M.TECH. DATA SCIENCE

DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING

This program is designed to enable learners to master critical skills such as mathematical modeling, machine learning and artificial intelligence. On the whole, the Master's Program is committed to produce engineers with excellent creative capabilities and caliber to solve real life problems pertaining to industry requirements and advance their career as a Data Scientist or Data Engineer, in tune with the objectives envisioned by Amrita Vishwa Vidyapeetham.

Programme Highlights

1. The curriculum covers areas that prepare you for most lucrative careers in the space of Data Science, Data Engineering and Advanced Analytics. The programme provides extensive knowledge on most popular data science techniques such as mathematical modeling, machine learning, artificial intelligence, product development and scripting languages.

2. Benefit from Case Studies, Simulations, Virtual Labs & Remote Labs that allow learners to apply concepts to simulated and real-world situations. Tools & Technologies covered include Apache Spark, Apache Storm for Big Data Systems/ Real time Processing, Tableau for data visualization, Tensor flow for Deep Learning and various packages within Python for data processing, machine learning and data visualization.

3. The programme offers core courses such as Data Structures and Algorithms, Foundation of Data Science, Big Data Mining, Computational Intelligence, Data Preparation and Analysis, Statistical Learning, Machine Learning, Deep Learning and Time Series Analysis and Forecasting. Industry experts in each stream will be invited to give sessions on practical implications of class room learned concepts in business use cases.

4. Integrated Industry approach for problem solving in the curriculum and the delivery of the course content.

5. The Dissertation enables students to apply concepts and techniques learnt during the programme.

Programme Outcomes:

Students who have completed the M.Tech in Data Science Program will be able to:

- Develop in depth understanding of the key technologies in data science and business analytics such as structured/unstructured data mining, machine learning, visualization techniques, predictive modeling, and statistics.
- Practice problem analysis and decision-making.
- Interpret data, extract meaningful information, and assess findings.

- Effectively communicate data science-related information effectively in various formats to appropriate audiences.
- Apply quantitative modeling and data analysis techniques to transform findings from data resources into actionable business strategies.
- Gain practical, hands-on experience with statistics programming languages and big data tools through coursework and applied research experiences.
- Develop an ability to contribute by research and innovation to solve engineering problems.

CURRICULUM

First Semester

Course Code	Type	Course	L T P	Credits
19MA610	FC	Linear Algebra and Optimization Techniques	3 0 0	3
19DS601	FC	Data Structures and Algorithms	3 0 1	4
19DS611	SC	Big Data Mining	3 0 1	4
19DS612	SC	Statistical Learning	3 0 0	3
19DS613	SC	Computational Intelligence	3 0 0	3
19DS614	SC	Data Preparation and Analysis	2 0 1	3
19HU601	HU	Amrita Values Program*	0	P/F
19HU602	HU	Career Competency I*	0	P/F
		Total Credits		**20**

*Non-credit course

Second Semester

Course code	Type	Course	L T P	Credits
19DS615	SC	Machine Learning	3 0 1	4
19DS616	SC	Deep learning	3 0 1	4
19DS617	SC	Time Series Analysis and Forecasting	2 0 1	3

	E	Elective-I	3 0 0	3
	E	Elective-II	3 0 0	3
19RM600	SC	Research Methodology	2 0 0	2
19HU603	HU	Career Competency II	0 0 2	1
		Total Credits		**20**

Third Semester

Course Code	**Type**	**Course**	**L T P**	**Credits**
	E	Elective-III	3 0 0	3
	E	Elective-IV	3 0 0	3
19DS798	P	Dissertation		8
		Total Credits		**14**

Fourth Semester

Course Code	**Type**	**Course**	**L T P**	**Credits**
19DS799	P	Dissertation		12
		Total Credits		**12**

Total Credits: 66

List of Courses

Foundation Core (FC)

Course Code	Course	L T P	Credits
19MA610	Linear Algebra and Optimization Techniques	3 0 0	3
19DS601	Data Structures and Algorithms	3 0 1	4

Subject Core (SC)

Course Code	Course	L T P	Credits
19DS611	Big Data Mining	3 0 1	4
19DS612	Statistical Learning	3 0 0	3
19DS613	Computational Intelligence	3 0 0	3
19DS614	Data Preparation and Analysis	2 0 1	3
19DS615	Machine Learning	3 0 1	4
19DS616	Deep learning	3 0 1	4
19DS617	Time Series Analysis and Forecasting	2 0 1	3

Electives (E)

Course Code	Course	L T P	Credits
19DS701	Natural Language Processing	3 0 0	3
19DS702	Information Retrieval	3 0 0	3
19DS703	Semantic Web	3 0 0	3
19DS704	Data Visualization	3 0 0	3
19DS705	Networks and Spectral Graph Theory	3 0 0	3
19DS706	Video Analytics	3 0 0	3
19DS707	Content Based Image and Video Retrieval	3 0 0	3
19DS708	3D Modeling for Visualization	3 0 0	3
19DS709	Computer Vision	3 0 0	3
19DS710	Image Analysis	3 0 0	3
19DS711	Reinforcement Learning	3 0 0	3
19DS712	Bio Informatics	3 0 0	3
19DS713	Data Compression	3 0 0	3
19DS714	Modeling and Simulation	3 0 0	3
19DS715	Recommender System	3 0 0	3
19DS716	Data Warehouse and Data Mining	3 0 0	3

19DS717	Web Analytics and Development	3 0 0	3
19DS718	Text Analytics	3 0 0	3
19DS719	Blockchain Technology	3 0 0	3
19DS720	Sensor Networks and IoT	3 0 0	3
19DS721	Predictive Analytics for Internet of Things	3 0 0	3
19DS722	Data Intensive Computing	3 0 0	3
19DS723	Parallel and Distributed Computing	3 0 0	3
19DS724	Pervasive Computing	3 0 0	3
19DS725	Data Security and Access Control	3 0 0	3
19DS726	Cloud Computing &Security in the Cloud	3 0 0	3
19DS727	Embedded Systems for Data Analytics	3 0 0	3

Students are allowed to choose the electives offered under M. Tech (DS)

19MA610LINEAR ALGEBRA AND OPTIMIZATION TECHNIQUES3-0-0-3

Linear Algebra: Review of Matrices: Geometry of linear equations, real vector spaces (Rn, matrices etc.) and subspaces, linear independence, basis and dimensions, linear transformations, orthogonality, Orthogonal basis, Gram Schmidt Process projections and least square applications, Eigenvalues, Eigenvectors, and Diagonalization, singular value decomposition. Positive definite Matrices-Minima, Maxima and saddle points, Test of Positive definiteness, semi-definite and indefinite Matrices.

Introduction- Formulation of optimization problems, classification of optimization problems,overview of analytical solution for unconstrained optimization problems, constrained optimization, convex set, convex functions, convex optimization problem, Kuhn-Tucker conditions, Search methods – Overview of single variable search methods, search methods for Multivariable unconstrained problems - Optimality criteria, unidirectional search – direct search methods- evolutionary search method, Hook-Jeeves pattern search method, gradient based methods –Cauchy's steepest descent method, Newton's method.

TEXT BOOKS/ REFERENCES:

1. Gilbert Strang, Linear Algebra and its Applications, Fourth Edition, Cambridge University Press. 2009.
2. Howard Anton and Chris Rorrers," Elementary Linear Algebra", Tenth Edition, 2010 John Wiley & Sons, Inc.
3. Kalyanmoy Deb, "Optimization for Engineering Design Algorithms and Examples", Prentice Hall of India, New Delhi, 2004.
4. S.S. Rao, "Optimization Theory and Applications", Second Edition, New Age International (P) Limited Publishers, 1995
5. M. AsgharBhatti, "Practical Optimization Methods: with Mathematics Applications", Springer Verlag Publishers, 2000.

Course Outcomes

	Course Outcomes
CO1	Understand fundamental properties of matrices including inverse matrices, eigenvalues and linear transformations. Be able to solve linear systems of equations.
CO2	understand the notions of a vector space, a subspace, linear dependence and independence, spanning sets and bases within the familiar setting of R2, R3..Rn etc.
CO3	Have an insight into the applicability of linear algebra.

CO4	Understand importance of optimization for Data Science & apply basic concepts of mathematics to formulate and understand the type of an optimization problem
CO5	Understand all the analytical methods for solving unconstrained optimization problems and convex constrained optimization problems
CO6	Understand all the search methods to solve single and multivariable unconstrained optimization problems

19DS601 DATA STRUCTURES AND ALGORITHM 3-0-1-4

Introduction to Algorithm Analysis Methodologies.Asymptotic notation – Big Oh, Big Theta, Big Omega.

Linear Data Structures – Linked Lists: - Singly LL, Doubly LL, Circular LL. Implementation–Applications. Stacks:-Implementation using Arrays and Linked Lists –Applications in Recursion. Queues -Implementation and Applications. Binary Trees -Basic tree traversals -Binary tree -Priority queues -Binary search tree.

Graphs -Data Structures for Graphs, Types of Graphs: Directed Graphs, Weighted Graphs, etc. Basic definitions and properties of Graphs, Graph Traversal –Breadth First Search and their applications, Spanning trees, Shortest Paths.
Hash tables – Collision using Chaining – Linear Probing – Quadratic Probing – Double Hashing.

Algorithm Design Techniques: Divide and Conquer technique. Mergesort, Quicksort and binary search.Complexity of recursive algorithms - Recurrence Relations and their solutions.Recursion tree method and Master theorem. Greedy Algorithms - Fractional Knapsack – Scheduling Algorithms. Introduction to: DP Algorithms – Subsequence Problems – 0-1 Knapsack.

Introduction to external memory algorithms: Distribution sorting, Sorting by merging, external graph algorithms.Text Processing: String Operations, Brute-Force Pattern Matching, The Boyer-Moore Algorithm, The Knuth-Morris-Pratt Algorithm, Standard Tries

TEXT BOOKS/ REFERENCES:

1. Thomas H Cormen, Charles E Leiserson, Ronald L Rivest and Clifford Stein, “Introduction to Algorithms”, Third Edition, Prentice Hall of India Private Limited, 2009.
2. Michael T Goodrich and Roberto Tamassia, “Algorithm Design Foundations - Analysis and Internet Examples”, John Wiley and Sons, 2007.

3. Dasgupta S, Papadimitriou C and Vazirani U, “Algorithms”, Tata McGraw-Hill, 2009.
4. Jeffrey Scott Vitter, “Algorithms and Data Structures for External Memory (Foundations and Trends (R) in Theoretical Computer Science)”, 2008

Course Outcomes

	Course Outcomes
CO1	Understand the concept and functionalities of Data Structures
CO2	Understand various algorithmic design techniques and solve classical problems
CO3	Identify and apply appropriate data structures and algorithms to solve problems and improve their efficiency
CO4	Analyze the complexity of data structures and Algorithms
CO5	Analyze the impact of various implementation and design choices on the data structure performance

19DS611 BIG DATA MINING 3-0-0-3

Introduction to big data- convergence of key trends, unstructured data, industry examples of big data, web analytics, big data and marketing, fraud and big data, risk and big data, credit risk management, big data and algorithmic trading, big data and healthcare, big data in medicine, advertising and big data, big data technologies, introduction to Hadoop, open source technologies, cloud and big data, mobile business intelligence, Crowd sourcing analytics, inter and trans firewall analytics.

Introduction to DBMS and NoSQL, aggregate data models, aggregates, key-value and document data models, relationships, graph databases, schemaless databases, materialized views, distribution models, sharding, master-slave replication, peer-to-peer replication, sharding and replication, consistency, relaxing consistency, version stamps, map-reduce, partitioning and combining, composing map-reduce calculations.

Data format, analyzing data with Hadoop, scaling out, Hadoop streaming, Hadoop pipes, design of Hadoop distributed file system (HDFS), HDFS concepts, Java interface, data flow, Hadoop I/O, data integrity, compression, serialization, Avro, file-based data structures

MapReduce workflows, unit tests with MRUnit, test data and local tests, anatomy of MapReduce job run, classic Map-reduce, YARN, failures in classic Map-reduce and YARN, job scheduling, shuffle and sort, task execution, MapReduce types, input formats, output formats, Apache Spark

Hbase, data model and implementations, Hbase clients, Hbase examples, praxis.Cassandra, Cassandra data model, Cassandra examples, Cassandra clients, Hadoop integration.
Pig, Grunt, pig data model, Pig Latin, developing and testing Pig Latin scripts. Hive, data types and file formats, HiveQL data definition, HiveQL data manipulation, HiveQL queries.

TEXT BOOKS/ REFERENCES:

1. Michael Minelli, Michelle Chambers, and AmbigaDhiraj, "Big Data, Big Analytics: Emerging
2. P. J. Sadalage and M. Fowler, "NoSQL Distilled: A Brief Guide to the Emerging World of Polyglot Persistence", Addison-Wesley Professional, 2012.
3. Tom White, "Hadoop: The Definitive Guide", Fourth Edition, O'Reilley, 2015.
4. Eric Sammer, "Hadoop Operations", Second Edition, O'Reilley, 2015.
5. E. Capriolo, D. Wampler, and J. Rutherglen, "Programming Hive:Data Warehouse and Query Language for Hadoop"", O'Reilley, 2012.
6. Lars George, "HBase: The Definitive Guide", Second Edition, O'Reilley, 2017.
7. Jeff Carpenter,Eben Hewitt, "Cassandra: The Definitive Guide", O'Reilley, 2016.
8. Alan Gates, Daniel Dai, "Programming Pig", O'Reilley, 2016.
9. SeemaAcharya, SubhashiniChellappan, "Big Data and Analytics", First Edition, Wiley, 2015.

Course Outcomes

	Course Outcome
CO1	To provide an overview of an exciting growing field of big data analytics
CO 2	To understand (i) The concept of Big Data and the various applications for which Big data analytics can be employed (ii) The concept of NoSQL databases (iii) To introduce the tools like Apache Hadoop, Apache Spark , Apache Cassandra, Apache Pig, Apache Hive and Apache HBase to manage and analyze big data
CO 3	To teach the fundamental techniques and principles in collecting, managing, storing, querying, and analyzing various forms of big data
CO4	To understand the differences between SQL and NoSQL databases

CO 5	To enable students to have hands-on experience on Big data technologies like MapReduce and tools that will help them to solve some open big data problems

19DS612 STATISTICAL LEARNING 3-0-0-3

Probability, Random Variables & Probability Distributions.Sampling, analysis of sample data--Empirical Distributions, Sampling from a Population Estimation, confidence intervals, point estimation--Maximum Likelihood.

Test of Hypothesis-- Z, t, Chi-Square & F-test. ANOVA & Designs of Experiments--Single, Two factor ANOVA, Factorials ANOVA models.

Correlation & Regression Models-- linear regression methods, Ridge regression, LASSO, univariate and Multivariate Linear Regression, probabilistic interpretation, Regularization, Logistic regression, locally weighted regression.

TEXT BOOKS/ REFERENCES:

1. Gareth James, Daniela Witten, Trevor Hastie, Robert Tibshirani, “An Introduction to Statistical Learning with Applications in R”, Springer 2013
2. Nils Nilsson, “Artificial Intelligence, A New Synthesis”, PHI, 2000
3. Douglas C. Montgomery and George C. Runger, “Applied Statistics and Probability for Engineers”, Third Edition, John Wiley & Sons Inc., 2003.
4. Ronald E. Walpole, Raymond H Myres, Sharon.L.Myres and Kying Ye, “Probability and Statistics for Engineers and Scientists”, Seventh Edition, Pearson Education, 2002.

Course Outcomes

	Course Outcomes
CO1	Learn basis of probability & probability distributions
CO2	Learn & use estimation and hypothesis testing procedures to make conclusions about populations based on information from samples.
CO3	Build and perform correlation and regression models
CO4	Use R to perform data analysis associated with statistical inference for a well-defined application model

19DS613 COMPUTATIONAL INTELLIGENCE 3-0-0-3

Computational intelligence (CI): Adaptation, Self-organization and Evolution, Biological and artificial neuron, Neural Networks Basic Concepts,- Single Layer perceptron-Multilayer

perceptron- Supervised and unsupervised learning- Back propagation networks-Kohnen's self-organizing networks-Hopfield networks- Implementations.
Fuzzy systems: Basic Concepts, Fuzzy sets- properties- membership functions- fuzzy operations, Applications, Implementation, Hybrid systems
Evolutionary computing: -Introduction to Genetic Algorithms. The GA computation process-natural evolution-parent selection-crossover-mutation-properties - classification – Advances in the theory GA. Genetic Programming, Particle Swarm optimization, Ant Colony optimization, artificial immune Systems.CI application: case studies may include image processing, digital systems, control, forecasting and time-series predictions.

TEXT BOOKS/ REFERENCES:

1. R.C. Eberhart, "Computational Intelligence: Concept to Implementations", Morgan Kaufmann Publishers, 2007.
2. Les Sztandera, Computational Intelligence in Business Analytics: Concepts, Methods, and Tools for Big Data Applications. Pearson FT Press, First Edition, 2014
3. Andries P. Engelbrecht, "Computational Intelligence: An Introduction", 2012
4. Laurence Fausett, "Fundamentals of Neural Networks", Prentice Hall,1994
5. Timothy J Ross, "Fuzzy Logic with Engineering Applications", Third Edition, Wiley, 1995.

Course Outcomes

	Course Outcomes
CO1	To understand the fundamental theory and concepts of neural networks, neuro-modeling, several neural network paradigms and its applications.
CO2	To understand the concepts of fuzzy sets, knowledge representation using fuzzy rules, approximate reasoning, fuzzy inference systems, and fuzzy logic control and other machine intelligence applications of fuzzy logic.
CO3	To understand the basics of an evolutionary computing paradigm known as genetic algorithms and its application to engineering optimization problems.
CO4	To apply on business/research use case using software tools
CO5	To design the intelligent system for a business/research use case

19DS614 DATA PREPARATION AND ANALYSIS 2-0-1-3

Data Gathering and Preparation: Numeric and linguistic data Data formats, parsing and transformation, Scalability and real-time issues, Data Cleaning: Consistency checking, Heterogeneous and missing data, Data Transformation and segmentation. Exploratory Analysis: Descriptive and comparative statistics, Clustering and association, Hypothesis generation. Visualization: Designing visualizations, Time series, Geo located data, Correlations and connections, Hierarchies and networks, interactivity.

TEXT BOOKS/ REFERENCES:

1. Glenn J. Myatt, Making sense of Data : A practical Guide to Exploratory Data Analysis and Data Mining, 2007, Wiley publications
2. Cathy O'Neil and Rachel Schutt. Doing Data Science, Straight Talk From The Frontline. O'Reilly. 2014.
3. AniAdhikari and John DeNero Online textbook: Computational and Inferential Thinking: The Foundations of Data Science. 2019

Course Outcomes

	Course Outcomes
CO1	To understand and implement how to prepare data prior to analysis
CO2	To understand and implement generation of summaries of the data
CO3	To identify non-trivial facts, patterns, and relationships in the data
CO4	To create models from the data to better understand the data and make predictions
CO5	To implement and design on a specific business/research use case

19DS615 MACHINE LEARNING 3-0-1-4

Introduction: Machine learning, Terminologies in machine learning, Types of machine learning supervised, unsupervised, semi-supervised learning, parametric and nonparametric models, curse of dimensionality, bias and variance, overfitting.

Classification: Decision Trees, CART, Decision Rules, Instance based learners, Support Vector Machines- Large margin classifiers, Nonlinear SVM, kernel functions, SMO algorithm. Evaluating classifiers, Ensemble Methods: Bagging - Simple methods, Boosting -

Adaboost, Gradient Boosting, Random Forest. Directed Graphical Models: Bayes nets, Learning Bayes nets, Markov and hidden Markov models.

Dimensionality reduction - Factor analysis, Principal components analysis, Independent Component Analysis

Clustering: EM algorithm, partitioned, hierarchical and density based clustering. Evaluating cluster quality.

Computational Learning theory- Sample complexity, ε- exhausted version space, PAC Learning, agnostic learner, VC dimensions, Sample complexity. ML Lab- SciLearn using Python

TEXT BOOKS/ REFERENCES:

1. John D. Killeher, Brian Mac, Namee, AoiFE D'Arcy, Fundamental of Machine Learning for Predictive Data Analytics, 2015 MIT press
2. AurélienGéron, Hands-On Machine Learning with Scikit-Learn and TensorFlow: Concepts, Tools, and Techniques to Build Intelligent Systems 1st Edition, O'REILY, 2017.
3. Python Machine Learning by Example, Yuxi (Hayden) Liu, First Edition, 2017.
4. Alex Smola and SVN. Viswanathan, "Introduction to Machine Learning", Cambridge University Press, 2008.
5. ShaiShalev-Shwartz and Shai Ben-David, "Understanding Machine Learning: From Theory to Algorithms", Cambridge University Press, 2014.
6. Tom Mitchell, "Machine Learning", McGraw Hill, 1997.
7. E. Alpaydin, "Introduction to Machine Learning", PHI, 2005.
8. Kevin P. Murphy, "Machine Learning, a Probabilistic Perspective", The MIT Press Cambridge, Massachusetts, 2012.

Course Outcomes

	Course Outcomes
CO1	Understand issues and challenges of machine learning: data, model selection, model complexity
CO2	Design and implement various machine learning algorithms in a range of real-world applications
CO3	Understand strengths and weaknesses of many popular machine learning approaches
CO4	Analyze the underlying mathematical relationships within and across Machine Learning algorithms
CO5	Apply the paradigms of supervised and un-supervised learning

19DS616 DEEP LEARNING 3-0-0-3

Basics of Parallelization and Parallelization strategies, Parallel/Distributed Computing Models, Shared and Distributed memory architectures, Sequential Vs Parallel programming models, Speed up and Amdahl's Law, CPU Vs GPU, tools of parallel computing - OpenMP, MPI, CUDA

Review of Neural Networks Basics, Introduction to TensorFlow, Programming structure in TensorFlow, Neural Network models using TensorFlow.

Computation graph, Data classification with a hidden layer – Deep Neural Networks: Deep L-layer neural network, Forward and Backward propagation, Deep representations, Parameters vsHyperparameters

Building a Deep Neural Network (Application) - Supervised Learning with Neural Networks – Practical aspects of Deep Learning: Train/Dev / Test sets, Bias/variance, Overfitting and regularization, Linear models and optimization, Vanishing/exploding gradients, Gradient checking – Logistic Regression, Convolution Neural Networks, RNN and Backpropagation – Convolutions and Pooling – Optimization algorithms: Mini-batch gradient descent, exponentially weighted averages, RMSprop, Learning rate decay, problem of local optima, Batch norm – Parameter tuning process.

Neural Network Architectures – Recurrent Neural Networks, Adversarial NN, Spectral CNN, Self-Organizing Maps, Restricted Boltzmann Machines, Long Short-Term Memory Networks (LSTM), Deep Meta Learning - Deep Reinforcement Learning

TEXT BOOKS/ REFERENCES:

1. Ian Goodfellow, YoshuaBengio and Aeron Courville, Deep Learning, MIT Press,First Edition, 2016.
2. Gibson and Josh Patterson, Deep Learning A practitioner’s approach, Adam O’Reilly, First Edition, 2017.
3. AurelienGeron, Hands-On Learning with Scikit-Learn and Tensorflow, O’Reilly, First Edition, 2017.
4. Francois Chollet, Deep Learning with Python, Manning Publications Co, First Edition, 2018.
5. Yuxi (Hayden) Liu, Python Machine Learning by Example, First Edition, 2017.
6. Geoffrey Hinton, 2010, https://www.cs.toronto.edu/~hinton/absps/guideTR.pdf
7. Peter Pacheco, An Introduction to Parallel Programming, Elsevier, 2011
8. Barry Wilkinson and Michael Allen, Parallel Programming: Techniques and Applications using Networked Workstations and Parallel Computers, 2nd Edition, Pearson Education, 2006

Course Outcomes

	Course Outcome
CO1	Apply deep neural networks from building to training models
CO2	Understand and use dropout regularization, Batch normalization and gradient checking in deep neural nets
CO3	Apply mini-batch, gradient descent, Momentum, RMSprop and Adam optimization algorithms with convergence
CO4	Understand train/dev/test datasets and test bias/variance
CO5	Analyse neural networks using tools - Tensorflow/Keras/MatConvNet
CO6	Analyse detection and recognition tasks using convolution/adversarial neural networks

19DS617 TIME SERIES ANALYSIS AND FORECASTING 2-0-1-3

(Prerequisites: Probability and Stochastic Processes)

Planning and Forecasting – Forecasting process – Time Series patterns – Statistical fundamentals for forecasting – Descriptive statistics - Measuring errors – Correlation and Covariance – Autocorrelations – Linear Regression analysis – Dependent and independent variables - Method of least square deviations - Durbin-Watson Statistic – Univariate methods, Univariate ARIMA methods – ARIMA model identification –Time series examples – Integrated Stochastic process – Backward shift operator - Autoregressive processes – Yule-Walker equations - ARIMA prediction intervals - Multiple Regression models – Serial correlation – Elasticities and Logarithmic relationships - Heteroscedasticity – Intervention functions – Nonstationary series – ARIMA intervention analysis, Smoothing methods – Decomposition methods – Trend-Seasonal and Holt-Winters smoothing - SARIMA processes - SARIMA fitting - Akaike Information Criterion and Model Quality – Schwarz Bayesian Information Criterion – Multivariate ARIMA modeling – Cyclical forecasting methods

TEXT BOOKS / REFERENCES:

1. Stephen A. Delurgio, “Forecasting Principles and Applications”, McGraw-Hill International Editions, 1998.
2. George E. P. Box, Gwilym M. Jenkins, Gregory C. Reinsel, Greta M. Ljung, “Time Series Analysis: Forecasting and Control”, Wiley, 5th Edition, 2015.

3. Terence C. Mills, “The Foundations of Modern Time Series Analysis”, Palgrave Macmillan, 2011
4. Kerry Patterson, “An Introduction to Applied Econometrics - A Time Series Approach”, Macmillan Press Limited, 2000.

Course Outcomes

	Course Outcome
CO1	Understand the principles and process of forecasting
CO2	Apply and analyze Univariate ARIMA methods for real world problems
CO3	Apply and analyze Smoothing methods for real world problems
CO4	Apply various criteria for evaluating model quality
CO5	Apply and analyze multivariate methods for real world problems

18RM600 RESEARCH METHODOLOGY 2-0-0-2

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.

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, Citation indexes

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

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

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

TEXT BOOKS/ 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; 6 edition July 2012

Course Outcomes

	Course Outcome
CO1	To define research, methodology and steps involved in research
CO2	To learn to define a problem, and research hypothesis. To understand the importance of literature survey, gaps and challenges
CO3	To learn the basic concepts of research design, sampling, modeling & simulation and understand the importance of citation, H-index, Scopus
CO4	To learn to write technical report, paper and thesis
CO5	To know about intellectual property rights, ethics in research and plagiarism

19DS701 NATURAL LANGUAGE PROCESSING 3-0-0-3

NLP tasks in syntax, semantics, and pragmatics. Applications such as information extraction, question answering, and machine translation. The problem of ambiguity. Basic Laws(Zif's law, Heaps law), Basic text processing, spelling correction, Corpus based work: Looking up text - Marked-up data. Introduction of NLTK Tool and programming with NLTK. N-gram Language Models- The role of language models. Simple N-gram models. Estimating parameters and smoothing. Evaluating language models.Part Of Speech Tagging and Sequence Labeling-Lexical syntax.Hidden Markov Models (Forward and Viterbi algorithms and EM training). Entropy based Markov Model(MEMM), POS tagging using Conditional Random Field(CRF). Syntactic parsing-Grammar formalisms and treebanks.Efficient parsing for context-free grammars (CFGs).Statistical parsing and probabilistic CFGs (PCFGs).overview of Lexicalized PCFGs. Semantic Analysis- Lexical semantics-Distributional hypothesis and word-sense disambiguation, Statistical alignment and Machine translation: Text alignment – Word alignment – Statistical Machine Translation.

TEXT BOOKS/ REFERENCES:

1. Bird, S., Klein, E., &Loper, E. (2009). Natural language processing with Python. O'Reilly Media, Inc.
2. Jurafsky, D. & Martin, J. H. (2008). Speech & language processing. Pearson.
3. Manning, C. D., Raghavan, P., & H. Schutze. (2008). Introduction to information retrieval. Cambridge University Press.
4. Julia Silge and David Robin, Text Mining with R, O'REILLY, 2017

Course Outcomes

	Course Outcome
CO1	Understand the models, methods, and algorithms of statistical Natural Language Processing (NLP) for common NLP tasks
CO2	Understand mathematical and statistical models for NLP
CO3	Understand linguistic phenomena and linguistic features relevant to each NLP task
CO4	Apply probabilistic models in code
CO5	Apply learning models to NLP tasks such as speech recognition, machine translation, spam filtering, text classification, and spell checking

19DS702 INFORMATION RETRIEVAL 3-0-0-3

Introduction to Information Retrieval -the nature of unstructured and semi-structured text.Inverted index and Boolean queries. Text Indexing, Storage and Compression-text encoding: tokenization, stemming, stop words, phrases, index optimization. Index compression: lexicon compression and postings lists compression. Gap encoding, gamma codes, Zipf's Law.Index construction. Postings size estimation, merge sort, dynamic indexing, positional indexes, n-gram indexes, real-world issues. Retrieval Models: Boolean, vector space, TFIDF, Okapi, probabilistic, language modeling, latent semantic indexing. Vector space scoring.The cosine measure.Efficiency considerations.Document length normalization.Relevance feedback and query expansion.Rocchio algorithm.Performance Evaluation-Evaluating search engines.User happiness, precision, recall, F-measure. Creating test collections: kappa measure, interjudge agreement. Text Categorization and Filtering-Introduction to text classification.Naive Bayes models. Spam filtering. Vector space classification using hyperplanes; centroids; k Nearest Neighbors. Support vector machine classifiers. Kernel functions. Boosting.Text Clustering-Clustering versus classification.Partitioning methods.k-means clustering. Mixture of Gaussians model.Hierarchical agglomerative clustering.Clustering terms using documents. Advanced Topics-Summarization, Topic detection and tracking, Personalization, Question answering, Cross language information retrieval. Web Information Retrieval: Hypertext, web crawling, search engines, ranking, link analysis, PageRank, HITS.Retrieving Structured Documents-XML retrieval, semantic web

TEXT BOOKS/ REFERENCES:

1. C. Manning, P. Raghavan, and H. Schütze, “Introduction to Information Retrieval”, Cambridge University Press, 2008.
2. R. Baeza-Yates and B. RibeiroNeto,“Modern Information Retrieval: The Concepts and Technology behind Search”, Second Edition, Addison Wesley, 2011.
3. David A. Grossman and OphirFrieder “Information Retrieval: Algorithms and Heuristics”, Second Edition, Springer 2004.
4. Stefan Büttcher, Charles L. A. Clarke and Gordon V. Cormack, "Information Retrieval Implementing and Evaluating Search Engines" , MIT Press, 2010

Course Outcomes

	Course Outcome
CO1	Understand boolean and vector space methods for IR
CO2	Apply efficient text indexing to application scenarios
CO3	Understand traditional machine learning based ranking approaches
CO4	Apply document clustering and classification
CO5	Understand IR techniques for the web, including crawling, linkbased algorithms, and metadata usage

19DS703 SEMANTIC WEB 3-0-0-3

The World Wide Web - Limitations of Today's Web – The Next Generation Web – Semantic Web - Layers –Semantic Web technologies – Semantics in Semantic Web – XML: Basics – Well-formed and valid Documents – Namespaces - XML schema – Addressing – Querying - Document Object Model (DOM) – XML Applications – XML limitations. 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) – Web Ontology Language (OWL) - Classes, Instances and Properties in OWL - Complex Classes - Property Restrictions - Role Inclusion. Ontology - Ontology Types – Logic - Description Logics - Rules - Inference and Reasoning - Ontology Engineering : Introduction – Constructing ontologies – Tools used in building and storing ontologies (Sesame, Jena, Protégé, NeOn) – Reusing ontologies – ontology reasoning. The web of data - Data on the web - shallow and deep web - Linked open data - linked data principles - Linked data design - Publishing linked data - Consuming and aggregating linked data.

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TEXT BOOKS/ REFERENCES:

1. Paul Groth, Frank van Harmelen, Rinke Hoekstra. A Semantic Web Primer, Third Edition, MIT press; 2012.
2. Michael C. Daconta, Leo J. Obrst, and Kevin T. Smith, "The Semantic Web: A Guide to the Future of XML, Web Services, and Knowledge Management", Fourth Edition, Wiley Publishing, 2003.
3. John Davies, Rudi Studer, and Paul Warren John, "Semantic Web Technologies: Trends and Research in Ontology-based Systems", Wiley and Son, 2006.
4. John Davies, Dieter Fensel and Frank Van Harmelen, "Towards the Semantic Web: Ontology- Driven Knowledge Management", John Wiley and Sons, 2003.

Course Outcomes

	Course Outcome
CO1	Understand and discuss fundamental concepts, advantages and limits of the semantic web
CO2	Understand and use ontologies in the context of Computer Science and the semantic web
CO3	Understand the relationship between Semantic Web and Web 2.0

CO4	Apply the RDF framework for Semantic Web L3
CO5	Understand the concepts of metadata, semantics of knowledge and resource, ontology, and their descriptions in XML-based syntax and web ontology language (OWL)

19DS704DATA VISUALIZATION 3-0-0-3

Overview of Data Visualization – "What's Vis and Why Do It?": Why Visualize Data? – The Shapes of Data – What: Data Abstraction – Why: Task Abstraction: Inputs for Visualization Data and Tasks. Case Study Example: Charles Joseph Minard – Napoleon's Invasion of Russia. Introduction to R Programming – Creation of Basic Visualization using R: Histogram, Bar / Line Chart, Box plot, Scatter plot (Examples and Exercises to be given for practice).

Marks and Channels – Encoding Data, Rendering Marks and Channels – Rules of Thumb: No Unjustified 3D and 2D – Arrange Tables: Reusable Scatter plot – Common Visualization Idioms: Bar Chart (Vertical and Horizontal), Pie Chart and Coxcomb plot, Line Chart, Area Chart. Case Study Example: The Cheddar Cheese Data Set – Creation of Scatter Plot Matrix (SPLOM) to analyze the taste of Cheddar Cheese – Visualization of Spatial Data, Networks and Trees: Arrange Spatial Data, Arrange Networks and Trees.

Using Color and Size in Visualization – Map Color and other Channels: Encoding Data using Color, Size; Stacked Bar Chart; Streamgraph; Line Charts with multiple lines – Creation of Advanced Visualization using R: Heat Map, 3D graphs, Colormaps – Interaction Techniques: Manipulate View – Panning and Zooming on a Globe – Facet into Multiple Views: Juxtapose and Coordinate views – Linked Navigation: Bird's Eye Map – Reduce Items and Attributes: Filter and Aggregate. Case Study Exercise using R: Impact of Vaccines on battling Infectious diseases (Source: Benefits from Immunization During the Vaccines for Children Program Era — United States, 1994–2013).

TEXT BOOKS/REFERENCES:

1. Tamara Munzner, Visualization Analysis and Design, A K Peters Visualization Series, CRC Press, 2014.
2. Scott Murray, Interactive Data Visualization for the Web, O'Reilly, 2013.
3. Alberto Cairo, The Functional Art: An Introduction to Information Graphics and Visualization, New Riders, 2012

4. Nathan Yau, Visualize This: The FlowingData Guide to Design, Visualization and Statistics, John Wiley & Sons, 2011.

Course Outcomes

	Course Outcome
CO1	Understand the key techniques and theory behind data visualization
CO2	Use effectively the various visualization structures (like tables, spatial data, tree and network etc.)
CO3	Evaluate information visualization systems and other forms of visual presentation for their effectiveness
CO4	Design and build data visualization systems

19DS705 NETWORKS AND SPECTRAL GRAPH THEORY 3-0-0-3

Graphs and Networks- Review of basic graph theory, Mathematics of networks- Networks and their representation, Graph spectra, Graph Laplacian, Thevisstructure of complex networks, Clustering, Community structures, Social networks - the web graph, the internet graph, citation graphs.

Measures and metrics- Degree centrality, Eigenvector centrality, Katz centrality, PageRank, Hubs and authorities, Closeness centrality, Betweenness centrality, Transitivity, Reciprocity, Similarity, assortative mixing.

Networks models - Random graphs, Generalized random graphs, The small-world model, Exponential random graphs, The large-scale structure of networks- small world effect, Degree distributions, Power laws and scale-free networks; Structure of the Internet, Structure of the World Wide Web.

Fundamental network algorithms- Graph partitioning, Maximum flows and minimum cuts, Spectral graph partitioning, Community detection, Girvan and Newman Algorithm, Simple modularity maximization, Spectral modularity maximization, Fast methods based on the modularity.

TEXT BOOKS/ REFERENCES:

1. M.E.J. Newman, “Networks: An Introduction”, Oxford University Press, 2010.
2. Dougles West, “Introduction to Graph Theory”, Second Edition, PHI Learning Private Limited, 2011.
3. Guido Caldarelli, “Scale-Free Networks”, Oxford University Press, 2007.

4. Alain Barrat, Marc Barthelemy and Alessandro Vespignani, “Dynamical processes on Complex networks”, Cambridge University Press, 2008.
5. Reuven Cohen and ShlomoHavlin, “Complex Networks: Structure, Robustness and Function”, Cambridge University Press, 2010.
6. ReinhardDiestel, “Graph Theory”, Springer GTM 173, 5th edition 2016

Course Outcomes

	Course Outcome
CO1	Describe fundamental tools to study networks, mathematical models of network structure, computer algorithms for network data analysis and the theories of processes taking place on networks.
CO2	Experience working with complex network data sets and implement computer algorithms to solve network problems, use modern network tools to analyze data
CO3	Compare different solutions of large network problems in terms of network performance measures, Compare structure of different types of networks
CO4	Design algorithms to solve large real-world network problems, devise models of network structure to predict the behavior of networked systems.

19DS706 VIDEO ANALYTICS 3-0-0-3

Introduction: Video Analytics. Computer Vision: Challenges- Spatial Domain Processing – Frequency Domain Processing-Background Modeling-Shadow Detection-Eigen Faces - Object Detection -Local Features-Mean Shift: Clustering, Tracking - Object Tracking using Active Contours – Tracking & Video Analysis: Tracking and Motion Understanding – Kalman filters, condensation, particle, Bayesian filters, hidden Markov models, change detection and model based tracking- Motion estimation and Compensation-Block Matching Method, Hierarchical Block Matching, Overlapped Block Motion and compensation,Pel-Recursive Motion Estimation,Mesh Based Method, Optical Flow Method - Motion Segmentation -Thresholding for Change Detection, Estimation of Model parameters - Optical Flow Segmentation-Modified Hough Transform Method- Segmentation for Layered Video Representation-Bayesian Segmentation-Simultaneous Estimation and Segmentation-Motion Field Model - Action Recognition - Low Level Image Processing for Action Recognition: Segmentation and Extraction, Local Binary Pattern, Structure from Motion - Action Representation Approaches: Classification of Various Dimension of Representation, View Invariant Methods, Gesture Recognition and Analysis, Action Segmentation. Case Study:

Face Detection and Recognition, Natural Scene Videos, Crowd Analysis, Video Surveillance, Traffic Monitoring, Intelligent Transport System.

TEXT BOOKS/ REFERENCES:

1. Richard Szeliski, “Computer Vision: Algorithms and Applications”, Springer, 2011.
2. Yao Wang, JornOstermann and Ya-Qin Zhang, “Video Processing and Communications”, Prentice Hall, 2001.
3. A.MuratTekalp, “Digital Video Processing”, Pearson, 1995.
4. Thierry Bouwmans, FatihPorikli, Benjamin Höferlin and Antoine Vacavant ,“Background Modeling and Foreground Detection for Video Surveillance: Traditional and Recent Approaches, Implementations, Benchmarking and Evaluation", CRC Press, Taylor and Francis Group, 2014.
5. Md. AtiqurRahmanAhad, "Computer Vision and Action Recognition-A Guide for Image Processing and Computer Vision Community for Action Understanding", Atlantis Press, 2011.
6. Debjyoti Paul and CharanPuvvala Video Analytics Using Deep Learning: Building Applications with TensorFlow, Keras, and YOLO Paperback – Nov 2019

Course Outcomes

	Course Outcome
CO1	Understand the algorithms available for performing analysis on video data and address the challenges
CO2	Understand the approaches for identifying and tracking objects and person with motionbased algorithms.
CO3	Understand the algorithms available for searching and matching in video content
CO4	Analyze approaches for action representation and recognition
CO5	Identify, Analyze and apply algorithms for developing solutions for real world problems

19DS707 CONTENT BASED IMAGE AND VIDEO RETRIEVAL 3-0-0-3

Architecture and Design: Introduction - Architecture of content-based image and video retrieval -Designing an image retrieval system - Designing a video retrieval system. Feature extraction and similarity measure: Color - Texture - Shape - Spatial relationships - MPEG 7 features. Video Indexing and understanding- Query Language for multimedia search- Relevance feedback- Semantic based retrieval – Trademark image retrieval- Standards relevant to Content based image retrieval- Query Specification - Metadata description. Content based video Retrieval: Feature extraction - Semantics understanding -Summarization - Indexing and retrieval of video, Case studies and applications.

TEXT BOOKS / REFERENCES:

1. Oge Marques and BorkoFurht, “Content Based Image and Video Retrieval”, Multimedia Systems and Applications, Springer, 2002
2. Lew, Michael S, “Principles of Visual Information Retrieval”, Advances in Pattern recognition, Springer, 2001.
3. Vittorio Castelli and Lawrence D. Bergman Image Databases: Search and Retrieval of Digital Imagery , Wiley-Interscience, 2001
4. Alan Hanjalic, Content-Based Analysis Of Digital Video,Springer, 2004.

Course Outcomes

	Course Outcome
CO1	Understand the modules involved in designing CBIVR systems and their applications
CO2	Extract different visual features from images and videos
CO3	Understand query specification and evaluate the retrieval
CO4	Understand indexing and the semantics of visual data
CO5	Develop and evaluate visual retrieval algorithms

19DS708 3D MODELING FOR VISUALIZATION 3-0-0-3

Introduction to Graphics, Two-dimensional Geometric Transformations, Three-dimensional Concepts. Modeling: Three-Dimensional Object Representations: Raw 3D data, Surface Representation, Solid Representation, High-Level Representation. Reconstruction of 3D Meshes from Polygon Soup: Cell complex, Solidity Determination, Meshes reconstruction. Advanced Rendering Techniques:Photorealistic Rendering, Global Illumination, Participating

Media Rendering, Ray tracing, Monte Carlo algorithm, Photon Mapping. Volume Rendering: Volume graphics Overview, Marching cubes, Direct volume rendering. Surfaces and Meshes.Visualization: Meshes for Visualization, Volume Visualization and Medical Visualization.

TEXT BOOKS / REFERENCES:

1. Tomas Akenine Moller, Eric Haines and NatyHoffman,“ Real-Time Rendering”, Third Edition, A K Peters Ltd, 2008.
2. Matt Pharr and Greg Humphreys,“Physically Based Rendering: From Theory to Implementation”, Second Edition, Morgan Kaufmann, 2010.
3. Lars Linsen, Hans Hagen and Bernd Hamann, “Visualization in Medicine and Life Sciences”, Springer-Verlag Berlin Heidelberg, 2008.
4. Donald Hearn, M. Pauline Baker and Warren Carithers, Computer Graphics with OpenGL, Fourth Edition, Pearson Education India, 2013.

Course Outcomes

	Course Outcome
CO1	Learning 2-D and 3-D modelling
CO2	Learning various Reconstruction of 3D Meshes
CO3	Analysing Various levels of surface representation
CO4	Developing Meshes for Visualisation

19DS709 COMPUTER VISION 3-0-0-3

Image Formation Models - Monocular imaging system, Orthographic & Perspective Projection, Camera model and Camera calibration, Binocular imaging systems. Image Processing and Feature Extraction - Image representations (continuous and discrete), Edge detection. Motion Estimation, Regularization theory, Optical computation, Stereo Vision, Motion estimation, Structure from motion. Shape Representation and Segmentation, Deformable curves and surfaces, Snakes and active contours, Level set representations, Fourier and wavelet descriptors, Medial representations, Multiresolution analysis. Object recognition - Hough transforms and other simple object recognition methods, Shape correspondence and shape matching, Principal component analysis, Shape priors for recognition

TEXT BOOKS/ REFERENCES:

1. D. Forsyth and J. Ponce, Computer Vision - A modern approach, Prentice Hall
2. B. K. P. Horn, Robot Vision, McGraw-Hill.
3. Adrian Rosebrock, Deep Learning for Computer Vision with Python
4. Jan Erick Solem, "Programming Computer Vision with Python", O'Reilly, First edition,2012.

Course Outcomes

	Course Outcome
CO1	Understand the morphological operations
CO2	Understand motion representation and estimation
CO3	Learn segmentation, query retrieval, fourier representation
CO4	Understand object recognition and shape correspondence
CO5	Develop case study applications

19DS710 IMAGE ANALYSIS 3-0-0-3

Image Morphology: Binary and gray scale Morphological analysis - Dilation and Erosion - Skeletons and Object Marking – Granulometry – Morphological Segmentation. Feature extraction: Global image measurement, feature specific measurement, characterizing shapes, Hough Transform. Representation and Description: Region Identification – Contour Based and Region Based Shape Representation and Description – Shape Classes. Flexible shape extraction: active contours, Flexible shape models: active shape and active appearance. Texture representation and analysis: Statistical Texture Description – Syntactic Texture Description Methods – Hybrid Texture description Methods – Texture Recognition Method Applications. Image Understanding: Control Strategies –RANSAC – Point Distribution Models – Scene Labeling and Constraint Propagation. Image Data Compression: Predictive Compression Methods – Vector Quantization, DCT, Wavelet, JPEG.

TEXT BOOKS / REFERENCES:

1. Milan Sonka, Vaclav Hlavac and Roger Boyle, "Image Processing, Analysis and Machine

Vision", Third Edition, Cengage Learning, 2007.
2. TinkuAcharya, Ajoy K Ray,"Image Processing- Principles and Applications", Wiley, 2005.
3. John C. Russ, "The Image Processing Handbook", Sixth Edition, CRC Press, 2007.
4. Mark S. Nixon, Alberto S. Aguado, "Feature Extraction and Image Processing", Second Edition, Academic Press, 2008.

Course Outcomes

	Course Outcome
CO1	Understand the modules involved in projection, camera calibration and imaging
CO2	Understand image representation and measurement
CO3	Understand the morphological operations
CO4	Understand motion representation and estimation
CO5	Learn edge and shape recognition. Motion analysis

19DS711 REINFORCEMENT LEARNING 3-0-0-3

Reinforcement learningvs all, Multi-armed bandit, Decision process & applications, Markov Decision Process, Cross entropy method, Approximate cross entropy method, More on approximate cross entropy method, Evolution strategies: core idea, math problems, log-derivative trick, duct tape. Blackbox optimization: drawback

Dynamic Programming, Reward design, state and Action Value Functions, Measuring Policy Optimality, Policy: evaluation & improvement, Policy and value iteration,

Model-free methods: Model-based vs model-free, Monte-Carlo & Temporal Difference; Q-learning, Exploration vs Exploitation, Footnote: Monte-Carlo vs Temporal Difference, Accounting for exploration. Expected Value SARSA, On-policy vs off-policy; Experience replay.

Approximate Value Based Methods: Supervised & Reinforcement Learning, Loss functions in value based RL, difficulties with Approximate Methods, DQN – bird's eye view, DQN – the internals,DQN: statistical issues, Double Q-learning, More DQN tricks, Partial observability

TEXT BOOKS / REFERENCES:

1. Sutton and Barto, Reinforcement Learning: An Introduction, 2nd Edition. MIT Press, Cambridge, MA, 2018
2. CsabaSzepesvári, Algorithms for Reinforcement Learning, Morgan & Claypool. 2010.
3. Marco Wiering and Martijn van Otterlo, Reinforcement Learning: State-of-the-Art (Adaptation, Learning, and Optimization, Springer, 2012.)

Course Outcomes

	Course Outcome
CO1	Define the key features of reinforcement learning that distinguishes it from AI and non-interactive machine learning
CO2	Given an application problem (e.g. from computer vision, robotics, etc), decide if it should be formulated as a RL problem; if yes be able to define it formally (in terms of the state space, action space, dynamics and reward model)
CO3	Describe (list and define) multiple criteria for analyzing RL algorithms and evaluate algorithms on these metrics: e.g. regret, sample complexity, computational complexity, empirical performance, convergence, etc
CO4	Describe the exploration vs exploitation challenge and compare and contrast at least two approaches for addressing this challenge (in terms of performance, scalability, complexity of implementation, and theoretical guarantees)

19DS712 BIO INFORMATICS 3-0-0- 3

Introduction: the central dogma – killer application – parallel universes – Watson's definition – top down vs bottom up approach – information flow – conversance – communications. Database networks: definition – data management – data life cycle – database technology – interfaces – implementation – networks: communication models – transmission technology – protocols – bandwidth – topology – contents – security – ownership – implementation.

Search engines and data visualization: search process – technologies – searching and information theory – computational methods – knowledge management - sequence visualizations – structure visualizations – user interfaces – animation vs simulation. Statistics, data mining and pattern matching: Statistical concepts – micro arrays – imperfect data –

basics – quantifying – randomness – data analysis – tools selection – alignment – clustering – classification – data mining methods – technology – infrastructure pattern recognition – discovery.

Machine learning – text mining – pattern matching fundamentals – dot matrix analysis – substitution matrix – dynamic programming – word method – Bayesian method – multiple sequence alignment tools.Modeling simulation and collaboration: Drug discovery fundamentals – protein structure – system biology tools – collaboration and communication – standards – issues – case study.

TEXT BOOKS / REFERENCES:

1. Bergeron B, "Bio Informatics Computing', Pearson Education India, 2015
2. Attwood T.K, Parry-Smith D.J.P, PhukanSamiron, 'Introduction to Bio Informatics", Pearson Education, 2011.
3. Baldi P and Brunk S, "Bio Informatics – The Machine Learning Approach", Second Edition, First East West Press, 2003.

Course Outcomes

	Course Outcome
CO1	To understand the fundamental concepts of databases, interfaces, approaches and types of network topology
CO2	Apply suitable data mining techniques to classify and structure the data
CO3	Analyze and visualize the structure of the pattern towards pattern discovery
CO4	Apply machine learning to formulate sequence alignment
CO5	Analyze the network model to collaborate and communicate

19DS713 **DATA COMPRESSION** **3-0-0-3**

Information Theory Foundation: Entropy, its properties, conditional entropy, mutual information, Types of codes, Krafts McMillan Inequality theorem, Source coding theorem. Introduction to Compression Techniques: Introduction, Types of compression - Lossy, lossless. Performance measures, Modeling, Coding. Text Compression: Huffmann - static and dynamic, application in text compression, Shannon Fano Elias Coding, Arithmetic coding, Dictionary based coding-static, adaptive, UNIX compress.
Scalar and Vector Quantization: Scalar Quantization – Introduction, Uniform and Adaptive quantization. Vector Quantization- Introduction, Advantages, LBG, Tree vector quantization, Trellis coded quantization
Audio Compression: Distortion criteria- Auditory perception, PCM, DPCM, ADPCM, Predictive coding- basic algorithm, Basic sub-band coding, MPEG Audio Coding
Image Compression: Distortion criteria- The human visual system, Transform coding- DCT, JPEG, JBIG II, GIF, Wavelet based compression- wavelets, the scaling function, Haar Transforms, JPEG-2000. Video Compression: Motion Estimation and Compensation- Full search and Fast search algorithms, H.261, MPEG-1, MPEG-2, MPEG-4, MPEG -7.

TEXTBOOKS/ REFERENCES:

1. Sayood and Khalid, "Introduction to Data Compression", Third Edition, Morgan Kaufmann, 2006.
2. Richardson I E G, "Video Codec Design: Developing Image and Video Compression Techniques", John Wiley and Sons, 2002.
3. Salomon D, "Data Compression: The Complete Reference", Fourth Edition, Springer, 2007.
4. Gersho A and Kluwer R M G, "Vector Quantization and Signal Compression", Academic Press, 1992.

Course Outcomes:

	Course Outcome
CO1	To understand the fundamentals of lossy and lossless compression
CO2	To understand and design text-based compression
CO3	To understand and design image/video/ audio based compression

CO4	To understand and extend compression schemes for mining large datasets

19DS714 MODELING AND SIMULATION 3-0-1-4

Introduction to Simulation: System and system environment, Component System, Type of systems, Types of models, Steps in simulation study, Advantages and disadvantages of Simulation. Types of Simulation: Discrete Event Simulation, Simulation of a single server queuing system, Simulation of an Inventory system, Continuous Simulation, Predator-prey system, Combined Discrete-Continuous Simulation, Monte Carlo Simulation. Statistical Models in Simulation: Useful statistical model, Discrete and Continuous Probability distributions, Poisson process and Empirical distribution. Random Numbers Generation: Properties of random numbers, Generation of pseudo random numbers, Techniques for generating random numbers, Tests for random numbers. Random Variate Generation: Inverse Transform technique, Convolution method, Acceptance Rejection Techniques. Input Modeling: Data Collection, Identifying the distribution of data, Parameter Estimation, Goodness of fit tests, Selection input model without data, Multivariate and Time series input models. Verification and Validation of Simulation Model: Model Building, Verification and Validation, Verification of Simulation models, Calibration and Validation of models. Output Analysis: Stochastic nature of output data, Measure of performance and their estimation, Output analysis of terminating simulators, Output Analysis of steady state simulation. Comparison and Evaluation of Alternate System Design: Comparison of two system design, Comparison of several system design, Confidence interval for the difference between expected responses of two systems.

TEXT BOOKS/ REFERENCES:

1. Bernard P. Zeigler, AlexandreMuzy, Ernesto Kofman, "Theory of Modeling and Simulation: Discrete Event & Iterative System Computational Foundation", Third Edition, 2018.
2. J. Banks, John S. Carson, Barry L. Nelson, 'Discrete-Event-System Simulation,' Prentice Hall of India Private Limited, 2010.
3. George S Fishman, "Discrete-Event Simulation: Modeling, Programming, and Analysis", 2013.
4. Averill. M. Law, " Simulation Modeling and Analysis, Tata McGraw-Hill, Fourth Edition, 2007.

Course Outcomes

	Course Outcome
CO1	To understand important probability distributions, Random number and random variate generation

CO2	Comprehend the applications of probability distributions in a simulation context
CO3	Analysis of service facilities, production and material handling systems, telephone and communications systems, using Queuing models
CO4	Apply the concept of random number and random variate generation in input modelling
CO5	Performance evaluation and Validation of Simulation models

19DS715 RECOMMENDER SYSTEM 3-0-0-3

Introduction: Overview of Information Retrieval, Retrieval Models, Search and Filtering Techniques: Relevance Feedback, User Profiles, Recommender system functions, Matrix operations, covariance matrices, Understanding ratings, Applications of recommendation systems, Issues with recommender system.

Content-based Filtering: High level architecture of content-based systems, Advantages and drawbacks of content based filtering, Item profiles, Discovering features of documents, pre-processing and feature extraction, Obtaining item features from tags, Methods for learning user profiles, Similarity based retrieval, Classification algorithms.

Collaborative Filtering: User-based recommendation, Item-based recommendation, Model based approaches, Matrix factorization, Attacks on collaborative recommender systems.

Hybrid approaches: Opportunities for hybridization, Monolithic hybridization design: Feature combination, Feature augmentation, Parallelized hybridization design: Weighted, Switching, Mixed, Pipelined hybridization design: Cascade Meta-level, Limitations of hybridization strategies

Evaluating Recommender System: Introduction, General properties of evaluation research, Evaluation designs: Accuracy, Coverage, confidence, novelty, diversity, scalability, serendipity, Evaluation on historical datasets, Offline evaluations.

Types of Recommender Systems: Recommender systems in personalized web search, knowledge-based recommender system, Social tagging recommender systems, Trust-centric recommendations, Group recommender systems.

TEXT BOOKS / REFERENCES:

1. Jannach D., Zanker M. and FelFering A., Recommender Systems: An Introduction, Cambridge University Press (2011), 1st ed.
2. Charu C. Aggarwal, Recommender Systems: The Textbook, Springer (2016), 1st ed.
3. Ricci F., Rokach L., Shapira D., Kantor B.P., Recommender Systems Handbook, Springer(2011), 1st ed.
4. Manouselis N., Drachsler H., Verbert K., Duval E., Recommender Systems For Learning, Springer (2013), 1st ed.

Course Outcomes

	Course Outcome
CO1	To learn techniques for making recommendations, including non-personalized, content-based, and collaborative filtering
CO2	To automate a variety of choice-making strategies with the goal of providing affordable, personal and high quality recommendations
CO3	Design recommendation system for a particular application domain.
CO4	Evaluate recommender systems on the basis of metrics such as accuracy, rank accuracy,

19DS716 DATA WAREHOUSE AND DATA MINING 3-0-0-3

Introduction to Data Warehousing; Data Mining: Mining frequent patterns, association and correlations; Sequential Pattern Mining concepts, primitives, scalable methods;

Classification and prediction; Cluster Analysis – Types of Data in Cluster Analysis, Partitioning methods, Hierarchical Methods; Transactional Patterns and other temporal based frequent patterns,

Mining Time series Data, Periodicity Analysis for time related sequence data, Trend analysis, Similarity search in Time-series analysis;

Mining Data Streams, Methodologies for stream data processing and stream data systems, Frequent pattern mining in stream data, Sequential Pattern Mining in Data Streams, Classification of dynamic data streams, Class Imbalance Problem; Graph Mining; Social Network Analysis;

Web Mining, Mining the web page layout structure, mining web link structure, mining multimedia data on the web, Automatic classification of web documents and web usage mining; Distributed Data Mining.

Recent trends in Distributed Warehousing and Data Mining, Class Imbalance Problem; Graph Mining; Social Network Analysis

TEXT BOOKS / REFERENCES:

1. Jiawei Han and M Kamber, Data Mining Concepts and Techniques,, Second Edition, Elsevier Publication, 2011.
2. Vipin Kumar, Introduction to Data Mining - Pang-Ning Tan, Michael Steinbach, Addison Wesley, 2006.
3. G Dong and J Pei, Sequence Data Mining, Springer, 2007.

Course Outcomes

	Course Outcome
CO1	Study of different sequential pattern algorithms
CO2	Study the technique to extract patterns from time series data and it application in real world.
CO3	Can extend the Graph mining algorithms to Web mining
CO4	Help in identifying the computing framework for Big Data
CO5	Study of different sequential pattern algorithms

19DS717 WEB ANALYTICS AND DEVELOPMENT 3-0-0-3

Introduction – Social network and Web data and methods, Graph and Matrices, Basic measures for individuals and networks, Information Visualization. Web Analytics tools: Click Stream Analysis, A/B testing, Online Surveys. Web Search and Retrieval: Search Engine Optimization, Web Crawling and indexing, Ranking Algorithms, Web traffic models. Making Connection: Link Analysis, Random Graphs and Network evolution, Social Connects: Affiliation and identity. Connection: Connection Search, Collapse, Robustness Social involvements and diffusion of Innovation

TEXT BOOKS / REFERENCES:

1. Hansen, Derek, Ben Sheiderman, Marc Smith. 2011. Analyzing Social Media Networks with NodeXL: Insights from a Connected World. Morgan Kaufmann, 304.
2. Avinash Kaushik. 2009. Web Analytics 2.0: The Art of Online Accountability.
3. Easley, D. & Kleinberg, J. (2010). Networks, Crowds, and Markets: Reasoning About a Highly Connected World. New York: Cambridge University Press.
4. Wasserman, S. & Faust, K. (1994). Social network analysis: Methods and applications. New York:
5. Monge, P. R. & Contractor, N. S. (2003). Theories of communication, Cambridge University Press.
6. http://www.cs.cornell.edu/home/kleinber/networks-book/

Course Outcomes

	Course Outcome
CO1	To explore the use of social network analysis and to understand the connectivity and complexities
CO2	To familiarize with web analytics tools
CO3	To learn web search and retrieval algorithms
CO4	To learn about making connections and search
CO5	

19DS718 TEXT ANALYTICS 3-0-0-3

Overview Text Mining and Analytics , Natural Language Content Analysis Methods & Text Representation, Word Association Mining and Analysis, Information Extraction, Topic Mining and Analysis- Probabilistic Topic Models , Probabilistic Latent Semantic Analysis, Latent Dirichlet Allocation (LDA), Text Clustering: Generative Probabilistic Models, Similarity-based Approaches, Text Categorization, Applications -Sentiment Analysis, Emotion Detection, Visualization.

TEXT BOOKS / REFERENCES:

1. Julia Silge and David Robin, Text Mining with R, O'REILLY, 2017

2. Benjamin Bengfort , Rebecca Bilbro , Tony Ojeda. Applied Text Analysis with Python: Enabling Language-Aware Data Products with Machine Learning, O'REILY, 2018
3. Bird, S., Klein, E., &Loper, E. (2009). Natural language processing with Python. O'Reilly Media, Inc.
4. Jurafsky, D. & Martin, J. H. (2008). Speech & language processing. Pearson.
5. Manning, C. D., Raghavan, P., & H. Schutze. (2008). Introduction to information retrieval. Cambridge University Press

Course Outcomes

	Course Outcome
CO1	Discuss the various ways in which text can be analyzed, and appropriate uses of each
CO2	Use open source text analytic tools
CO3	Develop simple text analysis tools
CO4	Design a project for textual analysis suitable for a specific domain

19DS719 BLOCKCHAIN TECHNOLOGY 3 0 0 3

The story of a transaction: From Transactions to Blocks -Blocks and Distributed Consensus - Basic interaction with a Bitcoin node. Keys and Addresses: Basic cryptography - From private keys to addresses. The Bitcoin Script language : Introduction to the Bitcoin Script language - Script writing and execution -Tools and libraries to access Bitcoin’s API and scripting capabilities. Blockchain deployment: Mining and forking - Upgrading the network - Related BIPs - Segregated Witness (SegWit). Blockchain architectures: Abstract Architecture - Ways to dive deeper - Introduction to major blockchain platforms. Smart contracts and Ethereum: Technical introduction to smart contracts - Ethereum overview - Web3 proposition for a decentralized internet - Using Ethereum sub-protocols, storage and ways of interacting with the external world. Comparing Bitcoin and Ethereum - Historical comparison - Conceptual distinction between a payment system and a decentralized applications platform - Differences in their architectures from security-first aspect to a rich feature set - Future roadmap for them, following their own paths with probable interconnections. Contract code walk-through: Demonstration of smart contract -Introduction to Solidity - Contract lifecycle - Solidity Building blocks - Popular contracts already in deployment.

TEXTBOOKS/REFERENCE BOOKS:

1. Andreas Antonopoulos, Mastering Bitcoin,O'Reilly Publishing 2014 978-0691171692
2. Arvind Narayanan, Joseph Bonneau, Edward Felten, Andrew Miller, and Steven Goldfeder. Bitcoin and Cryptocurrency Technologies: A Comprehensive Introduction. Princeton University Press (July 19, 2016)
3. William Mougayar. The BuisnessBlockchain: Promise, Practice, and Application of the Next Internet Technology. Wiley; 1st edition (May 9, 2016)
4. Bitcoin: A Peer-toPeer Electronic Cash System Satoshi Nakamoto Online 2009https://bitcoin.org/bitcoin.pdf
5. VitalikButerinEthereum White Paper Online 2017https://github.com/ethereum/wiki/wiki/WhitePaper

Course Outcomes

	Course Outcomes
CO1	Understand the concepts of cryptocurrency, blockchain, and distributed ledger technologies
CO2	Analyse the application and impact of blockchain technology in the financial industry and other industries
CO3	Evaluate security issues relating to blockchain and cryptocurrency
CO4	Design and analyse the impact of blockchain technology

19DS720 SENSOR NETWORKS AND IOT 3-0-0-3

Introduction and Applications: smart transportation, smart cities, smart living, smart energy, smart health, and smart learning. Examples of research areas include for instance: Self-Adaptive Systems, Cyber Physical Systems, Systems of Systems, Software Architectures and Connectors, Software Interoperability, Big Data and Big Data Mining, Privacy and Security
IoT Reference Architecture-Introduction, Functional View, Information View, Deployment and Operational View, Other Relevant architectural views. Real-World Design Constraints-Introduction, Technical Design constraints, hardware, Data representation and visualization, Interaction and remote control. Introduction to Data Analytics for IoT

IOT Physical Devices & Endpoints: What is an IOT Device, Exemplary Device Board, Linux on Raspberry, Interface and Programming & IOT Device. Hardware Platforms and Energy Consumption, Operating Systems, Time Synchronization, Positioning and Localization, Medium Access Control, Topology and Coverage Control, Routing: Transport Protocols, Databases

Recent trends in sensor network and IOT architectureCase study: Commercial building automation today and in the future, Industrial Automation, Smart and Connected Cities

TEXT BOOKS / REFERENCES:

1. Mandler, B., Barja, J., MitreCampista, M.E., Cagá-ová, D., Chaouchi, H., Zeadally, S., Badra, M., Giordano, S., Fazio, M., Somov, A., Vieriu, R.-L., Internet of Things. IoT Infrastructures, Springer International Publication
2. ArsheepBahga,VijayMadisetti, Internet of Things: A Hands-On Approach Paperback – 2015.
3. Pearson Paperback, Hanes David,SalgueiroGonzalo,GrossetetePatrick,Barton Rob, IoT Fundamentals: Networking Technologies, Protocols and Use Cases for the Internet of Things, 16 Aug 2017.

Course Outcomes

	Course Outcome
CO1	Understand the concept of IoT and its technologies
CO2	Understand the hardware and sensors used for IoT
CO3	To study the protocols used for IoT applications
CO4	Design and model the IoT system for real world applications
CO5	To learn and design data bases and perform Analytics

19DS721 PREDICTIVE ANALYTICS FOR INTERNET OF THINGS 3-0-0-3

IoT Analytics- Definition, Challenges, Devices, Connectivity protocols, data messaging protocols- MQTT, HTTP, CoAP, Data Distribution Services (DDS), IoT Data Analytics – Elastics Analytics Concepts, Scaling.

Cloud Analytics and Security, AWS / Azure /ThingWorx. Design of data processing for analytics, application of big data technology to storage, Exploring and visualizing data, solution for industry specific analysis problem.

Visualization and Dashboard – Designing visual analysis for IoT data- creating dashboard – creating and visualizing alerts – basics of geo-spatial analytics- vector based methods-raster based methods- storage of geo-spatial data-processing of geo spatial data- Anomaly detection-forecasting. case study: pollution reporting problem.

TEXT BOOKS / REFERENCES:

1. Andrew Minteer, Analytics for Internet of Things, Packt Publications Mumbai 2017
2. Kai Hwang, Min Chen, Big Data Analytics for Cloud, IoT and Cognitive Computing Hardcover

Course Outcomes

	Course Outcome
CO1	To study the protocols and communication models used in IoT
CO2	To learn and understand the data analysis concept related to IoT
CO3	To have a working knowledge of the platforms used for analysing the cloud data
CO4	To understand the Big Data technologies and to apply analytics concepts to Industrial problems
CO5	To create a dashboard for data visualization and performing analysis for geo-spatial databases

19DS722 DATA INTENSIVE COMPUTING 3-0-0-3

Data Intensive computing Paradigms-types, need and use - Supercomputing, Grid Computing, Cloud Computing, Many-core Computing. Parallel Programming Systems-MapReduce-Hadoop (Programming Project -TF-IDF Computation using MapReduce), Workflows-Swift, MPI-MPICH, OpenMP, Multi-Threading-PThreads. Job Management Systems- Batch scheduling, Light-weight Task Scheduling. Storage Systems-File Systems-EXT3, Shared File Systems -NFS, Distributed File Systems-HDFS, FusionFS, Parallel File Systems-GPFS, PVFS, Lustre, Distributed NoSQL Key/Value Stores-Casandra, MongoDB, ZHT, Relational Databases-MySQL.Big Data Applications: Android Malware Development on Public Malware Scanning Platforms: A large-scale data driven study

Data-Intensive Computing with GPUs and databases, many-core computing era and new challenges, Case studies on open research questions in data-intensive computing.

TEXT BOOKS/REFERENCES:

1. Ian Gorton, Pacific Northwest National Laboratory and Deborah K. Gracio, Data-Intensive Computing Architectures, Algorithms, And Applications: Edited by Pacific Northwest National Laboratory Cambridge University Press

Research papers from leading high-impact factor journals are listed as follows:

2. Sol Ji Kang, Sang Yeon Lee, and Keon Myung Lee**,** Performance Comparison of OpenMP, MPI, and MapReduce in Practical Problems, Advances in Multimedia, Volume 2015, Article ID 575687, 9 pages, http://dx.doi.org/10.1155/2015/575687.
3. T. Heym S. Tansley and K. Tolle (Eds) "The Fourth Paradigm: Data-Intensive Scientific Discovery"
4. H. Huang et al. "Android Malware Development on Public Malware Scanning Platforms: A Large-Scale Data-Driven Study", Big Data Conference 2016.
5. A. Abouzied et al. "HadoopDB: An Architectural Hybrid of MapReduce and DBMS Technologies for Analytical Workloads", VLDB 2008.

Course Outcomes

	Course Outcome
CO1	Explain the architecture and properties of the computer systems needed to process and store large volumes of data
CO2	Describe the different computational models for processing large data sets for data at rest (batch processing)
CO3	Identify data parallelism to be exploited in large-scale data processing problems
CO4	Compare and contrast advantages and disadvantages of the modern data-centric paradigm over the compute-centric one
CO5	Design experimental studies to assess the performance of data-intensive systems
CO6	Implement high-performance solutions to a real-world problem and sufficiently provide rationalizations to the design decisions and case studies

19DS723 PARALLEL AND DISTRIBUTED COMPUTING 3-0-0-3

Introduction-Asynchronous/synchronous computation/communication, concurrency control, fault tolerance, GPU architecture and programming, heterogeneity, interconnection topologies, load balancing, memory consistency model, memory hierarchies, Message passing interface (MPI), MIMD/SIMD examples.

Multithreaded programming, parallel algorithms & architectures, parallel I/O, performance analysis and tuning, power, programming models (data parallel, task parallel, process-centric, shared/distributed memory), scalability and performance studies, scheduling, storage systems, synchronization, and tools.

TEXT BOOKS/ REFERENCES:

6. Kai Hwang, Jack Dongarra& Geoffrey C. Fox, "Distributed and Cloud Computing: Clusters, Grids, Clouds, and the Future Internet (DCC)", 2012.
7. Andrew S. Tanenbaum& Maarten van Steen, "Distributed Systems: Principles and Paradigms", Prentice Hall, 2017.

Course Outcomes

	Course Outcome
CO1	Understand the requirements for programming parallel systems and how they can be used to facilitate the programming of concurrent systems.
CO2	To learn and apply knowledge of parallel and distributed computing techniques and methodologies.
CO3	To learn the architecture and parallel programming in graphics processing units (GPUs).
CO4	Understand the memory hierarchy and cost-performance tradeoffs.
CO5	To gain experience in the design, development, and performance analysis of parallel and distributed applications.

19DS724 PERVASIVE COMPUTING 3-0-0-3

Pervasive Computing Concepts: Perspectives of Pervasive Computing, Challenges, Technology; The Structure and Elements of Pervasive Computing Systems: Infrastructure and Devices, Middleware for Pervasive Computing Systems, Pervasive Computing Environments

Context Collection, User Tracking, and Context Reasoning; Resource Management in Pervasive Computing: Efficient Resource Allocation in Pervasive Environments, Transparent Task Migration, Implementation and Illustrations.

HCI interface in Pervasive Enviornments: HCI Service and Interaction Migration, Context-Driven HCI Service Selection, Scenario Study: Video Calls at a Smart Office, A Web Service–Based HCI Migration Framework .

Pervasive Mobile Transactions: Mobile Transaction Framework, Context-Aware Pervasive Transaction Model, Dynamic Transaction Management, Formal Transaction Verification, Evaluations

Case Studies: iCampus Prototype, IPSpace: An IPv6-Enabled Intelligent Space

TEXT BOOKS/REFERENCES:

1. MinyiGuo, Jingyu Zhou, Feilong Tang, Yao Shen," Pervasive Computing: Concepts, Technologies and Applications",CRC Press, 2016.
2. Obaidat, Mohammad S., Mieso Denko, and Isaac Woungang, eds. Pervasive computing and networking. John Wiley & Sons, 2011.

3. Laurence T. Yang, Handbook On Mobile And Ubiquitous Computing Status And Perspective, 2012, CRC Press.

Course Outcomes

	Course Outcome
CO1	Understand the fundamental theoretical concepts in pervasive computing.
CO2	Understand the aspects of context awareness
CO3	Study the methods for efficient resource allocation and task migration
CO4	Learn and Analyze the HCI Service Selection and HCI migration framework
CO5	Design and implement pervasive application systems

19DS725 DATA SECURITY AND ACCESS CONTROL 3-0-0-3

Introduction to Access Control, Purpose and fundamentals of access control, brief history, Policies of Access Control, Models of Access Control, and Mechanisms, Discretionary Access Control (DAC), Non- Discretionary Access Control, Mandatory Access Control (MAC). Capabilities and Limitations of Access Control Mechanisms: Access Control List (ACL) and Limitations, Capability List and Limitations.

Role-Based Access Control (RBAC) and Limitations, Core RBAC, Hierarchical RBAC, Statically Constrained RBAC, Dynamically Constrained RBAC, Limitations of RBAC. Comparing RBAC to DAC and MAC Access control policy.

Biba's integrity model, Clark-Wilson model, Domain type enforcement model, mapping the enterprise view to the system view, Role hierarchies- inheritance schemes, hierarchy structures and inheritance forms, using SoD in real system Temporal Constraints in RBAC, MAC AND DAC. Integrating RBAC with enterprise IT infrastructures: RBAC for WFMSs, RBAC for UNIX and JAVA environments Case study: Multi line Insurance Company

Smart Card based Information Security, Smart card operating system fundamentals, design and implantation principles, memory organization, smart card files, file management, atomic operation, smart card data transmission ATR, PPS Security techniques- user identification, smart card security, quality assurance and testing, smart card life cycle-5 phases, smart card terminals.

Recent trends in Database security and access control mechanisms. Case study of Role-Based Access Control (RBAC) systems.

Recent Trends related to data security management, vulnerabilities in different DBMS.

TEXT BOOKS/REFERENCES:

1. David F. Ferraiolo, D. Richard Kuhn, RamaswamyChandramouli, Role Based Access Control:
2. http://www.smartcard.co.uk/tutorials/sct-itsc.pdf : Smart Card Tutorial.

Course Outcomes

	Course Outcome
CO1	Provide fundamentals of database security.
CO2	Various access control techniques mechanisms were introduced along with application areas of access control techniques.
CO3	Understand and implement classical models and algorithms
CO4	Learn how to analyse the data, identify the problems, and choose the relevant models
CO5	To assess the strengths and weaknesses of various access control models and to analyse their behaviour.

19DS726 CLOUD COMPUTING AND SECURITY IN THE CLOUD 3-0-0-3

Introduction to cloud computing – Evolution of cloud computing, definition of cloud computing, SPI framework, Service delivery model, Deployment models, Key drivers to adopting the cloud, Barriers to cloud computing adoption in the cloud, Modular arithmetic background, concepts of security, how to assess security of a system, information theoretic security v/s computational security, Data security and storage in cloud, data dispersal techniques, High-availability and integrity layer for cloud storage, Encryption and key management in the cloud, Cloud forensics, Data location and availability, Data security tools and techniques for the cloud, Data distribution and information dispersal techniques, Data encryption/decryption methodologies and algorithms for a client-server setup such as SSL, IPSec, etc., Introduction to Homomorphic encryption. Approximate string searching over encrypted data stored in the cloud, Trustworthy cloud infrastructures, Secure computations, cloud related regulatory and compliance issues.

TEXTBOOKS/ REFERENCES:

1. Zeal Vors, “Enterprise Cloud Security and Governance: Efficiently set data protection and privacy principles”, First Edition, 2017.
2. Tim Mather, S. Kumaraswamy and S.Latif, “Cloud Security and Privacy: An Enterprise Perspective on Risks and compliance”, O’Reilly Media, 2009
3. William Stallings, “Cryptography and Network Security: Principles and Practice, Fifth Edition, Prentice Hall, 2011.
4. William Stallings, Lawrie Brown, “Computer Security: Principles and Practice”, Pearson, 2012.
5. Menezes. A, Oorschot. P, and Vanstone. S, Handbook of Applied Cryptography, CRC Press, 1996
6. B. Schneier, “Applied Cryptography: Protocols, Algorithms, and source Code in C”, Second Edition, Jhon Wiley and Sons, 1996.
7. John Sammons, “The Basics of Digital Forensics: The Primer for Getting Started in Digital Forensics”, second edition, 2014.
8. Terrence Lillard, “Digital Forensics for Network, Internet, and Cloud Computing, Elsevier, 2010.

Course Outcomes

	Course Outcome
CO1	Understand the basic principles of cloud computing
CO2	Analyze the Cloud computing setup with it's vulnerabilities and applications using different architectures.
CO3	Assess cloud Storage systems and Cloud security, the risks involved, its impact and develop cloud application

CO4	Understand the various data security and storage algorithms
CO5	Assess the strengths and weaknesses of various algorithms used in cloud security

19DS727 EMBEDDED SYSTEMS FOR DATA ANALYTICS 3-0-0-3

Embedded Systems: Basics of computer architecture and binary number systems, Introduction to embedded systems and Embedded Systems-The hardware point of view. Python Programming: Basic python concepts, Defining functions, Conditional statements, Loops, Data collections, Defining classes and Object oriented design. Raspberry Pi Hardware and Software: Introduction to Raspberry Pi, Linux introduction and basics, Programming the Raspberry Pi in python, Raspberry PI GPIO with sensors & actuators interfacing and networking using Raspberry Pi. Digital Systems: Design of P, PI and PID controllers, state space and filtering systems.

Embedded Real Time Machine Learning: Introduction to Artificial Intelligence, Basics concepts of AI, Introduction to Fuzzy logic, Neural networks, Expert systems demonstation using Pi, developing projects based on fuzzy and neural networks in Pi. Introduction to cloud based machine learning.

TEXTBOOKS/ REFERENCES:

1. Lyla B. Das, Embedded Systems - An Integrated Approach, Pearson Education, 2013
2. John Zelle, Python Programming: An Introdution to Computer Science, Franklin Beedle& Associates, 2004
3. John Nussey, Raspberry for Dummies, John Wiley & Sons, 2nd Edition, 2013
4. Donald J. Norris, Beginning Artificial Intelligence with the Raspberry Pi, Apress, 2017

Course Outcomes

	Course Outcome
CO1	Understand the fundamentals of embedded systems
CO2	Understanding Python programming language
CO3	Understanding Raspberry Pi for sensor and actuators interfacing and programming
CO4	Understanding and Implementing machine learning algorithms in Raspberry Pi