INDIAN INSTITUTE OF INFORMATION TECHNOLOGY KOTTAYAM

CURRICULUM AND SYLLABUS FOR THE PROGRAMME

Integrated M.Tech. (with BCA-MCA) in AI & Data Science for Working Professionals

Table of Contents

SEMESTER I **7**

IDSC111 Probability and Statistics for Data Science [3-1-0-4] **7**

IDSC112 IT Workshop I [3-1-2-5] **7**

IDSC113 Computer Programming [3-0-2-4] **8**

IDSC114 Communication Skills [1-0-0-1] **9**

IDSC115 Introduction to AI and Data Science [1-0-0-1] **10**

SEMESTER II **12**

IDSC121 Linear Algebra for Data Science [3-1-0] 4 ..... **12**

IDSC122 Data Structures [3-1-2] 5 ..... **12**

IDSC123 Computer Organization [3-0-0] 3 ..... **13**

IDSC124 IT Workshop II [3-0-2-4] **14**

IDSC125 Principles of Management [1-0-0-1] **15**

SEMESTER III **17**

IDSC211 Optimization Techniques for Data Science [3-1-0] 4 ..... **17**

IDSC212 Design and Analysis of Algorithms [3-1-0] 4 ..... **18**

IDSC213 IT Workshop III [4-0-2] 5 ..... **18**

IDSC214 Operating Systems [3-0-2] 4 ..... **19**

IDSC215 Financial Management and Accounting [1-0-0] 1 ..... **20**

SEMESTER IV **21**

IDSC221 Theory of Computation [3-1-0] 4 ..... **21**

IDSC222 Differential Equations and Transforms [3-1-0] 4 ..... **21**

IDSC223 Database Management Systems [3-1-2] 5 ..... **23**

IDSC224 Software Engineering and Project Management [3-0-2] 4 ..... **23**

IDSC225 Fundamentals of Economics [1-0-0] 1 ..... **24**

SEMESTER V **26**

IDSC311 Artificial Intelligence [3-1-2] 5 ..... **26**

IDSC312 Compiler Design [3-1-2] 5 ..... **26**

IDSC313 Computer Networks [3-1-2] 5 ..... **27**

IDSC314 Human Resource Management [1-0-0] 1 ..... **28**

SEMESTER VI 29

IDSC321 Introduction to IOT [3-0-2] 4 29

IDSC322 Blockchain Technology [3-0-2] 4 30

IDSC323 Cryptography and Network Security [3-1-0] 4 30

IDSC324 Parallel and Distributed Computing [3-0-2] 4 31

SEMESTER VII 33

IDSC411 Data Warehousing & Data Mining [3-0-2] 4 33

IDSC412 Cloud Computing [3-1-2] 5 34

IDSC413 Introduction to DevOps and Microservices [2-0-0] 2 35

SEMESTER VIII 36

IDSC421 Machine Learning [3-0-2] 4 36

IDSC422 Big Data Analytics [3-0-2] 4 36

IDSC423 Data handling analysis and visualization [3-0-0] 3 38

SEMESTER IX 39

IDSC511 Applied Predictive Analytics [3-0-0] 3 39

IDSC512 Machine Learning Operations (MLOps) [3-0-2] 4 40

IDSC513 Deep Learning [3-1-2] 5 41

IDSC514 Business Analytics [2-0-0] 2 42

IDSC515 Computer Graphics [3-0-0] 3 43

SEMESTER X 44

IDSC521 Streaming Data Analytics [3-0-2] 4 44

IDSC522 Speech and Natural Language Processing [3-0-2] 4 45

IDSC523 Computer Vision: Principles and Process [3-0-2] 4 46

IDSC524 Graph Algorithms and Mining [3-0-0] 3 47

IDSC525 Network Science Analytics [3-1-0] 4 48

IDSC526 Research Methodology [2-0-0] 2 49

SEMESTER XI 50

IDSC612 Responsible Artificial Intelligence [2-0-0] 2 50

IDSC613 Ethics for AI [1-0-0] 1 51

SEMESTER XII 52

IDSC622 Methods of Explainable-AI [2-0-0] 2 52

IDSC623 Interpretable Machine Learning [1-0-0] 1 52

Course Structure for 6-Year Integrated MTech in AI & Data Science

Semester –I							Semester -II					
Course	**Course Name**	**L**	**T**	**P**	**C**		**Course**	**Course Name**	**L**	**T**	**P**	**C**
IDSC111	Probability and Statistics for Data Science	3	1	0	4		IDSC121	Linear Algebra for Data Science	3	1	0	4
IDSC112	IT Workshop I	3	1	2	5		IDSC122	Data Structures	3	1	2	5
IDSC113	Computer Programming	3	0	2	4		IDSC123	Computer Organization	3	0	0	3
IDSC114	Communication Skills	1	0	0	1		IDSC124	IT Workshop II	3	0	2	4
IDSC115	Introduction to AI and Data Science	1	0	0	1		IDSC125	Principles of Management	1	0	0	1
Total		**11**	**2**	**4**	**15**		**Total**		**13**	**2**	**4**	**17**
Cumulative Credits at the End of First Year: 32												
Semester –III							**Semester -IV**					
Course	**Course Name**	**L**	**T**	**P**	**C**		**Course**	**Course Name**	**L**	**T**	**P**	**C**
IDSC211	Optimization Techniques for Data Science	3	1	0	4		IDSC221	Theory of Computation	3	1	0	4
IDSC212	Design and Analysis of Algorithms	3	1	0	4		IDSC222	Differential Equations and Transforms	3	1	0	4
IDSC213	IT Workshop III	4	0	2	5		IDSC223	Database Management Systems	3	1	2	5
IDSC214	Operating Systems	3	0	2	4		IDSC224	Software Engineering and Project Management	3	0	2	4
IDSC215	Financial Management & Accounting	1	0	0	1		IDSC225	Fundamentals of Economics	1	0	0	1
Total		**14**	**2**	**4**	**18**		**Total**		**13**	**3**	**4**	**18**
Cumulative Credits at the End of Second Year: 68												
Semester –V							**Semester -VI**					
Course	**Course Name**	**L**	**T**	**P**	**C**		**Course**	**Course Name**	**L**	**T**	**P**	**C**
IDSC311	Artificial Intelligence	3	1	2	5		IDSC321	Introduction to IOT	3	0	2	4
IDSC312	Compiler Design	3	1	2	5		IDSC322	Blockchain Technology	3	0	2	4
IDSC313	Computer Networks	3	1	2	5		IDSC323	Cryptography and Network Security	3	1	0	4
IDSC314	Human Resource Management	1	0	0	1		IDSC324	Parallel and Distributed Computing	3	0	2	4
Total		**10**	**3**	**6**	**16**		**Total**		**12**	**1**	**6**	**16**
Cumulative Credits at the End of Third Year: 100 BCA in AI and Data Science												
Semester –VII							**Semester -VIII**					
Course	**Course Name**	**L**	**T**	**P**	**C**		**Course**	**Course Name**	**L**	**T**	**P**	**C**
IDSC411	Data Warehousing & Data Mining	3	0	2	4		IDSC421	Machine Learning	3	0	2	4
IDSC412	Cloud Computing	3	1	2	5		IDSC422	Big Data Analytics	3	0	2	4
IDSC413	Introduction to DevOps and Microservices	2	0	0	2		IDSC423	Data handling analysis and visualization	3	0	0	3
IDSC414	Mini Project Phase I	6	0	0	6		IDSC424	Mini Project Phase II	6	0	0	6
Total		**14**	**1**	**4**	**17**		**Total**		**15**	**0**	**4**	**17**
Cumulative Credits at the End of Fourth Year: 134												
Semester –IX							**Semester -X**					
Course	**Course Name**	**L**	**T**	**P**	**C**		**Course**	**Course Name**	**L**	**T**	**P**	**C**
IDSC511	Applied Predictive Analytics	3	0	0	3		IDSC521	Streaming Data Analytics	3	0	2	4

IDSC512	Machine Learning Operations (MLOps)	3	0	2	4		IDSC522 /IDSC523	Speech and Natural Language Processing/ Computer Vision: Principles and Process	3	0	2	4
IDSC513	Deep Learning	3	1	2	5		IDSC524	Graph Algorithms and Mining	3	0	0	3
IDSC514	Business Analytics	2	0	0	2		IDSC525	Network Science Analytics	3	1	0	4
IDSC515	Computer Graphics	3	0	0	3		IDSC526	Research Methodology	2	0	0	2
Total		**14**	**1**	**4**	**17**		**Total**		**14**	**1**	**4**	**17**
Cumulative Credits at the End of Fifth Year: 168												
MCA in AI and Data Science												
Semester –XI							**Semester -XII**					
Course	**Course Name**	**L**	**T**	**P**	**C**		**Course**	**Course Name**	**L**	**T**	**P**	**C**
IDSC611	IMTP - I	18	0	0	18		IDSC621	IMTP - II	18	0	0	18
IDSC612	Responsible Artificial Intelligence	2	0	0	2		IDSC622	Methods of Explainable-AI	2	0	0	2
IDSC613	Ethics for AI	1	0	0	1		IDSC623	Interpretable Machine Learning	1	0	0	1
Total		21	**0**	**0**	**21**		**Total**		**21**	**0**	**0**	**21**
Cumulative Credits at the End of Sixth Year: 210												
Integrated M.Tech. in AI and Data Science												

SEMESTER I

IDSC111 Probability and Statistics for Data Science [3-1-0-4]

COURSE OBJECTIVES

- To expose the students to the modern theory of probability, concept of random variables and their expectations.
- To introduce various discrete and continuous distributions and concept of estimation theory, confidence interval.
- To illustrate the concept of hypothesis testing, tests for means and variances, Goodness of fit tests.
- To introduce the concept of simple regression and multiple regression.

COURSE OUTCOMES

- Define and apply the concepts of probability and conditional probability.
- Define and illustrate discrete and continuous random variables, their probability mass functions and probability density functions.
- Understand the concept and need of hypothesis testing.
- Perform the tests for means and variances and Goodness of fit test.
- Understand the concept of regression.

SYLLABUS

Introduction, data and presentations, descriptive statistics, sample spaces, set operations, axioms of probability, conditional probability, random variables (rv), pmfs/pdfs/cdfs, independence, expected value, joint rvs, conditional rvs, variance/covariance/correlations, inequalities, weak law of large numbers (LLN).

Discrete named distributions (Bernoulli, binomial, geometric, Poisson, etc.), continuous named distributions (normal, exponential, uniform, Chi-square), Poisson process.

Parameters, likelihood, maximum likelihood estimation (MLE), central limit theorem (CLT), general confidence intervals, z-scores, z-intervals, prediction intervals, sampling distribution of the mean estimator, t-intervals, binomial intervals.

Hypothesis testing, z-tests under different situations, one sample t-tests, two samples, paired, binomial tests.

Simple regression overview weighted least squares, linear regression, Analysis of Variance (ANOVA) approach to regression, multiple regression.

Chi-square goodness of fit.

TEXTBOOKS/ REFERENCES

1. S. Ross, Introduction to Probability and Statistics for and Engineers and Scientists, Third Edition, Elsevier, 2004.
2. P. G. Hoel, S. C. Port and C. J. Stone, Introduction to Probability Theory, Universal Book Stall, 2000.
3. Peter Bruce, Andres Bruce and Peter Gedeck, Practical Statistics for Data Scientist, O'Relly Media.
4. John A. Rice, Mathematical Statistics and Data Analysis, Cengage Learning, 3rd Edition.
5. Jay L. Devore, "Probability and Statistics for Engineering and the Sciences", Cengage Learning.
6. K. M. Ramachandran, "Mathematical Statistics with Applications", Academic Press.

IDSC112 IT Workshop I [3-1-2-5]

COURSE OBJECTIVES

To extend student's knowledge in basics of computers. This enables students to understand the internals of systems, which includes hardware parts, software and its installation procedure, basic Linux commands. They would be also studying to setup and develop a dynamic web application.

COURSE OUTCOMES

- Have a knowledge of the various hardware components.
- Understand Linux commands and shell scripting.
- Be aware of the basic web development scripting languages like HTML, CSS, Javascript, PHP, and AngularJS

SYLLABUS

Web development

HTML basics, working with CSS and JavaScript, page creation, AngularJS basics: MVC-basic concepts and it usage in programs, Filters and modules, Directives, Working with Forms and Validation, Fundamentals of React: JSX, Components, Dataflow, Events, Forms, Refs, Hooks and boundaries Basics of Server-side programming using PHP.

Computer software

Computer Software, Role of Operating System-Unix/Linux commands, Basic Shell Scripting with system calls (basics only)

LAB PROGRAMS

Familiarization of computer hardware and peripherals- CPU, Motherboard, Chip-set, Interface cards, Card slots, Hard disk, Cables, SMPS, NIC, Various ports, Computer Peripherals - I/O Devices. Storage devices, Interface cards – Buses – Firmware

Web Design - using HTML, CSS, Java Scripting, AngularJS, PHP, React

Familiarization of Linux Commands

Unix/Linux Shell scripting.

TEXTBOOKS/ REFERENCES

1. Kevin Wilson, Exploring Computer Systems: The Illustrated Guide to Understanding Computer Systems, Hardware & Networks, Volume 6 of Exploring Tech, Elluminet Press, 2019.
2. Irv Englander, Wilson Wong ,The Architecture of Computer Hardware, Systems Software, and Networking: An Information Technology Approach , 6th Ed., 2021
3. Craig Zacker, John Rourke, PC Hardware: The Complete Reference, McGraw Hill Education, 1st edition, 2017.
4. Christopher Negus, Linux Bible,11th Ed.,Wiley,2020
5. Shotts, W, The Linux command line: a complete introduction. 2nd Ed., No Starch Press, 2019
6. Alan Clements, Principles of Computer Hardware, Oxford University Press India, Fourth Edition, 2013
7. Robbins, J. N. (2012). Learning web design: A beginner's guide to HTML, CSS, JavaScript, and web graphics. “, O’Reilly Media, Inc.".
8. Meloni, Julie C., Kyrnin, Jennifer. HTML, CSS, and JavaScript All in One, Sams Teach Yourself. United Kingdom: Pearson Education, 2018.
9. Duckett, Jon. Web design with HTML, CSS, JavaScript and jQuery set. Vol. 1. IN: Wiley, 2014.
10. Andrew Grant, Beginning AngularJS. Apress, 2014.
11. Angular: Up and Running: Learning Angular, Step by Step, O'Reilly; 1st edition, 2018
12. Programming PHP: Creating Dynamic Web Pages 3rd Edition, Kindle Edition
13. Chris Minnick, Beginning ReactJS:Foundations Building User Interfaces with ReactJS An Approachable Guide, John Wiley & Sons, Inc,2022

IDSC113 Computer Programming [3-0-2-4]

COURSE OBJECTIVES

Student will learn programming terminology and will obtain a solid grasp of the basic mechanics of programming. This includes:

- Introduction to problem solving for programming.
- Write algorithms, flowcharts and programs.
- Syntax and program structure focus on the C programming language.
- Data types, Functions, Structures and Pointers.

COURSE OUTCOMES

Upon successful completion of this course, student will be able to:

- Understand the key concepts in the implementation of common features of programming languages.
- Apply appropriate Control structures to solve problems.
- Describe the fundamentals of C programming Language.

- Comprehend and implement concepts of Data type, Pointers, Structures, Functions

SYLLABUS

Introduction to Problem Solving, Problem Solving Strategies, Algorithms and Flowcharts.

C programming language introduction and significance, Constants, Variable and Data Types, Data Type modifiers, Variable scope, Operators and Expressions, Managing Input and Output Operations.

Decision Making and Branching, Arrays and Strings, Concept of Loops and Decision Making, Nested Loops, Multi-dimensional Arrays.

User-defined Functions, Recursion, Pointers, Structures, Union, Dynamic Memory Allocation, Structure Pointers.

LAB PROGRAMS

- Implement fundamental domain knowledge of the course for developing effective computing solutions by incorporating creativity and logical reasoning.
- Students should understand how to use arrays for storing/retrieving large amount of data. They should have a clear grasp of strings and string libraries used for their manipulation.
- Pupils should acquire knowledge of how decision making and various basic/advanced constructs for control flow and instruction repetition is done while programming.
- Comprehend the circumstances and need to break up a big program into independent modules and define functions and call them with appropriate parameters.
- Understand how to effectively use structures as a compound datatype. Pupils should also acquire the capability to design structures according to their requirement.
- Comprehend recursion, pointer referencing/dereferencing and dynamic memory allocation.

TEXTBOOKS/ REFERENCES

1. Kernighan B.W and Dennis M. Ritchie, "The C Programming Language", 2nd Edition, 2015, Pearson Education India, ISBN: 978-9332549449.
2. Dromey R.G, "How To Solve It By Computer", 2007, Pearson India, ISBN-13: 978-8131705629.
3. Herbert Schildt, "C: THE COMPLETE REFERENCE", 4th Edition, 2017, McGraw Hill Education, ISBN: 978-0070411838.
4. Byron S Gotrified, "Programming with C", 4th Edition, McGraw Hill Companies, 2018, ISBN: 978-9353160272.
5. Herbert Schildt, "C++: THE COMPLETE REFERENCE", 4th Edition, 2017, McGraw Hill Education, ISBN: 978-0070532465.

IDSC114 Communication Skills [1-0-0-1]

COURSE OBJECTIVES

- Provide methods for developing English language and communication skills for the current workspace
- Improve language skills to participate in the global business economy
- To help students write business documents and generate content effectively
- To help the students engage with other members of the corporate field confidently

COURSE OUTCOMES

- The students will be able to speak confidently interpersonally as well as in large groups
- The students will be able to develop effective writing skills and write in a clear, concise and audience centric manner
- The students will be able to communicate effectively in group discussions, interviews, meetings, conferences, and maintain good public relations

SYLLABUS

Module 1: Technical Communication- Non-verbal Communication- Presentation Skills- Group Communication- Meetings and Conferences- Interview Skills- The Power of Body Language

Module 2: Business Correspondence: Trade letters/emails (Letters of complaints, claims, letters related to RTI, claims, sales letters, etc.).- Technical Report- Investigative Reports

Module 3: Basic Grammar and Vocabulary Development: Parts of Speech-Tenses- Subject Verb Agreement- Active and Passive Voice- Common Errors in English- Synonyms ad Antonyms- Phrasal verbs

TEXTBOOKS/ REFERENCES

1. Raman, Meenakshi and Prakash Singh, Business Communication: Oxford University Press 2012.
2. Raman, Meenakshi and Sangeetha Sharma. Technical Communication:
3. Principles and Practice. Oxford University Press, 2015.
4. Roman, Kenneth, and Joel Raphaelson. *Writing that works: How to communicate effectively in business*. Harper Collins, 2010.
5. Reiman, Tonya. *The power of body language: How to succeed in every business and social encounter*. Simon and Schuster, 2007.
6. Rizvi, Ashraf M. Effective Technical Communication. McGraw Hill Education (India) Pvt, 2018.
7. Thomson, A.J & A.V. Martinet. A Practical English Grammar. Oxford University Press, 2016.
8. Yule, George. Oxford Practice Grammar: Advanced. Oxford University Press, 2009.

IDSC115 Introduction to AI and Data Science [1-0-0-1]

COURSE PREREQUISITES

- No Prerequisites

COURSE OBJECTIVES

- To provide a historical perspective and broad introduction to Artificial Intelligence
- To introduce the fundamental concepts and principles of AI for problem solving, knowledge representation
- To introduce the concepts, techniques and methodologies in data science.
- Understand the various aspects of data science and the skill sets necessary for a data scientist
- To introduce fundamentals of machine learning algorithms
- To provide skills required to uncover patterns and underlying relationships in small data

COURSE OUTCOMES

- Acquire a thorough knowledge and fundamental concepts and techniques of artificial Intelligence.
- Ability to solve basic problems by applying concepts of problem solving, knowledge representation
- Understand the various aspects of data science and the skill sets necessary for a data scientist
- Ability to perform data preprocessing and data visualization.
- Ability to design machine learning models and develop classification systems for real-world problems

SYLLABUS

Introduction to Artificial Intelligence: Artificial Intelligence (AI), Major Branches of AI, Applications - Intelligent systems, Characteristics of intelligent systems- Search Techniques: Why Search, Search strategies, Complexity of Search.

Introduction to statistics: Central tendencies and distributions, Variance, Distribution properties. Data Science process: Data sources, Data preprocessing and cleaning, Data integration and transformation, Feature engineering and extraction, Data sampling, Outlier detection. Exploratory data Analysis (EDA): tools and techniques. Case studies.

TEXTBOOKS/ REFERENCES

1. Stuart Russell, Peter Norvig, "Artificial intelligence: A Modern Approach", Prentice Hall, Fourth edition, 2020.
2. Kevin Night and Elaine Rich, Nair B "Artificial Intelligence (SIE)", McGraw Hill, 2008.

3. Jeffrey S. Saltz, Jeffrey M. Stanton, An Introduction to Data Science, SAGE Publications, 2018
4. Kotu, Vijay, and Bala Deshpande. Data science: concepts and practice. Morgan Kaufmann, 2018.
5. Patterson, Introduction to AI and Expert Systems, 3rd edition PHI

SEMESTER II

IDSC121 Linear Algebra for Data Science [3-1-0] 4

COURSE OBJECTIVES

- Represent data as vectors and matrices and identify their properties using concepts of singularity, rank, and linear independence.
- Express certain types of matrix operations as linear transformation, and apply concepts of eigenvalues and eigenvectors to machine learning problems
- Solve real-world problems using the foundational concept of matrices and explain where those problems might arise.
- Recognize what a matrix represents in n-dimensional space and how transformations act in that space
- Identify key properties of any system of equations, such as independence, basis, rank, and more, and what they mean for the overall system.
- Demonstrate the understanding of projections in lower dimensions, while being able to carry out higher dimension projections for real-world problems.

COURSE OUTCOMES

- Students will be able to model problems through abstract structures and arrive at insights or solutions by manipulating these models using their properties.

SYLLABUS

Vectors, operations on vectors, vector spaces and subspaces, inner product and vector norm, linear dependence and independence, Matrices, linear transformations, orthogonal matrices

System of linear equations, existence and uniqueness, left and right inverses, pseudo inverse.

LU decomposition and computational complexity, rotators and reflectors, QR decomposition, Gram Schmidt Orthogonalization.

Condition number of a square matrix, geometric interpretation, norm of matrix, sensitivity analysis results for the system of linear equations. Linear least squares, existence and uniqueness, geometrical interpretation, data fitting with least squares, feature engineering, application to Vector auto-regressive models, fitting with continuous and discontinuous piecewise linear functions, Application of least squares to classification. Eigenvalue eigenvector decomposition of square matrices, spectral theorem for symmetric matrices, SVD, relation to condition number, sensitivity analysis of least squares problems, variation in parameter estimates in regression. Multicollinearity problem and applications to principal component analysis (PCA) and dimensionality reduction, power method, application to Google page ranking algorithm.

TEXTBOOKS/ REFERENCES

1. Introduction to Applied Linear Algebra-Vectors, Matrices, and Least Squares, Stephen Boyd and Lieven Vandenberghe, Cambridge University Press, 2018
2. Linear Algebra and Learning from Data, Gilbert Strang, Wellesley-Cambridge Press, 2019
3. Fundamentals of Matrix Computations, David Watkins, Wiley, 2010
4. Matrix Computations, Gene Golub, C. F. Van Loan, Hindustan Book Agency, 2015
5. Matrix Computations by Gene H. Golub, C.F. Van Loan, The Johns Hopkins University Press, 2013.
6. Mathematics for machine learning., Deisenroth, Marc Peter, A. Aldo Faisal, and Cheng Soon Ong, Cambridge University Press, 2020.

IDSC122 Data Structures [3-1-2] 5

COURSE OBJECTIVE

To understand, Analyse, and implement the concepts of Linear, and non-linear data structures and various sorting and searching techniques.

COURSE OUTCOMES

- Demonstrate various operations of Singly and Doubly linked list
- Apply the different linear data structures like stack and queue to various computing problems.
- Demonstrate different types of trees and apply them to problem solutions

- Analyse graph structure and understand various operations on graphs and their applicability.
- Develop various sorting and searching algorithms.

SYLLABUS

Basic Analysis of Algorithm – Arrays – Pointers – Structure and Class – Functions - Static and Dynamic Memory allocation - String manipulation functions - Introduction to Data Structures and ADT

Linear Data Structures: Stack and its Applications – Queue and its Application – Linked List: Singly and Doubly linked List – Sorting: Bubble Sort- Selection Sort – Insertion sort – Searching: Linear Search - Binary Search

Non-Linear Data Structures – Tree: Terminology – Binary Tree construction & Traversal – Conversion from Generic tree to Binary tree – Binary Search Tree. Graph: Terminology – Graph Traversal

TEXTBOOKS/ REFERENCES

1. Introduction to Algorithms, by T. H. Cormen, C. E. Lieserson, R. L. Rivest, and C. Stein, Third Edition, MIT Press.
2. Fundamentals of Data Structures in C by Horowitz, Sahni, and Anderson-Freed, Universities Press, Second edition ,2008
3. Data Structures and Algorithm Analysis in C, by Mark Allen Weiss, 2nd Edition, Pearson Education, 2002.
4. Problem-Solving in Data Structures & Algorithms Using C, by Hemant Jain, First edition,2016
5. Data Structures Through C - 4th Edition: Learn the fundamentals of Data Structures through C, by Yashavant Kanetkar, BPB Publications; 4th edition,2022.

LAB PROGRAMS

1. Find the second largest number and second smallest number.
2. Swapping of two numbers with and without using a third variable using functions.
3. Display N employee details using the array structure variable.
4. Display N student details using the Pointer Structure Variable using dynamic memory allocation.
5. String manipulation with and without using the built-in methods.
6. Array implementation of Stack
7. Linked list Implementation of Stack
8. Expression conversion and evaluation
9. Array implementation of Queue
10. Linked list Implementation of Queue
11. Singly Linked List operations: Insertion, Deletion, and Search
12. Doubly Linked List operations: Insertion, Deletion, and Search
13. Binary Tree Construction and Traversal
14. Binary Search Tree Operation: Insertion, Deletion and Search Graph Traversal: BFS and DFS

IDSC123 Computer Organization [3-0-0] 3

COURSE PREREQUISITES

- Mathematical foundations for computer science

COURSE OUTCOMES

- This course will introduce to students the fundamental concepts underlying modern computer organization.
- Students should be able to know the overall working of a computer.
- Students should be able to get a detailed understanding of the design principles involved in developing a computer.
- They should know the representation of data, how programs are represented, executed and how programs manipulate and operate on data.
- They should also be able to appreciate how the memory organization is done and how to organize memory for faster execution of programs.

COURSE OBJECTIVES

- To understand the basics of computer hardware and how software interacts with computer hardware.
- To analyze and evaluate the performance of computers.
- Understand basics of Instruction Set Architecture (ISA) – RISC.

- To understand how computers, represent and manipulate data.
- To understand how the memory management takes place in a computer system.
- Design a simple computer with hardware design including data format, instruction format, instruction set, addressing modes, bus structure, input/output, memory, Arithmetic/Logic unit, control unit, and data, instruction and address flow.

SYLLABUS

Basic Structure of Computers: Basic Operational Concepts, Bus Structures, Performance – Processor Clock, Basic Performance Equation, Clock Rate, Performance Measurement.
Instructions: operations and operands of the computer hardware, representing instructions, making decision, supporting procedures, character manipulation, styles of addressing, starting a program.
Memory System: Basic concepts semiconductor RAM memories. Read-only memories Cache memories performance considerations, Virtual memories secondary storage. Introduction to RAID.
Input/output: Peripheral Devices, Input-Output Interface, Asynchronous data transfer Modes of Transfer, Priority Interrupt Direct memory Access, Input –Output Processor (IOP) Serial communication; Introduction to peripheral component, Interconnect (PCI) bus.
Introduction to multicores and multiprocessors: Characteristics of Multiprocessors, Interconnection Structures, Inter-Processor Communication and Synchronization Cache Coherance. Shared Memory Multiprocessors.

TEXT BOOKS/REFERENCES

1. William Stallings, Computer Organization and Architecture: Designing for Performance Pearson-Prentice Hall, 2016
2. Carl Hamazher, ZvonkoVranesic and SafwatZaky, Computer Organization, Fifth Edition, McGraw Hill, 2002.
3. Computer Organization and Architecture – William Stallings Sixth Edition, Pearson/PHI
4. Structured Computer Organization – Andrew S. Tanenbaum, 4th Edition PHI/Pearson
5. D. A. Pattersen and J. L. Hennesy, Computer Organisation and Design: The Hardware/ Software Interface, Fourth Edition, Morgan Kaufman, 2009.
6. V. P. Heuring and H. F. Jordan, Computer System Design and Architecture, Prentice Hall, 2003.
7. Computer Architecture: A Quantitative Approach, Fifth Edition, Morgan Kaufman, 2011.

IDSC124 IT Workshop II [3-0-2-4]

COURSE OBJECTIVES

- This course aims at equipping the learners to develop Object-Oriented software using the Java Programming Language.
- This course motivates to think of problem solving in Object-Oriented way

COURSE OUTCOMES

- Apply object-oriented concepts on real time scenarios.
- Apply the concepts of Multithreading and Exception handling to develop efficient and error free codes
- Design and develop Java applications to solve real world problems by using modern tools and collection framework
- Design and develop GUI based applications using swings for internet and system-based applications

SYLLABUS:

Introduction:

History of Java, Byte code, JVM, Java buzzwords, OOP principles, Data types, Variables, Scope of variables, Operators, Control statements, Type conversion and casting, Arrays.

Concepts of Classes and Objects: Introduction to methods, Method over loading, Constructors, Constructor overloading, Usage of static with data

and method, Access control, this keyword, Garbage collection, String class, String Tokenizer.

Inheritance and exceptions

Inheritance: Types of inheritance, Member access rules, Usage of super keyword, Method overriding, Usage of final keyword, Abstract classes, Interfaces - differences between abstract classes and interfaces, defining an interface, implementing interface, applying interfaces, variables in interface and extending interfaces. Packages-defining, creating and accessing a package, importing packages, access control in packages.

Exception Handling: Concepts of exception handling, Types of exceptions, Usage of try, catch, throw, throws and finally keywords, Built-in exceptions, User defined exception.

Multi threding and framework

Multithreading: Concepts of multi-threading, Differences between process and thread, Thread life cycle, creating multiple threads using Thread class and Runnable interface, Synchronization, Thread priorities, Inter thread communication.

Collection Framework: Collections Overview, Collection Interfaces - List, Set, Map, List – Array List, Linked List, Vector, Set - HashSet, TreeSet, Map - HashTable, HashMap, accessing a collection via an Iterator, comparator, comparable.

File Input/Output:

I/O Operations in Java(java.io Package),Streams and the new I/O Capabilities ,Understanding Streams, The Classes for Input and Output, The Standard Streams, Working with File Object, File I/O Basics, Reading and Writing to Files, Buffer and Buffer Management, Read/Write Operations with File Channel.

Swings

GUI Programming with Swing: Delegation event model-Events, Event sources, Event Listeners, Event classes, handling mouse , keyboard events.

Exploring Swing Controls: JLabel and Image Icon, JText Field, JButton, JCheckBox, JRadioButton, JTabbed Pane, JList, JCombo Box.

LAB PROGRAMS

1. Simple Programs without classes and objects, methods
2. Program based on the concepts of classes and objects, constructor, parameterized constructor
3. Method overloading, constructor overloading
4. Single level Inheritance, Multiple inheritance, Super, Order of Constructor calling, Method overriding
5. Final Keyword, Abstract Classes, Interface
6. Array and String
7. Exception handling through- Try, Catch, Throw, Throws and Finally
8. Making own package
9. Simple programs of multithreading
10. I/O& File Handling- Input from user, Creation of file and Reading data from file
11. Swing control

TEXTBOOKS/ REFERENCES

1. Deitel, Paul J. Java how to program. Pearson Education India, 2002.
2. Schildt, Herbert. Java: the complete reference. McGraw-Hill Education Group, 2014.
3. Ken Arnold, James Gosling and David Holmes, The Java Programming Language, Fourth Edition, 2005.
4. C. Thomas Wu, An Introduction to Object Oriented Programming with Java, Fifth Edition, 2009.
5. M.T. Somashekara, D. S. Guru, K.S. Manjunatha, "Object-Oriented Programming with Java", 1st Edition, PHI Learning, 2017.
6. E. Balagurusamy, "Programming with Java", 6th Edition, McGraw Hill, 2019.
7. Mark Lassoff," Java Programming for Beginners: Learn the fundamentals of programming with Java", 1st Edition, Packt Publishing Limited,2017.

IDSC125 Principles of Management [1-0-0-1]

COURSE OBJECTIVES

- To introduce Profession of Management and help the students gain understanding of the functions and responsibilities of the manager.
- To provide participants tools and techniques to be used in the performance of the managerial job and enable them to

analyze and understand the environment of the organization.

COURSE OUTCOMES

It will help the students to gain understanding of the functions and responsibilities of managers • It will provide them tools and techniques to be used in the performance of managerial job

SYLLABUS

Introduction to Management: Module 1

Management – An Emerging Profession, Definition, Nature, Scope, Purpose, and characteristics of Management, Functions, roles, skills of an effective Manager

Evolution of Management Thought: Classical Theory, Scientific Management, Management Process or Administrative Management, Bureaucracy, Behavioral Science Approach, Quantitative Approach, Systems Approach, Contingency Approach, Operational Approach

Planning: Types of Plans, Planning Process, Introduction to Strategic Management, Types of Strategies, Understanding environment of business: Environmental appraisal – Industry Analysis - Porter's Model of competitive advantage, analysis of organizational resources and capabilities

Management by Objectives and Styles of Management: Module 2

Core Concepts of MBO, Characteristics of Management by Objectives, Process of MBO, Defining the Goal, Action Plan, Final Review, Benefits of Management by Objectives, Limitations of Management by Objectives, Styles of Management, American Style of Management, Japanese Style of Management, Indian Style of Management

Organizing and Directing: Introduction, Organizational Design, Hierarchical Systems, Organization Structure, Types of Organization Structure, Formal and Informal Organization, Factors Determining Span of Management, Centralization and Decentralization, Span of control, understanding authority and responsibility, Principles of Delegation, Authority, Developing a culture of Innovation and performance

Career Development Strategy: Module 3

Introduction, Concept and Elements of Career, Overview of Career Development, Significance and Advantages of Career Development, Objectives of Career Development, Types of Career Development Programmes, Different Stages or Cycles of Career Development Process, Career Anchors, Steps in the career planning

Leadership styles of Managers: Module 4

Leadership Concept, Nature, Importance, Attributes of a leader, Role of a leader in demonstrating awareness of legal, personnel, and strategic issues relating to globalization, culture and gender diversity in an organization, Role of leader in conflict resolution and negotiations

Organizational Communication: Communication in Organizations: Introduction, Importance of Communication in the Workplace; Understanding Communication Process, Barriers to Communication, Use of tone, language and styles in Communication, Role of Perception in influencing communication, Role of culture in communication

Change management: Module 5

Concept of change, change as a natural process, Importance & Causes of change – social, economic, technological, organizational, developing a climate for learning, Concept of learning organizations

Challenges of Contemporary Business: Role of Ethics, Corporate social responsibility, and environmental issues

TEXTBOOKS AND REFERENCES

1. Stephen P. Robbins, David A. Decenzo, 2016. Fundamentals of Management, Pearson Education, 9th Edition
2. Harold Koontz, O'Donnell and Heinz Weihrich, 2012. Essentials of Management. New Delhi, 9th edition, Tata McGraw Hill
3. Management Fundamentals: Concepts, Applications, & Skill Development, 6th edition, Sage. 2014
4. Richard L. Daft, Principles of Management, Cengage Learning. 2009
5. Robbins, Management, 9th edition Pearson Education. 2008.

SEMESTER III

IDSC211 Optimization Techniques for Data Science [3-1-0] 4

COURSE OBJECTIVES

- To provide a conceptual understanding of optimization algorithms.
- To provide an ability to model a data science problem into an optimization problem.
- To provide an ability to select a specific optimization algorithm for solving a specific optimization problem.
- To provide new insights for observing machine learning and deep learning concepts through optimization point of view.

COURSE OUTCOMES

- Students will have a deep understanding of optimization algorithms
- Students will be able to model a data-science problem as an optimization problem.
- Students will be able to use a specific optimization algorithm for a specific data science problem.
- Students will be familiar with the application of different optimization techniques for nonlinear regression, logistic regression, deep neural network, and support vector machine models.
- Students will be able to use python or matlab for implementation of these optimization algorithms

SYLLABUS

Mathematical background:
Vectors, Matrices, Multivariate calculus, Derivatives, Gradient, Hessian, Taylor series, Local and global optima, Fundamental of mathematical optimization
Continuous optimization techniques:
Local decent: Decent direction, Line search, Approximated line search, Trust region methods. First order methods: Gradient decent (GD), Conjugate gradient, Wolfe conditions, Goldstein conditions, Sufficient decrease and backtracking, Momentum, Nesterov momentum, Adagrad, RMSprop, Adadelta, Adam, Hyper-gradient decent, Sub-gradient descent. GD variants for training model: stochastic gradient decent, batch gradient decent. Second order methods: Newton's algorithm, Quasi-newton's algorithm, BFGS method. Convexity and its significance in optimization.
Constrained handling:
Equality and inequality constraints, Lagrange multipliers, Karush-Kuhn-Tucker conditions, Duality, Penalty methods, Augmented Lagrange methods, Interior point methods.
Discrete optimization techniques: Integer Programs, Rounding, Cutting Planes, Branch and Bound, Dynamic Programming.
Evolutionary algorithms and Multi-objective optimization: Genetic algorithm, Particle swarm optimization, Ant colony optimization, Pareto optimality, Constraint methods, Weight methods, Multi-objective evolutionary algorithms.

LAB PROGRAMS

Implementation of various optimization algorithms in the contexts of ML\AI\DS domains.

TEXTBOOKS AND REFERENCES

1. Bertsekas, D. P. (1999). Nonlinear programming/Dimitri P. Bertsekas. Athena Scientific, Belmont, Mass., 2nd ed.. edition.
2. Bertsekas, D. (2015). Convex optimization algorithms. Athena Scientific.
3. Bertsekas, D. P. (2014). Constrained optimization and Lagrange multiplier methods. Academic press.
4. Boyd, S., Boyd, S. P., & Vandenberghe, L. (2004). Convex optimization. Cambridge university press.
5. Nocedal, J., & Wright, S. J. (Eds.). (1999). Numerical optimization. New York, NY: Springer New York.
6. Kochenderfer, M. J., & Wheeler, T. A. (2019). Algorithms for optimization. Mit Press.
7. Deb, Kalyanmoy. (2011). Multi-objective optimisation using evolutionary algorithms: an introduction. In Multi-objective evolutionary optimization for product design and manufacturing. London: Springer London.

IDSC212 Design and Analysis of Algorithms [3-1-0] 4

COURSE PREREQUISITES

- Basic Mathematics and Programming
- Data Structures

COURSE OBJECTIVES

- Analyze the asymptotic performance of algorithms.
- Detailed introduction to different algorithm design paradigms with associated problems.
- Analyzing computationally hard problems.

COURSE OUTCOMES

- Ability to analyze the running time.
- Ability to prove the correctness of basic algorithms.
- Ability to design efficient algorithms for computational problems.
- Ability to classify problems to various complexity classes and prove the hardness of NP hard problems by providing reductions.

SYLLABUS

Introduction: Efficiency – Run Time & Space. Analyzing an Algorithm Complexity – Asymptotic Notations.

Recurrence Relations – Solving Divide and Conquer Recurrences – Recursion Tree – Substitution Method – Master Theorem – Applications of the Master Theorem.

Divide and Conquer: Analyzing Recursive Algorithms – Binary Search, Merge Sort, Quick Sort.

Greedy Algorithms: Locally Optimal Solutions – Interval Scheduling – Minimum Spanning Trees.

Prim's Algorithm – Kruskal's Algorithm – Dijkstra's Algorithm.

Dynamic Programming: Reusing work across sub computations – Definition of Dynamic Programming – Optimal Matrix Chain Multiplication - Bellman-Ford Algorithm, Floyd-Warshall Algorithm – Longest Common Subsequence.

Intractable Problems: Polynomial Time – class P – Polynomial Time Verifiable Algorithms – class NP – NP completeness and reducibility – NP Hard Problems

TEXTBOOKS/ REFERENCES

1. Thomas H Cormen, Charles E Leiserson, Ronald L Rivest, Clifford Stein - Introduction to Algorithms, MIT Press, Third Edition, 2010.
2. Jon Kleinberg, Eva Tardos, Algorithm Design ,Pearson Addison, Wesley, 2013.

IDSC213 IT Workshop III [4-0-2] 5

COURSE OBJECTIVES

- To know Python scripting and the scripting shell.
- To learn the basics of programming constructs like conditions, loops, functions, etc.
- To familiarize sequence types in Python like Lists, Tuples, Sets and Dictionaries.
- To introduce the basics towards Database and python packages

COURSE OUTCOMES

- Understand the basics of python programming constructs
- Write python programs for various applications
- Write Database programs to create, access, modify and update data
- Write python programs which includes python packages

SYLLABUS

Introduction to Python: Python IDE, Python variables, Python basic Expressions and Operators, Understanding python Data types.

Control Flow, Conditional Statements, Loops Programming using Python conditional and loop blocks. Loop manipulation using pass, continue and break.

Lists and list processing, list operations, list traversals, Tuples, Maps, Sets and Dictionaries-creation and traversals. Strings and string processing, string functions, conversions, Regular expression.

User defined Functions, lambda functions, recursive functions, built-in functions, organizing python codes using functions.

Classes and object-oriented programming, Inheritance, Associations, Polymorphism.

Python File Operations: Reading files, writing files in python, Introduction to Database processing, creating tables, querying.

Python packages: Simple programs using the built-in functions of packages matplotlib, numpy and applications in matrices.

LAB PROGRAMS

- Python IDE
- Expressions and Operators, Syntax, Variables
- Python Data Types, Lists, Tuples, Maps, Strings, Dictionaries
- Control Flow, Conditional Statements, Loops
- Functions in Python, Function with Return Statement
- File Handling, Writing and Reading a file
- OOPs, Regular Expressions, Database
- NumPy, Matplotlib,

TEXTBOOKS/ REFERENCES

1. Ljubomir Perkovic, Introduction to Computing with Python, Wiley, Second Edition, 2015.
2. Narasimha Karumanchi, Data Structures and Algorithms With Python, Careermonk Publications, 2015.
3. Wesley J. Chun, "Core Python Applications Programming", 3rd Edition, Pearson Education, 2016
4. Charles Dierbach, "Introduction to Computer Science using Python", Wiley, 2015
5. Downey, A. et al., "How to think like a Computer Scientist: Learning with Python", John Wiley, 2015

IDSC214 Operating Systems [3-0-2] 4

COURSE OBJECTIVES

- To introduce the Fundamental concept of OS, and how OS works;
- To study the Building blocks of OS, Components of OS

COURSE OUTCOMES

- Students will be able to design an OS,
- Students will be able to implement various components of OS,
- Students will be able to implement a small OS

SYLLABUS

Operating system overview: Computer System Organization, Operating System structure, operations of OS, process management, memory management, storage management, protection and security, distributed systems.

Processes: Process concept, Process scheduling, Operations on processes, Cooperating processes, inter-process communication

Threads: Overview, Multi-threading models, threading issues, P threads, Windows XP threads

CPU Scheduling: Basic concepts, scheduling criteria, scheduling algorithms, multiple-processor scheduling

Process synchronization: The critical section problem, Peterson's solution, synchronization hardware, Semaphores, Monitors. Synchronization examples

Deadlocks: Methods for handling deadlocks, Deadlock prevention, deadlock avoidance, Deadlock recovery

Memory management: Swapping, Paging, Segmentation, Virtual memory, Demand paging, Page replacement

I/O Systems: I/O hardware, Application I/O interface, Kernel I/O subsystem, transforming I/O requests to hardware operations

TEXTBOOKS/REFERENCES

1. William Stallings,Operating systems: Internals & design principles, Pearson, Seventh edition, 2014.
2. Andrew S. Tanenbaum, Modern Operating Systems, Pearson Fourth Edition, 2016.
3. Charles Crowley, Operating Systems - Design Oriented Approach, Mc. Graw Hill Education, First edition, 2017.
4. Abraham Silberschatz, Galvin, Gagne Operating System Concepts, Wiley, Ninth Edition, 2016.

IDSC215 Financial Management and Accounting [1-0-0] 1

COURSE OBJECTIVES

- To familiarize participants with fundamentals of Financial Management in an Organization
- To provide the participants various techniques in Financial Management.
- To give an overview of the emerging financial issues facing an Organization Course Outcome
- Students will become aware of basics of accounting.
- Students will become familiar with accounting standards and financial management
- It will equip the skills for better financial management

SYLLABUS

Introduction to Finance

Introduction to Financial management: Business Finance- Concept, types and scope. Financial management: objectives, functions and scope - Interface of financial management with other functional areas. Role of finance manager

Investment Decisions: - Capital budgeting – Process of capital budgeting - selection of projects - Estimation of cash flows - Payback and Discounted payback period - Accounting rate of return- NPV – IRR – Capital Budgeting decisions under risk - Capital Rationing - Project selection under rationing.

Finance Decisions

Financing and Capital Structure Decision: Sources of Finance: External and Internal financing. Cost of different sources of capital – Weighted average cost of capital (WACC) and Marginal cost of capital. Capital structure decisions – meaning and pattern– Theories of capital structure- Net income approach - Net operating income approach- Traditional approach-MM approach - Optimum capital structure. Leverage - operating, financial and composite leverage.

Dividend Decisions

Dividend Decisions: Dividend policy – dividend and its forms – objectives of dividend policy– relevance and irrelevance. Theories of dividend decisions: Walter's Approach – Gordon's Approach – MM Approach

Working Capital

Management of Working capital: Meaning and Need of Working capital - factors affecting composition of working capital – Inter dependence among components of working capital – Estimation of working capital – Cash management- Cash flow statement and fund flow statement- Receivables management.

Basics of Accounting

Meaning and Nature of Financial Accounting, Scope of Financial Accounting, Financial Accounting and Management Accounting, Accounting concepts and convention, Accounting Standards in India. Basics of Accounting – Capital and Revenue Items, Application of Computer in Accounting, Double Entry System, Introduction to Journal, Ledger and Procedure for Recording and Posting, Introduction to Trial Balance, Preparation of Final Account, Profit and Loss Account and Related Concepts, Balance Sheet and Related Concept.

TEXBOOKS/REFERENCES

1. Brealey, Richard A and Stewart CMyers. Principles of Corporate Finance. McGraw Hill India, 2012.
2. Chandra Prasanna, Financial ManagementTheory & Practice, Tata McGraw Hill, 2014.
3. James C Vanhorne, John M WachowiczJr, Fundamentals of Financial Management, Pearson Education Limited, New Delhi.
4. Lawerence J Gitman, Principles of Managerial Finance, Pearson Education limited. New Delhi.
5. Pandey IM, Financial Management. Vikas Publishing House, 2009.
6. Reddy, G Sudarsana, Financial Management, Himalaya Publishing House, 2011.
7. Van Horne James, Financial Management Policy, Prentice Hall India
8. Achale, Atul. Fundamentals of Financial Accounting. Vision Publication, 2012.

SEMESTER IV

IDSC221 Theory of Computation [3-1-0] 4

COURSE PREREQUISITES

1. A strong background in discrete mathematics, including combinatorics, discrete probability, graph theory and basic abstract algebra, as well as in propositional logic
2. Experience with mathematical proofs, especially in the context of computation

COURSE OBJECTIVES

At successful completion of the course, students should:

- Demonstrate advanced knowledge of formal computation and its relationship to languages
- Distinguish different computing languages and classify their respective types
- Recognise and comprehend formal reasoning about languages
- Show a competent understanding of the basic concepts of complexity theory

COURSE OUTCOMES

- Gain proficiency with mathematical tools and formal methods
- Understand finite automata and formal languages
- Understand the equivalence of pushdown automata and context-free languages
- Understand Turing Machines and recognizable and decidable languages
- Describe unrecognizable languages and undecidable problems
- Analyze algorithm complexity and understand the basics of complexity theory
- Understand the fundamental open questions in computational complexity and their significance
- Analyse relationships between complexity classes

SYLLABUS

Automata and Languages:

- Finite Automata and Regular Expressions
- Pushdown Automata and Context-Free Grammars
- Pumping Lemmas and Closure Properties of Regular and Context-Free Languages
- Non-Context-Free Languages

Computability Theory:

- The Church-Turing Thesis
- Hilbert's Problem
- Decidability
- Halting Problem
- Reducibility

Complexity Theory:

- Time and Space Complexity
- Classes P
- NP
- NP-Complete
- PSPACE
- PSPACE-Complete

Intractability:

- Hierarchy Theorem
- Relativization
- Circuit Complexity

TEXTBOOKS

1. M. Sipser, Introduction to the Theory of Computation, Thomson, 2004.
2. H. R. Lewis and C. H. Papadimitriou, Elements of the Theory of Computation, PHI, 1981.

REFERENCES:

1. J. E. Hopcroft and J. D. Ullman, Introduction to Automata Theory, Languages and Computation, Narosa, 1979.
2. S. Arora and B. Barak, Computational Complexity: A Modern Approach, Cambridge University Press, 2009.
3. C. H. Papadimitriou, Computational Complexity, Addison-Wesley Publishing Company, 1994.
4. D. C. Kozen, Theory of Computation, Springer, 2006.
5. D. S. Garey and G. Johnson, Computers and Intractability: A Guide to the Theory of NP-Completeness, Freeman, New York, 1979.

IDSC222 Differential Equations and Transforms [3-1-0] 4

COURSE PREREQUISITES

- Single Variable Calculus
- Multivariable Calculus

COURSE OBJECTIVES:

- To provide a comprehensive understanding of differential equations and their practical applications.
- To introduce students to various types of transforms and their significance in data analysis, signal processing, and modeling.
- To develop problem-solving skills using differential equations and transforms for real-world applications.

COURSE OUTCOMES

- Analyze and solve ordinary differential equations relevant to various problem domains.
- Understand and apply various transforms (Laplace, Fourier, Z) to analyze data and signals.
- Apply differential equations and transforms in modeling and solving real-world challenges.
- Interpret and communicate solutions to problems using differential equations and transforms.

SYLLABUS

Module 1: Introduction to Differential Equations

- Overview of differential equations
- First-order differential equations
- Second-order differential equations
- Solutions and applications

Module 2: Laplace Transforms

- Laplace transform definition and properties
- Inverse Laplace transform
- Application of Laplace transforms to solve differential equations
- Convolution theorem

Module 3: Fourier Transforms

- Fourier transform definition and properties
- Inverse Fourier transform
- Fourier series
- Application of Fourier transforms in signal processing and data analysis

Module 4: Z-Transforms

- Z-transform definition and properties
- Inverse Z-transform
- Application of Z-transforms in discrete signal processing

Module 5: Partial Differential Equations

- Introduction to partial differential equations
- Classification and solutions of partial differential equations
- Applications in image processing and data analysis

TEXTBOOKS/REFERENCES:

1. G. F. Simmons and S. G. Krantz, Differential Equations: Theory, Technique, and Practice, McGraw Hill, 2006.
2. E. A. Coddington, An Introduction to Ordinary Differential Equations, Prentice Hall India, 1995.
3. E. L. Ince, Ordinary Differential Equations, Dover Publications, 1958.
4. S. L. Ross, Differential Equations, 3rd edition, Wiley India, 1984.
5. "Laplace Transforms and Their Applications to Differential Equations" by N. W. McLachlan
6. "Laplace Transform Solution of Differential Equations: A Tutorial" by Walter A. Strauss
7. I. N. Sneddon, Elements of Partial Differential Equations, McGraw Hill, 1957.
8. S. J. Farlow, Partial Differential Equations for Scientists and Engineers, Dover Publications, 1993.
9. "Fourier Analysis" by Elias M. Stein and Rami Shakarchi
10. "A First Course in Fourier Analysis" by David W. Kammler
11. "The Fourier Transform & Its Applications" by Ronald N. Bracewell
12. R. Haberman, Elementary Applied Partial Differential equations with Fourier Series and Boundary Value Problem, 4th Edition, Prentice Hall, 1998.
13. Fritz John, Partial Differential Equations, Springer-Verlag, Berlin, 1982.

IDSC223 Database Management Systems [3-1-2] 5

COURSE OBJECTIVES

- To understand the need for a database and its management using DBMS
- To model Entity-Relationship (ER) diagram for a real-world scenario
- To write relational algebra and relational calculus queries for data handling and retrieval, Write SQL queries for database creation and analysis
- Design efficient database systems using the principle of normalization
- Understand the basics of database transactions, deadlock handling and security.
- How to implement database indexing
- Usage of tools like RA Interpreter and MySQL for executing various queries

COURSE OUTCOMES

- Understand database concepts and structures and query language
- Understand the E R model and relational model
- Apply various Normalization techniques
- Understand query processing and techniques involved in query optimization.

SYLLABUS

Database Modeling: Concepts and architecture, Data modeling using Entity Relationship (ER) model, Specialization, Generalization. Database Indexing: Data Storage and indexing-Single level and multi-level indexing, Dynamic Multi level indexing using B Trees. Relational Databases: The Relational Model, Relational calculus, Tuple and Domain Relational Calculus, SQL. Database Design: Normal Forms, Algorithms for relational database schema design. Database Transactions: Transaction processing concepts, Schedules and serializability, Concurrency control, Database recovery techniques. Database Security: Introduction to database security

LAB PROGRAMS

- Data Definition Commands, Data Manipulation Commands for inserting, deleting, updating and retrieving Tables and Transaction Control statements
- Database Querying – Simple queries, Nested queries, Sub queries and Joins
- Views, Sequences, Synonyms
- Procedures and Functions
- Triggers
- Database Design using ER modeling, normalization

TEXTBOOKS/ REFERENCES

1. Raghu Ramakrishnan and Johannes Gehrke, Database Management Systems, Third Edition, McGraw Hill, 2014.
2. Abraham Silberschatz, Henry F. Korth, S. Sudharshan, —Database System Concepts, Sixth Edition, Tata McGraw Hill, 2011.
3. Ramez Elmasri and Shamkant B. Navathe, Fundamentals of Database Systems, Fifth Edition, Pearson Education, 2008.
4. Peter Rob and Carlos Coronel, Database System- Design, Implementation and Management, Seventh Edition, Cengage Learning, 2007.

IDSC224 Software Engineering and Project Management [3-0-2] 4

COURSE OBJECTIVES

The objective of this course is to prepare the students for successful careers in software engineering or related domain through a thorough study of software engineering principles.

In this course the student will be learn about the role of software, aim of the software system, different types of process models, how to use process models in project, software requirement specification, requirement and analysis, planning of a software project, estimations and Risk management.

COURSE OUTCOMES

Acquire a thorough knowledge of the fundamental concepts in software engineering.

Learn the actual need for software engineering and various software development life cycle models which will be helpful in software development process.

Study various approaches in software design and the major techniques in system testing for better software development process.

SYLLABUS

Module-I: Introduction to software engineering: Scope and necessity of software engineering-Evolution of software design techniques-Recent challenges in software industry-Software life cycle model: Need for software life cycle model-Different life cycle models.

Module-II: Requirement analysis and specification: Requirements engineering-Types of system requirements-Role of system analyst-Software requirement specification-Formal requirement specification.

Module-III: System Design: System modeling-Unified modeling language (UML)-Design Challenges-Design Practices- Top-down and bottom-up design- Experimental prototyping-Collaborative design. Basic concepts in user interface design: Characteristics of a user interface-Types of user interfaces-Component based graphical user interface design.

Module-IV: Software testing: Role of testing-Testing strategies-Unit tests-Integration testing-Other forms of high-level testing-Stress testing-Code inspections-Manual testing-Automated testing-Breaking tests-Regression testing.

Module-V: Software Project Management: Cost estimation- Project scheduling- Staffing-Software configuration management-Quality assurance-Software quality models-Project Monitoring-Risk management.

LAB PROGRAMS

1. Develop the Problem Statement for the given system.
2. Preparation of SRS for some defined project.
3. Capture the Requirements Specification for an intended Software System Using DFD.
4. Draw the Structural and behavioral Diagrams for the given specification.
5. Draw the Sequence Diagram for the given specifications.
6. Develop Activity Diagram and State Chart Diagram for the Given Specifications.
7. Development of object model using UML techniques for some defined project.
8. Design of Test suits for Black Box and White Box Testing.
9. Implementation of COCOMO Model for cost and time estimation.
10. Implementation of Halstead metric.

TEXTBOOKS

1. Roger S Pressman, Software Engineering: A Practitioner's Approach, McGraw-Hill Higher Education, 7th Edition.
2. Ian Sommerville, Software Engineering, Pearson Education, 9th Edition.

REFERENCES

1. Fundamentals of Software Engineering, Rajib Mall, Third Edition, PHI
2. Software Engineering: A Primer, Waman S Jawadekar, Tata McGraw-Hill, 2008.
3. Software Engineering, A Precise Approach, Pankaj Jalote, Wiley India, 2010.
4. Software Engineering, Principles and Practices, Deepak Jain, Oxford University Press.

IDSC225 Fundamentals of Economics [1-0-0] 1

COURSE OBJECTIVES

- To familiarize the participants concepts and techniques in Economics
- To make the participants appreciate the applications of core concepts in economics for managerial decision making
- To sensitize the participants how economic environment affects Organizations Course Outcome
- It will help the students to analyse the demand and supply conditions and assess the positions of a company.
- It will help to design competition strategies, including costing, pricing, product differentiation and market environment according to the natures of products and structures of market

SYLLABUS

Introduction to Economics

Meaning and Definition of Economics – Nature & Scope - Micro & Macro Economics Fundamental concepts in Economics – Scarcity – Choice – Resource Allocation - Incremental

Principle, Opportunity Cost, Discounting Principle, Time Concept, Equi-Marginal Principle – Risk – Uncertainty.

Theory of Demand and Supply

Meaning of Demand – Types of Demand - Demand Curve and Demand Schedule – Shift in Demand – Change in Demand - Law of Demand & its Exceptions, Elasticity of Demand – Price Elasticity, Income Elasticity, Cross Elasticity, Promotion Elasticity, Applications of the concepts of Elasticity. Supply – Meaning – Supply Schedule and curve – Shifts in the supply – change in supply – Equilibrium

Utility Analysis & Consumer Behaviour – Equilibrium of the consumer using Cardinal & Ordinal Utility (Indifference Curve) Theories.

Theory of Production and Cost

Theory of Production – Meaning of Production function, Production function with one variable input – Law of Variable Proportions – Returns to Scale, Production function with two variable inputs – Iso-quants – Producers' Equilibrium, Economies of Scale – Types – Economies of Scope, Theory of Costs – Classification of Costs - Short Run & Long Run Cost Curves, Revenue Curves.

Market Structure

Market – Meaning & Elements, Classification of Markets – Markets based on Competition, Theory of Firm – Profit Maximization Rules, Price & Output Determination under Perfect Competition, Price & Output Determination under Monopoly – Monopoly Price Discrimination, Price & Output Determination under Monopolistic Competition, Price & Output Determination under Oligopoly – Kinked Demand curve model only.

Macro Economic Concepts

National Income Concepts – Measurement of National Income, An overview of Financial System in India, An overview of Fiscal & Monetary Policies in India, Balance of Payments: Causes of Disequilibrium & Remedies, Inflation in India – Causes & Remedies. Free Market Economy & Need for Government Intervention – An appraisal of Economic Reforms in India

TEXT BOOKS/ REFERENCES

1. K.K. Dewett, Modern Economic Theory: Micro & Macro Analysis – Orient Book Distributors, New Delhi.
2. Gaurav Dutt & Aswani Mahajan, Dutt &Sundaram's Indian Economy – Sultan Chand & Sons
3. Samuelson (2009), Economics, Tata McGraw Hill, New Delhi
4. Sodersten and Reed Dominic, International Economics, Palgrave McMillan
5. Bade, Robin and Parkin Michael, Foundations of Economics, Global Edition
6. Ahuja, introductory Economic Theory, S Chand Publication
7. Koutsoyiannis, Modern Micro Economics, Palgrave Macmillan

SEMESTER V

IDSC311 Artificial Intelligence [3-1-2] 5

COURSE OBJECTIVES

- To introduce the student about the principles of AI & techniques and do exercises in the laboratory to increase the subject understanding.

COURSE OUTCOMES

- Acquire a thorough knowledge and fundamental concepts and techniques of Artificial Intelligence.
- Learn simulating tools and study AI language for problem solving.
- To develop and test mini intelligent systems.

SYLLABUS

Introduction: Artificial Intelligence (AI), Major Branches, Applications, Characteristics and Fundamental issues, steps to build AI systems. Intelligent systems: Characteristics, agents, Functions, Examples, Features, Structure of Agents, Models.

Search Techniques: Why Search, Applications of search, Tree and Graph, Search strategies, Complexity of Search.

Knowledge Representation: Knowledge, Characteristics, Types, Propositional Logic, Tautology and Contradiction, Predicate Logic.

Fuzzy logic: Crisp logic, Fuzzy logic, Member ship function, Member ship function, Fuzzy logic Applications.

Expert Systems: Introduction, Conventional vs. Expert systems, Human Expert Behaviors, Knowledge Types, Inferencing, Rules, Structure of Expert Systems, ES Components and Working, Problem Areas, benefits- limitations- Applications of expert systems.

LAB PROGRAMS

Topics covered from the syllabus

TEXTBOOKS/ REFERENCES

1. Sturat J Russell, Peter Norving. Artificial Intelligent: A Modern approach, Third Edition, 2015.
2. Elaine Rich and Kevin Knigh, Introduction to Artificial Intelligence, McGraw Hill, Third Edition, 2017.
3. Michael Negnevitsley, Artificial Intelligence: A guide to Intelligent Systems, Addison Wesley, Third Edition, 2017.
4. G.F. Luger, and W.A. Stubblefield, Artificial Intelligence: Structures and Strategies for Complex Problem Solving, Addison-Wesley Publishing Company, 2011.
5. C.S. Krishnamoorthy and S. Rajeev, Artificial Intelligence and Expert Systems for Engineers by CRC Press, 1996.

IDSC312 Compiler Design [3-1-2] 5

COURSE OBJECTIVES

- The main outcome of the course Compiler Design is to make the students capable of applying the principles, algorithm, and data structures involved in the design of compilers.
- Students should be able to design a lexical analyser in lex according to the specification. They should be able to design a parser in yacc when the specification is mentioned. They should be able to construct a compiler according to the rules and constrains given.

COURSE OUTCOMES

- To introduce the major concept areas of language translation and compiler design.
- To enrich the knowledge in various phases of compiler and the design issues involved in compilation, code optimization techniques, machine code generation, and use of symbol table.
- To extend the knowledge of parser by parsing LL parser and LR parser. 4. To provide practical programming skills necessary for constructing a compiler.

SYLLABUS

I. Introduction to compilers: Structure of a compiler, Lexical analysis, Role of lexical analyser, Input buffering, Specification of tokens, Recognition of tokens, Lex, Finite Automata,

Regular expressions to Automata, Minimizing DFA.

II. Syntax analysis: Role of Parser, Grammar, Error handling, Context-free grammars, Writing a grammar, Parse trees, Ambiguity, Elimination of left recursion, Left factoring, Eliminating ambiguity from dangling-else grammar, Classes of parsing,

Top down parsing — backtracking, recursive descent parsing, predictive parsers, LL(1)

Bottom up parsing — Handles, Handle pruning, Stack implementation of shift-reduce parsing, Conflicts during shift-reduce parsing, LR grammars, LR parser, Canonical LR (CLR) parser, Look Ahead LR (LALR) parser, Error recovery in parsing, Parsing ambiguous grammars, YACC - automatic parser generator.

III. Intermediate code generation: Syntax Directed Definitions, Evaluation orders for Syntax Directed Definitions, Intermediate languages — Syntax tree, Three address code, Types and declarations, Translation of expressions, Type checking.

IV. Run-time environment and code generation: Storage organization, Stack allocation space, Access to non-local data on the stack, Heap management, Issues in Code Generation, Design of a simple Code Generator.

V. Code optimization: Principal sources of optimization, Peep-hole optimization, DAG — Optimization of basic blocks, Global data flow analysis, Efficient data flow algorithm.

LAB PRACTICE

Generation of lexical analyzer using tools such as LEX - Generation of parser using tools such as YACC - Creation of Abstract Syntax Tree-Creation of Symbol tables, Semantic Analysis - Generation of target code.

TEXT BOOKS/REFERENCES

1. Aho A.V., Lam M. S., Sethi R., and Ullman J. D., Compilers: Principles, Techniques and Tools, Pearson Education, 2007.
2. Appel A.W, and Palsberg J., Modern Compiler Implementation in Java, Cambridge University Press, 2002.
3. W. Appel, Modern Compiler Implementation in C, Cambridge University Press, 1998.
4. V. Aho, M. S. Lam, R. Sethi, J. D. Ullman, Compilers- Principles, Techniques & Tools, Second Edition, Pearson Education, 2007.

IDSC313 Computer Networks [3-1-2] 5

COURSE OBJECTIVES

- The students should understand the concepts and implementation of computer networks; architecture, protocol layers.
- They should be familiar with network application development.

COURSE OUTCOMES

- To understand the concepts of computer networks architecture.
- To understand the functionalities and protocols in each layers.
- To write simple networking-based programs at real and simulator level.

SYLLABUS

Network Architecture-OSI, TCP/IP models.

Physical and Data link layer: Encoding, Framing, Error detection, HDLC, PPP, sliding window protocols, medium access control, Token Ring, Wireless LAN, Packet Switching.

Network Layer: Internet addressing, IP, ARP, ICMP, Routing algorithms (RIP, OSPF, BGP).

Transport Layer: UDP, TCP, flow control, congestion control Introduction to quality of service.

Application Layer: DNS, HTTP, HTTPS, SMTP email, authentication, encryption.

LAB PRACTICE

Network demonstration using any Network Simulators.

TEXTS BOOKS /REFERENCES

1. L. L. Peterson and B. S. Davie, Computer Networks: A Systems Approach, Fifth Edition, Elsevier, 2011.

2. A. S.Tanenbaum and D.J. Wetherall, Computer Networks, Fifth Edition, Pearson, 2011.
3. W. R. Stevens, UNIX Network Programming, Volume 1: Networking APIs: Sockets and XTI, Second Edition, PrenticeHall,1998.
4. S. S. Panwar, S. Mao, J. Ryoo, and Y. Li, TCP/IP Essentials: A Lab-based Approach, Cambridge Press, 2004.
5. J. F. Kurose and K. W. Ross, Computer Networking: A Top Down Approach, Seventh Edition, Pearson India, 2017.
6. D. E. Comer, Internetworking with TCP/IP Vol. 1, Sixth Edition, Prentice Hall of India, 2006.
7. B. Forouzan, Data Communications and Networking, Fifth Edition, Tata Mcgraw Hill, 2012.
8. Introduction to Network Simulator NS2, Second Edition, 2011.

IDSC314 Human Resource Management [1-0-0] 1

COURSE OBJECTIVES:

- To provide participants a synthesized framework of Human Resources theory & Practice
- To impart fundamentals of HR Practices in Organizations
- Learn to align HR systems with the strategic business objectives of a firm.

COURSE OUTCOMES

- Students will become familiar with the fundamentals of HR
- It will equip them the tools and techniques of modern Human Resources Management.

SYLLABUS

Introduction to Human Resource Management Importance Module 1-Scope and Objectives. Evolution. Line and Staff aspects of HRM, Line managers; Duties of Human Resources Managers-Human capital management. Job Analysis Job analysis: Methods for collecting Job Analysis Information,. Human Resource Planning and Recruiting:

The Recruitment and Selection process Module 2- Planning and Forecasting, Internal and External sources of candidates, Writing Job Description& Job Specification, Managing HR in challenging times- Testing and Selection: Basic testing concepts, Types of Tests. Interview: Process and Types, Guidelines for Interviews. Training & Performance Management Orientation, Training Process, Training Needs Analysis, Training Techniques- On -the-Job & Off-the -Job Training Methods, OJT Process, Training Evaluation. Management Development Programs: Case Study and other Modern Training Methods.

Performance Management & Appraisal Module 3: Process and Techniques. Career Planning and Management Concepts. Compensation Establishing Pay Rates: Steps, Job Evaluation – Wage and Salary administration-Steps and factors affecting, Incentives Benefits and services: Statutory Benefits - Non-statutory Benefits - Insurance Benefits -Retirement Benefits, Flexible Benefits Programs. ESOPs, QWL.

Industrial Relations & Trends in HR Industrial relations Module 4: Significance, Objectives, Approaches. Industrial Disputes-Causes, Forms, Preventive Machinery. Collective Bargaining: Basic Concepts. Long term settlements: Cases in India. Trade unions: Definition, Objectives, Functions Social Security in India, Employee welfare, Grievance Handling and Discipline Sources and forms of Grievances - Grievance Procedure, Disciplinary Procedure.

Participative Decision making process Module 5 – Role of quality circle in TQM. Strategic Human Resources Management, Strategic HRM tools. An over view of HR Analytics

REFERENCE BOOKS

1. Venkata Ratnam C. S. & Srivatsava B. K.,PERSONNEL MANAGEMENT AND HUMAN RESOURCES, Tata Mc-Graw Hill, NewDelhi,,
2. Aswathappa, HUMAN RESOURCE MANGEMENT, Tata McGraw Hill, NewDelhi, 2010
3. Garry Dessler &Varkkey, HUMAN RESOURCE MANAGEMENT, Pearson, New Delhi, 2009
4. Alan Price, HUMAN RESOURCE MANAGEMENT, Cengage Learning, NewDelhi, 2007
5. Pravin Durai, HUMAN RESOURCE MANGEMENT, Pearson, New

Delhi,2010
6. Snell, Bohlander & Vohra, HUMAN RESOURCES MANAGEMENT, Cengage, NewDelhi, 2010

SEMESTER VI

IDSC321 Introduction to IOT [3-0-2] 4

COURSE PREREQUISITES

The participants should have prior knowledge on the following topics/courses:

- Computer Networks
- Digital Design and Electric Circuits.
- Fundamentals of Programming

COURSE OBJECTIVES

- Understand the core concepts and historical development of IoT.
- Develop basic IoT applications using microcontrollers, sensors, and actuators.
- Analyze and compare different IoT communication protocols.
- Design and implement IoT solutions for specific use cases.

COURSE OUTCOMES

Upon successful completion of this course, students will be able to:

- Identify and describe the components of an IoT system.
- Configure and set up a functional IoT network using wireless communication technologies.
- Evaluate the impact of IoT on a specific industry, presenting data and insights.
- Design and implement a comprehensive IoT solution for a specific use case, presenting a working prototype.

SYLLABUS

Introduction to IoT- Overview of IoT and its significance, Historical development of IoT, Key concepts: Sensors, actuators, Wireless communication technologies: Wi-Fi, Bluetooth, LoRa, Zigbee, IoT network topologies, Communication protocols in IoT: MQTT, CoAP, HTTP

IoT basic architectures- Data processing mechanisms, scalability issues, visualization issues, connectivity challenges, analytics basics, utility of cloud computing, fog computing, and edge computing, IoT in 5G era, Data security and privacy in IoT, Real-world data management case studies.

IoT software development tools and platforms- Raspberry Pi, Arduino and Nodejs programming, Building IoT applications.

IoT Applications and Use Cases- Smart cities, smart homes, and industrial IoT, Healthcare, agriculture, and environmental monitoring, smart transportation, Case studies of successful IoT implementations, Emerging trends in IoT applications

LAB PROGRAMS

1. Familiarisation of Arudino
2. Setting up serial communication using Arduino
3. Setting up Arduino board for receiving Analog input
4. Setting analog in serial out using Arudino board
5. Setting Analog in digital out using Arduino board
6. Intrusion detection system using PIR sensor
7. Interfacing DHT11 using Arudino Uno
8. Familiarisation of Raspberry pi board
9. Establishing a VNC Server
10. Blinking LED using Raspberry Pi
11. Interfacing DHT11 using Raspberry Pi
12. Course/Lab project on various IoT use-cases.

TEXTBOOKS/ REFERENCES

1. Sudip Misra, Anandarup Mukherjee, Arijit Roy, Introduction to IoT, Cambridge University Press, June, 2021.
2. Pethuru Raj and Anupama C. Raman, The Internet of Things: Enabling Technologies, Platforms, and Use Cases, CRC Press, First edition, 2017.
3. Honbu Zhou, The Internet of Things in the Cloud: A Middleware Perspective, CRC press, First edition, 2012.
4. Arshdeep Bahga and Vijay Madisetti, Internet of Things: A Hands-on Approach, UniversitiesPress, First edition, 2014.
5. Mung Chiang, Bharath Balasubramanian, Flavio Bonomi, Fog for 5G and IoT

(Information and Communication Technology Series, Wiley series, First edition, 2017.
6. Alan A. A. Donovan, Brian W. Kernighan, The Go Programming Language, AddisonWesleyProfessional Computing Series, First edition, 2015.

IDSC322 Blockchain Technology [3-0-2] 4

COURSE PREREQUISITES

Bitcoin, Smart Contract, Distributed Ledger, Miners, Blockchain Applications.

COURSE OBJECTIVES

- Introduce the concept of blockchain technologies and its Architecture.
- Enable awareness on the different generations of blockchains.
- Provide knowledge on various applications of blockchain technologies.

COURSE OUTCOMES

Students who successfully complete this course will be able to:-

- Understand the basics of blockchain Technologies and its various applications.
- Capable to identifying problems on which blockchains could be applied.
- Basic implementation of blockchain using applicable programming Language.

SYLLABUS

Introduction – Blockchain history, basics, architectures, Types of blockchain, Base technologies – Dockers, Hash function, Digital Signature, Zero Knowledge Proof.

Bitcoins – Fundamentals, aspects of bitcoins, properties of bitcoins, bitcoin transactions, bitcoin P2P networks, block generation at bitcoins, consensus algorithms- Proof of Work, Proof of Stake, Proof of Burn.

Applications – Blockchain applications, e-governance, smart cities, smart industries, Finance, Medical Record Management System, use cases, trends on Blockchains.

LAB PROGRAMS

Topics covered from the syllabus

TEXTBOOKS/ REFERENCES

1. Baxv Kevin Werbach, The Blockchain and the new architecture of Trust, MIT Press, 2018
2. Joseph J. Bambara and Paul R. Allen, Blockchain – A practical guide to developing business, law, and technology solutions, McGraw Hill, 2018.
3. Joseph J. Bambara and Paul R. Allen, Blockchain, IoT, and AI: Using the power of three to develop business, technical, and legal solutions, Barnes & Noble publishers, 2018.
4. Melanie Swan, Blockchain – Blueprint for a new economy, OReilly publishers, 2018.
5. Jai Singh Arun, Jerry Cuomo, Nitin Gaur, Blockchain for Business, Pearson publishers, 2019. 6. Satoshi Nakamoto, Bitcoin: A Peer-to-Peer Electronic Cash System.

IDSC323 Cryptography and Network Security [3-1-0] 4

COURSE PREREQUISITES

Student should have a passing Grade in Number Theory and Mathematical Theory of Coding, and Discrete Mathematics

COURSE OBJECTIVES

- To lay a foundation on Security in Networks, Classical Cryptosystem and Block Cipher Modes of Operation.
- To analyse various Private and Public key Cryptosystem for encryption, key exchange and hashing, Authentication Protocols.
- To acquire the fundamental knowledge on applications of cryptography.

COURSE OUTCOMES

Students who successfully complete this course will be able to:-

- Understand the fundamental concepts of Classical and modern Cryptosystem.
- Compare various private and public key Cryptosystem for encryption, key exchange and authentication algorithms.
- Understand the different applications of cryptography.

SYLLABUS

INTRODUCTION – Cryptography, cryptanalysis, cryptology, classical cryptosystem-shift cipher, affine cipher, Vignere cipher, substitution, transposition techniques,

BLOCK CIPHERS AND MODES OF OPERATIONS- DES - Data Encryption Standard, AES-Block cipher principles-block cipher modes of operationAES-TripleDES

PUBLIC KEY CRYPTOGRAPHY- Public Key Cryptosystem, Key distribution, Diffie Hellman Key Exchange-MITM Attack - RSA, Random Number Generation-ECC-Key Management

HASH FUNCTIONS AND DIGITAL SIGNATURES- Authentication requirement– Authentication function – MAC – Hash function – SHA - HMAC - Digital signature and authentication protocols.

APPLICATIONS- Authentication – Kerberos, IP Security – IPSec, Web Security - SSL, TLS, Blockchain, IoT Security.

LAB PROGRAMS

1. Implementation of caesar cipher,affine cipher, Vignere cipherand transposition ciphers
2. Implementation of Simplified DES
3. Implementation of AES
4. Implementation of RSA
5. Implementation of Diffie Hellman Key exchange
6. Implementation of Elliptic curve cryptography
7. Implementation of SHA
8. Implementation of protocols- IPSec, SSL, TLS

TEXTBOOKS/ REFERENCES

1. William Stallings, Cryptography and Network Security –6th Edition, Pearson Education.
2. Behrouz A. Forouzan, Debdeep Mukhopadhyay, Cryptography and Network Security, 5nd Edition, Mc Graw Hill Education.
3. Rich Helton, Johennie Helton, Mastering Java Security: Cryptography Algorithms and Practices, John Wiley Publishers.
4. Charles P. Pleeger, "Security in Computing", Pearson Education Asia, 5th Edition.
5. William Stallings, "Network Security Essentials: Applications and standards", Person Education Asia.
6. Charlie Kaufman, Radia Perlman and Mike Speciner, "Network Security: Private Communication in a public world", Prentice Hall India, 6nd Edition.

IDSC324 Parallel and Distributed Computing [3-0-2] 4

COURSE PREREQUISITES

- Computer Organization
- Operating Systems
- Computer Networks
- Fundamentals of Programming

COURSE OBJECTIVES

- To introduce the concept and the basics of parallel and distributed computing.
- To map the concurrent pieces of work onto multiple processes running in parallel.
- To provide knowledge on various available parallel programming models.
- To familiar with parallel and distributed languages OpenMP and MPI.

COURSE OUTCOMES

On successful completion of this course students will be able to:

- Understand the basics of various parallel and distributed computing platforms
- Develop and apply knowledge of parallel and distributed computing techniques and methodologies.
- Use the application of fundamental Computer Science methods and algorithms in the development of parallel applications.
- Learn different parallel programming languages to solve the core and inter-disciplinary computer science applications.
- Learn the sufficient practical knowledge to utilize the performance

analysis tools.

SYLLABUS

Introduction to Parallel and Distributed Computing: Why parallel computing? Shared memory and distributed memory parallelism, Latency vs. Bandwidth, Applications and Challenges, Types of architecture, Flynn's taxonomy, Basic concepts: cores, nodes, threads, processes, speedup, efficiency, overhead, strong and weak scaling (Amdahl's law, Gustafson's law), Cache, Principle of Locality, Programming Models, Pipelining, Dependencies and Hazards, Problems on Pipelining.

Parallel Algorithm and Design: Preliminaries, Decomposition techniques, Characteristics of Tasks and Interactions – Mapping Techniques for Load balancing, Parallel Algorithm Models

Shared memory programming (OpenMP): OpenMP basics, Execution Model, Shared and private data, Directives, Barriers, Sections, Run-Time library functions, Scheduling strategies, Scalability study.

Distributed memory programming (MPI): MPI Basics, MPI, Collective operations, Non-Blocking, Collectives, Process topologies, Parallel I/O, Single sided communications.

LAB PROGRAMS

Using OpenMP and MPI solve the following problems:

1. Matrix Operations (Addition/Subtraction/Multiplication /Transpose/Inverse)
2. Sorting Algorithms
3. Searching Algorithms
4. Graph Components
5. Shortest-path algorithms
6. Solving System of Linear Equations using Gauss Elimination method, LU decomposition method.
7. Solving numerical integration problems using Trapezoidal and Simpsons rule.
8. Calculate value of pi using Monte-Carlo method.
9. Calculate value of pi using Trapezoidal rule.
10. Ring Program using MPI.

TEXTBOOKS

1. Ian Foster: Designing and Building Parallel Programs – Concepts and tools for Parallel Software Engineering, Pearson Publisher, 1st Edition, 2019.
2. Introduction to Parallel Computing, by AnanthGrama, Anshul Gupta, George Karypis, Vipin Kumar, Second Edition.
3. An Introduction to Parallel Programming, Morgan Kaufmann, by Peter S Pacheco, 2011.
4. Using OpenMP – The Next Step Using OpenMP - The Next Step – by Ruud van der Pas, Eric Stotzer and Christian Terboven (2017)
5. Parallel Programming in C with MPI and OpenMP by Michael J.Quinn
6. The Art of Multiprocessor Programming by Maurice Herlihy and NirShavit, Morgan Kaufmann Publishers.
7. William Gropp, Ewing Lusk, Anthony Skjellum, Using MPI: portable parallel programming with the message-passing interface, 3rd Ed., Cambridge MIT Press, 2014.
8. Principles of Parallel Programming, by Calvin Lin, Larry Snyder, Addison-Wesley.

REFERENCES

1. JL Hennessy and DA Patterson, Computer Architecture: A Quantitative Approach, 4th Ed., Morgan Kaufmann/Els India, 2006.
2. MJ Quinn, Parallel Computing: Theory and Practice, Tata McGraw Hill, 2002.

SEMESTER VII

IDSC411 Data Warehousing & Data Mining [3-0-2] 4

COURSE OBJECTIVES

- To understand the principles of Data warehousing and Data Mining.
- To examine the types of the data to be mined and apply pre-processing methods on raw data.
- To apply basic classification, clustering and outlier analysis on a set of data.
- To perform classification and prediction of data.

COURSE OUTCOMES

- Create a data warehouse and process raw data to make it suitable for various data mining algorithms.
- Apply the techniques of clustering, classification, association finding, feature selection and visualization to real world data.
- Solve real world problems in business and scientific information using data mining.
- Use data analysis tools for scientific applications.

SYLLABUS

Introduction to Data Warehousing:- Batch, OLTP, DSS Applications - Different natures of OLTP and DW databases - Commercial Importance of DW - Data Marts - Metadata - Data warehousing Components - Data Warehouse Architecture.

Business Dimensional Life Cycle:- Dimensional Modeling - Multidimensional Data Model - Data Cubes – OLAP - Star Schema and Snowflake Schema - Slicing and Dicing, Drilling, Drill-up, Drill-down, Drill-within, Drill-across.

Example Applications:- Retail, Telecom, E-Commerce, Insurance.

Data Mining:- KDD and Data Mining - SQL and Data Mining - Data Mining Functionalities - Data Preprocessing - Data Cleaning - Data Integration and Transformation - Data Reduction - Data Discretization and Concept Hierarchy Generation - Association Rule Mining.

Classification and Prediction:- Classification by Decision Tree Introduction - Bayesian Classification - Rule Based Classification - Classification by Back propagation - Support Vector Machines - Lazy Learners - Prediction - Accuracy and Error Measures - Evaluating the Accuracy of a Classifier or Predictor.

Cluster Analysis:- A Categorization of Major Clustering Methods - Partitioning Methods - Hierarchical methods - Density-Based Methods - Outlier Analysis.

Temporal and Spatial Data Mining - Sequence Mining - Text Mining - Web Mining.

LAB PROGRAMS

1. Integration of Data in Pentaho
2. Business Analysis using Power BI
3. Basics of R
4. Data Preprocessing and cleaning
5. Association rule mining
6. Classification and Prediction
7. Cluster Analysis, Outlier analysis

TEXTBOOKS/ REFERENCES

1. Jiawei Han, Micheline Kamber and Jian Pei “Data Mining Concepts and Techniques”, Third Edition, Elsevier, 2011.
2. Alex Berson and Stephen J. Smith “Data Warehousing, Data Mining & OLAP”, Tata McGraw – Hill Edition, Tenth Reprint 2007.
3. Anahory and Murray “Data warehousing in the real world, Pearson Education/Addison Wesley.
4. Berry Micheal and Gordon Linoff “Mastering Data Mining”. John Wiley & Sons Inc.
5. Margaret H. Dunham “Data Mining: Introductory and Advanced Topics. Prentice Hall”
6. K.P. Soman, Shyam Diwakar and V. Ajay “Insight into Data mining Theory and Practice”, Easter Economy Edition, Prentice Hall of India, 2006.
7. G. K. Gupta “Introduction to Data Mining with Case Studies”, Easter Economy Edition, Prentice Hall of India, 2006.
8. Pang-Ning Tan, Michael Steinbach and Vipin Kumar “Introduction to Data Mining”, Pearson Education.

9. M. Kantardzic, "Data mining: Concepts, models, methods and algorithms, John Wiley &Sons Inc.

IDSC412 Cloud Computing [3-1-2] 5

COURSE PREREQUISITES

The participants should have prior knowledge on the following course(s):

- Computer Networks

COURSE OBJECTIVES

The main objectives of this course are:

- To Understand the core concepts of cloud computing
- To gain knowledge on various virtualization principles with tools
- To virtualize computer resources and train to migrate VM machines.
- To practice working with existing clouds, such as Amazon, Azure, and others.
- To learn how to program clouds using new programming models and challenges.

COURSE OUTCOMES

The main Course Outcomes of this course are listed as follows:

- Demonstrate a solid understanding of cloud computing fundamentals and models
- Understand virtualization foundations and utilize virtualization tools to implement.
- Apply appropriate cloud architectures and services for their applications.
- Design a cloud framework with appropriate resource management policies and mechanism
- Collaborate with peers on practical exercises and cloud-based projects in public clouds such as AWS or GCE.

SYLLABUS

Base Technologies-Review: Introduction, Scalable Computing over the Internet, Technologies for Cloud, System Models for Distributed and Cloud Computing, Cloud Vulnerabilities, Cloud Challenges, Practical applications of Cloud Computing.

Virtualization: Virtualization concepts, levels of Virtualization, Virtualization Tools and mechanisms, Understanding Hypervisors, Virtualization of CPU, Memory, and I/o devices, VM server consolidation, Tools overview: VirtualBox and VMWare Vsphere.

Cloud Infrastructure / Architectures: Service models, Cloud deployment models, Generic cloud architecture, Design Challenges of Clouds, Public cloud platforms: GCE, AWS, Azure. Inter-cloud Resource Management. Cloud software environments: Eucalyptus and Open stack.

Introduction to programming models- The MapReduce Programming Model

Broad Approaches to Migrating into the Cloud, The Seven-Step Model of Migration into a Cloud, Efficient Steps for migrating to Cloud.,

Risks: Measuring and assessment of risks, Company concerns Risk Mitigation methodology for Cloud computing, Case Studies

Advanced topics: Docker containers, Kubernetes, and IoT cloud.

LAB PROGRAMS

VMs using virtualbox, VMs using AWS/GCP, server automation using VMwareCloud, cloud services, Dockers, Kubernetes, OpenStack or Eucalyptus

TEXTBOOKS/ REFERENCES

1. Kai Hwang, Geoffrey C. Fox, Jack K. Dongarra, Distributed and Cloud Computing: From parallel processing to Internet of Things, Morgen Kauffmann 2013.
2. Dan C. Marinescu," Cloud Computing Theory and Practice", Second Edition Copyright © 2018 Elsevier Inc.
3. Rajkumar Buyya, James Broberg, AndrzejGoscinski, Cloud Computing Principles and Paradigms, Wiley Publications, 2017.
4. Thomas Erl, ZaighamMahmood, and RichardoPuttini, "Cloud Computing: Concepts, Technology & Architecture", Prentice Hall/PearsonPTR, Fourth Printing, 2014, ISBN: 978013338752

5. William Stallings, Foundations of Modern Networking: SDN, NFV, QoE, IoT, and Cloud, Pearson publishers, 2016.
6. Jonathan Baier, Getting Started with Kubernetes: 2nd Edition, Packt publishers, 2015.
7. K. Chandrasekaran, "Essentials of Cloud Computing", Chapman and Hall/CRC Press, 2014, ISBN: 978148220543

IDSC413 Introduction to DevOps and Microservices [2-0-0] 2

COURSE OBJECTIVES

- To understand and explain the concepts of business needs for DevOps and Microservices.
- To gain knowledge in DevOps design issues and adopting DevOps in business use cases
- To develop and integrate Microservices using DevOps

COURSE OUTCOMES

- Understand the key concepts and principles of DevOps and Microservices
- Familiar with DevOps automation tools
- Apply Microservices in DevOps
- Apply DevOps for Business Analytics
- Correlate MLOps concepts with real time examples

SYLLABUS

Introduction to Devops: DevOps: An overview - Understanding the Business Needs for DevOps - History of DevOps - DevOps and Software Development Life Cycle – Waterfall Model _Agile Model – DevOps Lifecycle - Process and Technology in DevOps - DevOps Myths – Barriers

DevOps Adoption and Tools - Plan and Measure, Develop and Test (collaborative and continuous), Release and Deploy Monitor and Optimize. Tools: distributed version of control tool Git-Automation testing tools-Selenium – report generation –TestNG – User Acceptance Testing – Jenkins

Microservices: Introduction to Microservices, Architecture: Monolith and Microservices - Benefits, Challenges, Characteristics: Coordination model - Building and testing - Deployment pipeline - Development and Pre-commit Testing - Build and Integration Testing - Continuous integration - Monitoring.

Integration of Microservices and DevOps – Build a DevOps platform - Benefits of combining DevOps and Microservices- working of DevOps and Microservices in Cloud environment (Case studies: Openstack, GCP and AWS).

Devops Automation and MLOPS: Infrastructure Automation- Configuration Management - Deployment Automation - Performance Management - Log Management -Monitoring. Devops + Machine Learning (MLOPS) - Definition - Challenges -Developing Models - Deploying to production - Real world examples

TEXTBOOKS/REFERENCES

1. Joyner Joseph, “Devops for Beginners”, 1st Edition, Mihails Konoplovs publisher, 2015.
2. Stephen Flemming, “DevOps And Microservices Handbook: Non-Programmer's Guide to DevOps and Microservices”, 2018
3. Michael Hüttermann, DevOps for Developers, 1st Edition, APress, e-book, 2012.
4. Mark Treveil, and the Dataiku Team-”Introducing MLOps” - O’Reilly Media-2020
5. James A Scott, A Practical Guide to Microservices and Containers, MapR Data Technologies

SEMESTER VIII

IDSC421 Machine Learning [3-0-2] 4

COURSE PREREQUISITES

- Probability and Statistics for Data Science
- Linear Algebra for Data Science
- Programming in Python

COURSE OBJECTIVES

- To provide an in-depth introduction to supervised, unsupervised and reinforcement learning algorithms.
- To design and implement machine learning solutions to classification, regression, and clustering problems

COURSE OUTCOMES

- Illustrate Machine Learning concepts and basic parameter estimation methods.
- Demonstrate supervised learning concepts (regression, linear classification).
- Compare and Evaluate different learning algorithms and model selection
- Describe unsupervised learning concepts and dimensionality reduction techniques.

SYLLABUS

Machine learning paradigms-supervised, semi-supervised, unsupervised, reinforcement learning. Review of linear algebra, optimization and probability: Matrices, Eigenvalues and vectors, gradient, hessian, least squares, optimization; random variables and distributions,

Regression - Linear regression with one variable, Linear regression with multiple variables, solution using gradient descent algorithm and matrix method, basic idea of overfitting in regression. Linear Methods for Classification-Logistic regression, Naive Bayes, Decision tree algorithm ID3.

Introduction, Computational Learning Theory (CLT): PAC learning, Sample complexity, VC-dimension, Bias and variance, Experimental Evaluation: overfitting and underfitting, Cross-Validation, cost function optimization. Bagging, boosting, Evaluation Metrics: Precision, Recall, F1-score, ROC, AUPR, Cross Validation

SVM - Introduction, Maximum Margin Classification, Mathematics behind Maximum Margin Classification, Maximum Margin linear separators, soft margin SVM classifier, non-linear SVM, Kernels for learning non-linear functions, polynomial kernel, Radial Basis Function(RBF).

Unsupervised Learning: Clustering : K-means, Spectral clustering learning, DBSCAN, Expectation Maximization, Hidden Markov Models, Principal Component Analysis, Latent Dirichlet allocation

LAB PROGRAMS

1. Familiarizing Scikit Learn, Numpy and Pandas packages
2. Familiarizing Data preprocessing techniques
3. Implementation of Linear Regression
4. Implementation of Logistic Regression
5. Naive Bayes Classification
6. VC dimension and PAC Learnability
7. Support vector classification
8. Implementation of DBSCAN
9. Application of PCA

TEXTBOOKS/ REFERENCES

1. Christopher M. Bishop. Pattern Recognition and Machine Learning. Springer 2006.
2. Mitchell, Tom. Machine Learning. New York, NY: McGraw-Hill, 1997.
3. Ethem Alpaydin, Introduction to Machine Learning, 2nd edition, MIT Press 2010.
4. Kevin P. Murphy. Machine Learning: A Probabilistic Perspective, MIT Press 2012.
5. Géron, Aurélien. Hands-on machine learning with Scikit-Learn, Keras, and TensorFlow. " O'Reilly Media, Inc.", 2022.

IDSC422 Big Data Analytics [3-0-2] 4

COURSE OBJECTIVES:

Upon completion of this course, students should be able to:

- Understand the concepts and challenges of big data analytics.
- Perform data preprocessing, cleaning, and transformation on large datasets.

- Apply advanced analytics techniques, including machine learning, to big data.
- Work with distributed big data technologies such as Hadoop and Spark.
- Interpret and communicate insights derived from big data analysis.

SYLLABUS

Module 01: Introduction to Big Data and Hadoop

Introduction to Big Data, Big Data Analytics, What are the challenges? Data ingestion techniques (batch and streaming). Data preprocessing and cleaning. Data pipeline design. Introduction to Hadoop and HDFS.

Module 02: Hadoop Eco-System

Hadoop ecosystem components, MapReduce programming model, Map Reduce Job Run, Failures, Job Scheduling, Shuffle and Sort, Task Execution, Map Reduce Types and Formats, Map Reduce Features. YARN, Introduction to PIG, Execution Modes of Pig, Comparison of Pig with Databases, Grunt, Pig Latin, User Defined Functions, Data Processing operators. Hive : Hive Shell, Hive Services, Hive Metastore, Comparison with Traditional Databases, HiveQL, Tables, Querying Data and User Defined Functions. Hbase : HBasics, Concepts, Clients, Example, Hbase Versus RDBMS. Big SQL.

Module 03: Introduction to Apache Spark

Overview of big data and the need for Spark, Introduction to Spark's architecture and key components, Installation and setup of a Spark environment, Introduction to RDDs, Transformations and actions. Lazy Evaluation, Working with structured data in Spark, Spark SQL for querying and data manipulation, Schema inference and DataFrames, Spark's MLlib., Machine learning models using MLlib, Graph Learning with GrphX, Real-time data processing with Spark Streaming, deploying streaming applications.

Module 04: Real-time Analytics and Streaming Data

Definition of real-time analytics, Importance of real-time data processing, Event-driven architecture, Overview of Apache Kafka as a distributed data streaming platform, Kafka's architecture and components (Brokers, Producers, Consumers, Topics, Partitions, etc.), Installation and setup of a single-node Kafka cluster, Configuring multi-broker Kafka clusters. Apache Flink as a stream processing framework, Flink's data processing model. Basic Flink transformations and operations. Understanding windowed operations in stream processing. Tumbling and sliding windows.

Module 05: NoSQL Database

Understand the need for NoSQL databases. Types of NoSQL databases (Document, Key-Value, Column-family, Graph). NoSQL vs. SQL databases. Explore document-based NoSQL databases (e.g., MongoDB). Data modeling with documents and collections. CRUD operations and querying. Explore graph databases (e.g., Neo4j). Graph data modeling and traversal. Querying relationships in graph data.

LAB EXERCISE:

1. Experiments of various data plotting and visualization techniques.
2. Consider a few datasets and perform data transformations, filtering, join operations, aggregation and various other operations using PIG, HIVE, and Hbase.
3. On various datasets, applying Spark's core APIs (RDDs) for data transformations and actions. Perform basic operations like filtering, mapping, and reducing.
4. Implementation of Machine Learning techniques on Big Data using MLlib and GraphX.
5. With a NoSQL database (e.g., MongoDB) and learn to insert, query, and update documents. Explore the flexibility of schema-less data.
6. Set up a Kafka cluster and create producers to publish messages. Also, create consumer applications to consume and process messages from Kafka topics.

TEXTBOOKS/ REFERENCES

1. Tom White " Hadoop: The Definitive Guide" Third Edit on, O'reily Media, 2012.
2. Seema Acharya, Subhasini Chellappan, "Big Data Analytics" Wiley 2015.

3. Jay Liebowitz, "Big Data and Business Analytics" Auerbach Publications, CRC press (2013)
4. Tom Plunkett, Mark Hornick, "Using R to Unlock the Value of Big Data: Big Data Analytics with Oracle R
5. ArvindSathi, "BigDataAnalytics: Disruptive Technologies for Changing the Game", MC Press, 2012
6. Programming Pig by Alan Gates, Daniel Dai
7. Programming Hive by Jason Rutherglen.
8. Spark: The Definitive Guide - Big Data Processing Made Simple by Bill Chambers and Matei Zaharia.
9. High-Performance Spark: Best Practices for Scaling and Optimizing Apache Spark by Holden Karau, Rachel Warren.
10. Kafka: The Definitive Guide: Real-Time Data and Stream Processing at Scale. Authors: Neha Narkhede, Gwen Shapira, Todd Palino.
11. Mastering Kafka Streams and KsqlDB by Mitch Seymour.
12. Stream Processing with Apache Flink: Fundamentals, Implementation, and Operation of Streaming Applications Book by Fabian Hueske and Vasiliki Kalavri.

IDSC423 Data handling analysis and visualization [3-0-0] 3

COURSE OBJECTIVES

- To introduce students to the fundamental concepts of data handling, analysis, and visualization.
- To develop proficiency in data collection, cleaning, and preprocessing.
- To equip students with statistical analysis techniques for drawing meaningful conclusions from data.
- To enable students to create informative and visually appealing data visualizations.

COURSE OUTCOMES

Upon successful completion of this course, students will be able to:

- Describe the importance of data in decision-making processes and various applications of data analysis and visualization.
- Collect and clean data from different sources, ensuring data quality and integrity.
- Apply statistical techniques such as descriptive statistics, inferential statistics, and regression analysis to analyze data and make informed inferences.
- Employ best practices in data visualization to develop charts, maps, tables, etc. to effectively communicate insights from data.

SYLLABUS

Introduction to data types and sources - Data collection techniques and ethical considerations - Data cleaning and preprocessing - Tools for data handling: Python - Descriptive Statistics and Data Summarization: Measures of central tendency (mean, median, mode) - Measures of dispersion (range, variance, standard deviation) - Frequency distributions and histograms - Box plots and scatter plots

Data Visualization Techniques: Introduction to data visualization and its importance - Graphical representation of data: bar charts, pie charts, and line charts - Data visualization in Python using Matplotlib and Seaborn - Introduction to Tableau for creating interactive visualizations.

Advanced Data Visualization: Heatmaps and correlation plots - Geographic and spatial data visualization - Time series visualization - Dashboards and interactive data stories. Data Ethics and Communication: Ethical considerations in data handling and analysis - Communicating data insights effectively - Storytelling with data.

TEXTBOOKS/ REFERENCES

1. Andy Kirk, Data Visualization A Handbook for Data Driven Design, Sage Publications, 2016
2. Edward Tufte, The Visual Display of Quantitative Information (2nd edition), Graphics Press, 2001.
3. Colin Ware, Information Visualization: Perception for Design (2nd edition), Morgan Kaufmann, 2004.
4. Nathan Yau, Data Points: Visualization That Means Something, Wiley, 2013.

5. Charles D. Hansen and Chris R. Johnson, Visualization Handbook, Academic Press, 2004.
6. Tamara Munzner, Visualization Analysis and Design, A K Peters Visualization Series, CRC Press, 2014.
7. Scott Murray, Interactive Data Visualization for the Web, O'Reilly, 2013.

SEMESTER IX

IDSC511 Applied Predictive Analytics [3-0-0] 3

COURSE PREREQUISITES

- Basic understanding of statistics and probability.
- Familiarity with data manipulation and visualization.

COURSE OBJECTIVES

- Master the concepts and implementation of regression models for predictive analytics.
- Understand and apply Locally Weighted Regression (LWR) to capture complex relationships in data.
- Gain proficiency in advanced time series models for forecasting and decision-making.

COURSE OUTCOMES

Upon successful completion of this course, students will be able to:

- Implement and interpret linear regression models, making informed predictions based on data.
- Apply Locally Weighted Regression to model complex relationships and non-linear patterns in data.
- Apply advanced time series models to analyze and forecast temporal data accurately.
- Evaluate and interpret the performance of predictive models and time series forecasts.

SYLLABUS

Overview of predictive analytics and applications-Data Preprocessing and Feature Engineering techniques for predictive modeling- Data transformation and normalization- Introduction to Linear Regression-Assumptions of linear regression models-Interpreting regression coefficients and the role of predictors-Formulating and fitting a simple linear regression model-Assessing model fit and goodness of fit-Extending regression to multiple predictors-Interactions and multicollinearity-Model interpretation and visualization-Residual analysis and model diagnostics

Locally Weighted Regression (LWR)-Implementing LWR to model complex relationships in data-Comparing LWR with traditional linear regression models-Ridge, Lasso, and Elastic Net regularization techniques-Polynomial regression

Time Series Analysis-Introduction to time series decomposition and trend analysis-Simple exponential smoothing models-ARIMA and SARIMA Models-Seasonal-Trend decomposition using LOESS (STL) for trend and seasonal decomposition- Bayesian Structural Time Series (BSTS) Modeling-Vector Autoregressive (VAR) Models- Long Short-Term Memory (LSTM) Networks for Time Series modeling

TEXTBOOKS/ REFERENCES

1. Kuhn, M., & Johnson, K. (2013). Applied predictive modeling. Springer Science & Business Media.
2. Abbott, D. (2014). Applied predictive analytics: Principles and techniques for the professional data analyst. John Wiley & Sons.
3. Hyndman, R. J., &Athanasopoulos, G. (2018). Forecasting: Principles and practice. OTexts.
4. Siegel, E. (2013). Predictive analytics: The power to predict who will click, buy, lie, or die. John Wiley & Sons.
5. Taylor, S. (2020). Applied predictive modeling: An overview of applied predictive modeling. Steven Taylor.
6. James, G., Witten, D., Hastie, T., &Tibshirani, R. (2013). An introduction to statistical learning: With applications in R. Springer Science & Business Media.
7. Winters, R. (2017). Practical predictive analytics. Packt Publishing.
8. Kutner, M. H. (2005). Applied linear statistical models. McGraw-Hill Education.

IDSC512 Machine Learning Operations (MLOps) [3-0-2] 4

COURSE PREREQUISITES

- Introduction to DevOps and Microservices
- Machine Learning

COURSE OBJECTIVES

- To impart knowledge on challenges in ML models in production
- To provide comprehension of various activities involved in the development, deployment, and monitoring of ML models
- To familiarize the basic concepts in design of machine learning systems
- To provide practical exposure to MLOps platforms and their usage to solve real-world problems

COURSE OUTCOMES

On completion of this course, students will be able to:

- Design and implement end-to-end machine learning systems for practical problems
- Identify data drift issues and key metrics to optimize model performance
- Deploy ML models to production environments

SYLLABUS

Basic Concepts of ML system Design: Evolution of MLOps, Data-centric AI, ML Development and Deployment Lifecycle, MLOps Approach, Features of MLOps, ML Data Lifecycle in Production, MLOps maturity levels, ML artifacts, MLOps workflows, Challenges and best practices.

Machine Learning Pipelines and automation: CI/CD for Machine Learning- Continuous deployment for ML models, Monitoring and Feedback, Code version control: ML model version control, MLOps for containers, ML model serving, Data pipelines, Data drift, ML pipelines: Data ingestion, Feature engineering, Hyperparameter optimization, testing and packaging.

Model monitoring and performance tracking: Model management, Model deployment and monitoring, feedback, orchestration pipelines for ML workflows, Data drift issues, ML security, Model failures in production, Real-time Streaming ML models, Deployment on edge devices, Automated ML, case studies.

LAB PROGRAMS

1. MLOps with Tensorflow Extended pipelines
2. Model Deployment: Flask applications, container deployment, contionuous deployment on Kubernetes, Github Integration
3. Machine Learning Operations Platforms like Amazon SageMaker and Azure ML: Exploratory Data Analysis, Feature Engineering, Building and validating models: deploying pre-trained Hugging Face models, Model serving, Data drift, Monitoring and Logging
4. MLFlow: Registering runs, models and artifacts, Databricks, containerizing Hugging Face models, CI/CD Packaging with GitHub Actions, Automating Packaging

TEXTBOOKS/ REFERENCES

1. Treveil, Mark, Nicolas Omont, Clément Stenac, Kenji Lefevre, Du Phan, Joachim Zentici, Adrien Lavoillotte, Makoto Miyazaki, and Lynn Heidmann. Introducing MLOps. O'Reilly Media, 2020.
2. Burkov, Andriy. Machine Learning Engineering. True Positive Inc. , 2020.
3. Ameisen, Emmanuel. Building Machine Learning Powered Applications. O'Reilly Media, 2020.
4. Alla, Sridhar, and Suman Kalyan Adari. Beginning MLOps with MLFlow. Apress, 2021.
5. Rao, Dattaraj. Keras to Kubernetes: The Journey of a Machine Learning Model to Production. John Wiley & Sons, 2019.
6. Sculley, David, et al. "Machine learning: The high interest credit card of technical debt."(2014).
7. Jez Humble, David Farley. Continuous Delivery.

8. Noah Gift and Alfredo Deza: Practical MLOps, 1st Edition, O'Reilly Media, Inc., 2021

IDSC513 Deep Learning [3-1-2] 5

COURSE PREREQUISITES

- Knowledge of linear algebra concepts, as well as calculus, including derivatives and basic integrals.
- Familiarity with probability theory and basic statistics.

COURSE OBJECTIVES

- Understand the theoretical foundations of deep learning models and algorithms.
- Gain practical experience in implementing and training various deep learning architectures.
- Apply deep learning techniques to solve real-world problems in computer vision and natural language processing.

COURSE OUTCOMES

Upon successful completion of this course, students will be able to:

- Effectively employ Convolutional Neural Networks (CNNs) for tasks such as image classification, object detection, and image segmentation.
- Design and leverage autoencoders for unsupervised learning tasks.
- Demonstrate advanced proficiency in generating and assessing Generative Adversarial Networks (GANs) for tasks encompassing image synthesis and style transfer.
- Demonstrate adept utilization of Recurrent Neural Networks (RNNs) for processing sequential data in various applications.
- Apply Transformer models proficiently in tasks like machine translation and text generation, showcasing a deep understanding of their underlying principles and functionalities.

SYLLABUS

Artificial Neural Networks: Introduction to Artificial Neural Networks (ANNs) and their applications-Perceptron- Activation functions, loss functions and backpropagation-Optimization techniques

Convolutional Neural Networks: Introduction to convolutional layers and pooling- Architectures for image classification- Pretrained models- Model improvement methods-Object detection and localization - Image segmentation techniques

Autoencoders and Unsupervised Learning-Variational Autoencoders (VAEs) and Generative Models- Clustering and anomaly detection with autoencoders

Generative Adversarial Networks (GANs)-Training GANs and architecture variations

Image-to-Image translation, style transfer-GPU Acceleration- Introduction to GPU programming using CUDA- PyTorch-Caffe- Theano

Recurrent Neural Networks (RNNs)-Introduction to sequential data processing- Long Short-Term Memory (LSTM)- Gated Recurrent Units- RNNs for Natural Language Processing (NLP)

Transformers and Attention Mechanisms-Machine translation, text summarization- BERT and pre-trained language models

LAB PROGRAMS

1. Design and development of Convolutional Neural Networks for image classification, object detection and segmentation
2. Implementation of Autoencoders for dimensionality reduction, colorizing and noise removal.
3. Simulation of Generative Adversarial Network (GAN) for generating realistic images.
4. Implementation of Recurrent Neural Networks for sequence prediction and sentiment analysis on a text dataset.
5. Building Transformer models for machine translation.

TEXTBOOKS/ REFERENCES

1. Goodfellow, I., Bengio, Y., & Courville, A. (2016). Deep learning. MIT Press.
2. Aggarwal, C. C. (2018). Neural networks and deep learning: A textbook. Springer.
3. Géron, A. (2019). Hands-on machine learning with scikit-learn, Keras, and TensorFlow: Concepts, tools, and

techniques to build intelligent systems. O'Reilly Media.
4. Vasilev, I., Slater, D., Spacagna, G., Roelants, P., &Zocca, V. (2019). Python deep learning: Exploring deep learning techniques and neural network architectures with PyTorch, Keras, and TensorFlow (2nd ed.). Packt Publishing.

IDSC514 Business Analytics [2-0-0] 2

COURSE PREREQUISITES

Knowledge of concepts like probability, basic statistics, and mathematical modeling can be advantageous.
Familiarity with data concepts, such as data types, data sources, and data structures, can be helpful.

COURSE OBJECTIVES

Gain a foundational understanding of business analytics, its role in data-driven decision-making, and the key concepts and techniques involved.
Learn to visualize data effectively and calculate summary statistics to describe and interpret datasets.
To organize and critically apply the concepts and methods of business analytics that support the decision process in business operations.

COURSE OUTCOMES

Upon successful completion of this course, students will be able to:
Comprehend the practice of iterative, methodical exploration of an organization's data with emphasis on statistical analysis to automate and optimize business processes.
Understand how data science fits in your organization—and how you can use it for competitive advantage
Treat data as a business asset that requires careful investment if you're to gain real value
Approach business problems data-analytically, using the data-mining process to gather good data in the most appropriate way

SYLLABUS

Introduction: Overview of business analytics, Role of data in decision-making, Data sources and collection methods, Data quality and validation, Need for Business Analytics (BA), Business Analytics at the strategic level: Strategy and BA, Link between strategy and Business Analytics, BA supporting strategy at functional level, dialogue between strategy and BA functions, and information as strategic resource.

Statistics & Optimization: Sampling, Inferential Statistics Understanding the business problem and formulating hypotheses, Significance levels and P values, hypothesis testing- Z-test, T-test, One-tailed and two-tailed tests, Univariate Statistics, Bivariate and Multivariate Statistics, Analysis of Variance, Correlation.

Predictive Analytics: Spreadsheet Modelling of Data Analytics algorithms, Linear Time series Forecasting models and other Time Series Models in Business, ARIMA model, Real-world case studies in various domains -finance, healthcare, marketing.

Applications: Credit Analysis, Equity Analysis, Digital Advertising, Web& social media, Display advertising - Bundling and Revenue Management

TEXTBOOKS/ REFERENCES

1. Turban, Sharda, Decision Support and Business Intelligence Systems, Delen, Pearson, 9th Edition, 2014
2. Olivia Parr Rud, Business Intelligence Success Factors Tools for aligning your business in the global economy, John Wiley and Sons, 2009
3. Steve Williams and Nancy Williams, The Profit impact of Business Intelligence, Morgan Kauffman Publishers! Elsevier, 2007
4. Gert H.N. Laursen, JesperThorlund, Business Analytics for Managers: Taking Business Intelligence beyond reporting, Wiley and SAS Business Series. 2010
5. Palepu Healy and Bernard, : Business analysis & valuation, South western college publication, 2nd edition
6. Jim Sterne, Social Media Metrics: How to Measure and Optimize Your Marketing Investment, John Wiley & Sons (16 April 2010)
7. Robert L. Phillips., "Pricing and Revenue Optimization", Stanford Business Book, 2005.
8. Jonathan D. Cryer,Kung-SikChan, Time Series Analysis: With Applications in R

(Springer Texts in Statistics), second edition, November 17, 2010.

IDSC515 Computer Graphics [3-0-0] 3

COURSE PREREQUISITES

It is useful if you have knowledge of the following: C++, Calculus, Linear Algebra: Solving equations, derivatives, integral; vectors, matrices, basis, solving systems of equations

COURSE OBJECTIVES

- To understand the basic concepts of computer graphics and to have knowledge about the different hardware and software that supports computer graphics.
- To provide students with an understanding of the algorithms and theories that forms the basis for graphical objects.
- To understand the underlying algorithms and mathematical concepts that supports 2D and 3D viewing transformations and projections.
- To understand the different techniques used for rendering the graphical models.
- To analyse the characteristics of different color models.

COURSE OUTCOMES

- Know and be able to discuss hardware system architecture for computer graphics. This includes, but is not limited to graphics pipeline, frame buffers
- Know and be able to design and implement model and viewing transformations, the graphics pipeline
- Know and be able to use the underlying algorithms, mathematical concepts, supporting computer graphics. These include but are not limited to: Composite 3D homogeneous matrices for translation, rotation, and scaling transformations.
- Be able to discuss the application of computer graphics concepts in the development of computer games, information visualization, and business applications.

SYLLABUS

Introduction to Computer Graphics: Overview of Computer Graphics-Raster refresh graphics displays- CRT Flat Panel Displays- Hard copy output devices Logical interactive Devices-Physical interactive devices-Data generation devices-Graphical user interfaces

Raster Scan Graphics: Line Drawing algorithms Digital Differential Analyser- Bresenham's algorithm:-Integer Bresenham's algorithm, General Bresenham's algorithm, Circle generation Ellipse generation- Polygon filling:- Edge fill algorithm, Seed fill algorithms.

Two dimensional transformations: Representation of points- Transformations and matrices-transformation of points- Transformations of lines- Rotation Reflection- Scaling- Combined transformations- Windowing and clipping: Viewing transformations- Point clipping- Cohen Sutherland line clipping 2D Line clipping. Three Dimensional Transformations -Three dimensional scaling, shearing, rotation, reflection, translations - Rotation about arbitrary axis Parallel to coordinate axis- Rotation about arbitrary axis in space.

Rendering and color models: Illumination model-Determining surface normal and reflection vector-Gouraud shading- Phong Shading-ColorChromacity- RGB,CMYK, HSV color system.

LAB PROGRAMS

- Implement DDA line algorithm
- Implement Bresenham Line algorithm
- Implement Bresenham Circle Algorithm
- Implement Mid-point Ellipse algorithm
- Implement Polygon Filling using Edge fill and seed fill
- Implement algorithm of 2D Transformation of an Object
- Implement Line Clipping using Cohen-Sutherland Algorithm
- Implement algorithm of 3D Transformation of an object
- Lab project on various graphics use cases

TEXTBOOKS/ REFERENCES

1. David F.Rogers, Procedural Elements for Computer Graphics, Second Edition, Tata McGraw-hill,2001
2. David F.Rogers, Mathematical Elements for Computer Graphics, Second Edition, Tata McGraw- Hill,2001

3. Francis S. Hill, Stephen M. Kelley, " Computer Graphics using OpenGL, Third Edition, Person Education India, 2015
4. Donald D. Hearn, M. Pauline Baker, Warren Carithers, "Computer Graphics using OpenGL, Fourth Edition, Person Education India, 2013
5. Amarendra N Sinha, Aurn D Udai , Computer Graphics , Tata McGraw-hill, 2011
6. Donald Hearn ,Pauline Baker, Computer Graphics C version, 2/E Pearson Education ,2003
7. Donald Hearn ,M Pauline Baker, Computer Graphics with OpenGL, 3/E, Pearson Education ,2004
8. James D.Foley, Andries Van Dam,Steven K.Feiner, John F.Hughes, Computer Graphics Principles and Practice in C , 2/2, Pearson education, 2007
9. Newmann W and Sproull R.F., Principles of Interactive Computer Graphics, 2/e, McGraw-Hill,1997
10. C.S.Verma, Computer Graphics, Ane Books, 2011
11. Edward Angel, Interactive Computer Graphics A Top-Down approach Using OpenGL, 5/e

SEMESTER X

IDSC521 Streaming Data Analytics [3-0-2] 4

COURSE OBJECTIVES

- To understand the theoretical foundations, algorithms, methodologies, and
- To provide practical knowledge for handling and analysing streaming data.
- To implement different machine learning algorithms on streaming data

COURSE OUTCOMES

- Recognize the characteristics of data streams that make it useful to solve real-world problems
- Identify and apply appropriate algorithms for analysing the data streams for variety of problems.
- Practising the tools and platforms required for analysing streaming data
- Describe and apply current research trends in data-stream processing

SYLLABUS

Introduction to Data Streams: Characteristics of the data streams, Challenges in mining data streams Requirements and principles for real time processing, Concept drift Incremental learning Basic Streaming Methods, Counting the Number of Occurrence of the Elements in a Stream, Counting the Number of Distinct Values in a Stream, Bounds of Random Variables, Poisson Processes, Maintaining Simple Statistics from Data Streams

Machine Learning from Data Streams: Decision Tree (Very Fast Decision Tree Algorithm, The Base Algorithm) Clustering, Frequent Pattern Mining (Mining Frequent Itemset from Data Streams – Landmark window)

Complex Event Processing: Introduction to Complex Event Processing, Features of CEP, Need for CEP, CEP Architectural Layers, Scaling CEP, Events, Timing and Causality, Event Patterns, Rules and Constraint, Event Hierarchies

Advanced concepts on Stream Analytics: Synopsis construction in data streams - sampling methods - wavelets – sketches – histograms. Join processing in data streams - indexing and querying data streams - dimensionality reduction and forecasting on streams - distributed mining of data streams

Apache Kafka with case study: Kafka Architecture, Installation, Configuration, Performance Tuning, Kafka Client APIs and Stream APIs, Kafka Connect API and Kafka Integration with Big data ecosystems.
Case Study on Twitter Streaming, Stock Market Prediction

TEXTBOOKS/REFERENCES

1. Charu C. Aggarwal, "Data Streams: Models and Algorithms", Kluwer Academic Publishers,2007
2. Joao Gama, "Knowledge Discovery from Data Streams", CRC Press,2010
3. Byron Ellis, "Real Time Analytics: Techniques to Analyze and Visualize Streaming Data", John Wiley and Sons, 2014.

4. Shilpi Saxena, Saurabh Gupta, "Practical Real-time Data Processing and Analytics", Pack publishing 2017
5. Neha Narkhede, Gwen Shapira, Todd Palino "Kafka: The Definitive Guide: Real-Time Data and Stream" 2017, O'Reilly

IDSC522 Speech and Natural Language Processing [3-0-2] 4

COURSE PREREQUISITES

- Probability and Statistics for Data Science
- Programming in Python
- Machine Learning, Deep Learning

COURSE OBJECTIVES

- To provide students with a comprehensive understanding of the fundamental concepts and processes involved in both speech and natural language processing.
- To introduce students to various models and algorithms used in speech and language processing
- To delve into deep learning techniques and their application in speech and language processing
- To explore the power of large language models like Transformers, BERT,

COURSE OUTCOMES

- Deep understanding of the principles and techniques in speech and language processing
- Proficiency in applying statistical models to language processing, particularly for text classification, sentiment analysis, and speech recognition.
- Equip students to apply their knowledge to real-world problems in areas such as machine translation, sentiment analysis, and Indian language computing.
- Understanding with large language models like Transformers and their variants, knowing how to leverage them for various NLP tasks and fine-tuning for specific applications.

SYLLABUS

Introduction: The Role of Knowledge in Speech and Language Processing-Steps in Language Processing-Models and Algorithms-Computational Phonology and Pronunciation Modeling-Speech Sounds and Phonetic Transcription-The Bayesian Method for Pronunciation-Decision Tree Models of Pronunciation Variation- Overview of a Speech Recognition Architecture

Basics of Text processing-Fundamentals tasks in NLP: Processing text and speech data, Tokenization, Normalization, POS Tagging, NER, Word sense Disambiguation, Phrase level identification-chunking, Algorithms for Parsing-

Statistical models for Speech and Language Processing: Language Models-N-grams, Evaluating Language models, smoothing, back-off and interpolation-, Overview of Hidden Markov Models-The Viterbi Algorithms-Text Classification-Sentiment Analysis and Naive Bayes algorithm

Deep Learning for Speech and NLP: Neural Networks-Word Embedding: word2vec, glove, Sequence to sequence classification- Recurrent Neural Networks and variants. Neural Language Models: Encoder-Decoder models-Neural Machine Translation-Evaluation of neural network models for NLP

Large Language Models: Transformers-BERT and variants- Pre-trained models and Fine tuning LLMs, Generative models, Prompt Engineering, Applications in Indian Language Computing

LAB PROGRAMS

1. Basics of Text Processing (using NLTK/Spacy library)
2. Corpus Based processing of Text data (using NLTK corpuses)
3. Analyzing web page contents
4. N-gram language model for text generation
5. Text classification
6. Sentiment analysis using RNN, LSTM, GRU
7. Encoder-decoder model for NMT
8. Building chatbots using LLMs
9. Fine Tuning GPTs

TEXTBOOKS/ REFERENCES

1. Jurafsky, Dan. Speech & language processing. Pearson Education India, 2000.

2. Manning, Christopher, and Hinrich Schutze. Foundations of statistical natural language processing. MIT press, 1999.
3. Bird, Steven, Ewan Klein, and Edward Loper. Natural language processing with Python: analyzing text with the natural language toolkit. " O'Reilly Media, Inc.", 2009.
4. Goodfellow, Ian, Yoshua Bengio, and Aaron Courville. Deep learning. MIT press, 2016.
5. Jay Alammar, Maarten Grootendorst, Hands-On Large Language Models, O'Reilly Media, Inc. 2024

IDSC523 Computer Vision: Principles and Process [3-0-2] 4

COURSE PREREQUISITES

Python programming language.

COURSE OBJECTIVES

- To make the students understand basic principles of image formation, image processing algorithms and recognition from single or multiple images (video).
- To emphasize the core vision tasks of scene understanding and recognition.
- Practical applications to object recognition, image analysis, image retrieval and object tracking.

COURSE OUTCOMES

- Learn fundamentals of computer vision and its applications.
- Understand the basic image processing operations to enhance, segment the images.
- Understand the analyzing and extraction of relevant features of the concerned domain problem.
- Understand and apply the motion concepts and its relevance in real time applications.
- Apply the knowledge in solving high level vision problems like object recognition, image classification etc.

SYLLABUS

Overview of computer vision and its applications: Image Formation and Representation: Imaging geometry, radiometry, digitization, cameras and Projections, rigid and affine transformation.

Image Processing: Pixel transforms, color transforms, histogram processing, histogram equalization, filtering, convolution, Fourier transformation and its applications in sharpening, blurring and noise removal

Feature detection: edge detection, corner detection, line and curve detection, active contours, SIFT and HOG descriptors, shape context descriptors, Morphological operations

Segmentation: Active contours, split & merge, watershed, region splitting, region merging, graph-based segmentation, mean shift and model finding, Normalized cut

Camera calibration: camera models; intrinsic and extrinsic parameters; radial lens distortion; direct parameter calibration; camera parameters from projection matrices; orthographic, weak perspective, affine, and perspective camera models.

Motion representation: the motion field of rigid objects; motion parallax; optical flow, the image brightness constancy equation, affine flow; differential techniques; feature-based techniques; regularization and robust estimation

Motion tracking: statistical filtering; iterated estimation; observability and linear systems; the Kalman filter

Object recognition and shape representation: alignment, appearance-based methods, invariants, image eigenspaces

LAB PROGRAMS

1. Implementing various basic image processing operations in python/matlab/open-CV: Reading image, writing image, conversion of images, and complement of an image
2. Implement contrast adjustment of an image. Implement Histogram processing and equalization.
3. Implement the various low pass and high pass filtering mechanisms.
4. Use of Fourier transform for filtering the image.

5. Utilization of SIFT and HOG features for image analysis.
6. Performing/Implementing image segmentation
7. Implement optical flow computation algorithm.
8. Demonstrate the use of optical flow in any image processing application
9. Object detection and Recognition on available online image datasets
10. Character or digit or face classification project

TEXTBOOKS/ REFERENCES

1. Computer Vision: Algorithms and Applications, R. Szeliski, Springer, 2011.
2. Computer Vision - A modern approach, by D. Forsyth and J. Ponce, Prentice Hall
3. Robot Vision, by B. K. P. Horn, McGraw-Hill.
4. Introductory Techniques for 3D Computer Vision, by E. Trucco and A. Verri, Publisher: Prentice Hall.
5. R. C. Gonzalez, R. E. Woods. Digital Image Processing. Addison Wesley Longman, Inc., 1992.
6. D. H. Ballard, C. M. Brown. Computer Vision. Prentice-Hall, Englewood Cliffs, 1982.
7. Richard Szeliski, Computer Vision: Algorithms and Applications (CVAA). Springer, 2010
8. Image Processing, Analysis, and Machine Vision. Sonka, Hlavac, and Boyle. Thomson.

IDSC524 Graph Algorithms and Mining [3-0-0] 3

COURSE PREREQUISITES

Data Structures
Design and Analysis of Algorithms

COURSE OBJECTIVES

To provide a comprehensive overview of the basic concepts and properties of graphs
To impart understanding of algorithms on graphs
To introduce algorithms for extracting patterns, relationships and inferences from graph data
To familiarize learning concepts and methods to gather insights from graph data

COURSE OUTCOMES

On completion of this course, students will be able to:
Model, formulate and solve graph-based problems
Demonstrate deep knowledge of the fundamental graph mining algorithms and methods.
Apply graph algorithms and build learning models to real-life graph analytics problems.

SYLLABUS

Fundamental concepts of graphs: Graph data structures, graph databases, Random Graphs, Large Graphs, Graph Representations, Types of graphs, Paths and related concepts, Graph decomposition, Graph and subgraph Isomorphism.

Graph Algorithms: Graph Matching, Graph Colouring, Shortest Path, Flow Networks, Spanning Tree, Graph Traversal Algorithms.

Graph Mining: Frequent Subgraph Mining – BFS and DFS-based approaches: FSG, AGM, gSPAN and others, Supervised learning: Node classification, Link prediction, Recommender Systems. Unsupervised learning: Community Detection and Clustering, Node embedding: Random walks, Deep Walk, Network Embedding, Matrix Factorization. Influence maximization and centrality analysis.

Graph Neural Networks: Graph Representation Learning, Message passing, Graph Convolutional Networks, Graph Transformers, Generative Graph Learning, Responsible and Fair AI for GNNs.

TEXTBOOKS/ REFERENCES

1. Diestel, R. (2010). Graph Theory, 4th ed.Springer-Verlag, Heidelberg
2. J. Han and M. Kamber, Data mining–Concepts and Techniques, 2ndEdition, Morgan kaufman Publishers, 2006.
3. Jure Leskovec, Anand Rajaraman, Jeff Ullman. Mining of Massive Datasets. Book 2nd edition. Cambridge University Press
4. Deepayan Chakrabarti and Christos Faloutsos. Graph Mining: Laws, Tools, and Case Studies. Synthesis Lectures on Data Mining and Knowledge Discovery, Morgan & Claypool Publishers, 2012
5. Albert-László Barabási. Network Science. Cambridge University Press, 2016.

6. Jian Pei, Liang Zhao, Lingfei Wu and Peng Cui. Graph neural networks: foundation, frontiers and applications. Proceedings of the 28th ACM SIGKDD Conference on Knowledge Discovery and Data Mining, Springer Nature. 2022.
7. William L. Hamilton. Graph representation learning. Synthesis Lectures on Artificial Intelligence and Machine Learning, Morgan & Claypool Publishers, 2020.

IDSC525 Network Science Analytics [3-1-0] 4

COURSE OBJECTIVES

Upon completion of this course, students should be able to:

Demonstrate a deep understanding of complex network theory and concepts.

Apply various network analysis techniques to analyse and interpret real-world networks.

Develop programming skills to implement and evaluate network algorithms using Python.

Analyze and solve complex problems related to network structures and dynamics.

Gain practical insights into the application of network analysis across diverse fields.

SYLLABUS

Module 01: Introduction to Complex Networks

Overview of complex systems and networks, Graph theory fundamentals, Network types and properties, Data collection, cleaning and storage, Network data formats, Network data visualization tools.

Module 02: Network Metrics and Centrality Measures

Degree distribution and its significance, Clustering coefficient and transitivity, Average path length, Assortativity and disassortativity, Degree centrality, Betweenness centrality, Eigenvector centrality, Dynamic centrality measures.

Module 03: Network Models and Community Detection

Random networks, Small-world networks, Scale-free networks, Network model fitting and comparison. Introduction to Community and Various Community Detection Methods, Modularity-based methods, Hierarchical clustering, Spectral clustering, Evaluation metrics for community detection

Module 04: Advanced Network Structures and Dynamics

Dynamic Networks, Temporal networks and event sequences, Network growth models, Multi-layer networks, Bipartite and hypergraph networks, Protein-protein interaction networks, Gene regulatory networks.

LAB EXERCISE:

Use a network visualization tool like Gephi or NetworkX to load and visualize a small dataset. Perform basic visualization settings, layout algorithms, and customize the appearance of nodes and edges.

With a real-world network dataset (e.g., a social network), calculate and plot the degree distribution. Discuss the implications of the degree distribution in the context of the network.

Compute various centrality measures (e.g., degree centrality, betweenness centrality) for a given network and analyze the importance of nodes within the network.

Consider Real-world datasets and use community detection algorithms (e.g., modularity-based or spectral clustering) to identify and visualize communities within the network. Use various Validity Indices to evaluate the community quality and accuracy. Discuss the findings.

Consider a temporal network dataset and the track changes over time, calculate dynamic centrality measures, detect communities, Hub nodes etc., and visualize the network's evolution.

Consider multi-layer networks and calculate centrality measures, uncover the disjoint communities, and overlapping communities, analyze interactions between layers.

Explore a social network dataset, calculate social network metrics, and perform social network analysis tasks, such as identifying influential individuals and communities.

Consider biological network data (e.g., protein-protein interactions) and perform network analysis to identify important proteins, functional modules, etc.

TEXTBOOKS/ REFERENCES

1. Networks: An Introduction, by Mark Newman.

2. Network Science by Albert-László Barabási
3. Machine Learning In Complex Networks" By Hristiano Silva.
4. Dynamics on and of Complex Networks" by Mukherjee Deutsch Ganguly
5. Analysis, Structure and Organization of Complex Networks" by Faraz Zaidi
6. Complex Networks: An Algorithmic Perspective" by Erciyes Kayhan Erciyes.
7. Complex Network Analysis in Python: Recognize - Construct - Visualize - Analyze - Interpret by Dmitry Zinoviev.
8. Complex Networks by Vito Latora, Vincenzo Nicosia, Giovanni Russo.

IDSC526 Research Methodology [2-0-0] 2

COURSE OBJECTIVES

- To understand basic concepts of research and its methodologies
- To learn the methodology to conduct the Literature Survey
- To acquaint with the tools, techniques, and processes of doing research
- To learn the effective report writing skills and allied documentations
- To become aware of the ethics in research, academic integrity and plagiarism

COURSE OUTCOMES

- Identify appropriate topics for research work in computer engineering
- Carry out Literature Survey
- Select and define appropriate research problem and parameters
- Design the use of major experimental methods for research
- Use appropriate tools, techniques, and processes of doing research
- Become aware of the ethics in research, academic integrity and plagiarism 7. Write a research report and thesis

SYLLABUS

Unit I Introduction

Introduction to research, Definitions and characteristics of research, Types of Research, Research Process, Problem definition, Objectives of Research, Research Questions, Research design, Quantitative vs. Qualitative Approach, Building and Validating Theoretical Models, Exploratory vs. Confirmatory Research, Experimental vs. Theoretical Research, Importance of reasoning in research

Unit II Literature Search & Review, Developing Research Plan

Archival Literature, Why should engineers be ethical? Types of publications- Journal papers, conference papers, books, standards, patents, theses, trade magazine, newspaper article, infomercials, advertisement, Wikipedia & websites, Measures of research impact, Literature review, publication cost.

Developing Research Plan:

Research Proposals, Finding a suitable research questions, The elements of research proposals-title, details, budget, Design for outcomes-1D data, 2D data, 3D data, N-D data, The research tools- Experimental measurements, numerical modeling, theoretical derivations & Calculations, curve matching.

Case Studies : Engineering dictionary, Shodhganga, The Library of Congress, Research gate, Google Scholar, Bibliometrics, Citations, Impact Factor, h-index, Iindex, plagiarism, copyright infringement.

Unit III Statistical Analysis
Introduction, Sources of error and uncertainty, One-Dimensional Statistics: combining errors and uncertainties, t-test, ANOVA statistics, example, Two-Dimensional Statistics: example, Multi-Dimensional Statistics: partial correlation coefficients, example, Null hypothesis testing.

Case Studies GNU PSPP Tool, SOFA, NOST-Dataplot

Unit IV
Research presentation:
Introduction, Standard terms, Standard research methods and experimental techniques, Paper title and keywords, Writing an abstract, Paper presentation and review, Conference

presentations, Poster presentations, IPR, Copyright, Patents.

Reporting Research: Thesis, Structure and Style for writing thesis, Dissemination of research findings; Reporting and interpretation of results; cautions in interpretations, Type of reports, Typical report outlines.

The path forward: Publication trends, Getting started in research, Quality assurance (QA) Occupational health and safety.

Case Studies: Intellectual Property India- services, InPASS - Indian Patent Advanced Search System, US patent, IEEE / ACM Paper templates Patent act, 1970 and Patent Rules 1972 (with amendments)

TEXTBOOKS

1. David V Thiel, "Research Methods- for Engineers", Cambridge University Press, ISBN:978-1-10761019-4
2. Kothari C.R., "Research Methodology. New Age International, 2004, 2nd Ed; ISBN:13: 978-81224-1522-3.
3. Caroline Whitbeck, "Ethics in Engineering Practice and Research", 2nd Ed., Cambridge University Press; ISBN :978-1-107-66847-8
4. Gordana DODIG-CRNKOVIC, "Scientific Methods in Computer Science", Department of Computer Science Malardalen University, Vasteas, Sweden; ISBN: 91-26-97860-1

REFERENCES

1. WIPO: https://www.wipo.int/portal/en/index.html
2. IP India: http://www.ipindia.nic.in/
3. Cell For IPR Promotion and Management : http://cipam.gov.in/
4. Draft patent rules: http://cipam.gov.in/wp-content/uploads/2018/12/Draft-Patent-Rules-2018.pdf
5. Manual of Patent Office Practice and Procedure: http://www.ipindia.nic.in/writereaddata/Portal/Images/pdf/Manual_for_Patent_Office_Practice_a nd_Procedure_.pdf
6. WIPO IPR Resources: https://www.wipo.int/reference/en/

SEMESTER XI

IDSC612 Responsible Artificial Intelligence [2-0-0] 2

COURSE PREREQUISITES

Machine Learning, Artificial Intelligence

COURSE OBJECTIVES

- Identify and Address Bias in AI Systems: Learn how to detect, measure, and mitigate biases in datasets and algorithms to ensure fairness and equity in AI applications.
- Implement Privacy-Preserving Techniques: Acquire skills to implement privacy-preserving techniques in AI, such as differential privacy and federated learning, and understand legal frameworks like GDPR that govern data privacy.
- Evaluate Societal Impact of AI Technologies: Analyze the broader societal impacts of AI technologies, including both the potential benefits and risks, especially in sectors like healthcare, education, and environmental science.
- Design and Execute a Responsible AI Project: Apply the learned concepts to design and execute a project that demonstrates the application of responsible AI practices, focusing on ethical implications, technical execution, and societal impact.

COURSE OUTCOMES

- Apply ethical principles in the design and development of AI systems.
- Implement techniques to detect and mitigate bias in machine learning models.
- Utilize privacy-enhancing technologies in AI applications.
- Create transparent and explainable AI models.
- Develop strategies for responsible AI governance, considering both technical and policy aspects.

SYLLABUS

Responsible AI Primer: Overview of AI technologies and algorithms, Key terminologies. Python for AI: Basics and ethical coding practices Technical Approaches to Bias and Fairness: Identifying and measuring bias in datasets, Algorithmic techniques for fairness, Bias detection in a dataset
Privacy Techniques in AI: Introduction to differential privacy and federated learning, Implementing privacy-preserving machine learning models, Building a privacy-first AI application .Enterprise Risk Observability-Model Governance Transparency and Accountability: Interpretability Toolkits and Fairness Measures. AI auditing tools and techniques, Creating interpretable ML models. Robust ML – Monitoring and Management. Responsible AI Toolbox.
AI for Social Good: Technical review of AI in healthcare, education, and environmental science, Ethical considerations in implementation. Model Governance, Audit, and Compliance
Emerging Technologies and Ethical Implications: Advanced topics: Quantum AI, neuromorphic computing, Future ethical challenges and technical responses

TEXTBOOKS/ REFERENCES

1. Loukides, Mike, Hilary Mason, and D. J. Patil. Ethics and data science. O'Reilly Media, 2018.
2. Barocas, Solon, Moritz Hardt, and Arvind Narayanan. "Fairness in machine learning." Nips tutorial 1 (2017): 2017.
3. Samek, Wojciech, Thomas Wiegand, and Klaus-Robert Müller. "Explainable artificial intelligence: Understanding, visualizing and interpreting deep learning models." arXiv preprint arXiv:1708.08296 (2017).
4. Adnan Masood, Heather Dawe, Dr. Ehsan Adeli. Responsible AI in the Enterprise, O'Reilly Media, Inc. 2023
5. Patrick Hall, James Curtis, Parul Pandey. Machine Learning for High-Risk Applications, O'Reilly Media, Inc.,2023

IDSC613 Ethics for AI [1-0-0] 1

COURSE PREREQUISITES

Machine Learning, Artificial Intelligence

COURSE OBJECTIVES

- Understand the Ethical Foundations of AI
- Identify and Analyze Ethical Dilemmas in AI
- Examine the Legal and Policy Frameworks
- Develop Ethical AI Solutions

COURSE OUTCOMES

- Articulate Key Ethical Theories and Principles
- Capability to analyze Ethical Issues in AI
- Navigate Legal and Regulatory Environments
- Engage in Informed Ethical Discussions

SYLLABUS

Introduction: Ethical Theories and Frameworks, Building Ethics into machines. Philosophical foundations: Ethical frameworks, benefit and harm, power, automation

Social bias and algorithmic fairness: Psychological foundations of bias; social bias and disparities in NLP data and models.

Social bias in AI models. Hate speech: NLP for identifying and countering hate speech/toxicity/abuse

Misinformation: NLP for fact-checking and fake news detection. Computational propaganda and political misinformation. Green AI, ChatGPT and other topics

TEXTBOOKS/ REFERENCES

1. Coeckelbergh, Mark. AI ethics. Mit Press, 2020.
2. Liao, S. M. (Ed.). (2020). Ethics of artificial intelligence. Oxford University Press.
3. Wallach, W., & Allen, C. (2008). Moral machines: Teaching robots right from wrong. Oxford University Press.
4. Reichert, R. (2018). Rethinking AI. Neural Networks, Biometrics and the New Artificial Intelligence. Transcript Verlag.
5. Schneider, Susan. Artificial you: AI and the future of your mind. Princeton University Press, 2019.

SEMESTER XII

IDSC622 Methods of Explainable-AI [2-0-0] 2

COURSE PREREQUISITES

- Calculus and Linear Algebra
- Statistics and Probability
- Data Mining
- Machine Learning

COURSE OBJECTIVES

- To develop knowledge and proficiency in a range of explainable artificial intelligence (XAI) issues, such as the significance of explaining various AI techniques, the taxonomy of XAI, and traditional, well-known XAI techniques.
- To gain knowledge in both theoretical and practical skills of XAI.

COURSE OUTCOMES

- Able to understand the concepts of Explainable AI and several well-known XAI techniques;
- Describe knowledge of various metrics for assessing XAI techniques; and account for familiarity with various classifications of XAI approaches.
- Apply comprehension of current techniques for generating explanations from black-box machine-learning methods
- Demonstrate the ability to select and assess Explainable AI methods Judgement and approach

SYLLABUS

Introduction to Explainable AI (XAI): Definitions and concepts such as black-box models, transparency, interpretable machine learning and explanations. Role of Exploratory Data Analysis in Explainability. Broad taxonomy of XAI methods including Intrinsic vs post hoc, model-specific vs model-agnostic, and local vs global, Trade-off between accuracy and explainability, human-friendly explanations

Methods for Explainable AI: Partial Dependence Plot (PDP), Conformal Prediction, Individual Conditional Expectation (ICE), Feature Importance, Saliency Maps, Local Interpretable Model-Agnostic Explanations (LIME), SHAP, Integrated Gradient (IG), Explainability for Linear Models, Non-linear models and Deep Learning Models.

Applications of XAI: Explainability in Time Series Forecasting, Natural Language Processing, and Computer Vision

Evaluation and Ethical Issues: Evaluation of explainability, Ethical (fairness and bias in data, models, and outputs), legal and social issues of explainable AI.

TEXTBOOKS/ REFERENCES

1. Kamath, Uday, and John Liu. Explainable artificial intelligence: An introduction to interpretable machine learning. Cham: Springer, 2021.
2. Imoize, Agbotiname Lucky, et al., eds. Explainable Artificial Intelligence in Medical Decision Support Systems. IET, 2022.
3. Saranya, A., and R. Subhashini. "A systematic review of Explainable Artificial Intelligence models and applications: Recent developments and future trends." Decision analytics journal (2023): 100230.
4. Molnar, Christoph. Interpretable machine learning. Lulu. com, 2020.
5. Rothman, Denis. Hands-On Explainable AI (XAI) with Python: Interpret, visualize, explain, and integrate reliable AI for fair, secure, and trustworthy AI apps. Packt Publishing Ltd, 2020.
6. Holzinger, Andreas, et al. "Explainable AI methods-a brief overview." International Workshop on Extending Explainable AI Beyond Deep Models and Classifiers. Cham: Springer International Publishing, 2020.

IDSC623 Interpretable Machine Learning [1-0-0] 1

COURSE PREREQUISITES

Machine Learning

COURSE OBJECTIVES

- To make machine learning models and their decisions interpretable
- To provide sufficient knowledge on model-agnostic methods for interpreting black box models like feature importance and model settings.

COURSE OUTCOMES

- Have intuition grounded in theory for interpreting different machine learning models.
- Able to evaluate and critically discuss different machine learning models and interpret their outputs
- Correctly apply the methods that are most suitable for a particular application

SYLLABUS

Introduction to interpretability and machine learning: Introduction to interpretability and simple interpretable models, Explaining and understanding the data before applying machine learning, Interpreting and explaining the parameters and hyperparameters of Bayesian classifier and Bayesian belief networks,

Interpreting Linear and Nonlinear models: including Perceptron, Support vector Machine (SVM), Linear Regression, Logistic Regression, Generalized Linear Model (GLM), Generalized Additive Model (GAM), KNN, Decision Tree, and Regression Trees. Interpreting clustering approaches, Interpretation and consequences of Clusters and Proximity measures.

Post hoc interpretability: dataset-level interpretation, Prediction-level interpretation, Advances in Interpretable Machine Learning, Tools and Libraries

TEXTBOOKS/ REFERENCES

1. Kamath, Uday, and John Liu. Explainable artificial intelligence: An introduction to interpretable machine learning. Cham: Springer, 2021.
2. Molnar, Christoph. Interpretable machine learning. Lulu. com, 2020.
3. Rothman, Denis. Hands-On Explainable AI (XAI) with Python: Interpret, visualize, explain, and integrate reliable AI for fair, secure, and trustworthy AI apps. Packt Publishing Ltd, 2020.
4. Hall, Patrick, and Navdeep Gill. An introduction to machine learning interpretability. O'Reilly Media, Incorporated, 2019.
5. Nguyen, An-phi. Interpretable Machine Learning: Definitions, methods and applications to computational biology. Diss. ETH Zurich, 2022.