Rajiv Gandhi ProudyogikiVishwavidyalaya Bhopal

M.Tech (Artificial Intelligence & Data Science)

Second Semester Syllabus

MTAD 201 - Soft Computing

UNIT 1

Soft Computing: Introduction of soft computing, soft computing vs. hard computing, various types of soft computing techniques, applications of soft computing.

Artificial Intelligence: Introduction, Various types of production systems, characteristics of production systems, breadth first search, depth first search techniques, other Search Techniques like hill Climbing, Best first Search, A* algorithm, AO* Algorithms and various types of control strategies. Knowledge representation issues, Prepositional and predicate logic, monotonic and non monotonic reasoning, forward Reasoning, backward reasoning, Weak & Strong Slot & filler structures, NLP.

UNIT 2

Neural Network : Structure and Function of a single neuron: Biological neuron, artificial neuron, definition of ANN, Taxonomy of neural net, Difference between ANN and human brain, characteristics and applications of ANN, single layer network, Perceptron training algorithm, Linear separability, Widrow & Hebb;s learning rule/Delta rule, ADALINE, MADALINE, AI v/s ANN. Introduction of MLP, different activation functions, Error back propagation algorithm, derivation of BBPA, momentum, limitation, characteristics and application of EBPA.

UNIT 3

Counter propagation network, architecture, functioning & characteristics of counter Propagation network, Hopfield/ Recurrent network, configuration, stability constraints, associative memory, and characteristics, limitations and applications. Hopfield v/s Boltzman machine. Adaptive Resonance Theory: Architecture, classifications, Implementation and training. Associative Memory.

UNIT 4

Fuzzy Logic: Fuzzy set theory, Fuzzy set versus crisp set, Crisp relation & fuzzy relations, Fuzzy systems: crisp logic, fuzzy logic, introduction & features of membership functions, Fuzzy rule base system: fuzzy propositions, formation, decomposition & aggregation of fuzzy rules, fuzzy reasoning, fuzzy inference systems, fuzzy decision making & Applications of fuzzy logic.

UNIT 5

Genetic algorithm : Fundamentals, basic concepts, working principle, encoding, fitness function, reproduction, Genetic modeling: Inheritance operator, cross over, inversion & deletion, mutation operator, Bitwise operator, Generational Cycle, Convergence of GA, Applications & advances in GA, Differences & similarities between GA & other traditional methods.

Reference Books:

1. S, Rajasekaran & G.A. Vijayalakshmi Pai, Neural Networks, Fuzzy Logic & Genetic Algorithms, Synthesis & applications, PHI Publication.
2. S.N. Sivanandam, S.N. Deepa, Principles of Soft Computing, Wiley
3. Rich E and Knight K, Artificial Intelligence, TMH, New Delhi.
4. Bose, Neural Network fundamental with Graph , Algo.& Appl, TMH
5. Kosko: Neural Network & Fuzzy System, PHI Publication
6. Klir & Yuan ,Fuzzy sets & Fuzzy Logic: Theory & Appli.,PHI Pub.
7. Simon Haykin Neural Networks A Comprehensive Foundation, Pearson edu.

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Second Semester Syllabus

MTAD 202 - Computational intelligence

Pre-Requisite: Computer Programming
Course Outcomes:
After completing the course student should be able to:

1. Describe in-depth about theories, methods, and algorithms in computation Intelligence.
2. Compare and contrast traditional algorithms with nature inspired algorithms.
3. Examine the nature of a problem at hand and determine whether a computation intelligent technique/algorithm can solve it efficiently enough.
4. Design and implement Computation Intelligence algorithms and approaches for solving real-life problems.

Course Contents:

UNIT 1. Introduction to Computational Intelligence (CI): Basics of CI, History of CI, Adaptation, Learning, Self Organization and Evolution, CI and Soft Computing, CI Techniques; Applications of CI; Decision Trees: Introduction, Training Decision Trees, Evaluation, Splitting Criteria, Decision Tree Induction Algorithms.

UNIT 2. Evolutionary Computation: Genetic Algorithms: Basic Genetics, Concepts, Working Principle, Creation of Offsprings, Encoding, Fitness Function, Selection Functions, Genetic Operators-Reproduction, Crossover, Mutation; Genetic Modeling, Benefits; Problem Solving; Introduction to Genetic Programming, Evolutionary Programming, and Evolutionary Strategies.

UNIT 3. Fuzzy System:Fuzzy Sets: Formal Definitions, Membership Functions, Fuzzy Operators, Fuzzy Set Characteristics, Fuzzy Relations and Composition, Fuzziness and Probability; Fuzzy Logic and Reasoning: Fuzzy Logic, Fuzzy Rules and Inferencing; Fuzzy Controllers: Components of Fuzzy Controllers, Types, Defuzzification.

UNIT 4. Rough Set Theory: Introduction, Fundamental Concepts, Knowledge Representation, Set Approximations and Accuracy, Vagueness and Uncertainty in Rough Sets, Rough Membership Function, Attributes Dependency and Reduction, Application Domain, Hidden Markov Model (HMM),Graphical Models, Variable Elimination, Belief Propagation,Markov Decision Processes.

UNIT 5. Swarm Intelligence: Introduction to Swarm Intelligence, Swarm Intelligence Techniques: Ant Colony Optimization(ACO): Overview, ACO Algorithm;Particle Swarm Optimization(PSO): Basics, Social Network Structures, PSO Parameters and Algorithm;Application Domain of ACO and PSO; Bee Colony Optimization etc.; Hybrid CI Techniques and applications; CI Tools.

Recommended Books:

1. Russell C. Eberhart and Yuhui Shi, Computational Intelligence: Concepts to Implementations, Morgan Kaufmann Publishers, 2007.
2. Andries P. Engelbrecht, Computational Intelligence: An Introduction, Wiley Publishing, 2007.
3. David E. Goldberg, Genetic Algorithm in Search Optimization and Machine Learning, Pearson Education, 2009.
4. Jagdish Chand Bansal, Pramod Kumar Singh, Nikhil R. Pal, Evolutionary and Swarm Intelligence Algorithms, Springer Publishing, 2019.
5. S. Rajeskaran, G.A. VijaylakshmiPai, "Neural Networks, Fuzzy Logic, GeneticAlgorithms Synthesis and Applications", PHI, 2003.

Research Journals:

1. IEEE Transactions on Evolutionary Computation
2. IEEE Transactions on Systems, Man and Cybernetics
3. IEEE Transaction on Neural Networks and Learning Systems
4. IEEE Transaction on Fuzzy Systems
5. IEEE Transactions on Pattern Analysis and Machine Intelligence
6. ACM Transactions on Intelligent Systems and Technology
7. ACM Genetic and Evolutionary Computation Conference (GECCO)
8. ACM Journal of Machine Learning Research

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Second Semester Syllabus

MTAD 203 – Big Data

COURSE OUTCOMES:
After completing the course student should be able to:

1. Understand the concept and challenges of Bigdata and Demonstrate knowledge of big dataanalytics.
2. Explain Hadoop EcoSystem and develop Big Data Solutions using Hadoop EcoSystem.
3. Practice and gain hands on experience on large-scale analyticstools.
4. Understand social networks mining and analyse the social networkgraphs.

COURSE CONTENTS:
THEORY:

UNIT 1 Introduction to Big data, Big data characteristics, Types of big data, Traditional versus Big data, Evolution of Big data, challenges with Big Data, Technologies available for Big Data, Infrastructure for Big data, Use of Data Analytics, Desired properties of Big Data system.

UNIT 2 Introduction to Hadoop, Core Hadoop components, Hadoop Eco system, Hive Physical Architecture, Hadoop limitations, RDBMS Versus Hadoop, Hadoop Distributed File system, Processing Data with Hadoop, Mapreduce Programming, Managing Resources and Application with Hadoop YARN, Apache Spark.

UNIT 3 Introduction to Hive Hive Architecture, Hive Data types, Hive Hive Query Language, Introduction to Pig, Anatomy of Pig, Pig on Hadoop, Use Case for Pig, ETL Processing, Data types in Pig running Pig, Execution model of Pig, Operators, Evalfunction,Data types of Pig.

UNIT 4 Introduction to NoSQL, NoSQL Business Drivers, NoSQL Data architectural patterns, Variations of NOSQL architectural patterns using NoSQL to Manage Big Data.

UNIT 5 Mining social Network Graphs: Introduction Applications of social Network mining, Social Networks as a Graph, Types of social Networks, Clustering of social Graphs Direct Discovery of communities in a social graph.

TEXT BOOKS RECOMMENDED:

1. RadhaShankarmani, M. Vijaylakshmi, " Big Data Analytics", Wiley, Secondedition
2. Seema Acharya, SubhashiniChellappan, " Big Data and Analytics", Wiley, Firstedition

REFERENCE BOOKS:

1. KaiHwang,Geoffrey C., Fox. Jack, J. Dongarra, “Distributed and Cloud Computing”, Elsevier, Firstedition
2. Michael Minelli, Michele Chambers, AmbigaDhiraj, “Big Data Big Analytics”,Wiley

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Second Semester Syllabus

MTAD 204 – Natural Language Processing

UNIT -I :INTRODUCTION

Natural Language Processing tasks in syntax, semantics, and pragmatics – Issues - Applications - The role of machine learning - Probability Basics –Information theory – Collocations -N-gram Language Models - Estimating parameters and smoothing - Evaluating language models.

UNIT- II MORPHOLOGY AND PART OF SPEECH TAGGING

Linguistic essentials - Lexical syntax- Morphology and Finite State Transducers - Part of speech Tagging - Rule-Based Part of Speech Tagging - Markov Models - Hidden Markov Models – Transformation based Models - Maximum Entropy Models. Conditional Random Fields

UNIT- III SYNTAX PARSING

Syntax Parsing - Grammar formalisms and treebanks - Parsing with Context Free Grammars - Features and Unification -Statistical parsing and probabilistic CFGs (PCFGs)-Lexicalized PCFGs.

UNIT- IV SEMANTIC ANALYSIS

Representing Meaning – Semantic Analysis - Lexical semantics –Word-sense disambiguation - Supervised – Dictionary based and Unsupervised Approaches - Compositional semanticsSemantic Role Labeling and Semantic Parsing – Discourse Analysis.

UNIT-V APPLICATIONS

Named entity recognition and relation extraction- IE using sequence labeling-Machine Translation (MT) - Basic issues in MT-Statistical translation-word alignment- phrase-based translation .

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Second Semester Syllabus

MTAD 205(A) – Reinforcement Learning

Course Outcomes:

After completing the course student should be able to:

1. Define the key features of reinforcement learning that distinguishes it from others machine learning techniques.
2. Describe multiple criteria for analyzing RL algorithms and evaluate algorithms on RL performance metrics.
3. Design and Implement, train, and validate their own RL models.
4. Solve and implement the real world problems using reinforcement learning.

Course Contents:

UNIT 1 Introduction to Reinforcement Learning (RL), Elements of RL, RL framework and applications, Introduction to immediate RL, RL tabular solution methods: Bandit Algorithms, Bandit optimalities, Contextual bandits, Value function based methods,Gradient Bandit algorithms, UCB, UCB Theorem, Concentration bounds, Median elimination, Thompson sampling.

UNIT 2 Policies planning, policy evaluation, Policy search, Policy iteration, value iteration,Policy Gradient Methods,Markov Decision Process (MDP), MDP Formulation, MDP modelling, Bellman Equations & Optimality Proofs, Bellman optimality equation, Cauchy sequence & Green's equation, Banach fixed point theorem, Convergence proof, Dynamic Programming, LPI convergence.

UNIT 3 Monte Carlo(MC) methods, Control in MC, Off Policy MC, MC tree search, Temporal Difference Learning, , Q-learning, Eligibility traces, Backward view of eligibility traces, Eligibility trace control, n-step bootstrapping,

UNIT 4 Function approximation, Linear parameterization, State aggregation methods, Function approximation, Afterstatevalue functions, Batch RL: LSTD & LSTDQ, LSPI & Fitted Q, DQN, Fitted Q & Policy Gradient Approaches, DQN & Fitted Q-iteration, Actor critic &reinforce, Policy gradient with function approximation

UNIT 5 Hierarchical reinforcement learning, Types of optimality, Semi-Markov decision processes, Options, Learning with options, Hierarchical abstract machines, MAXQ, MAXQ value function decomposition, Option discovery, POMDP introduction, Solving POMDP, applications of RL.

Recommended Books:

1. "Reinforcement Learning: An Introduction" by Andrew Barto and Richard S. Sutton, Second Edition, MIT Press, 2018
2. "Deep Reinforcement Learning Hands-On: Apply Modern RL Methods, with Deep Q-networks, Value Iteration, Policy Gradients, TRPO, AlphaGo Zero and More" by Maxim Lapan, Third Edition, Packt Publishing, 2020
3. Marco Wiering and Martijn van Otterlo, "Reinforcement Learning: State-of-the-Art (Adaptation, Learning, and Optimization)" Springer publication, 2012

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Second Semester Syllabus

MTAD 205(B) – Recommender System

Unit-1

Introduction and basic taxonomy of recommender systems (RSs), Traditional and non-personalized RSs. Introduction of Information Retrieval, Retrieval Models, Search and Filtering Techniques: Relevance Feedback, User Profiles, Recommender system functions, Matrix operations, covariance matrices, Understanding ratings, Issues with recommender system.

Unit-2

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.

Unit-3

Collaborative Filtering (CF): Mathematical foundations Mathematical optimization in CF RSs. Baseline predictor through least squares. Regularization, over fitting. User-based recommendation, Item-based recommendation, Model based approaches, Matrix factorization. Recommender systems in personalized web search, knowledge-based recommender system, Social tagging recommender systems, Trust-centric recommendations, Group recommender systems

Unit-4

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. Evaluation of Recommender Systems: Performance Evaluation of RSs Experimental settings. Working with RSs data sets. Evaluation on historical datasets, Offline evaluations. Evaluation metrics: Rating prediction and accuracy. Other metrics (fairness, coverage, diversity, novelty, serendipity).

Unit-5

General properties of evaluation research, User behavior understanding in RSs Foundations of behavioral science. User choice and decisions models. Digital nudging and user choice engineering principles. Applications of RSs for content media, social media and communities Music and video RSs. Datasets. Group recommender systems. Social recommendations. Recommending friends: link prediction models. Similarities and differences of RSs with task assignment in mobile crowd sensing. Social network diffusion awareness in RSs.

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.
5. J. Leskovec, A. Rajaraman and J. Ullman, Mining of massive datasets, 2nd Ed., Cambridge, 2012. (Chapter 9).
6. M. Chiang, Networking Life, Cambridge, 2010. (Chapter 4).

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Second Semester Syllabus

MTAD 205(C) – Research Methodology and IPR

Unit-1

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-2

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. Literature Review: Effective literature review approaches, literature analysis, avoiding plagiarism, ethics in research, data collection, analysis, interpretation.

Unit-3

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-4

IPR: Introduction and significance of intellectual property rights, types of Intellectual Property Rights, copyright and its significance, introduction to patents and its filing, introduction to patent drafting, best practices in national and international patent filing, copyrightable work examples. 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

Unit-5

Patents and its basics, patentable items, designs, process of filing patent at national and international level, process of patenting and development, technological research and patents, innovation, patent and copyright international intellectual property, procedure for grants of patents, need of specifications, types of patent applications, provisional and complete specification, patent specifications and its contents, trade and copyright.

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. Michael P. Marder,“ Research Methods for Science”, Cambridge University Press, 2011
4. T. Ramappa, “Intellectual Property Rights Under WTO”, S. Chand, 2008
5. Robert P. Merges, Peter S. Menell, Mark A. Lemley, “Intellectual Property in New Technological Age”. Aspen Law & Business; 6 edition July 2012
6. Stuart Melville, Wayne Goddard, Research Methodology: An Introduction for Science and Engineering Students, Juta & Co Ltd.
7. Ranjit Kumar, Research Methodology: A Step by Step Guide for Beginners, Pearson.
8. T. Ramappa, Intellectual Property Rights under WTO: Tasks before India, S. Chand.

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Second Semester Syllabus

MTAD 205(D) – Deep Learning

Course Outcomes:
After completing the course student should be able to:

1. Describe in-depth about theories, fundamentals, and techniques in Deep learning.
2. Understanding of the on-going research in computer vision and multimedia field.
3. Design and Implement, train, and validate their own deep neural network.
4. Solve and implement the real world problems using deep learning.

Course Contents:

Unit-1 History of Deep Learning, Deep Learning Success Stories, review of Neuron model, activation functions, Perceptron Learning, Multilayer Perceptrons (MLPs), Feedforward Neural Networks,Backpropagation, weight initialization methods,Batch Normalization, Representation Learning,GPU implementation, Decomposition – PCA and SVD.

Unit-2 Deep Feedforward Neural Networks, Gradient Descent (GD), Momentum Based GD, Nesterov Accelerated GD, Stochastic GD, AdaGrad,Adam,RMSProp,Auto-encoder, Regularization in auto-encoders, Denoising auto-encoders, Sparse auto-encoders, Contractive auto-encoders,Variational auto-encoder, Auto-encoders relationship with PCA, Dataset augmentation.

Unit-3 Introduction to Convolutional neural Networks (CNN) and its architectures, CCN terminologies: ReLu activation function, Stride, padding, pooling, convolutions operations, Convolutional kernels, types of layers:Convolutional,pooling,fully connected,Visualizing CNN, CNN examples: LeNet, AlexNet, ZF-Net, VGGNet, GoogLeNet, ResNet, RCNNetc.Deep Dream, Deep Art. Regularization:Dropout, drop Connect, unit pruning, stochastic pooling, artificial data,injectingnoise in input,early stopping,Limit Number of parameters, Weight decay etc.

Unit-4 Introduction to Deep Recurrent Neural Networks and its architectures, Backpropagation Through Time (BPTT), Vanishing and Exploding Gradients, Truncated BPTT, Gated Recurrent Units (GRUs), Long Short Term Memory (LSTM), Solving the vanishing gradient problem with LSTMs, Encoding and decoding in RNN network, Attention Mechanism, Attention over images, Hierarchical Attention, Directed Graphical Models.

Unit-5 Introduction to Deep Generative Models,Restricted Boltzmann Machines (RBMs), Gibbs Sampling for training RBMs, Deep belief networks, Markov Networks, Markov Chains,Autoregressive Models: NADE, MADE, PixelRNN, Generative Adversarial Networks (GANs), Applications of Deep Learning inObject detection, speech/ image recognition, video analysis, NLP, medical science etc.

Recommended Books:

1. IanGoodfellow, YoshuaBengio and Aaron Courville; Deep Learning, MIT Press, 2017.
2. Chris Bishop; Pattern Recognition and Machine Learning,Springer publication, 2006
3. Aurelien Geon, “Hands-On Machine Learning with Scikit-Learn and Tensorflow: Concepts, Tools, and Techniques to Build Intelligent Systems”, First Edition, O'Reilly publication, 2017.
4. Francois Chollet, "Deep Learning with Python", First Edition, Manning Publications, 2018.
5. Andreas Muller, "Introduction to Machine Learning with Python: A Guide for Data Scientists", First edition,O'Reilly Edition, 2016.