NEW SCHEME FOR M. Sc. (Artificial Intelligence and Machine Learning)-Defence Specific COURSE

SEMESTER - I (M.Sc. (AI & ML)) Applicable from July 2020 onwards

Sr. No.	UBJECT NO.	NAME OF THE SUBJECT	TEACHING SCHEME			EXAMINATION SCHEME							
			THEORY TUTO Hr	:ACT. Hr.		ESSIONAL M. Hr.	THEORY M.	Hr	PRACT. M	H		T.W.	TOTAL MARKS
1	MSCAIDSR 111	Mathematical Foundation	3	1	-	25	2	100	3	-	-	25	150
2	MSCAIDSR 112	Problem Solving with Python	4	-	3	25	2	100	3	50	3	25	200
3.	MSCAI DSR113	Artificial Intelligence	3	1	0	25	2	100	3	-	-	25	150
4	MSCADSRI 114	Object Oriented Concepts & Programming using C++	4	-	3	25	2	100	3	50	3	25	200
5	MSCAI DSR115	Linear Algebra and Numerical Methods	4	-	3	25	2	100	3	50	3	25	200
6	MSCAIDSR 116	Project - I	-	2	6	25	-	-	-	100	-	25	150
7	MSCAIDSR117	Orientation Course on Defence Studies	4	-	-	-	-	-	-	-	-	-	-
	TOTAL		18	4	15	150	-	500	-	200	-	150	1050

Gujarat University
Syllabus
M.Sc. (Artificial Intelligence and Machine Learning) – Defence Specific
Semester-I

Course Name: Mathematical Foundation

Course code : MSCDSR111

Objectives:

With the current deployment of computer technology and tools, it is very important to develop the student's geometric insight into the concepts of Calculus, Vectors and Vector Spaces and applying these concepts to real life problems and machine learning problems Aim of the course is to enable students

To introduce the Concepts of Calculus, Vectors and Vector Spaces

To apply these concepts to real life problems and machine learning problems

Prerequisites:

Basic knowledge of Mathematical fundamentals

Contents:

1. **Introduction to Set Theory**
   Basic Concepts, notations, inclusion and equality, power set, operations of union, intersection and complement, Venn diagrams, set identities, ordered pairs and n-tuples, Cartesian product

2. **Introduction to Coordinate Geometry**
   Definition of coordinates and axes, coordinate plane, plotting of points, scatter diagram, general form of a straight line, slope and intercept, distance formula, section formula, mid-point formula angle between two lines, triangle in Cartesian plane, distance of a point from the line, equation of a normal to the line, Equation of plane, hyper plane, equation of normal to plane, to classify point to side of plane

3. **Fundamentals of Single Variable Calculus**

   Functions of single variable, definition and their graphs, special functions like polynomials, trigonometric , exponential , hyperbolic , limit, continuity, definition of derivative and its graphical meaning , rules of differentiation, chain rule, higher order derivatives, definition of integration and its geometric interpretation ,indefinite and definite integral and their evaluation, Optimization of functions : Local Maxima and minima of functions, saddle point, , necessary and sufficient conditions, global maxima, convex functions, Taylor Series

4. **Multivariable Calculus**

   Multivariable functions and their 3 D graphs, contour lines and maps, introduction to partial derivatives and formal definition, graphical meaning, computing of partial derivatives, chain rule, second order partial derivatives and their symmetry, higher order partial derivatives, Gradient and its physical interpretation, properties, directional derivatives, Jacobian, computing Jacobian matrix and its determinant, Lagrange multiplier method for finding local optimum

5. **Fundamentals of Vectors**

   Definition of vector, scalars, addition and subtraction of vectors, scalar multiplication, inner product(dot product) of vectors, norms, direction, orthogonal vectors, projection of vectors, cosine similarity, normal and orthonormal vectors, Gram-Schmidt procedure, orthogonal decomposition

6. **Vector Spaces**

   Vector Space and Subspaces, null Space, row space and column space , linear transformations, linear independence, basis vectors , linear combination, dimension , linear span, change of basis, invariant subspaces

Main Reference Books:

1. Advanced Engineering Mathematics, 10ed, ISV, Erwin Kreyszig, John Wiley & Sons, Inc.
2. Linear Algebra and Its Application, 3rd Edition, David C. Lay, Pearson
3. Introduction to Algorithms, 3rd Ed, Corman, Leiserson, Rivest and Stein, PHI
4. Advanced Mathematics for Engineers, Dr. Chandrika Prasad, Pothishala Private Ltd.
5. Linear Algebra, Kenneth Hoffman, PHI
6. Linear Algebra and Its Applications, Gilbert Strang, Cambridge University Press

Accomplishments of the student after completing the Course:

Demonstrate the ability to apply mathematical skills for problem solving applications

Apply mathematical techniques of geometry, calculus and vectors to solve problems

Represent and evaluate basic mathematical and/or logical information numerically, graphically, and symbolically

Interpret mathematical and/or logical models such as single and multivariable calculus as well as vectors and vector space

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Course Name: Problem Solving with Python

Course Code : MSCAIDSR112

Objectives:

Introduce students to Python, the modern language useful for writing compact codes specifically focusing on Data Analysis and Scientific Computing. Equal weightage has been given to both theory and practical

Aim of the course is to enable students

To introduce the principles of Python Programming

To understand and use functionality of various Python libraries for Network Programming

To gain basic insight of programming that can be used over Machine Learning Deep and Learning for problem solving

Prerequisites:

Fundamentals of Computers

Contents:

1. **Introduction**
   Introduction to Python, Data types in Python, Built in data type, Bool data type , Sequences in Python, Sets, Literals in python, Operator in Python, Arrays in Python, Strings and Characters, Control structure – Condition execution in Python, Using iteration within Python programs, Arrays in Python, Strings and characters in Python

2. **Functions in Python**
   Difference between a Function and a Method, Defining a Function, Calling a Functions, Returning Results from a Function, Returning Multiple Values from a Function, Functions are First Class Objects, Pass by Object reference, Formal and Actual Arguments, Positional Arguments, Keyword Arguments, Default Arguments, Variable Length Arguments, Local and Global Variables, The Global Keyword, Passing a Group of Elements to a function, Recursive Functions, Anonymous Functions or Lambdas, Function Decorators, Generators, Structured Programming, Creating our Own Modules in Python

3. **Lists, Tuples, Dictionaries & Sets in Python**
   Lists: Using Lists, List Traversal, Building Lists, List Membership, List Assignment and Equivalence, List Bounds, Slicing, List Element Removal Lists and Functions, List Methods, Prime Generation with a List, Command-line Arguments, List Comprehensions,

Multidimensional Lists, Lists Vs. Generators , Tuples, Dictionaries, Sets: Tuples, Arbitrary Argument Lists, Dictionaries, Using Dictionaries, Counting with Dictionaries, Grouping with Dictionaries, Keyword Arguments, Sets, Set Quantification with all and any, enumerating the Elements of a Data Structure

4. **Object Oriented Programming in Python**
   Introduction to Object Oriented Programming, Classes and Objects, Inheritance and Polymorphism, Abstract Classes and Interfaces, Exceptions

5. **Files in Python**
   Files, Types of Files in Python, Opening a File, Closing a File, Working with Text Files Containing Strings, Knowing Whether a File Exists or Not, Working with Binary Files, The with Statement, Pickle in Python, The seek() and tell() Methods, Random Accessing of Binary Files, Random Accessing of Binary Files Zipping and Unzipping Files, Working with Directories, Running Other Programs from Python Program, Points to Remember

Main Reference Books:

1. Core Python Programming, Rao N.R., Dreamtech Publication India
2. Foundations of Python Networking, Rhodes & Goerzen, Apress Publication
3. Python Network Programming Cookbook, Sarker M.O.F., Packt Publication
4. Fundamentals of Python Programming, Halterman R., Southern Adventist University
5. Introduction to Computation and Programming Using Python, Guttag J.V., Prentice Hall India
6. Core Python Programming, Chun W., Prentice Hall India

Accomplishments of the student after completing the Course:

Be able to Solve challenging problems using Python programming language

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Course Name: Artificial Intelligence

Course Code: MSCAIDSR 113

Objectives:

Introduce and define the meaning of Intelligence and explore various paradigms for knowledge encoding in computer systems is the basis of this course. Also it is important to introduce subfields of AI such as NLP, Game Playing, Bayesian Models, etc. Aim of the course is to enable students to

Learn and understand the concepts of artificial intelligence

Understand the concepts of NLP, Bayesian Models and Game playing

Prerequisites:

Basic knowledge of Mathematical Logic

Contents:

1. **Introduction to AI fundamentals**
   Defining Artificial Intelligence, History of AI, AI task domains, Defining AI techniques, Turing Test, Intelligent Agents: Agents and Environments, Nature of Environments, Rationality, Performance Measures, Structure of Agents, Problem-Solving Agents, Knowledge-Based Agents

2. **State Space Search and Heuristic Search Techniques**
   Defining problems as state space search, problem characteristics, production systems and characteristics, heuristics, breadth first and depth first search, Heuristic search, Best first search, Hill climbing, problems of Hill climbing techniques, A*, AND-OR graphs, iterative deepening A*

3. **Representing Knowledge**
   Knowledge Representation Techniques: Computable functions and predicates, Backward Chaining, Procedural vs. Declarative Knowledge, Forward vs. Backward Reasoning, Semantic Networks, Partitioned Semantic Networks, Conceptual Dependency, Issues in Knowledge Representation

4. **Symbolic Logic under Uncertainty**
   Uncertainty, Combining Beliefs and Desires under Uncertainty, Basis of Utility Theory, Utility Functions, Decision Networks, Monotonic vs. Non-monotonic Reasoning

5. **Game Playing**
   Games, optimal decisions in Games, Minimax method and its complexity, perfect and imperfect decisions, Alpha Beta pruning and its effectiveness, other refinements

6. **Expert Systems**

   Introduction to Expert systems, knowledge representation, architecture and knowledge engineering , Rules as knowledge representation technique, characteristics, Advantages and disadvantages, Forward and Backward Chaining, Real time example of Rule-based expert system

Main Reference Books:

1. Artificial Intelligence-A modern Approach, Stuart Russell and Peter Norvig, 3rd Edition, Pearson Education
2. Artificial Intelligence, Elaine Rich, Kevin Knight, Shivashankar B. Nair, 3rd Edition, McGraw Hill
3. Artificial Intelligence-Structures and Strategies for Complex Problem Solving, George F. Lugar, 5th Edition, Pearson Education
4. Artificial Intelligence-A guide to Intelligent Systems, Michael Negnevitsky, 2nd Edition, Pearson Education
5. Expert Systems-Principals and Programming, Joseph C. Giarratano, 4th Edition, Pearson Education
6. Artificial Intelligence and Intelligent Systems, N.P. Padhy, Oxford University Press

Accomplishments of the student after completing the Course:

Store and represent the knowledge in various applications and use different AI searching techniques

Deal with poorly defined or inexact problems that do not respond to the algorithmic solutions

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Course Name: Object Oriented Concepts and Programming using C++

Course Code : MSCAIDSR114

Objectives:

The programming for small devices like mobile phones, networking devices like routers, coding for graphics and multimedia, requires efficient coding as well as object oriented programming. The C++ language fits perfectly as a tool for this type of work. How this important language is to be mastered and how to use this knowledge in building efficient and flexible code is one of the prime requirements today. The course presented here is targeting to enable the student to master such skills.

Aim of the course is to enable students to

- Differentiate between procedural and object oriented programming
- Learn C++ as a language and various features of it
- Learn Object Oriented principles and their application using C++

Prerequisites:

Knowledge of C language, Programming concepts including algorithm building and logical problem solving

Contents:

1. **Introduction to C++, Overview of Core C++ Language, Classes and Objects**
   Identifiers and constants (Literals), Keywords, Data Types, The Operators, New Casting Operators, typeid and throw, The Conditional structures and Looping Constructs, , The Difference between struct and class in C++,The difference between Union and Class, Static Data members of a class, Pointer to objects and pointer to members of class, The local classes, Assigning Objects

2. **Functions**
   Introduction, The inline function, Default Arguments to the function,Functions with object as parameters,Call by reference and return by reference, Prototyping and Overloading, Friend functions, Const and Volatile functions, Static functions, Private and Public functions, Function Pointers, Adding C functions to the C++ program

3. **Constructors and Destructors**
   Introduction to constructors, The explicit constructors, Parameterized constructors, Having multiple constructors, Constructors with default arguments, Dynamic Initialization, Constructor with dynamic allocation, copy constructors, The member initialization list, destructors

4. **Operator Overloading and User Defined Conversions**

Introduction, Unary Operators, Binary Operators, Using Friends as operator functions, Overloading other Operators, The need for user defined conversion, Four different cases where user defined conversions are needed, Comparison of both the methods of conversion

5. **Templates**

   Function Templates, Non Generic (Non Type) Parameters in Template functions, Template function and specialization, Overloading a template function, Using Default Arguments, Class Templates, Classes with multiple generic data types, Static data members, Primary and Partial Specialization, The Export Keyword, The other use of typename

6. **Inheritance**

   The need, Defining derived class using single base class, Derivation using public, private and protected access modifiers, The implementation of inheritance in the C++ object model, The Access Control, The Access Declaration, The multiple-inheritance, Abstract classes, Composite objects (container objects)

7. **Runtime polymorphism by virtual functions**

   Compile Time and Runtime Polymorphism, Pointers to Objects, This pointer, Compatibility of Derived and base class pointers, The subobject concept, Virtual functions, Static invocation of virtual function, Default arguments to virtual functions, Virtual destructors, Pure virtual functions

8. **IO Streams**

   Need for streams, Advantages of using C++ I/O over C IO, The C++ Predefined streams, Formatting IO, Formatting using ios members, Manipulators, Creating our own manipulator

9. **Using Files for IO**

   Why IO is special, Text and binary streams, Opening and closing files, Dealing with text files Dealing with binary files, Providing Random Access using seek, IO Modes, Handling Errors

10. **Namespaces**

    Introduction and need, Use the using syntax, Defining namespaces, Extending the namespace, Unnamed namespaces, Nested Namespaces, Namespace aliases, The std namespace, The Koenig lookup, Overhead with namespaces

11. **The Standard Template Library**

    The STL (Standard Template Library) Introduction, Generic Programming, Generic Software Components, Generic Algorithms, Iterators, Containers, Algorithms

Main Reference Books:

1. Programming with ANSI C++, Bhushan Trivedi, Oxford University Press
2. C++ Primer, Stanley Lippmann Pearson Education
3. The C++ Programming Language, Bjarne Stroustrup, Pearson Education

4. Effective C++, Scott Mayer Addison Wesley
5. Complete Reference C++, Herbert Schildt McGraw Hill Publications
6. C++ FAQs, Pearson Education

Accomplishments of the student after completing the Course:

Understand and appreciate the Object Oriented approach of programming

Being aware of the working and architectural model of C++

Able to solve problems given to him/her using C++ keeping balance between efficiency and flexibility

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Course Name: Linear Algebra and Numerical Methods

Course Code : MSCAIDSR115

Objectives:

To review, strengthen and teach important Mathematical concepts required for AI & ML which the student has already been either exposed to in previous programs or is required to study Aim of the course is to enable students to

Learn and implement Mathematical concepts which are required in this course

Prerequisites:

Basic knowledge of Mathematical fundamentals

Contents:

1. **Introduction to Matrices**
   Definition, addition of two matrices, transpose, scalar multiplication, matrix multiplication, properties of matrix addition and multiplication, square matrix , null and identity matrix , invertible matrix and inverse, hadamard product and its properties, determinant of a square matrix and its properties, rank , trace, popular type of matrices-symmetric, diagonal, orthogonal, orthonormal, positive definite matrix

2. **Introduction to Numerical Methods**
   Introduction, Characteristic of numerical methods, Types and sources of errors in data, Quantification of errors, nature of iterative methods to find a solution, numerical methods of finding roots of an equation $f(x) = 0$: Bisection method, false position method, Secant method, Newton Raphson Method , Gradient Descent method

3. **Linear Equations**
   Systems of Linear Equations, Cramer's Rule, Elementary row operations, row reduced and Echelon forms, Homogeneous Systems, Matrix inversion method, Gaussian Elimination method, Ill-Conditioned Systems , Iterative methods Gauss-Jordon Method , Gauss Seidel Method

4. **Eigen Values and Eigen Vectors**
   Eigen Values and Eigen Vectors, Characteristic Equation of a matrix, Properties of Eigenvalues and Eigenvectors, Iterative methods to determine eigen values,

Diagonalization of symmetric matrices, Orthogonal Diagonization , Singular Value Decomposition, Principal Component Analysis

5. **Computational Complexity**
   Time Complexity: Growth of functions, Asymptotic notations, NP-Completeness and the P & NP Classes: Introduction, Polynomial Time & Verification, NP-Completeness and Reducibility, The Vertex Cover Problem ,The Traveling Salesman Problem, The Set Covering Problem

Main Reference Books:

1. Numerical Methods for Engineers, Steven C Chapra & Raymond P Canale, Fifth Edition, Tata McGraw Hill Publication, Special Indian Edition
2. Applied Numerical Analysis, C F Gerald & P O Wheatley, Seventh Edition, Pearson Education Asia, New Delhi
3. Linear Algebra and Its Application, 3rd Edition, David C. Lay, Pearson
4. Linear Algebra, Kenneth Hoffman, PHI
5. Linear Algebra and Its Applications, Gilbert Strang, Cambridge University Press
6. Numerical Methods, Dr. V. N. Vedamurthy & Dr. N.Ch. S.N. Iyengar, Vikas Publication

Accomplishments of the student after completing the Course:

Be able to apply properties and solutions to system of linear equations, matrices, properties of matrices, matrix algebra, determinants, eigenvalues, real vectors in two and three dimensions, vector algebra (including dot and cross products), linear combinations, and linear independence

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NEW SCHEME FOR M. Sc. (Artificial Intelligence and Machine Learning) Defence Specific COURSE

SEMESTER - II (M.Sc. (AI & ML)) Applicable from January 2021 onwards

Sr. No.	UBJECT NO.	NAME OF THE SUBJECT	TEACHING SCHEME			EXAMINATION SCHEME							
			THEORY TUTO HR	PRACT. HR.	ESSIONAL M. HR.	THEORY M.	HR	PRACT. M	H			T.W. TOTAL MARKS	
1	MSCAI 121	Numerical Optimization	3	1	-	25	2	100	3	-	0	25	150
2	MSCAI 122	Advanced Python	4	-	3	25	2	100	3	50	3	25	200
3.	MSCAI 123	Machine Learning	4	0	3	25	2	100	3	50	-	25	200
4	MSCAI 124	Computer Vision	3	1	3	25	2	100	3	50	3	25	200
	MSCAI 125	Statistical Foundation	4	-	-	25	2	100	3	-	-	25	150
	MSCAI 126	Project - II	-	2	6	25	-	-	-	100	3	25	150
	T O T A L		18	4	15	150	-	500	-	250	-	150	1050

Course Name: Numerical Optimization

Course Code: MSCAIDSR121

Objectives:

To teach the student fundamental concepts of optimization both from the point of view of theory as well as practical implementation of algorithms relevant to Machine Learning applications.

Prerequisites:

Undergraduate level course in Linear Algebra
Undergraduate level course in Multivariable Calculus

Contents:

1. Review of Multivariable Calculus

Multivariable functions, Partial Derivatives, Total Derivative, Vector Functions, Gradient, Physical interpretation of Gradient, Existence of Minimum and a Maximum, Continuity of Functions, Taylor's Theorem, Convex Functions

2. Optimization Problem Formulation

Statement of an Optimization problem, Historical development, Classification of Optimization problems and techniques, Single variable optimization problem, Iterative algorithmic approach

3. One Dimensional Unconstrained Optimization

Unimodality and bracketing, Fibonacci Method, Golden Section Method, Line search

4. Unconstrained Optimization

Necessary and Sufficient conditions for optimality, Convexity, Steepest Descent Method, Hessian Matrix, Conjugate Gradient Method, Newton's Method, Quasi-Newton Method, Approximate Line Search

5. Constrained Optimization

Necessary conditions for optimality, sufficient conditions for optimality, sensitivity of solution, Sequential Quadratic Programming, Duality, Exterior penalty functions, interior penalty functions

6. Direct Search methods

Hooke-Jeeves Pattern Search, Powell's Methods of Conjugate directions,
Nelder-Mead's, Simplex methods, Simulated Annealing, Genetic Algorithms

Reference Books:

1. "Optimization Concepts and Applications in Engineering"; Belegundu
2. "Engineering Optimization"; 2nd Edition; Ravindran & Reklaits
3. "Practical Methods of Optimization"; R. Fletcher

Accomplishments of the student after completing the Course:

After completion of this course, students will be able to formulate optimization problem and apply appropriate method and corresponding algorithm to obtain optimum value

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Course Name: Advanced Python

Course Code: MSCAI DSR122

Objectives:

This course will introduce advanced concepts of python implementations and the latest Machine Learning and Data analysis libraries such as NumPy, Pandas, Scikit-Learn, MatplotLib and TensorFlow to students. This course will be hands on with major focus on practical implementation of these concepts

To understand and use functionality of various Python libraries for various scientific and mathematical tasks

To gain basic insight of implementation of advanced concepts and use of various libraries for applying Machine Learning for problem solving

Prerequisites:

Fundamentals of Computers and basic Python

Contents:

1. Introduction

Review of Important Python Concepts, Overview of Advanced techniques in Python: Lambdas, Filter and map, is and id, Decorators, Iterators and Generators, Garbage Collector, environment, Exception handling, Interop module, Pickle, Marshal, Networking Concepts, Process and Threads, Sockets, Regular Expression

2. Scientific and Numerical Computing with Python

Introduction to Scientific and Numerical computing, Introduction to various modules used for Scientific and Numerical programming: NumPy; SciPy; Scikit-Learn; MatplotLib and Keras & Pandas, Introduction of Internal Statistics, overview of common approaches to multivariate statistics, Introduction to IPython

3. Implementation of Machine Learning concepts in Python

Introduction to Machine Learning Approaches, Overview of ML tasks: Supervised Learnings: Classifications; Regression, Unsupervised Learnings: Clustering, Semi-supervised Learning, Basics of implementation of Machine Learning modules using Python

4. Introduction to Frameworks used with Python – TensorFlow

Concept of Computational Graph and Nodes, Virtual Environment and Anaconda, Installing TensorFlow with GPU support on a Linux System, TF Datatypes, Placeholders, TF Variables, TF Session, Softmax, One Hot Encoding, Dropout, building hidden layers, Batching, Stochastic Gradient Descent, Building an Optimizer, Training and displaying outcome, Overview of various python frameworks

5. Introduction to Processing of Data Sets

Overview of various Data sets, Data handling Techniques: using Structured and unstructured Files; Excel Files and SQL Files; Data Preparation, Data munging and Data Analysis (using Pandas); Data Visualization (using MatplotLib, Pandas and Seaborn, Exploring duplicate data and missing data, Data fitting concepts, Introduction to collection modules, counter, data storage offline

Reference Books:

1. Rao N.R., "Core Python Programming", Dreamtech Publication India
2. Sarker M.O.F., "Python Network Programming Cookbook", Packt Publication
3. Sebastian Raschka, "Python Machine Learning", Packt Publication
4. Willi Richert, "Building Machine Learning Systems with Python", Packt publication
5. Fredrik Lundh, "Python Standard Library", O'Reilly Publications
6. Halterman R.,"Fundamentals of Python Programming", Southern Adventist University
7. Guttag J.V., "Introduction to Computation and Programming Using Python", Prentice Hall India
8. Chun W., "Core Python Programming", Prentice Hall India

Accomplishments of the student after completing the Course:

After completion of this course, students will be able to gain awareness about various libraries and able to solve challenging problems using Python programming language

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Course Name: Machine Learning

Course Code: MSCAIDSR123

Objectives:

Introduce the concept of learning patterns from data and develop a strong theoretical foundation for understanding of state of the art Machine Learning algorithms. To enable students to identify, formulate and solve machine learning problems that arise in practical applications.

Prerequisites:

Undergraduate level course in Linear Algebra
Undergraduate level course in Calculus

Contents:

1. Overview of Machine Learning

Introduction to Machine learning from data, Types of Machine Learning: Supervised, Unsupervised, Reinforcement, concepts of regression, classification, clustering

2. Linear Regression

Scatter diagram, Model representation for single variable, Single variable Cost Function, Least Square line fit, Normal Equations, Gradient Descent method for Linear Regression, Assumptions in linear regression, properties of regression line, Model Performance through R^2, Multivariable model representation, Multivariable cost function, multiple linear regression, Normal Equations and non-invertibility , Gradient Descent method for multiple linear regression , Overfitting, Underfitting, Bias and variance , Regularization

3. Logistic Regression

Issues of using Linear Regression in Classification, Sigmoid function, odds of an event, Logit function, Decision Boundary, Maximum Likelihood function, Linear regression verses Logistic Regression, Cost function, Multi-classification , confusion matrix, statistical measures to measure binary classification : Recall, sensitivity, specificity, precision, accuracy, pros and cons of logistic regression

4. Supervised Learning

Classification problems; decision boundaries; K nearest neighbour methods, Linear classifiers, Bayes' Rule and Naive Bayes Model, SVM - Introduction, Support Vectors & Margin, Optimization Objective, Linear & Non-Linear SVM, Hard Margin & Soft

Margin in, Large Margin Classifiers, Kernels, SVM practical considerations, Ensemble methods for classification and regression: Bagging, Random Forests, Boosting, Decision Tree

5. Unsupervised learning

Cluster Analysis, Classification and Clustering , Definition of Clusters ,Clustering Applications , Distance measures, Proximity Measures for Discrete Variables, Proximity Measures for Mixed Variables, Partitional Clustering, Clustering Criteria, K-Means Algorithm, Fuzzy Clustering , Hierarchical Clustering, Agglomerative Hierarchical Clustering, Divisive Hierarchical Clustering, Cluster Validity, External Criteria, Internal Criteria

Reference Books:

1. "Building Machine Learning Systems with Python"; Richert & Coelho; Packt Publishing Ltd.
2. "Data Science from Scratch"; Joel Grus; O'Reilly Publications
3. "MACHINE LEARNING: An Algorithmic Perspective; Stephen Marsland; CRC Press
4. "Clustering"; Rui Xu & Donald C. Wunsch II; IEEE Press
5. "Machine Learning"; Tom M. Mitchell; McGraw-Hill publications
6. "Machine Learning with SVM and other Kernel methods"; K.P. Soman R.Loganathan
7. "Introduction to Machine Learning"; Ethem Alpaydın; The MIT Press

Accomplishments of the student after completing the course:

After completion of the course, students should be able to:

Develop an appreciation for what is involved in learning models from data

Understand a wide variety of learning algorithms

Understand how to evaluate models generated from data

Understand and develop application involving computer vision and Natural Language Processing

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Course Name: Computer Vision

Course Code: MSCAIDSR 124

Objectives:

A.I. has major applications in Computer Vision, especially in object detection, recognition & classification. This course covers fundamentals of Image Processing and Computer Vision which plays an important role in fields such as Machine and Robot Intelligence. It provides means for machines and robots to interact intelligently with the outside world through visual perception like human vision. This course will provide sufficient background to prepare students for plentiful challenging applications in automation.

Prerequisites:

Introductory course in Linear Algebra
Introductory course in Calculus
Introductory course in Probability

Contents:

1. Introduction

Overview, Smoothing, Image Morphology, Flood Fill, Resize, Image Pyramids, Thresholding operation

2. Image Transforms

Convolution, Gradients and Sobel Derivatives, Laplace, Canny & Hough Transforms, Remap, Stretch, Shrink, Warp, and Rotate, Discrete Fourier Transform (DFT), Discrete Cosine Transform (DCT), Integral Images, Distance Transform, Histogram Equalization

3. Image Parts and Segmentation

Parts and Segments, Background Subtraction, Watershed Algorithm, Image Repair by Inpainting, Mean-Shift Segmentation, Delaunay Triangulation, Voronoi Tessellation

4. Tracking and Motion

The Basics of Tracking, Corner Finding, Subpixel Corners, Invariant Features, Optical Flow, Mean-Shift & Camshift Tracking, Motion Templates, Estimators, Lucas-Kanade algorithm for optical flow, Multi-scale Lucas-Kanade algorithm, Comparison of Horn-Shunck and Lucas-Kanade algorithms, Applications of optical flow

5. Camera Models and Calibration

Developing Camera Model, Calibration -Concept of camera calibration and basic aim of camera calibration, Motivation for camera calibration - implications for 3D reconstruction using two calibrated cameras, Un-distortion, Putting Calibration Together, Rodrigues Transform

Reference Books:

1. "Image Processing: Analysis and Machine Vision"; Sonka & Hlavac
2. "Digital Image Processing"; Gonzalez
3. "Computer Vision: Algorithms and Applications"; Richard Szeliski; Springer-Verlag London Limited 2011

Accomplishments of the student after completing the course:

After completion of the course, students will:

Have foundation of image formation, processing and analysis.

Understand the geometric aspects of images in spatial and frequency domain.

Gain exposure to object and image recognition with feature extraction, pattern analysis and geometric modeling

Develop practical skills necessary to build computer vision applications including mining of visual content, image rendering, camera surveillance etc.

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Course Name: Statistical Foundation

Course Code: MSCAIDSR 125

Objectives:

With the current deployment of computer technology and tools, it is very important to understand the concepts of Probability and Statistics to implement efficiency of algorithms for solving problems in science, engineering, technology, insurance & banking. Thus, the objective of this course is to enable students to obtain an intuitive and working understanding of probability and methods for the problems of analysis and prediction. Students will gain experience in the implementation of methods for data analysis and prediction using a computer. They would also gain an appreciation of the concept of error in these methods and the need to analyze and predict it.

Prerequisites:

Basic knowledge of Mathematics

Contents:

1. Introduction to Probability

Basic probability concepts (Experiment, sample space, events, exclusive events, exhaustive events, independent events, dependent events), methods for assigning probability (Classical method, relative frequency method, subjective method, axiomatic method), events and their probability, addition rule, multiplication rule, conditional probability Posterior Probability, Bayes's theorem, Conditional Independence, concept of measure and sigma algebra

2. Probability Distributions

Random variable, Discrete and continuous random variable, expected value and variance of random variable, *Probability distribution*: Joint probability distribution, Marginal Probability distribution, Conditional Probability distribution, *Standard Distributions:* Bernoulli distribution, Binomial distribution, Continuous probability distribution, Normal distribution

3. Probabilistic Graphical Models

Bayesian Networks, Markov Models, Independencies, MAP Inference

4. Descriptive Statistics

Introduction to statistics, Data, Scales of measurements, Sample vs. population, Introduction to frequency distribution, *Measures of central tendency:* Mean, median, mode, weighted mean, *Measures of dispersion*: absolute and relative measures of range, quartile deviation, standard deviation, basic mathematical properties and applications of the measures, *Measures based on shape of distribution*: Skewness and Kurtosis (basic concepts only, introduction using curve, possible values of these measures, relationship (distance) between mean, median, mode, *Measures of association between two variables* (Correlation: for paired observations only): Covariance, *Types of correlation*: (+ve, -ve, 0), (Linear, non-linear), Karl Pearson's correlation coefficient, its mathematical properties, regression line

5. Statistical Inference

Sampling methods, Sampling distribution, central limit theorem (statement only), Hypothesis testing: Null & alternative hypothesis, Type I & II errors, one and two tailed test, rejection rule using p-value and critical value approach, Analysis of variance (1-way, two-way), Chi-square test for goodness of fit and independence

Reference Books:

1. "Numerical A First Course in Probability"; 9th Edition; Sheldon Ross
2. "An Introduction to Probability and Statistics"; 2nd Edition; Rohatgi & Saleh
3. "Probabilistic Graphical Models"; Daphne Koller & Nir Friedman
4. "Statistics for Management", Richard I Levin & David S Rubin, Pearson
5. " Introduction to Probability and Statistics", J. Susan Milton & Jesse C Arnold, McGraw Hill Publication

Accomplishments of the student after completing the course:

After completion of the course, students will be able to apply probability and statistical concepts for analysis and prediction from data and able to infer the result

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