Title	**Data structures and practices**	Number	CSXXX
Department	Computer Science and Engineering	L-T-P [C]	0–0–2 [1]
Offered for	M.Tech. (CSE) 1st Year	Type	Compulsory
Prerequisite	Computer Programming		

Objectives

The Instructor will:

1. Explain various data structures and provide details to implement and use them in different algorithms

Learning Outcomes

The students are expected to have the ability to:

1. Write, debug and rectify the programs using different data structures
2. Expertise in transforming coding skills into algorithm design and implementation

Contents

Laboratory Experiments

Exercises based on

Abstract Data Types: Arrays, link-list/list, hash tables, dictionaries, structures, *stack, queues* (4 labs)

Data Structures: Heap, Sets, Sparse matrix, Binary Search Tree, B-Tree/ B+ Tree, Graph (4 labs)

Algorithm implementation: Quick or Merge sort, Breadth or Depth first search or Dijkstra's Shortest Path First algorithm, Dynamic programing (6 labs)

Textbook

1. Weiss, M. A. (2007), Data Structures and Algorithm Analysis in C++, Addison-Wesley.
2. Lipschutz, S. (2017), Data Structures with C, McGraw Hill Education.
3. Cormen, T. H., Leiserson, C. E., Rivest, R. L. and Stein, C., (2009), Introduction to Algorithms, MIT Press

Title	**Software and Data Engineering**	Number	CSXXX
Department	Computer Science and Engineering	L-T-P [C]	3–0–0 [3]
Offered for	M.Tech.	Type	Compulsory
Prerequisite			

Objectives

The Instructor will:

1. Discuss techniques to manage a large amount of data
2. Provide mechanisms to design and develop data-intensive computing systems

Learning Outcomes

The students are expected to have the ability to:

1. Design complex end-to-end data pipeline for data processing
2. Critically identify and use the tools for data handling and management
3. Use modern software technologies to design and develop data analytical systems

Contents

(fractal 1) *Basics of complex software design:* Concept of modular software, microservices, communication, 4+1 architectural views and patterns (5 lectures)
Cloud Computing: Architecture of cluster computing, design of data centers, open data center platforms, fault-tolerant system design (5 lectures)
Virtualization: Type-1 and Type-2 virtualization, virtual machine, containers, dockers (4 lectures)
(fractal 2) *Data Management:* Structured data, relational database management, unstructured data, semi-structured data, Nosql database management (mongodb), column database, graph database, XML, JSON, HDFS, Handling drift in data, sensor data reliability at software and algorithmic level, sensor data analysis techniques (14 lectures)
(fractal 3) *Data Intensive Processing Systems:* Architecture of large scale data processing systems, Hadoop, Apache Spark, Storm, parallel data processing concepts such as map-reduce, directed acyclic graph, resilient distributed datasets, dynamic resource allocation, partial & shared computation, storage architecture (14 lectures)

Textbook

1. Bass L., Clements P., Kazman R., (2012), *Software Architecture in Practice*, 3rd edition, Addison-Wesley Professional
2. Martin K., (2017), *Designing Data-Intensive Applications: The Big Ideas Behind Reliable, Scalable, and Maintainable Systems*, 1st Edition, O'Reilly Media

Self Learning Material

1. Tylor,R.N., Medvidovic,N. and Dashofy,E.M., (2014), *Software Architecture Foundation: Theory and Practice*, Wiley

Preparatory Course Material

1. IEEE Transactions on Knowledge and Data Engineering
2. International Conference on Data Engineering

Title	**Computer Architecture**	Number	CSXXX
Department	Computer Science and Engineering	L-T-P [C]	3–0–0 [3]
Offered for	M.Tech. 2nd Year	Type	Compulsory
Prerequisite	Computer Organization		

Objectives

The Instructor will:

1. Provide background to understand various components of a modern computer system, its interconnections, and performance issue

Learning Outcomes

The students are expected to have the ability to:

1. Explain the working principles of various components of modern computer systems
2. Compare between systems using benchmark data
3. Write, execute and debug parallel programs on GPU

Contents

(fractal 1) *Introduction:* Defining Computer Architecture, Flynn's Classification of Computers, Metrics for Performance Measurement. (4 lectures)

Memory Hierarchy: Introduction, Advanced Optimizations of Cache Performance, Memory Technology and Optimizations, Virtual Memory and Virtual Machines, The Design of Memory Hierarchies, Introduction to Pin Instrumentation and Cache grind, Case Study: Intel Core i7 (10 lectures)

(fractal 2) *Instruction-Level Parallelism:* Instruction-level Parallelism: Concepts and Challenges, Basic Compiler Techniques for Exposing ILP, Reducing Branch Costs with Advanced Branch Prediction, Dynamic Scheduling, Superscalar, Limitations of ILP, Case Study: Dynamic Scheduling in Intel Core i7. (9 lectures)

Multicore Processor: Introduction, CPU Interconnections, Network on Chip (NoC), Routing Protocols, Quality of Service on NoC. (5 lectures)

(fractal 3) *Data Level Parallelism:* Introduction, Vector Architecture, SIMD Instruction Set Extensions for Multimedia, Graphics Processing Units, GPU Memory Hierarchy, Detecting and Enhancing Loop- Level Parallelism, CUDA Programming, Case Study: Nvidia Maxwell. (14 lectures)

Textbook

1. Hennessy,J.L. and Patterson,D.A., (2012), *Computer Architecture: A Quantitative Approach*, 5th Edition, Morgan Kauffmann Publishers
2. Shen,J.P. and Lipasti,M.H., (2005), *Modern Processor Design: Fundamentals of Superscalar Processors*, McGraw-Hill Publishers

Self-Learning Material

1. *CUDA: https://developer.nvidia.com/cuda-zone*
2. *OpenMP: https://www.openmp.org/*

Preparatory Course Material

1. Department of Computer Science and Engineering, Indian Institute of Technology Madras, https://nptel.ac.in/courses/106106134/

Title	**Machine Learning-1**	Number	CSXXXX
Department	Computer Science and Engineering	L-T-P [C]	3–0–0 [3]
Offered for	M.Tech. 1st Year, Ph.D. 1st Year	Type	Compulsory
Prerequisite	None		

Objectives

The Instructor will:

1. Provide motivation and understanding of the need and importance of Machine Learning in today's world
2. Provide details about various algorithms in Machine Learning

Learning Outcomes

The students are expected to have the ability to:

1. Develop a sense of Machine Learning in the modern context, and independently work on problems relating to Machine Learning
2. Design and program efficient algorithms related to Machine Learning, train models, conduct experiments, and deliver ML-based applications

Contents

(fractal 1) *Introduction:* Motivation, Different types of learning, Linear regression, Logistic regression (2 lectures)
Gradient Descent: Introduction, Stochastic Gradient Descent, Subgradients, Stochastic Gradient Descent for risk minimization (2 lectures)
Support Vector Machines: Hard SVM, Soft SVM, Optimality conditions, Duality, Kernel trick, Implementing Soft SVM with Kernels (4 lectures)
Decision Trees: Decision Tree algorithms, Random forests (2 lectures)
Nearest Neighbour: k-nearest neighbour, Curse of dimensionality (1 lecture)
Neural Networks: Feedforward neural networks, Expressive power of neural networks, SGD and Backpropagation (3 lectures)
(fractal 2) *Clustering:* Linkage-based clustering algorithms, k-means algorithm, Spectral clustering (2 lectures)
Dimensionality reduction: Principal Component Analysis, Random projections, Compressed sensing (2 lectures)
Generative Models: Maximum likelihood estimator, Naive Bayes, Linear Discriminant Analysis, Latent variables and Expectation-maximization algorithm, Bayesian learning (4 lectures)
Feature Selection and Generation: Feature selection, Feature transformations, Feature learning (3 lectures)
Model selection and validation: Validation for model selection, k-fold cross-validation, Training-Validation-Testing split, Regularized loss minimization (3 lectures)
(fractal 3) *Statistical Learning Framework:* PAC learning, Agnostic PAC learning, Bias-complexity tradeoff, No free lunch theorem, VC dimension, Structural risk minimization, Adaboost (7 lectures)
Foundations of Deep Learning: DNN, CNN, RNN, Autoencoders (7 lectures)

Textbook

1. Shalev-Shwartz,S., Ben-David,S., (2014), *Understanding Machine Learning: From Theory to Algorithms*, Cambridge University Press

Reference Books

1. Mitchell Tom (1997). *Machine Learning,* Tata McGraw-Hill

Self Learning Material

1. Department of Computer Science, Stanford University, https://see.stanford.edu/Course/CS229

Title	**Ad-Hoc Wireless Networks**	Number	CS 6XX
Department	Computer Science and Engineering	L-T-P[C]	3–0–0 [3]
Offered for	M.Tech. 1st Year, PhD 1st Year	Type	Compulsory
Prerequisite	Networks		

Objectives

The Instructor will:

1. Introduce the mathematical models and network protocol designs in wireless Ad-hoc networks
2. Provide a systematic exposition of network protocols and their cross-layer interactions
3. To provide more advanced in-depth networking knowledge. Upon completion of this course, students will be able to apply the knowledge in their networking research. A broad perspective on the active research areas in wireless Ad-hoc networks

Learning Outcomes

The students are expected to have the ability to:

1. Demonstrate advanced knowledge of networking and wireless networking in particular
2. Compare different solutions for communications at each network layer
3. Demonstrate knowledge of protocols used in wireless communications

Contents

Basics of wireless networks and mobile computing: Ad hoc Networks: Introduction, Issues in Ad hoc wireless networks, Ad hoc wireless internet (3 lectures)

Media access control in ad hoc and sensor networks: MAC Protocols for Ad hoc Wireless Networks: Introduction, Issues in designing a MAC protocol for Ad hoc Wireless Networks, Design goals of a MAC protocol for Ad hoc Wireless Networks, Classification of MAC protocols, Contention based protocols with reservation mechanisms. Contention-based MAC protocols with scheduling mechanism, MAC protocols that use directional antennas, Other MAC protocols, Network and transport layer issues for ad hoc and sensor networks (8 lectures)

Routing protocols for Ad hoc Wireless Networks: Introduction, Issues in designing a routing protocol for Ad hoc Wireless Networks, Classification of routing protocols, Table drive routing protocol, On-demand routing protocol, Hybrid routing protocol, Routing protocols with effective flooding mechanisms, Hierarchical routing protocols, Power aware routing protocols (8 lectures)

Transport layer protocols: Transport layer protocols for Ad hoc Wireless Networks: Introduction, Issues in designing a transport layer protocol for Ad hoc Wireless Networks, Design goals of a transport layer protocol for Ad hoc Wireless Networks, Classification of transport layer solutions, TCP over Ad hoc Wireless Networks, Other transport layer protocols for Ad hoc Wireless Networks (8 lectures)

Security issues for ad hoc networks: Security: Security in wireless Ad hoc Wireless Networks, Network security requirements, Issues & challenges in security provisioning, Network security attacks, Key management, Secure routing in Ad hoc Wireless Networks (6 lectures)

QoS for ad hoc Networks: Quality of service in Ad hoc Wireless Networks: Introduction, Issues and challenges in providing QoS in Ad hoc Wireless Networks, Classification of QoS solutions, MAC layer solutions, network layer solutions (3 lectures)

Advanced Topics: Software-defined network (SDN), Mesh networking, Energy issues and Sensor networks (6 lectures)

Laboratory Experiments

Programming exercises using NS2/NS3, QualNet, Java and OmNet++

Textbook

1. Siva Ram Murthy, C., & Manoj, B. S. (2015). Ad hoc wireless networks: Architectures and protocols. *PHI Pearson Education*
2. Akyildiz, Ian F., and Xudong Wang(2015). *Wireless mesh networks*. Vol. 3. John Wiley & Sons

Reference Books

1. Basagni, S., Conti, M., Giordano, S., & Stojmenovic, I. (Eds.). (2015). *Mobile ad hoc networking*. John Wiley & Sons
2. Perkins, C. E. (2001). *Ad hoc networking* (Vol. 1). Reading: Addison-wesley
3. Toh, C. K. (2001). *Ad hoc mobile wireless networks: protocols and systems*. Pearson Education

4. Cheng, X., Huang, X., & Du, D. Z. (Eds.). (2013). *Ad hoc wireless networking* (Vol. 14). Springer Science & Business Media

Self Learning Material

1. Computer Networks - MIT OpenCourseWare
https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-829-computer-networks-fall-2002/lecture-notes/
2. Mobile and Wireless Networks and Applications, Stanford University,
https://web.stanford.edu/class/cs444n/
3. IEEE Transactions and other journals

Title	**Autonomous Systems**	Number	CSXXX
Department	Computer Science and Engineering	L-T-P [C]	0–0–2 [1]
Offered for	M.Tech. (CSE) 1st Year	Type	Compulsory
Prerequisite	Networks and Machine Learning-1		

Objectives

The Instructor will:

1. Provide the problem of Modelling and Estimation of Autonomous Systems
2. Introduce the Implementation of Autonomous Systems for solving Engineering Problems
3. Provide the theory of advanced techniques such as Fuzzy Logic, PSO and Neural Networks
4. Provide the implement simulations and real systems for the control and estimation of processes such as a mobile robotic platform

Learning Outcomes

The students are expected to have the ability to:

1. Understand the theory and application of the Systems and their Design for solving diverse types of problems in the area of Engineering
2. Be able to develop software for applying the theory and actually solving complex problems.
3. Have experience in using state of the art sensors, used in Field Robotics and Autonomous Systems

Contents

Systems and their Design: introduction to systems and design
The Global Architecture of an Autonomous System: Introduction to autonomous systems including the architecture of autonomous systems
Designing a Multi-Agent Autonomous System: design of agents
Generation of Current Representation and Tendencies
The Notions of Point of View, Intent and Organizational Memory
Towards the Minimal Self of an Autonomous System
Global Autonomy of Distributed Autonomous Systems
Real-time reactive systems

Laboratory Experiments

Textbook

1. Mhamed Itmi, Alain Cardon(2016), New Autonomous Systems, Wiley-ISTE
2. De Gyurky, S. M., & Tarbell, M. A. (2013). *The Autonomous System: A Foundational Synthesis of the Sciences of the Mind*. John Wiley & Sons

Reference Books

1. Tzafestas, S. G. (Ed.). (2012). *Advances in intelligent autonomous systems* (Vol. 18). Springer Science & Business Media
2. Ge, S. S. (2006). *Autonomous mobile robots: sensing, control, decision making and applications*. CRC press

Self Learning Material

IEEE Transactions and other journals