Haykin, *Neural Networks and Learning Machines*, Pearson, 2018
4 Charu C Agarwal, *Neural Networks and Deep Learning*, Springer 2018

ICT 5402 APPLIED NATURAL LANGUAGE PROCESSING [3 0 0 3]

Abstract
Word Vectors, Word Window Classification, Neural Networks and Backpropagation, Dependency Parsing, Recurrent Neural Networks and Language Models, Vanishing Gradients, Fancy RNNs, Seq2Seq, Machine Translation, Attention, Transformers, Question Answering, Natural Language Generation, Conference Resolution, Large Language Models, Integrating Knowledge in Language Models
Self-Directed Learning: Vector space, Basics of neural networks

Course Outcomes
At the end of this course, students will be able to:
1. Understand the basic concepts and algorithms of natural language processing.
2. Apply neural networks for language modelling
3. Generate natural language and transform using machine learning models
4. Discover entity-emotions relationship through conflict resolution
5. Develop language models by integrating knowledge.

References

1. Daniel Jurafsky and James H.Martin, *Speech and Language Processing*, 3rd Edition (draft), Pearson, 2021
2. Jacob Eisenstein, *Introduction to Natural Language Processing*, The MIT Press, 2019
3. Delip Rao, and Brian McMahan, *Natural Language Processing with PyTorch*, O'Reilly Media, 2019
4. Eugene Charniak, *Introduction to Deep Learning*, The MIT Press, 2019

ICT 5403 BIG DATA TECHNOLOGIES [3 0 0 3]

Abstract

Overview of Big data, Data Analysis, Hadoop, HDFS, Data ingestion using Fume and Scoop, MapReduce structure, Writing MapReduce programs, Hadoop Ecosystem: Pig, Hive, Working with Spark, Stream Data analytics: models, queries, NOSQL: properties, models, querying, Case Studies for big data analytics.

Self-Directed Learning: Map Reduce, Design of HDFS, HDFS Concepts

Course Outcomes
1. Describe the concept and challenge of big data analytics
2. Write Map reduce solutions for Big Data.
3. Demonstrate use of tools in Hadoop Ecosystem
4. Build Spark solutions for Big data problems
5. Design data stores using NOSQL.

References:

1. Tom White, *Hadoop: The definitive guide*, 4th Edition, O'Reilly, 2015.
2. Nataraj Dasgupta, *Practical Big Data Analytics*, 1st Edition, Packt Publishing, 2018
3. Shashank Tiwari, *Professional NOSQL*, 1st Edition, Wiley, 2011
4. Seema Acharya, *Demystifyng NoSQL*, Wiley, 2020
5. Bill Chambers and Matei Zaharia, *Spark: The Definitive Guide*, O'Reilly, 2018

ICT 5404 **EDGE COMPUTING** **[3 0 0 3]**

Abstract
Computing Paradigms, Edge Computing Essentials, Edge Analytics, Edge Data Storage Security, Blockchain and Edge Computing Systems, Edge Computing Use Cases and Case Studies, Edge Computing with Kubernetics

Self-Directed Learning: Kubernetes, Dockers and Containers

Course Outcomes
By the end of this course the student should be able to

1. Explore the need for new computing paradigms
2. Explain major components of edge computing
3. Identify potential technical challenges of the transition process and suggest solutions
4. Analyze data and application requirements and pertaining issues
5. Design and model infrastructure with kubernetics

References:

1. D.Dharani, G.Sudha Sadasivam, K.Anitha Kumari, and M.Niranjananurthy, *Edge Computing: Fundamentals, Advances and Applications*, 1st Edition, Taylor & Francis, 2021
2. Rajkumar Buyya, and Satish Narayana Srirama, *Fog and Edge Computing: Principles and Paradigms*, Wiley, 2019
3. Javid Taheri, and Shuiguang Deng, *Edge Computing: Models, Technologies and Applications*, IET, 2020.
4. Sergio Mendez, *Edge Computing Systems with Kubernetics*, Packt Publishing, 2022

ICT 5405 **FEDERATED LEARNING** **[3 0 0 3]**

Abstract
Introduction; Privacy-preserving Machine Learning: PPML, and secure ML; Distributed Machine Learning: Scalability Motivated DML; Horizontal Federated Learning: Architecture of HFL, Federated Averaging Algorithm; Vertical Federated Learning: Architecture of VFL; Algorithms of VFL; Federated Transfer Learning; Incentive Mechanism Design for Federated Learning; Federated Reinforcement Learning; Applications of Federated Learning

Self-Directed Learning: Basics of cloud and edge computing

Course Outcomes

At the end of this course, students will be able to:
1. Make use of concepts of federated learning for real world applications.
2. Apply federated learning for privacy preserving applications.
3. Choose suitable federated learning model for the given application
4. Design federated learning using incentive mechanisms
5. Apply federated learning model for secure reinforcement learning

References

1. Qiang Yang, Yang Liu, Yong Cheng, Yang Kang, Tianjian Chen, and Han Yu, *Federated Learning*, Morgan & Claypool Publishers, 2019

2. Qiang Yang, Lixin Fan and Han Yu, Editors, *Federated Learning: Privacy and Incentive*, Springer, 2020
3. Muhammad Habib ur Rehman, and Mohamed Medhat Gaber, Editors., *Federated Learning Systems*, Springer, 2021
4. J.Morris Chang, Di Zhuang, and G.Dumindu Samaraweera, *Privacy-Preserving Machine Learning*, Manning, 2022

ICT 5406 INFORMATION RETRIEVAL SYSTEM [4 0 0 4]

Abstract
Boolean Retrieval, Term Vocabulary and Postings Lists, Dictionaries and Tolerant Retrieval, Index Construction and Index Compression, Scoring, Term Weighting and Vector Space Model, Computing Scores in a Complete Search Systems, Evaluation in Information Retrieval, Relevance Feedback and Query Expansion, Matrix Decomposition and Latent Semantic Index, Web Search Basics, Web crawling and indexes, Probabilistic Information Retrieval, Multimedia Information Retrieval, Machine learning for Information retrieval

Self-Directed Learning: Probability theory, Vector space, Similarity metrics

Course Outcomes
At the end of this course, students will be able to:

1. Understand the various IR models that can be used to retrieve documents from large collection.
2. Explain various data structures used for index construction, compression techniques in IR.
3. Analyze performance of IR systems.
4. Demonstrate the application of IR techniques for web page ranking.
5. Illustrate the knowledge of Machine learning for Information Retrieval.

References

1. Christopher D.Manning, PrabhakarRaghavan and HinrichSchutze, *Introduction to Information Retrieval (1e)*, Cambridge University Press, 2008.
2. Marcia J Bates, *Understanding Information Retrieval Systems:management types and standards(1e)*, CRC press, 2011.
3. Charu C Agarwal, "*Machine Learning for Text" (2e)"* Springer 2022.
4. Morgan and Claypool, Multimedia Information Retrieval, 2010.

ICT 5408 MACHINE LEARNING [3 0 0 3]

Abstract
Introduction, Decision Trees, Limits of Learning, Geometry and Nearest Neighbors, Perceptron, Practical Issues, Beyond Binary Classification, Linear Models, Bias and Fairness, Neural Networks, Kernel Methods, Learning Theory, Ensemble Methods, Efficient Learning, Unsupervised Learning, Expectation Maximization, Structured Prediction, Imitation Learning

Self-Directed Learning: Data to Feature Vectors, K-Nearest Neighbors, Decision Boundaries, K-Means Clustering

Course Outcomes

At the end of this course, students will be able to:

1. Choose appropriate machine learning paradigm for a given learning problem
2. Make use of tools for debugging the machine learning models

3. Explain the relationship between complexity measures and regularizers
4. Recognize when a problem should be solved using a structured prediction technique
5. Formulate imitation learning problems.

References

1. Hall Daume III, A Course in *Machine Learning*, Self Publishing, 2017.
2. Mehryar Mohri, Afshin Rostamizadeh, and Ameet Talwalkar., *Foundations of Machine Learning*, MIT Press, 2012.
3. Daphne Koller and Nir Friedman, *Probabilistic Graphical Models: Principles and Techniques*, MIT Press, 2009.
4. Christopher M.Bishop., *Pattern Recognition and Machine Learning (2e),* Springer, 2013.
5. Solon Barocas, Moritz Hardt and Arvind Narayanan, *Fairness and Machine Learning*, failml.org, 2021

ICT 5409 SEMANTIC WEB TECHNOLOGIES [3 0 0 3]

Abstract

The Semantic Web Activity of W3C: Overview of techniques and standards, XML with Document Type Definitions and Schemas; Describing Web Resource: RDF data models, syntax, semantics, schema, RDFS, RDF Data structures, Containers and collections; Querying Semantic Web: SPARQL matching patterns, filters, querying schemas; Ontology and Information Systems: Use of ontologies, types, design principles, methodologies; Ontology Languages: OWL2, OWL2 profiles; Logic for the Semantic Web: Predicate and Description Logics; Ontology Reasoning: Monotonic rules, Rule interchange format, Semantic web rules languages, RuleML; Ontology Design and Management: Types, purposes, creating ontology manually, reusing existing, mapping

Self-Directed Learning: RDF-data model, syntaxes, RDFS-adding semantics, RDF schema, RDF and RDF schema in RDFS

Course Outcomes

By the end of this course, students will be able to

1. Demonstrate the understanding of the knowledge representation formalisms in use on the Semantic Web.
2. Build Queries using SPARQL to query the Semantic Web.
3. Represent and reason ontologies using OWL.
4. Apply ontology engineering approaches to develop ontologies.

References

1. Grigoris Antoniou, Paul Groth, Frank van Harmelen, Rinke Hoekstra, *A Semantic Web Primer*, 3rd edition, The MIT Press, 2012.
2. Peter Szeredi, Gergely Lukacsy, Tamas Benko, and Zsolt Nagy, *The Semantic Web Explained*, Cambridge University Press, 2014
3. Liyang Yu, *Introduction to the Semantic Web and Semantic Web Services*, CRC Press, 2019
4. Elisa F.Kendall, Deborah L.McGuinness, Ying Ding, and Paul Groth, *Ontology Engineering*, Morgan & Claypool Publishers, 2019

ICT 5410 TIME SERIES ANALYSIS AND FORECASTING [4 0 0 4]

Abstract
Introduction, R Language; Statistics for Forecasting: Graphical Displays, Numerical Description of Time Series Data; Regression Analysis and Forecasting: Least Square Estimation in Linear Regression Models, Statistical Inference in Linear Regression; Exponential Smoothing Methods: First and Second-Order Exponential Smoothing, Modeling Time Series Data; ARIMA Models: Linear Models for Stationary Time Series, Finite Order Moving Average Processes; Transfer Functions and Intervention Models: Transfer Function Models, Transfer Function-Noise Models

Self-Directed Learning: Basics of R language programming

Course Outcomes

At the end of this course, students will be able to:

1. Make use of concepts of time series data and represent real world problems.
2. Build regression analysis and forecast model for the given data
3. Build different time series models for forecasting
4. Apply intervention analysis using transfer function models
5. Demonstrate working of time series and forecasting algorithms using R language

References

1. Douglas C.Montgomery, Cheryl L.Jennings, and Murat Kulahci, *Introduction to Time Series Analysis and Forecasting*, 2nd Edition, Wiley-Interscience, 2015.
2. Peter J.Brockwell, and Richard A.Davis, *Introduction to Time Series and Forecasting*, 3rd Edition, Springer, 2016.
3. Jan G.De Gooijer, *Elements of Nonlinear Time Series Analysis and Forecasting*, Springer, 2018.
4. Galit Shmueli, and Kenneth C. Lichtendahl Jr, *Practical Time Series Forecasting with R*, 2nd Edition, Axelrod Schnall Publishers, 2016
5. Rob J Hyndman, and George Athanasopoulos, *Forecasting: Principles and Practice*, 3rd Edition, OTexts, 2021

OPEN ELECTIVES

ICT 5301 APPLIED GAME THEORY [3 0 0 3]

Abstract
Introduction, Single-Person Decision Problem, Uncertainty and Time, Rationality and Common Knowledge, Nash Equilibrium, Mixed Strategies, Credibility and Sequential Rationality, Multistage Games, Repeated Games, Strategic Bargaining, Bayesian Games, Auctions and Competitive Bidding, Mechanism Design, Applications of Game Theory

Self-Directed Learning: Case studies on applications of non-cooperative, and cooperative game theory

Course Outcomes
At the end of this course, students will be able to:

1. Identify strategic situations and represent them as games
2. Solve simple games using various techniques
3. Recommend and prescribe which strategies to implement
4. Develop mechanisms to elicit the required response
5. Analyze engineering situations using game theoretic techniques

References

1. Steven Tadelis, Game Theory: An Introduction, Princeton University Press, 2013
2. Vladimir Mazalov, *Mathematical Game Theory and Applications*, Wiley, 2014
3. Hans Peters, *Game Theory: A Multi-Leveled Approach*, 2nd Edition, Springer, 2015
4. Dario Bauso, *Game Theoy with Engineering Applications*, SIAM, Philadelphia, 2016

ICT 5302 BLOCKCHAIN TECHNOLOGIES [3 0 0 3]

Abstract

Introduction to technology stack: Blockchain, protocol, understanding how blockchain works. Introduction to consensus model. Architecture of decentralized application, Dapps development process and command, application model for Dapp, introduction to Dapp development environment. Introduction to smart contracts and its development environment. Introduction to blockchain applications in different domains like government, health and genomics.

Self-Directed Learning: Cryptography concepts, Hashing techniques

Course Outcomes

At the end of this course, students will be able to:

1. Apply concepts of Blockchain technologies to build application.
2. Analyze different components of blockchain ecosystem, the elements of trust in a blockchain: validation, verification, and consensus
3. Examine the relevance of Blockchain technology in different applications/ usecases
4. Develop smart contracts in Ethereum framework

References

1. Melani Swan, Blockchain: Blueprint for a New Economy (1e), O'Reilly Media, 2015.
2. Paul Vigma, Michael J. Casey, The Truth Machine: The Blockchain and the Future of Everything (1e), St Martin's Press, 2018.
3. Daniel Drescher, Blockchain Basics: A Non-Technical Introduction in 25 Steps (1e), Apress, 2017.
4. Elad Elrom, The Blockchain Developer: A Practical Guide for Designing, Implementing, Publishing, Testing, and Securing Distributed Blockchain-based Projects (1e) , Apress ,2019
5. Imran Bashir, Mastering Blockchain: Distributed Ledger Technology, decentralization, and smart contracts explained(2e), Packt Publishing Ltd, 2018.
6. Bellaj Badr, Richard Horrocks, Xun (Brian) Wu, Blockchain By Example: A developer's guide to creating decentralized applications using Bitcoin, Ethereum, and Hyperledger, Packt Publishing Limited, 2018.

ICT 5303 CYBER SECURITY AND CYBER LAW [3 0 0 3]

Abstract

Introduction to Information, Network and System Security, Encryption techniques, Message Integrity and Message Authentication, Digital Signature, Key Management, User Authentication. Web security model: Browser security model including same-origin policy, Client-server trust boundaries, Session management, authentication: Single sign-on, HTTPS and certificates. Application vulnerabilities and defenses: SQL injection, XSS, CSRF. Client-side security: Cookies security policy, HTTP security extensions, Plugins, extensions, and web apps, Web user tracking, Server-side security tools, e.g. Web Application Firewalls (WAFs) and fuzzers. Cybercrime, Cybercrime investigation, Laws and ethics

Self-Directed Learning: SQL injection, XSS, CSRF, Web Application Firewalls

Course Outcomes
By the end of this course, the student should be able to

1. Understand the symmetric and asymmetric cryptographic algorithms.
2. Describe common types of vulnerabilities and attacks in web applications, and defenses against them.
3. Understand client side and server side security concepts and tools
4. Propose and design security algorithm for a particular application
5. Understand cybercrimes, cybercrime investigation, Laws and ethics.

References:

1. Mayank Bhushan, *Fundamentals of cybersecurity*, BPB publications, 2017
2. Raef Meeuwisse, *Cyber Security for Beginners*, 2015
3. Nilakshi Jain and Ramesh Menon, *Cyber Security and Cyber Laws*, Wiley, 2020
4. Rolf Oppliger, *Security Technologies for the World Wide Web* (2e), Artech House, 2002.
5. Seth Fogie, Jeremiah Grossman, Robert Hansen and Anton Rager, *XSS Attacks: Cross Site Scripting Exploits and Defense*, Syngress, 2007.
6. Justin Clarke et.al.,*SQL Injection Attacks and Defense (2e)*, Syngress, 2012.
7. DafyddStuttard, and Marcus Pinto, *The Web Application Hacker's Handbook: Finding and Exploiting Security Flaws* (2e), Wiley, 2011.

ICT 5304 REAL TIME SYSTEMS [3 0 0 3]

Abstract:

Introduction to Real Time Systems, Resource management, Commonly used approaches for real time scheduling-static scheduling, priority driven scheduling, RM and DM algorithms, Aperiodic jobs and scheduling, Computation of average response time, Various servers: Deferrable, Sporadic etc. Bandwidth computation, Resource access protocols: various resources access protocols and features, Advantages and drawbacks, Priority ceiling protocols and its use in dynamic priority systems, multiprocessor scheduling, Task assignment and conditions, Faults and fault handling, Redundancy and handling redundancy, Real time communication

Self-Directed Learning: Motivation and features of real-time operating systems

Course Outcomes
By the end of this course, students should be able to:

- Understand basic real time system model
- Comprehend the salient features of various RTOS
- Analyse various real time scheduling algorithms
- Apply the principles of resource access protocols

References:

1. Jane W.S.Liu, *Real Time Systems*, Pearson Edition-2006.
2. C.M Krishna and K.G Shin, *Real Time Systems*, 1st Edition, McGraw Hill Education, 2017
3. Philip A Laplante and Seppo J Ovasaka , *Real-Time Systems Design and Analysis; Tools for the Practitioners* , 4th Edition, Wiley, 2013