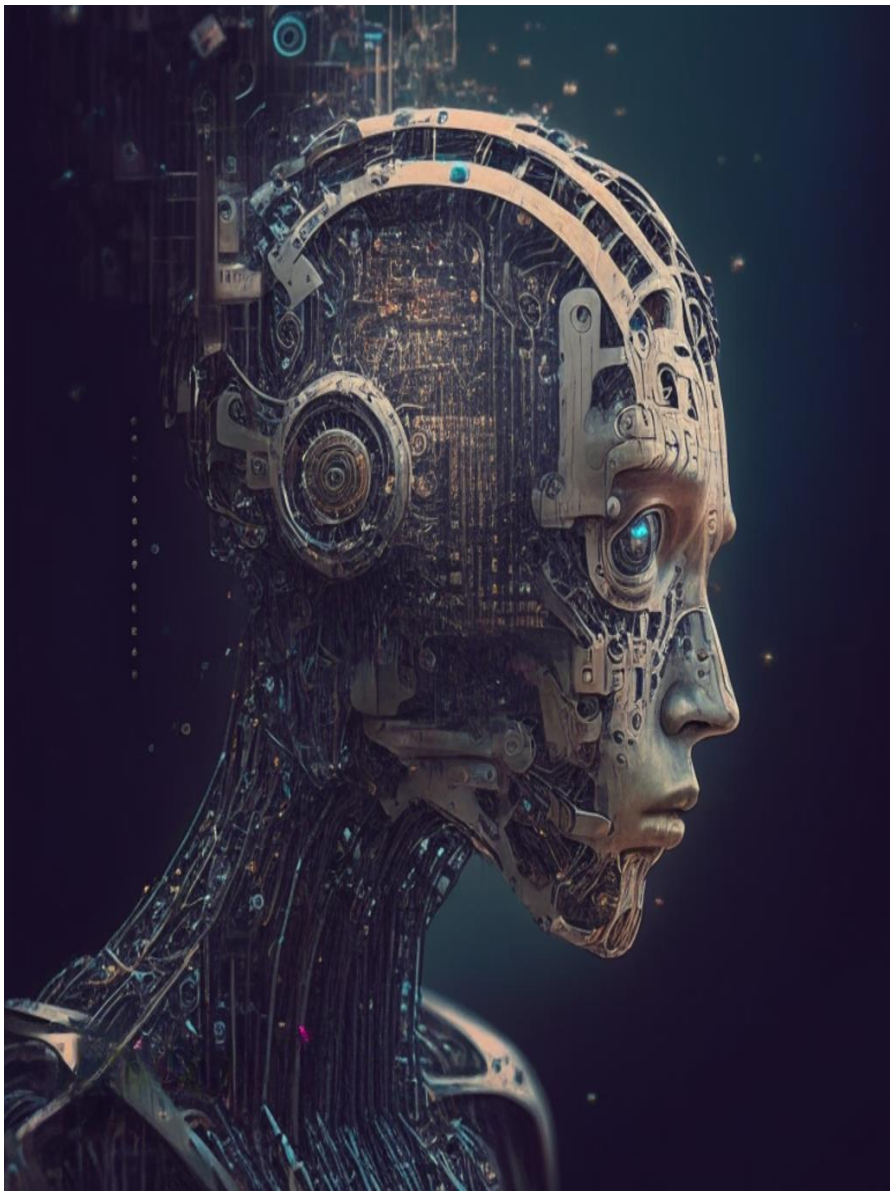
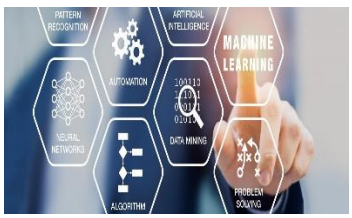
Learning Outcomes-based Curriculum Framework (LOCF) for

Post-Graduate Programme





M.Sc. Computer Science

Specialization in Machine Learning

Department of Computer Science

UNIVERSITY OF KERALA

कर्मणि व्यज्यते प्रज्ञा

www.keralauniversity.ac.in

Department of Computer Science
University of Kerala
Learning Outcomes-based Curriculum Framework (LOCF)
for Post-Graduate Programme

M.Sc. Computer Science
(Specialization in Machine Learning)

2023

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Preamble

The role of higher education is vital in securing gainful employment and providing further access to higher education comparable to the best available in world-class institutions elsewhere. The improvement in the quality of higher education, therefore, deserves to be given top-most priority to enable the young generation of students to acquire skills, training and knowledge to enhance their thinking, comprehension and application abilities and prepare them to compete, succeed and excel globally. Sustained initiatives are required to reform the present higher education system to improve and upgrade the academic resources and learning environments by raising the quality of teaching and standards of achievements in learning outcomes across all undergraduate programs in science, humanities, commerce and professional streams of higher education.

One of the significant reforms in undergraduate education is introducing the Learning Outcomes-based Curriculum Framework (LOCF), which makes it student-centric, interactive and outcome-oriented with well-defined aims, objectives and goals to achieve. The University Grants Commission (UGC) implemented the LOCF in the country's Colleges and Universities. Accordingly, the University of Kerala has decided to implement the LOCF in all its departments under the auspices of the Internal Quality Assurance Cell (IQAC). A series of teacher training workshops were organised by IQAC and the office of the Credit and Semester System (CSS), and the departments have revised the syllabus accordingly through workshops and in consultation with academic experts in the field.

Graduate Attributes

The Graduate Attributes (GAs) reflect particular qualities and abilities of an individual learner, including knowledge, application of knowledge, professional and life skills, attitudes and human values that are required to be acquired by the graduates of the University of Kerala. The graduate attributes include capabilities to strengthen one's professional abilities for widening current knowledge and industry-ready skills, undertaking future studies for global and local application, performing creatively and professionally in a chosen career and ultimately playing a constructive role as a socially responsible global citizen. The Graduate Attributes define the characteristics of learners and describe a set of competencies that are beyond the study of a particular area and programme.

The Graduate Attributes of the University of Kerala

- Continue life-long learning as an autonomous learner.
- Continuously strive for excellence in education.
- Apply and nurture critical and creative thinking.
- Promote sustainable development practices.

- Promote co-operation over competition.
- Balance rights with responsibilities.
- Understand and respect diversity and differences. Do Not be prejudiced by gender, age, caste, religion, or nationality.
- Use education as a tool for the emancipation and empowerment of humanity.

1. About the Department of Computer Science

Department of Computer Science, University of Kerala, was established in 1985 under the School of Applied Science and Technology and conducted four Post Graduate programmes alongside with PhD programme in different disciplines of Computer Science. The department offers an M Tech programme under the faculty of Engineering and Technology and three M Sc programmes under the Faculty of Applied Science and Technology. All the programmes are OBE mode and integrated with industry internships. The department gives at most importance to Research and Development besides regular teaching through knowledge dissemination globally. The department has a good track record of producing highly skilled professionals in Computer Science.

The thrust area of research focused on Image Processing, Pattern Recognition, Nature Inspired Computing, Cyber Security, Computer Vision, Machine Intelligence, High-Performance Computing, Data Mining, and Natural Language Processing. A good number of Ph Ds are awarded from this department in Computer Science, and Engineering. The department has achieved an h-index of 15 (Web of Science) with a consistent publication record. The fellows of the department received the highest impact factor, 13.751 (three times), and published their works in reputed journals. Achievement of an average impactor of 5.012 during the last five years. The alums are well-placed in National Institutes, Central/State Universities, R&D organisations and multi-national companies. Faculty and students received National and International recognition, including awards from Government organisations and best paper awards. The passed-out students are well placed in multi-national companies and other R&D Institutions.

2. About M Sc Computer Science (Machine Learning)

The curriculum of Machine Learning gives an eye-opener into the theoretical concerns and their related disciplines. It also opens discussions on human-centric applications. For example, while designing a Machine learning programme, formulate a theoretical blending scheme and create an entry point into its application domains. The performance of Machine learning allows the candidate to further domain expansion. Hence, while designing a programme in Machine learning, the curriculum should focus on theoretical and conceptual points in the subjects. This will help the candidates search for different Machine learning applied for domain job opportunity levels in the future.

The application domains of Machine learning, like computer vision, medical imaging, virtual reality, knowledge engineering, etc., are some evolving areas that are useful for a job seeker. The growth and use of these domains are different from a job seeker's point of view. Today, Machine learning and Artificial intelligence are tremendously evolved and fused in related subjects. Its practices are highly merged with real engineering applications. So, there are many scopes for ready-to-serve professionals in this area of interest through focused curriculum-designed programmes.

The scope of Machine learning is familiar to society, giving better domain applications available to the common people today. Some examples are modern digital applications in Industries, Finance, Banking, Agriculture, etc. The scope of this PG programme gives a building of industry-academy-ready Machine learning professionals. University is responsible for marking and making curriculum design of such programmes. This is achieved by a joint venture of industry-academia during curriculum and syllabus design, through which the passed-out students are IT-ready, industry-ready, and society-ready.MScComputer Science (Machine Learning) is committed to:

- Impart rigorous training to generate knowledge through state-of-the-art concepts and technologies in Machine learning.
- Transform the programme offered department to impart Machine learning education and research.
- Analyse, design and implement solutions and adapt to changes in technology by self/ continuous learning.
- Engage in higher learning and contribute to technological innovations and technology transfer.
- Work with professional ethics as an individual or team player to realise the project's goals or the organisation.
- Work with respect for societal values and environmental concerns in implementing engineering solutions.

3. General Information

3.1 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 recognised by the University of Kerala or a degree recognised as equivalent thereto, and who have secured the following, shall be eligible for the admission:

a) CGPA of 2 or above on a 4-point scale or
b) 3.5 or above on a 7-point scale or
c) 5 or above on a 10-point scale or
d) 50% or above in the case of Bachelor Degrees, which award marks
e) Relaxation for candidates from SC/ST category shall be as follows:

f) CGPA of 1.8 or above on a 4-point scale
g) 3.15 or above on a 7-point scale
h) 4. 5 or above on a 10-point scale
i) 45% or above in the case of Bachelor Degrees, which award marks.

The CSS academic council shall be competent to recommend revisions to decide the equivalence of any other system that may come up in admissions. The percentile of marks shall be converted to a percentage and normalised according to the CGPA of the University of Kerala for admission procedures.

3.2 Programme Duration

M Sc Computer Science (Machine Learning) programme shall be a period of two academic years comprising four semesters; each academic year shall be organised into two semesters with a group of courses as given in the curriculum and scheme of examination. The postgraduate programmes shall be under a credit and semester system (CSS). The programme shall be offered with different courses, each with an assigned credit.

3.3 Expected Outcome

Programme Objectives

1. Comprehend fundamental concepts and hands-on knowledge of state-of-the-art Artificial intelligence methodologies.
2. Design and Build real-world Machine learning systems for complex planning, decision-making and learning, solving application-specific problems, and reasoning about them.
3. Conceive, Design and Develop intelligent multi-modal multi-sensory Man-Machine interfaces.
4. Design, Develop and Deploy Machine learning-based applications using structured and unstructured data (e.g., speech, text, images/videos).
5. Understand and assess the reliability, dependability and trustworthiness of Artificial intelligence-based systems.
6. Design and develop Machine learning applications for resource-constrained environments.
7. Adhere to evolving ethics and privacy laws across various domains and territories.
8. Plan, manage and execute technical projects.

Learning Outcome

1. Develop the skill set for R&D and industry-ready professionals to join the Information Technology field.
2. Prepare and motivate students to do research in Computer Science, and Engineering, and its interdisciplinary fields.

3. Demonstrate advanced skills in designing, developing and implementing software that communicates effectively.
4. Develop cutting-edge developments in computing technology and contemporary research for society.
5. Develop application skillset in algorithm design, optimisation, and improved performance in computing.
6. Develop advanced knowledge for Machine learning systems with Big data systems, and Data Analytics.

3.4 Evaluation

Candidates in each semester shall be evaluated by Continuous Assessment (CA) and End Semester Examinations (ESE). The maximum marks allotted for continuous assessment and University examination for each subject are as prescribed by the scheme of study.

Continuous Assessment: An internal evaluation will be carried out during each semester's progress. The main purpose is to provide students with learning effectiveness and individual profoundness in their curriculum. The evaluation and award of CA marks differ for each course. Guidelines on conducting the continuous assessment of each course and comprehensive evaluation shall be approved by the Department Council and communicated effectively to the students.

End Semester Examinations: There will be University examinations at the end of the first academic year and the end of every semester onwards in courses as prescribed under the respective scheme of examinations. Every taught course shall be assessed through a written end-semester exam of a maximum of 3 hours' duration. As stated in the syllabus, the end-semester exams shall be summative and aimed at attesting to achieving course outcomes.

Letter Grades: Students' performance in individual courses shall be evaluated and assigned grades to indicate the achievement of objectives. The grading scale shall be the same as the national pattern recommended by the UGC. Each grade shall be indicated by a letter as in the table below:

Letter Grade	Grade Point (GP)	Marks
O (Outstanding)	10	90 to 100
A +(Excellent)	9	85 to less than 90
A (Very Good)	8.5	80 to less than 85
B+ (Good)	8	70 to less than 80
B (Above Average)	7	60 to less than 70
C (Average)	6	55 to less than 60
D (Pass)	5	50 to less than 55
F (Fail)	0	Less than 50
Ab (Absent)	0	Absent
CI (Course Incomplete)	0	Course Incomplete

Each grade shall have a corresponding grade point which serves as a means of aggregating letter grades and is not marks or scores.

3.5 Induction Programme

There will be a three-week induction program for first-semester students. It is a unique three-week immersion Foundation Programme designed specifically for the newly admitted students, which includes a wide range of activities, workshops, lectures and seminars to social works and much more. The programme is designed to mould students into well-rounded individuals, aware and sensitized to local and global conditions and foster their creativity, teach values and ethics, and help students to discover their passion. Foundation Programme also serves as a platform for the freshers to interact with their batch mates and seniors and start working as a team with them. The program is structured around the following five themes:
The programme is designed keeping in mind the following objectives:

- *Values and Ethics:* Focus on fostering a strong sense of ethical judgment and moral fortitude.
- *Creativity:* Provide channels to exhibit and develop individual creativity by expressing themselves through art, craft, music, singing, media, dramatics, and other creative activities.
- *Leadership, Communication and Teamwork*: Develop a teamwork and group communication culture.
- *Social Awareness:* Nurture a deeper understanding of the local and global world and our place in it as concerned citizens of the world.
- *Coding skills:* Students can develop programming skills to improve their values and standards.

4. Programme Structure

Every course of MSc Computer Science (Machine Learning) Programmes shall be placed in the following categories.

Sl. No	Category	Code	Credits
1	Core Course (Theory)	CC	33
2	Core Course (Laboratory)	CC	9
3	Core Course (Case study)	CC	2
4	Core Course (Dissertation)	CC	18
5	Discipline Specific Electives	DE	12
6	Generic Course (offer to Students in other Department)	GC	2
7	Extra Departmental Electives	GC	4
Total Mandatory Credits			78
8	Skill Enhancement Electives	SE	10

Semester-wise credit distribution shall be as below:

Semester	1	2	3	4	Total
Credits	20	20	20	18	78

Programme Code:CML

Core Course (CC): Course offered by a Department to the students in their Postgraduate programme, closely related to the area of specialisation. The assessment of the course will be per the regulations of the University for the Teaching and Learning Departments.

Laboratory Course (CC): The laboratory aims to develop and apply effective theory based on realistic practice; it is the primary way to train students properly in the rapidly advancing courses offered by the department. Each semester offers a laboratory course with at least 6 hours of weekly practices. The laboratory has two levels of programming exercises- basic and advanced. The basic level gives an awareness of the course through programming exercises. At the advanced level, a mini project/case study/advanced programming exercises are given to understand the application level of the course. Evaluation of Mini Project/Case Study/Advanced programming exercises and semester viva is performed by a panel of teachers in the department approved by the Department Council. Laboratory report submission is mandatory for each student and is to be submitted to the faculty in charge of the laboratory.

Skill Enhancement Course (SE): A course that provides value-based or skill-based knowledge should contain theory and laboratory/ hands-on/ training/ fieldwork. The main purpose of these courses is to provide students with life skills in the hands-on mode to increase their skill development and employability. The assessment of the course will be per the regulations of the University for the Teaching and Learning Departments.

Generic Course (GC): An elective course chosen from an unrelated discipline/subject to seek exposure beyond discipline/s. The Generic Course may also be interdisciplinary (to be offered collaboratively by more than one Department/discipline).The assessment of the course will be per the regulations of the University for the Teaching and Learning Departments.

Discipline-Specific Electives (DE): Courses offered under the main discipline/subject of study, primarily offered to the students of the same discipline each semester. The departments can modify such electives or add fresh electives from time to time based on the changing academic paradigms related to the course.The assessment of the course will be per the regulations of the University for the Teaching and Learning Departments.

Extra Departmental Generic Course: An elective course chosen from an unrelated discipline/subject to seek exposure beyond discipline/s to be offered collaboratively by more than one Department/discipline.

Case Study: Each student is required to undertake the Case Study during the third semester under the guidance of a faculty member. The students are expected to select an emerging research area/industrial problem in Computer Science.

Internship: During the fourth semester (it can be done during the vacation or semester break period), the students must complete the internship programme from the industry or R&D organisations. The students can identify industries and undergo industry training or workshop. A minimum of one month of internship is compulsory to complete Semester IV successfully. Each student should submit an internship certificate along with a detailed study report. The Department council will select industry/ R&D organisations from the student's choice.

MOOC: Massive Open Online Courses (MOOCs) bring knowledge to students in selected disciplines through online platforms. Each student must take a minimum of 30 hours' duration MOOC. It is compulsory to complete Semester III successfully. The Department council will announce the source of MOOCs from time to time.

Dissertation: Dissertation (Project work) is intended to challenge students' intellectual and innovative abilities. It allows students to synthesize and apply the knowledge and analytical skills learned in the different disciplines. All the students must do a project on a problem with industry or research potential as part of this course. The project work can be done in any of the following - R&D institutions, MNCs - IT companies and departments. 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 evaluations of the work.

4.1 Programme Outcome (PO)

PO1	A Critical Thinker with a Research mind
PO2	A Communicator and Resilient Leader
PO3	A Receptive, Adaptive Person with an Inclusive mind
PO4	A Life-long Learner
PO5	A Creative and Global Professional
PO6	An Ethical and Socially Responsible Person

4.2 Programme-Specific Outcome (PSO)

PSO1	Develop the skill set for R&D and industry-ready professionals to join the Information Technology field.
PSO2	Prepare and motivate students to do research in Computer Science and interdisciplinary fields.
PSO3	Demonstrate advanced skills in designing, developing and implementing software that communicates effectively.
PSO4	Develop cutting-edge developments in computing technology and contemporary research for society.

PSO5	Develop application skillset in algorithm design, optimisation, and improved performance in computing.
PSO6	Develop advanced knowledge in Advanced Database Management Systems, Big data systems, and Data science techniques.
PSO7	Understand the fundamentals of Artificial Intelligence, Machine Learning, Inference Engines, Speech, Vision, Natural Language Understanding, Robotics, and Human-Computer Interaction.
PSO8	Unify the knowledge of human cognition, Artificial Intelligence, Machine Learning and data engineering for designing systems.
PSO9	Demonstrate hands-on knowledge of state-of-the-art Machine learning techniques for real-world problem-solving.
PSO10	Possess the ability to take up advanced innovative development work in the industry and pursue higher research degree qualifications.
PSO11	Generate a new breed of computer science graduates with a solid Machine learning background and project management skills.
PSO12	Carry out projects using intelligent cognitive solutions provided by Machine learning algorithms to get more insights into stakeholder management, risk modelling, intelligent resource scheduling and managing project constraints with intelligent data models.

4.3 Mapping of PO to PSO

	PO1	PO2	PO3	PO4	PO5	PO6
PSO1	✓				✓	✓
PSO2	✓		✓	✓	✓	
PSO3	✓					
PSO4		✓		✓		
PSO5	✓				✓	✓
PSO6	✓				✓	
PSO7			✓	✓		
PSO8	✓			✓	✓	
PSO9	✓				✓	✓
PSO10		✓	✓			✓
PSO11		✓			✓	
PSO12	✓				✓	✓

4.4 Scheme

Semester	Course Code	Name of the course	Credits
I	**Core courses (CC)**		
	CML-CC-511	Theoretical Foundations of Machine Learning	3
	CML-CC-512	Algorithms- Complexity and Optimisation	3
	CML-CC-513	Machine Learning in Autonomous Systems	3
	CML-CC-514	Principles of Computing	3
	CML-CC-515	Soft Computing Techniques	3
	CML-CC-516	Machine Learning Laboratory	3
	Skill Enhancement Elective (SE)		
	CML-SE-4B1	Entrepreneurship and Professional Development	2
II	**Core courses (CC)**		
	CML-CC-521	Artificial Intelligence Systems Engineering	3
	CML-CC-522	Database Systems for Big Data	3
	CML-CC-523	Statistical Learning Techniques	3
	CML-CC-524	Machine Intelligence Laboratory	3
	Discipline Specific Electives (DE)		
	CML-DE-525(i)	Block Chain Technology	3
	CML-DE-525(ii)	Internet of Everything	3

	CML-DE-525(iii)	Cyber Security and Cyber Law	3
	CML-DE-525(iv)	Machine Vision and Pattern Recognition	3
	CML-DE-525(v)	Data Mining and Text Analytics	3
	CML-DE-526(i)	Computational Biology	3
	CML-DE-526(ii)	Software Agents and Multi-agent Systems	3
	CML-DE-526(iii)	Reinforcement Learning	3
	CML-DE-526(iv)	Expert Systems in Automation	3
	CML-DE-526(v)	Social Network Analysis	3
	Skill Enhancement Elective (SE)		
	CML-SE-4B2	IT Act and Constitution of India	2
	Generic Course (GC)		
	CML-GC-4A2	Machine learning with Python	2
III	**Core Courses (CC)**		
	CML-CC-531	Deep Architectures	3
	CML-CC-532	Applied Machine Learning	3
	CML-CC-533	Accelerated Natural Language Processing	3
	CML-CC-534	Case Study	2
	CML-CC-535	Deep Learning Laboratory	3
	Discipline Specific Electives (DE)		
	CML-DE-535(i)	Generative Deep Models	3
	CML-DE-535(ii)	Game Theory and Applications	3
	CML-DE-535(iii)	Deep Learning for Audio and Music	3
	CML-DE-535(iv)	Nature Inspired Computing	3
	CML-DE-535(v)	Intelligent Information Retrieval	3
	CML-DE-536(i)	Biomedical Signal Processing	3
	CML-DE-536(ii)	Image and video processing	3
	CML-DE-536(iii)	Computational Cognitive Systems	3
	CML-DE-536(iv)	Computational Creativity	3
	CML-DE-536(v)	Rule-based Learning	3
	Skill Enhancement Elective (SE)		
	CML-SE-4B3	Publication Ethics and Research Practices	2
	CML-SE-4B4	MOOC	2
IV	**Core Courses (CC)**		
	CML-CC-541	Dissertation and Viva Voce	18
	Skill Enhancement Elective (SE)		
	CML-SE-4B5	Industry Internship	2
Generic Courses from other Departments			
I	XXX-GC-41X	Extra Departmental Elective – I	2
II	XXX-GC-43X	Extra Departmental Elective – II	2

5. Syllabus

Semester 1	Course Code: CML-CC-511	Credits: 3

MATHEMATICAL FOUNDATIONS OF MACHINE LEARNING

Preamble: This course is an introduction to key mathematical concepts at the heart of machine learning. The focus is on matrix methods and statistical models and features real-world applications ranging from classification and clustering to denoising and recommender systems. Mathematical topics covered include linear equations, matrix rank, subspaces, regression, regularization, the singular value decomposition, and iterative optimization algorithms.

Prerequisite: Linear algebra, discrete mathematics and have exposure to numerical computing.

COURSE OUTCOMES & TAGGING

Course Outcomes		PO	PSO	CL	KC
CO1	Solve general linear algebra problems and apply rules to manipulate vectors	PO2	PSO3, PSO5	U, Ap	C,P
CO2	Perform matrix arithmetic and advanced operations involving matrices	PO3	PSO7, PSO9	U, Ap	C,P
CO3	Familiarize with matrix factorization methods including eigen decomposition and singular value decomposition	PO4	PSO9, PSO11	An, Ap	C,P
CO4	Implement functions using linear algebra tools such as PCA	PO1	PSO9, PSO 11	Ap	P
CO5	Apply the relevance of random variables and probability distributions in solving automated and logical reasoning	PO5	PSO5, PSO3	Ap	C, P
CO6	Apply mathematical concepts to solve linear regression and Parameterization	PO2	PSO11, PSO9	An	C,P
CO7	Familiarize types of logic: Propositional Calculus and Predicate logic	PO1	PSO3	Ap	P, C
CO8	Explore the concepts of Information theory	PO3	PSO3, PSO7	An	P

(CL- Cognitive Level: R-remember, U-understand, Ap- Apply, An-Analyse, E- Evaluate, Cr- Create,
KC - Knowledge Category: F-Factual, C- Conceptual, P-Procedural, M- Metacognitive)

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, Linear Equations, Linear Dependence and Independence, Bases and Dimension.

MODULE II

Matrices: Determinants, Hadamard product, linear transformation, Types of matrices, identity matrix, invertible matrix, rank, Covariance matrix, Eigen Value, Eigen Vector, Dimensionality Reduction with Principal Component Analysis, Diagonalization, Singular Value Decomposition.

MODULE III

Probability: Construction of a probability space, Discrete and Continuous Probabilities, Sum Rule, Product Rule, Conditional Probability, Bayes theorem, Probability distribution-Binomial, Poisson, Normal, Uniform, Exponential, Gaussian.

MODULE IV

Linear Regression: Problem Formulation, Parameter Estimation, Maximum Likelihood Estimation, Overfitting in Linear Regression, Maximum A Posteriori Estimation, MAP Estimation as regularization.

MODULE V

Propositional Calculus: Syntax and Semantics for Propositional Logic, first order Predicate Logic, Properties of WFFs, Inference Rules, Predicate Logic: Representing simple facts in logic, Representing Instance and Is-a Relationships, Resolution, Conversion to Clause form, resolution in Propositional Logic, Unification Algorithm.

MODULE VI

Markov Models: Markov Process, Markov Chain, Basics of Information theory-entropy, cross entropy, mutual information. Applications of Linear Algebra, Probabilistic approaches in Machine Learning, Mathematical Logic for Knowledge Representation.

LEARNING RESOURCES

References

- Gilbert Strang, "Linear Algebra and Its Applications",4ed., Academic Press 2006
- Gilbert Strang, "Introduction to Linear Algebra", Wellesley Publishers, 2016
- Erwin Kreyszig; Herbert Kreyszig; E J Norminton, "Advanced Engineering Mathematics", New York John Wiley, 2011.
- B S Grewal, "Higher Engineering Mathematics", 40ed., Khanna Publishers, 2012
- Axler, Sheldon, "Linear Algebra Done Right", Springer, 2014.
- Marc Peter Deisenroth, A. Aldo Faisal, Cheng Soon Ong, "Mathematics for Machine Learning", Cambridge University Press, 2020.
- Morin, David. Probability, "Probability: For the Enthusiastic Beginner", CreateSpace Independent Publishing Platform, 2016

Online Resources

- https://mml-book.github.io/book/mml-book.pdf
- https://www.mobt3ath.com/uplode/book/book

Semester 1	Course Code: CML-CC-512	Credits: 3

ALGORITHMS-COMPLEXITY AND OPTIMIZATION

Preamble: Learn to analyze iterative and recursive algorithms for the use of resources (time, memory, parallelism, bandwidth, randomness, etc.). Develop fluency with big-O notation, and learn to choose and implement efficient algorithms for numeric, combinatorial, and geometric problems. Learn fundamental concepts and terminology in computability and computational complexity.

Prerequisite: Data structures and Linear algebra.

COURSE OUTCOMES & TAGGING

Course Outcomes		PO	PSO	CL	KC
CO1	Analyze the performance of algorithms	PO1	PSO3	U	C, P
CO2	Explain the concepts including Recurrences, Dynamic programming and Branch and bound methods	PO2	PSO6	An	C, P
CO3	Knowledge in greedy algorithms with MST	PO4	PSO3, PSO7	U, Ap	C ,P
CO4	Prioritize the knowledge of advanced search andheuristic search techniques	PO3	PSO7	U, An	P, M
CO5	Discuss about P and NP- class problems	PO2	PSO5	U	P, C
CO6	Articulateoptimization procedures handled in artificial intelligence	PO4	PSO3	An	P
CO7	Apply the algorithm design skills in problem solving	PO1	PSO1	Ap	C, P
CO8	Implement String matching and algorithms related to Network flows	PO4	PSO12	Ap, Ev	C, P

(CL- Cognitive Level: R-remember, U-understand, Ap- Apply, An-Analyse, E- Evaluate, Cr- Create,
KC - Knowledge Category: F-Factual, C- Conceptual, P-Procedural, M- Metacognitive)

COURSE CONTENT

MODULE I

*Concepts in algorithm analysis:*Efficiency of algorithms, average and worst – case analysis, Asymptotic notation, time and space complexity. Analysis of Recursive Algorithms: Recurrence Equations, Solving Recurrence Equations – Iteration Method, Recursion Tree Method, Substitution method and Master's Theorem.

MODULE II

Greedy Strategy: Minimum Cost Spanning Tree Computation- Kruskal's Algorithms - Analysis, Single Source Shortest Path Algorithm - Dijkstra's Algorithm-analysis.
Graph Search Techniques: Depth First Search, Breadth First Search, Iterative Deepening search, Best first search, Beam search, Branch and Bound search, A* algorithm.

MODULE III

*Heuristic search techniques:*Generate and test, Hill climbing, simulated annealing, Problem

reduction, AO* algorithm, Constraints satisfaction, Means - Ends analysis.

MODULE IV

*Tractable and Intractable Problems:*Complexity Classes – P, NP, NP- Hard and NP-Complete Classes- NP Completeness proof of Clique Problem and Vertex Cover Problem- Approximation algorithms- Bin Packing, Graph Coloring.

MODULE V

*Optimization:*Classification of optimization problems, Optimization techniques – classical and advanced techniques, Optimum design concepts: Definition of Global and Local optima.

MODULE VI

*Applications:*Missionaries and Cannibals problem, String matching, vertex-cover problem, travelling-salesman problem, robotic motion planning, crypt arithmetic puzzles, Network flow analysis.

LEARNING RESOURCES

References

- Kalyanmoy Deb, "Optimization for Engineering Design, Algorithms and Examples" - Prentice Hall of India, 2012
- Stuart Russell and Peter Norvig, "Artificial Intelligence: A Modern Approach", 4ed. Prentice Hall of India, 2020
- Vinod Chandra S S, Anand H S, "Machine Learning: A Practitioners Approach", Prentice Hall of India, New Delhi, 2020
- Thomas H. Corman, Charles E. Leiserson and Ronald L. Rivest - "Introduction to Algorithms", 3ed., Prentice Hall of India, 2009
- Vinod Chandra S S, Anand H S - "Artificial Intelligence: Principles and Applications", 2ed., Prentice Hall of India, 2020

Semester 1	Course Code: CML-CC-513	Credits: 3

MACHINE LEARNING IN AUTONOMOUS SYSTEMS

Preamble: This course enables the learners to understand the fundamental concepts and algorithms in machine learning. The course covers the standard and most popular learning algorithms such as linear regression, logistic regression, decision trees, tree classifiers, support vector machines and kernels, basic clustering algorithms and basics of reinforcement learning. This course helps the students to provide machine learning-based solutions to real-world problems.

Prerequisite: Linear algebra, probability and Python language.

COURSE OUTCOMES & TAGGING

Course Outcomes		PO	PSO	CL	KC
CO1	Understand the growth and effect of AI in present society	PO2	PSO7	U	F
CO2	Demonstrate fundamental understanding of artificial intelligence (AI) and expert systems	PO4	PSO7, PSO11	Ap	C,F
CO3	Differentiate the different types Machine Learning	PO3	PSO7	Ap	C,F
CO4	Understanding the steps involved in Machine Learning	PO1	PSO9	U	F
CO5	Memorize the strength and weakness of popular and classical machine learning approaches	PO5	PSO7, PSO9	R	C
CO6	Designing solution for real-world applications using Machine Learning algorithms	PO2	PSO6	Cr	M,C
CO7	Select appropriate set of classical evaluation matrices for the evaluation of Machine Learning models	PO5	PSO9	E	C,M

(CL- Cognitive Level: R-remember, U-understand, Ap- Apply, An-Analyse, E- Evaluate, Cr- Create, KC - Knowledge Category: F-Factual, C- Conceptual, P-Procedural, M- Metacognitive)

COURSE CONTENT

MODULE I

Introductory note on Artificial Intelligence: Timelines of Artificial Intelligence, Branches and Applications of Artificial Intelligence. Autonomous systems and characteristics, intelligent agents - structure, types of agents. Expert systems - characteristics, components. Production Systems and Knowledge.

MODULE II

Introduction to Machine Learning: Steps in machine learning process, Types of machine learning – Supervised, unsupervised and reinforcement. Performance evaluation of ML models- confusion matrix and allied matrices, ROC and AUC. Bias variance trade-off.

MODULE III

Unsupervised Machine Learning: Clustering, k-Means clustering, Facts about k-means, k-Means clustering weakness. Hierarchical clustering Agglomerative and Divisive Clustering,

Hierarchical Agglomerative Clustering.

MODULE IV

*Supervised Machine Learning:*Decision Trees - Decision tree construction, Decision tree algorithms - C4.5 algorithms, ID3 algorithm, Random Forest. Support Vector Machines- Learning a maximum hyperplane, Kernel functions and Non-linear SVM, Multi class classification with SVM.

MODULE V

*Reinforcement Learning:*Definition and basic architecture, Reward, Agent, Environment, History, States, Information State and Markov Model, Q Function and learning, Discrete vs Continues Acton Space, Policy(π) Learning.

MODULE VI

*Case study:*Best and worst cases in k-Means clustering implementation, improving k-means clustering. Decision tree - List the possible rules before and after pruning. Convert binary class SVM into multi class classification algorithm. Reinforcement Learning and self-driving Cars.

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
- Anderson, K., "Designing Autonomous AI: A Guide for Machine Teaching" O'Reilly Media, 2022

Semester 1	Course Code:CML-CC-514	Credits: 3

PRINCIPLES OF COMPUTING

Preamble: Formal languages and automata theory deal with the concepts of automata, formal languages, grammar, computability and decidability. Automata Theory possesses a high degree of permanence and stability, contrasting with the ever-changing paradigms of computer systems technology, development, and management. Further, parts of the Automata theory directly affect practice, such as Automata on circuit design, compiler design, and search algorithms; Formal Languages and Grammars on compiler design; and Complexity on cryptography and optimization problems in manufacturing, business, and management. Research-oriented students will use the Automata theory studied in this course.

Prerequisite: Calculus, Data Structures and Algorithms, Set Theory.

COURSE OUTCOMES & TAGGING

Course Outcomes		PO	PSO	CL	KC
CO1	Familiarizing students with regular language and regular expressions	PO1	PSO5	U	C
CO2	Understand and Construct NFA, DFA, and minimal DFA	PO3	PSO4, PSO5	U,Ap	C,P
CO3	Identify Context-Free Grammar and construct equivalent push-down automata	PO2	PSO5	An,Ap	C,P
CO4	Illustrate the working of different Turing machines	PO4	PSO4, PSO5	Ap	P
CO5	Discuss the different types of computability problems	PO5	PSO5	U	C
CO6	Apply and Analyze the applications of computing principles	PO2	PSO4, PSO5	Ap,An	C,P

(CL- Cognitive Level: R-remember, U-understand, Ap- Apply, An-Analyse, E- Evaluate, Cr- Create,
KC - Knowledge Category: F-Factual, C- Conceptual, P-Procedural, M- Metacognitive)

COURSE CONTENT

MODULE I

*Introduction:*Alphabets, strings, languages, regular expressions, Closure Properties of Regular Languages, Proving Languages not to be regular –pumping lemma, Regular expressions.

MODULE II

*Finite Automata:*Deterministic Finite Automata – Non-deterministic Finite Automata – Finite Automata with Epsilon Transitions, Equivalence of NFA - DFA, DFA, Minimization-Myhill-Nerode theorem.

MODULE III

*Context-Free Languages:*Properties of context free languages, Context free Grammars, Ambiguity, Chomsky Normal form, Pumping lemma for CFG. Push down automata,

Equivalence of PDA-CFG, Deterministic push down automata.

MODULE IV

*Turing Machines:*Formal definition, Recursive enumerable languages and grammar, Variants of Turing machines, Multi tape Turing machine, Non-deterministic Turing machines, Enumerators.

MODULEV

*Computability Theory:*Decidability, halting Problem, Universal Turing Machine, Reducibility, The recursion theorem, posts-correspondence problem.

MODULE VI

*Applications:*Automata in electronic circuits**,** Applications of finite automata in networking, Application of regular expression in search engines, Application of context free grammar in natural language processing, A study on Turing machine and its applications.

LEARNING RESOURCES

References

- Michael Sipser, "Introduction to the Theory of Computation" 2ed., Thomson Course Technology, 2006
- Dexter C.Kozen, "Automata and computability", Springer,1997
- K. L. P. Mishra, N. Chandrasekaran, "Theory of Computer Science Automata, Languages and Computation", 3ed., PHI, 2006
- Derick Wood, "Theory of Computation", Harper and ROW Publishers, 1987

Online Resources

- https://www-2.dc.uba.ar/staff/becher/Hopcroft-Motwani-Ullman-2001.pdf
- https://www.awa2el.net/sites/default/files/nzry_hsbt_ltb_lthny.pdf

Semester 1	Course Code: CML-CC-515	Credits: 3

SOFT COMPUTING TECHNIQUES

Preamble: This course will provide students with the basic concepts of different methods and tools for processing uncertainty in intelligent systems, such as fuzzy models, neural networks and probabilistic models, and the foundations of their use in real systems. This course covers the main concepts of the philosophy of artificial intelligence, hybrid intelligent systems classification and architecture of hybrid intelligent systems.

Prerequisite: Nil.

COURSE OUTCOMES & TAGGING

Course Outcomes		PO	PSO	CL	KC
CO1	Understanding the concept of Neural Networks	PO2	PSO9	U, Ap	C, P
CO2	Prepare the students to apply Neural Networks to solve problems	PO3	PSO7, PSO9	Ap	C, P
CO3	Familiar the various rules and models used in NN	PO1	PSO 7, PSO 8	U	C
CO4	Implement the perceptron for classification	PO4	PSO7	Ap	C, P
CO5	Analyse the working of Backpropagation Algorithms	PO5	PSO9	Ap, An	C, P
CO6	Equip the students to apply fuzzy techniques in research problems	PO2	PSO5	Ap, An, E	C, P
CO7	Familiar the Genetic algorithm concepts with different operations	PO3	PSO5	U, Ap	C, P
CO8	Implement and evaluate different application using soft computing techniques	PO6	PSO9, PSO12	Ap, E	C, P

(CL- Cognitive Level: R-remember, U-understand, Ap- Apply, An-Analyse, E- Evaluate, Cr- Create,
KC - Knowledge Category: F-Factual, C- Conceptual, P-Procedural, M- Metacognitive)

COURSE CONTENT

MODULE I

*Artificial neural networks:*Structure of biological neuron, applications of neural network, Models of ANNs; Feedforward and feedback networks, Activation functions, Neuron Models,learning rules, Hebbian learning rule, perception learning rule, delta learning rule, Widrow-Hoff learning rule, correction learning rule, Winner –lake all learning rule.

MODULE II

Pattern Classification: Biases and thresholds, linear separability, HEBB NET- Algorithm, Implementing logic functions. Perceptron, Architecture, Algorithm, implementing logic functions. Perceptron learning rule convergence theorem, Adaline.

MODULE III

Neural network architectures: Linear inseparability, multi-layer perceptron, Back propagation

Network – Architecture, Algorithm, Learning factors, RBF Networks.

MODULE IV

*Fuzzy networks:*Classical Sets, Operations and properties, Fuzzy sets – Operations and Properties, Crisp Relations, Fuzzy Relations, Fuzzy Equivalence Relations, Features of Membership Functions, Various forms, Fuzzification and Defuzzification, λ-cuts for Fuzzy Relations, Classical Logic, Fuzzy Logic – Approximate reasoning. Fuzzy Rule-based Systems.

MODULE V

Genetic Algorithms: Introduction, Biological background, genetic algorithm Vs. Traditional algorithms, Basic terminologies, Genetic algorithm steps, Operators in gnetic algorithm-Encoding, Selection, Crossover, Mutation, stopping crieteria, Problem solving using Genetic algorithm .

MODULE VI

Neural network Applications: Character recognition, Speech recognition, signature verification, Fuzzy based applications- microwave oven, washing machine, Genetic algorithm-based applications.

LEARNING RESOURCES

References

- Fausett, Laurene V., "Fundamentals of neural networks: architectures, algorithms and applications", Pearson Education, 2006.
- Rajasekaran, Sanguthevar, and GA Vijayalakshmi Pai. "Neural networks, fuzzy logic and genetic algorithm: synthesis and applications", PHI Learning Pvt. Ltd., 2003.
- McAllister, Marialuisa N. "Fuzzy logic with engineering applications", SIAM, 1996
- Haykin, Simon. Neural networks: a comprehensive foundation. Prentice Hall PTR, 1998.
- Liang, Ping, and N. K. Bose. "Neural network fundamentals with graphs, algorithms, and applications." Mac Graw-Hill, 1996.
- Lamba, V. K., "Neuro fuzzy systems", University Science Press, 2008.
- Goldberg, David E. "Genetic algorithms in search, optimization and machine learning", Addsion-Wesley, 1989
- Sivanandam, S. N., and S. N. Deepa., "Principles of soft computing", John Wiley and Sons, 2007.
- Vinod Chandra S S, Anand H S, "Machine Learning: A Practitioners Approach", Prentice Hall of India, New Delhi, 2020

Online Resources

- https://link.springer.com/book/10.1007/978-3-319-04693-8
- https://link.springer.com/book/10.1007/978-3-030-75657-4
- https://link.springer.com/book/10.1007/978-981-16-8364-0
- https://pg.its.edu.in/sites/default/files/MCAKCA032-PRINCIPALES%20OF%20SOFT%20COMPUTING-SN%20SIVNANDAM%20AND%20DEEPA%20SN.pdf

Semester 1	Course Code: CML-CC-516	Credits: 3

MACHINE LEARNING LABORATORY

Preamble: The aim of this course is to understand the implementation procedures of basic machine learning algorithms using Java/Python programs. Students are expected to apply appropriate data sets (if required) to the Machine learning algorithms, identify and apply the resulted solutions to solve real-world problems.

Prerequisite: Python programming, Foundations in Soft computing and Machine learning techniques.

COURSE OUTCOMES & TAGGING

Course Outcomes		PO	PSO	CL	KC
CO1	Implement the machine learning concepts and algorithms in any suitable language of choice	PO2	PSO9, PSO4	U	C, P
CO2	Familiarize and implement appropriate machine learning algorithms	PO1	PSO4	Ap	C, P
CO3	Understand how to evaluate machine learning models generated from the given data classifications	PO4	PSO7, PSO9	Ap	C, P
CO4	Understand the difference between supervised and unsupervised learning	PO5	PSO9, PSO12	Ap	C, P
CO5	Design programs to Implement machine learning solution for a real-world problem	PO6	PSO4, PSO7	U, Ap	C, P
CO6	Analyze the various performance measures used for ML model evaluation	PO3	PSO9	Ap	C, P
CO7	Apply the algorithms to utilize advanced packages	PO2	PSO9, PSO12	Ap	C, P
CO8	Implement algorithms to develop the skills in applying appropriate supervised, semi-supervised or unsupervised learning algorithms for solving practical problems	PO1	PSO9, PSO12	Ap	C, P

(CL- Cognitive Level: R-remember, U-understand, Ap- Apply, An-Analyse, E- Evaluate, Cr- Create, KC - Knowledge Category: F-Factual, C- Conceptual, P-Procedural, M- Metacognitive)

COURSE CONTENT

It is advised to complete the problems to be given under each of the following cycles. There may be a set of experiments in each cycle, and all cycles are mandatory, where it should contain a minim of 80% of the problem from each cycle. The faculty in charge will give the list of exercises as and when you have completed the minimum experiments in each cycle.

Warmup Cycle

- Experiments that cover the use of functions/modules related to vectors, basic libraries etc.

Numerical Methods Cycle

- Basic and advanced operations in Vectors and Matrices
- Implementation of basic Probability and conditional probability problems
- Exercises related to Markov Models and their applications

Soft Computing Techniques Cycle

- Problem solving with ANN
- Exercises related to different types of Networks
- Exercises from Fuzzy and Genetic algorithm

Supervised Machine Learning Algorithm Cycle

- Problems in Decision Trees
- Exercises in SVM
- Exercise from Random Forest

Unsupervised Machine Learning Algorithm Cycle

- Exercises in different Clustering Algorithms
- Exercises related Fuzzy-C means Algorithm

ASSESSMENT

Basic LaboratoryPrograms: 30 marks

The programming exercises marked as basic level,to provide practical awareness for the main objective of the course.

Mini Project/Case Study Evaluation: 50 marks

At the advanced level, advanced programming exercises are given to understand the application level of the course.

End Semester Viva: 20 marks

The students have to attend a viva voce examination, where the knowledge in the different courses undergone in the semester and presentation skill of the students are evaluated systematically.

Laboratory Record:

All Students attending the End Semester Viva should produce a practical laboratory record at the time of evaluation. The record should be certified by the faculty-in-charge of the laboratory countersigned by the Course coordinator.

Semester 1	Course Code: CML-SE-4B1	Credits: 2

ENTREPRENEURSHIP AND PROFESSIONAL DEVELOPMENT

Preamble: This programme aims to inspire students and help them imbibe an entrepreneurial mindset. The students will learn what entrepreneurship is and how it has impacted the world and their country. They will be introduced to the critical traits of an entrepreneur and be allowed to assess their strengths and identify gaps that need to be addressed to become a successful entrepreneur.

Prerequisite: Nil

COURSE OUTCOMES & TAGGING

Course Outcomes		PO	PSO	CL	KC
CO1	Develop communication competence in prospective students	PO2	PSO3	Ap	C, P
CO2	Demonstrate the ability to plan, organize, and execute a project or new venture with the goal of bringing new products and service	PO3	PSO10	Ap	C, P
CO3	Possess the professional skills including learning skills and career skills	PO4	PSO3, PSO4	U, Ap	C,P
CO4	Provide critical thinking process within students	PO4	PSO5	Ap	P, M
CO5	Inculcate the soft skills competence in prospective students	PO2	PSO11	App	P, C
CO6	Equip the students to face interview and Group Discussion	PO4	PSO3	Ap, An, E	P
CO7	Able to work in Group and Teams	PO6	PSO3	Ap	C, P
CO8	Prepare the students to become an entrepreneur	PO1	PSO1	Ap, E	C, P
CO9	Promote Brain Storming and Idea Generation to solve real life problems	PO2	PSO4	Ap, An	C, P

(CL- Cognitive Level: R-remember, U-understand, Ap- Apply, An-Analyse, E- Evaluate, Cr- Create,
KC - Knowledge Category: F-Factual, C- Conceptual, P-Procedural, M- Metacognitive)

COURSE CONTENT

MODULE I

Entrepreneurship: Definition of Entrepreneurship, Entrepreneurship and Enterprise, Phases of Entrepreneurship Development, Role of Entrepreneurship, Characteristics of Entrepreneurship, Entrepreneurial Process: Venture Life Cycle and Product Life Cycle-Business Life Cycle.

MODULE II

Entrepreneurship skills: Types of Entrepreneurship Skills: Business management skills, Teamwork and leadership skills, Problem-solving skills, Critical thinking skills, Strategic

thinking and planning skills, Time management and organizational skills- Entrepreneurial Imagination and Creativity.

MODULE III

Interpersonal Skills: Communication skills- Verbal and Nonverbal Communication- Brain storming- Leadership skills- Team Building Skills- Team Work - Public Speaking.

MODULE IV

Learning Skills: Principles of study skills- Memory Techniques- Pomodoro technique- Improving your memory for studying- 3 Rs of memory- Mind Mapping.

MODULE V

Life Skills: SWOC Analysis- Self Awareness- Stress Management- Time management- Procrastination- Making Schedules - Interview Skills –Preparation for the Interview - Planning and Goal Setting.

MODULE VI

Career Skills: CV and Resume Writing, Brain Storming- Idea generation, Group Discussion, Facing Interviews - Long Term and Short-Term Goal Setting - Portfolio Preparation.

LEARNING RESOURCES

References

- Jonsthan Hancock, Cheryl Buggy, "Effective Memory techniques in a week", Hodder and Stoughton, 2003
- Cecile Niewwenhuizen, "Entrepreneurial Skills", 2ed., JUTA, 2008
- J. W. Bames – "Statistical Analysis for Engineers and Scientists", Tata McGraw-Hill, New York, 1994
- Katherine Carpenter, "Introduction to Entrepreneurship", University of Victoria, 2021
- Michael Laverty, Global Chris Littel, "Entrepreneurship" OpenStax, 2019

Semester 2	Course Code: CML-CC-521	Credits: 3

ARTIFICIAL INTELLIGENCE SYSTEMS ENGINEERING

Preamble: This course aims to develop a student as a software engineer in Artificial Intelligence applications. At the end of the course, a student can develop AI software through the software development lifecycle based on industrial perspectives.

Prerequisite: Knowledge in AI systems and programming concepts.

COURSE OUTCOMES & TAGGING

Course Outcomes		PO	PSO	CL	KC
CO1	Compare Procedural Programming and Object oriented Programming	PO4	PSO1	U, Ap	C
CO2	Illustrate the steps object oriented systems development life cycle	PO3	PSO8	U, An	P
CO3	Understand the principles of agile software development	PO2	PSO1, PSO3	U	C,P
CO4	Explain the steps in story boarding	PO1	PSO10	U, R	P
CO5	Able to comprehend the Machine Learning Operations (MLOps)	PO3	PSO10	A	P,C
CO6	Possess the ability to explore the open challenges for MLOps	PO5	PSO3	An	C
CO7	Illustrate the process of MLOps architecture and workflow	PO2	PSO1	An, Ap	P, C
CO8	Demonstrate the skill set to design UML diagrams for real world applications	PO2	PSO4	An, Ap	C,P

(CL- Cognitive Level: R-remember, U-understand, Ap- Apply, An-Analyze, E- Evaluate, Cr- Create, KC- Knowledge Category: F-Factual, C- Conceptual, P-Procedural, M- Metacognitive)

COURSE CONTENT

MODULE I

Introduction: Software Engineering, Why Object Orientation, Procedural Programming and Object-oriented Programming - Object Oriented Systems development life Cycle. Object oriented Methodologies- Patterns and Frameworks. Introduction to Legacy Code - Working with Legacy Code.

MODULE II

*UML:*UML diagrams - Use case diagram- Class diagram- Activity diagram- Sequence Diagram-

State Chart Diagram- Design Patterns – ArgoUML- Tropos- GAIA.

MODULE III

Agile Software Development Life Cycle: Agile Modeling -Scrum- Disciplined Agile Delivery (DAD)- The Agile Process Flow - The Agile Iteration Workflow - Making the Agile Process Work- Story Board- Steps in Story Boarding.

MODULE IV

*Machine learning operations:*Introduction to Machine Learning Operations (MLOps), Why MLOps- Machine Learning and Traditional Software- MLOps architecture, MLOps project initiation- Feature Engineering- Experimentation- Automated Workflow pipeline- Open Challenges.

MODULE V

*Workflows:*MLOps workflow -Risk in Machine Learning- Quantify Success in an MLOps Project- Define Clear Shared Objective and Metrics- MLOps Toolchain- Data Platforms- Model and data Exploration- metrics and Model Optimization- Productionalization- Testing- Deployment.

MODULE VI

*Application designs:*UML diagrams for designing the applications for Petrol Filling station, Railway Booking System- Library Management System- Payment Systems, MLOps- Real-World Example - The Story of Two Companies.

LEARNING RESOURCES

References

- Ali Bahrami, "Object Oriented Systems Development ", Tata McGraw-Hill, 1999
- Martin Fowler, "UML Distilled ", 2ed., Pearson Education, 2002.
- Noah Gift and Alfredo Deza: "Practical MLOps", O'Reilly Media, Inc., 2021
- James Rumbaugh, Ivar Jacobson, Grady Booch, "The Unified Modeling Language-Reference Manual", Addison Wesley, 1999.
- Eberhard Wolff, "Microservices: Flexible Software Architecture", Addison-Wesley, 2016
- Michael C, "Working effectively with legacy code", Pearson Edn., 2004
- Robert C., Martin, "Agile Software Development - Principles, Patterns, and Practices", Pearson, 2014

Online Resources

- https://poetiosity.files.wordpress.com/2011/04/art_of_agile_development.pdf
- https://dl.ebooksworld.ir/motoman/Pearson.Agile.Software.Development.Principles.Patterns.and.Practices.www.EBooksWorld.ir.pdf

Semester 2	Course Code: CML-CC-522	Credits: 3

DATABASE SYSTEMS FOR BIG DATA

Preamble: The course will focus on the diverse techniques, tools, and systems commonly used for performing data science on large volumes of data. It covers relational database systems, still a mainstay in data management systems, and the so-called "NoSQL" systems. The goals of the course are to provide a broad overview of data management systems, emphasize foundations and understand the strengths and limitations of the different systems.

Prerequisite: Programming skill, Practice SQL (queries and sub-queries), and have exposure to the open-source environment.

COURSE OUTCOMES & TAGGING

Course Outcomes		PO	PSO	CL	KC
CO1	Explain in detail about bigdata, its types, characteristics and bigdata databases	PO2	PSO6	U	F,C
CO2	Discuss about Hadoop technology, features, hadoop core components	PO1	PSO2	U, An	C,P
CO3	Explain in detail about Hadoop file system- HDFS and Mapreduce framework	PO4	PSO10	An, Ap	C,P
CO4	Describe about the architecture and working of YARN and HBase	PO5	PSO6	An, Ap	C,P
CO5	Discuss about the NoSQL data store, architecture and its advantages	PO2	PSO1	An, Ap	C,P
CO6	Explain the use of MongoDB and implement its basic commands- CRUD operations	PO3	PSO1	An, Ap	C, P
CO7	Apply big data technologies in various application areas including Uber and Google	PO6	PSO4	Cr, Ap	C,P

(CL- Cognitive Level: R-remember, U-understand, Ap- Apply, An-Analyze, E- Evaluate, Cr- Create, KC- Knowledge Category: F-Factual, C- Conceptual, P-Procedural, M- Metacognitive)

COURSE CONTENT

MODULE I

Introduction: Evolution of big data, need of bigdata, classification of data - structured, Semi-structured and Unstructured, bigdata - definition, characteristics of bigdata, Locality of reference, Latency, High availability, Parallel and distributed processing.

MODULE II

Bigdata systems: Characteristics, Reliability, Fault tolerance, availability, Consistency, Consistency types. CAP Theorem, Bigdata life cycle – Acquisition Extraction, Loading, Transformation, Analysis and Visualizations, Map-reduce paradigm– Divide and conquer,

map-reduce File Formats- avro, parquet, json, text, csv.

MODULE III

Hadoop: Introduction, architecture, Map-reduce in Hadoop, Hadoop distributed storage system HDFS, YARN – cluster resource manager and scheduler, life cycle of a Hadoop applications. Hadoop Ecosystem - Database- HBase, Querying- Pig and Hive, Integration, coordination and monitoring - Sqoop, Flume, Zookeeper, Oozie.

MODULE IV

Introduction to Apache Spark: Architecture, Features, RDD- Resilience, Lineage, Motivation, Streaming on spark.

MODULE V

NoSQL data store: Schema less models, Architecture patterns, Features MongoDB – Definition, Characteristics, SQL and MongoDB, Data modeling, data types, Commands in MongoDB, CRUD operations.

MODULE VI

*Applications:*Significance of Cloud computing in Big data, Big Data Case studies– Bigdata processing at Uber, Distributed Graph processing at Google. Introduction to Realtime Stream Processing.

LEARNING RESOURCES

References

- Jawad Ahmed Shamsi, Muhammad Ali Khojaye,"Big Data Systems A 360-degree Approach", Chapman and Hall, 2021
- Tom White, "Hadoop The Definitive Guide Storage and Analysis ar Internet Scale", O Reilly, 4ed., 2015
- Vignesh Prajapati, "Big Data Analytics with R and Hadoop", Packt Pub., 2013
- Jiawei Han, MichelineKamber, Jian Pei, "Data Mining: Concepts and Techniques", Morgan Kaufmann, 3ed., 2012
- Chris Eaton, Dirk deroos et al. "Understanding Big data", McGraw Hill, 2012.
- Pramod J. Sadalage and Martin Fowler, "NoSQL distilled", Addison-Wesley Educational Publishers Inc, 2012.

Semester 2	Course Code: CML-DE-525(i)	Credits: 3

BLOCK CHAIN TECHNOLOGY

Preamble: The purpose of this course is to create awareness and understanding among studentson the foundation of blockchain technology. The course introduces the cryptographic principlesbehind blockchain and helps the students understand concepts like consensus, crypto-currency, smart contracts, use cases etc. The course enables students to develop simple decentralized applications using blockchain networks such as Ethereum.

Prerequisite: Data structures and operating systems.

COURSE OUTCOMES & TAGGING

Course Outcomes		PO	PSO	CL	KC
CO1	Discuss and describe the history, technology, and applications of Blockchain	PO3	PSO3	U	C, P
CO2	Analyse the significance of crptocurrencies in the digital world	PO2	PSO6	An	C, P
CO3	Identify the functional/operational aspects of cryptocurrency ecosystem	PO4	PSO3, PSO6	U, Ap	C,P
CO4	Understand emerging abstract models for Blockchain Technology	PO1	PSO4	U, An	P, M
CO5	Illustrate the working of Ethereum Virtual Machine	PO2	PSO5	U	P, C
CO6	Assess Blockchain applications in a structured manner	PO5	PSO3	An	P
CO7	Analyse the process of creating a crypto currency	PO2	PSO11	Ap	C, P
CO8	Create an own Crypto token	PO6	PSO12	Ap, E	C, P

(CL- Cognitive Level: R-remember, U-understand, Ap- Apply, An-Analyze, E- Evaluate, Cr- Create, KC- Knowledge Category: F-Factual, C- Conceptual, P-Procedural, M- Metacognitive)

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.

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

MODULE VI

*Trends and Topics:*Block chain Use cases in Big Data- Ensuring Data Integrity, Preventing, Malicious Activities, Predictive Analysis, Real Time Data Analysis, Managing Data Sharing, Applications of Block Chain Technology with Big Data Analytics- Anti Money Laundering, Cyber Security, Supply chain monitoring, Financial AI systems, Medical Records, Block Chaining and Machine Learning-Recent Trends in Machine Learning Applications.

LEARNING RESOURCES

References

- Melanie Swan, "Blockchain: Blueprint for a New Economy", O'Reilly, 2015
- Arvind Narayanan, Joseph Bonneau, Edward Felten, Andrew Miller, and Steven Goldfeder. “Bitcoin and cryptocurrency technologies: a comprehensive introduction”, Princeton University Press, 2016.
- William Mougayar, "The Business Blockchain: Promise, Practice, and Application of the Next Internet Technology", Wiley, 2016
- Melanie Swa, “Blockchain”, O’Reilly Inc., 2015
- Joseph Bonneau et al, SoK: Research perspectives and challenges for Bitcoin and cryptocurrency, IEEE Symposium on security and Privacy, 2015
- Neeraj Kumar, N.Gayathri, Md. Arafatur Rahman and B. Balamurugan-“Block chain,Big Data, and Machine Learning – Trends and Applications”, CRC Press, 2020

Online Resources

- https://www.redbooks.ibm.com/Redbooks.nsf/RedbookAbstracts/crse0401.html

Semester 2	Course Code: CML-DE-525(ii)	Credits: 3

INTERNET OF EVERYTHING

Preamble: This course equips the learners with fundamental of the Internet of Things (IoT) andthe IoT ecosystem. It covers the architecture of IoT, communication mechanisms,protocols,hardware, software, data analytics, and the cloud platforms for IoT. This course enables thestudents to design smart IoT applications for real world problems.

Prerequisite: Data Communication, Computer Networks.

COURSE OUTCOMES & TAGGING

Course Outcomes		PO	PSO	CL	KC
CO1	Realize the revolution of Internet in smart systems	PO4	PSO1, PSO2	U	C
CO2	Understand the various concepts, terminologies and architecture of Smart systems	PO2	PSO4	U	C
CO3	Familiarize the terminology, technology and its applications	PO3	PSO1	An	C
CO4	Familiarize with the concept of M2M (machine to machine) with necessary protocols	PO1	PSO9, PSO10	An	C
CO5	Understand the role of IoE in various domains of Industry	PO5	PSO8	An	P
CO6	Understand the roles of sensors, APIs to connect IoE related technologies	PO2	PSO7	U	C
CO7	Analyzethe middleware for Internet of Everything and its future aspects	PO5	PSO10	An,E	P
CO8	Apply and identify the role of big data, cloud computing and data analytics in a typical computing system	PO1	PSO10, PSO11	Ap	P

(CL- Cognitive Level: R-remember, U-understand, Ap- Apply, An-Analyze, E- Evaluate, Cr- Create, KC- Knowledge Category: F-Factual, C- Conceptual, P-Procedural, M- Metacognitive)

COURSE CONTENT

MODULE I

*Introduction to Internet Technology:*Internet of Things and Related Future Internet Technologies - Internet of everything - Internet of Things: Definition, Vision, Characteristics, Physical design, Logical design, Functional blocks - Communication models and APIs.

MODULE II

*Internet Communication Technologies:*Networks and Communication, Processes, Data Management - IoT Related Standardization: Communication protocols, Addressing Schemes -

Machine to Machine (M2M),Software define Network2M Service Layer Standardization - OGC Sensor Web for IoT, IoT levels.

MODULE III

Internet of Everything: Constituent elements of the Internet of Everything-People, Things, Data, Processes. Internet of Things v/s Internet of Everything. Internet of Everything (IoE) Taxonomies.Key features of IoE-Decentralized data processing,Interconnection with other technologies,Data input / output.

MODULE IV

*Smart Technology:*Introduction, Smart devices, Smart environments.Embedded technology Vs IoT - Sensors Application building with smart technologies, - nodal network method.

MODULE V

Cloud computing and AI for Internet of Everything: Advanced Cloud Computing Techniques, Introduction to Fog Computing, Data Analytics, Machine learning, Types of ML models, Model building process, Security basis, Smart Security Architecture, Security Requirements, Research State of Crucial Technologies.

MODULE VI

Applications: Mirai botnet and the algorithm, Adafruit Cloud, Smart perishable tracking with IoT and Sensors, IFTTT, connected cars. Home automation.

LEARNING RESOURCES

References

- Shriram K Vasudevan,Abhishek S Nagarajan,RMD Sundaram, "Internet of things", Wiley,2020.
- Adrian McEwen, Hakim Cassimally, "Designing internet of things", Wiley, 2013.
- Anthony Townsend., "Smart cities: big data, civic hackers, and the quest for a new utopia", WW Norton and Company, 2013.
- Arshdeep Bahga, Vijay Madisetti, "Internet of things: a hands-on approach", CreateSpace Independent Publishing Platform, 2013.
- Dieter UckelmannarkHarrisoMichahelles Florian, "Architecting the internet of things", Springer, 2011.
- OvidiuVermesan, Peter Friess, "Internet of Things: Converging Technologies for Smart
- Environments and Integrated Ecosystems", River Publishers, 2013.

Semester 2	Course Code: CML-DE-525(iii)	Credits: 3

CYBER SECURITY AND CYBER LAW

Preamble: Objective of this course is to inculcate in students an awareness of cyber world. The student should realize the potential of technology in bringing in cyberlaws and cyber security. The course has been designed to give students an extensive overview of cyber security issues, tools and techniques critical in solving problems in cyber security domains. The course provides students with concepts of computer security, cryptography, digital money, secure protocols, detection and other security techniques. The course will help students understand essential techniques in protecting information systems, IT Infrastructure, analyzing and monitoring potential threats and attacks, devising security architecture and implementing security solutions. The students will also have a wider perspective on information security from a national security perspective from both a technology and legal perspective.

Prerequisite: Knowledge in Internet and Computer Networking.

COURSE OUTCOMES & TAGGING

Course Outcomes		PO	PSO	CL	KC
CO1	Understanding the security aspects in computing Profession and its vulnerabilities	PO1	PSO1	U	C
CO2	Understand the fundamentals of cyberspace, cyber security and threat landscape	PO3	PSO2	U	C
CO3	Analyze and evaluate the importance of personal data its privacy and security	PO4	PSO2, PSO3	An	C
CO4	Identify the role of human in security systems with an emphasis on ethics, social engineering vulnerabilities and training	PO2	PSO2	An	C
CO5	Evaluate the digital payment system security and remedial measures against digital payment frauds using modern cryptographic techniques	PO3	PSO3	E	P
CO6	Develop a deeper understanding and familiarity with various types of cyber-attacks, cybercrimes, vulnerabilities and remedies thereto	PO4	PSO3, PSO4	Ap	P
CO7	Apply different computer forensic tools to a given cybercrime scene and examine current practices to data recovery and acquisition	PO6	PSO2, PSO3	Ap	P
CO8	Generalize the impact based on the Risk assessment, plan suitable security controls, audit and compliance in network security	PO4	PSO2, PSO4	U	C

(CL- Cognitive Level: R-remember, U-understand, Ap- Apply, An-Analyse, E- Evaluate, Cr- Create, KC- Knowledge Category: F-Factual, C- Conceptual, P-Procedural, M- Metacognitive)

COURSE CONTENT

MODULE I

Introduction to Cyber Security: Types of Attacks, Unauthorized Access, Impersonation, Denial of Service, Malicious Software, Viruses, Worms, Trojan Horses. Cybercrime, classification of cybercrime, Modus Operandi of various cybercrimes and frauds – Definition of various types of cyber frauds – Modus Operandi - Fraud triangle – fraud detection techniques including data mining and statistical references – counter measures.

MODULE II

Risk Assessment Basis, Risk Analysis, Risk Evaluation, Information Security - Threats - Frauds, Thefts, Malicious Hackers, Malicious Code, Denial-of-Services Attacks, Access Control - Access Control fundamentals, User Identity and Access Management (IAM).

MODULE III

Introduction to Computer Forensics: Types of Computer Forensics techniques - Incident and incident response methodology, Forensic duplication and investigation. Preparation for IR: Creating response tool kit and IR team. Forensics Technology and Systems - Understanding Computer Investigation, Data Acquisition.

MODULE IV

Analysis and Validation: Validating Forensics Data, Data Hiding Techniques, Performing Remote Acquisition, Network Forensics, Email Investigations, Cell Phone and Mobile Devices Forensics.

MODULE V

Email security: Web authentication, SSL and SET, Penalties and Offences, amendments. Mobile forensics, Mobile forensic and its challenges, Mobile phone evidence extraction process, The evidence intake phase, The identification phase, The preparation phase, The isolation phase, The processing phase, The verification phase, Salient features of the IT Act, 2000, various authorities under IT Act and their powers.

MODULE VI

Applications: The Concept of Cyberspace E-Commerce, The Contract Aspects in Cyber Law, The Security Aspect of Cyber Law, The Intellectual Property Aspect in Cyber Law, The Evidence Aspect in Cyber Law, The Criminal Aspect in Cyber Law, Global Trends in Cyber Law, Legal Framework for Electronic Data Interchange Law Relating to Electronic Banking, The Need for an Indian Cyber Law

LEARNING RESOURCES

References

- Sumit Belapure and Nina Godbole, "Cyber Security Understanding Cyber Crimes, Computer Forensics and Legal

Perspectives", Wiley India Pvt. Ltd., 2011
- Dorothy F. Denning, "Information Warfare and Security", Addison Wesley, 1998.
- Natraj Venkataramanan and Ashwin Shriram , "Data Privacy Principles and Practice", CRC Press, 2016.
- W. KragBrothy "Information Security Governance, Guidance for Information Security Managers", Wiley Publication, 2007.
- Martin Weiss, Michael G. Solomon , "Auditing IT Infrastructures for Compliance", 2edn., Jones Bartlett Learning, 2015
- R. C Mishra , "Cyber Crime Impact in the New Millennium", Auther Press, 2010.
- Bill Nelson, Amelia Phillips, Frank Enfinger, Christopher Steuart, "Computer Forensics and Investigations", Cengage Learning, 2016.
- William Stallings,"Network Security Essentials: Applications and Standards", John R.Vacca, Computer Forensics, 2005.
- NinaGodbole, SunitBelapure,"Cyber Security", Wiley, 2008
- Talat Fatima, "Cyber Law in India", Wolters Kluwer, 2017

Semester 2	Course Code: CML-DE-525(iv)	Credits: 3

MACHINE VISION AND PATTERN RECOGNITION

Preamble: The course focuses on applications of pattern recognition techniques to machine vision problems. The course covers feature extraction techniques and the representation of patterns in feature space. Statistical, nonparametric and neural network techniques for pattern recognition have been discussed in this course. Techniques for the recognition of time-varying patterns have also been covered. Numerous examples from machine vision, speech recognition and movement recognition have been discussed as applications. Unsupervised classification or clustering techniques have also been addressed in this course.

Prerequisite: Foundation in Machine Learning, statistical concepts and programming in Python.

COURSE OUTCOMES & TAGGING

Course Outcomes		PO	PSO	CL	KC
CO1	Apply Machine Vision techniques in images and video	PO2	PSO4	Ap	C,P
CO2	Illustrate the skillset to solve real life problems using machine vision and pattern recognition	PO3	PSO8	An, E	C, P
CO3	Implement basic image and computer vision algorithms	PO4	PSO7	Ap, An	C, P
CO4	Summarize different texture, color-based feature extraction methods used for computer vision	PO1	PSO11	U, Ap	C, P
CO5	Selection of features and format into useful mode	PO5	PSO10	Ap	P

(CL- Cognitive Level: R-remember, U-understand, Ap- Apply, An-Analyse, E- Evaluate, Cr- Create, KC- Knowledge Category: F-Factual, C- Conceptual, P-Procedural, M- Metacognitive)

COURSE CONTENT

MODULE I

*Introduction to Machine vision and pattern recognition:*Human vision - Image formation - How machine sees and recognizes things - Basics of pattern recognition, Pattern recognition systems- Design cycle, Learning and adaptation, Pattern recognition approaches – Syntactical Pattern Recognition- Statistical Pattern Recognition

MODULE II

Image Processing:Steps in Digital Image Processing – Spatial Domain: Smoothening – Average filter- Median Filter - Sharpening – Unsharp masking- Edge Detection Methods- Frequency Domain – Fourier Transform- Processing images in frequency domain.

MODULE III

*Computer Vision:*Segmentation and Object Detection, Binary image morphology- Dilation- Erosion- Thresholding- Connected Component Analysis, Image Segmentation – Region based Segmentation, Watershed segmentation, MPEG standard.

MODULE VI

*Image Feature Extraction:*Texture Descriptors - Local Binary Pattern- GLCM, Edge Density and Direction – FeatureMatching – SIFT- SURF - Image Distance measures- Euclidean, Manhattan, Canberra, Bhattacharya distance- Color similarity- Shape similarity.

MODULE V

*Max likelihood and Least squares:*Non parametric methods- Kernel density estimators-Curse of dimensionality - Feature Selection - Discriminant functions-Fishers linear discriminant analysis- Decision theory- minimizing misclassification rate and expected loss.

MODULE VI

*Applications:*Color histograms for Segmentation- Object detection and recognition- YOLO- Content based Image retrieval- Image Classification, Super pixel Segmentation.

LEARNING RESOURCES

References

- J Duda, Richard O., Peter E. Hart, and David G. Stork. "Pattern classification". 2ed. Wiley, 2001
- Mallot, Hanspeter A. "Computational Vision: Information Processing in Perception and Visual Behavior", MIT Press, 2000
- Forsyth, David A., and Jean Ponce, "Computer Vision: a Modern Approach", Prentice Hall, 2003
- Hastie, Trevor, Robert Tibshirani, Jerome Friedman, "The Elements of Statistical Learning: Data Mining, Inference, and Prediction", Springer, 2001
- Stockman, G., Shapiro, L. G., "Computer vision", Prentice Hall, 2001

Semester 2	Course Code:CML-DE-525(v)	Credits: 3

DATA MINING AND TEXT ANALYTICS

Preamble: This course will cover the major mining and analyzing text data techniques t discover interesting patterns and extract useful knowledge. Students will also learn how dat mining can be effectively used in various application areas, focusing on healthcare, to driv decisions and actions. Support decision-making, emphasizing statistical approaches that ar generally applied to arbitrary text data in any natural language with no or minimum huma effort.

Prerequisite: Algorithm- complexity and optimization, Foundation in Database and Bigdata analytics

COURSE OUTCOMES & TAGGING

Course Outcomes		PO	PSO	CL	KC
CO1	Understand the basic data preprocessing techniques	PO2	PSO6	U	C
CO2	Analyze data integration and reduction methods and problems	PO1	PSO1, PSO6	An	C
CO3	Discuss data warehousing and OLAP	PO3	PSO6	U	C
CO4	Illustrate multidimensional data mining processes	PO4	PSO4, PSO6	Ap	P
CO5	Identify and evaluate different pattern mining models	PO5	PSO4, PSO6	U, E	C, P
CO6	Remember text mining architecture and basic steps of text processing	PO3	PSO6	R	C
CO7	Analyze and study different document representation models	PO2	PSO4 PSO6	An	C
CO8	Apply data mining and text analysis methods in various problems to find the solution	PO6	PSO2, PSO6	Cr, Ap	P

(CL- Cognitive Level: R-remember, U-understand, Ap- Apply, An-Analyse, E- Evaluate, Cr- Create, KC- Knowledge Category: F-Factual, C- Conceptual, P-Procedural, M- Metacognitive)

COURSE CONTENT

MODULE I

Datamining: Introduction, techniques, Data Preprocessing-Data Cleaning-Missing Values-Noisy Data. Data Integration-Entity Identification Problem -Redundancy and Correlation Analysis - Tuple Duplication - Data Value Conflict Detection and Resolution. Data Reduction -Wavelet Transforms -Principal Components Analysis -Attribute Subset Selection-Histograms -Clustering - Sampling - Data Cube Aggregation.

MODULE II

Data warehousing and OLAP: Data cube, Multidimensional data model, roll-up, drilldown, slicing and dicing in OLAP, data cube computation, OLAP data indexing and query processing, multidimensional datamining, generalization by attribute-oriented induction.

MODULE III

Advanced pattern mining: Frequent patterns, multilevel patterns, multidimensional patterns, patterns in continuous data, rare patterns, negative patterns, constrained frequent patterns, frequent patterns in high-dimensionaldata.

MODULE IV

Types of Data: Structured, Unstructured data, Text mining General Architecture, Applications. Text Analysis-Language Semantics, Tokenization, Stemming, Lemmatization, stop words, Parts of Speech Tagging.

MODULE V

Document Representation: Bag of Words model, Bag of N-Grams model, TF-IDF model, Word2Vec, GloVe. Document classification and evaluation.

MODULE VI

Applications: Data preprocessing with publicly available dataset, Finding frequent patterns from transaction data set, Document classification with decision tree and SVM.

LEARNING RESOURCES

References

- Jiawei Han,MichelineKamber,Jian Pei, "Data Mining: Concepts and Techniques", 3ed., Elsevier, 2012.
- Pang-Ning Tan, Michael Steinbach, Anuj Karpatne, Vipin Kumar, "Introduction to Data Mining", Pearson Education Limited, 2019.
- Feldman, James Sanger - "The Text Mining Handbook: Advanced Approaches inAnalyzing Unstructured Data"-Cambridge Uni. press, 2006
- Charu C. Aggarwal, ChengXiangZhai,Mining Text Data, Springer; 2012
- Dipanjan Sarkar," Text Analytics with Python A Practitioner's Guide to Natural Language Processing ", 2ed., APress, 2019

Online Resources

- http://myweb.sabanciuniv.edu/rdehkharghani/files/2016/02/The-Morgan-Kaufmann-Series-in-Data-Management-Systems-Jiawei-Han-Micheline-Kamber-Jian-Pei-Data-Mining.-Concepts-and-Techniques-3rd-Edition-Morgan-Kaufmann-2011.pdf

Semester 2	Course Code:CML-DE-525(v)	Credits: 3

DATA MINING AND TEXT ANALYTICS

Preamble: This course will cover the major mining and analyzing text data techniques to discover interesting patterns and extract useful knowledge. Students will also learn how data mining can be effectively used in various application areas, focusing on healthcare, to drive decisions and actions. Support decision-making, emphasizing statistical approaches that are generally applied to arbitrary text data in any natural language with no or minimum human effort.

Prerequisite: Algorithm- complexity and optimization, Foundation in Database and Bigdata analytics

COURSE OUTCOMES & TAGGING

Course Outcomes		PO	PSO	CL	KC
CO1	Understand the basic data preprocessing techniques	PO2	PSO6	U	C
CO2	Analyze data integration and reduction methods and problems	PO1	PSO1, PSO6	An	C
CO3	Discuss data warehousing and OLAP	PO3	PSO6	U	C
CO4	Illustrate multidimensional data mining processes	PO4	PSO4, PSO6	Ap	P
CO5	Identify and evaluate different pattern mining models	PO5	PSO4, PSO6	U, E	C, P
CO6	Remember text mining architecture and basic steps of text processing	PO3	PSO6	R	C
CO7	Analyze and study different document representation models	PO2	PSO4 PSO6	An	C
CO8	Apply data mining and text analysis methods in various problems to find the solution	PO6	PSO2, PSO6	Cr, Ap	P

(CL- Cognitive Level: R-remember, U-understand, Ap- Apply, An-Analyse, E- Evaluate, Cr- Create, KC- Knowledge Category: F-Factual, C- Conceptual, P-Procedural, M- Metacognitive)

COURSE CONTENT

MODULE I

Datamining: Introduction, techniques, Data Preprocessing-Data Cleaning-Missing Values-Noisy Data. Data Integration-Entity Identification Problem -Redundancy and Correlation Analysis - Tuple Duplication - Data Value Conflict Detection and Resolution. Data Reduction -Wavelet Transforms -Principal Components Analysis -Attribute Subset Selection-Histograms -Clustering - Sampling - Data Cube Aggregation.

MODULE II

Data warehousing and OLAP: Data cube, Multidimensional data model, roll-up, drilldown, slicing and dicing in OLAP, data cube computation, OLAP data indexing and query processing, multidimensional datamining, generalization by attribute-oriented induction.

MODULE III

Advanced pattern mining: Frequent patterns, multilevel patterns, multidimensional patterns, patterns in continuous data, rare patterns, negative patterns, constrained frequent patterns, frequent patterns in high-dimensionaldata.

MODULE IV

Types of Data: Structured, Unstructured data, Text mining General Architecture, Applications. Text Analysis-Language Semantics, Tokenization, Stemming, Lemmatization, stop words, Parts of Speech Tagging.

MODULE V

Document Representation: Bag of Words model, Bag of N-Grams model, TF-IDF model, Word2Vec, GloVe. Document classification and evaluation.

MODULE VI

Applications: Data preprocessing with publicly available dataset, Finding frequent patterns from transaction data set, Document classification with decision tree and SVM.

LEARNING RESOURCES

References

- Jiawei Han,MichelineKamber,Jian Pei, "Data Mining: Concepts and Techniques", 3ed., Elsevier, 2012.
- Pang-Ning Tan, Michael Steinbach, Anuj Karpatne, Vipin Kumar, "Introduction to Data Mining", Pearson Education Limited, 2019.
- Feldman, James Sanger - "The Text Mining Handbook: Advanced Approaches inAnalyzing Unstructured Data"-Cambridge Uni. press, 2006
- Charu C. Aggarwal, ChengXiangZhai,Mining Text Data, Springer; 2012
- Dipanjan Sarkar," Text Analytics with Python A Practitioner's Guide to Natural Language Processing ", 2ed., APress, 2019

Online Resources

- http://myweb.sabanciuniv.edu/rdehkharghani/files/2016/02/The-Morgan-Kaufmann-Series-in-Data-Management-Systems-Jiawei-Han-Micheline-Kamber-Jian-Pei-Data-Mining.-Concepts-and-Techniques-3rd-Edition-Morgan-Kaufmann-2011.pdf

Semester 2	Course Code: CML-DE-526(i)	Credits: 3

COMPUTATIONAL BIOLOGY

Preamble: This course helps the learners to understand the fundamental concepts in Molecular Biology, Genomics, Proteomics and Modelling. This course introduces bio macromolecules such as genes and proteins, different biological databases, tools and algorithms for biological data processing, analysis and interpretation, and the elements of the systems approach to Molecular Biology. This course enables the learners to contribute towards drug discovery, computational analysis and modelling of biological processes.

Prerequisite: Basic background in higher secondary biology

COURSE OUTCOMES & TAGGING

Course Outcomes		PO	PSO	CL	KC
CO1	Describe the basic concepts of molecular biology and biological data including DNA and RNA	PO2	PSO7	U	C, P
CO2	Analyze DNA, RNA, and protein sequences	PO3	PSO8	An	C, P
CO3	Explain the properties of DNA, RNA, and proteins, the relationships among these molecules	PO4	PSO3	U, An	C,P
CO4	Knowledge in different sequence alignment techniques in biological sequences	PO2	PSO5	U, An	P, M
CO5	Identify primers, motif and domain of RNA sequences (short sequence elements in RNA sequences)	PO5	PSO11	U	P, C
CO6	Describe about in algorithms computational biology including Gene Finding Approaches and Bayesian via Hidden Markov models	PO3	PSO10	An	P
CO7	Articulate the basic concepts of Genetic algorithm and its applications inMicrobial informatics, Biomedical Images and Microarray	PO2	PSO8	Ap	C, P
CO8	Investigate implementation of machine learning and optimization algorithm in biological sequences	PO1	PSO12	Ap, Ev	C, P

(CL- Cognitive Level: R-remember, U-understand, Ap- Apply, An-Analyze, E- Evaluate, Cr- Create, KC- Knowledge Category: F-Factual, C- Conceptual, P-Procedural, M- Metacognitive)

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, Chipseq 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.

MODULEIV

*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.
- Vinod Chandra S S, Amjesh R - "Bioinformatics for Beginers", Lambert Academic Publishers, UK, 2019.
- Diego Forero, Vinod Chandra S S, "Bioinformatics and Human Genomics Research", CRC Press, UK, 2021

Online Resources

- https://ocw.mit.edu/ans7870/6/6.047/f15/MIT6_047F15_Compiled.pdf
- https://link.springer.com/book/9783030456061
- https://open.oregonstate.education/computationalbiology/
- https://www.e-booksdirectory.com/details.php?ebook=8525

Semester 2	Course Code: CML-DE-526(ii)	Credits: 3

SOFTWARE AGENTS AND MULTI-AGENT SYSTEMS

Preamble: After reading this subject, students will be able to understand development of software agents, gain Knowledge in Multi agent and Intelligent agents, understand Agents and security and gain knowledge on applications of agents.

Prerequisite: Artificial Intelligence fundamentals and concepts in agent-based computing.

COURSE OUTCOMES & TAGGING

Course Outcomes		PO	PSO	CL	KC
CO1	Explain the significance of intelligent agents in the computing world	PO1	PSO2	U	C, P
CO2	Describe the basic concepts, methods, techniques, and tools for the use of intelligent agents in computer-based systems	PO2	PSO5	An	C, P
CO3	Identify the components and functions of intelligent agents	PO4	PSO3, PSO6	U, Ap	C,P
CO4	Apply the principles and methods of intelligent agents to a small-scale application problem	PO2	PSO4	U, An	P, M
CO5	Critically evaluate Agent Oriented methodologies	PO1	PSO5	U	P, C
CO6	Explain the problem solving and planning among agents	PO5	PSO7	An	P
CO7	Apply agent-based modeling techniques for solving real life problems	PO3	PSO11	Ap	C, P

(CL- Cognitive Level: R-remember, U-understand, Ap- Apply, An-Analyze, E- Evaluate, Cr- Create, KC- Knowledge Category: F-Factual, C- Conceptual, P-Procedural, M- Metacognitive)

COURSE CONTENT

MODULE I

*Introduction: A*gents, 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 mechanism. 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

- Michael Wooldridge, "An Introduction to Multi Agent Systems" 2ed., Wiley, 2009.
- Stuart Russell and Peter Norvig, "Artificial Intelligence: A Modern Approach", 3ed., Prentice Hall, 2009.
- Vinod Chandra S S, Anand H S, "Artificial Intelligence: Principles and Applications", 2ed., Prentice Hall of India, 2020
- G Weiss, "Multi-Agent Systems - A Modern Approach to Distributed Artificial Intelligence", MIT Press, 2013
- M. Wooldridge, "Reasoning about Rational Agents", MIT Press, 2000

Online Resources

- https://dimensionless.in/introduction-to-agent-based-modelling/
- https://uma.ac.ir/files/site1/a_akbari_994c8e8/gerhard_weiss___multiagent_systems_ __a_modern_approach_to_distributed_artificial_intelligence.pdf
- https://link.springer.com/book/10.1007/978-3-540-73131-3

Semester 2	Course Code: CML-DE-526(iii)	Credits: 3

REINFORCEMENT LEARNING

Preamble: Reinforcement learning is one powerful paradigm for doing so, and it is relevant to an enormous range of tasks, including robotics, game playing, consumer modelling and healthcare. The course will provide a solid introduction to the field of reinforcement learning and students will learn about the core challenges and approaches, including generalization and exploration. Through lectures and written and coding assignments, students will become well-versed in crucial ideas and techniques for Reinforcement learning.

Prerequisite: Linear algebra, Machine learning and programming in Python.

COURSE OUTCOMES & TAGGING

Course Outcomes		PO	PSO	CL	KC
CO1	Describe the key features of reinforcement learning that distinguishes it from artificial intelligence and non-interactive machine learning	PO1	PSO3	U	C, P
CO2	Exemplify an application problem decide if it should be formulated as a reinforcement learning problem	PO2	PSO8	U, An	C, P
CO3	Implement in code common reinforcement learning algorithms	PO4	PSO3	Ap	C,P
CO4	Explain the multiple criteria for analyzing reinforcement learning algorithms and evaluate algorithms on these metrics	PO3	PSO6	U, An	P, M
CO5	Illustrate the working of policy gradients in Reinforcement Learning	PO2	PSO5	AP	P, C
CO6	Knowledge in Markov decision problem and how to apply	PO5	PSO3	An	P
CO7	Understanding Q-learning and policies	PO4	PSO1	U	C, P
CO8	Apply reinforcement learning in Real world problems	PO6	PSO12	Ap, E	C, P

(CL- Cognitive Level: R-remember, U-understand, Ap- Apply, An-Analyse, E- Evaluate, Cr- Create, KC- Knowledge Category: F-Factual, C- Conceptual, P-Procedural, M- Metacognitive)

COURSE CONTENT

MODULE I

Introduction: 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

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. Overview of dynamic programing for MDP, definition and formulation of planning in MDPs, principle of optimality, iterative policy evaluation, policy iteration, value iteration.

MODULE IV

Q-learning: Q-learning Algorithm, Q-learning Example, Temporal Difference Learning: On-Policy and Off -Policy Learning, Advantages of TD Prediction Methods, Learning Automata.

MODULE V

*Monte Carlo Methods:*Overview of Monte Carlo methods for model free reinforcement learning, First visit and every visit Monte Carlo, Monte Carlo control, On policy and off policy learning, Importance sampling, MC for Model Free Prediction and Control.

MODULE VI

Real-world problems: Super Mario Game, Cross Junction Problem, learning with reinforcement case studies

LEARNING RESOURCES

References

- Richard S. Sutton and Andrew G. Barto, "Reinforcement Learning: An Introduction", 2ed., MIT Press, 2018
- Vinod Chandra S S, Anand H S - "Machine Learning: A Practitioners Approach", Prentice Hall of India, New Delhi, 2020
- Phil Winder, "Reinforcement Learning", O'Reilly Media, 2020

Online Resources

- http://incompleteideas.net/book/RLbook2020.pdf

Semester 2	Course Code: CML-DE-526(iv)	Credits: 3

EXPERT SYSTEMS IN AUTOMATION

Preamble: This course offers techniques for constructing expert systems, including compute inference and knowledge acquisition, knowledge representation schemes, conceptual data analysis, plausible reasoning techniques, validation and measurement methods, and production-rule programming.

Prerequisite: Foundation in Artificial Intelligence and Knowledge base systems.

COURSE OUTCOMES & TAGGING

Course Outcomes		PO	PSO	CL	KC
CO1	Introducing expert systems and its components	PO2	PSO4	U	C, P
CO2	Tools used in expert system	PO3	PSO10	An	C, P
CO3	Knowledge acquisition from a domain expert	PO1	PSO5	An	C, P
CO4	Expert system development with existing tools	PO5	PSO5	Ap	P, M
CO5	Rule generation and conflict solving	PO4	PSO11	Ap	P, C
CO6	Problems and limitations of Expert system	PO2	PSO8	An	P
CO7	Use of Expert system in engineering, business and manufacturing	PO1	PSO7	U, An	C, P
CO8	Study of selected old and modern expert systems	PO3	PSO12	Ap, E	C, P

(CL- Cognitive Level: R-remember, U-understand, Ap- Apply, An-Analyse, E- Evaluate, Cr- Create, KC- Knowledge Category: F-Factual, C- Conceptual, P-Procedural, M- Metacognitive)

COURSE CONTENT

MODULE I

*Introduction to Expert Systems:*Architecture of expert system, Representation and organization of knowledge, Basics characteristics, and types of problems handled by expert systems. Characteristics of Expert System- Components of an Expert System, Building Blocks of Expert Systems.

MODULE II

*Expert System Tools:*Techniques of knowledge representations in expert systems, knowledge engineering, system-building aids, support facilities, stages in the development of expert systems.

MODULE III

Expert System building: Expert system development, Selection of the tool, Acquiring

Knowledge, Building process. Expert System Development: Rule Based Expert Systems, Meta Rules and Meta Knowledge. Knowledge Engineering.

MODULE IV

*Problems with Expert Systems***:**Difficulties, common pitfalls in planning, dealing with domain experts, difficulties during development. Pitfalls in development process. Limitations of Expert Systems.

MODULE V

*Expert system in market place:*Expert system in universe, research organizations, engineering companies. High performance system in research organizations, business and companies. Expert system for Engineering, Self-learning expert systems, Expert systems in robotics and manufacturing, Next level expert systems.

MODULE VI

*Expert Systems and tools:*Applications of Expert System, Simple Medical Expert System, ORTESS - Expert System Shell for Power Plants, Successful Expert Systems, Engineering Expert Systems.

LEARNING RESOURCES

References

- Elain Rich and Kevin Knight, "Artificial Intelligence", Tata McGraw-Hill, 2009
- Waterman D.A., "A Guide to Expert Systems", Addison Wesley Longman, 2009
- Stuart Russel and other Peter Norvig, "Artificial Intelligence – A Modern Approach", 4ed.,Prentice Hall of India, 2020.
- Vinod Chandra S S, Anand H S - "Artificial Intelligence: Principles and Applications", 2ed., Prentice Hall of India, 2020
- Patterson, Artificial Intelligence and Expert System, Prentice Hall India,1999.
- Hayes-Roth, Lenat, and Waterman: Building Expert Systems, Cambridge University Press, 2009
- Weiss S.M. and Kulikowski C.A., "A Practical Guide to Designing Expert Systems", Rowman and Allanheld, New Jersey, 1984

Semester2	Course Code:CML-DE-526(v)	Credits: 3

SOCIAL NETWORK ANALYSIS

Preamble: This interdisciplinary course is designed to benefit from a broad representation of students from different disciplines. The primary learning objective of this course is to enable students to put Social Network Analysis projects into action in a planned, informed and efficient manner.

Prerequisite: Nil.

COURSE OUTCOMES & TAGGING

Course Outcomes		PO	PSO	CL	KC
CO1	Identify the basic concepts semantic web, social networks, and Ontology	PO1	PSO1, PSO2	U	C
CO2	Describe the basic concepts and measures of Social Network Analysis	PO2	PSO2, PSO3	U	C
CO3	Discuss the basic metrics used in social network analysis degree distribution, clustering coefficient, clique, k-core, k-plex, and network motifs	PO4	PSO1, PSO3	U, Ap	C, P
CO4	Understand and analyze the affiliation networks, graphs and partitioning techniques	PO3	PSO2, PSO4	U, An	C, P
CO5	Apply the centralities and find the relevance of web pages using page ranking algorithms	PO4	PSO1, PSO3, PSO10	Ap	P
CO6	Implement an algorithm to solve social media mining and sentimental analysis	PO6	PSO1, PSO5	Ap	P
CO7	Develop practical skills of network analysis in R programming language	PO6	PSO1, PSO3	Ap	C, P
CO8	Evaluate the working of social networks for various applications	PO2	PSO2, PSO10	E	P

(CL- Cognitive Level: R-remember, U-understand, Ap- Apply, An-Analyse, E- Evaluate, Cr- Create, KC- Knowledge Category: F-Factual, C- Conceptual, P-Procedural, M- Metacognitive)

COURSE CONTENT

MODULE I

Introduction: Semantic Web and social networks, limitations of current web, emergence of social

web, Ontology and Semantic Web-Ontology based knowledge Representation; Resource Description Framework.

MODULEII

*Network analysis:*Social Network analysis, Key concepts and measures- Networks- structure- Nodes and edges, network diameter, transitivity, centrality measures, Cohesion- reciprocity, density, clustering, average and longest distance, Applications of SNA.

MODULEIII

*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

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

MODULE V

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

MODULE VI

*Applications:*Implement social networks with some publicly available datasets and find the different centrality measures, community detection through centrality measures, Social media mining-sentiment mining, Knowledge graph and Neo4j.

LEARNING RESOURCES

References

- BorkoFurht, "Handbook of Social Network Technologies and Applications", 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.
- Peter J. Carrington, John Scott, Stanley Wasserman; "Models and Methods in Social Network Analysis"; Cambridge University Press, 2005
- Peter Mika, "Social Networks and the Semantic Web", Springer 2007.
- Song Yang, Franziska B. Keller, Lu Zheng; "Social Network Analysis: Methods and Examples"; SAGE Publications, 2017

On-line Sources

- http://library.uc.edu.kh/userfiles/pdf/18.Models%20and%20Methods%20in%20Social%20Network%20Analysis.pd

Semester 2	Course Code: CML-SE-4B2	Credits: 2

IT ACT AND CONSTITUTION OF INDIA

Preamble: To realize the significance of the constitution of India to students from all walks of life and help them to understand the basic concepts of the Indian constitution and the IT act. It covers the entire Information Technology Act, its amendments, and applicable rules. Apart from the statutory provisions related to cyberspace, this syllabus also emphasizes the social and intellectual property issues and legal analysis of emerging cyberspace technologies. Students can identify the importance of fundamental rights and duties, understand the functioning of Union, State and Local Governments in the Indian federal system. Students also learn the procedure and effects of emergencies, composition and activities of the election commission and amendment procedures.

Prerequisite: Nil

COURSE OUTCOMES & TAGGING

Course Outcomes		PO	PSO	CL	KC
CO1	Knowledge in Information Technology and its use	PO6	PSO1	U	C, P
CO2	Understand cyber space and cybercrimes	PO6	PSO2	U	C, P
CO3	Understand and explain Technology act	PO6	PSO1	U	C,P
CO4	Understand and explain the significance of Indian Constitution as the fundamental law of the land	PO6	PSO1	U, An	P, C
CO5	Exercise his fundamental rights in proper sense at the same time identifies their responsibilities in national building	PO6	PSO3	U	P, C
CO6	Knowledge in state and central government laws and powers	PO6	PSO1	U	P
CO7	Analyze the Indian political system, the powers and functions of the Union, State and Local Governments in detail	PO6	PSO1	An	C, P
CO8	Understand Electoral Process, Emergency provisions and Amendment procedure	PO6	PSO10	U	C, P

(CL- Cognitive Level: R-remember, U-understand, Ap- Apply, An-Analyse, E- Evaluate, Cr- Create, KC - Knowledge Category: F-Factual, C- Conceptual, P-Procedural, M- Metacognitive)

COURSE CONTENT

MODULE I

IT: Information Technology (use of computers to store, retrieve, transmit and manipulate data); understanding cyberspace (cyberspace is a notional environment in which communication over computer network occurs; borderless environment), scope and regulation; internet, e-mail and world wide web; use – academics, e-commerce (B2B,B2C,C2C), social networking by individuals.

MODULE II

Interface of information technology and law: Current challenges – mobiles, cyber security, cloud computing and data privacy, misuse of social media.

Cyber Crimes: financial frauds (money laundering, credit card frauds, social crimes -cyber stalking, pornography, identity theft, IPR related crimes, cyber terrorism, defamation.

MODULE III

Purpose and Object of Information: Technology Act, 2000 (to facilitate e- commerce to remove major hurdles of writing and signature requirement for legal recognition, providing regulatory regime for to supervise certifying authorities and digital signature certificates, to create civil and criminal liabilities for contravention of provisions, and consequential amendments in other Acts.

MODULE IV

Introduction to Constitution: Meaning and importance of the Constitution, salient features of Indian Constitution. Preamble of the Constitution. Fundamental rights- meaning and limitations. Directive principles of state policy and Fundamental duties -their enforcement and their relevance.

MODULE V

Union Government: Union Executive- President, Vice-president, Prime Minister, Council of Ministers. Union Legislature- Parliament and Parliamentary proceedings. Union Judiciary-Supreme Court of India –composition and powers and functions.

State and Local Governments: State Executive- Governor, Chief Minister, Council of Ministers. State Legislature-State Legislative Assembly and State Legislative Council. State Judiciary-High court. Local Government-Panchayat raj system with special reference to 73rd and Urban Local Self Govt. with special reference to74th Amendment.

MODULE VI

Election Commission and powers: Election provisions, Emergency provisions, Amendment of the constitution, Election Commission of India-composition, powers and functions and electoral process. Types of emergency-grounds, procedure, duration and effects. Amendment of the constitution- meaning, procedure and limitations.

LEARNING RESOURCES

References

- Kamath Nandan, "Law Relating to Computers Internet and E-commerce – A Guide to

Cyberlaws and The Information Technology Act, Rules, Regulations and Notifications along with Latest Case Laws", 2012
- Karnika Seth, "Computers Internet and New Technology Laws", LexisNexis, 2013
- Durga Das Basu, "Introduction to the Constitution of India", 15ed., LexisNexis, 2018.
- M.V. Pylee, "India's Constitution", S.Chand Pub., 2017.
- J.N.Pandey, "The Constitutional Law of India', Allahabad; Central Law Agency,55ed., 2018

Online Resources

- "Constitution of India "(Full Text), India.gov.in., National Portal of India, https://www.india.gov.in/sites/upload_files/npi/files/coi_part_full.pdf
- https://legislative.gov.in/constitution-of-india/
- https://eprocure.gov.in/cppp/rulesandprocs/kbadqkdlcswfjdelrquehwuxcfmijmuixngudufgbuubgubfugbububjxcgfvsbdihbgfGhdfgFHytyhRtMjk4NzY=
- https://www.loc.gov/resource/llscd.57026883/?st=gallery
- https://www.indiacode.nic.in/bitstream/123456789/13116/1/it_act_2000_updated.pdf

Semester 2	Course Code: CML-GC-4A2	Credits: 3

MACHINE LEARNING WITH PYTHON

Preamble: Machine Learning with Python is designed for beginners who have little to no prior experience in machine learning. The course aims to provide students with a foundational understanding of the core concepts and techniques used in machine learning and their implementation using the Python programming language. Students will learn the basics of data preprocessing, model training, and evaluation, and gain hands-on experience in building simple machine learning models. Through practical exercises and projects, students will develop the necessary skills to start their journey in the field of machine learning.

Prerequisite: Nil.

COURSE OUTCOMES & TAGGING

	Course Outcomes	PO	PSO	CL	KC
CO1	Explain the fundamental concepts and principles of machine learning, including supervised and unsupervised learning, regression, classification, and clustering.	PO4	PSO7	U	F, C
CO2	Apply Python programming language and relevant libraries such as NumPy, Pandas, and scikit-learn to manipulate and preprocess datasets for machine learning tasks.	PO5	PSO4	Ap	C, P
CO3	Implement and evaluate popular machine learning algorithms, including linear regression, logistic regression, decision trees and K-Means clustering	PO1	PSO3	Ap, An	C, P
CO4	Evaluate and interpret results from machine learning models using appropriate evaluation metrics and cross-validation techniques.	PO3	PSO9	An, E	C,P
CO5	Gain hands-on experience in applying machine learning algorithms to real-world datasets and solve practical problems.	PO5	PSO4	An,Ap	C,P

(CL- Cognitive Level: R-remember, U-understand, Ap- Apply, An-Analyse, E- Evaluate, Cr- Create, KC - Knowledge Category: F-Factual, C- Conceptual, P-Procedural, M- Metacognitive)

COURSE CONTENT

MODULE I

Introduction to Machine Learning: Understand the definition and scope of machine learning. Learn about different types of machine learning tasks, such as regression and classification. Explore various applications of machine learning in real-world scenarios.

MODULE II

Python Basics: Introduction to Python programming language.
Python libraries for machine learning: NumPy, Pandas, and Matplotlib. Hands-on exercises to practice Python programming skills.

MODULE III

Data Preprocessing: Exploratory data analysis- Data cleaning and handling missing values- Feature scaling and normalization- Data encoding for categorical variables.

MODULE IV

Supervised Learning Algorithms:Linear regression for continuous value prediction - Logistic regression for binary classification- Decision trees for classification- Unsupervised Learning Algorithms-Clustering algorithms- K-means clustering.

MODULE V

Introduction to model evaluation metrics: Model Evaluation and Validation-Cross-validation techniques.
Evaluation metrics for regression and classification models- Precision- Recall- Accuracy- Confusion Matrix - Overfitting and underfitting.

MODULE VI

Introduction to Model Deployment: Saving and loading trained models. Implementation of a simple machine learning project.Application of learned techniques and algorithms on a real-world dataset.

LEARNING RESOURCES

References

- Kuhn, M., & Johnson, K. Applied Predictive Modeling. Springer, 2018.
- Andrew N.G Machine Learning Yearning. Self-published, 2018.
- McKinney, W. Python for Data Analysis: Data Wrangling with Pandas, NumPy, and IPython. O'Reilly Media, 2017.
- Müller, A. C., & Guido, S. Introduction to Machine Learning with Python: A Guide for Data Scientists. O'Reilly Media, 2016.
- Géron, A. Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow. O'Reilly Media, 2019
- Raschka, S., &Mirjalili, V. Python Machine Learning. Packt Publishing, 2019.

Semester 3	Course Code: CML-CC-531	Credits: 3

DEEP ARCHITECTURES

Preamble: Explain the fundamental methods involved in deep learning, including the underlying optimization concepts (gradient descent and backpropagation), typical modules they consist of, and how they can be combined to solve real-world problems.

Prerequisite: Machine learning and Programming in Python.

COURSE OUTCOMES & TAGGING

Course Outcomes		PO	PSO	CL	KC
CO1	Understand about deep architectures	PO2	PSO7, PSO9	U	C, P
CO2	Use Deep learning for solving problems	PO3	PSO7, PSO9	U, Ap	C
CO3	Familiar with DBN and CNN	PO1	PSO5	U	C,P
CO4	Familiar LSTM and RNN	PO4	PSO5, PSO7	U	C,P
CO5	Implement RNN, DBN and CNN	PO5	PSO7	U, Ap	C,P
CO6	Compare different Deep architectures and their learning models	PO4	PSO5	U, An	C,P
CO7	Familiar with different deep frameworks like Tensorflow, Keras, Caffe, GAN	PO4	PSO9	U	C, P

(CL- Cognitive Level: R-remember, U-understand, Ap- Apply, An-Analyse, E- Evaluate, Cr- Create, KC - Knowledge Category: F-Factual, C- Conceptual, P-Procedural, M- Metacognitive)

COURSE CONTENT

MODULE I

Deep architecture: Recurrent and Recursive networks, Bidirectional RNNs, Deep Recurrent Networks, Recursive Neural Networks, LSTM, GRU.

MODULE II

Deep Belief networks: Deep reinforcement learning, Geometric stability, Effectivetraining in Deep Net- early stopping, Dropout, Batch Normalization, Instance Normalization, Group Normalization

MODULE III

*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 IV

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 V

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 optimizer.

MODULE VI

Application of deep architectures: Image captioning, word prediction. Flood forecasting, Natural language understanding, Generating databases.

LEARNING RESOURCES

References

- Aggarwal, Charu C. "Neural networks and deep learning." Springer 10.978 (2018).
- Géron, Aurélien. Hands-on machine learning with Scikit-Learn, Keras, and TensorFlow. " O'Reilly Media, Inc.", 2022.
- Goodfellow, Ian, YoshuaBengio, and 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.

Semester 3	Course Code: CML-CC-532	Credits: 3

APPLIED MACHINE LEARNING

Preamble: Students will learn how to correctly apply, interpret results. Iteratively refine and tune supervised and unsupervised machine learning models to solve diverse problems on real-world datasets. Application is emphasized over theoretical content. The main aim of the course is to provide skills to apply machine learning algorithms to real applications.

Prerequisite: Machine learning and Programming in Python.

COURSE OUTCOMES & TAGGING

Course Outcomes		PO	PSO	CL	KC
CO1	Understand PCA and its use	PO1	PSO5	U	C, P
CO2	Understand about fuzzy systems and networks	PO3	PSO8	U	C, P
CO3	Use fuzzy set theory for solving problems	PO4	PSO5, PSO6	U, An	C, P
CO4	Understand concept of ensembles and interconnected models	PO5	PSO7	U	P, M
CO5	Ensemble and adaBoost classifiers for Machine learning	PO2	PSO5	U,Ap	P, C
CO6	Compare different unsupervised ANN and their learning models	PO3	PSO10	An	P,M
CO7	Familiar with advanced ANN frameworks of SOM, ART, PNN	PO2	PSO11	U	C, P
CO8	Familiarization of real-world problems in Machine learning	PO6	PSO12	Ap, E	C, P

(CL- Cognitive Level: R-remember, U-understand, Ap- Apply, An-Analyse, E- Evaluate, Cr- Create, KC - Knowledge Category: F-Factual, C- Conceptual, P-Procedural, M- Metacognitive)

COURSE CONTENT

MODULE I

Dimensionality reduction and Visualization: Dimensionality reduction basics, Row vector, and Column vector, Representation of a dataset. Data preprocessing: Feature Normalization, Mean of a data matrix, Column Standardization, Co-variance of a Data Matrix. Principal Component Analysis: Geometric intuition, Mathematical objective function, Alternative formulation of PCA: distance minimization, Eigenvalues and eigenvectors, PCA for dimensionality reduction and visualization, Limitations of PCA.

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

Ensemble classifier: Types of ensembles, Simple ensemble models, Advanced ensemble models, AdaBoost, Bayes Optimal classifier, Bayesian model averaging, Gradient boosting. Applying boosting models, XGBoost, Stacking ensembles, Ensemble models in dynamic applications.

MODULE IV

Pattern Association: Hebb rule, Outer products rule, Auto associative memory, hetro associative memory, Bidirectional associative memory, Hopfield networks Self-Organising Maps: Architecture of SOM, Learning Process of SOM, SOM Algorithm, SOM Example, Implications of SOM. Applications of SOM.

MODULE V

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.

MODULE VI

Real world problems: Quora Question pair similarity problem, Microsoft Malware Detection, AD-Click Prediction, Human Activity Recognition, Self-Driving Car, Music Generation using Deep Learning, Survey Blog, Movie Recommendation System, Fashion Discovery Engine.

LEARNING RESOURCES

References

- M. Gopal, "Applied Machine Learning", McGraw-Hill Education, 2019
- David Forsyth, "Applied Machine Learning", Springer International Publishing, 2019
- Vinod Chandra S S, Anand H S - "Machine Learning: A Practitioners Approach", Prentice Hall of India, New Delhi, 2020
- Marc Peter Deisenroth, A. Aldo Faisal, Cheng Soon Ong, "Mathematics for Machine Learning", Cambridge University Press, 2020

Semester 3	Course Code: CML-CC-533	Credits: 3

ACCELERATED NATURAL LANGUAGE PROCESSING

Preamble: This course enables the learners to understand the concepts of Natural Language Processing. The course covers basic pre-processing steps, language models, text classification using machine learning algorithms, information and relation extraction methods, Information Retrieval, Question Answer Systems and Machine Translation models. This course enables the students to apply techniques and methods to solve challenging real-world problems in NLP.

Prerequisite: Natural Language Processing

COURSE OUTCOMES & TAGGING

Course Outcomes		PO	PSO	CL	KC
CO1	Understand key concepts from NLP those are used to describe and analyze language	PO1	PSO2	U	F
CO2	Describe the characteristics of classical document representation models.	PO2	PSO7	U	C,F
CO3	Compare the basic working principles of recent deep learning frameworks for NLP	PO4	PSO4	Ap	C,F
CO4	Analyse the theoretical background behind the semantic computing in NLP	PO5	PSO8	An	F
CO5	Distinguish the word embedding techniques available in NLP	PO3	PSO7, PSO9	Ap	C
CO6	Design document analysis model for NLP using new generation Machine Learning	PO4	PSO9	Ap	M,C

(CL- Cognitive Level: R-remember, U-understand, Ap- Apply, An-Analyse, E- Evaluate, Cr- Create, KC - Knowledge Category: F-Factual, C- Conceptual, P-Procedural, M- Metacognitive)

COURSE CONTENT

MODULE I

Introduction to Natural Language Processing and applications: Different levels of NLP; Text Normalization: Basic pre-processing, Word and sentence segmentation, Lemmatization, Stemming, Morphology; Language Models: n-gram models, smoothing techniques

MODULE II

*Sequence Learning Tasks and Models***:** Computational Syntax-part of speech tagging and named entity recognition, Statistical Model - HMM, MEMM. Language computational models: Vector Space Model-representation, weighting Schema –TIF-DF, similarity measures.

MODULE III

*Computational Semantics-Lexical semantics:*WordNet and FrameNet, Word Sense Disambiguation, Distributional Semantics and Word-Space models, Logical approaches to sentence semantics, GloVe, word2vec.

MODULE IV

Machine learning Models: RNN in language computing, Role of LSTM in advanced machine learning models for languages. Attention model - additive and multiplicative attention and its importance.

MODULE V

Transformer and advanced algorithms in language computing: Prompting Pre-Trained Language Models, architecture and applications of BERT, architecture and evolution of GPT.

MODULE VI

Applications: Document classification and summarization using VSM and weighting scheme. Comparative analysis of word embedding with word2vec, BERT and GPT.

LEARNING RESOURCES

References

- Eisenstein, Introduction to Natural Language Processing, MIT Press, 2019.
- Anderson, K, Designing Autonomous AI: A Guide for Machine Teaching. Japan: O'Reilly Media, Incorporated, 2022.
- Camacho-Collados, J., Pilehvar, M. T. Embeddings in Natural Language Processing: Theory and Advances in Vector Representations of Meaning. Switzerland: Morgan and Claypool Publishers, 2020
- Hellrich, J, Word Embeddings: Reliability and Semantic Change. Germany: IOS Press, 2019.
- Hvitfeldt, E., Silge, J. Supervised Machine Learning for Text Analysis in R. United States: CRC Press, 2021.

Online Resources

- D. Jurafsky, J.H. Martin, Speech and Language Processing, 3ed. Online Edition (available at https://web.stanford.edu/~jurafsky/slp3/).

Semester 3	Course Code: CML-CC-534	Credits: 2

CASE STUDY

Preamble: The objective of doing Case Study allows students with real expertise and understanding, how and why an innovation has worked in a specific case.

Prerequisite: Nil.

COURSE OUTCOMES & TAGGING

Course Outcomes		PO	PSO	CL	KC
CO1	Identify a research problem which is significant in the area of computerscience	PO1	PSO2, PSO7	U	F
CO2	Analyze the literature survey in the selected topic as an individual	PO2	PSO5	An	C,F
CO3	Design the experiment with proper hypothesis	PO4	PSO12	Ap	C,F
CO4	Evaluate and interpret the experimental results.	PO5	PSO8, PSO5	An	F
CO5	Analyze effectiveness of the method implemented.	PO3	PSO7, PSO9	Ap	C
CO6	Suggest modifications and improvement of the system.	PO4	PSO9	Ap	M,C

(CL- Cognitive Level: R-remember, U-understand, Ap- Apply, An-Analyse, E- Evaluate, Cr- Create, KC - Knowledge Category: F-Factual, C- Conceptual, P-Procedural, M- Metacognitive)

COURSE CONTENT

A case study is a detailed investigation done by a student on a specific topic in the courses studied till Semester III. It is a milestone and precursor to the final presentation of the Project. The students must implement a published article from the Research and Development area. The presentation will be oral. A faculty member is assigned by the Department council for each student to select the case. The case study report should contain the case's background, analysis, alternatives, recommendations, and implementation plan. Students can use 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, and defending the questions.

ASSESSMENT

Continuous interaction and Discussion with guide: 20 marks

Continuous interaction and work progress will lead to a valuable contribution to the final project work.

Case study Report: 30 marks

A technical report on studies and experiments will improve your technical writing skill.

Presentation and Viva: 50 marks

The presentation skills of the students are evaluated systematically.

Semester 3	Course Code: CML-CC-535	Credits: 3

DEEP LEARNING LABORATORY

Preamble: Aim of this course is to understand the implementation procedures for deep learning algorithms using Java/Python programs. Students are expected to apply appropriate image and signal data sets in to the designed deep learning algorithms to solve real-world problems.

Prerequisite: Python Programming, Foundation in Deep learning techniques.

COURSE OUTCOMES & TAGGING

Course Outcomes		PO	PSO	CL	KC
CO1	Implement the machine learning concepts and algorithms in any suitable language of choice	PO2	PSO9, PSO4	U	C, P
CO2	Understand fundamental concepts and methods of machine learning, statistical pattern recognition and its applications	PO1	PSO4	Ap	C, P
CO3	Understand neural network layers for various learning problems	PO3	PSO7, PSO9	Ap	C, P
CO4	Design how to predict the results using a trained model	PO4	PSO9, PSO12	Ap	C, P
CO5	Perform different pre-processing operations on structured or unstructured data	PO5	PSO4, PSO7	U, Ap	C, P
CO6	Implement, train, and validate neural network	PO2	PSO9	Ap	C, P
CO7	Illustrate simple neural networks and deep neural networks	PO4	PSO9, PSO12	Ap	C, P
CO8	Interpret the model results and analyze the performance of the model	PO3	PSO9, PSO12	Ap	C, P

(CL- Cognitive Level: R-remember, U-understand, Ap- Apply, An-Analyse, E- Evaluate, Cr- Create, KC - Knowledge Category: F-Factual, C- Conceptual, P-Procedural, M- Metacognitive)

COURSE CONTENT

It is advised to complete the problems to be given under each of the following cycles. There may be a set of experiments in each cycle, and all cycles are mandatory. The faculty in charge will give the list of exercises as and when you have completed the minimum experiments in each cycle. The students can suggest new and innovative exercises in the second cycle, provided it can be implemented with the available lab infrastructure.

Advanced Neural Network Cycle

- Exercises in Pattern association problems
- Exercises in ARTMAP
- Exercises related to real world problems

Deep Architecture Cycle

- Exercises in implementing deep architecture for solving real world problems
- Exercises in Recurrent networks
- Exercises in Convolutional neural networks
- Understanding of GAN

Real-world problem-solving cycle

- Exercises in implementing deep architecture for solving real world problems
- Natural language processing
- Image processing applications
- NLP using LSTM

Problems with different algorithms in this category will be given. The dataset to be used will be mentioned in the problem statement itself. Evaluation matrices that have to be projected as out will also be given.

ASSESSMENT

Basic laboratory programs: 30 marks

The programming exercises marked as basic level,to provide practical awareness for the main objective of the course.

Mini Project/Case Study Evaluation: 50 marks

At the advanced level, advanced programming exercises are given to understand the application level of the course.

End Semester Viva: 20 marks

The students have to attend a viva voce examination, where the knowledge in the different courses undergone in the semester and presentation skill of the students are evaluated systematically.

Laboratory Record

All Students attending the End Semester Viva should produce a practical laboratory record at the time of evaluation. The record should be certified by the Faculty-in-charge of the laboratory countersigned by the Course coordinator.

Semester 3	Course Code:CML-DE-536(i)	Credits: 3

GENERATIVE DEEP MODELS

Preamble: This course offers probabilistic foundations and learning algorithms for deep generative models, includes variation auto encoders, generative adversarial networks, autoregressive models, normalizing flow, energy-based, and score-based models. The course will also discuss application areas that have benefitted from deep generative models, including computer vision, speech and natural language processing, graph mining, reinforcement learning, reliable machine learning, and inverse problem-solving.

Prerequisite: Machine learning, Foundation in Deep learning

COURSE OUTCOMES & TAGGING

Course Outcomes		PO	PSO	CL	KC
CO1	Understand about Generative deep models	PO1	PSO7,PSO9	U, Ap	C, P
CO2	Familiarize the use of Autoregressive models	PO1	PSO7	U	C
CO3	Understand the concept of BERT, GPT-3, language modeling techniques.	PO3	PSO 11	U	C,P
CO4	Familiarize the working of Deep Boltzmann Machines	PO4	PSO7, PSO5	U	C,P
CO5	Able to understand the concept of Controllable Generation	PO3	PSO7	U	C,P
CO6	Equip the students with the capability of analyzing the generative models	PO5	PSO5	U, An	C, P
CO7	Understand Generative Adversarial Imitation Learning (GAIL)	PO2	PSO7	U	C, P
CO8	Familiarize the various applications of Energy-based models	PO5	PSO9	U	C, P

(CL- Cognitive Level: R-remember, U-understand, Ap- Apply, An-Analyse, E- Evaluate, Cr- Create, KC - Knowledge Category: F-Factual, C- Conceptual, P-Procedural, M- Metacognitive)

COURSE CONTENT

MODULE I

Generative modeling: Statistical generative models, Conditional generative models. Autoregressive models- Fully Visible Sigmoid Belief Network. Autoregressive autoencoders, Generative transformers, Pixel RNN. Density estimation- KL Divergence.

MODULE II

*Latent variable models:*Deep latent variable models, Variation auto encoder. Deep Generative Models, Flow-based models, Continuous Autoregressive models as flow models, Masked

Autoregressive Flow (MAF), Inverse Autoregressive Flow (IAF)

MODULE III

WaveNet, Parallel Wavenet, MintNet, Gaussianization Flows, Generative modeling and two-sample tests, F-divergences, Bidirectional Generative Adversarial Networks, CycleGAN. Transformers ; Language Modeling- BERT, GPT-3.

MODULE IV

Energy- based model, Applications of Energy-based models, Deep Boltzmann Machines, Score-based generative modeling, Annealed Langevin Dynamics, Predictor-Corrector sampling, Controllable Generation

MODULE V

*Evaluating Generative Models***:** Kernel Density Estimation, Sample quality, Inception Scores-Frechet Inception Distance, Kernel Inception Distance. Variants and Combinations of Basic Models- FlowGAN, Adversarial Autoencoder. Generative Adversarial Imitation Learning(GAIL).

MODULE VI

Case studies: Audio Super Resolution, Machine Translation, Language Generation, Code Generation, Image Translation.

LEARNING RESOURCES

References

- David Foster, "Generative Deep Learning", O'Reilly Media, 2019
- Jason Brownlee, "Generative Adversarial Networks with Python", Machine Learning Mastery,2019
- Ruslan Salakhutdinov, “Learning deep generative models”, Annual Review of Statistics and Its Application, April 2015.

Online Resources

- https://www.frontiersin.org/articles/10.3389/fmats.2022.865270/full
- https://uvadlc-notebooks.readthedocs.io/en/latest/tutorial_notebooks/tutorial8/Deep_Energy_Models.html
- https://ermongroup.github.io/generative-models/
- https://www.youtube.com/watch?v=sgHdUYHGvtA
- https://www.youtube.com/watch?v=JrO5fSskISY
- https://arxiv.org/pdf/1701.00160.pdf
- https://www.youtube.com/watch?v=HGYYEUSm-0Q

Semester 3	Course Code: CML-DE-536(ii)	Credits: 3

GAME THEORY AND APPLICATIONS

Preamble: Aim of this course is to introduce students to the novel concepts of Game Theory with special emphasis on its applications in diverse fields and current research. This course is intended to provide students with a comprehensive treatment of game theory with specific emphasis on applications.

Prerequisite: Mathematical foundation in Artificial Intelligence.

COURSE OUTCOMES & TAGGING

Course Outcomes		PO	PSO	CL	KC
CO1	Acquaint with scope and applications of Game Theory	PO2	PSO2, PSO12	Ap, An	C,P,M
CO2	Exposes to use various mathematical tools to model and analyze situations of interactive decision making	PO4	PSO5, PSO7	Ap, An	C,P
CO3	Apply strategic form games for the analysis of strategic interactions in multi agent environment	PO1	PSO7, PSO11	Ap, An	C,P
CO4	Present fundamental results for existence and uniqueness of Nash equilibria and discuss their efficiency properties	PO5	PSO7, PSO 8	Ap, An	C,P
CO5	Familiarize with concepts of dynamic changing game environments applications in Flexi Pricing of air lines, Premium pricing by hoteliers, taxi food aggregators etc.	PO3	PSO11, PSO12	U, Ap	C,P,M
CO6	Explore utility theory, a theoretical approach that quantifies an agent's degree of preference across a set of available alternatives	PO2	PSO8, PSO11	U, Ap	C,P
CO7	Study Bayesian games and introduce different equilibrium notions in Bayesian games such as Bayesian Nash equilibrium	PO5	PSO8, PSO 12	U, Ap	C,P
CO8	Introduce games with incomplete information, which are crucial to the theory of mechanism design	PO1	PSO7, PSO12	An, Ap	C,P,M
CO9	Apply Mechanism design as the reverse engineering of games or equivalently as the art of designing the rules of a game to achieve a specific desired outcome	PO2	PSO2, PSO12	Ap, An	C,P,M

(CL- Cognitive Level: R-remember, U-understand, Ap- Apply, An-Analyse, E- Evaluate, Cr- Create, KC - Knowledge Category: F-Factual, C- Conceptual, P-Procedural, M- Metacognitive)

COURSE CONTENT

MODULE I

Introduction to Game Theory: Current Trends and Modern Applications, Key Notions in Game Theory- Strategic Form Games, Preferences, Utilities, rationality, Intelligence, Classification of Games, Extensive Form Games, Transforming Extensive Forms into Strategic Forms

MODULE II

Strategic Form Games: Matching Pennies with Simultaneous Moves, Rock-Papers, Scissors Game, A Coordination Game, Prisoner's Dilemma Game, Dominant Strategy Equilibria- Strong Dominance, Weak Dominance, Very Weak Dominance- Illustrations of Dominant strategy Equilibria

MODULE III

*Nash equilibrium:*Maxmin strategies, elimination of dominated strategies, preservation of pure Nash equilibrium (PSNE), matrix games, relation between maxmin and PSNE in matrix gamesMixed strategies, mixed strategy Nash equilibrium (MSNE), finding MSNE, MSNE characterization theorem, algorithm to find MSNE

MODULE IV

Utility Theory: Need for Utility Theory, Axioms of Von Neumann Morgenstern Utility Theory, Bayesian Games, Games with incomplete information, Examples of Bayesian Games, Type Agent Representation and the Selten Game, Bayesian Nash Equilibrium, Dominant Strategy Equilibria

MODULE V

Introduction to mechanism design: Mechanism Design Environment, Direct and Indirect Mechanism, Vickrey – Clarke- Groves(VCG) mechanisms, The Quasi Linear Environment, Groves Mechanism, Clarke Mechanism – Examples of VCG Mechanisms

MODULE VI

*Applications:*Implementation in multiple Equilibria, Implementation in Nash Equilibrium, implementation in Complete Information setting, Mechanism Design Space in Quasi Linear Environment

LEARNING RESOURCES

References

- Y. Narahari, "Game Theory and Mechanism Design: 4 (IISc Lecture Notes Series)," World Scientific Publishing Co Pvt Ltd, 2014,
- Roger B. Myerson, "Game Theory: Analysis of Conflict," Harvard University Press, September, 1997

- Maschler, M., Solan, E., Zamir, S, "Game Theory". Cambridge: Cambridge University Press, 2013
- Y. Shoham and K. Leyton Brown, Multiagent Systems Algorithmic, Game-Theoretic, and Logical Foundations Cambridge University Press, 2007
- Anna R. Karlin and Yuval Peres, "Game Theory, Alive," American Mathematical Society, 2017

Online Resources

- https://mathematicalolympiads.files.wordpress.com/2012/08/martin_j-_osborne-an_introduction_to_game_theory-oxford_university_press_usa2003.pdf
- https://www.cse.iitb.ac.in/~swaprava/courses/cs711/lecnotes.pdf
- https://www.sciencedirect.com/book/9780123701824/game-theory-and-applications
- http://www.eecs.harvard.edu/cs286r/courses/fall08/files/SLB.pdf
- http://www.masfoundations.org/mas.pdf

Semester 3	Course Code:CML-DE-536(iii)	Credits: 3

DEEP LEARNING FOR AUDIO AND MUSIC

Preamble: It covers digital signal processing, representation learning, time series models of music as information sources, generative deep learning networks, source separation and audio synthesis.

Prerequisite: Machine learning and foundation in Deep architectures.

COURSE OUTCOMES & TAGGING

Course Outcomes		PO	PSO	CL	KC
CO1	Understand Perception of Sound, Psycho-acoustic analysis, Spatial Audio Perception and rendering	PO2	PSO4	U	C, F
CO2	Implement the audio features including spectrogram, MFCC for audio classification	PO3	PSO5	Ap, An	C, P
CO3	Possess the skill set of theoretical and practical study of how computers synthesize and process audio and music	PO1	PSO8	An, Ap	C, P
CO4	Provide advanced knowledge in audio and music deep architectures	PO4	PSO7	U, Ap	C, P
CO5	Develop systems for various applications of audio and music processing	PO6	PSO9	Ap, An	C, P
CO6	Design Deep Neural Network models for time and frequency representations	PO6	PSO12	Cr, An, Ap	C, P

(CL- Cognitive Level: R-remember, U-understand, Ap- Apply, An-Analyse, E- Evaluate, Cr- Create, KC - Knowledge Category: F-Factual, C- Conceptual, P-Procedural, M- Metacognitive)

COURSE CONTENT

MODULE II

Introduction to Audio Processing: Fundamentals of sound and psychoacoustics; working of digital audio -Signal Processing Pipeline- MFCCs: Mel-frequency cepstral coefficients- Spectrogram: - Statistical Functionals- Zero Crossing rate- Enerygy- Pitch- Temporal Dynamics- Guassian Mixture models for Acoustic modelling- Audio storage formats

MODULE II

Introduction to Music Processing: Definition- Musical sound characteristics- MIDI- MIDI message- MIDI Channel- Music processing- Deep learning Approaches- Learning audio features from data- Alignment Problem- Music Synchronization – Image – Audio- Optical Music Recognition-Soft Attention Mechanism

MODULE III

DNN architectures for audio processing: Convolutional Neural Network (CNN)- Temporal Convolutional Networks (TCN) - Recurrent Neural Network (RNN)- DNN meta-

architectures- Auto Encoder- Variational Auto Encoder- Generative Adversarial Network (GAN)- Encoder/Decoder (ED)- Attention Mechanism- Attention Mechanism.

MODULE IV

*DNN inputs for audio processing:*Time-Frequency Audio Representations- Spectrograms- Mel-Frequency-Cepstral-Coefficients (MFCC)- Log-Mel-Spectrogram (LMS)- Constant-Q-Transform (CQT)- Spectrogram images versus natural images- Self Supervised Learning - Audio-Visual Correspondence (AVC)- AVE-Net- SPICE (Self-supervised Pitch Estimation), Semi Supervised Learning – SoundNeT

MODULE V

DNN models for time and frequency representations as inputs- in Speech – In Music- Using waveform representations as input – Speech – Music- 1D CNN- MutliScale – Using knowledge-driven representations as input- Harmonic CQT- Source/ Filter- SincNeT- Harmonic CNN- Neural Autoregressive Models

MODULE VI

Applications: Music content description- Beat Tracking- Environmental Sounds Classification- Detection and classification of Acoustic Scene and Events (DCASE)- Music Genre Classification, Music Information Retrieval- Music Source Separation

LEARNING RESOURCES

References

- Curtis Roads, Curtis Roads, John Strawn, "The Computer Music Tutorial", MIT Press, 1996.
- Dodge, Charles and Thomas A. Jerse. "Computer Music: Synthesis, Composition, and Performance," 2ed., Schirmer Books, 1997.
- Moore, F. Richard. "Elements of Computer Music" Prentice Hall, 1990.
- AkkaZemmari, Jenny Benois-Pineau, "Multi-faceted Deep Learning: Models and Data", Springer, 2021.

Semester 3	Course Code:CML-DE-536(iv)	Credits: 3

NATURE INSPIRED COMPUTING

Preamble: This course provides an overview of popular nature-inspired computing methods. Methods that are inspired by both biological and non-biological systems are considered. These methods have been applied to solve problems in various areas of computing, such as optimization, machine learning, and robotics. Examples of nature-inspired computing methods studied include cellular automata, neural networks, evolutionary computing, swarm intelligence, artificial life, and complex networks. Contributions made in nature-inspired computing that have led to advances in the natural sciences are also discussed.

Prerequisite: Algorithms-complexity and Optimization

COURSE OUTCOMES & TAGGING

Course Outcomes		PO	PSO	CL	KC
CO1	Describe about bio inspired computing fundamentals	PO2	PSO3	U	C, P
CO2	Explain about optimization problems and its types	PO3	PSO8	U, An	C, P
CO3	Familiar with Genetic algorithm and its applications	PO4	PSO3	U	C,P
CO4	Compare different Ant Colony Optimization algorithmic models	PO5	PSO6	U, An	P, M
CO5	Compare different Artificial Bee Colony Optimization algorithmic models	PO5	PSO5	An	P, C
CO6	Illustrate Particle swam optimization algorithm with an example	PO1	PSO8	AP	P
CO7	Compare different natural inspired computing algorithms	PO3	PSO7	An	C, P
CO8	Real world problem with nature inspired optimization	PO6	PSO12	Cr, Ap, E	C, P

(CL- Cognitive Level: R-remember, U-understand, Ap- Apply, An-Analyse, E- Evaluate, Cr- Create, KC - Knowledge Category: F-Factual, C- Conceptual, P-Procedural, M- Metacognitive)

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 and 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

Semester 3	Course Code: CML-DE-536(v)	Credits: 3

INTELLIGENT INFORMATION RETRIEVAL

Preamble: This course will cover algorithms, design, and implementation of modern information retrieval systems. The main objective of this course is to present scientific support in the information search and retrieval field. This course explores the fundamental relationship between information retrieval, hypermedia architectures, and semantic models, thus deploying and testing several important retrieval models.

Prerequisite: Mathematical foundations and Knowledge in Internet and web technology.

COURSE OUTCOMES & TAGGING

Course Outcomes		PO	PSO	CL	KC
CO1	Compare Boolean and vector-space retrieval models	PO1	PSO4	An	C, P
CO2	Provide the ability to solve novel and practical information retrieval problems	PO2	PSO11	Ap	C, P
CO3	Illustrate the process of Document clustering in information retrieval	PO1	PSO3	U, An	C,P
CO4	Evaluate the information retrieval algorithms using precision and recall	PO4	PSO8	E	P, C
CO5	Implement Document ranking algorithm using TF-IDF algorithm	PO4	PSO4, PSO5	An	P, C
CO6	Provide the knowledge of searching and indexing in information retrieval	PO2	PSO5	U, An	P

(CL- Cognitive Level: R-remember, U-understand, Ap- Apply, An-Analyse, E- Evaluate, Cr- Create, KC - Knowledge Category: F-Factual, C- Conceptual, P-Procedural, M- Metacognitive)

COURSE CONTENT

MODULE I

*Information Retrieval:*Early Developments – The IR Problem – The Users Task – Information versus Data Retrieval - The IR System – The Software Architecture of the IR System – The Retrieval and Ranking Processes - The Web – The e-Publishing Era – How the web changed Search – Practical Issues on the Web – How People Search – Search Interfaces Today – Visualization in Search Interfaces.

MODULE II

Basic IR Models: Boolean Model - TF-IDF (Term Frequency/Inverse Document Frequency) Weighting - Vector Model – Probabilistic Model – Latent Semantic Indexing Model – Neural Network Model – Retrieval Evaluation – Retrieval Metrics – Precision, Recall.

MODULE III

Characterization of Text Classification: Unsupervised Algorithms: Clustering – Naïve Text Classification – Supervised Algorithms – Decision Tree – k-NN Classifier – SVM Classifier – Feature Selection or Dimensionality Reduction – Indexing and Searching – Inverted Indexes – Sequential Searching – Multi-dimensional Indexing.

MODULE IV

*Web Retrieval:*Web – Search Engine Architectures – Cluster based Architecture – Distributed Architectures – Search Engine Ranking – Link based Ranking – Simple Ranking Functions – Learning to Rank – Evaluations - Search Engine Ranking – Search Engine User Interaction – Browsing – Applications of a Web Crawler – Taxonomy – Architecture and Implementation – Scheduling Algorithms – Evaluation.

MODULE V

*Recommender Systems Functions:*Data and Knowledge Sources – Recommendation Techniques – Basics of Content-based Recommender Systems – High Level Architecture – Advantages and Drawbacks of Content-based Filtering – Collaborative Filtering –– Neighborhood models.

MODULE VI

*Information Retrieval applications:*Document Retrieval using Boolean Model and Vector Space Model - Product recommender system - Text Classification using clustering- Document ranking algorithm using TF-IDF algorithm.

LEARNING RESOURCES

References

- Christopher D. Manning, Prabhakar Raghavan and Hinrich Schutze, "Introduction to Information Retrieval", Cambridge University Press, 2008.
- R. Baeza-Yates, B. Ribeiro-Neto", Addison-Wesley, 2011.
- D.A. Grossman, O. Frieder. "Information Retrieval: Algorithms and Heuristics ", Springer, 2004.
- B. Croft, D. Metzler, T. Strohman, "Information Retrieval in Practice", Pearson Education, 2009.
- Ricci, F, Rokach, L. Shapira, B. Kantor, "Recommender Systems Handbook", Springer, 2011.

Semester 3	Course Code:CML-DE-537(i)	Credits: 3

BIOMEDICAL SIGNAL PROCESSING

Preamble: Biomedical signals are the observation of the physiological activities of organisms, ranging from gene and protein sequences to neural and cardiac rhythms. Biomedical signal processing aims to extract meaningful information from biomedical signals. This course primarily focused on filtering signals to remove noises. A fundamental method for noise cancellation analysed the signal spectra and suppressed undesired frequency components. At the end of this course successful students will be able to choosing a class of signal model,selecting a specific form of the model and process the biomedical signal.

Prerequisite: Digital signal processing and foundation in programming.

COURSE OUTCOMES & TAGGING

Course Outcomes		PO	PSO	CL	KC
CO1	Knowledge in the mathematical principles of continuous and digital signal processing	PO	PSO	CL	KC
CO2	Identify the basics of biomedical signal pre-processing and digital filtering	PO1	PSO3	U	P
CO3	Generalize the origins and characteristics of the most commonly used biomedical signals, like ECG, EEG, evoked potentials, and EMG	PO3	PSO2	R	C
CO4	Understand the theoretical background underlying the use of signal processing and statistical techniques for biomedical applications	PO4	PSO2, PSO4	U	C
CO5	Recognize the need for, and an ability to describe various sources of bio signal distortions and its remedial techniques	PO4	PSO10	R,U	P
CO6	Familiarize the sources and characteristics of noise and artifacts in bio-signals and be able to classify them	PO5	PSO9	An	C
CO7	Analyze the physiological data with the particular focus of detecting events in bio-medical signals like ECG, EEG signal with their characteristic feature points	PO2	PSO4	U	C
CO8	Apply fundamental concepts gained for understanding advanced biomedical techniques tosolve problems in an ECG spectrum using Fourier Series and calculation of Heart Rate	PO2	PSO10	An	C

(CL- Cognitive Level: R-remember, U-understand, Ap- Apply, An-Analyse, E- Evaluate, Cr- Create, KC - Knowledge Category: F-Factual, C- Conceptual, P-Procedural, M- Metacognitive)

COURSE CONTENT

MODULE I

Probability Density Functions (PDFs): Estimating PDFs-Practical techniques for estimating PDFs from real data. Random signals and linear systems. Analog Signal Processing-Basics of Instrumentation Amplifier, Isolation amplifier, Grounding and shielding techniques. Integer Filters- Basic Design Concept, Low Pass and High Pass Filters, Band Pass, Band Stop and Band Reject Filters.

MODULE II

*Adaptive Filters:*Basic Concept, Principal noise cancellation model, removal of periodic events using adaptive cancellation. Digital signal Processing- Characteristics, frequency domain representation, Stationary and non-stationary bio-signals, waveform detection, Sampling Theory, Finite data considerations -Edge effects.

MODULE III

*Introduction to biomedical signals:*Bioelectric Signals and Classification of biomedical signals,ECG, EEG, EMG, ENG, ERG, EOG, MEG. Biomedical Instrumentation System, biomedical transducers, electrodes and their characteristics. Origin of bio potentials. Sources and contamination of Noise in bio signals. Motion artifacts and skin Impedance.

MODULE IV

Biomedical Signal Analysis: Objectives of Biomedical Signal Analysis, Difficulties in Biomedical Signal Analysis, Computer-Aided Diagnosis. Analysis of Electrical Activity of Heart -ECG signal parameters and their estimation - Use of multiscale analysis for ECG parameter estimation.

MODULE V

Muscle noise filtering: QRS detection, Highlight the Feature points of ECG and its classification for Normal and Abnormal state using Multilayer Perceptron. Analysis of Electrical Activity of Brain- Electroencephalogram, Structure of brain, EEG signal acquisition,10-20 electrode placement, EEG rhythms and waveform - categorization of EEG activity - recording techniques.

MODULE VI

*EEG applications:*Epilepsy sleep disorders, brain computer interface. Use of Fourier Transform in EEG Signal Analysis.Adaptive Filters: Basic Concept, Principal noise cancellation model, removal of periodic events using adaptive cancellation, adaptive cancellation of maternal ECG from fetal ECG of Interest.

LEARNING RESOURCES

References

- Willis J. Tompkins, "Biomedical Digital Signal Processing", PHI, 2004.
- D C Reddy, "Biomedical Signal Processing: Principles and Techniques", TMH, 2005.
- J G Webster, "Medical Instrumentation: Application and Design", John Wiley, 2001.
- C Raja Rao, S K Guha, "Principles of Medical Electronics and Biomedical Instrumentation", Universities Press, 2001.
- AV Oppenheim, RW Shafer, "Discrete-time Signal Processing", Prentice Hall, 1989.
- Steven M. Kay, "Modern spectral estimation theory and application ", Prentice Hall, 1988.
- Joseph J. Carr, John M. Brown, "Introduction to Biomedical Equipment Technology",4ed. Prentice Hall, 2000.
- R. Rangayan, "Biomedical Signal Analysis", Wiley, 2002.
- John L Semmlow, "Bio-signal and Biomedical Image Processing", McGraw Hill, 2005

Semester 3	Course Code:CML-DE-537(ii)	Credits: 3

IMAGE AND VIDEO PROCESSING

Preamble: The students shall be able to apply the knowledge gained during the course to solve real time problems. The students shall be able to develop new state of the art image and video processing methods.

Prerequisite: Signals and Systems, Digital Signal Processing.

COURSE OUTCOMES & TAGGING

Course Outcomes		PO	PSO	CL	KC
CO1	Understand the concepts of Image processing	PO1	PSO2	U	C
CO2	Familiarize and implement Histogram equalization in digital images	PO3	PSO7	U, Ap	C, P
CO3	Analyse the working of different filtering methods	PO2	PSO6	U, An	C,P
CO4	Perform image enhancement methods on digital images and evaluate it	PO4	PSO7	U, Ap, E	C, P
CO5	Implement different filtering methods so that the students are able to apply the methods based on applications	PO5	PSO8	Ap, E	C,P
CO6	Understand different color models	PO2	PSO7	U	C
CO7	Familiarize the basics of video processing, video sampling and different methods for 2D motion estimation	PO3	PSO9	U	C, P
CO8	Familiar with different image processing applications in the field of industry, medical imaging, super resolution etc.	PO1	PSO12	U	C, P

(CL- Cognitive Level: R-remember, U-understand, Ap- Apply, An-Analyse, E- Evaluate, Cr- Create, KC - Knowledge Category: F-Factual, C- Conceptual, P-Procedural, M- Metacognitive)

COURSE CONTENT

MODULE I

Steps in Digital Image Processing: Sampling and Quantization- Applications of Image Processing, Intensity Transformation and Spatial Filtering, Intensity Transformation Functions, Piecewise Linear Transformation Functions, Histogram Processing, Histogram Equalization, Histogram Matching, Local Enhancement, Enhancement using Arithmetic and Logic operations, Image Subtraction, Image Averaging.

MODULE II

Spatial Filtering: Smoothening Spatial Filters, Sharpening Spatial Filters, Laplacian Filter, Unsharp masking and High Boost Filter, Gradient operators – Edge detection filters, Filtering in Frequency domain, Frequency Domain Smoothening Filters: Ideal Filter,

Butterworth Filter, Gaussian Filter, Frequency Domain Sharpening Filters, Laplacian in Frequency domain, Homomorphic Filtering.

MODULE III

Image degradation/Restoration process model, Noise probability density functions, Spatial Filtering: Mean Filters, Order-statistics filter, Adaptive Filters, Periodic Noise Reduction – Frequency domain filters: Band-reject filters, Band-pass filters, Notch filters. Estimating the degradation function, Inverse filtering, Wiener filtering, Performance measures.

MODULE IV

Color image processing: Color fundamentals, Color models – RGB, CMYK, HSI, YCbCr, La*b* color spaces. Video Capture and Display, Principles of Color Video Imaging, Analog Video Raster, Analog color television system, Digital Video - Notation, ITU-R BT.601 Digital Video, Other Digital Video Formats and Applications, Video Sampling Rate Conversion, Video Modeling-Camera Models, Pinhole Model, CAHV Model, Camera Motions.

MODULE V

2-D Motion Estimation:Optical flow, General Methodologies, Pixel Based Motion Estimation, Block Matching Algorithm, Mesh based Motion Estimation, Global Motion Estimation, Region based Motion Estimation, Multi resolution motion estimation.

MODULE VI

Applications of Digital image processing: Industry, medical imaging, restoration, Image conversions, Applications of video processing and Motion estimation in video processing.

LEARNING RESOURCES

References

- Gonzalez, Rafael C., "Digital image processing", Pearson education, 2009.
- Wang, Yao, Jörn Ostermann, and Ya-Qin Zhang, "Video processing and communications". Pearson Education, 2002.
- Sonka, Milan, Vaclav Hlavac, and Roger Boyle, "Image processing, analysis, and machine vision", Cengage Learning, 2014.
- Tekalp, A. Murat, "Digital video processing", Prentice Hall India, 2015.
- Jayaraman, S., S. Esakkirajan, and T. Veerakumar. "Digital Image Processing", TMH Publication, 2009

Semester 3	Course Code:CML-DE-537(iii)	Credits: 3

COMPUTATIONAL COGNITIVE SYSTEMS

Preamble: This course is an introduction to computational theories of human cognition. Drawing on formal models from classic and contemporary artificial intelligence, it will explore fundamental issues in human knowledge representation, inductive learning and reasoning. The course will comprise a mixture of lectures and discussions. Readings will include seminal and state-of-the-art research papers from the cognitive, AI, and machine learning literature, textbook chapters and tutorials on technical approaches.

Prerequisite: Foundation in Artificial Intelligence and Knowledge base systems.

COURSE OUTCOMES & TAGGING

	Course Outcomes	PO	PSO	CL	KC
CO1	Understand the mechanisms and concepts of human cognition and their impact on human performance	PO2	PSO7	U, An	C, P
CO2	Generate a keen interest in cognitive science and who expect to pursue a career in human-computer interaction	PO1	PSO4, PSO12	Ap	C, P
CO3	Designed to build systems introducing theories of human cognition and building practical problem-solving skills for real-world applications	PO6	PSO9	An, Ap	C,P
CO4	Explain the different perspectives and methodologies in cognitive science	PO4	PSO8	U, An	P, M
CO5	Illustrate the knowledge Representation of cognitive science and understand categories of mental representation	PO5	PSO11	Ap	P, C
CO6	Describe advantages to using network approach for understanding learning and knowledge representation	PO3	PSO12	U, An	P
CO7	The real-world reasoning with knowledge with characteristic representation by the use of artificial intelligence and machine learning systems	PO6	PSO6, PSO12	Cr, An	P

(CL- Cognitive Level: R-remember, U-understand, Ap- Apply, An-Analyse, E- Evaluate, Cr- Create, KC - Knowledge Category: F-Factual, C- Conceptual, P-Procedural, M- Metacognitive)

COURSE CONTENT

MODULE I

Cognitive Science: Introduction - Representation -Digital Representations -Analog Representations- Propositional Representations- Computation -Tri-Level Hypothesis, Interdisciplinary perspective- Cognitive Approach - Neuroscience Approach- Network approach- Linguistic approach – Artificial Intelligence approach- Categories of Mental Representation - Benefits of Cognitive Science- Issues in Cognitive Science

MODULE II

Rise of Cognitive Psychology: Cognitive Approach: Mind as an Information Processor- Modularity of Mind- Theories of Vision and Pattern Recognition- Template Matching- feature Detection- Computational Theory of Vision- Feature Integration Theory- Broadbent's Filter attention Model- Biederman's Recognition-by-Components - Theory of Pattern Recognition

MODULE III

Cognitive Approach: Memory, Imagery, and Problem Solving- - Neuroscience of Attention- ACT* Model- Evaluating the ACT* Model- Visual Imagery- Problem Solving- General Problem Solver Model- SOAR Model- Neuroscience Perspective- Techniques for the Study of Brain Damage - Brain Recording Techniques- CAT- PET- MRI, Brain Anatomy- Neuroscience of Visual Object Recognition- Neuroscience of Executive Function and Problem Solving

MODULE IV

Network Perspective: Artificial Neural Networks- Characteristics- Back Propagation and Convergent Dynamics- Artificial Neural Network Typologies- Semantic Networks: Meaning in the Web- Hierarchical Semantic Network- Propositional Semantic Networks

MODULE V

Artificial Intelligence and Linguistics: Natural Language Processing- Speech Recognition- Syntactic Analysis- Semantic Analysis- Pragmatic Analysis- Evaluation of Natural Language Processing - Defining Artificial Intelligence, Evaluating the Concept of AI- Strong AI - Applied AI - Cognitive Simulation and Natural Language Communication - AI Methodologies- The Computer as the Tool of AI Research- Evaluation of the Computer as a Model of Brain Organization

MODULE VI

Practical World of Artificial Intelligence: Goals of Practical Machines- Approaches to the Design of Intelligent Agents- Machine Intelligence, Knowledge, and Machine Reasoning- Machine Representation of Knowledge- Cyc Project - Evaluation of the Cyc Project - Objectives of Knowledge Representation - Characteristics of Knowledge Representation- Machine Reasoning -Predicate Calculus - Logical Reasoning (Deduction, Abduction, Induction) - Drawing Inferences - Inductive Reasoning -Evaluation of Rule-Based Reasoning

LEARNING RESOURCES

References

- Friedenberg, J., Silverman, G., Spivey, M. J. , "Cognitive science: an introduction to the study of mind", Sage Publications, 2021
- Kriegeskorte, Nikolaus, and Pamela K. Douglas. "Cognitive computational neuroscience." Nature neuroscience 21.9 (2018): 1148-1160.
- Thagard, Paul., "Mind: Introduction to cognitive science", MIT press, 2005.
- Posner, Michael, "Foundations of cognitive science", MIT press, 1993.

Semester 3	Course Code:CML-DE-537(iv)	Credits: 3

COMPUTATIONAL CREATIVITY

Preamble: Computational Creativity is an emerging subfield of Artificial Intelligence that studies the potential for computers to be more than feature-rich tools and instead to act as autonomous creators and co-creators in their own right. The course will enable students to consider questions concerning the creative capabilities of critical computer systems and the impact of computing on the arts and prepare students to contribute to research in this exciting field.

Prerequisite: Knowledge in basic Artificial Intelligence

COURSE OUTCOMES & TAGGING

Course Outcomes		PO	PSO	CL	KC
CO1	Outline the basic concepts of Computational Creativity	PO2	PSO7	U	C
CO2	Analyse/critique developments in computational creativity like an expert	PO3	PSO8	U, An, Ap	C,P
CO3	Identify problems in addressing creative tasks	PO4	PSO11	U, An	C,P
CO4	Describe about creative machines and creative algorithms	PO1	PSO7	U, An	C,P
CO5	Design, develop, and document creativity tools from ideation to realization	PO3	PSO9	An, Ap	C,P
CO6	Differentiate creative artificial intelligence and architectural intelligence	PO5	PSO8	An	P

(CL- Cognitive Level: R-remember, U-understand, Ap- Apply, An-Analyse, E- Evaluate, Cr- Create, KC - Knowledge Category: F-Factual, C- Conceptual, P-Procedural, M- Metacognitive)

COURSE CONTENT

MODULE I

Computational Creativity: Introduction, Basic concepts, Computers and creativity, computational creativity and human level creativity, building blocks of creativity, Computational creativity frontier, automating creativity.

MODULE II

Casual creator: System as a creative agent, Creative machines, Creative algorithms, creative design process, thinking – lateral and vertical.

MODULE III

Autonomous Systems for Creative Design and Creative Modelling, Information-Processing Theories of Creativity, Computational tools and software–Lyric writing tool.

MODULE IV

Creative Artificial Intelligence: architectural intelligence, Creativity in Swarms – Freedom and Constraint, Weak and strong computational creativity.

MODULE V

Evaluation of computational creativity: Interaction design, creativity in design, creativity in modelling.

MODULE VI

*Application Design:*Machine composed music, CATIA, painting fool, Robot musicians, Computational Creativity and Built Environment Design.

LEARNING RESOURCES

References

- Oliver Bown, Beyond the creative species: Making machines that make art and music, MIT Press, 2021
- Tarek R. Besold, Marco Schorlemmer, Alan Smaill, "Computational Creativity Research: Towards Creative Machines",Atlantis Press, 2014
- Anna Katerina Jordanous, "Evaluating Computational Creativity: A Standardised Procedure for Evaluating Creative Systems and its Application",2012.

Online Resources

- http://doc.gold.ac.uk/aisb50/AISB50-S04/AISB50-S4-McCormack-paper.pdf
- https://gala.gre.ac.uk/id/eprint/21023/7/21023%20AL-RIFAIE_Weak_Strong_Computational_Creativity_%28AAM%29_2014.pdf
- https://www.creativitypost.com/science/what_is_computational_creativity

Semester 3	Course Code: CML-DE-537(v)	Credits: 3

RULE BASED LEARNING

Preamble: Data Mining studies algorithms and computational paradigms that allow computers to find patterns and regularities in databases, perform prediction and forecasting, and improve their performance through interaction with data. This course gives an insight into First Order Logic and how to do data mining by this logic. It is currently regarded as the key elements of a more general process called Knowledge Discovery that deals with extracting useful knowledge from raw data. The knowledge discovery process includes data selection, cleaning, coding, using different statistical and machine learning techniques, and visualization of the generated structures. The course will cover all these issues and illustrate the whole process with examples.

Prerequisite: Machine Learning, Artificial Intelligence and knowledgebase systems.

COURSE OUTCOMES & TAGGING

Course Outcomes		PO	PSO	CL	KC
CO1	Knowledge in Data mining system	PO1	PSO3	U	C, P
CO2	Knowledge in First order logic	PO4	PSO5	U, An	C, P
CO3	Application techniques in ILP	PO3	PSO6	Ap	C ,P
CO4	ILP Learning process in Machine leaning and selected techniques	PO2	PSO7	U, An	P, M
CO5	Knowledge in Rule based learning	PO5	PSO5	U	P, C
CO6	Application of different association learning techniques	PO5	PSO8	Ap	P
CO7	Different association rule mining algorithms and its use	PO4	PSO9	An	C, P
CO8	Real world problems using association rule learning techniques in data mining	PO6	PSO12	Ap, E	C, P

(CL- Cognitive Level: R-remember, U-understand, Ap- Apply, An-Analyse, E- Evaluate, Cr- Create, KC - Knowledge Category: F-Factual, C- Conceptual, P-Procedural, M- Metacognitive)

COURSE CONTENT

MODULE I

Data–Types of Data: Data Mining Functionalities– Interestingness Patterns–Classification of Data Mining systems– Data mining Task primitives –Integration of Data mining, system with a Data warehouse–Major issues in Data Mining–Data Preprocessing.

MODULE II

First Order Logic: Basic Predicate Representations, Conversion of WFF to Clause Form, Resolution, Issues with Resolution, Unification Algorithm.

MODULE III

Inductive Logic Programming: 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, Progol, FOIL, ILP Applications

MODULE IV

Association Rule Learning: (Veridical Algorithms): Concepts and Terminology, Apriori Algorithm - Working Principle, Probabilistic Correlation Algorithm, FP-growth Algorithm-FP Tree Creation, Working Principle, Performance Analysis

MODULEV

Association Rule Learning: (Horizontal Algorithms): Eclat Algorithm, Working Principle, Sparse Eclat, Tertius Algorithm, Treap Mining Algorithm - Priority Procedure, Build Treap Procedure, Performance Analysis

MODULE VI

*Real world problems:*FOL problems, Personalized scheduling, Finite Element Mesh Design, SCADA Database, UNOS Database, Advertisement Mining, Kerala Water Authority database

LEARNING RESOURCES

References

- Jiawei Han andMichelineKamber, "Data Mining – Concepts and Techniques", 3rd Edition Elsevier ,2000
- 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
- Johannes Fürnkranz, Dragan Gamberger, Nada Lavrač, "Foundations of Rule Learning", Springer Berlin Heidelberg, 2012

Semester 3	Course Code: CML-SE-4B3	Credits: 3

PUBLICATION ETHICS AND RESEARCH PRACTICES

Preamble: This course focuses on the basics of the philosophy of science and ethics, research integrity, and publication ethics. Sessions are designed to identify research misconduct and predatory publications. Indexing and citation databases, open-access publications, research metrics (citations, h-index, impact factor, etc.) and plagiarism tools are introduced in this course.

Prerequisite: Nil

COURSE OUTCOMES & TAGGING

Course Outcomes		PO	PSO	CL	KC
CO1	Develop research skills in a student	PO2	PSO2	Ap, An	C
CO2	Provide expertise in writing a research article	PO1	PSO4	Ap	C, P
CO3	Able to compare Copyright, Trademark and Patent	PO3	PSO10	An	C
CO4	Assess the quality of scientific publications	PO4	PSO10	An	C
CO5	Identify whether a journal is indexed in WoS and Scopus	PO5	PSO1	U, An	C, P
CO6	Understand the best practices followed for performing research	PO4	PSO2	U, Ap	C
CO7	Analyse the publication ethics practiced in research	PO2	PSO11	An	C

(CL- Cognitive Level: R-remember, U-understand, Ap- Apply, An-Analyse, E- Evaluate, Cr- Create, KC - Knowledge Category: F-Factual, C- Conceptual, P-Procedural, M- Metacognitive)

COURSE CONTENT

MODULE I

Research Skills: Introduction, Research Process, how to read a research paper? Steps to perform Literature Review- Structure of Research Report, Layout of Research paper, Mechanism of writing a research Thesis, IMRAD format

MODULE II

*Article level Metrics:*H-index- i10- index- g index- Altmetrics - Google Scholar- Journal Level Metrics- Impact factor- SCImago Journal ranking, Scientometrics -Citations- ORCID ID, Journal Citation Report, SNIP, SJR, Cite Score.

MODULE III

Indexing Databases: Citation databases- Web of Science, Scopus. Intellectual Property Rights- Copyrights, Trademarks and Patents, IPR Laws. Creative commons licenses. Digital Object

Identifier (DOI), Journal - ISSN. Referencing styles- IEEE, Vancover, APA style

MODULE IV

Publication Ethics: Committee on Publication Ethics (COPE)- Predatory publishers and journals. Scientific Conduct: Intellectual honesty and research integrity - Scientific misconducts: Falsification, Fabrication and Plagiarism (FFP)- Redundant publications: duplicate and overlapping publications.

MODULE V

*Best Practice in Scholarly Publishing:*Directory of Open Access Journals (DOAJ), the Open Access Scholarly Publishing Association (OASPA), Publication: Steps for publication- Paper Publication Process- Peer Review Process- Open Access publications.

MODULE VI

Prepare References using reference management software including Mendeley, Zotero. Plagiarism Checking software including Turnitin, Urkund. Publication: Steps for publication- Paper Publication Process– Prepare documents with creative common licences. Identify whether a journal is indexed in WoS and Scopus.

LEARNING RESOURCES

References

- Kara, Helen. "Research ethics in the real world". Bristol: Policy Press, 2018.
- Sismondo, Sergio, and Mathieu Doucet. "Publication ethics and the ghost management of medical publication." Bioethics, 2010
- Paneerselvam. R, "Research Methodology", 2ed., PHI, 2014
- Vinod Chandra S S, Anand H S, "Research Methodology", Pearson Education, 2017
- Santhosh Kumar Yadav, Research and Publication Ethics, Ane Books 2020
- Beisiegel, Ulrike. "Research integrity and publication ethics." Atherosclerosis, 2010

Semester 3	Course Code: CML-SE-4B4	Credits: 2

MASSIVE ONLINE OPEN COURSE (MOOC)

Preamble: MOOCs enable access to quality education for as many students as possible and contribute to the continuous education of various social groups. MOOCs can be addressed to the unemployed, helping them develop skills needed for employability.

Prerequisite: Nil

COURSE CONTENT

Massive Open Online Courses (MOOCs) are free online courses for anyone to enroll. MOOCs provide an affordable and flexible way to learn new skills, advance your career and deliver quality educational experiences at scale. Millions of people worldwide use MOOCs to learn for various reasons, including career development, changing careers, college preparations, supplemental learning, lifelong learning, corporate eLearning and training, and more. For instance, SWAYAM provides an integrated platform for online courses, using information and communicationtechnology (ICT) and covering courses for post-graduate subjects, including skill sector courses, to ensure that every student benefits from learning material through ICT.

The Department Council will announce the sources of MOOC at the time of the semester beginning. Students can choose their course from MOOC as per their choice and inform the course coordinator before they join. Each student must submit a report on what MOOC has completed during their M Sc programme to complete their Semester III.

LEARNING RESOURCES

On-line Sources

- https://www.ugc.gov.in/pdfnews/8449573_Intruction-Manual.pdf

Semester 4	Course Code: CML-CC-541	Credits: 18

DISSERTATION AND VIVA VOCE

Preamble: The case study and dissertation are sequentially ordered, where the studies conducted in the initial course can be exploited further in the later. The course aims to equip the students to understand high standard research publications and construct research questions that can be empirically addressed during the study. In addition, the students should understand the purposes, assumptions, and logic inherent in research methodologies. The experimentally evaluated studies should be documented systematically in the form of a dissertation, and it will help the students to prepare their own research publications in later stages.The objectives are:

1. To analyse the practical knowledge for solving a research-oriented problem.
2. To enable the students to experience the method of solving real-life problems under the guidance of a supervisor.
3. To prepare the students for the demand of national/international organizations.
4. To train the students in scientific approaches in solution formulation and result analysis.
5. Develop technical document writing and presentation skills.
6. Inculcate the spirit of collaborative work and time management.

Prerequisite: CML-CC-535-Case study,Strong foundation of Machine Learning and AI Techniques

COURSE OUTCOMES & TAGGING

Course Outcomes		PO	PSO	CL	KC
CO1	Investigate the related and recent works in the area of dissertation	PO2	PSO4	U, An	C
CO2	Apply critical thinking and design new strategies for the work	PO1	PSO5	Ap	C, P
CO3	Implement and analyse the performance of the new method	PO3	PSO10	An	C
CO4	Propose a new algorithm or design in the area of study	PO4	PSO11	An, Ap	C
CO5	Prepare a dissertation on the work done in the prescribed format	PO5	PSO12	U, An, Ap	C, P
CO6	Presentation on the entire work done as part of the course	PO4	PSO2	U, Ap	C

(CL- Cognitive Level: R-remember, U-understand, Ap- Apply, An-Analyse, E- Evaluate, Cr- Create,
KC - Knowledge Category: F-Factual, C- Conceptual, P-Procedural, M- Metacognitive)

COURSE CONTENT

This programme will equip the student with a skillset on Machine learning techniques. The courses up to the last semesters will give a comprehensive perspective of the theories and concepts of Machine learning methods. The case study and dissertation are sequentially

pipelined to conduct continuous studies through experiments in a particular area of research. An enthusiastic student can critically evaluate methods and design experiments to evaluate them further for possible contributions. The supervisor will assist the student throughout the course to properly study the problem, design and evaluation the experiments. The finding of the studies should be documented in the form of a dissertation with all the components of a typical research document focusing on the literature reviews, understanding concepts, defining research problems and methods, collecting and analysing data, experimental evaluation and communicating the findings. Students are expected to

- Perform an in-depth study of the topic assigned in light of the detailed study in Semester III.
- Prepare the problem statement with proper objectives with the help of the supervisor.
- Prepare a detailed action plan for conducting the investigation, process flow and design.
- Perform detailed analysis/ modelling/ simulation/ design/ problem solving/ experiment as needed.
- Evaluate and fine-tune the model with proper enhancements and modifications.
- Analyse the outcome of the experiments and studies, and validate with the objectives targeted.
- Prepare the list of achievements and challenges of the studies.
- Plan for a research publication by exploiting the findings of the experiments.
- Prepare a dissertation of the work in the standard format for being evaluated by the External Assessment.
- Present the work precisely and concisely in front of the panel at the evaluation.

The assessment of the course will be carried out in two phases - continuous assessment and end-semester examination. Apart from the continuous monitoring by the respective supervisor, the continuous assessment will consist of two presentations in front of the panel of teachers. The first internal presentation will be carried out in the midst of the semester, which will evaluate the progress and feasibility of the proposal. The second internal presentation will be conducted before preparing for the final presentation. Students have to incorporate the recommendations of the panel while preparing the final dissertation and presentation. A panel chaired by the Head of the Department will conduct the end-semester examination. In addition to the external expert, the supervisor will be a mandatory panel member. The marks will be awarded in the continuous evaluation and end-semester examination in a 40:60 ratio. The assessment will be on the basis of Content (40), Methodology (30), Presentation (20), and Viva(10); where the figure in bracket represents the maximum % of grades that can be awarded in each category. In the internal evaluation, the criteria content will be awarded by the respective supervisor based on the continuous monitoring of the work and dissertation, and others by the panel of teachers.

Semester 3	Course Code: CML-SE-4B4	Credits: 2

INDUSTRY INTERNSHIP

Preamble: The Internship course provides students with the opportunity to intern in the professional setting of a company, and help develop their abilities as a professional.

Prerequisite: Nil

COURSE OUTCOMES & TAGGING

Course Outcomes		PO	PSO	CL	KC
CO1	Apply classroom and laboratory concepts and principles in an industry work environment.	PO2	PSO2	U, Ap	C,P
CO2	Establish goals by working with supervision to define work objectives for the internship experience	PO1	PSO5	An,Ap	C, P
CO3	Demonstrate time and project management skills by completing the objectives within the time limits	PO3	PSO10	An	P
CO4	Demonstrate the ability to work as a team member to successfully complete the assigned work objectives in an assigned company work group.	PO4	PSO11	An, Ap	P
CO5	Demonstrate effectively the ideas and solutions in the context of written, oral, and electronic media.	PO5	PSO12	U, An, Ap	C, P
CO6	Demonstrate and promote a proper work ethic.	PO4	PSO11	U, Ap	P

(CL- Cognitive Level: R-remember, U-understand, Ap- Apply, An-Analyse, E- Evaluate, Cr- Create,
KC - Knowledge Category: F-Factual, C- Conceptual, P-Procedural, M- Metacognitive)

COURSE CONTENT

Internships are educational and career development opportunities, providing practical experience in a field or discipline. They are structured, short-term, supervised placements focused on particular tasks or projects with defined timescales. An internship may be compensated, non-compensated, or sometimes may be paid. The internship has to be meaningful and mutually beneficial to the intern and the organization. The internship program's objectives and activities must be clearly defined and understood. The following are the intended objectives of internship training:

- Will expose students to the industrial environment, which cannot be simulated in the classroom, creating competent professionals for the industry.
- Provide possible opportunities to learn, understand and sharpen the real-time technical/managerial skills required on the job.
- Exposure to the current technological developments relevant to the subject area of training.
- Experience gained from the 'Industrial Internship' in the classroom will be used in classroom discussions.
- Create conditions conducive to the quest for knowledge and its applicability on the job.

LEARNING RESOURCES

On-line Sources

https://aicte-india.org/sites/default/files/AICTE%20Internship%20Policy.pdf