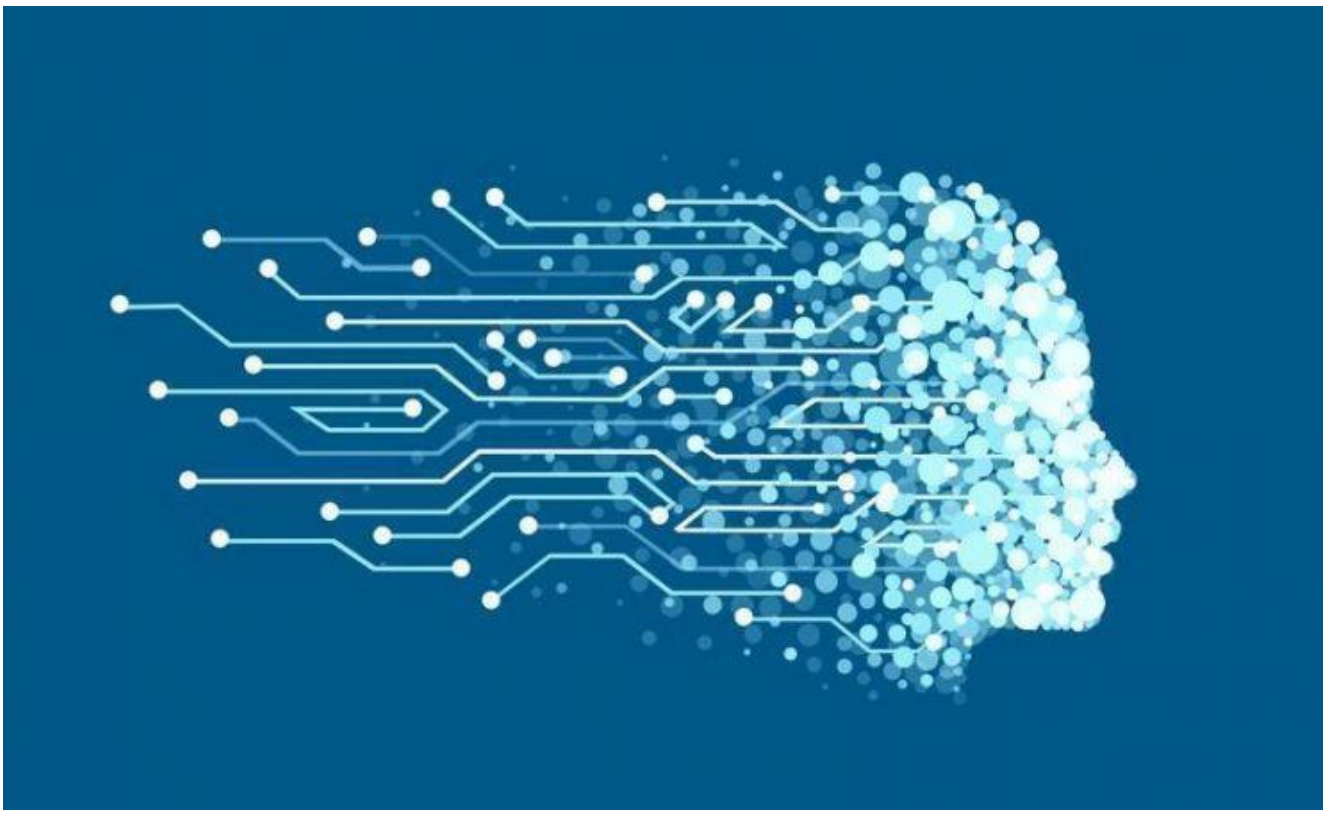
University of Kerala

Learning Outcomes-based Curriculum Framework (LOCF)

for Post-Graduate Programme



M.Sc. Computer Science

With Specialization in Machine Learning

UNIVERSITY OF KERALA

2022

UNIVERSITY OF KERALA

Syllabus for M. Sc in Computer Science
(With specialization in Artificial Intelligence)

PROGRAMME OUTCOMES

PO1	Ability to apply theoretical and advanced knowledge to solve the real world problems.
PO2	Develop the skill to do research-oriented projects.
PO3	Inculcate the process of lifelong learning to promote self-learning among students.
PO4	Develop moral values and ethics to live a better life.

PROGRAMME SPECIFIC OUTCOMES

PSO1	Develop advanced knowledge in Machine Learning Models, Intelligent Agents, Advanced Machine Learning, Deep Learning algorithms, applications of Machine Learning and Optimization
PSO2	Provide students mathematical and technical skill set of Machine Learning, Data Analytics, Pattern Recognition and thereby facilitating them for developing intelligent system based on these technologies.
PSO3	Develop the skill set for industry ready professionals to join the Information Technology field.
PSO4	Prepare and motivate students for doing research in Computer Science and Machine Learning.
PSO5	Acquire flair on solving real world Case study problems.
PSO6	Hands on experience on doing experiment for solving real life problems using advanced programming languages.
PSO7	Allow graduates to increase their knowledge and understanding of computers and their systems, to prepare them for advanced positions in the workforce.

PSO8	Develop cutting edge developments in computing technology and contemporary research for society.
PSO9	Possess the ability to take up advanced innovative development work in the industry as well as to pursue higher research degree qualifications.
PSO10	Provide great flexibility through extensive choices of electives to respond to rapidly changing industry needs as well as their interests.
PSO11	Industrial-style methods of analysis, design, implementation, testing and documentation in software development.
PSO12	Produce a new breed of computer science graduates that have a strong mathematical background along with project management skills.
PSO13	Graduates with strong technical expertise, and ability to work effectively in interdisciplinary teams and be able to tackle problems that require both technical and non-technical solution.

Programme structure of **M.Sc. Computer Science**

*(With Specialization in **Machine Learning**)*

Semester	Course Code	Name of the course	Credits
I	**Core courses (CC)**		
	CSM-CC-511	Mathematics of Machine Learning	4
	CSM-CC-512	Basics of Artificial Intelligence	4
	CSM-CC-513	Theoretical Foundations of Machine Learning	4
	CSM-CC-514	Machine Learning Lab	3
	Skill Enhancement Elective (SE)		
	CSM-SE-501	Entrepreneurial Skills and Scientific Writing	2
	Generic Course (GC)		
	CSM-GC-501	Introduction to Machine Learning and Applications	2
II	**Core courses (CC)**		
	CSM-CC-521	Advanced Learning Models	4
	CSM-CC-522	Statistical Techniques	4
	CSM-CC-523	Machine Learning with Large Datasets	4
	CSM-CC-524	Machine Intelligence Lab	3
	Discipline Specific Electives (DE)		
	CSM-DE-525(i)	Digital Image Processing	4
	CSM-DE-525(ii)	Natural Language Processing	4
	CSM-DE-525(iii)	Block Chain Technology	4
	CSM-DE-525(iv)	Computational Biology	4
	CSM-DE-525(v)	Cyber Security and Cyber Law	4
III	**Core courses (CC)**		
	CSM-CC-531	Advanced Deep Architectures	4

	CSM-CC-532	Deep Learning Lab	3
	CSM-CC-533	Case Study	2
	CSM-CC-534	Seminar	2
	Discipline Specific Electives (DE)		
	CSM-DE-535(i)	Foundations of Robotics	4
	CSM-DE-535(ii)	Reinforcement Learning Techniques	4
	CSM-DE-535(iii)	Intelligent Agent based Computing	4
	CSM-DE-535(iv)	High Performance Computing	4
	CSM-DE-536(i)	Optimization Techniques	4
	CSM-DE-536(ii)	Social Network Analysis	4
	CSM-DE-536(iii)	Smart Applications	4
	CSM-DE-536(iv)	Nature Inspired Computing	4
	Generic Course (GC)		
	CSM-GC-502	Machine Learning and Daily Life	2
	Core courses (CC)		
	CSM-CC-541	Dissertation and Viva Voce	18
IV			

Eligibility:

Candidates shall be required to possess First class Bachelor's Degree in Computer Science/Computer Applications/Electronics/Any other degree in Science with Computer Science or Computer Applications as major components or an equivalent degree recognized by the University of Kerala.

SEMESTER I	Course Code: CSM-CC-511	Credits: 4

MATHEMATICS FOR MACHINE LEARNING

COURSE OUTCOMES:

	Course Outcome
CO1	Find the relationship between the vectors by the help of vector algebra
CO2	Prioritize the components of a matrix with the help of Eigen values & eigenvectors
CO3	Articulate the concept and derivation of gradients
CO4	Describe the role of local-global maxima & minima Gradient algorithms optimization
CO5	State the basics conditional probability and its applications
CO6	Illustrate the use of Information theory in machine learning algorithms

TAGGING OF COURSE OUTCOMES

	Course Outcome	PSO	CL	KC
CO1	Find the relationship between the vectors by the help of vector algebra	PSO2	U, A	C, P
CO2	Prioritize the components of a matrix with the help of Eigen values & eigenvectors	PSO12	U, An, C	C, P
CO3	Articulate the concept and derivation of gradients	PSO9	U	C

CO4	Describe the role of local-global maxima & minima Gradient algorithms optimization	PSO2	U, An	C, P
CO5	State the basics conditional probability and its applications	PSO12	U	C, P
CO6	Illustrate the use of Information theory in machine learning algorithms	PSO1	An	C, P

COURSE CONTENT

MODULE I: Linear Algebra –Review of basic ideas of Vectors and its operations, cosine similarity, orthogonal vectors. Review of vector norms, Vector space and basis, Spanning sets, Linear independence, Bases and Dimension.

MODULE II: Matrices, Hadamard product, linear transformation, identity matrix, invertible matrix and inverse, rank, Type of matrices- symmetric, diagonal, orthogonal, orthonormal, positive definite matrix.

MODULE III: Calculus – review of Functions, rules of differentiation, partial derivatives, Gradient concept, intuition properties, directional derivative.

MODULE IV: Vector and matrix calculus, Eigen values & eigenvectors, Jacobian Gradient algorithms, local-global maxima and minima, saddle point, convex functions, gradient descent algorithms- batch, mini-batch, stochastic.

MODULE V: Probability - Basic rules and axioms, events, sample space, frequentist approach, dependent and independent events, conditional probability, Random variables- continuous and discrete, expectation, variance.

MODULE VI: Distributions- joint and conditional, Bayes' Theorem, Distributions- binomial, bernoulli, gaussian. Basics of Information theory- entropy, cross-entropy, mutual information.

SUGGESTED CLASS ROOM ACTIVITIES

- Written or Lab assignments for each modules will be made available in between the lectures.
- Seminar on different application areas of course contents in AI.
- Rapid Computing Context – who will solve the mathematical problem first in class.

LEARNING RESOURCES

References

- Axler, Sheldon. *Linear Algebra Done Right*. Springer, 2014.
- Deisenroth, Marc Peter, et al. *Mathematics for Machine Learning*. Cambridge University Press, 2020.
- Härdle, Wolfgang Karl, and Léopold Simar. *Applied Multivariate Statistical Analysis*. Springer, 2015.
- Morin, David. *Probability*. Createspace Independent Publishing Platform, 2016.

On-line Sources

- https://mml-book.github.io/book/mml-book.pdf
- https://rubikscode.net/2019/05/13/mathematics-for-artificial-intelligence-calculus-optimization/
- https://www.mobt3ath.com/uplode/book/book-33342.pdf

ASSESSMENT

As per the regulations of the University for the Teaching and Learning Departments

SEMESTER I	Course Code: CSM-CC-512	Credits: 4

BASICS OF ARTIFICIAL INTELLIGENCE

COURSE OUTCOMES:

	Course Outcome
CO1	Discuss Artificial Intelligence including topics, branches, and applications.
CO2	Explain the significance of intelligent agents in the Artificial Intelligence.
CO3	Discuss about knowledge representation and its structures.
CO4	Compare different reasoning methods and Bayesian networks.
CO5	Compare different association rule mining algorithms.
CO6	Illustrate how Artificial Intelligence works in Gaming applications (basics only).
CO7	Explain the principles, components, operations and other technological advancements in Robotics.
CO8	Evaluate a selected robotic expert system and discuss its working principle.

TAGGING OF COURSE OUTCOMES

	Course Outcome	PSO	CL	KC
CO1	Discuss Artificial Intelligence including topics, branches, and applications.	PSO1	U	F

CO2	Explain the significance of intelligent agents in the Artificial Intelligence.	PSO2	U	C, F, P
CO3	Discuss about knowledge representation and its structures.	PSO4	U	C, P
CO4	Compare different reasoning methods and Bayesian networks.	PSO9	An	C, P
CO5	Compare different association rule mining algorithms.	PSO8	U	C, P
CO6	Illustrate how Artificial Intelligence works in Gaming applications (basics only)**.**	PSO10	A	P
CO7	Explain the principles, components, operations and other technological advancements in Robotics.	PSO9	U	C, P
CO8	Evaluate a selected robotic expert system and discuss its working principle.	PSO13	E	P

COURSE CONTENT

MODULE I: Topics of Artificial Intelligence, Timelines of Artificial Intelligence, Branches of Artificial Intelligence, Applications of Artificial Intelligence. - Intelligent agents - structure, types of agents, environment, autonomous agents.
Problem Solving - Production Systems, State space representation.

MODULE II: Knowledge Representation - Knowledge Management, Types of Knowledge, Knowledge representation - bases and structures - First Order logic, Unification algorithm, Frames, Conceptual Dependency, Scripts, Semantic network

MODULE III: Reasoning - Types of reasoning, Non-monotonic reasoning, reasoning with Fuzzy logic, Rule Based reasoning, Case Based reasoning, Model based reasoning systems. - Bayes rule, Bayesian networks, probabilistic inference, sample applications

MODULE IV: Game playing - Minimax procedure, Alpha-Beta pruning, combined approach, Iterative Deepening.

MODULE V: Expert systems - characteristics, components. Expert system development, knowledge engineering, application of expert systems. Case studies in expert systems.

MODULE VI: Robotics – principles and components, operations, mathematics of robotics, line flow robot, applications of robots, case studies in robotics.

LEARNING RESOURCES

References

- Kevin Knight, Elaine Rich – "Artificial Intelligence" ,3rd Edn, Pearson, Chennai
- Stuart Russell and Peter Norvig – "Artificial Intelligence: A Modern Approach", 3rd Edition Prentice Hall of India, New Delhi, 2009
- Vinod Chandra S S, Anand H S- "Artificial Intelligence: Principles and Applications", Prentice Hall of India, New Delhi, 2020

ASSESSMENT

As per the regulations of the University for the Teaching and Learning Departments.

SEMESTER II	Course Code: CSM-CC-521	Credits: 4

THEORETICAL FOUNDATIONS OF MACHINE LEARNING

COURSE OUTCOMES

	Course Outcome
CO1	Explain the basics of machine learning and applications. (Understand)
CO2	Compare different quantification methods of classification. (Analyze)
CO3	Compare different supervised, semi supervised, and unsupervised algorithms. (Analyze)
CO4	Explain about reinforcement learning and its different learning methods. (Understand)
CO5	Compare different association rule mining algorithms. (Understand)
CO6	Differentiate different clustering techniques and algorithms. (Analyze)
CO7	Implement Support Vector Machine algorithm and its variants. (Analyze)
CO8	Explain different learning algorithms based on decision tree. (Understand)

TAGGING OF COURSE OUTCOMES

	Course Outcome	PSO	CL	KC
CO1	Explain the basics of machine learning and applications. (Understand)	PSO1	U	C

CO2	Compare different quantification methods of classification. (Analyze)	PSO2	An	C, P
CO3	Compare different supervised, semi supervised, and unsupervised algorithms. (Analyze)	PSO4	An	C, P
CO4	Explain about reinforcement learning and its different learning methods. (Understand)	PSO3	U	C
CO5	Compare different association rule mining algorithms. (Understand)	PSO8	U	C
CO6	Differentiate different clustering techniques and algorithms**.** (Analyze)	PSO6	An	C, P
CO7	Implement Support Vector Machine algorithm and its variants. (Analyze)	PSO6, PSO7	An, A	C, P
CO8	Explain different learning algorithms based on decision tree. (Understand)	PSO9	U, A	C

COURSE CONTENT

MODULE I: Learning - Types of learning, Learning of Input/ Output Function, history and timelines of machine learning, Aspects of machine learning, Machine Learning Applications and examples, intelligent agents.

Quantification of classification - Threshold Fixing, ROC Graphics, ROC formulation

MODULE II: Supervised vs. Unsupervised learning - Prediction system, Training, testing and validation datasets, cross validation. Supervised learning model - Bias-variance trade-off, classification problems. Unsupervised learning model - clustering, data compression, PCA.

MODULE III: Semi-supervised learning- self-training, co-training, generative methods, graph-based methods, Semi-supervised SVM.

MODULE IV: Reinforcement learning - Reinforcement learning model, limitation of reinforcement learning, applications of reinforcement learning. Markov Decision problem, Q-learning, Temporal Difference learning, On-policy and Off-policy learning, learning Automata

MODULE V: Association Rule mining - Concepts and terminology, Apriori algorithm, Probabilistic correlation algorithm, FP-growth algorithm, Eclat algorithm, Sparse Eclat, Tertius algorithm, Treap mining algorithm

MODULE VI: Clustering - k-Means clustering, Facts about k-means, k-Means clustering weakness. Fuzzy clustering, hierarchical clustering Agglomerative and Divisive Clustering, Hierarchical Agglomerative Clustering, Cluster similarity.

LEARNING RESOURCES

References

- C. Bishop - "Pattern Recognition and Machine Learning", Springer, 2007.
- K. Murphy - "Machine Learning: a Probabilistic Perspective", MIT Press, 2012.
- Vinod Chandra S S, Anand H S - "Machine Learning: A Practitioners Approach", Prentice Hall of India, New Delhi, 2020
- Vinod Chandra S S, Anand H S- "Artificial Intelligence and Machine Learning", Prentice Hall of India, New Delhi, 2014

ASSESSMENT

As per the regulations of the University for the Teaching and Learning Departments.

SEMESTER I	Course Code: CSM-CC-514	Credits: 3

MACHINE LEARNING LAB

COURSE OUTCOMES:

	Course Outcome
CO1	Understand Python programs using packages such as Numpy, Scipy, Pandas, Scikit-learn, etc.
CO2	Implement programs in association rules mining.
CO3	Implement algorithms in reinforcement learning.
CO4	Implement algorithms in clustering
CO5	Implement algorithms in classification problems.

TAGGING OF COURSE OUTCOMES

	Course Outcome	PSO	CL	KC
CO1	Implement Python programs using packages such as Numpy, Scipy, Pandas, Scikit-learn, etc.	PSO6	U	C, P
CO2	Implement programs in association rules mining.	PSO7	A	C, P
CO3	Implement algorithms in reinforcement learning.	PSO7, PSO8	A	C, P
CO4	Implement algorithms in clustering	PSO10	A	C, P
CO5	Implement algorithms in classification and prediction.	PSO6, PSO13	U, A	C, P

COURSE CONTENT

Students should practice python programming and implement different algorithms in Machine learning.

List of Experiments

Implement the following algorithms on following methods.

1. Support Vectors Machine.
2. Association rule mining.
3. Reinforcement learning.
4. Clustering.
5. Decision Trees.
6. Classification.

SEMESTER I	Course Code: CSM-SE-501	Credits: 2

ENTREPRENEURIAL SKILLS & SCIENTIFIC WRITING

COURSE OUTCOMES:

	Course Outcome
CO1	Demonstrate the ability to plan, organize, and execute a project or new venture with the goal of bringing new products and service**.**
CO2	Develop skill set to carry out scientific research in the field of entrepreneurship.
CO3	Prepare scientific reports and communicate the results in journal/conferences.
CO4	Analyze and prepare research papers and literature review.
CO5	Assess the commercial viability of new technologies, business opportunities.

TAGGING OF COURSE OUTCOMES

	Course Outcome	PSO	CL	KC
CO1	Demonstrate the ability to plan, organize, and execute a project or new venture with the goal of bringing new products and service**.**	PSO7	A	C, P
CO2	Develop skill set to carry out scientific research in the field of entrepreneurship.	PSO9	C	P
CO3	Prepare scientific reports and communicate the results in journal/conferences.	PSO4	C	P
CO4	Analyze and prepare research papers and literature review.	PSO4	An	C, P
CO5	Assess the commercial viability of new technologies, business opportunities.	PSO8	E	C, P

COURSE CONTENT

MODULE I: Introduction to entrepreneurship- Idea generation and business opportunity – Who is an entrepreneur –Traits- Qualities - competence of an entrepreneur- Factors affecting entrepreneurship development- Creativity and entrepreneurship.

MODULE II: Steps in Creativity - Innovation and invention- Legal Protection of innovation - Skills of an entrepreneur - Decision making and Problem Solving (steps indecision making) - Procedures for initiation of the Startup.

MODULE III: Introduction to Soft Skills- Communication Skills - Presentation Skills -Time Management Skills- Group Discussion & Interview Skills - Preparation of CV- Emotional Intelligence Skills - Life Skills.

MODULE IV: Self awareness- SWOT Analysis- Planning & Goal setting -Leadership skills- Stress Management Skills- Life Skills.

MODULE V: How to read a research paper? Structure and Components of Research Report, Data Presentation , Types of Report, Layout of Research Report, Mechanism of writing a research Thesis, Formats of a research paper, IMRAD format.

MODULE VI: Google Scholar, Web of Science, Scopus, Impact Factor, h-Index, g- index, Copyrights and Patents, IPR Laws. Citation, Plagiarism, Creative commons licenses.

LEARNING RESOURCES

References

- C. R. Kothari – " Research Methodology", New Age International, 2004
- Cecile Niewwenhuizen, Entrepreneurial Skills: Second Edition, Isbn-13: 978-0702176937
- J. W. Bames – "Statistical Analysis for Engineers and Scientists", Tata McGraw-Hill, New York, 1994
- R. Panneerselvam - "Research Methodology", Prentice Hall India, New Delhi, 2014

- Vinod Chandra S S, Anand H S - "Research Methodology", Pearson Education, Chennai, 2017

ASSESSMENT

As per the regulations of the University for the Teaching and Learning Departments.

SEMESTER I	Course Code: CSM-GC-501	Credits: 2

INTRODUCTION TO MACHINE LEARNING AND APPLICATIONS

COURSE OUTCOMES:

	Course Outcome
CO1	Explain the basic concepts and applications of Machine learning.
CO2	Compare and contrast different supervised machine learning algorithms.
CO3	Explain the approaches of machine learning.
CO4	Compare predictive analysis and descriptive analysis.
CO5	Apply machine learning algorithms to solve real world problems.
CO6	Illustrate the training process in machine learning.
CO7	Identify and categorize the types of machine learning.

TAGGING OF COURSE OUTCOMES

	Course Outcome	**PSO**	**CL**	**KC**
CO1	Explain the basic concepts and applications of Machine learning.	PSO10	U	F, C
CO2	Compare and contrast different supervised machine learning algorithms.	PSO3	U	C, P

CO3	Explain the approaches of machine learning.	PSO7	U	C
CO4	Compare predictive analysis and descriptive analysis.	PSO10	U	C, P
CO5	Apply machine learning algorithms to solve real world problems.	PSO8	A	C, P
CO6	Illustrate the training process in machine learning.	PSO10	A	P
CO7	Identify and categorize the types of machine learning.	PSO7	U	C

COURSE CONTENT

MODULE I: Understanding Machine Learning -What Is Machine Learning? - Defining Big Data- Big Data in Context with Machine Learning - Leveraging the Power of Machine Learning- Descriptive analytics - Predictive analytics

MODULE II: The Roles of Statistics and Data Mining with Machine Learning - Approaches to Machine Learning -Supervised learning -Unsupervised learning - Reinforcement learning - Neural networks

MODULE III: Applying Machine Learning - Understanding Machine Learning Techniques- Tying Machine Learning Methods to Outcomes - Applying Machine Learning to Business Needs

MODULE IV: Looking inside Machine Learning - The role of algorithms - Types of machine learning algorithms - Training machine learning systems - Data Preparation - Identify relevant data -The Machine Learning Cycle

MODULE V: Understanding How Machine Learning Can Help - Focus on the Business Problem- Executing a Pilot Project- Determining the Best Learning Model- Learning Machine learning skills that you need.

MODULE VI: Using Machine Learning to Provide Solutions to Business Problems - Applying Machine Learning to Patient Health - Proactively Responding to IT -Issues - Protecting Against Fraud

LEARNING RESOURCES

References

- Aurélien Géron "Hands-On Machine Learning with Scikt-Learn & TensorFlow", O'Reilly Media, Inc.,2019.
- Ethem Alpaydın "Introduction to Machine Learning Second Edition", The MIT Press Cambridge, Massachusetts, London, England.
- Judith Hurwitz and Daniel Kirsch, Machine Learning For Dummies, IBM Limited Edition, Wiley, 2018.

ASSESSMENT

As per the regulations of the University for the Teaching and Learning Departments.

SEMESTER II	Course Code: CSM-CC-522	Credits: 4

ADVANCED LEARNING MODELS

COURSE OUTCOMES:

	Course Outcome
CO1	Understand about fuzzy systems and networks. (Understand)
CO2	Use fuzzy set theory for solving problems. (Apply)
CO3	Familiar with Neuro-fuzzy systems and EM models. (Understand)
CO4	Explain basic programming structure and control statements in scilab. (Understand)
CO5	Implement KNN, ensemble and adaBoost classifiers for Machine learning. (Apply)
CO6	Compare different supervised ANN networks and working structure**.** (Analyze)
CO7	Compare different unsupervised ANN and their learning models**.** (Analyze)
C08	Familiar with ANN frameworks like MLP, RBF, SOM, ART, PNN. (Understand)

TAGGING OF COURSE OUTCOMES

	Course Outcome	PSO	CL	KC
CO1	Explain about fuzzy systems and networks. (Understand)	PSO1	U	C

CO2	Use fuzzy set theory for solving problems. (Apply)	PSO2, PSO12	A	P
CO3	Familiar with Neuro-fuzzy systems and EM models. (Understand)	PSO4	U	C
CO4	Describe basic programming structure and control statements in scilab. (Understand)	PSO3, PSO6	U	C
CO5	Implement KNN, ensemble and adaBoost classifiers for Machine learning. (Apply)	PSO1	A	C, P
CO6	Compare different supervised ANN networks and working structure**.** (Analyze)	PSO8	An	C, P
CO7	Compare different unsupervised ANN and their learning models**.** (Analyze)	PSO4	An	C, P
C08	Familiarize with different ANN like MLP, RBF, SOM, ART, PNN. (Understand)	PSO6	U	C

COURSE CONTENT

MODULE I: Support Vector Machines- Margins, Learning a maximum hyperplane, Kernel functions, Linear SVM, Non-linear SVM, Applications of SVM.

MODULE II: Fuzzy Network-Fuzzy systems, Info Fuzzy networks, Fuzzy neural systems, Fuzzy logic and fuzzy set, Fuzzy control, defining fuzzy operation, Making Fuzzy decision, Fuzzy reasoning, De-fuzzification, Neuro-fuzzy systems, ANFIS, Types of Neuro-fuzzy Systems, Applications and advantages of Fuzzy systems.

MODULE III: Nearest neighborhood - Distance measure, Hamming distance, Euclidean distance, City Block Distance, Square distance, KNN algorithm, KNN algorithm implications, Nearest Neighborhood applications

MODULE IV: Ensemble classifier, Types of ensemble, Simple ensemble models, Advanced ensemble models, AdaBoost, Bayes Optimal classifier, Bayesian model averaging, Gradient boosting

MODULE V: ANN Basics, ANN - Learning Process, Types of Networks, The Perceptron, Multilayer Perceptron, Error back Propagation Algorithm, MLP Example, Implications of MLP

Networks. RBF Networks: Architecture of RBF Networks, Training of RBF Networks, RBF Network Example, MLP vs. RBF

Self-Organising Maps: Architecture of SOM, Learning Process of SOM, SOM Algorithm, SOM Example, Implications of SOM. Applications of SOM

MODULE VI: Adaptive Resonance Theory: Architecture and Operation, Implementation of ARTMAP Network, ART Example, Implications of ARTMAP Network. Recurrent Neural Network, Hopfield Networks, Boltzmann Machines, Training Boltzmann Machine, Restricted Boltzmann Machine, Probabilistic Neural Network: PNN Architecture, PNN Algorithms, Implications of PNN. Comparison of Neural Network Structures.

LEARNING RESOURCES

References

- C. Bishop - "Pattern Recognition and Machine Learning", Springer, 2007.
- K. Murphy - "Machine Learning: a Probabilistic Perspective", MIT Press, 2012.
- Vinod Chandra S S, Anand H S - "Machine Learning: A Practitioners Approach", Prentice Hall of India, New Delhi, 2020
- Vinod Chandra S S, Anand H S- "Artificial Intelligence and Machine Learning", Prentice Hall of India, New Delhi, 2014

ASSESSMENT

As per the regulations of the University for the Teaching and Learning Departments.

SEMESTER II	Course Code: CSM-CC-522	Credits: 4

STATISTICAL LEARNING TECHNIQUES

COURSE OUTCOMES

	Course Outcome
CO1	Explain the basics of Convergence and applications. (Understand)
CO2	Compare different ILP methods of classification. (Analyze)
CO3	Compare different Statistical learning algorithms. (Analyze)
CO4	Explain about Statistical learning and its different learning methods. (Understand)
CO5	Compare different EM and Bayesian Networks algorithms. (Understand)
CO6	Differentiate different Decision making algorithms**.** (Analyze)
CO7	Implement HMM and its variants. (Analyze)
CO8	Explain different learning algorithms based on decision tree. (Understand)

TAGGING OF COURSE OUTCOMES

	Course Outcome	PSO	CL	KC
CO1	Explain the basics of convergence algorithms and applications. (Understand)	PSO1	U	C

CO2	Compare different ILP methods of classification. (Analyze)	PSO2	An	C, P
CO3	Compare different Statistical learning. (Analyze)	PSO4	An	C, P
CO4	Explain about Statistical learning methods. (Understand)	PSO3	U	C
CO5	Compare different EM and Bayesian Networks techniques. (Understand)	PSO8	U	C
CO6	Differentiate different Decision making and algorithms**.** (Analyze)	PSO6	An	C, P
CO7	Implement HMM algorithm and its variants. (Analyze)	PSO6, PSO7	An, A	C, P
CO8	Explain different learning algorithms based on decision tree. (Understand)	PSO9	U, A	C

COURSE CONTENT

MODULE I: Convergence and Regression - Formal Learning Model, Learning via Uniform Convergence, Uniformly Convergent Series, Linear Regression, Types of Regression, Polynomial regression, regularization methods, Lasso, Ridge and Elastic nets, Categorical Variables in Regression Correlation, Regression Analysis.

MODULE II: Inductive Logic Programming - First Order Logic, Background Knowledge - Types of ILP, Generic ILP Algorithm, Principal Approaches to ILP: Inverse Resolution. Generating Inverse Proofs, Discovering New Predicates and New Knowledge, Top-Down Learning System, Single and Multiple-predicate Learning, Characteristics of ILP System, Other ILP systems: Progol, FOIL, ILP Applications

MODULE III: Expectation Maximization, General EM, EM algorithm, Features of EM, Mathematics of EM

MODULE IV: Hidden Markov Models - Stochastic Processes - Definition, Characteristics of Stochastic Process, Classification of Stochastic Processes, Markov Process: Regular Markov Chains, Representation of Markov Chains, Classification of States, Transition Probability Matrix

Hidden Markov Models: Types of HMM, Gradually into the HMM, Three Basic Problems for HMMs, Forward - Backward Procedure, Viterbi Algorithm, Baum-Welch Algorithm, Applications of HMM

MODULE V: Statistical Classifiers: Linear Classifiers, Fisher Linear Discriminant, Quadratic Classifiers, Probability Density Function Modelling, 1D Gaussian PDF Modelling. Naive Bayes Classifier: Bayes Theorem, Bayes Probability Assumptions, Bayes Characteristics, Examples Bayesian Networks: Bayesian Networks Example, Naive Bayesian Learning, Bayesian Network Algorithms, Limitation of Bayesian Networks, Applications

MODULE VI: Decision Trees - Decision tree construction, types of decision trees. Decision tree algorithms - C4.5 algorithms, ID3 algorithm, CART, random forest. Univariate trees and Multivariate trees - functional tree, J48 tree, J48-graft, Best-first trees, Naive Bayesian tree.

LEARNING RESOURCES

References

- C. Bishop - "Pattern Recognition and Machine Learning", Springer, 2007.
- K. Murphy - "Machine Learning: a Probabilistic Perspective", MIT Press, 2012.
- Vinod Chandra S S, Anand H S - "Machine Learning: A Practitioners Approach", Prentice Hall of India, New Delhi, 2020
- Vinod Chandra S S, Anand H S- "Artificial Intelligence and Machine Learning", Prentice Hall of India, New Delhi, 2014

ASSESSMENT

As per the regulations of the University for the Teaching and Learning Departments.

SEMESTER II	Course Code: CSM-CC-523	Credits: 4

MACHINE LEARNING WITH LARGE DATASETS

COURSE OUTCOMES:

	Course Outcome
CO1	This course teaches students to develop scalable machine learning techniques, both in standalone and in distributed settings. Students learn about design considerations in this area, available tools and algorithms, and also about open problems. Students also get to learn about developments in the industry
CO2	Explain in detail about bigdata, its types, characteristics, handling techniques and bigdata databases.
CO3	Describe about the architecture, challenges and the applications of bigdata.
CO4	Discuss about Hadoop technology, hadoop ecosystem components and its features.
CO5	Explain in detail about Hadoop file system- HDFS and Mapreduce framework.
CO6	Discuss about the NoSQL data store, architecture and its advantages.
CO7	Explain the use of MongoDB and implement its basic commands- CRUD operations.

TAGGING OF COURSE OUTCOMES

	Course Outcome	PSO	CL	KC
CO1	Bigdata analytics by the students also get to learn about developments in the industry	PSO7	U	F, C
CO2	Explain in detail about bigdata, its types, characteristics, handling techniques and bigdata databases.	PSO3	U	F, C

CO3	Describe about the architecture, challenges and the applications of bigdata.	PSO8	U	C
CO4	Discuss about Hadoop technology, hadoop ecosystem components and its features.	PSO9	U	C
CO5	Explain in detail about Hadoop file system- HDFS and Mapreduce framework.	PSO7,PSO8	U, A	C, P
CO6	Discuss about the NoSQL data store, architecture and its advantages.	PSO3	U, A	P
CO7	Explain the use of MongoDB and implement its basic commands- CRUD operations.	PSO10	U, A	P

COURSE CONTENT

MODULE I : Introduction, bigdata concepts, classification of data - structured, semi-structured and unstructured, bigdata - definition, characteristics, types, bigdata handling techniques, bigdata databases.

Introduction to Spark, Bigdata architecture and Spark, challenges of bigdata, bigdata applications and case studies- big data and credit risk management, bigdata in healthcare and medicine, bigdata and advertising, Limitations of bigdata.

MODULE II : Hadoop Technology- Introduction to hadoop, hadoop and its ecosystem – core components, features of hadoop, hadoop ecosystem components, hadoop streaming and pipes.

MODULE III : Hadoop file system – HDFS, Data storage and file system, Mapreduce framework and programming model, hadoop ecosystem tools.

MODULE IV : NoSQL datastore – Introduction and motivation, Schema less models, Need of NoSQL, Architecture patterns, Features - CAP theorem, Advantages of NoSQL.

MODULE V : MongoDB – Definition, Characteristics, SQL and MongoDB, Data modeling, datatypes, Commands in MongoDB, CRUD operations.

MODULE IV : Streaming algorithms and Naive Bayes, fast nearest neighbor, parallel perceptrons, parallel SVM, randomized algorithms, hashing, sketching, scalable SGD, parameter servers, graph based semi-supervised learning, scalable link analysis, large-scale matrix factorization, speeding up topic modeling, big learning and data platforms, learning with GPUs.

LEARNING RESOURCES

References

- Chris Eaton, Dirk deroos et al. "Understanding Big data ", McGraw Hill, 2012.
- Connolly, Thomas M; Begg, Carolyn E, Database systems: a practical approach to Design, Implementation, and Management.6th ed., Pearson Education, 2015 ISBN: 978-0132943260.
- Martin Fowler "NoSQL distilled".
- Vignesh Prajapati, Big Data Analytics with R and Hadoop, Packt Publishing, 2013, ISBN: 978-1-78216-328-2.

On-line Sources

- http://www.ccs.neu.edu/home/kathleen/classes/cs3200/20-NoSQLMongoDB.pdf
- https://hostingdata.co.uk/nosql-database/

ASSESSMENT

As per the regulations of the University for the Teaching and Learning Departments.

SEMESTER II	Course Code: CSM-CC-524	Credits: 3

MACHINE INTELLIGENCE LAB

COURSE OUTCOMES:

	Course Outcome
CO1	Implement First order logic and ILP algorithms
CO2	Implement programs in SVM.
CO3	Implement algorithms in ANN.
CO4	Implement algorithms in HMM.
CO5	Implement algorithms in Decision trees.

TAGGING OF COURSE OUTCOMES

	Course Outcome	PSO	CL	KC
CO1	Implement First order logic and ILP algorithms	PSO6	U	C, P
CO2	Implement programs in SVM.	PSO7	A	C, P
CO3	Implement algorithms in ANN.	PSO7, PSO8	A	C, P
CO4	Implement algorithms in HMM.	PSO10	A	C, P
CO5	Implement algorithms in Decision trees.	PSO6, PSO13	U, A	C, P

COURSE CONTENT

Students should practice python programming and implement different algorithms in Machine learning.

List of Experiments

Implement the following algorithms on following methods.

1. Support Vectors Machine.
2. HMM.
3. ANNs
4. Bayes Network
5. Decision Trees.
6. Classification, prediction and forecasting.

SEMESTER II	Course Code: CSM-DE-525(i)	Credits: 4

DIGITAL IMAGE PROCESSING

COURSE OUTCOMES:

	Course Outcome
CO1	Define the elements of image processing.
CO2	Differentiate color image models in image representation.
CO3	Discuss about various spacial domain image transformations and filtering.
CO4	Discuss about various frequency domain image transformations and filtering.
CO5	Illustrate different morphological operations on an image.
CO6	Illustrate different boundary representation methods on an image.
CO7	Discuss about image restoration process.
CO8	Discuss about image segmentation process.
CO9	Compare the current technologies and issues specific to Digital Image Processing.

TAGGING OF COURSE OUTCOMES

	Course Outcome	PSO	CL	KC
CO1	Define the elements of image processing.	PSO4	U	F, C

CO2	Differentiate color image models in image representation.	PSO9	U	C
CO3	Discuss about various spacial domain image transformations and filtering.	PSO3, PSO4	U	C
CO4	Discuss about various frequency domain image transformations and filtering.	PSO3, PSO7	U	C
CO5	Illustrate different morphological operations on an image.	PSO8	A	C, P
CO6	Illustrate different boundary representation methods on an image.	PSO9	A	C, P
CO7	Discuss about image restoration process.	PSO4, PSO12	U	C, P
CO8	Discuss about image segmentation process.	PSO4, PSO12	U	C, P
CO9	Compare the current technologies and issues specific to Digital Image Processing.	PSO8	U	C, P

COURSE CONTENT

MODULE I: Digital Image Fundamentals-Elements of Digital Image Processing Systems, color Image fundamentals, RGB, HSI Color Models, Image sampling, Quantization.

MODULE II: Spatial Domain: Gray level transformations – Histogram processing – Basics of Spatial Filtering–Smoothing and Sharpening Spatial Filtering.

MODULE III: Frequency Domain**:** Introduction to Fourier Transform – Smoothing and Sharpening frequency domain filters – Ideal, Butterworth and Gaussian filters.

MODULE IV: Morphological operations: Dilation, Erosion, Opening and Closing; Applications: Boundary extraction - Boundary representation – Chain Code – Boundary descriptors - Regional Descriptors– Shape number – Fourier Descriptor.

MODULE V: Image Restoration: Noise models – Mean Filters – Order Statistics – Adaptive filters – Band reject Filters – Band pass Filters – Notch Filters – Optimum Notch Filtering – Inverse Filtering – Wiener filtering.

MODULE VI: Image Segmentation-Edge detection, Hough transform – Thresholding - Region based segmentation – Region growing – Region splitting and Merging –Watershed segmentation algorithm.

LEARNING RESOURCES

References

- Anil Jain K. "Fundamentals of Digital Image Processing", PHI Learning Pvt. Ltd., 2011.
- D,E. Dudgeon and RM. Mersereau, , Multidimensional Digital Signal Processing', Prentice Hall Professional Technical Reference, 1990.
- Kenneth R. Castleman, Digital Image Processing, Pearson, 2006.
- Milan Sonka et aI, 'IMAGE PROCESSING, ANALYSIS AND MACHINE VISION',Brookes/Cole, Vikas Publishing House, 2nd edition, 1999.
- Rafael C. Gonzales, Richard E. Woods, "Digital Image Processing", Fourth Edition, Pearson Education, 2017.
- Rafael C. Gonzalez, Richard E. Woods, Steven L. Eddins, "Digital Image Processing Using MATLAB", Third Edition Tata McGraw Hill Pvt. Ltd., 2011.
- William K. Pratt, , Digital Image Processing' , John Wiley, New York, 2002.

ASSESSMENT

As per the regulations of the University for the Teaching and Learning Departments.

SEMESTER II	Course Code: CSM-DE-525(ii)	Credits: 4

NATURAL LANGUAGE PROCESSING

COURSE OUTCOMES:

	Course Outcome
CO1	Apply the n-gram & Language models in various NLP applications.
CO2	Evaluate the different issues & applications of NLP activity.
CO3	Apply and generalize the different types of Parts-of- speech tagging.
CO4	Identify the different models for computational Morphological analysis.
CO5	Apply and execute the statistical parsing & probabilistic theory.
CO6	Generalize the grammar formalisms & tree banks of syntactical parsing.
CO7	Differentiate between semantic role labelling and semantic parsing.
CO8	Predicate the ambiguity & solutions of different methods.
CO9	Describe the place and manner of articulation in speech processing.
CO10	Evaluate the recall & F-score method in speech processing.
CO11	List out the applications of NLP in research and development.
CO12	Criticize the Named Entity Recognition & relation extraction methods.

TAGGING OF COURSE OUTCOMES

	Course Outcome	PSO	CL	KC
CO1	Apply the n-gram & Language models in various NLP applications.	PSO8	A	C, P
CO2	Evaluate the different issues & applications of NLP activity.	PSO4	E	C, P
CO3	Apply and generalize the different types of Parts-of- speech tagging.	PSO9	A	C, P
CO4	Identify the different models for computational Morphological analysis.	PSO8	U	C
CO5	Apply and execute the statistical parsing & probabilistic theory.	PSO12	A	C, P
CO6	Generalize the grammar formalisms & tree banks of syntactical parsing.	PSO8	C	C
CO7	Differentiate between semantic role labelling and semantic parsing.	PSO9	U	C
CO8	Predicate the ambiguity & solutions of different methods.	PSO4	U	C
CO9	Describe the place and manner of articulation in speech processing.	PSO3	U	C, P
CO10	Evaluate the recall & F-score method in speech processing.	PSO3, PSO4	E	P
CO11	List out the applications of NLP in research and development.	PSO9	U	C
CO12	Criticize the Named Entity Recognition & relation extraction methods.	PSO8	E	C, P

COURSE CONTENT

Module I: Introduction **-** Natural Language Processing - phonology, morphology, 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.

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

Module 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.

Module IV: Semantic analysis **-** Representing Meaning – Semantic Analysis - Lexical semantics – ambiguity - Word sense disambiguation - Supervised – Dictionary based and Unsupervised Approaches - Compositional semantics - Semantic Role Labeling and Semantic Parsing – Pragmatics - Discourse Analysis.

Module V: Speech **-** Phonetics, Hidden Markov Model, Morphology, Graphical Models for Sequence Labeling in NLP, Consonants (place and manner of articulation) and Vowels; Phonology**:** ASR, Speech Synthesis, Hidden Markov Model and Viterbi, Precision, Recall , F-score, Map.

Module VI: 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, Question Answering, Text Summarization, Corpus Design, OCR.

LEARNING RESOURCES

References

- Dash, Niladri Sekhar Corpus Linguistics and Language Technology, New Delhi : Mittal Publications 2005.
- Jacob Eisenstein, Introduction to Natural Language Processing, 2019.

- Bird, Ewan Klein and Edward Loper, Natural Language Processing with Python. Steven 2016.
- James Allen, Natural Language Understanding (2nd Edition) 2nd Edition- 2017.
- Ruslan Mitkov, The Oxford Handbook of Computational Linguistics, Oxford University Press 2003.
- Dan Jurafsky and James H. Martin, Speech and Language Processing (3rd ed. draft), Draft chapters in progress, October 16, 2019
- Philipp Koehn , Statistical Machine Translation, 2016.
- Alexander Clark (Editor), Chris Fox (Editor), Shalom Lappin (Editor), The Handbook of Computational Linguistics and Natural Language Processing (Blackwell Handbooks in Linguistics) 1st Edition, Kindle Edition.

ASSESSMENT

As per the regulations of the University for the Teaching and Learning Departments.

SEMESTER II	Course Code: CSM-DE-525(iii)	Credits: 4

BLOCK CHAIN TECHNOLOGY

COURSE OUTCOMES:

	Course Outcomes
CO1	Discuss and describe the history, technology, and applications of Blockchain
CO2	Analyse the significance of crptocurrencies in the digital world
CO3	Identify the functional/operational aspects of cryptocurrency ecosystem
CO4	Compare emerging abstract models for Blockchain Technology
CO5	Illustrate the working of Ethereum Virtual Machine
CO6	Assess Blockchain applications in a structured manner
CO7	Analyse the process of creating a crypto currency
CO8	Create an own Crypto token

TAGGING OF COURSE OUTCOMES

	Course Outcomes	**PSO**	**CL**	**KC**
CO1	Discuss and describe the history, technology, and applications of Blockchain	PSO2	U	C

CO2	Analyse the significance of crptocurrencies in the digital world	PSO3, PSO7, PSO9	An	P
CO3	Identify the functional/operational aspects of cryptocurrency ecosystem	PSO8	U	F, C
CO4	Compare emerging abstract models for Blockchain Technology	PSO3, PSO7, PSO9	U	C, P
CO5	Illustrate the working of Ethereum Virtual Machine	PSO7, PSO8	A	P
CO6	Assess Blockchain applications in a structured manner	PSO3, PSO7, PSO9	E	C, P
CO7	Analyse the process of creating a crypto currency	PSO3, PSO7, PSO9	An	C, P
CO8	Create an own Crypto token	PSO4, PSO9	Cr	P,M

COURSE CONTENT

MODULE I: Introduction to Blockchain: Evolution and Technology –Applications - Core components of Block Chain technology- Private block chain vs Public block chain - The consensus problem - Asynchronous Byzantine Agreement - AAP protocol and its analysis - Nakamoto Consensus on permission-less, nameless, peer-to-peer network

MODULE II: Abstract Models for BLOCKCHAIN - GARAY model - RLA Model - Proof of Work (PoW) as random oracle - formal treatment of consistency, liveness and fairness - Proof of Stake (PoS) based Chains - Hybrid models (PoW + PoS)

MODULE III: Cryptographic basics for cryptocurrency - a short overview of Hashing, signature schemes, encryption schemes and elliptic curve cryptography

MODULE IV: Bitcoin - Wallet - Blocks - Merkley Tree - hardness of mining - transaction verifiability - anonymity - forks - double spending - mathematical analysis of properties of Bitcoin.

MODULE V: Ethereum - Ethereum Virtual Machine (EVM) - Wallets for Ethereum - Solidity - Smart Contracts - some attacks on smart contracts

MODULE VI: (Trends and Topics) - Zero Knowledge proofs and protocols in Blockchain - Succinct non interactive argument for Knowledge (SNARK) - pairing on Elliptic curves - Zcash.

LEARNING RESOURCES

References

- Mastering Bitcoin: Unlocking Digital Cryptocurrencies, Andreas M. Antonopoulos O'Reilly 2010.
- Arvind Narayanan, Joseph Bonneau, Edward Felten, Andrew Miller, and Steven Goldfeder, Bitcoin and cryptocurrency technologies: a comprehensive introduction. Princeton University Press, 2016.
- Joseph Bonneau et al, SoK: Research perspectives and challenges for Bitcoin and cryptocurrency, IEEE Symposium on security and Privacy, 2015 (article available for free download) { curtain raiser kind of generic article, written by seasoned experts and pioneers}.
- J.A.Garay et al, The bitcoin backbone protocol - analysis and applications EUROCRYPT 2015 LNCS VOl 9057, (VOLII), pp 281-310. (Also available at eprint.iacr.org/2016/1048) . (serious beginning of discussions related to formal models for bitcoin protocols).
- R.Pass et al, Analysis of Blockchain protocol in Asynchronous networks , EUROCRYPT 2017, (eprint.iacr.org/2016/454) . A significant progress and consolidation of several principles).

On-line Sources

- Hyperledger Fabric - https://www.hyperledger.org/projects/fabric

- Zero to Blockchain - An IBM Redbooks course, by Bob Dill, David Smits- https://www.redbooks.ibm.com/Redbooks.nsf/RedbookAbstracts/crse0401.html

ASSESSMENT

As per the regulations of the University for the Teaching and Learning Departments.

SEMESTER II	Course Code: CSM-DE-525(iv)	Credits: 4

COMPUTATIONAL BIOLOGY

COURSE OUTCOMES:

	Course Outcome
CO1	Describe the basic concepts of molecular biology and biological data including DNA and RNA.
CO2	Analyze DNA, RNA, and protein sequences.
CO3	Explain the properties of DNA, RNA, and proteins, the relationships among these molecules.
CO4	Describe about in algorithms computational biology including Gene Finding Approaches and Bayesian via Hidden Marko.
CO5	Articulate the basic concepts of Genetic algorithm and its applications in Microbial informatics, Biomedical Images and Microarray.

TAGGING OF COURSE OUTCOMES

	Course Outcome	PSO	CL	KC
CO1	Describe the basic concepts of molecular biology and biological data including DNA and RNA.	PSO10	U	C
CO2	Analyze DNA, RNA, and protein sequences.	SO9	An	C, P

CO3	Explain the properties of DNA, RNA, and proteins, the relationships among these molecules.	PSO8	U	C
CO4	Describe about in algorithms computational biology including Gene Finding Approaches and Bayesian via Hidden Marko.	PSO12	U	C, P
CO5	Articulate the basic concepts of Genetic algorithm and its applications in Microbial informatics, Biomedical Images and Microarray.	PSO10	U	C, P

COURSE CONTENT

MODULE I: Central dogma of Molecular biology, Concepts in Biological data – DNA, RNA, Protein sequences, RNA classification – coding and non-coding RNA- mRNA, tRNA, miRNA etc. Genomics and Proteomics.

MODULE II: Sequencing of biological samples, Sequencing Methods – Sanger sequencing, NGS, WGS, Chi pseq RNA seq etc., Sequence Formats – FASTA, SRA, BED etc., Databases- NCBI SRA, Genebank, refseq, uniport, PDB etc.

MODULE III: Sequence alignment – local, global, pairwise, multiple, sequence alignment, scoring methods.
Needleman and Wunsch algorithm, global and local alignments. Protein and RNA structure prediction, polypeptic composition, secondary and tertiary structure, algorithms for modelling RNA and protein folding.

MODULE IV: Algorithms in computational biology. Gene Finding Approaches: statistical, homology-based, Bayesian via Hidden Marko. Viterbi and forward/backward algorithms Phylogeny, Jukes-Cantor model, maximum-likelihood method, distance-based methods, neighbour-joining, HMMs. Genome rearrangements

MODULE V: RNA Secondary Structure: Definitions, scoring schemes, dynamic programming approaches. Motif Finding: Repeat finding. Promoter and enhancer

recognition. Signal peptide recognition. Genotyping: Basic genetics, haplotype determination, haplotype blocks, forensic identification. Genome Sequence Assembly: Technology overview. Overlap-layout-consensus paradigm. Approaches.

MODULE VI: Combinatorial Pattern Matching- Hash Tables, Repeat Finding, Exact Pattern Matching; Expectation and Maximation (EM) with forward and backward algorithms, discriminative learning; Genetic Algorithm: Basic Concepts, Reproduction, Cross over, Mutation, Fitness Value, Optimization using GAs; Applications in Microbial informatics, Biomedical Images, Microarray etc. Image acquisition Region of interest (RoI), Segmentation, Labelling of images, Image artefacts, Image analysis

LEARNING RESOURCES

References

- Andreas Baxevanisand Francis Ouellette - "Bioinformatics- A practical guide to the Analysis of Genes and proteins", Wiley India, 2010.
- P. Baldi and S. Brunak - "Bioinformatics: The Machine Learning Approach", MIT Press, 2001.
- R. Durbin, S. Eddy, A. Krogh and G. Mitchison –" Biological Sequence Analysis", Wiley, 1999.
- Rastogi et. al. – "Bioinformatics: Methods and Applications Genomics, Proteomics and Drug Discovery", Prentice Hall of India, New Delhi, 2013.
- Vinod Chandra S S, Amjesh R - "Bioinformatics for Beginers", Lambert Academic Publishers, UK, 2019.

ASSESSMENT

As per the regulations of the University for the Teaching and Learning Departments.

SEMESTER II	Course Code: CSM-DE-525(v)	Credits: 4

CYBER SECURITY AND CYBER LAW

COURSE OUTCOMES:

	Course Outcome
CO1	Identify Networking and its issues.
CO2	Explain the concepts of Information security, Threats, Vulnerabilities, Impact and control measures.
CO3	Evaluate different methods in cryptography.
CO4	Discuss network security issues and Virtual Private Networks.
CO5	Relate Cyber laws with security incidents**.**
CO6	Analyze fundamentals of Cyber Law.
CO7	Discuss IT Act & its Amendments.
CO8	Relate Cyber laws with security incidents**.**

TAGGING OF COURSE OUTCOMES

	Course Outcome	**PSO**	**CL**	**KC**
CO1	Identify Networking and its issues.	PSO10	U, A	C
CO2	Explain the concepts of Information security, Threats, Vulnerabilities, Impact and control measures.	PSO1	U	C

CO3	Evaluate different methods in cryptography.	PSO8	E	P
CO4	Discuss network security issues and Virtual Private Networks.	PSO1	U	C, P
CO5	Relate Cyber laws with security incidents**.**	PSO10	A	C, P
CO6	Analyze fundamentals of Cyber Law.	PSO13	An	C, P
CO7	Discuss IT Act & its Amendments.	PSO1	U	C
C08	Relate Cyber laws with security incidents**.**	PSO10	A	P

COURSE CONTENT

MODULE I: Information System Threats and attacks, Classification of Threats and Assessing Damages, Security in Mobile and Wireless Computing- Security Challenges in Mobile Devices, authentication Service Security, Security Implication for organizations, Laptops Security, confidentiality, Integrity Availability, Access Control- Biometrics.

MODULE II: Model of Cryptographic Systems, Issues in Documents Security, System of Keys, Public Key Cryptography, Digital Signature, Requirement of Digital Signature System, Finger Prints, Firewalls, Design and Implementation Issues, Policies Network Security- Basic Concepts, Dimensions, Perimeter for Network.

MODULE III: Network Perimeter Security Fundamentals**:** Introduction, layers of Network Security, Security by Router – Firewall: Basics, Types - Network Address Translation Issues. - Virtual Private Networks**:** VPN Basics, Types of VPN, IPSec Tunneling & Protocols. - VLAN: introduction, Links, Tagging, VLAN Trunk Protocol (VTP).

MODULE IV: Constitutional & Human Rights Issues in Cyberspace Freedom of Speech and Expression in Cyberspace - Right to Access Cyberspace – Access to Internet- Right to Privacy - Right to Data Protection.

MODULE V: Cyber Crimes & Legal Framework Cyber Crimes against Individuals - Institution and State - Hacking - Digital Forgery - Cyber Stalking/Harassment - Cyber Pornography - Identity Theft & Fraud Cyber terrorism - Cyber Defamation - Different offences under IT Act, 2000.

MODULE VI: Intellectual Property Issues in Cyber Space Interface with Copyright Law - Interface with Patent Law- trademarks & Domain Names Related issues. Indian Context of Jurisdiction and IT-Act, 2000. , International Law and Jurisdictional Issues in Cyberspace.

LEARNING RESOURCES

References

- Forouzan, B.A., Cryptography & Network Security. Tata McGraw-Hill Education, 2010.
- Godbole," Information Systems Security", Willey.
- IT Act 2000 Jeffrey M. Bradshaw, Software Agents (Editor). MIT Press.
- Kahate, A. Cryptography and Network Security. McGraw-Hill Higher Ed., 2009.
- Luger., Artificial Intelligence. 4 ed.- Pearson Education.
- Merkov, Breithaupt," Information Security", Pearson Education
- Schou, Shoemaker, "Information Assurance for the Enterprise", Tata McGraw Hill,"Cyber Laws Simplified", Mc Graw HillFurnell, "Computer Insecurity", Springer.

ASSESSMENT

As per the regulations of the University for the Teaching and Learning Departments.

SEMESTER III	Course Code: CSM-CC-531	Credits: 4

ADVANCED DEEP ARCHITECTURES

COURSE OUTCOMES:

	Course Outcome
CO1	Understand about deep architectures. (Understand)
CO2	Use Deep learning for solving problems. (Apply)
CO3	Familiar with DBN and CNN. (Understand)
CO4	Familiar LSTM and RNN. (Understand)
CO5	Implement RNN, DBN and CNN. (Apply)
CO6	Compare different Deep architectures and their learning models**.** (Analyze)
C07	Familiar with different deep frameworks like Tensorflow, Keras, Caffe, GAN. (Understand)

TAGGING OF COURSE OUTCOMES

	Course Outcome	PSO	CL	KC
CO1	Understand about deep architectures. (Understand)	PSO1	U	C
CO2	Use Deep learning for solving problems. (Apply)	PSO2, PSO12	A	P

CO3	Familiar with DBN and CNN. (Understand)	PSO4	U	C
CO4	Familiar LSTM and RNN. (Understand)	PSO3, PSO6	U	C
CO5	Implement RNN, DBN and CNN. (Apply)	PSO1	A	C, P
CO6	Compare different Deep architectures and their learning models**.** (Analyze)	PSO8	An	C, P
C07	Familiarize with different deep frameworks like Tensorflow, Keras, Caffe, GAN. (Understand)	PSO6	U	C

COURSE CONTENT

MODULE I:

MODULE II: Deep architecture - Recurrent and Recursive networks, Bidirectional RNNs, Deep Recurrent Networks, Recursive Neural Networks, LSTM, GRU. Image captioning, word prediction.

MODULE III: Deep Belief networks, Deep reinforcement learning, Geometric stability, Effective training in Deep Net- early stopping, Dropout, Batch Normalization, Instance Normalization, Group Normalization

MODULE IV: CNN- Image classification, Text classification, Image classification and hyper-parameter tuning, Emerging NN architectures. **RNN**- Building recurrent NN, Long Short-Term Memory, Time Series Forecasting

MODULE V: TensorFlow - Implementing object classification and detection using CNN networks using any of deep libraries like Tensorflow, Keras, Caffe. Generative Networks: Auto encoders, Generative Models, GANs framework, GANs application, Variation auto encoders, DCGANS. Instance recognition, Category recognition, Context and scene understanding.

MODULE VI: Auto-encoders and unsupervised learning, Stacked auto-encoders and semi-supervised learning, Regularization - Dropout and Batch normalization, Generative Adversarial Network Revisiting Gradient Descent, Momentum Optimizer, RMSProp, Adam

LEARNING RESOURCES

References

- Aggarwal Charu – "Neural Networks and Deep Learning", Springer, 2015.
- Aurélien Géron's, "Hands-On Machine Learning with Scikit-Learn and TensorFlow", O'Reilly Media, Inc.,2017.
- Ian Goodfellow, Yoshua Bengio, Aaron Courville – "Deep Learning", MIT Press, 2016.
- Mike Krebbs - "Deep Learning with Python", CreateSpace Independent Publishing Platform, 2018.
- Vinod Chandra S S, Anand H S - "Machine Learning: A Practitioners Approach", Prentice Hall of India, New Delhi, 2020.

ASSESSMENT

As per the regulations of the University for the Teaching and Learning Departments.

SEMESTER III	Course Code: CSM-CC-532	Credits: 3

DEEP LEARNING LAB

COURSE OUTCOMES:

	Course Outcome
CO1	Implement the basic image processing operations like Histogram equalization, thresholding, edge detection, data, data augmentation, morphological operations.
CO2	Implement SVM/Softmax classifier for CIFAR-10 dataset: (i) using KNN, (ii) using 3 layer neural network.
CO3	Study the effect of batch normalization and dropout in neural network classifier Familiarization of image labelling tools for object detection, segmentation Image segmentation using Mask RCNN, UNet, SegNet.
CO4	Implement Image Captioning with LSTMs, Network Visualization: Saliency maps, Class Visualization, Generative Adversarial Networks, Chatbot using bi-directional LSTMs.
CO5	Familiarization of cloud based computing like Google colab.

TAGGING OF COURSE OUTCOMES

	Course Outcome	PSO	CL	KC
CO1	Implement the basic image processing operations like Histogram equalization, thresholding, edge	PSO8	C, A	C, P

	detection, data, data augmentation, morphological operations.			
CO2	Implement SVM/Softmax classifier for CIFAR-10 dataset: (i) using KNN, (ii) using 3 layer neural network.	PSO9	C, A	C, P
CO3	Study the effect of batch normalization and dropout in neural network classifier Familiarization of image labelling tools for object detection, segmentation Image segmentation using Mask RCNN, UNet, SegNet.	PSO4	U, C	C, P
CO4	Image Captioning with LSTMs, Network Visualization: Saliency maps, Class Visualization, Generative Adversarial Networks, Chatbot using bi-directional LSTMs.	PSO7	C	C, P
CO5	Familiarization of cloud based computing like Google colab.	PSO3, PSO6	U, C	C

SEMESTER III	Course Code: CSM-CC-533	Credits: 2

CASE STUDY

COURSE OUTCOMES:

	Course Outcomes
CO1	Identify a research problem which is significant in the area of computer science
CO2	Analyze the literature survey in the selected topic as an individual
CO3	Design the experiment with proper hypothesis
CO4	Evaluate and interpret the experimental results.
CO5	Analyze effectiveness of the method implemented.
CO6	Suggest modifications and improvement of the system.

TAGGING OF COURSE OUTCOMES

	Course Outcomes	PSO	CL	KC
CO1	Identify a research problem which is significant in the area of computer science	PSO12	C	C,P
CO2	Analyze the literature survey in the selected topic as an individual	PSO1, PSO9PSO13	An	C,P
CO3	Design the experiment with proper hypothesis	PSO5, PSO6, PSO13	C	C,P
CO4	Evaluate and interpret the experimental results.	PSO5, PSO6	An	C,P

CO5	Analyze effectiveness of the method implemented.	PSO8	An	P
CO6	Suggest modifications and improvement of the system.	PSO3	C	P

COURSE CONTENT

A case study is a detailed investigation done by a student on a specific topic in the courses studied till third semester. It is a milestone and precursor to the final presentation of the Project. The objective of doing Case Study allows students with real expertise and understanding, how and why an innovation has worked in a specific case. The students have to implement a published article from the Research and Development area. The presentation will be oral. The report of the case study should contain Background of the case, Analysis, Alternatives and recommendations and Implementation plan.

SEMESTER III	Course Code: CSM-CC-534	Credits: 2

SEMINAR

COURSE OUTCOMES

	Course Outcomes
CO1	Acquire in-depth knowledge in specific area of study.
CO2	Develop presentation skill and communication skill.
CO3	Apply Professional skills for preparing presentation slides
CO4	Develop defending ability

TAGGING OF COURSE OUTCOMES

	Course Outcomes	PSO	CL	KC
CO1	Acquire in-depth knowledge in specific area of study.	PSO2, PSO5, PSO6	U,E	C
CO2	Develop presentation skill and communication skill	PSO9	C	C, P
CO3	Apply Professional skills for preparing presentation slides	PSO3, PSO11	A	C, P
CO4	Develop defending ability	PSO13	C	C, P

COURSE CONTENT

Seminar is an outstanding work, published in an international journal in the field that covered in the course need to be presented. The in depth knowledge of the underlying technology/method of the work is evaluated through this course. Students can make use of the presentation aids to deliver the theoretical aspects of the work. The interaction with the audience, Students and faculty is beneficial for the student to strengthen the different aspects of the presentation such as presentation skill, depth of knowledge, language and rendering, defending the questions.

SEMESTER III	Course Code: CSM-DE-535(i)	Credits: 4

FOUNDATIONS OF ROBOTICS

COURSE OUTCOMES:

	Course Outcomes
CO1	Illustrate the evolution and technological advancements in Robotics
CO2	Demonstrate the working principle of robots
CO3	Articulate the working of sensors for the success of a robot
CO4	Describe the role of grippers in industrial robots
CO5	Sketch the Kinematics of robots
CO6	Outline the challenges and importance of robot programming

TAGGING OF COURSE OUTCOMES

	Course Outcomes	**PSO**	**CL**	**KC**
CO1	Illustrate the evolution and technological advancements in Robotics	PSO7	A	C, P
CO2	Demonstrate the working principle of robots	PSO8, PSO9	A	P
CO3	Articulate the working of sensors for the success of a robot	PSO5, PSO10	An	C, P
CO4	Describe the role of grippers in industrial robots	PSO4	U	C
CO5	Sketch the Kinematics of robots	PSO3, PSO7, PSO9	C	C, P

CO6	Outline the challenges and importance of robot programming	PSO13	U	C

COURSE CONTENT

MODULE I: Robotics history through research of the industry, applications of automation and robotics, technologies and their implications on the field of robotics, Robotics classification with respect to geometrical configuration (Anatomy), Controlled system & chain type: Serial manipulator & Parallel Manipulator.

MODULE II: Components of Industrial robotics-precession of movement-resolution, accuracy & repeatability-Dynamic characteristics- speed of motion, load carrying capacity & speed of response

MODULE III: Sensors- types of sensors and ways in which they can be categorized, Internal sensors: Position sensors, Velocity sensors. External sensors: Proximity sensors, Tactile Sensors, & Force or Torque sensors.

MODULE IV: Grippers – Mechanical Gripper-Grasping force-Engelberger-g-factors-mechanisms for actuation, Magnetic gripper, vaccume cup gripper-considerations in gripper selection & design. Industrial robots specifications. Selection based on the Application.

MODULE V: Kinematics-Manipulators Kinematics, Rotation Matrix, Homogenous Transformation Matrix, D-H transformation matrix, D-H method of assignment of frames. Direct and Inverse Kinematics for industrial robots.

MODULE VI: Robot programming languagesand systems – Levels of Robot Programming, Sample Application, Requirements of a Robot Programming Language, Problems peculiar to Robot Programming Language.Off-line programming systems

SUGGESTED CLASS ROOM ACTIVITIES

- Written for each modules will be made available in between the lectures.
- Presentation (Video) of different robots and its working.
- Model Your Idea Context – Illustrate and model a robot for your own idea.

LEARNING RESOURCES

References

- Craig, John J. *Introduction to Robotics*. Prentice Hall, 2017.
- *Industrial Robotics (Special Indian Edition)*. Tata McGraw-Hill Education, 2012.
- Jazar, Reza N. *Theory of Applied Robotics*. Springer Science & Business Media, 2010.
- Yang, Richard (Chunhui), et al. *Robotics and Mechatronics*. Springer, 2019.

On-line Sources

- http://engineering.nyu.edu/mechatronics/smart/Archive/intro_to_rob/Intro2Robotics.pdf
- http://www.mech.sharif.ir/c/document_library/get_file?uuid=5a4bb247-1430-5e46-942c-d692dead831f&groupId=14040

ASSESSMENT

As per the regulations of the University for the Teaching and Learning Departments

SEMESTER III	Course Code: CSM-DE-535(ii)	Credits: 4

REINFORCEMENT LEARNING TECHNIQUES

COURSE OUTCOMES

	Course Outcomes
CO1	Describe the key features of reinforcement learning that distinguishes it from AI and non-interactive machine learning
CO2	Exemplify an application problem (e.g. from computer vision, robotics, etc), decide if it should be formulated as a RL problem
CO3	Implement in code common RL algorithms
CO4	Explain the multiple criteria for analyzing RL algorithms and evaluate algorithms on these metrics
CO5	Illustrate the working of policy gradients in Reinforcement Learning
CO6	Identify the significance of importance sampling in Monte Carlo Methods

TAGGING OF COURSE OUTCOMES

	Course Outcomes	**PSO**	**CL**	**KC**
CO1	Describe the key features of reinforcement learning that distinguishes it from AI and non-interactive machine learning	PSO2	U	C
CO2	Exemplify an application problem (e.g. from computer vision, robotics, etc), decide if it should be formulated as a RL problem	PSO3	U	C
CO3	Implement in code common RL algorithms.	PSO7	An	C, P
CO4	Explain the multiple criteria for analyzing RL algorithms and evaluate algorithms on these metrics	PSO8	An	C, P
CO5	Illustrate the working of policy gradients in Reinforcement Learning	PSO4	An	C, P

CO6	Identify the significance of importance sampling in Monte Carlo Methods	PSO7	U, A	C

COURSE OUTCOMES

MODULE I : Origin and history of Reinforcement Learning research. : Reinforcement learning framework- Its connections with other related fields and with different branches of machine learning. Applications of Reinforcement learning.

MODULE II: Brush up of Probability concepts - Axioms of probability, concepts of random variables, PMF, PDFs, CDFs, Expectation. Concepts of joint and multiple random variables, joint, conditional and marginal distributions. Correlation and independence.

MODULE III : Markov Decision Process -Introduction to RL terminology, Markov property, Markov chains, Markov reward process (MRP). Introduction to Markov decision process (MDP), state and action value functions, Bellman expectation equations, optimality of value functions and policies, Bellman optimality equations

MODULE IV : Overiew of dynamic programing for MDP, definition and formulation of planning in MDPs, principle of optimality, iterative policy evaluation, policy iteration, value iteration,

MODULE V: Monte Carlo Methods for Model Free Prediction and Control- Overiew of Monte Carlo methods for model free RL, First visit and every visit Monte Carlo, Monte Carlo control, On policy and off policy learning, Importance sampling.

MODULE VI: Policy Gradients -Getting started with policy gradient methods, Log-derivative trick, Naive REINFORCE algorithm, bias and variance in Reinforcement Learning, Reducing variance in policy gradient estimates, baselines, advantage function, actor-critic methods.

References

1."Reinforcement Learning: An Introduction", Richard S. Sutton and Andrew G. Barto, 2nd Edition

2."Probability, Statistics, and Random Processes for Electrical Engineering", 3rd Edition, Alberto Leon-Garcia

3.MLAPP "Machine Learning: A Probabilistic Perspective", Kevin P. Murphy

ASSESSMENT

As per the regulations of the University for the Teaching and Learning Departments

SEMESTER III	Course Code: CSM-DE-535(iii)	Credits: 4

INTELLIGENT AGENT BASED COMPUTING

COURSE OUTCOMES:

	Course Outcomes
CO1	Explain the significance of intelligent agents in the computing world.
CO2	Describe the basic concepts, methods, techniques, and tools for the use of intelligent agents in computer-based systems.
CO3	Identify the components and functions of intelligent agents.
CO4	Apply the principles and methods of intelligent agents to a small-scale application problem
CO5	Critically evaluate Agent Oriented methodologies.
CO6	Explain the problem solving and planning among agents
CO7	Apply agent based modeling techniques for solving real life problems
CO8	Illustrate Agent oriented methodologies including Gaia Methodology, MASE, OPEN process framework, Tropos with neat diagram

TAGGING OF COURSE OUTCOMES

	Course Outcome	PSO	CL	KC

CO1	Explain the significance of intelligent agents in the computing world.	PSO2, PSO4	An	C
CO2	Describe the basic concepts, methods, techniques, and tools for the use of intelligent agents in computer-based systems.	PSO7, PSO10	U	F
CO3	Identify the components and functions of intelligent agents.	PSO4, PSO7	U	F, C
CO4	Apply the principles and methods of intelligent agents to a small-scale application problem	PSO12	A	P
CO5	Critically evaluate Agent Oriented methodologies	PSO2, PSO7, PSO12	E	C, P
CO6	Explain the problem solving and planning among agents	PSO7, PSO12	An	C
CO7	Apply agent based modeling techniques for solving real life problems	PSO5, PSO7, PSO12	A	C, P
CO8	Illustrate Agent oriented methodologies including Gaia Methodology, MASE, OPEN process framework, Tropos with neat diagram	PSO2, PSO7, PSO12	A	C, P

COURSE CONTENT

MODULE I: Introduction What are agents Abstract architectures for intelligent agents Concrete architecture for intelligent agents Agent Programming languages Multi-agent Systems and Societies of Agents Introduction Agent Communications Agent Interaction Protocols Societies of Agents.

MODULE II: Distributed Problem Solving and Planning Introduction Task Sharing Result Sharing Distributed Planning Distributed Plan Representations- Distributed Planning and Execution

MODULE III: Distributed Rational Decision making- Introduction Evaluation Criteria Voting Auctions Bargaining _ General Equilibrium market mechanisms Contract nets coalition formation Learning in multi-agent systems general characterization Learning and activity coordination Learning about and from other agents

MODULE IV: Computational Organization Theory Introduction Organizational Concepts useful in modelling organizations Formal Methods in DAI Logic based representation and reasoning.

MODULE V: Agents Development frameworks and languages- Development tools applications of agents. Agent Oriented methodologies - Agent oriented analysis and design,

MODULE VI: Agent Oriented Methodologies : Gaia Methodology, MASE, OPEN process framework, Tropos, Agent UML. Agent-based modeling - Entities in Agent-Based Modelling- An Example of Agent-Based Models- Tools for Agent-Based Modelling

LEARNING RESOURCES

References

- M. Wooldridge: Reasoning about Rational Agents. MIT Press, 2000
- Michael Wooldridge: An Introduction to MultiAgent Systems (2nd ed.). Wiley, 2009. ISBN 978-0-570-51946-2.
- Stuart Russell and Peter Norvig: Artificial Intelligence: A Modern Approach (3rd ed.). Prentice Hall, 2009. ISBN 978-G. Weiss (ed.): Multi-Agent Systems - A Modern Approach to Distributed Artificial Intelligence (2nd ed.). MIT Press, 2013

On-line Sources

- Introduction to Agent-Based Modelling https://dimensionless.in/introduction-to-agent-based-modelling/

ASSESSMENT

As per the regulations of the University for the Teaching and Learning Departments.

SEMESTER III	Course Code: CSM-DE-535(iv)	Credits: 4

HIGH PERFORMANCE COMPUTING

COURSE OUTCOMES:

	Course Outcome
CO1	Illustrate the computational complexity of modern problem methodology.
CO2	Demonstrate the working of parallel computing.
CO3	Discuss the nature and working of parallel algorithms.
CO4	Demonstrate the randomization techniques in parallel programming.
CO5	Illustrate the use SPMD Programming.
CO6	Assess the performance of the parallel programming.

TAGGING OF COURSE OUTCOMES

	Course Outcome	PSO	CL	KC
CO1	Illustrate the computational complexity of modern problem methodology.	PSO4	A	C, P
CO2	Demonstrate the working of parallel computing.	PSO8	A	P
CO3	Discuss the nature and working of parallel algorithms.	PSO9	U	C
CO4	Demonstrate the randomization techniques in parallel programming.	PSO10	A	C, P

CO5	Illustrate the use SPMD Programming.	PSO7	A	C, P
CO6	Assess the performance of the parallel programming.	PSO4	E	C, P

COURSE CONTENT

MODULE I: Review of Computational Complexity, Granularity and Partitioning, Locality: temporal, spatial, stream, kernel, Basic methods for parallel programming, Real-world case studies (drawn from multiscale, multi-discipline applications)

MODULE II: High-End Computer Systems: Memory Hierarchies, Multi-core Processors: Homogeneous and Heterogeneous, Shared-memory Symmetric Multiprocessors, Vector Computers, Distributed Memory Computers, Supercomputers and Petascale Systems, Application Accelerators / Reconfigurable Computing, Novel computers: Stream, multithreaded, and purpose-built

MODULE III: Parallel Algorithms: Parallel models: ideal and real frameworks, Basic Techniques: Balanced Trees, Pointer Jumping, Divide and Conquer, Partitioning, Regular Algorithms: Matrix operations and Linear Algebra, Irregular Algorithms: Lists, Trees, Graphs.

MODULE IV: Randomization: Parallel Pseudo-Random Number Generators, Sorting, Monte Carlo techniques. Parallel Programming: Revealing concurrency in applications, Task and Functional Parallelism, Task Scheduling, Synchronization Methods, Parallel Primitives (collective operations).

MODULE V: SPMD Programming (threads, OpenMP, MPI), I/O and File Systems, Parallel Matlabs (Parallel Matlab, Star-P, Matlab MPI), Partitioning Global Address Space (PGAS) languages (UPC, Titanium, Global Arrays)

MODULE VI: Achieving Performance: Measuring performance, Identifying performance bottlenecks, Restructuring applications for deep memory hierarchies, Partitioning applications for heterogeneous resources, using existing libraries, tools, and frameworks.

SUGGESTED CLASS ROOM ACTIVITIES

- Written ASSIGNMENTS for each modules will be made available in between the lectures.
- Presentation (Video) of different robots and its working.
- Model Your Idea Context – Illustrate and model a robot for your own idea.

LEARNING RESOURCES

References

- Bader, David A. Petascale Computing. CRC Press, 2007.
- David Culler Jaswinder Pal Singh,"Parallel Computer Architecture: A hardware/Software Approach", Morgan Kaufmann, 1999.
- G.E. Karniadakis, R.M. Kirby II, Parallel Scientific Computing in C++ and MPI: A Seamless Approach to Parallel Algorithms and their Implementation, Cambridge University Press,2003.
- G.S. Almasi and A. Gottlieb, Highly Parallel Computing, 2/E, Addison-Wesley, 1994.
- Grama, A. Gupta, G. Karypis, V. Kumar, An Introduction to Parallel Computing, Design and Analysis of Algorithms: 2/e, Addison-Wesley, 2003.

On-line Sources

- http://index-of.co.uk/Algorithms/Petascale%20Computing%20Algorithms%20and%20Applications.pdf
- http://srmcse.weebly.com/uploads/8/9/0/9/8909020/introduction_to_parallel_computing_second_edition-ananth_grama..pdf

ASSESSMENT

As per the regulations of the University for the Teaching and Learning Departments

SEMESTER III	Course Code: CSM-DE-536(i)	Credits: 4

OPTIMIZATION TECHNIQUES

COURSE OUTCOMES:

	Course Outcome
CO1	Identify the concepts of optimization techniques and its types
CO2	Discuss different optimum design concepts and methods
CO3	Solve the Linear Programming models using graphical and simplex methods
CO4	Evaluate different algorithmic methods for solving constrained and unconstrained optimization problems
CO5	Explain the need of optimization of engineering systems
CO6	Illustrate how dynamic programming used to solve multi stage decision problems

TAGGING OF COURSE OUTCOMES

	Course Outcome	PSO	CL	KC
CO1	Identify the concepts of optimization techniques and its types	PSO2, PSO7, PSO12	U	F, P
CO2	Discuss different optimum design concepts and methods	PSO2, PSO7, PSO12	U	C
CO3	Solve the Linear Programming models using graphical and simplex methods	PSO2, PSO7, PSO12	A	C, P

CO4	Evaluate different algorithmic methods for solving constrained and unconstrained optimization problems	PSO2, PSO7, PSO12	E	C, P
CO5	Explain the need of optimization of engineering systems	PSO2, PSO7, PSO12	An	C
CO6	Illustrate how dynamic programming used to solve multi stage decision problems	PSO2, PSO7, PSO12	A	C, P

COURSE CONTENT

MODULE I: Optimization: Introduction, Statement of an Optimization problem, formulation of Optimal Problem, Types of Optimization problem.

MODULE II: Optimum design concepts: Definition of Global and Local optima, Optimality criteria, Convexity and concavity of functions of one and two variables, Lagrangian function, Hessian matrix formulation.

MODULE III: Linear programming: Standard form of Linear Programming Problem, Canonical form, Elementary operations, Graphical method for two variable optimization problem, Simplex method, Karmarkar's projective scaling method.

MODULE IV: Optimization algorithms for solving unconstrained optimization problems – Gradient based method: Cauchy's steepest descent method, Newton's method, Conjugate gradient method.

MODULE V: Optimization algorithms for solving constrained optimization problems – direct methods – penalty function methods – steepest descent method

MODULE VI: Dynamic Programming**:** Representation of multistage decision process, Types of multistage decision problems, Computational procedure in dynamic programming.

LEARNING RESOURCES

References

- G. Hadley, Linear programming, Narosa Publishing House, New Delhi, ISBN 13: 9788185015910.
- Singiresu S. Rao, Engineering Optimization: Theory and Practice by John Wiley and Sons, (5th edition), ISBN: 978-1-119-55479-3.

ASSESSMENT

As per the regulations of the University for the Teaching and Learning Departments.

SEMESTER III	Course Code: CSM-DE-536(ii)	Credits: 4

SOCIAL NETWORK ANALYSIS

COURSE OUTCOMES:

	Course Outcome
CO1	Identify the basic concepts semantic web and social networks.
CO2	Explain how semantic web and ontology related.
CO3	Describe about the basic concepts and measures of Social Network Analysis including ego networks, tie strength, key players and cohesion.
CO4	Discuss about the basic metrics used in Social network analysis degree distribution, clustering coefficient, clique, k-core, k-plex and network motifs.
CO5	Explain the centralities and find the relevance of web pages using page ranking algorithms.
CO6	Discuss about the affiliation networks, graphs and its partitioning techniques.
CO7	Implement an algorithm to solve social media mining and sentimental analysis.

TAGGING OF COURSE OUTCOMES

	Course Outcome	PSO	CL	KC
CO1	Identify the basic concepts semantic web and social networks.	PSO4	U	F, C
CO2	Explain how semantic web and ontology related.	PSO8	U	C

CO3	Describe about the basic concepts and measures of Social Network Analysis including ego networks, tie strength, key players and cohesion.	PSO10	U	F, C
CO4	Discuss about the basic metrics used in Social network analysis degree distribution, clustering coefficient, clique, k-core, k-plex and network motifs.	PSO9	U	C, P
CO5	Explain the centralities and find the relevance of web pages using page ranking algorithms.	PSO9	U	C, P
CO6	Discuss about the affiliation networks, graphs and its partitioning techniques.	PSO8	U	C
CO7	Implement an algorithm to solve social media mining and sentimental analysis.	PSO10	A	P

COURSE CONTENT

MODULE I: Introduction to Semantic Web and social networks, limitations of current web, emergence of social web, Ontology and Semantic Web-Ontology based knowledge Representation; Resource Description Framework;

MODULE II: Network analysis - Social Network analysis, Key concepts and measures- Networks- structure- Nodes and edges, network diameter ,ego networks, tie strength- homophily, transitivity, key players- centrality measures, Cohesion- reciprocity, density, clustering, average and longest distance, small worlds, preferential attachment, Applications of SNA.

MODULE III: Basic metrics for social network analysis - Degree distribution, clustering coefficient, Cliques, k- cores, k-clans, k-plexes, F-groups, Frequent patterns - Network motifs.

MODULE IV: Centralities and ranking on network- Node centrality metrics: degree, closeness and betweenness, eigenvector centrality, Katz centrality, Page Ranking Algorithm, HITS.

MODULE V: Network communities- Divisive methods, Graph partitioning and cut metrics. Edge betweenness. Modularity clustering. Affiliation network and bipartite graphs.

MODULE VI: Information and influence propagation on networks, Social Diffusion, Basic cascade model, Influence maximization, Social media mining-sentiment mining.

LEARNING RESOURCES

References

- Borko Furht, "Handbook of Social Network Technologies and Applications", 1st Edition, Springer, 2010.
- Dion Goh and Schubert Foo, "Social information Retrieval Systems: Emerging Technologies and Applications for Searching the Web Effectively", IGI Global Snippet, 2008.
- Guandong Xu ,Yanchun Zhang and Lin Li, "Web Mining and Social Networking – Techniques and applications", First Edition Springer, 2011.
- Maksim Tsvetovat, Alexander Kouznetsov; "Social Network Analysis for Startups: Finding Connections on the Social Web"; O'Reilly Media, Inc., ISBN 1449306462, 9781449306465
- Peter J. Carrington, John Scott, Stanley Wasserman; "Models and Methods in Social Network Analysis"; Cambridge University Press; ISBN 1139443437, 9781139443432
- Peter Mika, "Social Networks and the Semantic Web", First Edition, Springer 2007.
- Song Yang, Franziska B. Keller, Lu Zheng; "Social Network Analysis: Methods and Examples"; SAGE Publications; ISBN 1506362125, 9781506362120.

ASSESSMENT

As per the regulations of University Teaching Departments.

SEMESTER III	Course Code: CSM-DE-536(iii)	Credits: 4

SMART APPLICATIONS

COURSE OUTCOMES:

	Course Outcome
CO1	Describe methods and technologies for the development of smart connected applications.
CO2	Explain about smart objects, mobile devices (smart phones, tablets), wearables (smart watches, fitness trackers) and home automation devices.
CO3	Discuss about management of smart devices in virtual environments, human user-centered environments and physical environments.
CO4	Articulate the concepts of Autonomous systems and artificial life.
CO5	Assess common designs for smart applications.
CO6	Examine development platforms and cloud services for smart applications.

TAGGING OF COURSE OUTCOMES

	Course Outcome	PSO	CL	KC
CO1	Describe methods and technologies for the development of smart connected applications.	PSO1	U, A	C
CO2	Explain about smart objects, mobile devices (smart phones, tablets), wearable (smart watches, fitness trackers) and home automation devices.	PSO8	U	F, C
CO3	Discuss about management of smart devices in virtual environments, human user-centered environments and physical environments.	PSO4	U	C

CO4	Articulate the concepts of Autonomous systems and artificial life.	PSO8	U	C, P
CO5	Assess common designs for smart applications.	PSO9	E	C, P
CO6	Examine development platforms and cloud services for smart applications.	PSO3	U, A	P

COURSE CONTENT

MODULE I: Smart devices and services: Service architecture models, service provision life-cycle, virtual machines and operating systems, Application and requirements, device technology and connectivity. Smart mobiles, cards and device networks: Smart mobile devices, users, resources and code, operating systems for mobile computers and communicator devices, smart card devices, device networks

MODULE II: Management of smart devices - Managing smart devices in virtual environments, managing smart devices in human user-centered environments, managing smart devices in physical environments. Smart Expert system - Building Smart systems using different learning techniques, smart system applications, agent based concurrent engineering

MODULE III: Human Computer Interaction: Explicit HCI, Implicit HCI, User Interface and Interaction for four hand-held widely used devices, Hidden UI via basic smart devices, Hidden UI via wearable and implanted devices, Human centered design, user models, iHCI Design.

MODULE IV: Autonomous systems and artificial life - Basic autonomous intra-acting systems, reflective and self-aware systems, self-management and autonomic computing, complex systems, artificial life

MODULE V: Common designs for smart applications (e.g. fuzzy logic in control systems or cloud analysis of field sensors data streams). Make or buy: selecting appropriate procurement strategies). Development platforms for smart objects (e.g.: Brillo (IoT devices) or Android TV

(Smart TVs). Development platforms for smart architectures (e.g. TensorFlow (server-side RNNs), or the Face Recognition API (mobile)). Cloud services for smart applications (e.g. Google Cloud Machine Learning API, Google Cloud Vision API, Google Cloud Speech API, or Deploying Deep Neural Networks on Microsoft Azure GPU VMs)

MODULE VI: Deployment and operations (e.g.: cloud hosting vs. device hosting, or harnessing user feedback to drive improvement). Measuring success: methods and metrics (e.g: defining user engagement and satisfaction metrics, or assessing the naturalness of smart interactions)

LEARNING RESOURCES

References

- Aurélien Géron's - "Hands-On Machine Learning with Scikit-Learn and TensorFlow", O'Reilly Media, Inc.,2017
- Jan Holler, Vlasios Tsiatsis, Catherine Mulligan, Stefan Avesand, Stamatis Karnouskos, David Boyle – "From Machine-to-Machine to the Internet of Things: Introduction to a New Age of Intelligence", Elsevier Science Publishing, 2014.
- Stefan Poslad –"Ubiquitous Computing, Smart devices, environment and interaction", Wiley, 2011

ASSESSMENT

As per the regulations of the University for the Teaching and Learning Departments.

SEMESTER III	Course Code: CSM-DE-536(iv)	Credits: 4

NATURE INSPIRED COMPUTING

COURSE OUTCOMES:

	Course Outcome
CO1	Describe about bio inspired computing fundamentals. (Understand)
CO2	Explain about optimization problems and its types. (Understand)
CO3	Familiar with Genetic algorithm and its applications. (Understand)
CO4	Compare different Ant Colony Optimization algorithmic models. (Analyze)
CO5	Compare different Artificial Bee Colony Optimization algorithmic models. (Analyze)
CO6	Illustrate Particle swam optimization algorithm with an example. (Apply)
CO7	Compare different natural inspired computing algorithms. (Analyze)

TAGGING OF COURSE OUTCOMES

	Course Outcome	PSO	CL	KC
CO1	Describe about bio inspired computing fundamentals. (Understand)	PSO1	U	F, C
CO2	Explain about optimization problems and its types. (Understand)	PSO4	U	C

CO3	Familiar with Genetic algorithm and its applications. (Understand)	PSO7	U	C
CO4	Compare different Ant Colony Optimization algorithmic models**.** (Analyze)	PSO8	An	C, P
CO5	Compare different Artificial Bee Colony Optimization algorithmic models**.** (Analyze)	PSO9	An	C, P
CO6	Illustrate Particle swam optimization algorithm with an example**.** (Apply)	PSO4	A	P
CO7	Compare different natural inspired computing algorithms. (Analyze)	PSO9	U	C, P

COURSE CONTENT

MODULE I: Models of Life and Intelligence - Fundamentals of bio-inspired models and bio-inspired computing. Evolutionary models and techniques, Swarm models and its self-organisation, swarm and evolutionary algorithms. Optimisation problems – single and multi-objective optimisation, heuristic, meta-heuristic and hyper heuristic functions.

MODULE II: Genetic algorithms - Mathematical foundation, Genetic problem solving, cross over and mutation. genetic algorithms and Markov process, applications of genetic algorithms

MODULE III: Ant Colony Algorithms - Ant colony basics, hybrid ant system, ACO in combinatorial optimisation, variations of ACO, case studies.

MODULE IV: Particle Swam algorithms - particles moves, particle swarm optimisation, variable length PSO, applications of PSO, case studies.
Artificial Bee Colony algorithms - ABC basics, ABC in optimisation, Multi-dimensional bee colony algorithms, applications of bee algorithms, case studies.

MODULE V: Selected nature inspired techniques - Hill climbing, simulated annealing, Gaussian adaptation, Cuckoo search, Firey algorithm, SDA algorithm, bat algorithm, case studies.

Other nature inspired techniques - Social spider algorithm, Cultural algorithms, Harmony search algorithm, intelligent water drops algorithm, Artificial immune system, Flower pollination algorithm, case studies.

MODULE VI: Selected nature inspired optimization techniques - Bacterial colony optimization, Glow-worm Swarm optimization, Plant growth adaptation in optimization, Termite colony optimization, African Buffalo optimization, case studies.

LEARNING RESOURCES

References

- Albert Y.Zomaya - "Handbook of Nature-Inspired and Innovative Computing", Springer, 2006
- Floreano, D. and C. Mattiussi -"Bio-Inspired Artificial Intelligence: Theories, Methods, and Technologies", MIT Press, 2008
- Leandro Nunes de Castro - " Fundamentals of Natural Computing, Basic Concepts, Algorithms and Applications", Chapman & Hall/ CRC, Taylor and Francis Group, 2007
- Marco Dorrigo, Thomas Stutzle -" Ant Colony Optimization", Prentice Hall of India, New Delhi, 2005
- Vinod Chandra S S, Anand H S - "Machine Learning: A Practitioners Approach", Prentice Hall of India, New Delhi, 2020

ASSESSMENT

As per the regulations of the University for the Teaching and Learning Departments.

SEMESTER III	Course Code: CSM-GC-502	Credits: 2

ARTIFICIAL INTELLIGENCE AND DAILY LIFE

COURSE OUTCOMES:

	Course Outcome
CO1	Demonstrate fundamental understanding of the history of artificial intelligence (AI) and its foundations.
CO2	Demonstrate awareness and a fundamental understanding of various applications of AI techniques in intelligent agents, expert systems, Natural language Processing - machine learning models.
CO3	Demonstrate an ability to share in discussions applications of AI, its current scope and limitations.
CO4	Apply basic principles of AI in solving daily life.

TAGGING OF COURSE OUTCOMES

	Course Outcome	PSO	CL	KC
CO1	Demonstrate fundamental understanding of the history of artificial intelligence (AI) and its foundations.	PSO1	A	F, C
CO2	Demonstrate awareness and a fundamental understanding of various applications of AI techniques in intelligent agents, expert systems, Natural language Processing - machine learning models.	PSO10	A	C, P
CO3	Demonstrate an ability to share in discussions applications of AI, its current scope and limitations.	PSO8	A	C, P
CO4	Apply basic principles of AI in solving daily life.	PSO7	A	P

COURSE CONTENT

MODULE I: Introduction to Artificial Intelligence- History of AI- Advantages and Disadvantages of AI- Applications- AI domains.

MODULE II: Search and Control Strategies- State- Space representation- Problem Solving - Heuristic Techniques – Hill Climbing – Simulated Annealing – Generate and Test, Problem reduction- Constraint Satisfaction- Means End Analysis.

MODULE III: Machine Learning- Supervised and Unsupervised Algorithms- Neural Networks- Classification and Predictions model – Applications.

MODULE IV: Natural Language Processing - Natural Language Processing Tasks - NLP Applications- Recommender System - Sentimental Analysis.

MODULE V: Introduction to Game Theory- Two player game - Mini- Max Procedure- Alpha Beta Cut off.

MODULE VI: AI in real life, Expert system - Expert system development- Modern expert systems.

LEARNING RESOURCES

References

- Stuart Russell and Peter Norvig, Artifcial Intelligence: A Modern Approach Third Edition Pearson Education 2010 Inc. ISBN: 978-0-13-604259-5.
- Dan W Patterson, Artificial Intelligence, Prentice Hall of India (1999)
- Nils J.Nilsson, Artificial Intelligence, ELSEVIER.
- E.Rich and K.Knight, Artificial Intelligence, - TMH

On-line Sources

- https://www.tutorialspoint.com/artificial_intelligence/artificial_intelligence_overview.htm

ASSESSMENT

As per the regulations of the University for the Teaching and Learning Departments.

SEMESTER IV	Course Code: CSM-CC-541	Credits: 18

DISSERTATION AND VIVA VOCE

COURSE OUTCOMES:

	Course Outcome
CO1	Identify a problem statement for the final project.
CO2	Perform literature review by analyzing the related works.
CO3	Implement the existing work from the literature.
CO4	Analyze the existing system capture the limitations.
CO5	Propose a method improvement to overcome the limitations.
CO6	Evaluate and interpret the design and experimental results.
CO7	Develop the skill set to write research papers and project thesis.

TAGGING OF COURSE OUTCOMES

	Course Outcome	PSO	CL	KC
CO1	Identify a problem statement for the final project.	PSO12	U	C
CO2	Perform literature review by analyzing the related works.	PSO8	U	C, P

CO3	Implement the existing work from the literature.	PSO9	A	P
CO4	Analyze the existing system capture the limitations.	PSO6	An	C, P
CO5	Propose a method improvement to overcome the limitations.	PSO4	C	C, P
CO6	Evaluate and interpret the design and experimental results.	PSO3	E	C, P
CO7	Develop the skill set to write research papers and project thesis.	PSO12, PSO13	C	P

COURSE CONTENT

All the students have to do a project work on a problem which has industry or research potential as part of this course. The project work can be done in any of the following - R&D institutions, MNC - IT companies and Department. At the end of the course, all the students should submit a project report with the details of the work done, findings and suggestions for evaluation. There will be internal and external evaluation of the work.

All students need to attend a course viva of the programme at the end of project work. All students will be evaluated by a panel of experts on their knowledge on different courses in the program, case studies done and the final project work. There will be evaluation of their professional development acquired by the programme.