Rajiv Gandhi ProudyogikiVishwavidyalaya Bhopal

M.Tech (Artificial Intelligence & Machine Learning)

First Semester Syllabus

MTAL 101 - DATA STRUCTURES AND ALGORITHMS

Course Outcomes:

After completing the course student should be able to:

1. Visualize and implement appropriate data structure for efficiently solving a problem.
2. Analyze an algorithm and evaluate its efficiency.
3. Examine the nature of a problem at hand and design most optimal algorithm for a given problem.
4. Classify a problem into correct computational class.

Course Contents:

Unit 1:Review study: ADT, Memory representation of data structure; Data structures operations and its cost, Review of data structures like Stack, Queue, Linked List, Tree, Graph, Hashing etc.

Unit 2: Characteristics and Properties of algorithms. Time and Space Complexity issues, Worst case and Average case analysis. Code profiling, Asymptotic Notations: O, o, Ω, ω, θ, Solving Recurrences- Recursion tree method, Master Method; Amortized Analysis.

Unit 3: Advanced Data Structure Topics: M-ary Tree, Red-Black Tree, Heaps: Binary, Binomial, Fibonacci; Graph algorithms: DFS, BFS, Shortest path, Minimum Spanning Tree; Searching: Linear and Binary search; Sorting: Exchange Sort methods, Linear sort.

Unit 4: Divide and Conquer: Basic Concept, Finding median, Counting Inversion, Quick sort, Merge Sort etc. Dynamic Programming: Concept, Matrix Chain multiplication, 0/1 knapsack problem. Greedy Algorithm: Basic Concept, fractional knapsack problem, Scheduling problem.

Unit 5:Solvable and Unsolvable problems: P, NP, NP Hard and NP complete problems, Cooks theorem, reduction, Introduction to Approximation Algorithms: TSP. Backtracking,Case Study: Application of various data structures and algorithms in operating system, DBMS etc.

Recommended Books:

1. Aho, Hopcroft, Ullman, "Data Structures and Algorithms", Pearson Education, Asia, 2002
2. T.H. Cormen, C.E. Leiserson, R. L. Rivest and C. Stein, "Introduction to Algorithms", 3rd edition, PHI-EEE, 2003.
3. Tenenbaum, Langsam, Augustein, "Data Structures Using C", Pearson, 2019
4. Micheal T. Goodrich, Roberto Tamassia, Data Structures and Algorithms in C++, Willey,2007
5. Jon Kleinberg, Eva Tordos, "Algorithm Design", Pearson, 2013.
6. Ellis Horowitz, SartajSahani, SanguthevarRajsekaran, "Fundamentals of Computer Algorithms", 2nd Edition, University Press, 2010
7. G. Brassard and P. Bratley, "Fundamentals of Algorithms", Prentice Hall of India 2003.
8. Michael T. Goodrich and Roberto Tamassia, "Algorithm Design: Foundations, Analysis and Internet Examples", John Wiley& Sons Inc., 2002.
9. D.E. Knuth, "The Art of Computer Programming", Vol 1, 2, 3.Addison-Wesley, 1997

MTAL 102 - Advances in Operating System

1. Review of Operating System Fundamentals; Different Types, Dedicated Operating Systems; The Genesis of Modern Operating Systems; Operating Systems Design Strategies/Kernel Architectures– Microkernels,Exokernels etc.
   Operating Systems Services, System Calls and their Implementation.

2. File Systems and Main Memory Management: File Concept, Different Modules of a File System; File Protection; Disk Partitioning; Kernel I/O Subsystem; Advancements for improving File System Performance;System Calls for File Systems Management.
   Review of Main Memory Management Techniques including Virtual Memory.

3. Process Management : Review of Process and Scheduling Concepts; System Calls for Process Management; IPC; Concept of Threads: Process v/s Threads, User Level & Kernel Level Threads, Threads Scheduling, Threading Issues, Solutions to Critical Section Problem and Synchronization for Threads;
   Scheduling in Multi-core Systems. Load Balancing Techniques for Multicore and Multiprocessor systems- Dynamic Load Balancing, Process Migration.

4. Distributed Operating Systems: Design Issues; Overview of Distributed File Systems, Distributed Process Management and Distributed Memory Management.
   Embedded and IoT Operating Systems: Introduction, Characteristics and Features, Challenges and Issues in Designing the Operating Systems for Resource Constrained Systems.

5. Virtualization: Basic Concepts, Benefits and Features, Building Blocks, Virtualization and O/S Components, Hypervisors; Virtual Machines, CPU and Memory Virtualization.
   Case Studies: Unix/Linux, Windows and Contemporary Embedded Operating Systems like Embedded Linux;Study of Source Code of Open Source Operating System like Linux.

Text Books

1. Silberschatz, Galvin, Gagne, "Operating System Concepts'', Wiley, 9/E
2. William Stallings, "Operating Systems: Internals and Design Principles",Pearson
3. Pradeep K. Sinha, "Distributed Operating System: Concept and Design'', PHI
4. Matthew Portnoy, "Virtualization Essentials",Sybex

Reference Books

1. Andrew S. Tanenbaum, Albert S. Woodhull, "Operating Systems: Design and Implementation", Pearson
2. Wang K.C., "Embedded and Real-Time Operating Systems", Springer
3Bovet&Cesati, "Understanding the Linux Kernel", O'Reily
4. Maurice J. Bach, "The Design of Unix Operating System", Prentice Hall

Reference Links

1. http://www.kernel.org/
2. http://www.linux.org/
3. http://www.linuxquestions.org/

MTAL 103 - Mathematics for Machine Learning

Course Outcomes:

After completing the course student should be able to:

1. Describe in-depth about mathematics used in machine learning and deep learning.
2. Compare and analyzes differentmathematical techniques used in machine learning.
3. Examine the nature of a problem at hand and determine best suitablemathematics technique.
4. Solve the real world problems using machine learning mathematics.

Course Contents:

Unit 1:linear algebra basics, vector spaces and subspaces, linear independence, basis and dimensions, linear transformation, four fundamental subspaces,orthogonality, geometry of linear equations,linear programming

Unit 2: Matrix theory- Norms and spaces, eigenvalues and eigenvectors, least squared and minimum normed solutions, matrix decomposition algorithms- SVD: Properties and applications, low rank approximations, Gram Schmidt process, polar decomposition, dimensions reduction algorithms and JCF- Principal component analysis, linear discriminant analysis, minimal polynomial and Jordan canonical form.

Unit 3: Calculus – Basic concepts of calculus: partial derivatives, gradient, directional derivatives, Jacobian, hessian, convex sets, convex functions and its properties, optimization – Unconstrained and constrained optimization, Numerical optimization techniques for constrained and unconstrained optimization: Newton's method, steepest descent method, Penalty function method, nonlinear, non-convex optimization.

Unit 4: Probability – Basic concepts of probability: conditional probability, Bayes' theorem, independence, theorem of total probability, expectation and variance, few discrete and continuous distributions, joint distributions and covariance.

Unit 5: Statistics - measures of central tendency-, mean, median, mode, weighted average mean, measures of dispersion, types of dispersion, standard deviation, variation, measures of skewness, correlation, regression.

Recommended Books:

1. W. Cheney, Analysis for Applied Mathematics. New York: Springer Science+Business Medias, 2001.
2. S. Axler, Linear Algebra Done Right (Third Edition). Springer International Publishing, 2015.
3. J. Nocedal and S. J. Wright, Numerical Optimization. New York: Springer Science+Business Media, 2006.
4. J. S. Rosenthal, A First Look at Rigorous Probability Theory (Second Edition). Singapore: World Scientific Publishing, 2006
5. Fundamentals of Statistics: D. N. Elhance, VeenaElhance and B. M. Aggarwal
6. GilbertStrang, LinearAlgebra and its Applications, Fourth edition, Cengage(previ-ously Brooks/Cole)(2006).

MTAL 104 - Machine Learning

Pre-Requisite: Computer Programming using python or R language

Course Outcomes:

After completing the course student should be able to:

1. Describe in-depth about theories, methods, and algorithms in machine learning.
2. Find and analyze the optimal hyper parameters of the machine learning algorithms.
3. Examine the nature of a problem at hand and determine whether a machine learning can solve it efficiently enough.
4. Solve and implement the real world problems using machine learning.

Course Contents:

UNIT 1. Introduction to machine learning (ML): Basics of ML, History of ML, Evolution of ML, ML Models, Learning and testing models, ML Algorithm and Convergence, MLTechniques, Types of ML, supervised and unsupervised learning, classification and clustering, Applications of ML,Bias-Variance tradeoff.

UNIT 2. Neural Networks: McCulloch Pitts Neuron models,Activation Functions, Loss Functions, perceptron,Gradient Descent,Multilayer neural networks: back-propagation, backpropagation calculus, Initialization, Training rules, issues in back-propagation, Bayesian Learning,Competitive learning and self-organization map.

UNIT 3. Support Vector Machines(SVM):SVM Formulation, Interpretation & Analysis, hard and soft margin, Hinge loss, SVM dual, SVM tuning parameters, SVM Kernels, twin SVM.

UNIT 4. Clustering: K-Means Clustering, Mean Shift Clustering, Aagglomerative clustering, Association Rule Mining, Partition Clustering, Hierarchical Clustering, Birch Algorithm, CURE Algorithm, Density-based Clustering, Gaussian Mixture Models, and Expectation Maximization. Parameters estimations – MLE,MAP,

UNIT 5. Learning Theory: Probably Approximately Correct (PAC) Model, PAC Learnability, Agnostic PAC Learning, Theoretical analysis of machine learning problems and algorithms,Generalization error bounds,VC Model,ML Tools.

Recommended Books:

1. Tom Mitchell, Machine Learning, McGraw-Hill, 1997.
2. Leonard Kaufman and P. J. Rousseau. Finding groups in data: An introduction to cluster analysis, Wiley, 2005
3. NelloCristianini and John Shawe-Taylor, An Introduction to Support Vector Machines,Cambridge University Press, 2000.
4. Bernhard Schölkopf and Alexander J. Smola, Learning with Kernels, MIT Press, 2002.
5. Shai Shalev-Shwartz and Shai Ben-David, Understanding Machine Learning:From Theory to Algorithms, Cambridge University Press.,2014

Research Journals:

1. IEEE Transaction on Neural Networks and Learning Systems
2. ACM Journal of Machine Learning Research

MTAL 105 *(A)* Programming System

Course Outcomes:

After completing the course student should be able to:

5. Develop ability to write a computer program to solve specified problems.
6. Develop skills in algorithmic problem-solving, expressed in a programming language like C, C++, python, Java.
7. Write and document the quality program.
8. Solve the real world business problems.

Course Contents:

Unit-1 Fundamentals of programming systems,elements of programming systems, basic data types and their memory representations, Operators and Expressions, I/O streams, statements, Sequential and conditional execution, Iterative solutions, arrays, matrices and their applications, Strings, Elements of string processing,.

Unit-2 Introduction to pointers, types of pointers, arithmetic of pointers and use of pointers in applications, functions, types of functions, declaration, definition, scope, parameter passing and recursion, structures, union, pointers to structures,file processing, file creation, I/O operations on files, file functions, working with text and binary files.

Unit-3 Introduction to Standard Template Library (STL): components of STL: containers, iterators, algorithms, functions, Introduction to container, types of containers and their use,types of Iterators,building application using STL, boots libraries.

Unit-4 Programming life cycles, coding standards, code tuning techniques, version controlling: Git, CVC etc.Internals of program compilation and execution, Programming errors and error handling. Documentation tools: LaTex, bibtex etc.

Unit-4 Introduction to object oriented Programming paradigm: object, class, object oriented design principles: encapsulation, information hiding, inheritance,Polymorphism,Overriding & Overloading, Comparison of Procedural and Object Oriented Programming paradigm.

Recommended Books:

1. YeshwantKanetkar, “Let us C”, BPB Publications, 2002.
2. B. Kernighan & D. Ritchie, “ The ANSI C programming Language”, PHI, 2000
3. R.G. Dromey, “How to solve it by computer”, PHI,1992
4. Jumping into C++ by Alex Allain. ISBN-13: 978-0988927803
5. Timothy Budd, “An Introduction to Object-Oriented Programming”, Addison-Wesley Publication, 3rd Edition 2002.
6. G. Booch, “Object Oriented Analysis & Design”, Addison Wesley, 2006
7. Herbert Schildt, “Java 2: The Complete Reference”, McGraw-Hill Osborne Media, 11th Edition, 2018.

MTAL 105 *(B)* Data Engineering

Pre-Requisite: Statistics and probability

Course Outcomes:

After completing the course student should be able to:

9. Describe in-depth about data, data types, data models and data distributions.
10. Compare and analyzes different data preprocessing and data visualization techniques.
11. Examine the nature of a data at hand and determine best suitabledata engineering technique/algorithm.
12. Solve and implement the real world problems using data engineering.

Course Contents:

Unit-I

Understanding Data: Types of data, Data Quality, Data Distributions,Data models, Data Wrangling and Exploratory Analysis, Introduction to contemporary tools. Data mathematics: probability, linear programming, statistics, calculus, metrics calculus: SVD, Eigen vectors, factorization.

Unit-II

Data Preprocessing: Data Transformation & Cleaning, Aggregation, Sampling, Dimensionality reduction, Feature subset Selection, feature creation, PCA, LDA, Discretization &Binarization, variable transformation, Data Normalization, Data similarity measures, missing values, filters, Wrapper Method ,Noise reduction techniques.

Unit-III

Exploring Data: Summary Statistics, measures of location & spread, Multivariate summary statistics, Data Visualization: boxplots, histograms,scatterplots, features map visualization, t-SNE, learning model data visualization,OLAP & Multidimensional Data Analysis.

Unit-IV

Statistical & Probabilistic analysis of Data, Multiple hypothesis testing, Parameter Estimation methods, Confidence intervals, Correlation & Regression analysis, logistic regression, Shrinkage Methods, Lasso Regression, Bayesian statistics. L1 and L2 regularizations.

Unit-V

Data Analysis, performance metrics, ROC curve,types of errors, Overfitting & Under fitting, evaluating performance of learning model: Holdout, Random sampling, cross validation and Bootstrap method. Bagging & boosting, Gradient Boosting, Random Forests, Committee Machines.

Recommended Books:

8. Trevor Hastie, Robert Tibshirani, Jerome H. Friedman , The Elements of Statistical Learning, Springer Series in Statistics, second edition, 2008
9. Brian Shive , Data Engineering: A Novel Approach to Data Design, Technics Publications, LLC, NJ, USA, 2013
10. Field Cady, "The Data Science Handbook" , 1/e,Publisher: Wiley, 2018
11. Pang-Ning Tan, "Introduction to Data Mining", Pearson Edu., 2007.
12. Sinan Ozdemir, "Principles of Data Science ", 1/e, 2016Packt Publishing Limited.
13. Peter Bruce, "Practical Statistics for Data Scientists: 50 Essential Concepts",Shroff/O'Reilly; First edition (2017)

MTAL 105 *(C)* Database Engineering

Course Outcomes:

After completing the course student should be able to:

1. Illustrate the knowledge of SQL for retrieving data from database by writing Queries using SQL.
2. Apply,analyze and plan the process of query optimization.
3. Use the basic concepts of transaction processing and apply concurrency control to given scenarios & will be able to solve the problems related to storage structures and access techniques.
4. Compare & contrast the distributed databases, Illustrate the use of distributed & parallel databases.

Course Contents:

Unit 1:Review of Basic Concepts of DBMS: Database system architecture, Conceptual modelling of database, Normalization theory, Query languages: Relational Algebra, SQL – Joins, nested queries, DDL, DML constraints, PL/SQL, Indexing, and Dynamic SQL

Unit 2: Query Optimization: Introduction, Measures of Query Cost, Various algorithms to implement select, project & join operation of relational algebra, Sorting, Selectivity Estimation, Improving query performance with variant indices.

Unit 3: Transaction Processing: Transaction Concepts, Isolation, Concurrent Executions, Serializability, Recoverability. Concurrency Control Protocols, Deadlock: Prevention and Recovery, Various Recovery methods with Concurrent Transactions, Buffer Management, Failure with Loss of Non-volatile Storage.

Unit 4: Distributed Database System: Distributed database architecture,Heterogeneous and Federated Database Systems, Distributed database design, Distributed Query processing, Distributed Transaction processing, Fragmentation and Distribution Parallel Database Systems, Deductive database system, Object Relational Database Systems.

Unit 5: Advance Topics: Brief review of Data mining, Data Ware Housing, Client server computing, XML database and web mining.

Recommended Books:

1. Korth H.F. & Silberschatz A., Sudarshan, "Database Systems", McGraw-Hill, Seventh edition, 2019.

2. Elmasri R., Navathe S.B., "Fundamentals of Database Systems", The Benjamin/ Cummings Publishing Company, Pearson. seventh edition Inc., 2015.

3. George Coulouris, " Distributed systems concepts and Design", Pearson Education, fifth edition, 2017.

4. Tannenbaun and Van Steen, " Distributed systems principles and paradigm". PHI, 2007.

5.D.Ullman, J.Widom, "Database Systems: The Complete Book", Pearson Education, 2011.

6. Alexis Leon, Mathews Leon, "Database Management Systems", Vikas Publishing House Pvt Ltd, New Delhi, 2008.

MTAL 105 *(D)* Artificial intelligence

Pre-Requisite: Computer Programming and Statistics

Course Outcomes:

After completing the course student should be able to:

5. Describe fundamentals of Artificial Intelligence (AI) and its foundations.
6. Understand formal methods of knowledge representation, logic and reasoning.
7. Apply basic principles of AI in solutions that require problem solving, inference, perception, knowledge representation, and learning.
8. Demonstrate awareness and understanding of various applications of AI techniques in intelligent agents, expert systemsand other machine learning models.

Course Contents:

Unit- I Introduction to Artificial Intelligence (AI): Basics, The Foundations of AI, History of AI, Intelligent Agents;Problem Solving by Searching: Problem spaces and search, Uninformed strategies-BFS, DFS, Dijkstra, Informed Strategies- A* Search, Heuristic Functions, Hill-climbing, Adversarial Search- Minimax Algorithm, Alpha-beta Pruning, Constraint Satisfaction Problems.

Unit-II Knowledge Representation: Knowledge-Based Agents, Representations and Mappings, Issues, Propositional Logic and Predicate Logic, First Order Logic and Inference, Ontological Engineering, Semantic Networks, Categories and Objects, Events.

Unit-III Reasoning: Quantifying Uncertainty, Baye's Rule and Its Use, Naive Bayes Models, Probabilistic Reasoning: Semantics and Inference in Bayesian Networks, Probabilistic Reasoning over Time: Time and Uncertainty, Inference in Temporal Models, Hidden Markov Models and other Models.

Unit-IV Expert Systems: Architecture of Expert Systems, Features, Roles of Expert Systems: Knowledge Acquisition, Meta knowledge, Heuristics, Knowledge Representation in Expert Systems; Typical Expert Systems: MYCIN, DART, XCON etc.; Expert System Tools and Shells.

Unit-V AI Applications: Case Study of Various Applications of AI in Game Playing, Natural Language Processing, Computer-Vision, Roboticsetc.

Recommended Books:

1. Russel,S., and Norvig,P., "Artificial Intelligence: A Modern Approach", 4th Edition,2020, Pearson.
2. Elaine Rich,Kevin Knight,Shivashankar B. Nair**,** "Artificial Intelligence", 3rd Edition, 2008, McGraw-Hill International.
3. Nils J. Nilsson, Artificial Intelligence: A New Synthesis, 2015, Morgan-Kauffman,Morgan-Kaufmann.
4. Janakiraman, K.Sarukesi, 'Foundations of Artificial Intelligence and Expert Systems', 2005, Macmillan Series in Computer Science.
5. W. Patterson, 'Introduction to Artificial Intelligence and Expert Systems', 5th Edition, 2003, Prentice Hall of India.

Research Journals:

3. IEEE Transactions on Artificial Intelligence
4. IEEE Transactions on Pattern Analysis and Machine Intelligence
5. Elsevier Journal on Artificial Intelligence
6. Elsevier Journal on Information Fusion
7. Elsevier Journal on Expert Systems with Applications
8. IEEE Transactions on Systems, Man and Cybernetics
9. IEEE Transaction on Neural Networks and Learning Systems
10. IEEE Transaction on Fuzzy Systems
11. ACM Transactions on Intelligent Systems and Technology
12. ACM Journal of Machine Learning Research