III SEMESTER

21ZC71 PROJECT WORK I

Vide Automotive Engineering 21AE71

IV SEMESTER

21ZC81 PROJECT WORK II

Vide Automotive Engineering 21AE81

PROFESSIONAL ELECTIVE THEORY COURSES (Four to be opted)

21ZC21 RANDOMIZED AND APPROXIMATION ALGORITHMS

3 0 0 3

ADVANCED RANDOMIZATION AND HARDNESS OF APPROXIMATION: Algorithm for Bipartite Matching - Constructing Perfect Matching - Randomized Markov Chains - Ergodicity - Time Reversal. Hardness of Approximation: Reductions from NP-Complete Problems - Reductions that Preserve Approximation. (12)

MULTITHREADED ALGORITHMS: Dynamic Multithreaded Algorithms - Performance Measures and Scheduling – Analyzing Multithreaded Algorithms - Parallel Loops and Race Conditions - Multithreaded Matrix Multiplication – Merge Sort. (11)

ONLINE ALGORITHMS: Investment Problem- Ski Rental Problem – Randomized On-Line Algorithms - Analysis of Marking Algorithm and Finding Lower Bound - The K-Server Problem. (11)

STRING MATCHING: Notations - Naive String Matching Algorithm - Rabin-Karp Algorithm - String Matching with Finite Automata -Knuth-Morris - Pratt Algorithm (11)

Total L: 45

REFERENCES:

1. Thomas H Cormen, Charles E Leiserson, Ronald L Rivest and Clifford Stein, “Introduction to Algorithms” ”, PHI learning Pvt.Ltd., New Delhi, 2010.
2. David P. Williamson and David B. Shmoys, ”The Design of Approximation Algorithms”, Cambridge University Press, 2010
3. Allan Borodin and Ran El-Yaniv, “Online Computation and Competitive Analysis”, Cambridge-UK, Cambridge University Press, 1998.
4. Vijay V. Vazirani, "Approximation Algorithms", Springer Nature (SIE), San Francisco, USA, 2013.
5. James Aspnes, "Notes on Randomized Algorithms", http://www.cs.yale.edu/homes/aspnes/#classes, 2020.

21ZC22 / 21ZS22 AGILE SOFTWARE DEVELOPMENT

3 0 0 3

AGILE PRINCIPLES AND MODELING: Introduction - Traditional, IID and Agile Methodologies – Comparison - Need - Manifesto – Values and Practices – Agile Modeling Values, principles and practices – Agile modeling with RUP. (11)

EXTREME PROGRAMMING: Life Cycnetle – User Stories – Architecture – Planning – Iteration – Testing – Release – XP Values – XP Practices – Planning – Coding – Pair Programming Model – Refactoring – Agile Modeling and XP – case study, (11)

SCRUM: Introduction – Practices - Applying Scrum – Need – Scrum Values – Practices - Tools in Agile Software Development – Case Study – Applying Scrum for IoT projects, Applying Scrum for Big Data Projects. (11)

OTHER METHODOLOGIES: FDD – Lean and Kanban Software development – Comparison of agile approaches - DevOps: Motivation -Operations- Overall Architecture - Building and Testing- Deployment. (12)

Total L: 45

REFERENCES:

1. Robert Martin, “Agile Software Development: Principles, Patterns, and Practices”, Pearson Education Ltd. 2014.
2. Jim Highsmith, “Agile Data Warehousing Project Management”, Morgan Kaufmann, 2012.
3. Patrick Jeff, "Agile Software Development for Beginners and Dummies Extensive Guide To Agile Software Development", 2020.
4. Scott Ambler, “Agile Modeling: Effective Practices for eXtreme Programming and the Unified Process”, Wiley Computer Publishing, 2002.
5. Len Bass, Ingo Weber and Liming Zhu, “DevOps: A Software Architect‘s Perspective”, Pearson Education, 2016.

21ZC23 / 21ZS23 BLOCKCHAIN AND DISTRIBUTED LEDGER TECHNOLOGY

3 0 0 3

INTRODUCTION : Fundamental of Distributed Systems -distributed databases- transaction processing - Overview of Blockchain- Public Ledgers- Bitcoin- Smart Contracts- Block in a Blockchain- Transactions- Distributed Consensus- Public vs Private Blockchain- Understanding Cryptocurrency. (12)

DISTRIBUTED LEDGER TECHNOLOGY (DLT) : Working of DLT- Key Features of DLT- Relation between DLT and blockchain in digital currency- Open vs Permissioned Digital ledger- Advantages - Challenges and Risks related to DLT. (9)

BLOCKCHAIN PLATFORMS: Open Source Platforms : Architecture, Identities and Policies, Membership and Access Control, Channels, Transaction Validation, Writing smart contract (12)

BLOCKCHAIN APPLICATION DEVELOPMENT: Internet of Things, Medical Record Management System, Privacy & Security In Blockchain , Scalability issues (12)

Total L: 45

REFERENCES:

1. Imran Bashir,”Mastering Blockchain”,Packt Publishing, March 2017
2. Rogen Wattenhofer , “Blockchain Science : Distributed Ledger Technologies”, Inverted Forest Publishing, 2019
3. Arvind Narayanan, Joseph Bonneau, Edward Felten, Andrew Miller and Steven Goldfeder, “Bitcoin and Cryptocurrency Technologies: A Comprehensive Introduction”, Princeton University Press ,July 19, 2016.
4. Distributed Ledger Technology (DLT) and Blockchain, Fintech Note,2017
5. Melanie Swan ,”Blockchain: Blueprint for a New Economy”, O’Reilly, 2015
6. Daniel Drescher, “Blockchain Basics”,Apress; 1stedition, 2017

21ZC24 BRAIN COMPUTER INTERFACE

3 0 0 3

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OVERVIEW: Basic Neuroscience, working of the Brain, BCI components, Types of BCI – non-invasive, semi-invasive and invasive techniques, Recording techniques-EEG, MEG, fNIRS, fMRI, limitations of BCI. (10)

SIGNAL PROCESSING AND MACHINE LEARNING FOR BCI: Spike Sorting, Frequency Domain Analysis, wavelet Analysis, Time Domain Analysis, Spatial Filtering, Artifact Reduction Techniques, Classification and Regression (12)

EEG FEATURES FOR BCI: EEG Process, Temporal characteristics, Spatial Characteristics, Oscillatory EEG activity, event-related potentials (ERP), slow cortical potentials (SCP), and neuronal potentials. Motor Imagery BCI. (11)

APPLICATIONS OF BCI: BCI that stimulate, bidirectional BCI, Medical applications**:** Sensory Restoration, Motor Restoration, Cognitive Restoration, Restoring Communication with Menus, Cursors, and Spellers, Brain-Controlled Wheelchairs, Non-medical applications: Web Browsing, lie detection, gaming, education and learning, Toolboxes for BCI. (12)

Total L: 45

REFERENCES:

1. Rajesh P N Rao ,” Brain-Computer Interfacing: An Introduction. Cambridge: Cambridge University Press” ,2013
2. Jonathan Wolpaw and Elizabeth Winter Wolpaw , “Brain–Computer Interfaces: Principles and Practice”, , OUP 2012.
3. Chang S. Nam, Anton Nijholt, Fabien Lotte Brain–Computer Interfaces Handbook: Technological and Theoretical Advances, 2018. CRC Press

4. Dipali Bansal and Rashima Mahajan. EEG-Based Brain-Computer Interfaces - Cognitive Analysis and Control Applications, Elsevier, 2019
5. Dornhege, G," Toward brain-computer interfacing", MIT press, 2007.
6. Siuly, Siuly, Li, Yan, Zhang, Yanchun , EEG Signal Analysis and Classification - Techniques and Applications, 2017, Springer

21ZC25 CLOUD COMPUTING

3 0 0 3

INTRODUCTION TO CLOUD COMPUTING: The Vision of Cloud Computing - Defining a Cloud- A Cloud Computing Reference Model –Cloud Deployment Models: Public, Private, Community, Hybrid Clouds - Cloud Delivery Models: IaaS, PaaS, SaaS Characteristics and Benefits - Challenges Ahead - Historical Developments - Computing Platforms and Technologies. (10)

VIRTUALIZATION: Introduction - Hypervisors – Challenges of X86 Architecture-Main Categories of Virtualization: Full, Para - Levels of virtualization: Hardware, Programming language, Application, Operating system, Storage, network, desktop, Application Server - Benefits of Virtualization - Cost of Virtualization - Virtualization Drawbacks – Xen-KVM - Cloud container: Docker. (12)

CLOUD ARCHITECTURE AND TECHNOLOGIES: Infrastructure as a service: Amazon EC2 - Platform as Service: Google App Engine, Microsoft Azure Amazon AWS , Aneka – Software as a service : RESTFul Web Services – SLA- Resource Management - Scheduling. (12)

CLOUD SECURITY: Infrastructure Security: Network level, Host level and Application level –Data Security- Identity and access Management: Architecture and Practices - Security Management in the Cloud - Federation in Cloud - Cloud Storage - Edge Computing. (11)

Total L: 45

REFERENCES:

1. Rajkumar Buyya, Christian Vecchiola and Thamarai SelviS, "Mastering Cloud Computing", Tata McGraw Hill Education Private Limited,New Delhi,2013.
2. Chen, Lei, Le-Khac, Nhien-An, Takabi, Hassan , "Security, privacy and digital forensics in the cloud", John Wiley & Sons, 2019.
3. Sébastien Goasguen , "Docker in the Cloud -Recipes for AWS, Azure, Google, and More", O'Reilly Media ,2016.
4. Tim Mather, Subra Kumarasamy and Shahed Latif,"Cloud Security and Privacy: An Enterprise Perspective on Risks and Complainace",O'Reilly, USA,2011.
5. Raj Samani; Jim Reavis; Brian Honan, " CSA Guide to Cloud Computing : Implementing Cloud Privacy and Security", Syngress, 2014.
6. Jim Smith, Ravi Nair, "Virtual Machines: Versatile Platforms for Systems and Processes", Morgan Kaufmann Publisher, 2005.

21ZC26 COMPUTER VISION

3 0 0 3

IMAGE PROCESSING TECHNIQUES: Introduction to Computer Vision - Challenges - Process of recognition - Images and Imaging processing operations - classical Image Filtering operations - Thresholding techniques - Region Growing methods - Edge detection techniques - Corner and Interest point detection (11)

SHAPES AND REGIONS: Binary shape analysis - Object labeling and counting – Size filtering – distance Functions – Skeletons and thinning – deformable shape analysis - Boundary Pattern analysis – active contours – shape models and shape recognition - centroidal profiles – handling occlusion – boundary length measures – boundary descriptors (11)

HOUGH TRANSFORM AND ITS APPLICATIONS: Hough Transform (HT) for line detection – Line localization – line fitting – RANSAC for straight line detection - HT based Circular Object Detection - Ellipse detection – Case study: Human Iris location – hole detection - Generalized Hough Transform (GHT) – Spatial matched filtering – GHT for ellipse detection – object location - GHT for feature collation (12)

3D VISION AND MOTION TECHNIQUES: 3D Vision - Methods for 3D vision - projection schemes - 3D object recognition - 3D reconstruction - 3D motion - Triangulation - bundle adjustment – translational alignment - Parametric motion – spline-based motion – optical flow – layered motion - Real time pattern recognition applications - Image acquisition- Real time hardware and systems design considerations (11)

Total L: 45

REFERENCES:

1. E. R. Davies, Computer and Machine Vision, Fourth Edition, Academic Press, 2012
2. R. Szeliski, Computer Vision: Algorithms and Applications, Springer 2011
3. Sandipan Dey, Python Image Processing cookbook, Packt Publishers, 2020
4. D. L. Baggio et al, Mastering OpenCV with Practical Computer Vision projects, Packt Publishing, 2012
5. 3. D.Forysth et al, Computer Vision - A Modern Approach, Second Edition, Prentice Hall,2012

21ZC27 CRYPTOGRAPHY AND NETWORK SECURITY

3 0 0 3

SECURITY CONCEPTS & SYMMETRIC CIPHER: The OSI Security Architecture - Security Attacks, Security Services - Security Mechanisms - A Model for Network Security - Classical Encryption Techniques: Symmetric Cipher model, substitution techniques, Transposition techniques, Steganography. Block Ciphers and Data Encryption Standard: Block Cipher Principles, DES. (10)

PUBLIC-KEY CRYPTOGRAPHY: Number Theory: Prime Numbers, Fermat's and Euler's Theorems - Principles of Public-Key Cryptosystems - The RSA Algorithm - Diffie - Hellman Key Exchange - Elliptic Curve Cryptography (10)

CRYPTOGRAPHIC HASH FUNCTIONS: Applications of Cryptographic Hash Functions - Secure Hash Algorithm (SHA) Message Authentication Codes - Message Authentication Requirements - Message Authentication Functions- MD5- HMAC- Digital Signatures - Digital Signature Standard (DSS). Blockchain: The growth of blockchain technology - Types, Consensus, and Mining Task - Platforms. (10)

MUTUAL TRUST, NETWORK& INTERNET SECURITY: Key Management and Distribution: Symmetric Key Distribution Using Symmetric Encryption, Asymmetric Encryption - Distribution of Public Keys - X.509 Certificates - Public Key Infrastructure – Transport Level Security - Basic Concepts, Secure Sockets Layer (SSL) - Transport-Level Security, Transport Layer Security (TLS) - HTTPS - Secure Shell (SSH) - Introduction to quantum cryptography - Ethical hacking (15)

Total L: 45

REFERENCES:

1. William Stallings , "Cryptography and Network Security: Principles and Practice", 7 th Edition, Prentice Hall of India, Pearson Education, New Delhi, 2017.
2. AtulKahate, "Cryptography and Network Security", Tata McGraw Hill Ltd., New Delhi, 2013.
3. Hans, Knebl, Helmut, Delfs , "Introduction To Cryptography Principles And Applications", 3rd Edition, Springer- Verlag, Berlin Heidelberg, 2015.
4. Imran Bashir , "Mastering Blockchain: Distributed Ledger Technology, Decentralization, and Smart Contracts Explained", 7 th Edition, Packt Publishing Ltd, 2018.

21ZC28 DEEP LEARNING

3 0 0 3

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DEEP LEARNING FOUNDATIONS: AI, Machine learning, Representation learning and Deep learning – ML Algorithms - Challenges and Motivation for Deep learning – Deep feedforward networks - Cost functions - Output units - Hidden units – Architecture design – Regularization for Deep learning – Optimization for training deep models. (12)

CONVOLUTIONAL NEURAL NETWORKS: Convolution operation – Motivation – Pooling – Convolution variants – Down sampling, stride and padding –Local, convolution, tiled and full connections– CNN training – Structured outputs – Data types – Efficient convolution algorithms – Random or unsupervised features – Neuro scientific basis of CNN. (11)

RECURRENT NEURAL NETWORKS: Recurrent networks – Unfolding computational graphs – RNN design patterns - Backpropagation through time - Teacher forcing - Gradient computation - RNN as directed graphical models - Modeling sequences conditioned on context – Bidirectional RNN – Encoder Decoder Sequence-to-Sequence Architectures – Deep recurrent networks – Recursive neural networks - Challenge of long-term dependencies – Strategies for multiple time scales – LSTM and GRU – Optimization for long-term dependencies – Explicit memory. (11)

AUTOENCODERS, GENERATIVE MODELS AND APPLICATIONS: Autoencoders (AE) – AE variants - Undercomplete AE - Regularized AE – Overcomplete AE - Sparse AE – Denoising AE – Learning Manifolds with Autoencoders - Contractive AE – Variational AE - Representation Learning – Greedy pre-training – Transfer learning and domain adaptation – Restricted

Boltzmann Machine – Generative Adversarial Networks - Practical methodology - Monte Carlo methods – Gibbs sampling – Deep learning applications. (11)

Total L: 45

REFERENCES:

1. Ian Goodfellow, Yoshua Bengio, Aaron Courville, “Deep Learning”, MIT Press, 2016.
2. John D. Kelleher, "Deep Learning (The MIT Press Essential Knowledge series)", MIT Press, 2019.
3. François Chollet, “Deep Learning with Python”, Manning Publications, 2017.
4. Eugene Charniak, “Introduction to Deep Learning”, MIT Press, 2018.
5. David Foster, “Generative Deep Learning”, O'Reilly Media, 2019.
6. Christopher M. Bishop, "Pattern Recognition and Machine Learning (Information Science and Statistics)", Springer, 2010.

21ZC29 / 21ZS26 EVOLUTIONARY COMPUTING TECHNIQUES

3 0 0 3

HEURISTIC AND METAHEURISTIC APPROACHES: Challenges in Solving Complex Problems - Evolutionary algorithms: Principles, Historical development, Features, Classification and Components, Advantages, Applications. Heuristic Search: Problem representation as search - Generate and Test - Breadth First Search - Depth First Search - Hill Climbing: Principles, Local and Global maxima, Ridges, Plateau - Steepest Ascent - Simulated annealing: Annealing schedule, Parameter Selection (12)

GENETIC ALGORITHM: Biological Background - Simple Genetic Algorithm (SGA) - Representation types - Recombination Types - Mutation types - GA Algorithm - Schema Theorem - Variations of GA: Adaptive GA, Real Coded GA - Differential Evolution: Principles, Mutation, Crossover, Selection (11)

SWARM INTELLIGENCE: Particle Swarm Optimization: Swarms, Operating principles, PSO Algorithm, Neighborhood Topologies - Variations of PSO: Binary, weighted - Ant Colony Optimization: Ant foraging behavior, Theoretical Considerations, ACO Algorithm, Variations of ACO: Elitist Ant System (EAS), MinMax Ant System (MMAS) and Rank Based Ant Colony System (RANKAS). (11)

MULTI-OBJECTIVE OPTIMIZATION AND MEMETIC ALGORITHMS: Multi-Objective Principles - Classical Methods - Challenges - Evolutionary algorithms for multi-objective optimization - Multimodal function optimization - Non-Dominated Sorting Genetic Algorithm (NSGA): Non-elitist, elitist - Controlled elitism in NSGA - Memetic Algorithms: Need - Template - Design Issues - Considerations for Discrete and Combinatorial Optimization problems (11)

Total L: 45

REFERENCES:

1. Eiben A E and Smith J E, “Introduction to Evolutionary Computing”, Second edition, Springer, Heidelberg, 2015.
2. Rich E and Knight K, “Artificial Intelligence”, Tata McGraw Hill Education Private Limited, India, 2011.
3. Kennedy J and Eberhart R C, “Swarm Intelligence”, Morgan Kaufmann Publishers, USA, 2001.
4. Deb K, “Multi-Objective Optimization Using Evolutionary Algorithms”, Wiley-Blackwell, USA, 2008.
5. Dorigo M and Stutzle T, “Ant Colony optimization”, Prentice Hall of India, New Delhi, 2005.
6. Ferrante N and Carlos C, "Handbook of Memetic Algorithms", Springer, Heidelberg, 2012

21ZC30 GPU COMPUTING

3 0 0 3

GPU ARCHITECTURE -Evolution of GPU architectures - Understanding Parallelism with GPU –Typical GPU Architecture - CUDA Hardware Overview - Threads, Blocks, Grids, Warps, Scheduling - Memory Handling with CUDA: Shared Memory, Global Memory, Constant Memory and Texture Memory. (11)

CUDA PROGRAMMING: Using CUDA - Multi GPU - Multi GPU Solutions - Optimizing CUDA Applications: Problem Decomposition, Memory Considerations, Transfers, Thread Usage, Resource Contentions (12)

OPENCL BASICS: OpenCL Standard – Kernels – Host Device Interaction – Execution Environment – Memory Model – Basic OpenCL Examples - Demonstration (11)

APPLICATIONS: Video and Image Processing - Experiences on Image and Video Processing with CUDA and OpenCL, Signal and Audio Processing -Efficient Automatic Speech Recognition on the GPU -Emerging Data-Intensive Applications - Large-Scale Machine Learning (11)

Total L: 45

REFERENCES:

1. Shane Cook, CUDA Programming: —A Developer's Guide to Parallel Computing with GPUs , Morgan Kaufmann, 2013.
2. David R. Kaeli, Perhaad Mistry, Dana Schaa, Dong Ping Zhang, —Heterogeneous computing with OpenCL, 3rd Edition, Morgan Kauffman, 2015.
3. Wen-mei W. Hwu, GPU Computing Gems Emerald Edition. A volume in Applications of GPU Computing Series,2011
4. Tolga Soyata,GPU Parallel Program Development Using CUDA, CRC Press,2018.

21ZC31 INFORMATION RETRIEVAL

3 0 0 3

IR SYSTEM DESIGN: Boolean retrieval –inverted index – Processing Boolean queries – Tokenization – Stop words – Normalization – Stemming – Lemmatization – Search structures for dictionaries – Wild card queries – Spelling correction – Index construction - Index Compression. (11)

SCORING AND EVALUATION: Parametric and zone indexes – Weighted zone scoring – Learning weights – Term frequency and weighting – Inverse document frequency – TF-IDF – Vector space mode for scoring – Efficient scoring and ranking – Components of an IR system – IR system evaluation – Evaluation of unranked retrieval sets - Evaluation of ranked retrieval results - Assessing relevance – Kappa statistic – Relevance feedback – Query expansion. (12)

IR MODELS: Probabilistic information retrieval - The Probability Ranking Principle - The Binary Independence Model - Language Models - Query likelihood language models - Query generation probability (11)

TEXT CLASSIFICATION AND WEB SEARCH: Text classification - Naive Bayes - Bernoulli model - Multinomial model - Text classification evaluation – Web search – Web graph - Components of a web search engine – Web crawling – Crawler architecture – Distributed crawler – URL frontier – Link analysis – PageRank – Topic specific PageRank – Hubs and authorities. (11)

Total L: 45

REFERENCES:

1. Manning C, Raghavan P, and Schutze H, “Introduction to Information Retrieval”, Cambridge University Press, New Delhi, 2012.
2. Ricardo Baeza-Yates and Berthier Ribeiro-Neto, “Modern Information Retrieval: The Concepts and Technology behind Search”, Addison Wesley, USA, 2012.
3. Stefan Büttcher, Charles L. A. Clarke, Gordon V. Cormack, "Information Retrieval – Implementing and Evaluating Search Engines", MIT Press, 2016.
4. Gerald Kowalski, “Information Retrieval Architecture and Algorithms”, Springer, Heidelberg, 2013.
5. David A. Grossman and Ophir Frieder,”Information Retrieval: Algorithms and Heuristics”, Dordrecht, Netherlands, Springer, 2014.
6. Surbhi Bhatia, Poonam Chaudhary, Nilanjan Dey, “Opinion Mining in Information Retrieval”, Springer Singapore, 2020.

21ZC32 INTERNET OF THINGS

3 0 0 3

IOT ARCHITECTURE: Introduction To IoT- M2M Architecture- - Design Principles For Connected Devices: Scalability and Security Issues - Definitions And Functional Requirements – IOT Architecture-**Moving Intelligence to the Edge** - the Need for Edge Analytics- Challenges in Centralized IoT – Edge Analytics Architecture- the Capabilities needed at Edge Devices- Running Data Analytics at Edge Device (12)

INDUSTRIAL IOT PROTOCOLS: SCADA – BACNET Protocol – MODBUS-**Open Source Networking Protocols for IoT:** IEEE 802.15.4 – Zigbee Architecture – 6LOWPAN – LoRA-COAP – MQTT (11)

ELECTRONIC PROTOTYPING: Sensors and Actuators- Prototypes and Production- Open Source versus Closed Source - Prototyping Embedded Devices- - Prototyping IoT Projects With Arduino- Prototyping IOT Projects With Raspberry PI (11)

CASE STUDIES AND IOT DATA ANALYTICS : Real world design constraints - Large Scale Use Cases of IoT- Open Research Challenges - Asset management, Food supply chain management, - Smart grid, Connected Health Care, Smart City Applications- Role of AI & Big data analytics in Industry 4.0 (11)

Total L: 45

REFERENCES:

1. Dieter Uckelmann, Mark Harrison and Florian Michahelles, "Architecting the Internet of Things ", Springer, 2011
2. Olivier Hersent, David Boswarthick and Omar Elloumi, "The Internet of Things - Key applications and Protocols", Wiley, 2012
3. Enterprise IoT, "Strategies and Best Practices for Connected Products and Services", Dirk Slama, Frank Puhlmann, Jim Morrish, Rishi Bhatnagar, O'Reilly Media, November 2015
4. Arshdeep Bagha, Vijay Madisetti, Internet of Things: A Hands- on Approach, Universities Press, 2015
5. L.S.Jayashree, Selvakumar, Getting Started with Enterprise IoT - Design Approaches, Software Architecture Models and Use Cases, Springer, USA, 2020
6. Honbo Zhou, "The Internet of Thingsin the Cloud: A Middleware Perspective", CRC Press, 2012.

21ZC33 NATURAL LANGUAGE PROCESSING

3 0 0 3

WORDS: Introduction - Mathematical Foundations – Linguistic Essentials - Regular Expressions, Text Normalization, Edit Distance - Finite State Transducers - Language Modeling with N-grams - Naive Bayes Classification and Sentiment - Neural Nets and Neural Language Models - Hidden Markov Models - Neural Sequence Modeling: RNNs and LSTMs - Part-of-Speech Tagging (12)

SYNTAX: Formal Grammars of English - Syntactic Parsing – Ambiguity – Cocke Kasami Younger (CKY) algorithm - Partial Parsing - Statistical Parsing (11)

SEMANTICS: Vector Semantics - Semantics with Dense Vectors - Word Senses: WSD and WordNet - Lexicons for Sentiment and Affect Extraction - Representation of Sentence Meaning - Computational Semantics - Information Extraction - Semantic Role Labeling and Argument Structure - Coreference Resolution and Entity Linking. (11)

PRAGMATICS AND APPLICATIONS: Discourse Coherence – Sequence To Sequence Models and Machine Translation - Summarization - Topic Modelling - Question Answering (11)

Total L: 45

REFERENCES:

1. Daniel Jurafsky and James H. Martin, "Speech and Language Processing", Prentice-Hall, Inc., 2017
2. Christopher D. Manning, Hinrich Schütze, "Foundations of Statistical Natural Language Processing", The MIT Press, 2018.
3. Nitin Indurkhya, Fred J. Damerau, "Handbook of Natural Language Processing Machine Learning & Pattern Recognition Series, Chapman & Hall/CRC, Taylor and Francis Group, 2010.
4. Yoav Goldberg, "Neural Network Methods for Natural Language Processing", Synthesis Lectures on Human Language Technologies, April 2017.
5. Steven Bird, Ewan Klein, and Edward Loper, "Natural Language Processing with Python - Analyzing Text with the Natural Language Toolkit", O,Reilly. 2012
6. Li Deng and Yang Liu, "Deep Learning in Natural Language Processing", Springer, Germany. 2018.

21ZC34 / 21ZS27 MACHINE LEARNING

3 0 0 3

COMPUTATIONAL LEARNING THEORY BASICS: Introduction: Types of Learning - Designing a learning system – Concept learning - Find-s – Candidate Elimination - PAC Learnability- Sample complexity for finite and Infinite hypothesis spaces-VC Dimension - Evaluating Hypothesis - Estimating Hypothesis Accuracy - Error Estimation – Bias - Variance - Confidence Interval - Central Limit Theorem. (12)

LINEAR MODELS: Linear Models For Regression – Linear basis function models - Maximum Likelihood Estimation - Least Squares - Bias-Variance Decomposition - Bayesian Linear Regression - Limitations of fixed basis functions - Linear Models for

Classification – Linear Discriminant Analysis - Probabilistic Generative Models – Maximum Likelihood solution - Probabilistic Discriminative Models – Logistic regression. (11)

NEURAL NETWORKS AND MIXTURE MODELS: Neural Networks - Feed-forward Networks - Network Training - Delta Rule-Gradient Descent - Error Backpropagation - Regularization in Neural Networks - Mixture Models – Expectation Maximization - Combining models - Committees - Boosting - Tree-based models (11)

KERNEL AND GRAPHICAL METHODS: Kernel Methods - Constructing Kernels - Radial Basis Function Networks - Gaussian Processes - Maximum Margin Classifiers – SVM - Graphical Methods – Bayes Theorem - Bayesian Networks – Conditional Independence - Markov Random Fields - Inference in Graphical Models. (11)

Total L: 45

REFERENCES:

1. Christopher Bishop, “Pattern Recognition and Machine Learning”, Springer-Verlag New York, 2013.
2. Tom M. Mitchell, “Machine Learning”, First edition reprint, McGraw Hill education, 2017.
3. Yaser S. Abu Mostafa, Malik Magdon Ismail, Hsuan Tien Lin, “Learning From Data: A Short Course”, AMLBook publishers, 2012.
4. Ethem Alpaydin, "Introduction to Machine Learning", Third edition, PHI Learning, 2015.
5. Trevor Hastie, Robert Tibshirani, Jerome Friedman, “The Elements of Statistical Learning - Data Mining, Inference, and Prediction”, Second Edition, Springer Series in Statistics, Springer-Verlag New York, 2013.
6. Marc Peter Deisenroth, A. Aldo Faisal, Cheng Soon Ong, "Mathematics for Machine Learning", Cambridge University Press, 2020.

21ZC35 REAL TIME SYSTEMS

3 0 0 3

INTRODUCTION TO REAL-TIME COMPUTING: Structure of a real-time system - Characterization of real-time systems and tasks - Hard and Soft timing constraints - Design Challenges - Performance measures - Programming Languages for Real-Time Systems (10)

REAL TIME OS: Real Time Tasks and Characteristics - Task Assignment and Scheduling- Task allocation algorithms - Single-processor and Multiprocessor task scheduling - Task assignment - Fault tolerant scheduling - Case Study: VxWorks. (12)

REAL-TIME COMMUNICATION & CLOCK SYNCHRONISATION: Network topologies and architecture issues - Protocols - Contention-based, token-based, polled bus - Fault tolerant routing - Clock Synchronisation (11)

FAULT TOLERANCE & RELIABILITY EVALUATION TECHNIQUES - Fault Types - Fault Detection - Fault and Error Containment - Hardware, Software, Time, and Information Redundancy - Byzantine Failures - Reliability Evaluation Techniques - Parameter values - Reliability models for hardware redundancy - Software Error Models (12)

Total L: 45

REFERENCES:

1. C.M. Krishna, Kang G. Shin ,“ Real Time Systems”, International Edition, McGraw Hill Companies, Inc., New York, 2017
2. Jane W.S. Liu, “Real-Time Systems, Pearson Education India”, 2018
3. Philip A. Laplante and Seppo J. Ovaska, “Real-Time Systems Design and Analysis: Tools for the Practitioner’’ IV Edition IEEE Press, Wiley. 2011
4. R. Mall, “Real-Time Systems”, Pearson , 2015
5. P. A. Laplante,” Real-Time Systems Design & Analysis”, Willey , 2011
6. S. V. Iyer & P. Gupat, “Embedded Real-Time System Programming”, Tata McGraw Hill , 2016

21ZC36 SOFTWARE DEFINED NETWORKS

3 0 0 3

HISTORY AND EVOLUTION OF SOFTWARE DEFINED NETWORKING (SDN): Separation of Control Plane and Data Plane, IETF Forces, Active Networking**Network Function Virtualization:** Concepts, Applications, Existing Network Virtualization Framework (VMWare and others), Mininet based examples. (11)

CONTROL AND DATA PLANE SEPARATION: Concepts, Advantages and Disadvantages, the OpenFlow protocol. **Control Plane:** Overview, Existing SDN Controllers including Floodlight and OpenDaylight projects**- Data Plane:** Software-based and

Hardware-based; Programmable Network Hardware**. Programming SDNs:** Northbound Application Programming Interface, Current Languages and Tools, Composition of SDNs. (12)

SOFTWARE DEFINED NETWORKS FOR THE INTERNET-OF-THINGS: Challenges-Understanding the nature of IoT traffic flows in different use cases-A software defined end-to-end IoT Infrastructure-Effective resource provisioning in the IoT Multinetwork environments- Addressing scalability and security issues- Adding SDN automation and verification in IoT infrastructure. (11)

USE CASES OF SDNS: Data Centers, Internet Exchange Points, Backbone Networks, Home automation Systems , Industrial automation Systems and Smart grids. (11)

Total L: 45

REFERENCES:

1. Thomas D. Nadeau,"SDN: Software Defined Networks, An Authoritative Review of Network Programmability Technologies", Ken Gray Publisher: O'Reilly Media, August 2019.
2. Paul Goransson and Chuck Black, "Software Defined Networks: A Comprehensive Approach", Morgan Kaufmann, June 2014, Print Book ISBN: 9780124166752,
3. Vivek Tiwari, "SDN and OpenFlow for Beginners", Amazon Digital Services, Inc., ASIN: , 2013.
4. Fei Hu ,"Network Innovation through OpenFlow and SDN: Principles and Design", CRC Press, ISBN-10: 1466572094, 2014.
5. William Stallings ,"Foundations of Modern Networking: SDN,NFV, QoE, IoT and Cloud", Kindle Edition, 2016
6. Jason Edleman, Scott S. Lowe ,"Network Programmability and Automation: Skills for the Next-Generation Network Engineer" , O'Reilly Publishers, 2018

21ZC37 QUANTUM COMPUTING

3 0 0 3

FOUNDATIONS: Quantum bits – Multiple qubits – Quantum computation: single qubit gates, multiple qubits gates – Quantum circuits – Qubit copying circuit – Bell state – Quantum teleportation – State space – State evolution – Quantum measurement – Distinguishing quantum states – Projective measurements - Positive Operator-Valued Measure (POVM) – Phase - Density operator - Ensembles of quantum states - Reduced density operators. (11)

QUANTUM COMPUTATION: Quantum circuits – Quantum algorithms – Single qubit operations – Controlled operations – Measurements – Universal quantum gates – Simulation of quantum systems – Quantum Fourier transform – Phase estimation – Order finding - Factoring – Shor's algorithm for integer factorization – Period finding – Discrete logarithms – Hidden subgroup problem (11)

QUANTUM ALGORITHMS: Quantum algorithms - Classical computations - Quantum parallelism - Deutsch's algorithm – Deutsch-Jozsa algorithm - Grover's algorithm - Quantum search as quantum simulation - Quantum counting - Speeding up NP complete problems - Searching unstructured database - Optimality of search - Black box algorithm limits. (11)

QUANTUM INFORMATION AND ERROR CORRECTION: Quantum noise - Quantum operations - Environments - Operator-sum representation - Axiomatic approach - Trace and partial trace - Geometric interpretation - Bit flip and phase flip channels - Depolarizing channel - Amplitude damping - Phase damping - Distance measures - Information preservation - Quantum error correction - Three qubit bit flip code - Three qubit phase blip code – Shor's code - CSS codes - Stabilizer formalism and examples - Fault-tolerant quantum logic - Fault-tolerant measurement (12)

Total L: 45

REFERENCES:

1. Michael A. Nielsen & Isaac L. Chuang, "Quantum Computation and Quantum Information", 10th Anniversary edition, Cambridge university press, 2010.
2. David N. Mermin, "Quantum Computer Science: An Introduction", Cambridge University Press, New York, 2007.
3. Chris Bernhardt, "Quantum Computing for Everyone", The MIT Press, 2019.
4. Franklin de Lima Marquezino, Renato Portugal, Carlile Lavor, "A Primer on Quantum Computing", Springer, 2019.
5. Abraham Asfaw, Luciano Bello, Yael Ben-Haim, Sergey Bravyi, Nicholas Bronn, et. al, "Learn Quantum Computation Using Qiskit", 2020. http://community.qiskit.org/textbook.
6. Robert S. Sutor, "Dancing with Qubits: How quantum computing works and how it can change the world", Packt Publishing Limited, 2019.

OPEN ELECTIVE THEORY COURSES (One to be opted)

21ZC91 GAME THEORY

3 0 0 3

GAMES: Games – Utility Theory – Preference Relations – Characterization Theorem –Extensive-Form Games – Graphs and Trees – Game Trees – Games with Chance – Games with Imperfect Information - Strategic Form Games - Relation with Extensive Form Games – Solution Concepts – Notation – Domination – Second-Price Auctions – Order of Elimination of Domination – Nash Equilibrium – Maxmin Concept – Elimination of Dominated Strategies – Two-Player Zero-Sum Games – Games with Perfect Information – Games on Unit Square (12)

STRATEGIES: Mixed Extension of Strategic Form Game – Computing Equlibria in Mixed Strategies – Generalizing Nash Theorem – Utility Theory and Mixed Strategies – Maxmin and Minmax in N-Player Game – Imperfect Information – Value of Information – Evolutionary Stable Strategies – Behaviour Strategies – Kuhn's Theorem – Equilibria in Behaviour Strategies – Kuhn's Theorem for Infinite Games (11)

EQUILIBRIUM, GAMES WITH INCOMPLETE INFORMATION: Subgame Perfect Equilibrium – Rationality, Backward and Forward Induction – Perfect Equilibrium – Sequential Equilibrium – Correlated Equilibria – Properties – Games with Incomplete Information – Aumann Model and Concept of Knowledge – Aumann Model with Beliefs – Infinite Set of States of the World – Harsanyi Model – Interpretation of Mixed Strategies – Common Prior Assumption – Belief Spaces – Belief and Knowledge – Belief Subspaces – Consistency (11)

REPEATED GAMES: Model – T-Stage Repeated Game – Equilibrium Payoffs – Infinitely Repeated Games – Discounted Game – Uniform Equilibrium – Repeated Games with Vector Payoffs – Notation – Model – Approachable and Excludable Sets – Approachability of a Set – Convex Approachable Sets – Applications (11)

Total L: 45

REFERENCES:

1. Michael Maschler, Eilon Solan, Shmuel Zamir, "Game Theory", Cambridge University Press, 2013.
2. Anna R. Karlin and Yuval Peres (eds), Game Theory, Alive, AMS, 2017.
3. Steven Tadelis, "Game Theory: An Introduction", Princeton University Press, 2013.
4. M. J. Osborne, "An Introduction to Game Theory", Oxford University Press, 2012.
5. William Spaniel, "Game Theory 101: The Complete Textbook", CreateSpace Independent Publishing Platform, 2011.
6. John Von Neumann, Oskar Morgenstern, "Theory of Games and Economic Behavior", Golden Keys Success, 2020.

21ZC92 OPTIMIZATION TECHNIQUES

3 0 0 3

INTRODUCTION AND LINEAR PROGRAMMING: Mathematical Optimization–Classification – Linear Programming Model– Graphical method– Simplex Method – Sensitivity Analysis –Applications (11)

DUALITY AND POST-OPTIMALITY ANALYSIS: Primal and Dual – Dual Simplex Method – Revised Simplex Method – Sensitivity Analysis – Transportation Problem and its Solution – Assignment Problem and its Solution–Karmarkar's Method – Applications (11)

INTEGER LINEAR AND HEURISTIC PROGRAMMING: Branch and Bound – Cutting Plane – Set Covering Problem – Zero-One Implicit Enumeration Algorithm – Greedy Heuristics – Discrete Variable – Continuous Variable – Metaheuristics – Tabu Search – Simulated Annealing – Applications (11)

DETERMINISTIC DYNAMIC AND NONLINEAR PROGRAMMING: Recursive Nature – Forward and Backward Recursion – Applications –Unconstrained Algorithms – Direct Search – Gradient –Constrained Algorithms – Separable – Quadratic (12)

Total L: 45

REFERENCES:

1. Hamdy A Taha, "Operations Research – An Introduction", Pearson Education Limited, 2017.
2. Singiresu S Rao, "Engineering Optimization – Theory and Practice", John Wiley & Sons, 2020.
3. Hillier F and Lieberman G J, "Introduction to Operations Research", McGraw Hill, 2015.
4. Kambo N S, "Mathematical Programming Techniques", East-West Press, 2012.
5. G. Hadley,"Linear programming", Narosa Publishing House, New Delhi, 2002.
6. Slephen Boyd and LievenVandenberghe" Convex Optimization" Cambridge University Press, 2009.