August, 2019

M.TECH - ARTIFICIAL INTELLIGENCE AND DATA SCIENCE

Building human-level thought processes through the creation of artificial intelligence (AI) is the state-of-the-artinComputerScience.Intelligentmachinesareinfluencedbyemergingtechnologies, smartdevices,sensors,computingpower,fasterdataprocessing,hugestorageandhuman-machine interaction capabilities. Data Science is an interdisciplinary field with the ability to extract knowl-edge/insights from data - be it structured, unstructured, or semi-structured data. Twinned with Artificial Intelligence, more efficient solutions to find meaningful information from huge pools of data that are possible today, with data from multiple sources - sensors, images, streaming video, satellite, medical imagery and the cloud. This graduate program has a comprehensive coverage of appliedmathematicsusedindatascienceandartificialintelligencewhilepreparingthestudentsto analyze,designandexperimentsolutionstoproblems.Thecurriculumtargetstechnicalanddesign skills,AIknowledge,andcompetenciesneededtomasterstrategicanalyticalmethodsandtools,and datamanagement,withtheobjectiveofcreatinginnovativestrategiestosolvechallengingreal-world problems.

Program Outcomes

1. EnablegraduatestodesignandharnessthepowerofAIinbroadapplicationfieldsfromvision to advanced autonomoussystems.
2. Examine large amounts of data to uncover hidden patterns, correlations, insights, and help organizationsharnesstheirdatatoidentifynewopportunities.
3. Obtainexpertisetoturnactionableinsightsandcutting-edgetechnologyintoinnovativeprod- ucts to solve real-worldproblems.
4. Effectivelycommunicatefindingsintermsofreportsandpresentations.
5. Inculcateindependentresearchabilitythataddressesfundamentalproblems.

CURRICULUM M.TECH - ARTIFICIAL INTELLIGENCE AND DATA SCIENCE (2019)

Semester I				
Course Code	**Type**	**Courses**	**L T P**	**Cr**
19MA608	F	Linear Algebra and Optimization	3-0-2	4
19AD601/ 19AD602	SC	Data Structures and Algorithms/Scalable Algorithms for Data Analysis	3-0-3	4
19AD603	C	Foundations of Data Science	3-0-3	4
19AD604	C	Principles of AI and Machine Learning	3-0-3	4
19AD605	C	Distributed System Technologies	2-0-3	3
19HU601	HU	Amrita Values Program□		P/F
19HU602	HU	Career Competency I		P/F
		Total Credits		**19**

□Non-credit course

Semester II				
Course Code	**Type**	**Courses**	**L T P**	**Cr**
19AD611	C	ANN and Deep Learning	3-0-3	4
19AD612	C	Scalable Systems for Data Science	2-0-3	3
19AD613	C	Probabilistic Graphical Models	3-0-3	4
19AD614	C	Data Science Applications of NLP	2-0-3	3
19AD615	C	Data Science Applications of Vision	2-0-3	3
19RM600	SC	Research Methodology	2-0-0	2
19HU603	HU	Career Competency II	0-0-2	1
		Total Credits		**20**

Semester III				
Course Code	**Type**	**Courses**	**L T P**	**Cr**
	E	Elective-1	2-0-3	3
	E	Elective-2	2-0-3	3
		Dissertation-1		10
		Total Credits		**16**

SemesterIV				
Course Code	**Type**	**Courses**	**L T P**	**Cr**
19AD798		Dissertation-2		10
		Total Credits		**10**

S.No	**Type**	**Course Type**	**Credits**
1.	F	Foundation Maths	4
2.	SC	Softcore Algorithms	4
3.	C	Core Subjects	28
4.	E	Electives	6
5.		Research Methodology/Amrita Values Program	3
6.		Dissertation	20
		Total Credits	**65**

Electives List			
Course Code	**Courses**	**L T P**	**Cr**
19AD701	Artificial Intelligence and Robotics	2-0-3	3
19AD702	Neuroevolution	2-0-3	3
19AD703	Game theory for AI and Data Science	2-0-3	3
19AD704	Analysis of Large-Scale Social Networks	2-0-3	3
19AD705	Knowledge Representation and Reasoning	2-0-3	3
19AD706	Real-time AI Video Analytics	2-0-3	3
19AD707	Quantum Artificial Intelligence	2-0-3	3
19AD708	Virtual and Augmented Reality	2-0-3	3
19AD709	Geospatial Analytics	2-0-3	3
19AD710	Medical AI	2-0-3	3
19AD711	Spatio-temporal Data Analytics	2-0-3	3
19AD712	Autonomous Systems and Drones	2-0-3	3
19AD713	Big Data Security	2-0-3	3
19AD714	Large-Scale Visual Analytics	2-0-3	3
19AD715	Business Data Analytics	2-0-3	3
19AD716	Semantic Web	2-0-3	3

19MA608 Linear AlgebraandOptimization 3-0-2-4

Preamble

Data Science is one of the most influential field of science with many real time applications in engineering, information technology, medicine and finance. Linear Algebra and Optimizations are two important subjects required for Data Science. In this course, concepts of matrix depositions, SVD and some optimization techniques will be discussed.

Course Objectives

- Tolearnhowtoanalyzeandsolvealinearsystemofequations
- To understand important characteristics of matrices, such as its four fundamental subspaces, rank, determinant, eigenvalues and eigenvectors
- Tolearn concepts of vector spaces such as independence, basis, dimensions,orthogonality
- TolearnhowtouseSVDformachinelearning
- Tostudyoptimizationalgorithmswithsingleandmult-variablesforlargedatasets

Course Outcomes

COs	Description
CO1	Understand the basic concepts of vector space, subspace, basis and dimension
CO2	Understand the basic concepts of inner product space, norm, angle, Orthogonality and projection and implementing the Gram-Schmidt process, to obtain least square solution and SVD
CO3	Understand the techniques for solving single variable functions
CO4	Understand the concept of multi-variable optimization techniques

Prerequisites

None

Syllabus

Unit I

Linear Algebra - Review of Matrix Algebra - Matrices, Eigen Values and Eigen Vectors- Vector Spaces - Vector spaces - Sub spaces - Linear independence - Basis Dimension. Inner Product Spaces:Innerproducts-Orthogonality-Orthogonalbasis-GramSchmidtProcess-Changeofbasis - Orthogonal complements - Projection on subspace - Least Square Principle-QRdecomposition.

Unit II

Eigen values and Eigen vectors -Problems in Eigen Values and Eigen Vectors, Matrix LUdecompositions. Orthogonal Diagonalization, Quadratic Forms, Diagonalizing Quadratic Forms - Principal Component Analysis and Singular ValueDecomposition.

Unit III

UnitIIIIntroduction,Conditionsforlocalminimization-OnedimensionalSearchmethods:Golden search method, Fibonacci method, Newton's Method, Secant Method, Remarks on Line Search Gradient-basedmethods-introduction,themethodofsteepestdescent,analysisofGradientMeth- ods, Convergence, Convergence Rate.Analysis of Newton's Method, Levenberg-Marquardt Modification, Newton's Method for Nonlinear Least-Squares. Conjugate direction method, Conjugate Direction Algorithm, Conjugate Gradient Algorithm for Non-Quadratic Quasi Newtonmethod.

Text Book / References

1. Howard Anton, Chris Rorres, Elementary Linear Algebra, Tenth edition, John Wiley & Sons, 2010
2. 2.Edwin K.P. Chong, Stanislaw H. Zak, An introduction to Optimization, Second edition, Wiley,2013
3. NabilNassif,JocelyneErhel,BernardPhilippe,IntroductiontoComputationalLinearAlgebra, CRC press,2015
4. GilbertStrang,LinearAlgebraandItsApplications,Fourthedition,Cengage,2006
5. Mohan C. Joshi andKannan M. Moudgalya, Optimization: Theory and Practice, Narosa Publishing House, New Delhi,2004
6. HalDaumIII,ACourseinMachineLearning,2015

CO-PO Mapping

COs	Description	PO1	PO2	PO3	PO4	PO5
CO1	Understandthebasicconceptsofvectorspace, subspace, basis and dimension	2	2	–	–	3
CO2	Understand the basic concepts of inner product space, norm, angle, Orthogonality and projection and implementing the Gram-Schmidt process, to obtain least square solution and SVD	3	2	–	–	2
CO3	Understand the techniques for solving single variable functions	2	2	–	–	2
CO4	Understand the concept of multi-variable optimization techniques	3	2	–	–	3

Evaluation Pattern - 3A

19AD601 Data Structures and Algorithms3-0-3-4

Preamble

This course deals with foundations of Computer Science offered to multidisciplinary graduates. It aims to provide an overview of Data structures and algorithms commonly used in Computer Science Engineering in a way to bridge the gap between Computer science and Non computer science graduates. This course focuses on application of data structures to complex problems at post graduatelevel.

Course Objectives

- ToprovideanoverviewofDatastructuresandalgorithmscommonlyusedinComputerScience andEngineering
- Tosolve complex problems by applying appropriate Datastructures andalgorithms
- Tocriticallyanalyzethecomplexityofvariousalgorithms
- Toselectappropriatedesignstrategytosolverealworldproblems

Course Outcomes

COs	Description
CO1	Understand the concept and functionalities of Data Structures
CO2	Identify and apply appropriate data structures to solve problems and improve their efficiency
CO3	Analyze the complexity of data structures and associated methods
CO4	Analyze the impact of various implementation and design choices on the data structure performance
CO5	Understand the correctness and analyze complexity of algorithms
CO6	Understandvariousalgorithmicdesigntechniquesandsolveclassicalproblems
CO7	Solverealworldproblemsbyidentifyingandapplyingappropriatedesigntech-nique

Prerequisites

- Basic programmingskills

Syllabus

Unit I

Data Structures - Asymptotic notation. Introduction to Algorithm Analysis Methodologies Review of Data Structures: Linear Data Structures Linked Lists: - Singly Linked List, Doubly Linked List,CircularLinkedList-ImplementationApplications.Stacks-ImplementationusingArraysand Linked Lists Applications in Recursion.Queues -Implementation and Applications. Binary Trees - Basictreetraversals-Binarytree-Priorityqueues-Binarysearchtree

Unit II

AVL trees - Graphs -Data Structures for Graphs, Types of Graphs - Directed Graphs, Weighted Graphs - Basic definitions and properties of Graphs, Graph Traversal Breadth First Search and their applications, Spanning trees, Shortest Paths. Hashtables Collision using Chaining Linear Probing Quadratic Probing Double Hashing - Algorithms - Review of sets and relations, and matrices. Logic.Series, counting principles. Basic sorting and searching algorithms

Unit III

AlgorithmAnalysis-RecurrenceRelationsandtheirsolutions.Recursiontreemethod,substitution method and Master theorem. Introduction to Amortized Analysis. Introduction to Divide and Conquer technique. Mergesort, Quicksort and binary search.Introduction to Greedy Algorithms - Fractional Knapsack Scheduling Algorithms. Introduction to Dynamic programming Algorithms Matrix Chain Subsequence Problems 0-1Knapsack

TextBook/References

1. Michael T Goodrich and Roberto Tamassia and Michael H Goldwsasser, Data Structures and AlgorithmsinPython++,JohnWileypublication,2013
2. Goodrich, Michael T., and Roberto Tamassia. Data structures and algorithms in Java. John Wiley & Sons,2008
3. Tremblay J P and Sorenson P G, An Introduction to Data Structures with Applications, Second edition, Tata McGraw-Hill,2002
4. Thomas H Cormen, Charles E Leiserson, Ronald L Rivest and Clifford Stein, Introduction to Algorithms,Thirdedition,PrenticeHallofIndiaPrivateLimited,2009
5. Michael T Goodrich and Roberto Tamassia, Algorithm Design Foundations - Analysis and InternetExamples,JohnWiley&Sons,2007
6. Dasgupta S, Papadimitriou C and Vazirani U, Algorithms, TataMcGraw-Hill,2009

CO-PO Mapping

COs	Description	PO1	PO2	PO3	PO4	PO5
CO1	Understand the concept and functionalities of Data Structures	–	1	1	1	1
CO2	Identify and apply appropriate data structures to solve problems and improve their efficiency	–	3	3	1	2
CO3	Analyze the complexity of data structures and associated methods	–	3	2	1	1
CO4	Analyze the impact of various implementation and design choices on the data structure performance	–	3	3	1	2
CO5	Understand the correctness and analyze complexity of algorithms	–	3	1	–	1
CO6	Understand various algorithmic design techniques and solve classical problems	–	1	1	–	–
CO7	Solve real world problems by identifying and applying appropriate design techniques	–	2	3	1	2

Evaluation Pattern - 3A

19AD602 ScalableAlgorithmsforDataAnalysis 3-0-3-4

Preamble

This course will cover the scalability aspects of algorithms, worst case analysis of complexity and the techniques to deal with massive data. The transformation of data for scalable analysis using geometric,electricalflowandothermethodsareincludedinthetopics.Thecoursegivesanideaon howtodealwithlarge-scaledataanalysisusingmathematicstools,representationanddimensionality reductiontechniques.

Course Objectives

- Tounderstandscalabilityasacomplexitynotionofcomputation
- Tolearn algorithmic techniques for the design of provably-good scalablealgorithms

- To explore spectral graph-theoretical methods, electrical flows and Gaussian Markov random fields for scalability

Course Outcomes

COs	Description
CO1	Understand the characteristics of massive data
CO2	Understand complexity and algorithmic primitives of scalable algorithms
CO3	Apply geometric techniques for large-scale data analysis
CO4	Apply clustering techniques for local computation of data
CO5	Apply sparsification, reduction and approximation of data

Prerequisites

- Basic ProgrammingSkills
- Data Structures andAlgorithms

Syllabus

Unit I

Challenges of massive data - Scalability of algorithms - Complexity class S - Scalable reduction and algorithmicprimitives-BeyondGraphmodelsforInformationnetworks-Sampling-Makingdata smaller-Multi-precisionsampling-PageRank-PersonalizedPageRankmatrix-Clustering-local algorithms for network analysis - Scalable local computation of personalized PageRank - Interplay between dynamic processes andnetworks.

Unit II

Partitioning-Geometrictechniquesfordataanalysis-CenterpointsandRegressionDepth-Scalable algorithmsforcenterpoints-DimensionReduction-RandomvsSpectral-Scalablegeometricdivide and conquer - Geometry of a graph - Sparsification - Spectral similarity of graphs - Spectral graph sparsification-Low-stretchspanningtrees-Spectralapproximation.

Unit III

Electrical Flows - Laplacian paradigm for network analysis - Laplacian linear systems - Learning from labeled network data - Sampling from Gaussian Markov Random fields - Scalable Newtons method - Laplacian paradigm - Scaling invariant clusterability - Beyond worst case analysis.

Text Book / References

1. Shang Hua Teng, Scalable algorithms for data and network analysis, FoundationTrends TheoreticalComputerScience,Firstedition,NowPublishersInc.,2016

2. NathalieJapkowicz,JerzyStefanowski,BigDataAnalysis:NewAlgorithmsforaNewSociety, First edition, Springer,2016

CO-PO Mapping

COs	Description	PO1	PO2	PO3	PO4	PO5
CO1	Understandthecharacteristicsofmassivedata	2	3	2	–	3
CO2	Understand complexity and algorithmic primitives of scalable algorithms	2	3	2	–	3
CO3	Apply geometric techniques for large-scale data analysis	2	2	2	–	2
CO4	Apply clustering techniques for local computation of data	2	2	2	–	2
CO5	Apply sparsification, reduction and approximation of data	2	2	2	–	3

Evaluation Pattern - 3A

19AD603 Foundations ofDataScience 3-0-3-4

Preamble

Data Science is about drawing useful conclusions from large and diverse data sets through exploration, prediction, and inference. Exploration involves identifying patterns in information. Prediction involves using information we know to make informed guesses about values we wish we knew. Inference involves quantifying our degree of certainty. The primary tools for exploration are visualizations and descriptive statistics, for prediction are machine learning and optimization, and for inferencearestatisticaltestsandmodels.Throughunderstandingaparticulardomain,thestudents learntoaskappropriatequestionsabouttheirdataandcorrectlyinterprettheanswersprovidedby inferential and computationaltools.

Course Objectives

- ToobtainaComprehensiveknowledgeofvarioustoolsandtechniquesforDatatransformation andvisualization
- Tolearntheprobabilityandprobabilisticmodelsofdatascience
- Tolearnthebasicstatisticsandtestinghypothesisforspecificproblems
- Tolearn about the predictionmodels

Course Outcomes

COs	Description
CO1	Apply preprocessing techniques to convert raw data so as to enable further analysis
CO2	Apply exploratory data analysis and create insightful visualizations to identify patterns
CO3	Understand how to derive the probability density function of transformations of random variables and use these techniques to generate data from various distributions
CO4	Understand the statistical foundations of data science and analyze the degree of certainty of predictions using statistical test and models
CO5	Introduce machine learning algorithms for prediction and to derive insights

Prerequisites

- Basic PythonKnowledge

Syllabus

Unit I

Introduction, Causality and Experiments - Data Pre processing: Knowing data, Data cleaning, Data reduction, Data transformation, Data discretization -Visualization and Graphing: Visualizing Categorical Distributions, Visualizing Numerical Distributions, Overlaid Graphs, plots, and summary statistics of Exploratory Data Analysis (EDA). Exploring Univariate Data - Histograms-Stem-and-LeafQuantileBasedPlots-ContinuousDistributions-QuantilePlots-QQPlot-BoxPlots.

Unit II

Probability Concepts -Axioms of Probability - Conditional Probability and Independence - Bayes Theorem -Expectation - Mean and Variance Skewness Kurtosis ; Common Distributions Binomial PoissonUniform-NormalExponentialGamma-Chi-SquareWeibullBeta-IntroductiontoStatistics - Sampling,SampleMeansandSamplevariancesamplemoments,covariance,correlation,Sampling Distributions - Parameter Estimation Bias -Mean Squared Error -Relative Efficiency - Standard Error - Maximum Likelihood Estimation. Empirical Distributions- Sampling from a Population-Empirical Distribution of a Statistic -Testing Hypotheses Errorprobabilities- Assessing Models -Multiple Categories -Decisions and Uncertainty- Comparing Two Samples -A/B Testing -ANOVA.

Unit III

Estimation-Percentiles-TheBootstrap-ConfidenceIntervals-UsingConfidenceIntervals-TheSD and the Normal Curve - The Central Limit Theorem - point and interval estimation, Prediction-Correlation-TheRegressionLine-TheMethodofLeastSquares-LeastSquaresRegression-Visual Diagnostics-NumericalDiagnostics-InferenceforRegression-ARegressionModel-Inferencefor theTrueSlope-PredictionIntervals-simpleandmultipleregression.

Text Book / References

1. Adi Adhikari and John De Nero, Computational and Inferential Thinking: The Foundations ofDataScience,Firstedition,2019
2. JiaweiHan,MichelineKamber,JianPei,DataMiningConceptsandTechniques,Thirdedition, Elsevier Publisher,2006
3. WendyL. Martinez, Angel R. Martinez, Computational Statistics Handbook with MATLAB, Second edition, Chapman Hall/CRC,2008
4. Douglas C. Montgomery, George C. Runger, Applied Statistics and Probability for Engineers, Sixth Edition, Wiley,2013
5. Dr.J.Ravichandran, Probability And Statistics For Engineers, First Edition,Wiley, 2010

CO-PO Mapping

COs	Description	PO1	PO2	PO3	PO4	PO5
CO1	Applypreprocessingtechniquestoconvertraw data so as to enable further analysis	–	3	–	–	1
CO2	Apply exploratory data analysis and create insightful visualizations to identify patterns	–	3	–	–	1
CO3	Understandhowtoderivetheprobabilitydensity function of transformations of random variables and use these techniques to generate data from various distributions	–	2	–	–	–
CO4	Understand the statistical foundations of data science and analyze the degree of certainty of predictions using statistical test and models	2	3	2	–	1
CO5	Introduce machine learning algorithms for prediction and to derive insights	3	2	2	–	2

Evaluation Pattern - 4F

19AD604 Principles of AI andMachineLearning 3-0-3-4

Preamble

This course will deal with the fundamental principles of Artificial Intelligence including knowledge representation,reasoning,decisionmakingandprogrammingtechniques.Thecoursewillalsocover the principles of machine learning, algorithms which underpin many popular Machine Learning techniques,aswellassupportdevelopinganunderstandingofthetheoreticalrelationshipsbetween thesealgorithms.

Course Objectives

- Tounderstand basic principles of ArtificialIntelligence
- Tolearn and design intelligentagents
- To understand the basic areas of artificial intelligence including problem solving, knowledge representation, reasoning, decision making, planning, perception and action
- Tomasterthefundamentalsofmachinelearning,mathematicalframeworkandlearningalgorithm

Course Outcomes

COs	Description
CO1	Understand formal methods of knowledge representation, logic and reasoning
CO1	Understand foundational principles, mathematical tools andprogram paradigms of artificial intelligence
CO1	Understand the fundamental issues and challenges of machine learning: data, model selection, model complexity
CO1	Analyze the underlying mathematical relationships within and across Machine Learningalgorithmsandtheparadigmsofsupervisedandun-supervisedlearning
CO1	Apply intelligent agents for Artificial Intelligence programming techniques

Prerequisites

None

Syllabus

Unit I

Automated Reasoning - foundations of knowledge representation and reasoning, representing and reasoning about objects, relations, events, actions, time, and space; predicate logic, situation calculus, description logics, - Logic - Propositional and predicate logic - Syntax - Informal and formal semantics - Equivalence - De Morgans laws - Decidable problems - Many-sorted logic -first-order, higher-order logic- Reasoning methods - Formal program techniques - pre- and post-conditions, derivationandverificationofprograms-SPINTool.

UnitII

UncertainKnowledge-Bayesiannetworks;Basicsofdecisiontheory,sequentialdecisionproblems,elementarygametheory;Problem-solvingthroughSearch-forwardandbackward,state-space,blind, heuristic, problem-reduction, A, A*, AO*, minimax, constraint propagation, neural andstochastic; Introduction to intelligent agents; Machine Learning - Foundations of supervised learning - Decisiontreesandinductivebias,RegressionVsClassification,Supervised-LinearRegression,Logistic Regression.

Unit III

Generalisation, Training, Validation and Testing, Problem of Overfitting, Bias vs Variance ,Confusion Matrix, Precision, Recall, F Measure, Support Vector Machine, Decision Tree, RandomForest, Perceptron, Beyond binary classification, Boosting and bagging, bootstrapping - Advanced supervised learning - K-Nearest Neighbour, Markov model, Hidden Markov Model - Nearest Neighbor Classification-Gaussianprocesses-UnsupervisedLearning-DimensionalityReductionTechniques, Linear Discriminant Analysis - Clustering: K-means, Hierarchical, Spectral ,subspace clustering, association rulemining.

Text Book / References

1. Russell,Norvig,ArtificialIntelligence:AModernApproach,Thirdedition,PrenticeHall,2010
2. Hastie, Tibshirani, Friedman. The elements of statistical learning, Second edition, Springer, 2009
3. Tsang. Foundations of constraint satisfaction, Academic press,1993
4. Daphne Koller and Friedman. Probabilistic Graphical Models - Principles and Techniques, The MIT Press,2009

CO-PO Mapping

COs	Description	PO1	PO2	PO3	PO4	PO5
CO1	Understandformalmethodsofknowledgerep-resentation, logic and reasoning	3	3	3	–	3
CO2	Understand foundational principles, mathe-matical tools and program paradigms of ar-tificial intelligence	3	3	3	–	3
CO3	Understand the fundamental issues and chal-lengesofmachinelearning:data,modelselec-tion, modelcomplexity	3	3	3	2	3
CO4	Analyze the underlying mathematical rela-tionshipswithinandacrossMachineLearning algorithms and the paradigms of supervised and un-supervisedlearning	3	3	3	3	3
CO5	Apply intelligent agents for Artificial Intelli-gence programming techniques	3	3	3	2	3

Evaluation Pattern - 4E

19AD605 DistributedSystemTechnologies 2-0-3-3

Preamble

The rate and amount of data being generated in todays world by both humans and machines are unprecedented. Being able to store, manage, and analyze large-scale data has critical impact on businessintelligence,scientificdiscovery,socialandenvironmentalchallenges.Moderndistributed technologies such as cloud computing, hadoop and containerization technologies. The goal of this courseistoequipstudentswiththeunderstanding,knowledge,andpracticalskillstodealwithlarge amountofdatawithdistributedtechnologiessuchascloudandHadoopfortheirmachinelearning applications.

Course Objectives

- Tointroducevariousmoderndistributedsystemtechnologiesandtheiruseformachinelearning and big dataanalytics
- Tointroduce principles of cloudcomputing
- Tolearnbigdataanalyticsformachinelearningthroughhadoopecosystem
- Tolearn containers and microservices for developing and deploying applications withcloud

Course Outcomes

COs	Description
CO1	Understand principles of various modern distributed system technologies
CO2	Learn the principles of cloud computing
CO3	Perform big data analytics for machine learning through hadoop eco system
CO4	Develop and deploy container images of applications with cloud
CO5	Learn various techniques for cloud-based machine learning

Prerequisites

- Basic programmingskills

Syllabus

Unit I

Distributed Computing Taxonomy Cluster, Grid, P2P, Utility, Cloud, Edge, Fog computing paradigms - Cloud Computing Cloud delivery models - Cloud deployment models - Data Analytics, Internet of things and cognitive computing, Overview of Cyber Physical Systems (CPS), Overview of Cloud based CPS, Introduction to Big Data and distributed File systems (HDFS), Solving problems with MapReduce.

Unit II

Hadoop eco system - Data Logistics, Importing and Exporting Data, Big data analyis with Scala and Spark - Data Analysis with Spark, Reduction Operations and Distributed Key-Value Pairs, Partitioning and Shuffling, Structured data - SQL, Dataframes, and Datasets.

Unit III

Virtualization,DockersandContainers,containerizationvsvirtualization,dockerarchitecture,Microservices overview, Public Cloud Using public cloud for infrastructure management, Web application deployment using public cloud services, Deploying container images in public cloud; Case study:Cloud based machinelearning.

Text Book / References

1. Kai Hwang, Cloud Computing for Machine Learning and Cognitive Applications, The MIT Press,2017
2. Sean P. Kane, Karl Matthias, Docker: Up and Running: Shipping Reliable Containers in Production, OReilly,2018
3. AlexHolmes,Hadoopinpractice,ManningPublications,2012
4. Sean Owen, Robin Anil, Ted Dunning, Ellen Friedman, Mahout in Action, Manning Publications Co.,2011
5. Holden Karau, Andy Konwinski, Patrick Wendell, Matei Zaharia, Learning Spark, OReilly, 2015
6. Noah Gift, Pragmatic AI: An Introduction to Cloud-Based Machine Learning, AdisonWesley, 2018
7. Parminder Singh Kocher, Microservices and Containers, AddisonWesley, 2018
8. Aurobindo Sarkar, Amit Shah, Learning AWS: Design, build, and deploy responsive applications using AWS, Second edition, Packt,2018
9. JustinMenga,DockeronAmazonWebServices,Packt,2018

CO-PO Mapping

COs	Description	PO1	PO2	PO3	PO4	PO5
CO1	Understand principles of various modern distributed system technologies	–	2	2	1	1
CO2	Learn the principles of cloud computing	–	1	3	1	–
CO3	Perform big data analytics for machine learning through hadoop eco system	1	3	2	1	–
CO4	Developanddeploycontainerimagesofapplications with cloud	–	2	3	1	–
CO5	Learn various techniques for cloud-based machine learning	1	3	2	2	1

Evaluation Pattern - 4E

19AD611 ANN andDeepLearning 3-0-3-4

Preamble

This course deals with deep learning algorithms, architectures and mathematical tools which are appropriateforvarioustypesoflearningtasksinvariousdomains.Studentswillbetaughtthebasics ofneuralnetworks,convolutionalnetworks,recurrentnetworks;andintroducedtoconceptssuchas: dropout, batch normalization, types of hyper-parameter optimization, distributed andconstrained computing variants. Applications in the area of image processing and vision will bediscussed.

Course Objectives

- TounderstandandmasterthetoolsofArtificialIntelligence
- Toexploreindepthdeepneuralarchitecturesforlearningandinference
- To evaluate the performance of neural architectures in comparison to other machine learning methods

Course Outcomes

COs	Description
CO1	Understand basic Neural Network architectures
CO2	Apply fundamental principles, theory and approaches for learning with deep neural networks
CO3	Understand key concepts, issues and practices, core algorithms and optimization when training and modeling with deep architectures
CO4	Analyzemainvariantsofdeeplearning(convolutional,recurrent,reinforcement and generative architectures), and their typical applications
CO5	Analyze how deep learning fits within the context of other Machine Learning approaches and what learning tasks it is considered to be suited and not well suited to perform

Prerequisites

- Linear Algebra andOptimization,
- Machine Learning,Statistics

Syllabus

Unit I

Neuralnetworks-Perceptrons,sigmoidunits;Learninginneuralnetworks-outputvshiddenlayers; linearvsnonlinearnetworks;linearmodels(regression)-LMSalgorithmPerceptronsclassification - limitationsoflinearnetsandperceptrons-multi-LayerPerceptrons(MLP)-activationfunctions-linear,softmax,tanh,ReLU;errorfunctions-feed-forwardnetworks.

Unit II

Backpropagation - recursive chain rule (backpropagation) - Learning weights of a logistic output neuron-lossfunctions-learningviagradientdescent-optimizationmomentummethod;Adaptive learning rates RmsProp - mini-batch gradient descent - bias-variance trade off, regularization - overfitting - inductive bias regularization - drop out - generalization. Deep neural networks - convolutional nets case studies usingKeras/Tensorflow.

Unit III

Introductiontodeepreinforcementlearning-neuralnetsforsequences-RecurrentNetsLong-Short-Term-memory-IntroductiontoDeepunsupervisedlearningautoencoders-PCAtoautoencoders-DeepGenerativeModels-GenerativeModelsandVariationalInference-AutoregressiveModelsand Invertible Transformations - Adversarial Learning -Adversarial Variational Bayes: Unifying VariationalAutoencodersandGenerativeAdversarialNetworks-AdverserialAutoencoders-Evaluationof GenerativeModels-ALagrangianPerspectiveonLatentVariableGenerativeModeling-Geometry ofDeepGenerativeModels-Application-ModelbasedReinforcementLearning.

Text Book / References

1. Ian Goodfellow, YoshuaBengio, Aaron Courville. Deep Learning, Second edition, MIT Press, 2016
2. Duda R.O., Hart P.E., Stork D.G., Pattern Classification, Second edition, Wiley-Interscience, 2001
3. Theodoridis, S., Koutroumbas, K. Pattern Recognition, Fourth edition, Academic Press,2008
4. Russell S., Norvig N., Artificial Intelligence: A Modern Approach, Prentice Hall Series in Artificial Intelligence,2003
5. BishopC.M.NeuralNetworksforPatternRecognition,OxfordUniversityPress,1995
6. HastieT.,TibshiraniR.andFriedmanJ.,TheElementsofStatisticalLearning,Springer,2001
7. KollerD.andFriedmanN.ProbabilisticGraphicalModels,MITPress,2009

CO-PO Mapping

COs	Description	PO1	PO2	PO3	PO4	PO5
CO1	Understand basic Neural Network architectures	2	1	2	–	1
CO2	Apply fundamental principles, theory and approaches for learning with deep neural networks	2	1	2	–	1
CO3	Understandkeyconcepts,issuesandpractices, core algorithms and optimization when training and modeling with deep architectures	3	2	2	–	1
CO4	Analyze main variants of deep learning (convolutional,recurrent,reinforcementandgenerative architectures), and their typicalapplications	3	2	3	2	2
CO5	Analyzehowdeeplearningfitswithinthecontext of other Machine Learning approaches and what learning tasks it is considered to be suited and not well suited to perform	2	2	3	2	2

Evaluation Pattern - 4D

19AD612 Scalable Systems forDataScience 2-0-3-3

Preamble

This course will introduce the fundamental systems aspects of big data platforms, and how these platforms can be used to build large-scale data intensive applications. It will cover problems of the interestonlargescaledatasciencedomainsuchaslinkanalysis,findingsimilaritemsandclustering. Itwillalsointroducelargescaleanddistributedmachinelearningtechniques.

Course Objectives

- Tointroducesystemsandapproachesforlargescaledatascienceproblems
- Tounderstand handling large datasets
- Tolearn how large scale machine learning and distributed machine learning approacheswork

Course Outcomes

COs	Description
CO1	Understand handling large data sets
CO2	Learn approaches for solving large scale data science problems link analysis and finding similar items
CO3	Understand real-world problems which need scalable systems for large scale data science such as web advertising and recommendation systems
CO4	Learn the basic principles of large scale machine learning and distributed machine learning
CO5	Implement models using programming languages to solve large scale data science projects

Prerequisites

- Machinelearning
- Python
- Foundations of datascience

Syllabus

Unit I

Overview of data mining and map-reduce, Hash Functions- Indexes, Shingling LSH, Mining Data Streams-Findingsimilaritemsnear-neighborsearch,shinglingofdocuments,Similarity-Preserving Summaries of Sets, Locality-Sensitive Hashing for Documents, Distance Measures, Link-analysis PageRank,Linkspam,Hubsandauthorities.

Unit II

Frequent Item sets Market based model, A-Priori Algorithm, Handling larger data sets in memory, Limited-pass algorithms, Clustering Hierarchical clustering, k-means, CURE, Clustering in Non-Euclidean Spaces, Clustering for Streams and Parallelism.

Unit III

AdvertisingonthewebMatchingproblem,ad-wordsproblem,Recommendationsystems-Content-Based Recommendations, Collaborative Filtering, Dimensionality Reduction, Large-scalemachine learning Parallel Implementation of Perceptrons, Parallel implementation of SVM, Dealing with High-Dimensional Euclidean Data in nearest neighbors, Distributed machine learning.

Text Book / References

1. Jure Leskovec, Anand Rajaraman, Jeffrey David Ullman, Mining of massive datasets, Cambridge University Press,2014
2. Jimmy Lin and Chris Dyer, Data-Intensive Text Processing with MapReduce, First edition, Morgan and Claypool Publishers,2010
3. Sandy Ryza, Uri Laserson, Sean Owen, Josh Wills, Advanced Analytics with Spark: Patterns for Learning from Data at Scale,Oreilly, 2015
4. Ankit Jain, Mastering Apache Storm: Processing big data streaming in real time, Packt Publishing,2017

CO-PO Mapping

COs	Description	PO1	PO2	PO3	PO4	PO5
CO1	Understand handling large data sets	1	3	2	–	–
CO2	Learn approaches for solving large scale data science problems link analysis and finding similar items	–	3	3	–	–
CO3	Understand real-world problems which need scalable systems for large scale data science suchaswebadvertisingandrecommendation systems	2	2	3	–	–
CO4	Learn the basic principles of large scale machinelearninganddistributedmachinelearning	3	2	1	–	–
CO5	Implement models using programming languages to solve large scale data science projects	2	3	2	–	–

Evaluation Pattern - 3D

19AD613 ProbabilisticGraphicalModels 3-0-3-4

Preamble

For humans and machines, intelligence requires making sense of the world-inferring simpleexplanationsforthemishmashofinformationcominginthroughoursenses,discoveringregularitiesand patterns, and being able to predict future states. Probabilistic graphical models are a powerful framework for representing complex domains using probability distributions, with numerous applications in machine learning, computer vision, natural language processing and computational biology.Graphicalmodelsbringtogethergraphtheoryandprobabilitytheoryandprovideaflexible frameworkformodelinglargecollectionsofrandomvariableswithcomplexinteractions.Thiscourse willprovideacomprehensivesurveyofthetopic,introducingthekeyformalismsandmaintechniques used to construct them, make predictions, and support decision-making underuncertainty.

Course Objectives

- The aim of this course is to develop the knowledge and skills necessary to design implement and apply probabilstic graphical models to solve real problems
- The course will cover Bayesian networks, undirected graphical models and their temporal extensions
- Tointroduce exact and approximate inferencemethods
- Tolearnestimationoftheparametersandthestructureofgraphicalmodels

Course Outcomes

COs	Description
CO1	Understand different PGM representations
CO2	Apply different inference techniques to problems
CO3	Apply inference and learning as optimization tools for decision making
CO4	Analyze actions and decisions from PGM
CO5	Explore PGM methods to solve real-world applications

Prerequisites

- Foundations of DataScience
- Principles of AI andML
- Pythonknowledge

Syllabus

Unit I

Representation - Bayesian network representation - independencies in graphs, distributions to graphs, Undirected Graphical Models - parameterization, Markov network independencies, Bayesian to Markovnetworks,partiallydirectedmodels-LocalprobabilisticModels-Tabularconditionalprob-ability distributions (CPDs), deterministic CPDs, context specific CPDs, independence of causal influence, continuous variables, conditional Bayesian networks, Template based representations - temporal models, directed models, undirected models, structural uncertainty - Gaussian network models.

Unit II

Inference - Variable elimination, conditioning, inference with structured CPDs, exact inference - clique trees, message passing, inference as optimization, exact inference as optimization,propaga-tion based approximation, propagation with approximate messages, Particle-Based Approximate Inference-likelihoodweightingandimportancesampling,MarkovchainMonteCarlomethods,col-lapsedparticles,Deterministicsearchmethods,MAPInference-variableeliminationforMAP,Max product in clique trees, Max-product belief propagation in loopy cluster graphs, MAP as a linear optimizationproblem,graphcutsfor MAP, Inferenceintemporalmodels-Inferenceinhybridnet-works-variableeliminationinGaussiannetworks-non-lineardependencies-inferenceintemporal models.

Unit III

Learning-LearningGraphicalModels-learningasoptimization,learningtasks,Parameterestima-tion-learningwithsharedparameters,Bayesiannetworks,StructurelearninginBayesiannetwork - constraint based approaches, structure scores, structure search, Bayesian model averaging, Par-tially observed data - Bayesian learning with incomplete data, structure learning, learning models with hidden variables, Learning undirected models - learning with approximate inference, score based learning, Actions and decisions - Causality, learning causal models, utilities and decisions - Structured decision problems - influence diagrams, optimization in influencediagrams.

Text Book / References

1. Daphne Koller, Nir Friedman, Probabilistic Graphical Models - Principles and Techniques, The MIT Press,2009
2. KirenRKarkera,BuildingProbabilisticGraphicalModelswithPython,Packt,2014
3. AdnanDarwiche,ModelingandReasoningwithBayesiannetworks,Firstedition,Cambridge University Press,2014
4. ChristopherM.Bishop,PatternRecognitionandMachineLearning,Secondedition,Springer, 2011
5. Kevin P. Murphy, Machine Learning: a Probabilistic Perspective, MIT Press,2012

6. David J. C. Mackay, Information Theory, Inference, and Learning Algorithms, Cambridge University Press,2003

7. DavidBarber,BayesianReasoningandMachineLearning,Firstedition,CambridgeUniversity Press,2012

8. Martin J. Wainwright, Michael I. Jordan, Graphical models, exponential families, and variational inference, Now Publishers Inc.,2008

CO-PO Mapping

COs	Description	PO1	PO2	PO3	PO4	PO5
CO1	Understand different PGM representations	1	3	2	1	–
CO2	Apply different inference techniques to problems	1	3	3	1	–
CO3	Apply inference and learning as optimization tools for decision making	2	3	3	1	–
CO4	Analyze actions and decisions from PGM	2	3	3	1	–
CO5	Explore PGM methods to solve real-world ap- plications	3	3	3	1	–

Evaluation Pattern - 4F

19AD614 Data Science ApplicationsofNLP 2-0-3-3

Preamble

This course will cover the techniques, models, and algorithms that enable computers to deal with the ambiguity and implicit structure of natural language. The computational and linguisticaspects of natural language will be dealt with. How Knowledge will be extracted from unstructured text by identifyingreferencestonamedentitiesaswellasstatedrelationshipsbetweensuchentities,willbe taught.

Course Objectives

- Tounderstand text processing for extractinginformation
- Tounderstand language specific tasks and learningmodels
- Toexploreartificialintelligenceinunderstandingthesemanticsoftextdata

Course Outcomes

COs	Description
CO1	Understand the mechanics of language - the sound system, word structure, sentence structure, and meaning
CO2	Understand how to formulate NLP tasks as learning and inference tasks, and address the computational challenges involved
CO3	Apply text processing at syntactic, semantic, and pragmatic levels
CO4	Analyze text mining and manipulation techniques
CO5	Analyze entity recognition and relationship between entities to retrieve information from text

Prerequisites

- Linear Algebra, Probability andStatistics
- MachineLearning

Syllabus

Unit I

Introduction to Computational Linguistics - Word meaning - Distributional Semantics - Word Sense Disambiguation - Sequence Models - N-gram Language Models - Feedforward Neural Language Models - Word Embeddings - Recurrent Neural Language Models - POS tagging and Sequence Labeling - Structured Perceptron, Viterbi - Loss-augmented Structured Prediction - Neural text models and tasks.

Unit II

Information Extraction from Text - Sequential Labeling - Named Entity Recognition - Semantic LexiconInduction-RelationExtraction-ParaphrasesInferenceRules-EventExtraction-Opinion Extraction - Temporal Information Extraction - Open Information Extraction - Knowledge Base Population - Narrative Event Chains and Script Learning - Knowledge graph augmented neural networks for NaturalLanguage.

Unit III

Machine Translation - Encoder-decoder models, beam search - Attention Models - Multilingual Models-Syntax,Trees,Parsing-Transition-basedDependencyParsing-Graph-basedDependency Parsing - Deep Generative Models for Natural Language Data - Text Analytics - Information ExtractionwithAQL-ConversationalAI.

Text Book / References

1. Emily Bender, Linguistics Fundamentals for NLP, Morgan Claypool Publishers,2013
2. JacobEisenstein,NaturalLanguageProcessing,MITPress,2019
3. Dan Jurafsky, James H. Martin, Speech and Language Processing, Third edition, Prentice Hall,2018
4. Chris Manning, Hinrich Schuetze, Foundations of Statistical Natural Language Processing, MIT Press,1999

CO-PO Mapping

COs	Description	PO1	PO2	PO3	PO4	PO5
CO1	Understand the mechanics of language - the soundsystem,wordstructure,sentencestruc-ture, andmeaning	2	2	2	–	2
CO2	Understand how to formulate NLP tasks as learning and inference tasks, and address the computational challenges involved	2	3	2	–	3
CO3	Apply text processing at syntactic, semantic, and pragmatic levels	3	3	3	–	2
CO4	Analyze text mining and manipulation tech-niques	2	2	2	–	2
CO5	Analyze entity recognition and relationship between entities to retrieve information from text	2	2	2	–	2

Evaluation Pattern - 3E

19AD615 Data Science ApplicationsofVision 2-0-3-3

Preamble

Computer vision has become ubiquitous in our society, with applications in search, image understanding, apps, mapping, medicine, drones, and self-driving cars. This course will cover visual recognition tasks such as image classification, localization, detection and extraction. Students will learn applications with combination of vision, machine learning and AI.

Course Objectives

- To understand the capability of a machine to get and analyze visual information and make decisions
- Tolearn methods and algorithms forVision
- TolearnhowtousedeeplearningforVisiontasks

Course Outcomes

COs	Description
CO1	Understand the methods and algorithms for image processing
CO2	Apply vision algorithms in OpenCV for applications
CO3	Apply scalable algorithms for large datasets in vision
CO4	Analyze deep neural architectures for image and video processing
CO5	Apply vision based solutions for specific real-world applications

Prerequisites

- Linear Algebra andOptimization
- Python
- MachineLearning

Syllabus

Unit I

ImageRepresentationandProperties-Introduction-ImageRepresentation-ImageDigitization-Digital Image Properties Discrete Fourier Transform - Image Pre-Processing in Spatial and Fre-quencyDomain:PixelBrightnessTransformation-GeometricTransformations-LocalPreprocessing - ImageSmoothing,sharpening-Conventionalimageprocessingediting,filtering,extraction,clas-sification-EdgeDetectors-CornerDetectors-Convolution-ImageRestoration-featureextraction filters - Image recognition applications - character recognition - authentication of documents - eg: IDs or drivinglicenses.

Unit II

Image Segmentation - Thresholding Segmentation techniques - Deep learning for vision tasks - ObjectdetectionandsemanticsegmentationwithConvolutionNeuralNetworks,objectsegmentation fromimagesandvideos-identificationofobjects-Facialrecognition-Emotionrecognition-Active observation and inferences - Introduction to AmazonGo - detecting events for visual surveillance, autonomousdrivingvideoprocessing-Passiveobservationandanalysis-observeandanalyzeobjects overtime-Analysisofmedicalimages-predictiveanalysisonmedicalimages.

Unit III

Communicating with humans through vision - situational awareness - detection and recognition - Control-visuallexicondesignforinteraction-multimodalintegraion-visionunderstanding-scene understanding - inference and decision making - video image characteristics - motion, brightness, trajectories, optical flow - activity recognition - segmentation, classification and location network-Imagedatabases-indexing-imagesequences.

Text Book / References

1. Rafael C. Gonzalez, Richard E. Woods, Digital Image Processing, Third edition, Pearson Education,2009

2. Milan Sonka, Vaclav Hlavac, Roger Boyle, Image Processing, Analysis and Machine Vision, Third edition, Cengage Learning,2007

3. Gary Bradski, Learning OpenCV , First edition,2008

4. Ian Goodfellow, Yoshuo Bengio, Aaron Courville, Deep Learning (Adaptive Computationand MachineLearningseries),MITPress,2017

5. Fan Jiang, Anomalous Event Detection From Surveillance Video, ProQuest,2012

6. AlokKumarSinghKushwaha,RajeevSrivastava,RecognitionofHumansandTheirActivities forVideoSurveillance,IGIGlobal,2014

7. Ying-li Tian, Arun Hampapur, Lisa Brown, Rogerio Feris, Max Lu, Andrew Senior, Event Detection, Query, and Retrieval for Video Surveillance, IGI Global,2009

8. Matthew Turk, Gang Hua, Vision-based Interaction, First edition, MorganClaypool,2013

CO-PO Mapping

COs	Description	PO1	PO2	PO3	PO4	PO5
CO1	Understand the methods and algorithms for image processing	2	3	2	–	1
CO2	Apply vision algorithms in OpenCV for applications	–	3	3	–	–
CO3	Apply scalable algorithms for large datasets in vision	2	2	3	2	–
CO4	Analyze deep neural architectures for image and video processing	3	2	2	2	3
CO5	Apply vision based solutions for specific real-world applications	2	3	2	2	3

Evaluation Pattern - 3E

19RM600 ResearchMethodology 2-0-0-2

Syllabus

Unit I

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

Unit II

Problem Formulation, Understanding Modeling & Simulation, Conducting Literature Review, Referencing, Information Sources, Information Retrieval, Role of libraries in Information Retrieval, Tools for identifying literatures, Indexing and abstracting services, Citationindexes

Unit III

Experimental Research: Cause effect relationship, Development of Hypothesis, Measurement Systems Analysis, Error Propagation, Validity of experiments, Statistical Design of Experiments, Field Experiments, Data/Variable Types & Classification, Data collection, Numerical and Graphical Data Analysis: Sampling, Observation, Surveys, Inferential Statistics, and Interpretation of Results

Unit IV

Preparation of Dissertation and Research Papers, Tables and illustrations, Guidelines for writing the abstract, introduction, methodology, results and discussion, conclusion sections of a manuscript. References, Citation and listing system of documents

Unit V

Intellectual property rights (IPR) - patents-copyrights-Trademarks-Industrial design geographical indication. Ethics of Research- Scientific Misconduct- Forms of Scientific Misconduct. Plagiarism, Unscientific practices in thesis work, Ethics in science

TextBook/References

1. Bordens, K. S. and Abbott, B. B., "Research Design and Methods – A Process Approach", 8th Edition, McGraw-Hill, 2011
2. C. R. Kothari, "Research Methodology – Methods and Techniques", 2nd Edition, New Age International Publishers
3. Davis, M., Davis K., and Dunagan M., "Scientific Papers and Presentations", 3rd Edition, Elsevier Inc.
4. Michael P. Marder," Research Methods for Science", Cambridge University Press, 2011
5. T. Ramappa, "Intellectual Property Rights Under WTO", S. Chand, 2008
6. Robert P. Merges, Peter S. Menell, Mark A. Lemley, "Intellectual Property in New Technological Age". Aspen Law & Business; 6th Edition July 2012

ELECTIVES

19AD701 Artificial Intelligenceand Robotics 2-0-3-3

Preamble

Inrecentyears,severaloff-the-shelfrobotshavebecomeavailableandsomeofthemhavemadetheir way into our homes, offices, and factories. The ability to program robots has therefore become an importantskill;e.g.,forroboticsresearchaswellasinseveralcompanies(suchasiRobot,ReThink Robotics, Willow Garage, medical robotics, and others). We study the problem of how a robot can learn to perceive its world well enough to act in it, to make reliable plans, and to learn from its own experience. The focus will beon algorithms and machine learning techniques for autonomous operation ofrobots.

Course Objectives

- To understand the principles of reinforcement learning which is one of the key learning techniques for robots
- Tounderstand uncertainty handling in robotics through probabilisticapproaches
- Tolearn how measurements work forrobots

Course Outcomes

COs	Description
CO1	Learn the foundations of reinforcement learning for robotics
CO2	Understand basic probabilistic principles behind Robotics intelligence
CO3	Learn different measurement techniques for robotics
CO4	Understand POMDP and its significance for robotics
CO5	Implement principles of robotics intelligence for solving real world problems

Prerequisites

- Data Structures andalgorithms
- Foundation of DataScience
- Linear Algebra andOptimization
- Principles of AI andML

Syllabus

Unit I

Overview: Robotics introduction, historical perspective on AI and Robotics, Uncertainty in Robotics Reinforcement Learning: Basic overview, examples, elements, Tabular Solution Methods - Multi-armed bandits, Finite Markov decision process, Dynamic programming (Policy Evaluation, Policy Iteration, Value Iteration), Monte Carlo Methods, Temporal-Difference Learning (Q-learning, SARSA)

Unit II

ApproximateSolutionMethods-On-policyPredictionwithApproximation,Valuefunctionapproximation, Non-linear function approximation, Reinforcement Learning in robotics, Recursive state estimation: Robot Environment Interaction, Bayes filters, Gaussian filters The Kalman filter, The Extended Kalman Filter, The information filter, The particle filter Robot motion: Velocity Motion Model,OdometryMotionModel,Motionandmaps

Unit III

Measurement: Beam Models of Range Finders, Likelihood Fields for Range Finders, Correlation-Based Sensor Models, Feature-Based Sensor Models, Overview of POMDP

Text Book / References

1. Sebastian Thrun, Wolfram Burgard, Dieter Fox, Probabilistic Robotics, MIT Press2005
2. Richard S. Sutton, Andrew G. Barto, Reinforcement Learning: An Introduction, Second edition, MIT Press,2018
3. Jens Kober, Jan Peters, Learning Motor Skills: From Algorithms to Robot Experiments, Springer,2014
4. Francis X. Govers, Artificial Intelligence for Robotics, Packt,2018

CO-PO Mapping

COs	Description	PO1	PO2	PO3	PO4	PO5
CO1	Learn the foundations of reinforcement learning for robotics	3	1	3	-	1
CO2	Understand basic probabilistic principles behind Robotics intelligence	3	1	3	-	1
CO3	Learn different measurement techniques for robotics	3	-	3	-	1
CO4	Understand POMDP and its significance for robotics	3	-	3	-	1
CO5	Implement principles of robotics intelligence for solving real world problems	3	-	3	1	-

Evaluation Pattern - 3E

19AD705 Knowledge RepresentationandReasoning 2-0-3-3

Preamble

The course introduces the field of knowledge representation and reasoning. The main focus will be on decidable fragments of first order logic that are well suited for knowledge representation. We explore how such logics can be used to represent knowledge, identify relevant reasoning problems and show how these can be used to support the task of constructing suitable representations. We willalsoconsiderthecomputationalpropertiesoftheselogics,andstudyalgorithmsforsolvingthe relevant reasoning problems. Finally, we will also discuss logics that depart from first order logic, such as non-monotoniclogics.

Course Objectives

- Tomodelsimpleapplicationdomaininaa DescriptionLogiclanguage
- Tounderstand the fundamentals of the reasoningalgorithms
- Tounderstandthebasicsofareasoningservice
- Toexpose knowledge representationlanguages

Course Outcomes

COs	Description
CO1	Understand the fundamentals of logic-based Knowledge Representation
CO2	Model applications in Description Logic
CO3	Understand the basics of Reasoning system
CO4	Understand basics of knowledge representation languages
CO5	Knowledge representation in Ontology Languages

Prerequisites

- Principles of AI andML

Syllabus

Unit I

OverviewofKnowledgeRepresentation,RepresentingKnowledgeinFirstOrderPredicateLogic, Limitations of Propositional and First Order Predicate Logic, Description Logics as Knowledge Representation Languages - A basic DL and its extensions : Basic reasoning problems andservices , reasoning services, Extensions of basic DL ALC, Relationship with Predicate Logic and Modal Logic.

Unit II

Reasoning in the knowledge base: Tableau basics, A tableau algorithm for ALC, A tableau algorithm for ALCIN. Reasoning in the EL: Subsumption in EL, Subsumption in ELI, Comparison of subsumption algorithms.

Unit III

Ontology Languages and Applications: The OWL ontology language, OWL tools and applications: The OWL API, OWL reasoners, Ontology engineering tools, OWL applications

Text Book / References

1. FranzBaader, Ian Horrocks, Carsten Lutz, Uli Sattler, An Introduction to Description Logic, CambridgeUniversityPress,FirstEdition,2017
2. KarinBreitman,MarcoAntonioCasanova,WaltTruszkowski,SemanticWeb:Concepts,Technologiesand Applications,NASAMonographsinSystemsandSoftwareEngineering,Springer, 2007
3. PascalHitzler,MarkusKroetsch,andSebastianRudolph,FoundationsofSemanticWebTechnologies,ChapmanandHall,CRCTextbooksinComputing,2009

CO-PO Mapping

COs	Description	PO1	PO2	PO3	PO4	PO5
CO1	Understand the fundamentals of logic-based Knowledge Representation	3	-	-	3	3
CO2	Model applications in Description Logic	-	3	2	3	3
CO3	Understand the basics of Reasoning system	2	3	3	-	2
CO4	Understand basics of knowledge representation languages	3	0	0	3	3
CO5	Knowledge representation in Ontology Languages	2	3	3	0	2

Evaluation Pattern - 3E

19AD702 Neuroevolution 2-0-3-3

Preamble

Current neural network research is predominantly focused in the fields of deep learning and deep reinforcement learning. In these fields, the neural network weights are typically trained through variantsofstochasticgradientdescent.Thismethodhasprovidedremarkableresultsbothinsuper- vised and reinforcement learning. An alternative approach, inspired by the fact that natural brains themselves are the products of an evolutionary process, harnesses evolutionary algorithms totrain neuralnetworks.ThisfieldiscalledNeuroevolution.Neuroevolutionenablesimportantcapabilities that were not hitherto available to stochastic gradient methods. Such capabilities include learning neural network building blocks (for example activation functions), hyperparameters,architectures andeventhealgorithmsforlearningthemselves.

Course Objectives

- Tointroduce to students the state-of-the-art in simulated evolution of complexsystems.
- To introduce sophisticated encoding techniques inspired from generative and developmental systems to realize complexity.
- To provide comprehensive overview of neuroevolution algorithms that demonstrates alternative way (i.e. search) to produce controllers for a diversified range of tasks.

Course Outcomes

COs	Description
CO1	Understand the Evolutionary Computation paradigm
CO2	Understand sophisticated encoding techniques (i.e. generative and developmental systems)
CO3	Understand the theory and working of neuroevolution algorithms
CO4	Apply the neuroevolution algorithms for real-world learning tasks

Prerequisites

- Data Structures andAlgorithms
- Programming
- Linear Algebra andOptimization

Syllabus

Unit I

TopicsinEvolutionaryComputation(EC):CanonicalEvolutionaryAlgorithms(EAs),UnifiedView of Simple EAs, Components of EAs, Working with EAs, Interactive EAs, Coevolutionary Systems, Evolutionary Algorithms as problemsolvers.

Unit II

Neuroevolution:ClassicNeuroevolutioncombiningANNsandEC,classicobstacles,NeuroEvolution of Augmenting Topologies (NEAT), Post-NEAT methods, Generative and Developmental Systems CPNNs, Novelty Search, QualityDiversity.

Unit III

Neuroevolution at scale: Evolutionary Algorithms as scalable alternative to Reinforcement/deep learning,Meta-learningandArchitectureSearch.EvolvingPlasticArtificialNeuralNetworks(EPANNs) Evolutionarydiscoveryoflearning,Evolvingneuromodulation,evolvingplasticity.

Text Book / References

1. A.E. Eiben and J. E. Smith, Introduction to Evolutionary Computing 2nd Edition, Springer (Natural Computing Series),2015.
2. GeneISher,HandbookofNeuroevolutionthroughErlang,Springer,2012.
3. KennethA.DeJong,EvolutionaryComputationAUnifiedApproach,MITPress,March2016 (PaperbackEdition)
4. IanGoodfellow,YoshuaBengioandAaronCourville,DeepLearning,MITPress,2016.
5. Richard S. Sutton and Andrew G. Barto, Reinforcement Learning An Introduction, MIT Press, Second Edition,2018.
6. Dario Floreano and Stefano Nolfi, Evolutionary Robotics The Biology, Intelligence, andTech-nologyofSelf-OrganizingMachines,MITPress,2004(PaperbackEdition)

CO-PO Mapping

COs	Description	PO1	PO2	PO3	PO4	PO5
CO1	Understand the Evolutionary Computation paradigm	1	-	1	-	-
CO2	Understandsophisticatedencodingtechniques (i.e. generative and developmental systems)	2	-	1	-	1
CO3	Understand the theory and working of neu-roevolution algorithms	2	-	1	-	2
CO4	Apply the neuroevolution algorithms for real-world learning tasks	3	-	3	-	1

Evaluation Pattern - 3E

19AD703 Game theory for AI andDataScience 2-0-3-3

Preamble

Decision making plays the core of artificial intelligence. When decision making involves multiple agentsespeciallyselfishandrationalagents,gametheoryandmechanismdesignplaysanimportant role.Similarly,datausedfordatasciencemaynotbealwaysauthenticduetoitsdistributednature. Gametheoryfordatahastofocusonincentivesforgeneratingnovelandaccuratedata.

CourseObjectives

- Course aims to introduce how human behavior can be modeled using game theoryprinciples for artificialintelligence
- Tolearn various ways game theory helps in differentlearningmechanisms
- Tointroducehowgametheorycanbeusedtoproducenovelandaccuratedatafordatascience problems

Course Outcomes

COs	Description
CO1	Understand behavioral game theory for artificial intelligence domain
CO2	Learn the concepts of game theory for learning techniques in artificial intelligence
CO3	Apply game theoretic principles for dealing data for data science
CO4	Model modern problems in AI and DS using game theory
CO5	Implement game-theoretic solutions for AI and DS

Prerequisites

- Probability and graph theoryconcepts.
- KnowledgeofArtificialintelligenceandfoundationsofdatascience

Syllabus

Unit I

Behavioral game theory: Dictator, Ultimatum and trust games, Mixed strategy equilibrium, Bargaining, Dominant solvable games, Coordination games, Signaling and reputation

Unit II

TypesoflearningReinforcement,Belief,Imitation,stochasticgametheory,evolutionarygamesand markov games for multi-agent reinforcement learning,Economic Reasoning and Artificial Intelligence

Unit III

Game Theory for data science: Mechanisms for verifiable and unverifiable information, non-parametric mechanisms, prediction markets, decentralized machine learning

TextBook/References

1. Colin F. Camerer, Behavioral Game Theory: Experiments in Strategic Interaction, Princeton University Press,2003
2. BoiFaltings,GoranRadanovic,GameTheoryforDataScience:ElicitingTruthfulInformation, Morgan and claypool publishers,2017
3. YoavShoham, Kevin Leyton-Brown, Multiagent Systems: Algorithmic, Game-Theoretic, and Logical Foundations, Cambridge University Press,2009
4. H. M. Schwartz, Multi-Agent Machine Learning: A Reinforcement Approach, Wiley publications,2014
5. PeterVrancx,DecentralizedReinforcementLearninginMarkovGames,VUBPress,2010

CO-PO Mapping

COs	Description	PO1	PO2	PO3	PO4	PO5
CO1	Understand behavioral game theory for artificial intelligence domain	1	–	2	2	3
CO2	Learntheconceptsofgametheoryforlearning techniques in artificial intelligence	1	–	2	2	3
CO3	Apply game theoretic principles for dealing data for data science	1	2	2	2	–
CO4	Model modern problems in AI and DS using game theory	2	–	2	2	2
CO5	Implement game-theoretic solutions for AI and DS	2	–	2	2	3

Evaluation Pattern - 3E

19AD704 Analysis of Large ScaleSocialNetworks 2-0-3-3

Preamble

Social networks have always been at the heart of human interaction, but with the explosive growth of the internet over the last two decades, network analysis has become increasingly central to all branches of the social sciences: sociology, economics, political science, psychology, and so on.How dopeopleinfluenceeachother,bargainwitheachother,exchangeinformation(orgerms),orcommunicate online? A diverse array of deep questions about human behavior can only be answered by examining the social networks encompassing and shifting around us. This network analysis has emergedasacross-disciplinaryscienceinitsownright,andhasinfactproventobeofevengreater generality and broader applicability than just the social, extending to ecology, physics, genetics, computer science, and other domains. This course seeks to teach students the foundations of what hasbecomethenewandquitecoherentfieldofnetworkanalysis.

Course Objectives

- ToIntroducemicro-structureofnetworksandmacro-structureandothermeansofdescribingand characterizing large-scale structures
- Tolearnthenetworkformation,thestructureofrandomnetworks,andtheoriginsoflarge-scale structuresinthestrategiccreationofnetworkties
- Toimpart knowledge on social behavior onnetworks
- To learn the concepts of strategic interaction in networks and do social network analysis through python

Course Outcomes

COs	Description
CO1	Knowledge on structure of small-scale and large-scale social networks
CO2	Analysisofdifferentmeasuresandmetricsandfundamentalnetworkalgorithms
CO3	Analysis of information diffusion in networks and dynamic social networks
CO4	Understanding of social network graph analysis
CO5	Implement large scale social network analysis using model programming language such as Python/R

Prerequisites

- Linear algebra andoptimization
- MachineLearning
- Foundations of DataScience

Syllabus

Unit I

Introduction to social networks - Representing and Measuring Networks, Measures and metrics Centrality - different types, hubs and authorities, Balance and Homophily, Large-scale structures and small worlds, Fundamental network algorithms.

Unit II

SocialnetworkgraphanalysisMiningsocialnetworkgraphs,Graphclustering,PartitioningGraphs, Findingoverlappingcommunities,Algorithmstodeterminegraphclustering,partitioningandoverlappingcommunities.

Unit III

Information diffusion in networks - Markets and Strategic interaction Games on networks, Spatial and agent-based models, Power in social networks, Network dynamics Information cascades, Network effects, Cascading behavior in networks, Dynamic social networks Applications and research trends.

TextBook/References

1. Newman, Networks: An introduction, Oxford Univ. Press,2010
2. Jure Leskovec, Anand Rajaraman and Jeffrey David Ullman, Mining of massive datasets, Cambridge University Press,2014
3. DavidEasleyandJonKleinberg,Networks,crowds,andmarkets,CambridgeUniversityPress, 2010
4. Jackson,SocialandEconomicNetworks,PrincetonUniversityPress,2008
5. MohammedZuhairAl-Taie,SeifedineKadry,PythonforGraphandNetworkAnalysis,Springer 2017
6. Krishna Raj P.M., Ankith Mohan, K.G. Srinivasa, Practical Social Network Analysis with Python, Springer2018

CO-PO Mapping

COs	Description	PO1	PO2	PO3	PO4	PO5
CO1	Knowledge on structure of small-scale and large-scale social networks	1	2	–	–	1
CO2	Analysisofdifferentmeasuresandmetricsand fundamental network algorithms	2	2	–	–	2
CO3	Analysis of information diffusion in networks and dynamic social networks	1	3	–	–	2
CO4	Understanding of social network graph analysis	2	3	–	–	2
CO5	Implement large scale social network analysis using model programming language such as Python/R	3	2	3	1	–

Evaluation Pattern - 3E

19AD705 Knowledge RepresentationandReasoning 2-0-3-3

Preamble

The course introduces the field of knowledge representation and reasoning. The main focus will be on decidable fragments of first order logic that are well suited for knowledge representation. We explore how such logics can be used to represent knowledge, identify relevant reasoning problems and show how these can be used to support the task of constructing suitable representations. We willalsoconsiderthecomputationalpropertiesofthese logics,andstudyalgorithmsforsolvingthe relevant reasoning problems. Finally, we will also discuss logics that depart from first order logic, such as non-monotoniclogics.

CourseObjectives

- TomodelsimpleapplicationdomaininaDescriptionLogiclanguage
- Tounderstand the fundamentals of the reasoningalgorithms
- Tounderstandthebasicsofareasoningservice
- Toexpose knowledge representationlanguages

Course Outcomes

COs	Description
CO1	Understand the fundamentals of logic-based Knowledge Representation
CO2	Model applications in Description Logic
CO3	Understand the basics of Reasoning system
CO4	Understand basics of knowledge representation languages
CO5	Knowledge representation in Ontology Languages

Prerequisites

- Principles of AI andML

Syllabus

Unit I

OverviewofKnowledgeRepresentation,RepresentingKnowledgeinFirstOrderPredicateLogic, Limitations of Propositional and First Order Predicate Logic, Description Logics as Knowledge Representation Languages - A basic DL and its extensions : Basic reasoning problems andservices , reasoning services, Extensions of basic DL ALC, Relationship with Predicate Logic and Modal Logic.

Unit II

Reasoning in the knowledge base: Tableau basics, A tableau algorithm for ALC, A tableau algorithm for ALCIN. Reasoning in the EL: Subsumption in EL, Subsumption in ELI, Comparison of subsumption algorithms.

Unit III

Ontology Languages and Applications: The OWL ontology language, OWL tools and applications: The OWL API, OWL reasoners, Ontology engineering tools, OWL applications

Text Book / References

1. Franz Baader, Ian Horrocks, Carsten Lutz, Uli Sattler, An Introduction to Description Logic, CambridgeUniversityPress,FirstEdition,2017

2. KarinBreitman,MarcoAntonioCasanova,WaltTruszkowski,SemanticWeb:Concepts,Technologiesand Applications,NASAMonographsinSystemsandSoftwareEngineering,Springer, 2007

3. PascalHitzler,MarkusKroetsch,andSebastianRudolph,FoundationsofSemanticWebTechnologies,ChapmanandHall,CRCTextbooksinComputing,2009

CO-PO Mapping

COs	Description	PO1	PO2	PO3	PO4	PO5
CO1	Understand the fundamentals of logic-based Knowledge Representation	3	-	-	3	3
CO2	Model applications in Description Logic	-	3	2	3	3
CO3	Understand the basics of Reasoning system	2	3	3	-	2
CO4	Understand basics of knowledge representation languages	3	0	0	3	3
CO5	Knowledge representation in Ontology Languages	2	3	3	0	2

Evaluation Pattern - 3E

19AD706 Real time VideoAITechnologies 2-0-3-3

Preamble

Therehasbeenincreaseintheusageofvideosbypeopleforentertainment,educationandbusiness purposes.Inthiscoursevariousaspectsofstoringvideos,storageformats,analysingobjects,tracking objects of interest, scenario modelling and object behavior modelling will be taught using case studies.

Course Objectives

- Tolearn fundamentals of videoanalytics
- Togainadetailedunderstandingofvideoanalysistechniquesofmachinelearning
- Tointroduce students to the practical use of visual context information from real timevideos

Course Outcomes

COs	Description
CO1	Understand video storage formats and pre-processing
CO2	Apply learning methods to identify and classify objects
CO3	Apply modelling techniques to objects and scenes from videos
CO4	Analyze visual context from real-time videos
CO5	Apply non-deep learning methods to real-time videos

Prerequisites

- Python
- ArtificialNeuralNetworksandDeeplearning
- Linear Algebra andOptimization
- MachineLearning
- ComputerVision

Syllabus

Unit I

Intelligentsurveillance-storageoptimization-eventdetection-illuminationandartificiallighting - smart video observation - Frame differencing - mean filter - Maximally stable extremal regions (MSER) - video motion detection detects valid motion, tracking, filtering out noise such aslighting changes and tree/animal movements - Intrusion detection - line crossing - Objects unattended - Loitering-Wrongdirection-Falldetection-Countingobjects-Personrunning-Videosummaries.

Unit II

Videocompressionformats-MPEG4-H.264AVC,SVC-spatialandtemporalredundancy-change point detection - detection of objects of interest - ontology based scenario models - Case study - modelling the behavior of elderly people - activity analysis and detection of events - topic models - Data mining in a video database - Analysis of crowded scenes in video - detection of visualcontext - visualdescription,multiclasslearning-detectionandclassificationwithexternalappearanceand movement - vehicles andpeople.

Unit III

Case studies - Traffic intersections - Video queries - In-vehicle video analytics - Surveillance with wirelesscamerasandedgecomputing-Roadsidevideodata-vegetationsegmentationandclassifi-cation-Non-deeplearningtechniquesforvideodataanalysis-FuzzyC-meanslearning-Ensemble learning.

Text Book / References

1. Jean-YvesDufour,IntelligentVideoSurveillanceSystems,Wiley-ISTE,2012
2. Yunqian Ma, Gang Qian, Intelligent Video Surveillance: Systems and Technology, CRC Press, 2009
3. Thierry Bouwmans, FatihPorikli, Benjamin Hferlin and Antoine Vacavant, Background Modeling and Foreground Detection for Video Surveillance: Traditional and Recent Approaches, Implementations,BenchmarkingandEvaluation,CRCPress,TaylorandFrancisGroup,2014
4. Ahad, Md. Atiqur Rahman, Computer Vision and Action Recognition-A Guide for Image Processing and Computer Vision Community for Action Understanding, Atlantis Press,2011
5. Fredrik Nilsson, Intelligent Network Video: Understanding Modern Video Surveillance Systems, Second edition, CRCPress,2017
6. Halina Kwanicka, Lakhmi C. Jain (eds.), Bridging the Semantic Gap in Image and Video Analysis,Firstedition,SpringerInternationalPublishing,2018

CO-PO Mapping

COs	Description	PO1	PO2	PO3	PO4	PO5
CO1	Understand video storage formats and pre-processing	3	3	2	2	3
CO2	Apply learning methods to identify and classify objects	3	2	–	3	3
CO3	Apply modelling techniques to objects and scenes from videos	3	2	2	3	2
CO4	Analyze visual context from real-time videos	3	3	2	3	3
CO5	Applynon-deeplearningmethodstoreal-time videos	3	2	–	2	2

Evaluation Pattern - 3E

19AD707 QuantumArtificialIntelligence 2-0-3-3

Preamble

This course deals with how to use quantum algorithms in artificial intelligence. The course also coversQuantumphysicsbasedinformationandprobabilitytheory,andtheirrelationshipstoartificial intelligencebyassociativememoryandBayesiannetworks.Studentswillgetanintroductiontothe principlesofquantumcomputationanditsmathematicalframework.

Course Objectives

- To understand how the physical nature, as described by quantum physics, can lead to algorithms that imitate human behavior
- To explore possibilities for the realization of artificial intelligence by means of quantum computation
- Tolearn computational algorithms as described by quantumcomputation

Course Outcomes

COs	Description
CO1	Understand the computation with Qubits
CO2	Apply Quantum algorithms - Fourier Transform and Grovers amplification
CO3	Apply Quantum problem solving using tree search
CO4	UnderstandandexplorethemodelsofQuantumComputerandQuantumSimulation tools
CO5	Explore open source Quantum computer libraries for applications

Prerequisites

- MachineLearning
- Programminglanguages
- Probability

Syllabus

Unit I

Introduction-artificialintelligence-computation-Cantorsdiagonalargument-complexitytheory-Decisionproblems-PandNP-ChurchTuringThesis-VonNeumannarchitecture-ProblemSolving - Rules-Logic-basedoperators-Frames-Categorialrepresentation-Binaryvectorrepresentation-ProductionSystem-Deductionsystems-Reactionsystems-Conflictresolution-Humanproblem-solving-Informationandmeasurement-ReversibleComputation-Reversiblecircuits-Toffoligate

Unit II

Introductiontoquantumphysics-UnitaryEvolution-QuantumMechanics-Hilbertspace-Quan- tum Time Evolution - Von Neumann Entropy - Measurement - Heisenbergs uncertaintyprinciple - Randomness - Computation with Qubits - Computation with m Qubit - Matrix Representation of Serial and Parallel Operations - Quantum Boolean Circuits - Periodicity - Quantum Fourier Transform - Unitary Transforms - Search and Quantum Oracle - Grovers Amplification - Circuit Representation - Speeding up the Traveling Salesman Problem - The Generate-and-Test Method - Quantum Problem-Solving - Heuristic Search - Quantum Tree Search - Tarratacas Quantum ProductionSystem.

Unit III

A General Model of a Quantum Computer - Cognitive architecture - Representation - Quantum Cognition - Decision making - Unpacking Effects - Quantum walk on a graph - Quantum annealing - Optimization problems - Quantum Neural Computation - Applications on Quantum annealing Computer-Developmentlibraries-QuantumComputersimulationtoolkits.

Text Book / References

1. AndreasWichert,PrinciplesofQuantumArtificialIntelligence,Firstedition,WorldScientific Publishing,2014
2. PeterWittek,QuantumMachineLearning,Firstedition,AcademicPress,2014

CO-PO Mapping

COs	Description	PO1	PO2	PO3	PO4	PO5
CO1	Understand the computation with Qubits	2	2	2	−	3
CO2	Apply Quantum algorithms - Fourier Transform and Grovers amplification	2	2	2	−	3
CO3	Apply Quantum problem solving using tree search	3	3	3	2	3
CO4	Understand and explore the models ofQuantumComputerandQuantumSimulationtools	3	3	3	3	3
CO5	Explore open source Quantum computer libraries for applications	3	3	2	2	3

Evaluation Pattern - 3E

19AD708 Virtual Reality andAugmentedReality 2-0-3-3

Preamble

This course covers algorithms and techniques required to develop virtual reality and augmented reality applications. Students will be introduced to VR and AR hardware, stereoscopic vision, VR software development, 3D user interfaces and augmented presence.

Course Objectives

- Understand the elements, architecture, input and output devices of virtual and augmented reality systems
- Be able to develop and evaluate 3D interactive applications involving stereoscopic output, virtual reality hardware and 3D user interfaces

Course Outcomes

COs	Description
CO1	nderstand the characteristics, fundamentals and architecture of AR /VR. Also, to understand the scope for AR/VR
CO2	nderstand the Hardware Requirement, Selection of Hardware for the AR / VR application development
CO3	nderstand the software development aspects for AR / VR
CO4	esign and develop the interactive AR / VR applications
CO5	nalyze and build AR/VR applications for chosen industry, healthcare, education case study

Prerequisites

- Programming in Java Script, C Sharp

Syllabus

Unit I

Introduction - VR and AR Fundamentals, Differences between AR/VR Selection of technology AR or VR AR/VR characteristics Hardware and Software for AR/VR introduction. Requirements for VR/AR. Benefits and Applications of AR/VR. AR and VR case study.

Unit II

Hardware Technologies for AR / VR Visual Displays (VR cardboard, VR headsets, Mixed Reality headsets), Auditory Displays, Haptics and AR/VR, Choosing the Output devices for AR/VR applications, Hardware considerations and precautions with VR/AR headsets - 3D user interface input hardware - Input device characteristics, Desktop input devices, Tracking Devices, 3D Mice, SpecialPurposeInputDevices,DirectHumanInput,Home-BrewedInputDevices,ChoosingInput Devices for 3DInterfaces

Unit III

oftware technologies - Database - World Space, World Coordinate, World Environment, Objects - Geometry, Position / Orientation, Hierarchy, Bounding Volume, Scripts and other attributes, VR Environment - VR Database, Tessellated Data, LODs, Cullers and Occluders, Lights and Cameras,Scripts,Interaction-Simple,Feedback,GraphicalUserInterface,ControlPanel,2DControls, HardwareControls,Room/Stage/AreaDescriptions,WorldAuthoringandPlayback,VRtoolkits, Available software in the market (Unity and Vuforia based) - Case Studies in AR, VR - Industrial applications,medialAR/VR,educationandAR/VR.

Text Book / References

1. Alan B Craig, William R Sherman, Jeffrey D Will, Developing Virtual Reality Applications: FoundationsofEffectiveDesign,MorganKaufmann,2009
2. Gerard Jounghyun Kim, Designing Virtual Systems: The Structured Approach,2005.
3. Doug A Bowman, Ernest Kuijff, Joseph J LaViola, Jr and Ivan Poupyrev, 3D User Interfaces, Theory and Practice, Addison Wesley, USA,2005
4. OliverBimber,RameshRaskar,SpatialAugmentedReality:MegingRealandVirtualWorlds, 2005
5. Burdea, Grigore C, Philippe Coiffet, Virtual Reality Technology, Wiley Interscience, India, 2003
6. John Vince, Virtual Reality Systems, AddisonWesley, 1995
7. Howard Rheingold, Virtual Reality: The Revolutionary Technology and how it Promises to Transform Society, Simon and Schuster,1991
8. William R Sherman, Alan B Craig, Understanding Virtual Reality: Interface, Application and Design,MorganKaufmannPublishers,SanFrancisco,CA,2002

CO-PO Mapping

COs	Description	PO1	PO2	PO3	PO4	PO5
CO1	nderstand the characteristics, fundamentals and architecture of AR /VR. Also, to understand the scope for AR/VR	2	3	1	−	−
CO2	nderstand the Hardware Requirement, Selection of Hardware for the AR / VR application development	3	3	2	2	−
CO3	nderstand the software development aspects for AR / VR	2	2	2	−	−
CO4	esign and develop the interactive AR / VR applications	2	2	3	2	−
CO5	nalyzeandbuildAR/VRapplicationsforchosenindustry,healthcare,educationcasestudy	2	2	2	3	1

Evaluation Pattern - 3E

19AD709 GeospatialDataAnalysis 2-0-3-3

Preamble

Thecourseexplainsdigitalrepresentationandanalysisofgeospatialphenomenaandprovidesfoun- dations in methods and algorithms used in Geographical Information System (GIS) analysis. The courseincludesterrainmodelingandintroductoryGIS-basedmodelingoflandscapeprocesses(wa- ter, sediment). Students will learn to visualize GIS data using tools and explore decision making from GISdata.

Course Objectives

- Tolearn about GIS and DecisionMaking
- Tolearn about data visualization techniques andcartography
- Toexplore Geo-processingtools

Course Outcomes

COs	Description
CO1	Understand the characteristics of GIS data
CO2	Understand 2D and 3D data visualization techniques for spatial data
CO3	Apply terrain modeling techniques for real world applications
CO4	Apply quantitative mapping methods and tools for applications
CO5	Analyze decision making techniques for GIS data

Prerequisites

- Calculus and LinearAlgebra
- MachineLearning
- Statistics

Syllabus

Unit I

Makingmapsandspatialanalysis-analysisofcontinuousanddiscretephenomena-neighborhood operationsandbuffers-analysisandmodelingwithmapalgebra-costsurfacesandleastcostpath - spatial interpolation and approximation (gridding) - Data display and visualization - display of continuous and discrete data, use of color, shading, symbols, to extract the spatial pattern and relationships-3Dvisualization:multiplesurfacesandvolumes,3Dvectorobjects-visualizationfor dataanalysis(lighting,zscaling,transparency,cuttingplanes,animations)-view/createmaps/post yourdataon-line(GoogleEarth/Maps,GPSvisualizer).

Unit II

Geoprocessing Analytics and GIS - Geoprocessing Tools (Buffer, Clip, Dissolve, Update, Union) - Quantitative Mapping: Census Data - Census Geometry, Calculating New Variables and Making NewTableFields-CensusVariables-EstimationMethods-TerrainModelingandAnalysis-terrain andbathymetrymapping-mathematicalanddigitalrepresentations(pointclouds,contour,raster, TIN)-DEMandDSM,workingwithmultiplereturnLIDARdata-spatialinterpolationofelevation dataandtopographicanalysis-Geodatabases,Shapefiles,andformats-Topology.

Unit III

Geocoding and finding address locations - Geocoding process - Datasets - Raster Decision Making and Suitability - Raster Data Format - Map Algebra - Overlay - Suitability Analysis - Decision Making and GIS - Applications.

Text Book / References

1. Neteler, M. and Mitasova, H., Open Source GIS: A GRASS GIS Approach, Third Edition, Springer New York Inc.,2008
2. Michael John De Smith, Michael F. Goodchild, Paul Longley, Geospatial Analysis: A Comprehensive Guide to Principles, Techniques and Software Tools, Second edition, Troubador Publishing Ltd,2007
3. JulianaMaantayandJohnZiegler,GISfortheUrbanEnvironment,ESRIPress,2006
4. Hengl, T. and Reuter, H. I., Geomorphometry: Concepts, Software, Applications, Elsevier, 2008
5. Wilson,JohnP, Environmentalapplicationsofdigitalterrainmodelling,WileySonsLtd,2008
6. Petrasova A, Harmon B, Petras V, Tabrizian P, Mitasova H., Tangible Modeling with Open Source GIS, Second edition. Springer International Publishing,2018

CO-PO Mapping

COs	Description	PO1	PO2	PO3	PO4	PO5
CO1	Understand the characteristics of GIS data	2	2	2	–	3
CO2	Understand 2D and 3D data visualization techniques for spatial data	2	2	2	–	3
CO3	Apply terrain modeling techniques for real world applications	3	2	3	2	3
CO4	Apply quantitative mapping methods and tools for applications	3	2	3	2	3
CO5	Analyze decision making techniques for GIS data	3	3	3	–	3

Evaluation Pattern - 3E

19AD710 MedicalAI 2-0-3-3

Preamble

Thiscourseintroducesthestudentstotheinterdisciplinaryareaofartificialintelligenceinmedicine. Followingtheadvancementintheareaofcloudandbig-dataplatform,therehasbeenmanyadvancements in the area of applications of AI to medical diagnosis, data analytics, mining of biomedical data and visualization.

Course Objectives

- ThisisanintensiveintroductiontoAIappliedtoissuesinmedicaldiagnosis,therapyselection, monitoring,andlearningfromhealthdataandmedicalvisualisation
- It will briefly cover the healthcare industry in India, electronic medical records, and ethical/security concerns

Course Outcomes

COs	Description
CO1	Introduction to Machine Learning Applications in Medical domain.
CO2	Introduction to decision making in Medical domain
CO3	Introduction to Biomedical text extraction and Robotic surgeries
CO4	Introduction to different types of medical data
CO5	Introduction to volume visualization in medical data

Prerequisites

- Calculus and LinearAlgebra
- MachineLearning

Syllabus

Unit I

Overview of Prominent Machine Learning and Data Mining methods with example applications in the Medical Domain-Application of Computational Intelligent techniques for Medicine.

Unit II

ClinicalDecisionSupportinMedicine-AutomaticDataMiningfortheBestTreatmentofaDisease-NaturalLanguageProcessinginMedicine-IntelligentPersonalHealthRecord-ApplicationofArtificial Intelligence in Minimally Invasive Surgery and ArtificialPalpation.

Unit III

Medical Image Data and Visual Perception - Acquisition of Medical Image Data- Medical Volume Data in Clinical Practice - Image Analysis for Medical data visualization.

Text Book / References

1. ArvinAgah,MedicalApplicationsofArtificialIntelligence,CRCPress,FirstEdition,2013
2. TonJCleophas,MachineLearninginMedicine,Springer,2015
3. Bernhard Preim and Dirk Bartz, Visualization in Medicine: Theory, Algorithms, and Applications,(MorganKaufmannSeriesinComputerGraphics),FirstEdition,MorganKaufmann, 2007

CO-PO Mapping

COs	Description	PO1	PO2	PO3	PO4	PO5
CO1	Introduction to Machine Learning Applications in Medical domain.	1	–	–	–	–
CO2	Introduction to decision making in Medical domain	–	3	2	–	1
CO3	Introduction to Biomedical text extraction and Robotic surgeries	–	3	2	–	1
CO4	Introduction to different types of medical data	1	2	2	–	–
CO5	Introduction to volume visualization in medical data	1	–	2	–	1

Evaluation Pattern - 3E

19AD711 Spatio-temporalDataAnalysis 2-0-3-3

Preamble

Spatiotemporaldataanalysisisanemergingresearchareaduetothedevelopmentandapplication ofnovelcomputationaltechniquesallowingfortheanalysisoflargespatiotemporaldatabases.Spatiotemporal models arise when data are collected across time as well as space and has at least one spatial and one temporal property. An event in a spatiotemporal dataset describes a spatial and temporalphenomenonthatexistsatacertaintimetandlocationx.

Course Objectives

- Tounderstandstatisticalandalgebraicmethodsusedtoanalyzespatiotemporaldata
- Tounderstand the theory and methods for analyzing spatiotemporaldata
- Toanalyzemultidimensionaldatasetsinspecificfieldsincludingmedicine

Course Outcomes

COs	Description
CO1	Understand spatiotemporal datasets and databases
CO2	Applymathematicalandstatisticalmethodsfortheanalysisofspace-timedata
CO3	Understand available spatiotemporal statistical tools and when to best or appropriately apply them to exploratory data analysis, hypothesis testing, and data reduction and regularization
CO4	Apply specific methodologies to the analysis of temporal and spatial correlations
CO5	Analyze the potential and limitation of statistical and data analytical methods withrespecttotheconstraintsfromtheunderlyingphysicalprocessforspatial data acquisition in real-worldapplications

Prerequisites

- MachineLearning
- Foundations of DataScience
- LinearAlgebra

Syllabus

Unit I

Spatial Data - Components - Mathematics of Location: Vector and Polygon - Sources of Spatial Data - GeographicInformationSystems-BasicGISOperations-SpatialAnalysiswithinGIS-Problems with Spatial Data and GIS - Visualizing Spatial Data - Analysis of Spatial Point Patterns - K function-PoissonClusterProcesses-SpatialClustering-Descriptiveandpredictivespatiotemporal analysis - Spatialautocorrelation.

Unit II

Modeling spatial structure - Conditional Autoregression - Space-Time Autoregressive Integrated MovingAverage-SpatialMultivariateAge-Period-Cohort(APC)Effects-P-splinemodels-Spatial ExposureData-LinkingSpatialExposuretoEvents-Bayesianmodelsforeventmapping.

Unit III

Visualization of Spatial data - Time on horizontal axis - Time as conditioning or group variable - Thematicmaps-Referenceandphysicalmaps-Spatiotemporalrasterdata-Spatiotemporalpoint observations - Dynamic Mode Decomposition - Applications - 3D clustering of Geo-urban data, Spatiotemporal datasets inmedicine.

Text Book / References

1. Peter J. Diggle, Statistical Analysis of Spatial and Spatio-Temporal Point Patterns, Third Edition, CRC Press,2013
2. Oscar Perpinan Lamigueiro, Displaying Time Series, Spatial, and Space-Time Data with R, Second Edition, CRC Press,2018
3. ShashiShekhar,HuiXiong,EncyclopediaofGIS,Springer,2017

CO-PO Mapping

COs	Description	PO1	PO2	PO3	PO4	PO5
CO1	Understand spatiotemporal datasets and databases	2	2	2	–	2
CO2	Apply mathematical and statistical methods for the analysis of space-time data	3	3	3	–	3
CO3	Understand available spatiotemporal statistical tools and when to best or appropriately apply them to exploratory data analysis, hypothesis testing, and data reduction and regularization	2	2	2	–	2
CO4	Apply specific methodologies to the analysis of temporal and spatial correlations	2	3	2	–	2
CO5	Analyze the potential and limitation of statistical and data analytical methods with respect to the constraints from the underlying physicalprocessforspatialdataacquisitionin real-worldapplications	2	2	2	–	1

Evaluation Pattern - 3E

19AD712 Autonomous SystemsandDrones 2-0-3-3

Preamble

Self-driving vehicles represent one of the most exciting advances in modern history. Their impact willgobeyond technology, beyondtransportation,beyondurbanplanningtochangeourdailylives in ways we have yet to imagine. Students will gain knowledge of deep learning through the applied theme of autonomous driving. The areas of focus include functional architecture of autonomous vehicles,SLAM,vehiclecontrolanddrones.

Course Objectives

- Toimpartknowledgeonthefunctionalarchitectureofautonomousvehicles
- TounderstandLocalization and mappingfundamentals
- Tolearn the principlesofdrones

Course Outcomes

COs	Description
CO1	Understand architecture and modeling of autonomous systems
CO2	Employ localization mapping techniques for autonomous systems
CO3	Design solutions for autonomous systems control
CO4	Interpret the architecture and mechanisms of drones
CO5	Implement solutions for autonomous systems

Prerequisites

- DeepLearning
- Probability

Syllabus

Unit I

unctional architecture - Major functions in an autonomous vehicle system, Motion Modeling - Coordinateframesandtransforms,pointmassmodel,Vehiclemodeling(kinematicanddynamicbicycle model-two-trackmodels),SensorModeling-encoders,inertialsensors,GPS.

Unit II

SLAM - Localization and mapping fundamentals, LIDAR and visual SLAM, Navigation - Global path planning, Local path planning, Vehicle control - Control structures, PID control, Linear quadratic regulator, Sample controllers.

Unit III

Drones-overview,definition,applications,componentsplatforms,propulsion,on-boardflightcon-trol,payloads,communications,conceptsofflight,regulatorynormsandregulations,Machinelearn-inganddeeplearningforautonomousdrivingCasestudy.

Text Book / References

1. KarstenBerns,EwaldPuttkamer,Springer,AutonomousLandVehicles:StepstowardsService Robots,2009
2. Sebastian Thrun, Wolfram Burgard, Dieter Fox., Probabilistic robotics. MIT Press,2005
3. StevenM.LaValle.,Planningalgorithms,CambridgeUniversityPress,2006
4. DanielWatzenigandMartinHorn(Eds.),AutomatedDriving:SaferandMoreEfficientFuture Driving, Springer,2017
5. Markus Maurer, Autonomous driving: technical, legal and social aspects. Springer,2016
6. Jha,Theory,DesignandApplicationsofUnmannedAerialVehicles,CRCPress,2016

CO-PO Mapping

COs	Description	PO1	PO2	PO3	PO4	PO5
CO1	Understand architecture and modeling of autonomous systems	2	–	2	–	–
CO2	Employ localization mapping techniques for autonomous systems	3	–	2	–	1
CO3	Designsolutionsforautonomoussystemscontrol	3	–	2	–	1
CO4	Interpret the architecture and mechanisms of drones	1	–	2	–	1
CO5	Implement solutions for autonomous systems	3	–	2	1	1

Evaluation Pattern - 3E

19AD713 BigDataSecurity 2-0-3-3

Preamble

This course aims at introducing concepts related to big data security with an emphasis in understanding privacy issues in big data. It provides users with a strategic view on how to build an informationsecurityframeworkthatalignswithbusinessobjectives.Italsohelpslearnerstounderstand how to limit the ability of an attacker to corrupt or modify data in the event of a security breach.

Course Objectives

- Tointroduce models of InformationSecurity
- Toimpartnecessaryskillstounderstandprivacypreservingdatasharing
- Tointroducetheproceduretosecurebigdata
- Toenable understanding on Hadoop Kerberossecurity

Course Outcomes

COs	Description
CO1	Understand and apply the models of Information Security
CO2	Apply and critique strategies for personal privacy protection
CO3	Understand and build security frameworks for big data
CO4	Build security in Hadoop environment

Prerequisites

- Knowledge on BigData

Syllabus

Unit I

Information System Security: Critical characteristics of Information - NSTISSC Security Model -Components of information System SDLC Information assurance - Security Threats and vulnera-bilities - Overview of Security threats- Security Standards.

Unit II

Privacy in Big Data: Privacy needforDataSharingAnonymizationdesignprinciples Data Anonymizationinmultidimensionaldata-DataAnonymizationintimeseriesdataThreatstoanonymized data-PrivacypreservingdataminingDynamicdataProtection-Security,Compliance,Auditing and Protecting: Steps to secure big data Classifying Data Protecting Big Data Compliance Intellectual Property Rights and challenges.

Unit III

Security Design: Kerberos Default Hadoop Model without security - Hadoop Kerberos Security-Open source authentication in Hadoop-Log monitoring Encryption for Hadoop.

Text Book / References

1. Mark Van Rijmenam, Think Bigger: Developing a Successful Big Data Strategy for Your Business, First edition, Amazon,2014
2. Ben Spivey, Joey Echeverria, Hadoop Security Protecting Your Big Data Problem, OReilly Media,2015
3. Nataraj Venkataramanan, Ashwin Shriram, Data Privacy: Principles and Practice, First edition, Chapman and Hall/CRC,2016
4. Michael E. Whitman, Herbert J Mattord, Principles of Information Security, Sixth edition, Vikas Publishing House,2017

CO-PO Mapping

COs	Description	PO1	PO2	PO3	PO4	PO5
CO1	Understand and apply the models of Information Security	–	1	2	–	–
CO2	Apply and critique strategies for personal privacy protection	2	3	2	–	2
CO3	Understandandbuildsecurityframeworksfor big data	2	3	–	–	–
CO4	Build security in Hadoop environment	2	3	3	–	1

Evaluation Pattern - 3E

19AD714 Large-ScaleVisualAnalytics 2-0-3-3

Preamble

Visualanalyticscombinesinteractivevisualinterfacesandinformationvisualizationtechniqueswith automaticalgorithmstosupportanalyticalreasoningthroughhuman-computerinteraction.People usevisualanalyticstoolsandtechniquestosynthesizeinformationandderiveinsightfrommassive, dynamic, ambiguous, and often conflicting data, and to communicate their findings effectively for decision-making. Visual analytics is an advanced form of visualization, in which a visualization processfeaturesasignificantamountofcomputationalanalysisandhuman-computerinteraction.

Course Objectives

- Beconversantwithacollectionofvisualizationandanalysistechniques
- Gainconfidenceandcompetenceinperformingdataanalysisandvisualizationtasks
- Appreciatetheusesandimportanceofvisualizationindata-intensiveapplications

Course Outcomes

COs	Description
CO1	Differentiate different visualization and computational systems
CO2	Analyze various challenges in visual analytics
CO3	Analyze data science challenges in large scale visual analytics
CO4	Implement algorithms for large scale visual analytics
CO5	Understand the usage of visual analytics for text, audio and video

Prerequisites

- Foundations of DataScience

Syllabus

Unit I

Dealingwithclassicaldata-Typesofdata-Exploratoryvisualizationsofclassicaldatabases-Comparingvisualizationssystems(opensourceandcommercial)-ExploratoryanalyticsComparing analytic / computational systems (open source and commercial) - Integrating visualization and analytics - VAST Challenge problem (single data type, larger data).

Unit II

Classifying the VAST Challenges, the KDD, Amazon, Netflix and Biology Challenges - Data Science challenges - Dealing with text and time - Identify semantic ontologies that support heterogeneous data - Compare analysis vs visualization for one of the text/time VAST Challenges or other data set - Graphs and time - Comparison analysis and visualization results - Identify where analytics is mostusefulandhowvisualizationssupportcomputationalsteering.

Unit III

Text and Documents -Using one of the VAST Challenges that deals with text, emails or web pages overtimeextendtheclassontology-Audioandvideo-extendtheclassontologyforaudioandvideo - Dealingwithdatathatdoesnotfitintomemory-Dataanddimensionalreductionwithguarantees (or constraints) - Alternative algorithms with guarantees - Sampling with guarantees -Streaming data-Realtimedatabases-Taskdrivenandexploratoryapproaches-Exploreandsolveoneofthe complex heterogeneous data setsproblems.

Text Book / References

1. Matthew Ward, Georges Grinstein, and Daniel Keim, Interactive Data Visualization: Foundations, Techniques, and Applications, First Edition, AK Peters,2010.

2. Alexandru C. Telea, Data Visualization: Principles and Practice, First edition, AK Peters, 2008.

3. Pang-Ning Tan, Michael Steinbach and Vipin Kumar, Introduction to Data Mining, Second Edition, Pearson,2018

4. Colin Ware,Information Visualization: Perception for Design, 3rd edition, MorganKaufman, 2012

5. Robert Spence,Information Visualization: Design for Interaction, 2nd Edition, PrenticeHall, 2007

CO-PO Mapping

COs	Description	PO1	PO2	PO3	PO4	PO5
CO1	Differentiate different visualization and computational systems	1	1	1	–	1
CO2	Analyze various challenges in visual analytics	1	2	1	–	1
CO3	Analyze data science challenges in large scale visual analytics	1	2	2	–	1
CO4	Implementalgorithmsforlargescalevisualanalytics	1	3	3	1	1
CO5	Understand the usage of visual analytics for text, audio and video	1	3	1	–	2

Evaluation Pattern - 3E

19AD715 BusinessDataAnalytics 2-0-3-3

Preamble

The course presents an applied approach to data mining concepts and methods, using Python software for illustration. Readers will learn how to implement a variety of popular data mining algorithms to tackle business problems and opportunities. It covers both statistical and machine learning algorithms for prediction, classification, visualization, recommender systems, clustering, text mining.

Course Objectives

- Understandthemethodsforbusinessdataanalytics
- Designsolutionsforbusinessanalyticssolutionsusingcomputerprogramming
- Learnandapplymachinelearningalgorithmsforbusinessdataanalysis

Course Outcomes

CO1	Apply data mining processes, visualize data spread, build predictive models, and evaluate the models
CO2	Extract features, and design a solution for a classification problem employing Regression, NB Classifier and Decision trees
CO3	Design solution using clustering algorithms
CO4	Employ ARIMA and other forecasting methods in business
CO5	Implement solutions for business data analytics real-world problems

Prerequisites

- Foundations of DataScience

Syllabus

Unit I

Introduction - The Steps in Data Mining - Preliminary Steps - Building a Predictive Model - Data Exploration - Data Visualization - Dimension Reduction - Correlation Analysis - Converting a Categorical Variable to a Numerical Variable - Performance Evaluation - Evaluating Predictive Performance - Judging Classifier Performance.

Unit II

Prediction and Classification Methods - Linear Regression - The k-NN Classifier (Categorical Outcome)-TheNaiveBayesClassifier-ClassificationandRegressionTrees-EvaluatingthePerformance of a Classification Tree - Avoiding Overfitting - Logistic Regression - Association Rules andCollaborative Filtering - Cluster Analysis - Measuring Distance - Hierarchical (Agglomerative)Clustering - The k-MeansAlgorithm.

Unit III

Forecasting Time Series - Descriptive vs. Predictive Modeling, Popular Forecasting Methods in Business-Regression-BasedForecasting-AutocorrelationandARIMAModels-MovingAverage-SimpleExponentialSmoothingDataAnalytics-CaseStudies.

Text Book / References

1. Galit Shmueli, Peter C. Bruce, Inbal Yahav, Nitin R. Patel, Kenneth C. Lichtendahl Jr., Data Mining for Business Analytics: Concepts, Techniques, and Applications in Python, First edition, Wiley,2017

2. Jake VanderPlaas, Python Data Science Handbook Essential Tools for Working with Data, First Edition, O Reilly,2016

3. WesMcKinney,PythonforDataAnalysis,DataWranglingwithPandas,Numpy,andIPython, Second Edition, O Reilly,2017

CO-PO Mapping

COs	Description	PO1	PO2	PO3	PO4	PO5
CO1	Apply data mining processes, visualize data spread, build predictive models, and evaluate the models	3	3	1	–	1
CO2	Extract features, and design a solution for a classification problem employing Regression, NB Classifier and Decision trees	2	–	2	–	2
CO3	Design solution using clustering algorithms	2	–	2	–	2
CO4	Employ ARIMA and other forecasting methods in business	2	1	1	–	1
CO5	Implement solutions for business data analytics real-world problems	3	2	3	1	1

Evaluation Pattern - 3E

19AD716 SemanticWeb 2-0-3-3

Preamble

This course facilitates students to understand the rationale behind Semantic web. They should be abletomodelandquerydomainknowledgeasontologiesdefinedusingstandardssuchasRDFand OWL. This in turn helps students to understand the applications of semantic web to web services and Web2.0.

Course Objectives

- Tolearn formal representationlanguages
- TounderstandfundamentalsofSemanticWebtechnologiesandhowtheyareappliedforknowledge representation in the World WideWeb
- To represent knowledge with ontologies and how to access and benefit from semantic data on the Web

Course Outcomes

COs	Description
CO1	Understand the limits of the World Wide Web and need of intelligent web
CO2	UnderstandtheconceptsofWebScience,Needforunderstandingthemeaning, and techniques
CO3	Describing Simple Facts in RDF and OWL.
CO4	Understand the formal methods and methodologies for building ontologies
CO5	Learn Web graph processing and applications of semantic web
CO6	Program web applications and graph processing techniques using appropriate programming languages and tools.

Prerequisites

- PrinciplesofAIandMachineLearning

Syllabus

Unit I

The World Wide Web - Limitations of Todays Web The Next Generation Web Semantic Web - Layers Semantic Web technologies Semantics in Semantic Web XML Basics - RDF Basic Ideas - RDF Specification RDF Syntax: XML and Non- XML RDF elements RDF relationship: Reification, Container, and collaboration RDF Schema Editing, Parsing, and Browsing RDF/XML Discovering Information Querying (RQL, SPARQL).

Unit II

Web Ontology Language (OWL) - Classes, Instances and Properties in OWL - Complex Classes - PropertyRestrictions-RoleInclusion.Ontology-OntologyTypesOntologyEngineering-Ontology Design Methodologies - Ontology Learning - Ontology Alignment - ontology reasoning (RACER) - OntologyEvaluation.

Unit III

The web of data - Data on the web - shallow and deep web - Linked open data - linked data principles - Linkeddatadesign-Publishinglinkeddata-Consumingandaggregatinglinkeddata.

Text Book / References

1. Paul Groth, Frank van Harmelen, Rinke Hoekstra, A Semantic Web Primer, Third edition, MIT press,2012

2. Gmez-Prez, A. Fernndez-Lpez, M. Corcho, O. Ontological Engineering. SpringerVerlag2003

3. Michael C. Daconta, Leo J. Obrst, Kevin T. Smith, The Semantic Web: A Guide to the Future ofXML,WebServices,andKnowledgeManagement,FourthEdition,WilleyPublishing,2003

4. John Davies, Rudi Studer, Paul Warren , Semantic web technologies: Trends and Researchin ontology-based systems, Wiley amp; Sons,2006

CO-PO Mapping

COs	Description	PO1	PO2	PO3	PO4	PO5
CO1	Understand the limits of the World Wide Web and need of intelligent web	2	–	2	1	2
CO2	Understand the concepts of Web Science, Need for understanding the meaning, and techniques	–	–	2	–	2
CO3	Describing Simple Facts in RDF and OWL.	2	3	3	–	–
CO4	Understand the formal methods and methodologies for building ontologies	3	–	2	3	2
CO5	Learn Web graph processing and applications of semantic web	2	2	–	2	–
CO6	Program web applications and graph processing techniques using appropriate programming languages and tools.	2	–	3	–	2

Evaluation Pattern - 3E

DISSERTATION

19AD798 Dissertation 22 Credits

Preamble

Students will work on a dissertation to apply the knowledge of artificial intelligence and data science for solving a wide variety of real-world problems. Problems and concepts may be defined based on extensiveliteraturesurveybystandardresearcharticles.Significanceofproposedproblemandthe state-of the art to be explored. Industry relevant tools may be used for demonstrating the results withphysicalmeaningandcreatenecessaryresearchcomponents.Publicationsinreputedjournals andconferencesmaybeconsideredforauthenticatingtheresults.

Dissertation Outcomes

COs	Description
CO1	To conduct state-of-the-art literature review on identified problem domain
CO2	To design and analyze principles of Artificial Intelligence / Data Science for solving real-world problems / fundamental research issues
CO3	Toevaluate the proposed solution through extensive performance experiments
CO4	To conduct independent research in the areas of Artificial Intelligence / Data Science
CO5	ApplyArtificialIntelligence/DataSciencegivingdueconsiderationtosocietal, environmental, economic and financial factors

CO-PO Mapping

COs	Description	PO1	PO2	PO3	PO4	PO5
CO1	Toconductstate-of-the-artliteraturereviewoniden-tified problem domain	1	1	2	3	3
CO2	To design and analyze principles of ArtificialIntelli-gence/DataScienceforsolvingreal-worldproblems / fundamental research issues	1	1	3	3	3
CO3	To evaluate the proposed solution through extensive performance experiments	–	–	3	3	3
CO4	To conduct independent research in the areas of Ar-tificial Intelligence / Data Science	1	1	2	3	3
CO5	Apply Artificial Intelligence / Data Science giving due consideration to societal, environmental, eco-nomic and financial factors	–	–	–	3	3