M.TECH. ARTIFICIAL INTELLIGENCE

DEPARTMENT OF COMPUTER SCIENCE

M.Tech in Artificial Intelligence programme has been designed for students with sufficient background in computer science and engineering to develop into adept professionals. M.Tech in CSE is a graduate degree that builds skill and knowledge in advanced and current topics of computer science. The degree is suitable for students with a bachelor's degree in a computing related field as well as students who want to demonstrate computer science expertise in addition to a degree in another field. The curriculum has been designed to prepare students for highly prolific careers in industry. Some of the job profiles include: Application analyst, Data Scientist, Data analyst, Database administrator, Information systems manager, IT consultant, Multimedia analyst.

It is a reality that that computer technology has revolutionized the modern world. Technologies that we now use for granted - Internet, mobile phones, medical technology, would not be possible without the major developments made in the field of computing. This M.Techprogramme gives a specialized focus on areas of technology, aiming to develop skills and career prospects. The master's degree program offers an integrated course of study covering the theory, implementation and design of information, computing, communication and embedded systems. This programme has specialized courses in the streams of Data Science, Computer Vision, IoT and High Performance Computing with significant focus on research. As a part of the programme during the period of study, students have the opportunity to intern at leading companies and R&D labs for a period of 6 months to one year. There are opportunities for the students to take up a semester or one-year study at International Universities like Virje University, Netherlands, UC Davis, UNM for an exchange programme or to pursue a dual degree programme.

Graduates of this programme are well represented in Oracle, IBM, HP, Cerner, Intuit, and other major MNCs as well as in research in premier academic institutions in India and abroad. The graduates are competent to take up R&D positions in Industry, academia and research laboratories.

Programme Objectives:

- Hone the skill of computer science professionals in areas of research and innovation
- Develop experts with high professional competence in recent and futuristic technologies
- Create man power with technical competency in computer science to design and develop solutions for the societal problems

CURRICULUM

First Semester

Course Code	Type	Course	L T P	Cr
19AI601	FC	Advanced Data structures and Algorithms	3 0 1	4
19MA609	FC	Mathematics for Artificial Intelligence	3 0 1	4
19AI602	FC	Foundations of Artificial Intelligence	3 0 1	4
	SC	Soft Core I	3 0 1	4
	SC	Soft Core - II	3 0 1	4
	Elective	Elective I	3 0 0	3
19HU601	HU	Amrita Values Program*		P/F
19HU602	HU	Career Competency I*		P/F
Total Credits				**23**

*Non-credit course

Second Semester

Course Code	Type	Course	L T P	Cr
	SC	Soft Core - III	3 0 1	4
	SC	Soft Core - IV	3 0 1	4
	Elective	Elective - II	3 0 0	3
	Elective	Elective - III	3 0 0	3
	Elective	Elective - IV	3 0 0	3
	SC	Negotiated Studies		2
19RM600	SC	Research Methodology	2 0 0	2
19HU603	HU	Career Competency II	0 0 2	P/F
Total Credits				**21**

Third Semester

Course Code	Type	Course	L T P	Cr
19AI798		Dissertation		10
Total Credits				**10**

Fourth Semester

Course Code	Type	Course	L T P	Cr
19AI799		Dissertation		12
Total Credits				**12**

Total Credits - 66

Foundation Courses

Course Code	Course	L T P	Cr
19AI601	Advanced Data Structures and Algorithms	3 0 1	4
19MA609	Mathematics for Artificial Intelligence	3 0 1	4
19AI602	Foundations of Artificial Intelligence	3 0 1	4

SOFT CORE

Students have to select any four soft core subjects from the list given below:

Course Code	Course	L T P	Cr
19AI611	Foundation of Data Science	3 0 1	4
19AI612	Statistical Learning Theory	3 0 1	4
19AI613	Machine Learning	3 0 1	4
19AI614	Probabilistic Graphical Models	3 0 1	4
19AI615	Optimization Techniques	3 0 1	4
19AI616	Computational Statistics and Inference Theory	3 0 1	4
19AI617	Multi Agent Systems	3 0 1	4
19AI618	Computational Intelligence	3 0 1	4
19AI619	Deep Learning	3 0 1	4
19AI620	Reinforcement Learning	3 0 1	4
19AI621	Computer Vision	3 0 1	4
19AI622	Negotiated Studies	2 0 0	2

Course Code	Course	L T P	Cr
19RM600	Research Methodology	2 0 0	2

Electives

Course Code	Course	L T P	Cr
Electives			
19AI701	Machine Learning for Big Data	3 0 0	3
19AI702	Applications of Machine Learning	3 0 0	3
19AI703	Representation Learning	3 0 0	3
19AI704	Applied Predictive Analytics	3 0 0	3
19AI705	AI in Natural Language Processing	3 0 0	3
19AI706	Introduction to Robotics	3 0 0	3
19AI707	Introduction to Game Theory	3 0 0	3
19AI708	Computational Linear Algebra	3 0 0	3
19AI709	Modeling and Simulation	3 0 0	3
19AI710	Advanced Algorithms and Analysis	3 0 0	3
19AI711	Information Retrieval	3 0 0	3
19AI712	Web Intelligence and Big Data	3 0 0	3
19AI713	Data Visualization	3 0 0	3
19AI714	Networks and Spectral Graph Theory	3 0 0	3
19AI715	Parallel and Distributed Data Management	3 0 0	3
19AI716	Cloud & Big Data Analytics	3 0 0	3
19AI717	Medical Signal Processing	3 0 0	3
19AI718	IoT Protocols and Architecture	3 0 0	3
19AI719	Parallel and Distributed Computing	3 0 0	3
19AI720	Modern Computer Architecture	3 0 0	3
19AI721	GPU architecture and Programming	3 0 0	3

Elective (Live-in-Labs)

19AI797	Live-in-Labs	0 0 3	3

Students can do Live-in-Labs course in lieu of an elective from II Semester or III Semester.

19AI601ADVANCED DATA STRUCTURES AND ALGORITHMS 3-0-1-4

Unit I:
Algorithm Analysis - Methodologies for Analyzing Algorithms, Asymptotic growth rates, Amortized Analysis. Number Theory: Preliminaries, FLT, Euclid's algorithm (extended), Totient function, Sieve for primes, Modular exponentiation, Applications of graph algorithms: Topological sort, Strongly connected Components, Bi-connected Components, Bridges, Articulation points, All Pairs Shortest Paths, Single Source Shortest Paths. Computational Geometry: Convex Hull, Closest pair of points.

Unit II:
Applications of Divide-and-Conquer, Greedy and Dynamic programming techniques - Knapsack, Median finding, Scheduling algorithms, Party planning, bitonic TSP. String matching algorithms: Z Algorithm, KMP algorithm, Rabin-Karp, Aho-Corasick, 2D queries, efficient algorithms for longest palindrome, longest common substring/subsequence.

Unit III:
B-trees, Suffix trees, Segment trees, Flow Networks: Ford-Fulkerson algorithm, Edmonds Karp algorithm, Applications of maximum flows - Maximum bipartite matching, minimum cost matching. NP-Completeness: Important NP-Complete Problems, Polynomial time reductions, Approximation algorithms.

Text Books/References:
1) Cormen T H, Leiserson CE, Rivest R L and Stein C, "Introduction to Algorithms", Prentice Hall of India Private Limited. Third Edition 2009.
2) Michael T Goodrich and Roberto Tamassia, "Algorithm Design and Applications", Wiley, 2014.
3) Rajeev Motwani and PrabhakarRaghavan, "Randomized Algorithms", Cambridge University Press, 1995.
4) Vijay V. Vazirani, "Approximation Algorithm", Springer Science and Business Media, 2003.

19MA609MATHEMATICS FOR ARTIFICIAL INTELLIGENCE 3-0-1-4

Fractral 1- Linear Algebra for Computer Science (Fractal: 2 Credits)
Vector – Spaces – Slicing and Dicing – Linear transformations and Matrices – Principle of Mathematical Induction – Special Matrices – Vector Spaces – Span, Linear Independence, and Bases - Orthogonal Vectors and Spaces – Linear Least Squares –Eigenvalues, Eigenvectors, and Diagonalization – Applications in Computer Science.

Text Books/References:

1. Ernest Davis, “Linear Algebra and Probability for Computer Science Applications”, CRC Press, 2012.
2. Gilbert Strang, “Introduction to Linear Algebra”, Fourth Edition, Wellesley- Cambridge Press, 2009.
3. Howard Anton and Chris Rorrers,” Elementary Linear Algebra”, Tenth Edition, 2010 John Wiley & Sons, Inc.

Fractral 2- Probability and Statistics for Computer Science (Fractal: 2 Credits)

Introduction to Statistics and Probability – Probability and Conditioning – Conditional Probability – Baye’s rule – Random variables – Expectation and Variance – Covariance – Discrete and Continuous Distributions- Uniform, Gaussian and Rayleigh distributions; Binomial, and Poisson distributions; Multivariate Gaussian distribution – Central Limit Theorem – Statistics and Parameter estimation – Confidence intervals and Hypothesis testing. Elements of estimation theory: linear minimum mean-square error and orthogonality principle in estimation; Moment-generating and characteristic functions and their Applications-Bounds and approximations: Chebysev inequality and Chernoff Bound

Text Books/References:

1. David Forsyth, “Probability and Statistics for Computer Science”, Springer international publishing, 2018
2. Ernest Davis, “Linear Algebra and Probability for Computer Science Applications”, CRC Press, 2012.
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.
5. A. Papoulis and UnnikrishnaPillai, “Probability, Random Variables and Stochastic Processes”, Fourth Edition, McGraw Hill, 2002.

19AI602 FOUNDATIONS OF ARTIFICIAL INTELLIGENCE 3-0-1-4

UnitI:

Problem Solving: AI Problems, AI Techniques and Types –The Level of the Model, Criteria for Success – Defining the Problem as a State Space Search –Problem Characteristics Un-Informed Search, Heuristic Search Techniques: Generate-And- Test, Hill Climbing – Constraint Satisfaction Problem– game trees – Adversarial Search: Minimax algorithm – Alpha beta pruning – Game playing.

Unit II:

Automated Reasoning: Logic Agent – Knowledge Representation – Propositional logic – First Order Predicate Logic– inferences in first order logic – forward chaining – backward chaining – Natural Deduction – Representing Knowledge using rules –Techniques – Matching Techniques.

UnitIII:

Quantifying Uncertainty – Probabilistic Reasoning - Probabilistic Reasoning over Time – Planning with state-space search – Partial-order planning – planning graphs – planning and acting in the real world – Learning from observation – Inductive learning – Decision trees – Explanation based learning – Statistical Learning methods - Reinforcement Learning.

Text Books/References:

1. Russell and P. Norvig, Artificial Intelligence: A Modern Approach, Prentice Hall, Third Edition, 2009.
2. I. Bratko, ―Prolog: Programming for Artificial Intelligence, Fourth edition, Addison-Wesley Educational Publishers Inc, 2011.
3. KishanMehrotra, "Elements of ANN", IIEdition, Pen ram International Publishing (I)Pvt. Ltd.Unit.
4. M.Tim Jones, ―Artificial Intelligence: A Systems Approach (Computer Science), Jones and Bartlett Publishers, Inc.; 1 edition, 2008
5. Nils J. Nilsson, ―The Quest for Artificial Intelligence, Cambridge University Press, 2009.

19AI611 FOUNDATIONS OF DATA SCIENCE 3-0-1-4

Unit I

Introduction – High Dimensional Spaces - Best-Fit Subspaces and Singular Value Decomposition (SVD) - Random walks and Markov Chains.

Unit II

Concentration of measure, VC dimension, Machine Learning and Algorithms for Massive Data Problems: Johnson-Linden Strauss lemma and Streaming algorithms, sketching methods, community detection, and regression, Clustering.

Unit-III

Random Graphs - Topic Models, Nonnegative Matrix Factorization, Hidden Markov Models, and Graphical Models, Belief Propagation, Sparse Models- Wavelets.
Case study on Data scrapping and Data Wrangling tools.

Text Books/References

1. Avrim Blum, John Hopcroft and RavindranKannan,"Foundations of Data Science", Cambridge University Press, 2020.
2. Roman Vershynin," High dimensional probability - An introduction with applications in Data Science", Cambridge University Press, 2018.
3. AniAdhikari and John DeNero," Computational and Inferential Thinking - The Foundations of Data Science", eBook from UC Berkeley

19AI612 STATISTICAL LEARNING THEORY3-0-1-4

Unit I:

Overview of Supervised Learning, Linear methods for Regression, Linear methods for Classification, Basis Expansions and Regularization, Kernel smoothing.

Unit II:

Model assessment and Selection, Model Inference and Averaging, Additive Models, Trees & Related Methods, Boosting and Additive Trees, Random Forests, Ensemble Learning.

Unit III:

Support Vector Machines and Flexibilities, Prototype methods and Nearest Neighbors, Unsupervised Learning, Undirected graphical Models, High dimensional Problems.

Text Books/References:

1. Trevor Hastie, Robert Tibshirani and Jerome Friedman, "Elements of StatisticalLearning" Second Edition, Springer, 2008.
2. E. Alpaydin, "Introduction to Machine Learning", PHI, 2005.

19AI613 MACHINE LEARNING 3-0-1-4

Unit I:
Introduction: Machine learning, Terminologies in machine learning, Types of machine learning: supervised, unsupervised, semi-supervised learning. Review of probability.Discriminative Models: Least Square Regression, Gradient Descent Algorithm, Univariate and Multivariate Linear Regression, Prediction Model, probabilistic interpretation, Regularization, Logistic regression, multi class classification, Support Vector Machines- Large margin classifiers, Nonlinear SVM, kernel functions, SMO algorithm.

Unit II:

Computational Learning theory- Sample complexity, ε- exhausted version space, PAC Learning, agnostic learner, VC dimensions, Sample complexity - Mistake bounds.
Gaussian models: Multivariate Gaussian distributions, Maximum Likelihood Estimate, Inferring parameters, Linear and Quadratic Discriminant Analysis, Mixture models, EM algorithm for clustering and learning with latent variables.

Unit III:
Generative models: k-Nearest Neighbor Classification, Bayesian concept learning, Likelihood, Posterior predictive distribution, beta-binomial model, Naive Bayes classifiers, classifying documents using bag of words. Bayesian Statistics and Frequentist statistics. Directed graphical models (Bayes nets), Conditional independence, Inference. Dimensionality Reduction, Combining weak learners- AdaBoost.

Text Books/References:

1. E. Alpaydin, "Introduction to Machine Learning", PHI, 2005.
2. Tom Mitchell, "Machine Learning", McGraw Hill, 1997
3. Kevin P. Murphy, "Machine Learning, a probabilistic perspective", The MIT Press Cambridge, Massachusetts, 2012.
4. Alex Smola and SVN. Viswanathan, "Introduction to Machine Learning", Cambridge University Press, 2008.
5. http://robotics.stanford.edu/people/nilsson/mlbook.html

19AI614 PROBABILISTIC GRAPHICAL MODELS 3-0-1-4

Unit I:
Introduction: Probability distributions, random variables, joint distributions, graphs, undirected and Directed Graphical Models. Representation: Bayesian Networks – Independence in graphs – d-separation, I-equivalence, minimal I-maps. Undirected Graphical models: Gibbs distribution and Markov Networks, Markov models and Hidden Markov Models. From Bayesian to Markov and Markov to Bayesian networks, Triangulation and Chordal Graphs.Directed Gaussian graphical models.Exponential Family Models.Factor Graph Representation.Conditional Random Fields. Other special Cases: Chains, Trees.

Unit II:
Inference: Variable Elimination (Sum Product and Max-Product). Junction Tree Algorithm.Forward Backward Algorithm (for HMMs).Loopy Belief Propagation.Markov Chain Monte Carlo.Metropolis Hastings.Importance Sampling.Gibbs Sampling.Variational Inference.

Unit III:
Learning Graphical models: Discriminative vs. Generative Learning., Density estimation, learning as optimization, maximum likelihood estimation for Bayesian networks, structure learning in Bayesian networks, Parameter Estimation in Markov Networks. Structure

Learning.Learning undirected models- EM: Handling Missing Data.Applications in Vision, Web/IR, NLP and Biology.Advanced Topics: Statistical Relational Learning, Markov Logic Networks.

Text Books/References:

1. Daphne Koller and Nir Friedman," Probabilistic Graphical Models: Principles and Techniques", First Edition, MIT Press, 2009.
2. Michael Jordan (ed.)," Learning in Graphical Models". MIT Press, 1998. Collection of Papers.
3. Judea Pearl. Morgan Kaufmann," Probabilistic Reasoning in Intelligent Systems" 1988.
4. Kevin P. Murphy, "Machine Learning, a probabilistic perspective", The MIT Press Cambridge, Massachusetts, 2012

19AI615OPTIMIZATION TECHNIQUES3-0-1-4

Unit I:
Mathematical Optimization – Least Squares and Linear Programming – Simplex Methods – Primal and Dual problems, Graphs and Networks: The Maximal Flow Problem.

Unit II:
Constrained minimization, Interior point methods Convex optimization in finite dimension – Dimension-free convex optimization, Convex Optimization and Randomness.

Unit III:
Convex Optimization Problem: Convex sets, Convex functions, Duality, Applications: Approximation and fitting, Statistical estimation, Geometric problems, Algorithms: Unconstrained minimization.

Text Books/References:

1. Bernard Kolman and Robert E," Beck Elementary Linear Programming with Applications", https://www.sciencedirect.com/book/9780124179103/elementary-linear-programming-with-applications.
2. Stephen Boyd, LievenVandenberghe,"Convex Optimization", Cambridge University Press http://stanford.edu/~boyd/cvxbook/bv_cvxbook.pdf
3. SebastianBubeck,"Convex Optimization: Algorithms and Complexity", Microsoft Research, Foundations and TrendsR © in Machine Learning, Vol. 8, No. 3-4 (2015) 231–358c©2015 S. Bubeck DOI: 10.1561/2200000050, https://arxiv.org/pdf/1405.4980.pdf
4. Singiresu S. Rao, John Wiley & Sons, Inc, "Engineering Optimization: Theory and Practice", 2009

19AI616COMPUTATIONAL STATISTICS AND INFERENCE THEORY3-0-1-4

Unit I:

Computational Statistics- Probability concepts, Sampling Concepts, Generating Random Variables, Exploratory Data Analysis, Monte Carlo Methods for Inferential Statistics, Data Partitioning, Probability Density Estimation, Statistical Pattern Recognition, Nonparametric Regression.

Unit II:

Data Mining- data mining Algorithms-Instance and Features, Types of Features (data), Concept Learning and Concept Description, Output of data mining Knowledge Representation; Decision Trees- Classification and Regression trees constructing.

Unit-III:

Classification trees, Algorithm for Normal Attributes, Information Theory and Information. Entropy, Highly-Branching Attributes, ID3 to c4.5, CHAID, CART, Regression Trees, Model Trees, Pruning. Preprocessing and Post processing in data mining – Steps in Preprocessing, Discretization, Manual Approach, Binning, Entropy- based Discretization, Gaussian Approximation, K-tile method, Chi Merge, Feature extraction, selection and construction, Feature extraction, Algorithms, Feature selection, Feature construction, Missing Data, Post processing. Association Rule Mining.Multiple Regression Analysis, Constructing new attributes for algorithms of decision trees. Induction, Quick, Unbiased and Efficient Statistical tree.

Text Books/References:

1. Wendy L. Martinez and Angel R, “Martinez Computational Statistics,” Chapman &Hall/CRC, 2002.
2. Jiawei Han and Micheline Kamber, “Data Mining: Concepts and Techniques,” Morgan Kaufmann Publishers, 2001.
3. Ian H. Witten, “Data Mining: Practical Machine Learning Tools and Techniques with Java Implémentations”, Morgan Kaufmann, 2000.
4. K. P. Soman, V. Ajay and DiwakarShyam, “Insight into Data Mining: Theory and Practice”, Prentice Hall India, 2005.

19AI617 MULTI AGENT SYSTEMS 3-0-1-4

Unit I:
Intelligent Agents - Problem Solving - Searching - Heuristics - Constraint satisfaction problems - Knowledge representation and reasoning. Logical Agents-First Order Logic-First Order Inference-Unification - Chaining- Resolution Strategies

Unit II:
Agents - State Space Search - Partial Order Planning – Graphs – Non deterministic Domains Conditional Planning - Continuous Planning – Multi Agent Planning. Agents and Uncertainty, Acting under uncertainty – Probability Notation-Bayes Rule - Bayesian Networks - Time and Uncertainty - Temporal Models - Utility Theory - Decision Network – Complex Decisions.

Unit III:
Higher level Agents, Knowledge in Learning- Statistical Learning Methods -Reinforcement Learning- Formal Grammar - Augmented Grammars.

Text Books/References:

1. Stuart Russell and Peter Norvig, "Artificial Intelligence - A Modern Approach", 2nd Edition, Prentice Hall, 2002.
2. Michael Wooldridge, "An Introduction to Multi Agent System", John Wiley, 2002.
3. Patrick Henry Winston, Artificial Intelligence, III Edition, AW, 1999.
4. Nils.J. Nilsson, Principles of Artificial Intelligence, Narosa Publishing House, 1992

19AI618 COMPUTATIONAL INTELLIGENCE 3-0-1-4

Computational intelligence (CI): Linear Separable Problems and Perceptron, Multi-Layer neural networks – Back Propagation-radial basis function based multilayer perceptron - Kohonen's Self-Organizing Networks - Hopfield Networks, ART networks, Boltzmann Machine.

Fuzzy systems: Fuzzy sets – properties - membership functions - fuzzy operations, Applications, Implementation, Hybrid systems.

Evolutionary computing: - Genetic algorithm – Schema theorem - Advances in the theory GA. Genetic Programming, Particle swarm optimization, Ant colony optimization, Artificial immune Systems.

Applications: 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. Laurence Fausett, “Fundamentals of Neural Networks”, Prentice Hall,1994
3. Timothy J Rose, “Fuzzy Logic with Engineering Applications”, Third Edition, Wiley, 1995.
4. NazmulSiddique, HojjatAdeli, “Computational Intelligence: Synergies of Fuzzy Logic, Neural Networks and Evolutionary Computing”, Willey 2013

19AI619 DEEP LEARNING 3-0-1- 4

Unit I:

Neural Networks basics – Linear Separable Problems and Perceptron – Multi layer neural networks and Back Propagation, Practical aspects of Deep Learning: Train/ Dev / Test sets, Bias/variance, Overfitting and regularization, Linear models and optimization, Vanishing/exploding gradients, Gradient checking, Hyper Parameter Tuning

Unit II:

DeepNeural Network Architectures – Convolutional neural networks, Recurrent neural networks - LSTM

Unit III:

DeepBelief Networks, Generative Adversarial Networks – Deep Reinforcement Learning.Tensor Flow, Keras or MatConvNet for implementation.

Text Books/References:

1. Ian Goodfellow, YoshuaBengio and Aeron Courville,” Deep Learning”, MIT Press, First Edition, 2016.
2. Adam Gibson and Josh Patterson,” Deep Learning, A practitioner’s approach”, O’Reilly, First Edition, 2017.
3. Francois Chollet,” Deep Learning with Python”, Manning Publications Co, First Edition, 2018.

19AI620 REINFORCEMENT LEARNING (3 0 1 4)

Unit I:
Introduction to Reinforcement Learning – Elements of Reinforcement Learning – Multi-armed Bandits. Finite Markov Decision Processes – Dynamic Programming

Unit II:
Monte Carlo Methods – Temporal-Difference Learning – n-step Bootstrapping - Planning and Learning with Tabular Methods

Unit III:
Deep Reinforcement Learning – Policy Gradients – Deep Q Learning – Actor-Critic Models - Inverse Reinforcement learning

The course must include RL case studies/project to different fields including robotics, video game, and health care.

Text Books/References:

1. Richard.S. Sutton and Andrew G. Barto, Reinforcement Learning, second edition, MIT Press, 2018.
2. MohitSewak, Deep Reinforcement Learning: Frontiers of Artificial Intelligence. First Ed., Springer Singapore, 2019.
3. Mnih, Volodymyr; et al., Playing Atari with Deep Reinforcement Learning, NIPS Deep Learning Workshop 2013.

19AI621 COMPUTER VISION 3-0-1-4

Unit I:
Introduction to Image Processing-Basic mathematical concepts: Image enhancement: Grey level transforms, Spatial filtering. Extraction of special features: edge and corner detection. Morphological processing,Image transforms, Discrete Fourier Transform, Fast Fourier Transform.Frequency domain enhancement.

Unit II:
ImageSegmentation Algorithms: contextual, non-contextual segmentation, texture segmentation. Feature Detectors and Descriptors, Feature Matching-Object Recognition, The Use of Motion in Segmentation Optical Flow & Tracking Algorithms, Face detection (Viola Jones), Face Recognition.

Unit III:
2D and 3D feature-based alignment, Poseestimation, Geometric intrinsic calibration, -Camera Models and Calibration: Camera Projection Models – orthographic, affine, perspective, projective models. Projective Geometry, transformation of 2-d and 3-d, Internal Parameters,

Lens Distortion Models, Calibration Methods – linear, direct, indirect and multiplane methods. Visual servo.Stereo correspondence-Epipolar geometry, Fundamental matrix, Introduction to SLAM (Simultaneous Localization and Mapping).

Text books/References:

1. R. C. Gonzalez, R. E. Woods, 'Digital Image Processing', Addison-Wesley,2002
2. Introduction to Computer Vision and its Application, Richard Szelinski,2010
3. E. Trucco and A. Verri, Prentice Hall, 1998.Introductory techniques for 3D Computer Vision.
4. Marco Treiber, "An Introduction to Object Recognition Selected Algorithms for a Wide Variety of Applications", Springer, 2010.
5. Forsyth and Ponce, "Computer Vision – A Modern Approach", Second Edition, Prentice Hall, 2011.

19AI622 NEGOTIATED STUDIES 2-0-0-2

This course is intended to be a self-study course. Each student can select an area of self-study in consultation with the Faculty. Collect and study basic and recent research articles (project reports, review articles, published articles in journals and book chapters) on the topic. It can also involve semester long case study or mini projects involving programming, implementation, testing performance analysis etc. in different application specific contexts. Students will be required to make two in-class presentation and prepare a review article, possibly of publishable quality. The seminars and article will be evaluated for grading purpose. The evaluation will be done by a panel of (at least) two Faculty members.

19RM600 RESEARCH METHODOLOGY 2-0-0-2

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, Citation indexes

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

Textbooks/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

19AI701 MACHINE LEARNING FOR BIG DATA 3-0-0-3

Unit I:
Concept of Machine Learning: Approaches to Modelling- Importance of Words in Documents - Hash Functions- Indexes - Secondary Storage -The Base of Natural Logarithms - Power Laws - Map Reduce. Finding similar items: Shingling – LSH - Distance Measures. Mining Data Streams: Stream data model - Sampling data - Filtering streams. Link Analysis: Page Rank, Link Spam.

Unit II:
Frequent Item Sets: Market Basket Analysis, A-Priori Algorithm - PCY Algorithm,
Clustering: Hierarchical clustering, K-Means, Clustering in Non-Euclidean Spaces, BFR, CURE. Recommendation Systems: Utility matrix - Content based - Collaborative filtering - UV Decomposition. Mining Social Network Graphs: Social networks as graphs–Clustering – Partitioning - Simrank. Dimensionality Reduction: Eigen Value Decomposition- PCA - SVD.

Unit III:
Large Scale Machine Learning: Neural Networks - The Support Vector Machines model and use of Kernels to produce separable data and non-linear classification boundaries.

Overview - Deep learning; Tools for Data Ingestion; analytics and visualization.

Text Books/References:

1. Tom M. Mitchel, “Machine Learning”, McGraw Hill, 2013.
2. AnandRaja Raman, Jure Leskovec and J.D. Ullman, “Mining of Massive Data Sets”, eBook, Cambridge University Press, 2014.
3. Kevin P. Murphey, “Machine Learning, a Probabilistic Perspective”, The MIT Press Cambridge, Massachusetts, 2012,

19AI702 APPLICATIONS OF MACHINE LEARNING 3-0-0-3

UNIT I

Review of machine learning Concepts, Design of ML system – Model selection, bias, variance, learning curves, and error analysis.

Recommendation Systems – Model for Recommendation Systems, Utility Matrix, Content-Based Recommendations, Discovering Features of Documents, Collaborative Filtering.

UNIT II

Mining Social network graphs – Clustering of Social Network Graphs, Partitioning of Graphs, and Finding Overlapping Communities.

Advertising on the Web: Issues in Online Advertising, Online and offline algorithms, The matching Problem, The AdWords Problem, The Balance Algorithm, A Lower Bound on Competitive Ratio for Balance.

UNIT III

Application of dimensionality reduction - PCA, Singular Value decomposition for data compression, LU decomposition for recommendation systems, Image Processing – compression and Visualization.

Sparse models, State space models, Markov Decision Process, Markov random Fields, Review of Inference for graphical models, Latent Linear and Variable models for discrete data, random algorithms in Computational Linear algebra.

Text Books/References:

1. AnandRaja Raman, Jure Leskovec and J.D. Ullman, “Mining of Massive Data sets”, e-book, Publisher, 2014.
2. Kevin P. Murphey, “Machine Learning, a Probabilistic Perspective”, The MIT Press Cambridge, Massachusetts, 2012.
3. Selected Journal papers to be given as case study from each module.

19AI703 REPRESENTATION LEARNING 3-0-0-3

Unit I:

Dimensionality reduction - Principal Component Analysis (PCA), sparse PCA, Independent Component Analysis, Singular Value Decomposition, CUR decomposition.Non-negative matrix factorization, incremental matrix factorization algorithms. Subspace Learning: Top down subspace clustering – PROCLUS, FINDIT, Bottom up subspace clustering – CLIQUE, MAFIA.

Unit II:

Manifold Learning: Kernel K-means, kernel PCA, similarity-based clustering. Deep Learning: Stochastic optimization, stochastic approximation algorithms. Restricted Boltzmann machines, auto encoders, deep belief networks, convolutional neural networks, Multi-view Learning: Partial least squares, canonical correlation analysis (CCA), Kernel CCA, Deep CCA. State of the art models in applications such as text classification, speech recognition and image classification

Unit III:

Spectral Learning: Spectral methods, spectral clustering, co-training, spectral learning of Hidden Markov Models (HMMs), tensor factorization, latent variable PCFGs, multivariate latent tree structures.

Text Books/References:

1. EthemAlpaydin, “Introduction to Machine Learning”, MIT Press
2. Jeremy Watt, Reza Borhani, Aggelos K. Katsaggelos, “Machine Learning Refined: Foundations, Algorithms, and Applications”. Cambridge University Press.
3. Shiliang Sun, Liang Mao, Ziang Dong, Lidan Vu, “Multiview Machine Learning”. Springer
4. Ian Goodfellow, YoshuaBengio and Aaron Courville, “Deep Learning”, MIT Press

19AI704 APPLIED PREDICTIVE ANALYTICS 3-0-0-3

Unit-I:

Introduction and Overview of the Predictive Analytics – Building a Predictive Model - Predictive Power and Overfitting - Data Partitioning – Exploratory Data Analysis - Data Visualization - Dimension Reduction - Principal Components Analysis - Performance Evaluation - Evaluating Predictive Performance - Judging Classifier Performance – Lift and Decile Charts – Oversampling.

Unit-II:

Prediction and Classification Methods - Multiple Linear Regression - Explanatory vs. Predictive Modeling - Estimating the Regression Equation and Prediction - The k-NN Classifier

(Categorical Outcome) - The Naive Bayes Classifier - Classification and Regression Trees - Logistic Regression - Neural Nets - Discriminant Analysis - Combining Methods: Ensembles - Uplift Modeling - Association Rules and Collaborative Filtering - Clustering.

Unit-III:

Forecasting Time Series – Components of a Time Series – Data Partitioning and Performance Evaluation for Time Series – Naïve Forecasts - Smoothing Methods - Introduction - Moving Average - Simple Exponential Smoothing – Advanced Exponential Smoothing–Regression-Based Forecasting - Autocorrelation and ARIMA Models - Data Analytics - Social Network Analytics - - Text Mining -predictive analytics in business application - Other Case Studies.

Text Books/References

1. GalitShmueli, Peter C. Bruce, InbalYahav, Nitin R. Patel, Kenneth C. LichtendahlJr"Data Mining for Business Analytics: Concepts, Techniques, and Applications in Python", Wiley, 2019
2. Daniel T. Larose and Chantal D. Larose, "Data Mining and Predictive Analytics" (Wiley Series on Methods and Applications in Data Mining), Wiley, 2015
3. Max Kuhn and Kjell Johnson, "Applied Predictive Modeling", Springer, 2018

19AI705 AI INNATURAL LANGUAGE PROCESSING3-0-0-3

Unit I:

Introduction - terminologies - empirical rules – Statistical Properties of words – Probability and NLP – Vector Space Models - Pre-processing- Vector Representation of words – Contextual Understanding of text – Co-occurrence of matrix – N-grams – Dense Word Vector – SVD Dimensionality reduction – Query Processing – Topic Modelling. Introduction of Probability in the context of NLP – Probabilistic language model – Chain rule and Markov Assumption – Generative Models – Bigram and Trigram Language Model – Out of vocabulary – Curse of dimensionality – Naïve Bayes Algorithm for classification

Unit II:

Neural Networks for NLP – Why Word2Vec – CBOW and Skip-gram Models – One-word learning architecture- Forward pass for Word2Vec – Reduction of complexity – sub-sampling and negative sampling – Hierarchical softmax – Updation of weights using Hierarchical softmax – ANN as a LM and its limitations – Sequence learning and its applications.

Unit III:

Historical Approaches to Machine Translation – Statistical Machine Translation – Translation Models – Phrase Based Translation – Extraction of Phrases – Evaluation of MT using BLEU metric – Encoder Decoder Model for Neural Machine Translation – Introduction of Attention based Translation. ConversationModelling, Chat-bots, dialog agents, Question Processing

Text Books/References:

1. NiladriSekhar Dash and S. Arulmozi, Features of a Corpus. Singapore: Springer Singapore, 2018, pp. 17–34. ISBN: 978-981-10-7458-5.
2. Ian Goodfellow, YoshuaBengio, and Aaron Courville, Deep Learning, http://www.deeplearningbook.org. MIT Press, 2016.
3. NitinIndurkhya and Fred J Damerau, "Handbook of natural language processing," Chapman and Hall/CRC, 2010.
4. Daniel Jurafsky and James H. Martin "Speech and Language Processing: An Introduction to Natural Language Processing, Computational Linguistics, and Speech Recognition," 1st. Upper Saddle River, NJ, USA: Prentice Hall PTR, 2000. isbn: 0130950696.
5. C.D. Manning et al, “Foundations of Statistical Natural Language Processing," MitPress. MIT Press, 1999. isbn: 9780262133609.
6. Christopher D. Manning, PrabhakarRaghavan, and HinrichSchutze, "An Introduction to Information Retrieval," Cambridge UP, 2009. Chap. 6, pp. 109–133.
7. Jacob Perkins, "Python 3 text processing with NLTK 3 cookbook," Packet Publishing Ltd, 2014.
8. Noah A. Smith, "Linguistic Structure Prediction. Synthesis Lectures on Human Language Technologies," Morgan and Claypool, May 2011.

19AI706 INTRODUCTION TO ROBOTICS 3 0 0 3

Unit I:
Introduction to robots – Types of robots – Technology and basic principles of robots – Sensors in robots: types & measurements – Mathematical representation of robots – Robot kinematics: forward and inverse

Unit II:
Introduction to mobile robots: wheeled robots, legged robots and drones – Environment perception – Path planning – Probabilistic based localization and mapping

Unit III:
Introduction to robotic vision – Object detection – Pose estimation – Introduction to Robot Operating System

Textbooks / References:

1. P. Corke,” Robotics, Vision & Control”, 2nd edition, Springer, 2011.

2. M.W. Spong, S. Hutchinson and M. Vidyasagar, “Robot Modeling and Control”, Wiley, 2006.
3. A. Ghosal, “Robotics: Fundamental Concepts & Analysis”, Oxford University Press, Ninth Edition, 2006.
4. T. Bajd, M. Mihelj and M. Munih,” Introduction to Robotics”, Springer Briefs in Applied Sciences and Technology, 2013.
5. Robin Murphy, “Introduction to AI Robotics”, MIT Press, 2000.
6. Roland Siegwart and IllahNourbakhsh, “Introduction to Autonomous Mobile Robots” MIT Press, 2004

19AI707 INTRODUCTION TO GAME THEORY 3-0-0-3

Unit I:
Games with Perfect Information: Strategic Games: Concepts and Examples. Nash Equilibrium and Existence Properties. Market Equilibrium and Pricing: Cournot and Bertrand Games. Games with Perfect Information Continued: Electoral Competition: Median Voter Theorem.

Unit II:
Auctions: Definitions and The role of knowledge. Decision Making and utility Theory: Mixed Strategy Equilibrium: Extensive Frame Game with Perfect Information Theory: Stackelberg Model of Duopoly.

Unit III:
Buying Votes.Committee Decision-Making. Repeated games: The Prisoner’s Dilemma General Result-Super Modular Game and Potential Game:

Text books/References:
1. Martin Osbome, “An Introduction to Game Theory”, Oxford University Press,2003
2. Gibbons, R,” Game Theory for Applied Economists”, Princeton university pree,1992.
3. Dixit A, B. Nalebuff, “The Art of Strategy”, WWW Norton,2008(Hereafter DN).
4. Dixit A, B.Nalebuff,” Thinking Strategically”, WW Norton, 1991.
5. PrajitDatta,” Strategies and Games”, MIT press.

19AI708 COMPUTATIONAL LINEAR ALGEBRA 3-0-0-3

Unit I:
Matrices and Gaussian Elimination – Introduction, Geometry of LinearEquations, Gaussian Elimination, Matrix multiplication, Inverses andTransposes, Special matrices and applications. Vector spaces andLinear equations– Vector spaces and subspaces, linear independence,basis and dimension, the four fundamental subspaces.

Unit II:
Orthogonality -Perpendicular vectors and orthogonal subspaces, inner products andprojections onto lines, projections and least square applications,orthogonal basis, orthogonal spaces, orthogonal matrices, GramSchmidt orthogonalization, FFT.

Unit III:
Eigenvalues and Eigenvectors –Introduction, diagonal form of a matrix, difference equations and thepowers of A^k, Positive Definite Matrices - Minima, Maxima and saddlepoints, tests for positive definiteness, semi-definite and indefinitematrices, Singular Value Decomposition, iterative methods for Ax = b,Applications in sparse signal and image processing. Concept of Streaming algorithms, Sketching methods with examples.

Text books/References:

1. Gilbert Strang, "Linear Algebra and its Applications", ThirdEdition, Harcourt College Publishers, 1988.
2. Gene H. Goluband V. Van Loan, "Matrix Computations", ThirdEdition, John Hopkins University Press, Baltimore, 1996.
3. David C. Lay, "Linear Algebra and Its Applications", PearsonAddison Wesley, 2002.
4. https://doi.org/10.1073/pnas.0803205106

19AI709 MODELING AND SIMULATION 3-0-0-3

Unit I:
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.

Unit II:
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.

Unit III:
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. J. Banks, John S. Carson, Barry L. Nelson, ‘Discrete-Event-System Simulation,’ Prentice Hall of India Private Limited.
2. Averill. M. Law: Simulation Modeling and Analysis, Tata McGraw-Hill, Fourth Edition.

19AI710 ADVANCED ALGORITHMS AND ANALYSIS 3-0-0-3

Unit I:

Data Structures - More Advanced Solutions to Basic Data Structuring Problems: Fibonacci Heaps. Van Emde Boas Priority Queues.Dynamic Data Structures for Graph Connectivity/Reachability. Bit Tricks - Word-level Parallelism. Trans dichotomous Model.O(nlogn) Integer Sorting. String Algorithms - Rabin-Karp Fingerprinting Algorithm. Suffix Trees.Maximum Flows - Augmenting Paths and Push-Relabel Methods. Minimum Cost Flows. Bipartite Matching.

Unit II:

Linear Programming - Formulation of Problems as Linear Programs.Duality.Simplex, Interior Point, and Ellipsoid Algorithms.Online Algorithms - Ski Rental.River Search Problem.Paging.The k-Server Problem.List Ordering and Move-to-Front.Approximation Algorithms - One Way of Coping with NP-Hardness.Greedy Approximation Algorithms.Dynamic Programming and Weakly Polynomial-Time Algorithms.Linear Programming Relaxations.Randomized Rounding.Vertex Cover, Wiring, and TSP. Fixed-Parameter Algorithms - Another Way of Coping with NP-Hardness.Parameterized Complexity.Kernelization.Vertex Cover.Connections to Approximation.

Unit III:

Parallel Algorithms - PRAM.Pointer Jumping and Parallel Prefix.Tree Contraction. Divide and Conquer. Randomized Symmetry Breaking. Maximal Independent Set.External-Memory Algorithms - Accounting for the Cost of Accessing Data from Slow Memory.Sorting.B-trees.Buffer Trees.Cache-oblivious Algorithms for Matrix Multiplication and Binary Search.Computational Geometry - Convex Hull.Line-segment Intersection. Sweep Lines. Voronoi Diagrams. Range Trees. Seidel's Low-dimensional LP Algorithm. Streaming Algorithms - Sketching.Distinct and Frequent Elements.

Textbooks/References:

1. Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest, and Clifford Stein, Introduction to Algorithms, MIT Press, Third edition, 2009.
2. J Hromkovic, Design and Analysis of Randomized Algorithms, Springer, 2009
3. S. Dasgupta, C. H. Papadimitriou, and U. V. Vazirani, Algorithms, McGraw-Hill 2008

4. David P. Williamson and David B. Shmoys, The Design of Approximation Algorithms, Cambridge University Press, 2010

19AI711 INFORMATION RETRIEVAL 3-0-0-3

Unit I:
Introduction to IR: Space Retrieval Models - Ranked Retrieval - Text Similarity Metrics - Tokenizing- Stemming-Evaluations on benchmark text collections - Components of an information retrieval system.

Unit II:
Indexing for IR: Inverted Indices - Postings lists - Optimizing indices with skip lists - Proximity and phrase queries - Positional indices - Dictionaries and tolerant retrieval - Dictionary data structures - Wild-card queries- n-gram indices - Spelling correction and synonyms - Edit distance - Index construction - Dynamic indexing - Distributed indexing - real-world issues.

Unit III:
Relevance in IR: Parametric or fielded search - Document zones - Vector space retrieval model - tf.idf weighting - queries as vectors - Computing scores in a complete search system - Efficient scoring and ranking - Evaluation in information retrieval: User happiness- Creating test collections: kappa measure-interjudge agreement - Relevance feedback and query expansion: Query expansion - Automatic thesaurus generation - Sense-based retrieval -. Document Classification and Clustering: Introduction to text classification -Latent Semantic Indexing.

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.

19AI712 WEB INTELLIGENCE & BIG DATA 3-0-0-3

Unit I:
Introduction to Web Intelligence: Ingredients of Web Intelligence, Topics of Web Intelligence. Information Retrieval - Document Representation, Retrieval Models, Evaluation of Retrieval Performance.

Unit II:

Semantic Web: The Layered-Language Model, Metadata and Ontologies, Ontology Languages for the Web. Web Usage Mining: Web-Log Processing, Analyzing Web Logs, Applications of Web Usage Mining, Clustering of Web Users, Classification Modeling of Web Users, Association Mining of Web Usages, Sequence-Pattern Analysis of Web Logs.

Unit III:

Web Content Mining- Web Crawlers, Search Engines, Personalization of Web Content. Web Structure Mining- Modeling Web Topology, PageRank Algorithm, Hyperlink-Induced Topic Search (HITS) Random Walks on the Web, Social Networks & Graphs

Text books/References:

1. GautamShroff, The Intelligent Web: Search, Smart Algorithms, and Big Data, Oxford Press,2019
2. Akerkar, R. &Lingras, P. (2008). Building an Intelligent Web: Theory and Practice. Jones and Bartlett Publishers, Sudbury, Massachusetts. ISBN-13: 978-0-7637-4137-2
3. Bing Liu: Web Data Mining, Springer, 2nd ed. 2011
4. Marmanis&Babenko: Algorithms of the Intelligent Web, Manning Publications, 2009, ISBN: 978-1933988665
5. Manning, Raghavan and Schuetze: Introduction to Information Retrieval, Cambridge University Press, 2008

19AI713 DATA VISUALIZATION 3-0-0-3

Unit I:

Value of Visualization – What is Visualization and Why do it: External representation – Interactivity – Difficulty in Validation. Data Abstraction: Dataset types – Attribute types – Semantics. Task Abstraction – Analyze, Produce, Search, Query. Four levels of validation – Validation approaches – Validation examples. Marks and Channels

Unit II:

Rules of thumb – Arrange tables: Categorical regions – Spatial axis orientation – Spatial layout density. Arrange spatial data: Geometry – Scalar fields – Vector fields – Tensor fields. Arrange networks and trees: Connections, Matrix views – Containment. Map color: Color theory, Color maps and other channels.

Unit III:

Manipulate view: Change view over time – Select elements – Changing viewpoint – Reducing attributes. Facet into multiple views: Juxtapose and Coordinate views – Partition into views – Static and Dynamic layers – Reduce items and attributes: Filter – Aggregate. Focus and context:

Elide – Superimpose - Distort – Case studies.

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.

19AI714 NETWORKS AND SPECTRAL GRAPH THEORY 3-0-0-3

Unit I:

Graphs and Networks- Review of basic graph theory, Mathematics of networks- Networks and their representation, Graph spectra, Graph Laplacian, Structure 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.

Unit II:

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.

Unit III:

Models of network Formation-Preferential attachment, Model of Barabasi and Albert, Vertex copying models, Network optimization models; Epidemics on networks- Models of the spread of disease, SI model, SIR model, SIS model, SIRS model; Network Search-Web search, Searching distributed databases.

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.

19AI715 PARALLEL & DISTRIBUTED DATA MANAGEMENT 3-0-0-3

Unit I:
Introduction: Parallel and Distributed architectures, models, complexity measures, Communication aspects, A Taxonomy of Distributed Systems - Models of computation: shared memory and message passing systems, synchronous and asynchronous systems, Global state and snapshot algorithms.

Unit II:
Distributed and Parallel databases: Centralized versus Distributed Systems, Parallel versus Distributed Systems, Distributed Database Architectures-Shared disk, shared nothing, Distributed Database Design – Fragmentation and Allocation, Optimization.

Unit III:
Query Processing and Optimization – Parallel/Distributed Sorting, Parallel/Distributed Join, Parallel/Distributed Aggregates, Network Partitions, Replication, Publish/Subscribe Systems-Case study on Apache Kafka Distributed Publish/Subscribe messaging Hadoop and Map Reduce – Data storage and analysis, Design and concepts of HDFS, YARN, Map Reduce workflows and Features, Setting up a Hadoop cluster.

Text books/References:

1. M. Tamer Ozsu, Patrick Valduriez, "Principles of Distributed Database Systems", 3rd ed. 2011 Edition, Springer
2. Dimitri P. Bertsekas and John N. Tsitsiklis, "Parallel and distributed computation : Numerical methods",
3. Andrew S. Tannenbaum and Maarten van Steen "Distributed Systems: Principles and Paradigms", Second Edition, Prentice Hall, October 2006.
4. Ajay D. Kshemkalyani and MukeshSinghal, "Distributed Computing: Principles, Algorithms, and Systems", Cambridge University Press, 2011.
5. Vijay K Garg, "Elements of Distributed Computing", Wiley-IEEE Press, May 2002
6. Parallel database systems: The future of high performance database systems
7. Tom White, Hadoop-The Definitive Guide, 4th edition, O'Reilly

19AI716 CLOUD &BIG DATA ANALYTICS (3 0 0 3)

Unit I:

Introduction: Cloud Computing – Different service models - – Deployment Model-Virtualization Concepts – Cloud Platforms – Amazon AWS – Microsoft Azure – Google APIs Big Data – characteristics – Model data, perform ingestion, replicate and shard data, Exploratory

Data analysis versus Hypothesis Testing, Design of Data processing for Analytics, Elastic Analysis Concepts.

Unit II:

Management of Big data in cloud Computing, Big Data platforms – exposure to Hadoop ecosystem, Spark, Scala, Spark Streaming, Hive and Kafka Architecture

Unit III:

Real-world Case studies – Web Analytics, Web-scrapping, Google Analytics, Social medial Analytics, Issues in integrating Big data with Clouds- security concerns and measures to handle them.

Text books/References:

1. SeemaAcharya and SubhashiniChellapan, “Big Data and Analytics”, Publisher - Wiley – second edition, 2019

2. Kai Hwang, Min Chen,“Big–Data Analytics for Cloud, IoT and Cognitive Computing Hardcover”, John-Wiley and Sons, 2017

3.V. K. Jain, Big Data and Hadoop, Khanna Publishing, 2017.

19AI717 MEDICAL SIGNAL PROCESSING 3-0-0-3

Unit I:

Signals and systems: Review, Medical Imaging Modalities and the need for different modalities (MRI, CT, OCT for Retinal Images, PET, X-Ray, Ultra Sound, Microscopy, Flow Cytometry, Imaging Flow Cytometry, etc.

Pre-processing – Image Enhancement – Focus Analysis - Noise reduction (Additive and Speckle Noise) – Image Quality Measures - Domain Transformation: Fourier Domain and Wavelet Domain- Thermal Imaging. Basic electrocardiography, ECG lead systems, ECG signal characteristics.

Unit II:

Medical Image Segmentation – Deep Learning based Segmentation on 2D or 3D volume of Data Feature Extraction – Morphological Features – Textural Features –, Feature extraction for 1D Biomedical signals– Deep Features. Image Registration and Fusion –- Key Point Matching - Geometric transformations.

ECG data acquisition, ECG lead system, ECG signal characteristics (parameters and their estimation), Analog filters, ECG amplifier, and QRS detector, Power spectrum of the ECG, Band

pass filtering techniques, Differentiation techniques, Template matching techniques, A QRS detection algorithm

Unit III:

Classification and Clustering– Examples of image classification for diagnostic/assistive technologies –Deep learning based classifiers.3D volume reconstruction – Reconstruction techniques for CT, MRI-. Reconstruction of cell structure from focus stack of images - CT and MRI volume reconstruction – Wavelet based Volume Rendering, Applications of EEG

Text book/References:

1. Klaus D. Toennies,"Guide to Medical Image Analysis - Methods and Algorithms", Advances in Computer Vision and Pattern Recognition, 2nd Edition, Springer-Verlag London, DOI: 10.1007/978-1-4471-7320-5, ISBN 978-1-4471-7318-2

2. Geoff Dougherty, "Medical Image Processing Techniques and application", Springer New York 2011

3. MostafaAnaloui, Joseph D. Bronzino, Donald R. Peterson, "Medical Imaging: Principles and Practices", Taylor and Francis group, 2012

4. Analysing Neural Time Series Data-Theory and Practice (MIT Press) 2014

5. William O. Tatum, "Handbook of EEG Interpretation", IV, 2008 Demos Medical Publishing, LLC., 2008

19AI718 IOT PROTOCOLS AND ARCHITECTURE 3-0-0 3

Unit I:
Introduction to IOT, Applications of IOT, Use cases of IOT**.** The IoT Architectural Reference Model as Enabler, IoT in Practice: Examples: IoT in Logistics and Health, IoT Reference Model: Domain, information, functional and communication models; IoT Reference Architecture: Architecture, Functional, information, deployment and operation views; SOA based Architecture, API-based Architecture, OPENIoT Architecture for IoT/Cloud Convergence

Unit II:
Application Protocols for IoT: UPnP, CoAP, MQTT, XMPP. SCADA, Web Socket; IP-based protocols: 6LoWPAN, RPL; Authentication Protocols; IEEE 802.15.4

Unit III:
Case study: Cloud-Based Smart-Facilities Management, Healthcare, Environment Monitoring System

Text books/References:

1. Bassi, Alessandro, et al, “Enabling things to talk”, Springer-Verlag Berlin, 2016.
2. David Hanes, Gonzalo Salgueiro, Patrick Grossetete, Robert Barton, Jerome Henry, “IoT Fundamentals: Networking Technologies, Protocols, and Use Cases for the Internet of Things”, CISCO Press, 2017
3. Hersent, Olivier, David Boswarthick, and Omar Elloumi. The internet of things: Key applications and protocols. John Wiley & Sons, 2011.
4. Buyya, Raj Kumar, and Amir VahidDastjerdi, eds. Internet of Things: Principles and paradigms. Elsevier, 2016.

19AI719 PARALLEL AND DISTRIBUTED COMPUTING 3-0-0-3

Unit I:
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.

Unit II:
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:

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

19AI720MODERN COMPUTER ARCHITECTURE 3-0-0-3

Unit I
Introduction-Fundamentals of computer design, evaluating performance -Pipelining-Instruction set design principles. Caches and memory hierarchy Design-Review of memory Hierarchy-Advanced memory hierarchy design concepts.

Unit II:

Instruction level parallelism and its Exploitation-Limits on instruction level parallelism. Multiprocessors and Thread-level Parallelism-Models of parallel computation, network topologies, consistency models.

Unit III

Simultaneous Multi-Threading (SMT), Chip Multi-Processors (CMP), General Purpose Graphics Processing Units (GPGPU). VLSI Scaling issues, data speculation, dynamic compilation, communication architectures, near data processing, and other advanced topics.

Text Books/References:

1. L. Hennessy & David A. Patterson, Morgan Kaufmann," Computer Architecture: A Quantitative Approach", 5th Edition, 2011, , ISBN: 978-0-12-383872-8
2. David A Patterson & John L. Hennessy, Morgan Kaufmann, "Computer Organization and Design", the Hardware/Software Interface, 5th Edition.

19AI721 GPU ARCHITECTURE AND PROGRAMMING 3-0-0-3

(Prerequisite – Modern Computer Architecture)

Unit I:

Introductionto Parallel Programming – Types of Parallelism - Introduction to OpenCL - OpenCL Device Architectures - Basic OpenCL – examples - Understanding OpenCL - Concurrency and Execution Model - Dissecting a CPU/GPU - OpenCL Implementation – OpenCL.

Unit II:

CUDA programming – CUDA C – Setting up CUDA, Grids, Blocks - Thread Cooperation – Memory types – CUDA streams.

Unit III:

Case study: Convolution, Video Processing, Histogram and Mixed Particle Simulation - OpenCL Extensions - OpenCL Profiling and Debugging – WebCL, Applications of GPU Architecture like Gaming, Computer Vision, etc.

Text Books/References:

1. Benedict R Gaster, Lee Howes, David, R. Kaeli, PerhaadMistry and Dana Schaa, "Heterogeneous Computing with OpenCL", Elsevier, 2013.
2. Jason Sanders, Edward Kandrot, "CUDA by Example: An Introduction to General-Purpose GPU Programming", Addison-Wesley Professional, 2010

3. Shane Cook, “CUDA Programming: A Developer's Guide to Parallel Computing with GPUs”, Newnes, 2012
4. AaftabMunshi, Benedict Gaster, Timothy G. Mattson, James Fung & Dan Ginsburg, “OpenCL Programming Guide”, Addison-Wesley Professional, 2011.
5. RyojiTsuchiyama, Takashi Nakamura, TakuroIizuka& Akihiro Asahara, “The OpenCL Programming Book”, Fixstars Corporation, 2010.
6. Matthew Scarpio, “OpenCL in Action: How to Accelerate Graphics and Computations”, Manning Publications, 2011.