Learning Outcomes-based Curriculum Framework (LOCF) for
Post-Graduate Programme

M.Sc Computer Science
Specialization in Artificial Intelligence

Department of Computer Science
University of Kerala

www.keralauniversity.ac.in

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Preamble

The role of higher education, apart from living as the best human, is to direct the learners to their desired objectives, either to the dream job or a world-class higher education avenue. Therefore, the improvement in the quality of higher education deserves to be given top-most priority to enable the young generation of students to acquire skills, training and knowledge. The education institute has to plan sustained initiatives to improve and upgrade the academic resources and learning environments by enhancing the quality of teaching to achieve learning outcomes.

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 Ph.D 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 (Artificial Intelligence)

Artificial Intelligence (AI) is increasingly important in the developments in all parts of business and society. Department of Computer Science, University of Kerala has been doing active research in Machine Learning and Intelligent Systems, and AI related modules. M.Sc. Computer Science (with specialization in Artificial Intelligence) Programme intends to provide specialist skills in artificial intelligence, opening the door to a range of careers for students. Students will develop strong theoretical and technical knowledge, and skills including a thorough grounding in machine learning and specialist skills in artificial intelligence, which will provide the directly transferable skills for a career in the field of AI.

AI plays a major role in shaping the future education. AI is expected to have an enormous impact in addressing many of the greatest societal challenges that face us today. It is expected that it will improve the quality of life of citizens of all kind. In addition, it will contribute greatly to increasing industrial competitiveness across all sectors, including small and medium-sized enterprises and non-tech industries. India is developing to be a leading edge in AI and its allied fields. This strong expertise is also reflected in the level of investment in India from world-leading companies, either in existing laboratories or in creating new major R&D laboratories. In addition, India has an exciting start-up landscape through which AI resources are scattered.

Therefore, in order to fully exploit the potential of AI for the benefit of society, it is essential to start a programme that will satisfy the need of society and industry. The deep investigation into state-of-the-art technologies, concepts and theories, supported by thriving active research projects are the major objectives of this programme. Focus of the programme are AI concepts, Machine Learning, Data Analytics and interdisciplinary areas such as Blockchain, Agent technology, Robotics and Deep learning. The students should be able to develop specialist knowledge and experience in the development of Artificial Intelligent Systems and solve and automate the projects/ case studies based on AI concepts and methods.

3. General Information

3.1 Eligibility for Admission

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

Relaxation for candidates from SC/ST category shall be as follows:

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

Other relaxations and reservation of seats will be according to the University orders in accordance with the Government decisions and orders.

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 (Artificial Intelligence) 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. Acquire knowledge in AI algorithms, technologies and methodologies, and understand how these are designed, developed and optimised for the AI systems.
2. Comprehend fundamental concepts and hands-on knowledge of state-of-the-art AI methodologies.
3. Conceive, Design and Develop intelligent multi-modal multi-sensory Man-Machine interfaces.
4. Build scalable machine learning technologies, and optimise them for structured and unstructured data (e.g., speech, text, images/videos)
5. Understand and assess the reliability, dependability and trustworthiness of AI - based systems.
6. Design and develop AI 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.
9. Provide a comprehensive environment for career development, innovation and higher studies.

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 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 the society.
5. Develop application skillset in algorithm design, optimisation, and improved performance in computing.
6. Develop advanced knowledge for AI 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 fresher, which includes a wide range of activities right, from workshops, lectures and seminars to sports tournaments, social works and much more. The Programme is designed to equip the 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 technical knowledge and standards.

4. Programme Structure

Every course of M.Sc. Computer Science (Artificial Intelligence) 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: CAI

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 practicals. 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.

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

Dissertation: The Dissertation (Project work) is intended to challenge students' intellectual and innovative abilities. It allows students to synthesise 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.

Industry 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.

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	The basic theoretical understandings of machine learning, natural language processing, and computer vision, and their state-of-the-art system architectures.
PSO2	The possession of excellent skills in the design and implementation of Artificial intelligence systems with the help of Machine Learning and AI technologies.
PSO3	Concrete theoretical foundations in Artificial Intelligence and allied areas to enrich their abilities for employment or research in R&D institutions.
PSO4	The ability to understand, analyze and demonstrate the knowledge of human cognition, Knowledge, Artificial Intelligence, Machine Learning and data analysis to meet the challenges to intelligently solve real-life problems.
PSO5	The ability to convert descriptions of abstract AI challenges into descriptions of specific AI project requirements.
PSO6	The ability to validate the performance and fine tune the AI based models.
PSO7	Capability to demonstrate the theoretical background and working of AI based systems like agents and expert systems taking some sample use cases.
PSO8	The ability to understand standard research publications in AI and ML, design and write the works scientifically for publishing.
PSO9	The knowledge in natural language processing and their advancements with the help of new generation ML methods so that capable of tracing the developments in NLP and information processing.
PSO10	Practical knowledge of the basic theoretical concepts of AI and ML either in the form of working case studies or hands own exercises.
PSO11	The ability to understand the theoretical basics of the scientific process of designing machines that are capable of performing human-like thinking and inductive decision-making.
PSO12	Talent to understand the basics of different computational techniques and thereby find solutions and design optimized algorithms to improve computing performance

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)**		
	CAI-CC-511	Mathematical Foundations of Artificial Intelligence	3
	CAI-CC-512	Algorithms- Complexity and Optimization	3
	CAI-CC-513	Principles and Ethics of Artificial Intelligence	3
	CAI-CC-514	Principles of Computing	3
	CAI-CC-515	Knowledge Representation and Reasoning	3
	CAI-CC-516	Theory of Computing Laboratory	3
	Skill Enhancement Elective (SE)		
	CAI-SE-4B1	Entrepreneurship and Professional Development	2
II	**Core courses (CC)**		
	CAI-CC-521	Artificial Intelligence Systems Engineering	3
	CAI-CC-522	Database Systems for Big Data	3
	CAI-CC-523	Machine Vision and Pattern Recognition	3
	CAI-CC-524	Pattern Recognition Laboratory	3
	Discipline Specific Electives (DE)		
	CAI-DE-525(i)	Block Chain Technology	3
	CAI-DE-525(ii)	Internet of Everything	3
	CAI-DE-525(iii)	Cyber Security and Cyber Law	3
	CAI-DE-525(iv)	Statistical Learning Techniques	3
	CAI-DE-525(v)	Data Mining and Text Analytics	3
	CAI-DE-526(i)	Computational Biology	3
	CAI-DE-526(ii)	Learning Models for Intelligent System	3
	CAI-DE-526(iii)	Reinforcement Learning	3
	CAI-DE-526(iv)	Expert Systems in Automation	3
	CAI-DE-526(v)	Social Network Analysis	3
	Skill Enhancement Elective (SE)		
	CAI-SE-4B2	IT Act and Constitution of India	2
III	**Core courses (CC)**		
	CAI-CC-531	Computational Cognitive Systems	3
	CAI-CC-532	Applied Machine Learning	3
	CAI-CC-533	Accelerated Natural Language Processing	3
	CAI-CC-534	Machine Interaction Laboratory	3
	CAI-CC-535	Case Study	2
	Discipline Specific Electives (DE)		
	CAI-DE-536(i)	Foundation in Robotics	3
	CAI-DE-536(ii)	Game Theory and Applications	3
	CAI-DE-536(iii)	Speech Processing and Recognition	3
	CAI-DE-536(iv)	Nature Inspired Computing	3
	CAI-DE-536(v)	Intelligent Information Retrieval	3

	CAI-DE-537(i)	AI Planning	3
	CAI-DE-537(ii)	Methods for Causal Inference	3
	CAI-DE-537(iii)	Deep Architectures	3
	CAI-DE-537(iv)	Computational Creativity	3
	CAI-DE-537(v)	Evaluation of AI systems	3
	Skill Enhancement Elective (SE)		
	CAI-SE-4B3	Publication Ethics and Research Practices	2
	CAI-SE-4B4	MOOC	2
	Generic Course		
	CAI-GC-4B1	Artificial Intelligence and Daily Life	2
IV	**Core Courses (CC)**		
	CAI-CC-541	Dissertation and Viva-Voce	18
	Skill Enhancement Elective (SE)		
	CAI-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: CAI-CC-511	Credits: 3

MATHEMATICAL FOUNDATIONS OF ARTIFICIAL INTELLIGENCE

Preamble: This course introduces a set of mathematical concepts through which the fundamental theories of Artificial Intelligence have developed. The focus is given to various matrix manipulation methods and statistical models commonly used to evolve many AI algorithms. Topics such as linear equations, matrix rank, subspaces, regression, regularization, singular value decomposition, and iterative optimization algorithms are essential and the basis of several well-known strategies in AI methods.

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

COURSE OUTCOMES & TAGGING

Course Outcomes		PO	PSO	CL	KC
CO1	Solve general linear algebra problems and apply rules to manipulate vectors	PO2	PSO, PSO2	U, Ap	C, P
CO2	Perform matrix arithmetic and advanced operations involving matrices	PO3	PSO4, PSO7	U, Ap	C, P
CO3	Familiarize with matrix factorization methods including Eigen decomposition and singular value decomposition	PO4	PSO4, PSO8	An, Ap	C, P
CO4	Implement functions using linear algebra tools such as PCA	PO1	PSO4, PSO11	Ap	P
CO5	Apply the relevance of random variables and probability distributions in solving automated and logical reasoning	PO5	PSO2, PSO4	Ap	P, C
CO6	Apply mathematical concepts to solve linear regression and Parameterization	PO2	PSO4, PSO6	An	C, P
CO7	Familiarize types of logic: Propositional Calculus and Predicate logic	PO1	PSO4, PSO11	Ap	P, C
CO8	Explore the concepts of Information theory	PO3	PSO1, PSO 3	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 their operations, cosine similarity, orthogonal vectors. Review of vector norms, Vector space and basis, Linear Equations, Linear Dependence and Independence, Bases and dimensions.

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.
- Härdle, Wolfgang Karl, and Léopold Simar, "Applied Multivariate Statistical Analysis", Springer, 2015.
- 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-33342.pdf

Semester: 1	Course Code: CAI-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 proficiency 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	PSO8	An	C, P
CO3	Knowledge of greedy algorithms with MST	PO4	PSO3, PSO4	U, Ap	C, P
CO4	Prioritize the knowledge of advanced search and heuristic search techniques	PO3	PSO6	U, An	P, M
CO5	Discuss P and NP- class problems	PO2	PSO5	U	P, C
CO6	Articulate optimization 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: CAI-CC-513	Credits: 3

PRINCIPLES AND ETHICS OF ARTIFICIAL INTELLIGENCE

Preamble: Artificial Intelligence is going to drive our society. An immense collection of technologies and AI applications are coming from R&D institutions to support the daily and regular routine of individuals and organizations. In this context, the content of this particular course has been designed to create an awareness of the principles and ethics while you are thinking about designing an application or technique with the help of AI. The things which are done by a human being and sometimes beyond that can be possible with AI, so understanding the challenges, principles, and ethics are unavoidable.

Prerequisite: Students are supposed to have a basic idea about the working and services provided by different AI applications in the market.

COURSE OUTCOMES & TAGGING

Course Outcomes		PO	PSO	CL	KC
CO1	Familiarize the stages of development and various applications with AI	PO1	PSO2	U	C, P
CO2	Identify the harms that can be caused by AI applications.	PO4	PSO2	U, Ap	C
CO3	Explore the scope of moral values in designing scientific inventions.	PO6	PSO11	An, Ap	C, P
CO4	Differentiate the role of ethics and moral values in AI.	PO6	PSO11	U	P
CO5	Debate on the hurdles of framing stringent rules for AI developments.	PO6	PSO8	An	P, C
CO6	Elaborate on the importance of Professional Ethics	PO5	PSO2	An	C, P
CO7	Appraise the importance of transparency in the solutions	PO5	PSO2, PSO11	Ap	P, C
CO8	Propose an AI product that can critically consider the importance of ethical issues that can be occurred	PO5	PSO8	Cr	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

Introductory note on Artificial Intelligence, Timelines of Artificial Intelligence, Branches of Artificial Intelligence, Applications of Artificial Intelligence. Potential Harms Caused by AI Systems, Intellectual Background of AI.

MODULE II

Artificial Intelligence and Ethics-need of Ethics in AI, Codes of Ethics, Epistemic Strategies: Precision and the Reduction of Uncertainty, Technological Strategies to Ensure Safe and Beneficial AI, Moral Strategies in the Pursuit of Beneficial AI. Understand About Ethics- Ethics Is Not About 'Banning' Things, Normative Ethical Theories, Ethics and Empirical Evidence, Objective of Moral Concerns.

MODULE III

Four Domains of Ethics: Self, Friend, Stranger, World. Autonomy & Responsibility, Singularity, Machine Ethics, Moral Knowledge, Elimination of 'Bias', Moral Relativism, Moral Justification and AI, Moral Agents, Moral Motivation, AI-Codes of Ethics and the Law. Impacts of AI Hype on Moral Thinking,

MODULE IV

AI Challenges and Professional Ethics, AI Professional Organisations & Companies and Development and Production, Third Layer of Complexity in Codes for AI: The Behaviour of Machines. Building Ethics into AI and the Idealisation of Moral Agency, Replacing and Enhancing Human Agency, Boundaries and AI, Addressing the Increased Gradient of Vulnerability, Miscommunication and the Search for Clarity

MODULE V

SUM Values, FAST Track Principles-Fairness, Accountability, Sustainability, Safety, Transparency, Process transparency-Establishing a Process-Based Governance Framework, Outcome transparency-Explaining outcomes, clarifying content, implementing responsibility

MODULE VI

Case study on Ethical principles of artificial intelligence for health-principles of artificial intelligence for health- Protect autonomy, Promote human well-being, human safety and the public interest, Ensure transparency, explainability and intelligibility, Foster responsibility and accountability, Ensure inclusiveness and equity, Promote artificial intelligence that is responsive and sustainable; health-Laws, policies and principles, Ethical challenges to use of artificial intelligence for health care.

LEARNING RESOURCES

References

- Boddington, P. (2017). Towards a Code of Ethics for Artificial Intelligence. Germany: Springer International Publishing.
- World Health Organization. Ethics and governance of artificial intelligence for health: WHO guidance, 2021.
- Leslie, David. Understanding artificial intelligence ethics and safety. arXiv preprint arXiv:1906.05684, 2019.
- Rodrigues, R., Stahl, B. C., Schroeder, D. (2022). Ethics of Artificial Intelligence: Case Studies and Options for Addressing Ethical Challenges. Germany: Springer International Publishing.
- Müller, Vincent C. (forthcoming 2021), "Ethics of artificial intelligence", in Anthony Elliott (ed.), The Routledge social science handbook of AI (London: Routledge), http://www.sophia.de & http://orcid.org/0000-0002-4144-4957

Online Resources

- https://www.europarl.europa.eu/RegData/etudes/STUD/2020/634452/EPRS_STU(2020)634452_EN.pdf

Semester: 1	Course Code: CAI-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	PSO11	U	C
CO2	Understand and Construct NFA, DFA, and minimal DFA	PO3	PSO11, PSO12	U, Ap	C, P
CO3	Identify Context-Free Grammar and construct equivalent push-down automata	PO2	PSO12	An, Ap	C, P
CO4	Illustrate the working of different Turing machines	PO4	PSO11, PSO12	Ap	P
CO5	Discuss the different types of computability problems	PO5	PSO12	U	C
CO6	Apply and Analyze the applications of computing principles	PO2	PSO12	Ap, An	C, P
CO7	Familiarizing students with regular language and regular expressions	PO1	PSO11	U	C
CO8	Apply and Analyze the applications of computing principles	PO3	PSO11, PSO12	U, 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: 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.

MODULE V

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: CAI-CC-515	Credits: 3

KNOWLEDGE REPRESENTATION AND REASONING

Preamble: Knowledge acquisition and management is one of the critical phases in the artificial intelligence system design. The effectiveness of the AI-based system will depend on the systematic approach to knowledge management. This course is designed to introduce the different strategies to represent knowledge in AI systems. The different knowledge representation and manipulation strategies are introduced through the working of agents and expert systems.

Prerequisite: Probability and Statistics.

COURSE OUTCOMES & TAGGING

Course Outcomes		PO	PSO	CL	KC
CO1	Discuss Artificial Intelligence including topics, branches, and applications.	PO1	PSO1	U	F
CO2	Explain the significance of intelligent agents in Artificial Intelligence.	PO1	PSO1, PSO11	U	C, F, P
CO3	Discuss knowledge representation and its structures.	PO1	PSO1	U	C ,P
CO4	Compare different reasoning methods and Bayesian networks.	PO5	PSO11, PSO12	An	C, P
CO5	Compare different association rule mining algorithms.	PO5	PSO12	U	C ,P
CO6	Illustrate how Artificial Intelligence works in Gaming applications (basics only).	PO3	PSO3	A	P
CO7	Explain the principles, components, operations of Expert Systems.	PO1	PSO11	U	C ,P
CO8	Explain the working of typical agents and expert systems.	PO5	PSO11	U	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

Topics of Artificial Intelligence, – Intelligent agents - structure, types of agents, environment, autonomous agents. Problem Solving - Production Systems, State space representation.

MODULE II

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

MODULE III

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

MODULE IV

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

MODULE V

Expert systems - characteristics, components. Expert system development, knowledge engineering, application of expert systems.

MODULE VI

Case study on Agents: architecture and working of any agents. Bayes rule and Applications. Case studies in expert systems-architecture and working of MYCINE.

LEARNING RESOURCES

References

- Kalyanmoy Deb, "Optimization for Engineering Design, Algorithms and Examples" - Prentice Hall of India, New Delhi, 2012
- Stuart Russell and Peter Norvig - "Artificial Intelligence: A Modern Approach", 3rd Edition Pearson, Chennai, 2015
- Thomas H. Corman, Charles E. Leiserson and Ronald L. Rivest - "Introduction to Algorithms", 3rd Eed., Prentice Hall of India, New Delhi, 2009
- Vinod Chandra S S, Anand H S - "Artificial Intelligence: Principles and Applications", Prentice Hall of India, New Delhi, 2020

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

THEORY OF COMPUTING LABORATORY

Preamble: This course aims to implement some of the computational concepts studied in this semester to strengthen the theoretical knowledge acquired in the classroom. According to your proficiency, any programming language can be used in the laboratory. But we prefer to encourage the use of Python language. The list of exercises will start with the basic programming problems you have covered in the degree programs. A detailed list of exercises will be provided as part of the semester plan at the start of the semester.

Prerequisite: Programming with data structures, Algebra

COURSE OUTCOMES & TAGGING

Course Outcomes		PO	PSO	CL	KC
CO1	Rewind and refresh the problem solving along with the implementation of basic data structures	PO5	PSO2	Cr, U	C, P
CO2	Experiment with different algorithm design methodologies and identify the characteristics of each.	PO5	PSO12	Ap, An	M,P
CO3	Implement the basic and advanced functions and techniques with vectors and matrices.	PO5	PSO12	Ap, Cr	P,M
CO4	Implement and analyse the complexity of the algorithms	PO5	PSO12	Ap, An	P
CO5	Implement various algorithm design strategies such as divide and conquer, Greedy, Dynamic programming, branch and bound, backtracking etc.	PO5	PSO12	Cr	P
CO6	Implement and feel how the regular expressions and working with string searching and matching.	PO5	PSO12	E, Cr	P
CO7	Implement various graph algorithms and differentiate the searching and traversal methods	PO2	PSO12	E, Cr	P,M
CO8	Formulate the different tree structures formed in between the compiling process.	PO1	PSO12	Ap, Cr	P
CO9	Understand the differences between NFA and DFA through implementing those effectively.	PO5	PSO12	E, Cr	P,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

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 set of experiments in each cycle.

Warmup Cycle

- Experiments that cover the use of functions/modules, basic data structures, file operations, linked lists etc.

Numerical Methods Cycle

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

Algorithms and Complexity Cycle

- Problems in Greedy Strategy
- Exercises in Graph Searching and traversal
- Exercise from Tractable and Intractable Problems

Language and Automata Cycle

- Problems related to regular expression and strings
- Exercises in Syntax and semantic tree
- Problems associated with NFA to DFA conversion

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 the 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 and countersigned by the Course coordinator.

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

ENTREPRENEURSHIP AND PROFESSIONAL DEVELOPMENT

Preamble: This programme aims to inspire students and help them imbibe an entrepreneurial mind set. 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	PSO1	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	PSO3, PSO4	Ap	C, P
CO3	Possess professional skills including learning skills and career skills	PO4	PSO3	U, Ap	C, P
CO4	Provide critical thinking process within students	PO4	PSO11	Ap	P, M
CO5	Inculcate the soft skills competence in prospective students	PO2	PSO7, PSO3	App	P, C
CO6	Equip the students to face interviews Group Discussion	PO4	PSO12	Ap, An, E	P
CO7	Able to work in Group and Teams	PO6	PSO10	Ap	C, P
CO8	Prepare the students to become an entrepreneur	PO1	PSO4	Ap, E	C, P
CO9	Promote Brain Storming and Idea Generation to solve real life problems	PO2	PSO4, PSO12	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: CAI-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 concept.

COURSE OUTCOMES & TAGGING

Course Outcomes		PO	PSO	CL	KC
CO1	Compare Procedural Programming and Object Oriented Programming	PO4	PSO5	U, Ap	C
CO2	Illustrate the steps in object oriented systems development life cycle	PO3	PSO11	U, An	P
CO3	Understand the principles of agile software development	PO2	PSO3	U	C,P
CO4	Explain the steps in story boarding	PO1	PSO4	U, R	P
CO5	Able to comprehend Machine Learning Operations (MLOps)	PO3	PSO1	A	P,C
CO6	Possess the ability to explore the open challenges for MLOps	PO5	PSO10	An	C
CO7	Illustrate the process of MLOps architecture and workflow	PO2	PSO10	An, Ap	P, C
CO8	Demonstrate the skill set to design UML diagrams for real world applications	PO2	PSO2	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: 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.

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 stations, 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: CAI-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, emphasise 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	PSO3	U	F, C
CO2	Discuss Hadoop technology, features, and Hadoop core components	PO1	PSO6	U, An	C, P
CO3	Explain in detail about Hadoop file system- HDFS and Mapreduce framework	PO4	PSO10	An, Ap	C, P
CO4	Describe the architecture and working of YARN and HBase	PO5	PSO4	An, Ap	C, P
CO5	Discuss NoSQL data store, architecture and its advantages	PO2	PSO3	An, Ap	C, P
CO6	Explain the use of MongoDB and implement its basic commands- CRUD operations	PO3	PSO4	An, Ap	C, P
CO7	Apply big data technologies in various application areas including Uber and Google	PO6	PSO3	Cr, 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: 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, the 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: Schemaless 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: CAI-CC-523	Credits: 3

MACHINE VISION AND PATTERN RECOGNITION

Preamble: The course aims to provide students with detailed knowledge of how Machine Learning methods work and how statistical models can be brought to bear in computer systems. The analysis of large data sets and to let computers perform tasks that traditional computer science methods are addressed. Examples range from speech recognition and text analysis through bioinformatics and medical diagnosis. This course first introduces the statistical methods and mathematical concepts that make such technologies possible.

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	PO1	PSO1, PSO2	Ap	C,P
CO2	Illustrate the skillset to solve real life problems using machine vision and pattern recognition	PO3	PSO4, PSO8	An, Ev	C, P
CO3	Implement basic image and computer vision algorithms.	PO4	PSO10	Ap, An, Ev	C, P
CO4	Summarize different texture, colour-based feature extraction methods used for computer vision	PO5	PSO3	U, Ap	C, P
CO5	Perform experiments to demonstrate the skill to develop vision based algorithms	PO2	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 the 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 IV

Image Feature Extraction- Texture Descriptors - Local Binary Pattern- GLCM, Edge Density and Direction – Feature Matching – 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

- JDuda, Richard O., Peter E. Hart, and David G. Stork. Pattern classification. 2nd ed. New York, NY: Wiley, 2001. ISBN: 0471056693.
- Mallot, Hanspeter A. Computational Vision: Information Processing in Perception and Visual Behavior. Translated by John S. Allen. Cambridge, MA: MIT Press, 2000. ISBN: 0262133814.
- Forsyth, David A., and Jean Ponce. Computer Vision: a Modern Approach. Upper Saddle River, NJ: Prentice Hall, 2003. ISBN: 0130851981.
- Hastie, Trevor, Robert Tibshirani, and Jerome Friedman. The Elements of Statistical Learning: Data Mining, Inference, and Prediction: with 200 full-color illustrations. New York, NY: Springer, c2001. ISBN: 0387952845.
- Stockman, G., & Shapiro, L. G. (2001). Computer vision. Prentice Hall PTR.

Semester: 1	Course Code: CAI-CC-524	Credits: 3

PATTERN RECOGNITION LABORATORY

Preamble: This course aims to implement various methods and techniques that you studied in the pattern recognition course. Through this course, the theoretical knowledge acquired in the classroom will be strengthened through visualizing the concepts. It will be better to use Python language to do the exercises. The list of exercises will start with the basic pre-processing methods in digital images, and the exercises in the later cycles are planned to use machine learning methods in pattern recognition. A detailed list of exercises will be provided as part of the semester plan at the start of the semester.

Prerequisite: Python programming, Basic theoretical understanding of image processing and machine learning

COURSE OUTCOMES & TAGGING

Course Outcomes		PO	PSO	CL	KC
CO1	Design, Implement and apply pattern recognition techniques based on real world problems	PO5	PSO2 PSO4	Ap, E	M
CO2	Differentiate the working of types of machine learning algorithms	PO5	PSO12 PSO10	An, Cr	P
CO3	Design and program efficient algorithms related to recent machine learning techniques, train models, conduct experiments, and solve complex problems	PO5	PSO4 PSO10	Ap, Cr	P
CO4	Apply mathematical and statistical techniques used in pattern recognition	PO5	PSO4 PSO8	Ap, E	M
CO5	Impart ability to choose appropriate datasets for learning algorithms	PO5	PSO2 PSO6	An, E	M
CO6	Demonstrate the working of Regression, K-NN, SVM, Naïve Bayes Classifier, Decision Tree through hands-on experiments	PO5	PSO2 PSO4	Ap, E	P
CO7	Implement the clustering algorithms K- Means, Single Linkage and Complete Linkage Clustering to differentiate their working	PO2	PSO2 PSO4	Ap ,E	P
CO8	Design an Artificial Neural Network with backpropagation for solving real life problems	PO1	PSO11 PSO12	Ap, E, Cr	P
CO9	Analyse the importance of Dimensionality reduction using PCA, LDA	PO5	PSO2 PSO5	Ap, 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

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 set of experiments in each cycle.

Image Processing Cycle

- Basic preprocessing methods
- Edge manipulation methods
- Images in the frequency domain

Computer Vision Cycle

- Segmentation and Object Detection methods
- Image Feature Extraction Strategies
- Feature selection and similar methods

Unsupervised Machine Learning Cycle

- 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.

Supervised Machine Learning Cycle

- 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 of the different courses undergone in the semester and the 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 and countersigned by the Course coordinator.

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

BLOCK CHAIN TECHNOLOGY

Preamble: The purpose of this course is to create awareness and understanding among students on the foundation of blockchain technology. The course introduces the cryptographic principles behind 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: Basic knowledge of 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 crypto currencies 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 your own Crypto token	PO6	PSO12	Ap, Ev	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 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: CAI-DE-525(ii)	Credits: 3

INTERNET OF EVERYTHING

Preamble: This course equips the learners with fundamentals of the Internet of Things (IoT) and the IoT ecosystem. It covers the architecture of IoT, communication mechanisms, protocols, hardware, software, data analytics, and the cloud platforms for IoT. This course enables the students 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 the 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	PSO11	An	C
CO4	Familiarize with the concept of M2M (machine to machine) with the necessary protocols	PO1	PSO5, PSO10	An	C
CO5	Understand the role of IoE in various domains of the Industry	PO5	PSO8	An	P
CO6	Understand the roles of sensors, APIs to connect IoE related technologies	PO2	PSO9	U	C
CO7	Analyze the 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	PSO4, PSO5	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: 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 vs Internet of Everything. Internet of Everything (IoE)

Taxonomies. Key features of IoE-Decentralized data processing, Interconnection with other technologies, Data input/output.

MODULE III

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

MODULE IV

Cloud computing and AI for the 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 Uckelmannark Harriso Michahelles 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: CAI-DE-525(iii)	Credits: 3

CYBER SECURITY AND CYBER LAW

Preamble: The Objective of this course is to inculcate in students an awareness of the cyber world. 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 IT Infrastructure, analyzing and monitoring potential threats and attacks, 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 the Internet and Computer Networking

COURSE OUTCOMES & TAGGING

Course Outcomes		PO	PSO	CL	KC
CO1	Understanding the security aspects in the computing Profession and its vulnerabilities	PO1	PSO10	U	C
CO2	Understand the fundamentals of cyberspace, cyber security and the threat landscape	PO3	PSO12	U	C
CO3	Analyze and evaluate the importance of personal data its privacy and security	PO4	PSO12	An	C
CO4	Identify the role of humans in security systems with an emphasis on ethics, social engineering vulnerabilities	PO2	PSO2	An	C
CO5	Evaluate the digital payment system security and remedial measures against fraud	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 for data recovery and acquisition	PO6	PSO12	Ap	P
CO8	Generalize the impact of the Risk assessment, plan 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: Cyberspace E-Commerce, The Contract Aspects in Cyber Law, The Security Aspect of Cyber Law, The Intellectual Property and 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 and 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.
- William Stallings,"Network Security Essentials: Applications and Standards", John R.Vacca, Computer Forensics, 2005.
- NinaGodbole, Sunit Belapure,"Cyber Security", Wiley, 2008
- Talat Fatima, "Cyber Law in India", Wolters Kluwer, 2017

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

STATISTICAL MACHINE LEARNING TECHNIQUES

Preamble: The course aims to provide students with detailed knowledge of how Machine Learning methods work and how statistical models can be brought to bear in computer systems. The analysis of large data sets and to let computers perform tasks that traditional computer science methods are addressed. Examples range from speech recognition and text analysis through bioinformatics and medical diagnosis. This course first introduces the statistical methods and mathematical concepts that make such technologies possible.

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

COURSE OUTCOMES & TAGGING

Course Outcomes		PO	PSO	CL	KC
CO1	Explain the basics of Convergence and applications	PO1	PSO3	U	C, P
CO2	Application of KNN	PO3	PSO8	An	C, P
CO3	Knowledge in EM	PO4	PSO3, PSO4	U, An	C, P
CO4	Explain Statistical learning and its different learning methods	PO5	PSO7	U, An	P, M
CO5	Compare different Naïve bays and Bayesian Networks algorithms	PO2	PSO10	U	P, C
CO6	Practice Markov models and HMM	PO3	PSO10	An	P
CO7	Implement HMM and its variants	PO4	PSO8	Ap	C, P
CO8	Real-world application using statistical learning techniques	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

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

MODULE II

Nearest Neighbourhood: Distance Measure, Hamming Distance, Euclidean Distance, City Block Distance (Manhattan), Euclidean and Manhattan Distances, Square Distance, KNN Algorithm, KNN Algorithm Implications, Nearest Neighbourhood Applications.

Expectation Maximization: General EM, EM algorithm, Features of EM, Mathematics of EM.

MODULE III

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

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

MODULE IV

Statistical Classifiers: Linear Classifiers, Fisher Linear Discriminant, Quadratic Classifiers, Probability Density Function Modelling, 1D Gaussian PDF Modelling. Naive Bayes Classifier.

MODULE V

Bayesian Networks: Bayesian Networks Example, Naive Bayesian Learning, Bayesian Network Algorithms, Naive Bayesian tree, Limitation of Bayesian Networks, Applications

MODULE VI

Real-world problems: Education Loans, Internet Usage Prediction, Derivation of PCFG, Object Tracking, Markov Chain for DNA/Protein Family Happiness HMM, Markov Model Based Software Reliability Testing, Two Letter Word – HMM, Linguistic Colouring – HMM Handwritten Character Identification, Sudden Infant Child Death – Investigation, Naive Bayes Classifier Person Identification.

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

Semester: 2	Course Code: CAI-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, Database for Bigdata analytics.

COURSE OUTCOMES & TAGGING

Course Outcomes		PO	PSO	CL	KC
CO1	Understand the basic data preprocessing techniques	PO2	PSO4	U	C
CO2	Analyze data integration and reduction methods and problems	PO1	PSO3, PSO4	An	C
CO3	Discuss data warehousing and OLAP	PO3	PSO7	U	C
CO4	Illustrate multidimensional data mining processes	PO4	PSO4, PSO7	Ap	P
CO5	Identify and evaluate different pattern mining models	PO5	PSO3, PSO5	U, E	C, P
CO6	Remember text mining architecture and the basic steps of text processing	PO3	PSO7	R	C
CO7	Analyze and study different document representation models	PO2	PSO4 PSO9	An	C
CO8	Apply data mining and text analysis methods to various problems to find the solution	PO6	PSO5, PSO7	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-dimensional data.

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 datasets, Finding frequent patterns from transaction data set, Document classification with decision tree and SVM.

LEARNING RESOURCES

References

- Jiawei Han,Micheline Kamber,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: CAI-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 biomacromolecules 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 of different sequence alignment techniques in biological sequences	PO2	PSO5	U, An	P, M
CO5	Identify primers, motif and domains of RNA sequences (short sequence elements in RNA sequences)	PO5	PSO11	U	P, C
CO6	Describe algorithms in 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 in Microbial informatics, Biomedical Images and Microarray	PO2	PSO8	Ap	C, P
CO8	Investigate the 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-Analyse, 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.

MODULE IV

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

MODULE V

RNA Secondary Structure: Definitions, scoring schemes, dynamic programming approaches. Motif Finding: Repeat finding. Promoter and enhancer recognition. Signal peptide recognition. *Genotyping:* Basic genetics, haplotype determination, haplotype blocks, forensic identification. *Genome Sequence Assembly:* Technology overview. Overlap-layout-consensus paradigm. Approaches.

MODULE VI

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

LEARNING RESOURCES

References

- Andreas Baxevanisand Francis Ouellette - "Bioinformatics- A practical guide to the Analysis of Genes and proteins", Wiley India, 2010.
- P. Baldi and S. Brunak-"Bioinformatics: The Machine Learning Approach",MIT Press, 2001.
- R. Durbin, S. Eddy, A. Krogh and G. Mitchison, "Biological Sequence Analysis", Wiley, 1999.
- Rastogi et. al. – "Bioinformatics: Methods and Applications Genomics, Proteomics and Drug Discovery", Prentice Hall of India, New Delhi, 2013.
- Vinod Chandra S S, Amjesh R - "Bioinformatics for Beginers", Lambert Academic Publishers, UK, 2019.
- 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: CAI-DE-526(ii)	Credits: 3

LEARNING MODELS FOR INTELLIGENT SYSTEM

Preamble: AI applications are powered by machine learning algorithms, so it is important to understand the theoretical aspects of the classical models in ML. This course helps the learners to understand the machine learning process and its evaluation methods. Different types of machine learning models and some of the specific algorithms in each category are included in this course. The basic concepts and working of the artificial neural network will definitely give an entry to the new generation learning models that are going covered in the coming semesters.

Prerequisite: Students are supposed to have a basic knowledge in probability and statistics.

COURSE OUTCOMES & TAGGING

Course Outcomes		PO	PSO	CL	KC
CO1	Describe the basic concepts of the machine learning process and different types of machine learning methods	PO2	PSO7	U	C, P
CO2	Analyse the differences between supervised and unsupervised machine learning models.	PO1	PSO8	An	C, P
CO3	Explain the working of classical machine learning models.	PO1	PSO3	U, An	C, P
CO4	Demonstrate how the reinforcement learning models are widely used in modern AI applications.	PO2	PSO5	U, An	P, M
CO5	Differentiate the working of activation functions with the help of artificial neural network	PO5	PSO1	An	P, C
CO6	Describe the importance of statistical machine learning models with examples.	PO3	PSO10	An	P
CO7	Articulate the basic theoretical concept of machine learning algorithms.	PO5	PSO3	Ap	C, P
CO8	Investigate the implementation of machine learning algorithms with proper datasets and constraints.	PO1	PSO11	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

Introduction to Machine Learning, Steps in the 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 II

Unsupervised Machine Learning- Clustering, Agglomerative and Divisive Clustering, k-Means clustering; Supervised Machine Learning- Decision Trees -ID3 algorithm, Support Vector Machines- Learning a maximum hyperplane, Kernel functions and Non-linear SVM.

MODULE III

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 IV

Artificial neural networks, Models of ANNs- Feedforward & feedback networks, Activation functions, Learning rules; perception learning rule, delta learning rule. Fuzzy sets – Operations and Properties, Relations- Crisp, Fuzzy, Fuzzy Equivalence; Features of Membership Functions, Fuzzification and Defuzzification

MODULE V

Statistical Classifiers- Linear Classifiers, Fisher Linear Discriminant, Quadratic Classifiers, Probability Density Function Modelling, 1D Gaussian PDF Modelling. Naive Bayes Classifier.

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. ANN for Logic gates – code from scratch.

LEARNING RESOURCES

References

- C. Bishop - "Pattern Recognition and Machine Learning", Springer, 2007.
- K. Murphy - "Machine Learning: a Probabilistic Perspective", MIT Press, 2012.
- Deisenroth, Marc Peter, A. Aldo Faisal, and Cheng Soon Ong. Mathematics for machine learning. Cambridge University Press, 2020.
- Richert, W., Coelho, L. P. (2013). Building Machine Learning Systems with Python. United Kingdom: Packt Publishing.
- Michalski, R. S., Tecuci, G., & Bala, J. W. (1994). Machine learning: An artificial intelligence approach. Morgan Kaufmann.
- Michalski, R. S., Carbonell, J. G., & Mitchell, T. M. (1984). Machine learning an artificial intelligence approach. by Springer-Verlag Berlin Heidelberg New York Tokyo in 1983.
- Vinod Chandra S S, Anand H S- "Artificial Intelligence and Machine Learning", Prentice Hall of India, New Delhi, 2014

Semester: 2	Course Code: CAI-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: Mathematical background, Machine learning and programming in Python.

COURSE OUTCOMES & TAGGING

Course Outcomes		PO	PSO	CL	KC
CO1	Describe the key features of reinforcement learning that distinguish it from artificial intelligence and non-interactive machine learning	PO1	PSO3	U	C, P
CO2	Exemplify an application problem and 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 of Markov decision problem and how to apply	PO5	PSO3	An	P
CO7	Understanding Q-learning and policies	PO4	PSO11	U	C, P
CO8	Apply reinforcement learning to 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: CAI-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 their components	PO2	PSO3	U	C, P
CO2	Tools used in expert system	PO3	PSO10	An	C, P
CO3	Knowledge acquisition from a domain expert	PO1	PSO3	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 the Expert system	PO2	PSO8	An	P
CO7	Use of Expert systems in engineering, business and manufacturing	PO1	PSO7	U, An	C, P
CO8	Study of selected old and modern expert systems	PO3	PSO11	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

Semester: 2	Course Code: CAI-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	PSO3, PSO4	U	C
CO2	Describe the basic concepts and measures of Social Network Analysis	PO2	PSO4, PSO5	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	PSO3, PSO6	U, Ap	C, P
CO4	Understand and analyze the affiliation networks, graphs and partitioning techniques	PO3	PSO3, PSO11	U, An	C, P
CO5	Apply the centralities and find the relevance of web pages using page ranking algorithms	PO4	PSO4, PSO12	Ap	P
CO6	Implement an algorithm to solve social media mining and sentimental analysis	PO6	PSO3, PSO5	Ap	P
CO7	Develop practical skills in network analysis in R programming language	PO6	PSO3, PSO4	Ap	C, P
CO8	Evaluate the working of social networks for various applications	PO2	PSO4, PSO12	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;

MODULE II

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.

MODULE III

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

MODULE IV

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

- Borko Furht, "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.
- Maksim Tsvetovat, Alexander Kouznetsov;" Social Network Analysis for Startups: Finding Connections on the Social Web"; O'Reilly Media, 1994
- 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
- Steven S. Muchnick, "Advanced Compiler Design and Implementation", Harcourt Asia PTE TD,1997

Online Resources

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

Semester: 2	Course Code: CAI-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, the composition and activities of the election commission and amendment procedures.

Prerequisite: Nil

COURSE OUTCOMES & TAGGING

Course Outcomes		PO	PSO	CL	KC
CO1	Knowledge of Information Technology and its use	PO6	PSO1	U	C, P
CO2	Understand cyber space and cybercrimes	PO6	PSO4	U	C, P
CO3	Understand and explain the Technology Act	PO6	PSO1	U	C, P
CO4	Understand and explain the significance of the Indian Constitution as the fundamental law of the land	PO6	PSO1	U, An	P, C
CO5	Exercise fundamental rights in the proper sense and identifies their responsibilities in national building	PO6	PSO4	U	P, C
CO6	Knowledge of state and central government laws and powers	PO6	PSO11	U	P
CO7	Analyze the Indian political system, the powers and functions of the Union, State and Local Governments	PO6	PSO1	U	C, P
CO8	Understand Electoral Process, Emergency provisions and Amendment procedure	PO6	PSO4	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 requirements 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 to 74th 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://www.loc.gov/resource/llscd.57026883/?st=gallery
- https://www.indiacode.nic.in/bitstream/123456789/13116/1/ it_act_2000_updated.pdf

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

COMPUTATIONAL COGNITIVE SYSTEMS

Preamble: This course introduce the basic concepts and methodology needed to implement and analyse computational models of cognition. It considers the fundamental issues of using a computational approach to explore and model cognition. It also explores the way that computational models relate to, are tested against, and illuminate psychological theories and data. The course will introduce both symbolic and sub symbolic modelling methodologies, and provide practical experience with implementing models.

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	PSO1	U, An	C, P
CO2	Generate a keen interest in cognitive science and who expect to pursue a career in human-computer interaction	PO3	PSO5	Ap	C, P
CO3	Designed to build systems introducing theories of human cognition and building practical problem-solving skills for real-world applications.	PO1	PSO 4	An, Ap	C ,P
CO4	Explain the different perspectives and methodologies in cognitive science	PO4	PSO11	U, An	P, M
CO5	Illustrate the knowledge Representation of cognitive science and understand categories of mental representation	PO5	PSO7	Ap	P, C
CO6	Describe advantages to using network approach for understanding learning and knowledge representation.	PO4	PSO3	U, An	P
CO7	Understand the mechanisms and concepts of human cognition and their impact on human performance	PO2	PSO1	U, An	C, P
CO8	Generate a keen interest in cognitive science and who expect to pursue a career in human-computer interaction	PO3	PSO5	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

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. (2021). Cognitive science: an introduction to the study of mind. Sage Publications.
- 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 I., ed. Foundations of cognitive science. Cambridge, MA: MIT press, 1989.

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

APPLIED MACHINE LEARNING

Preamble: Students will learn how to correctly apply, and 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: Foundation in Machine learning, soft computing, statistical learning techniques and programming in Python language

COURSE OUTCOMES & TAGGING

Course Outcomes		PO	PSO	CL	KC
CO1	Understand PCA and its use	PO1	PSO2	U	C, P
CO2	Understand fuzzy systems and networks	PO3	PSO3	U	C, P
CO3	Use fuzzy set theory for solving problems	PO4	PSO5	U, An	C, P
CO4	Understand the concept of ensembles and interconnected models	PO5	PSO9	U	P, M
CO5	Ensemble and AdaBoost classifiers for Machine learning	PO2	PSO9	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 with real-world problems in Machine learning	PO6	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

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: CAI-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: Basic understanding of Natural Language Processing

COURSE OUTCOMES & TAGGING

Course Outcomes		PO	PSO	CL	KC
CO1	Understand key concepts from NLP that are used to describe and analyze language	PO1	PSO1	U	F
CO2	Describe the characteristics of classical document representation models.	PO2	PSO1, PSO3	U	C,F
CO3	Compare the basic working principles of recent deep learning frameworks for NLP	PO4	PSO7	Ap	C,F
CO4	Analyse the theoretical background behind the semantic computing in NLP	PO5	PSO1, PSO9	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: 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: CAI-CC-534	Credits: 3

MACHINE INTERACTION LABORATORY

Preamble: This course aims to experiment with real-time data which can be collected from various sensors and cameras. A list of experiments is designed in this course for hands-on experience with Raspberry-pi, a low-cost SBC developed by the Raspberry Pi Foundation, a UK-based charity. Raspberry-Pi can be used to develop applications in various fields, such as Home Automation, surveillance, etc., with the support of IoT and Machine Learning. Since it has such diverse applications in various fields, the experiences with Raspberry Pi projects have a great significance in engineering & research. Any programming language that supports the experiment can be used in the laboratory. The list of exercises will start with the basic exercise to start with the environment, and the exercises in the later cycles are planned to use machine learning and AI methods with live data. A detailed list of exercises will be provided as part of the semester plan at the start of the semester.

Prerequisite: Python programming, Image processing and Machine learning.

COURSE OUTCOMES & TAGGING

Course Outcomes		PO	PSO	CL	KC
CO1	Design and develop products for various Real-Time Applications through interdisciplinary research.	PO5	PSO2 PSO4	Ap,E	M
CO2	Hands-On Experience with Raspberrypi and development of Internet of Things (IoT) prototypes	PO5	PSO12 PSO10	An,Cr	P
CO3	Acquire expertise in handling real-time data which has great significance in engineering & research.	PO5	PSO4 PSO10	Ap,Cr	P
CO4	Identify, analyze and provide solutions to day-to-day life problems by means of IoT technology.	PO5	PSO4 PSO8	Ap,E	M
CO5	Design, Implement and apply pattern recognition techniques based on real world problems	PO5	PSO2 PSO6	An,E	M
CO6	Design and program efficient algorithms related to recent machine learning techniques, train models, conduct experiments, and solve real-time complex problems	PO5	PSO2 PSO4	Ap,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

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 set of experiments in each cycle. The students can suggest new and innovative exercises in the second cycle, provided they can be implemented with the available lab infrastructure.

Starter Cycle
The experiments in this cycle are to make the students comfortable with the Raspberry Pi kit and its environment. There will be experiments starting with Raspberry Pi Installation & Configuration, Basic Program over Raspberry Pi to understand the General-Purpose Input Outputs and interfacing Sensors with Raspberry Pi IoT, etc. Some sample exercises in this category are

- Raspberry Pi Installation & Configuration
- Linux Commands for Applications
- LED Blinking
- LCD Interfacing
- Web server Creation

Sensors and ML Cycle
This cycle is intended to practice the IoT experiments with Raspberry Pi. The experiments are designed to experiment with live data from the various sensors, which can be processed with the help of ML and AI methods. Some sample exercises in this category are

- Real-time object recognition
- Real-time face detection
- Tesseract-OCR based Label reading
- Real-time license plate Recognition

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 of the different courses undergone in the semester and the 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: CAI-CC-535	Credits: 2

CASE STUDY

Preamble: The objective of a Case Study is to create expertise to understand a novel research work in a specific area by re-implementing it. The area of the work is restricted to AI, Machine Learning, Data analysis and NLP.

Prerequisite: Theoretical and practical knowledge in AI and related areas.

COURSE OUTCOMES & TAGGING

Course Outcomes		PO	PSO	CL	KC
CO1	Identify a research problem which is significant in the area of computer science	PO1	PSO2, PSO7	U	F
CO2	Analyze the literature survey on the selected topic as an individual	PO4	PSO12	Ap	C,F
CO3	Design the experiment with a proper hypothesis	PO5	PSO8, PSO5	An	F
CO4	Evaluate and interpret the experimental results.	PO3	PSO7, PSO9	Ap	C
CO5	Analyze the effectiveness of the method implemented.	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 milestone and precursor to the final Project work and presentation. There is much importance in the selection of the work, since the final project work can be the extension of the same. The work should be based on a published article in an internationally reputed journal. The faculty member assigned by the Department council will assist you throughout the course from the selection process. Continuous interaction and discussion with the respective guide will help the students to successfully finish the course which leads to a valuable contribution to the final project work. A case study report should submit at the completion of the work which contains the background, related works, experiment and Analysis. The same has to present before the panel of teachers. 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:CAI-DE-536(i)	Credits: 3

FOUNDATION IN ROBOTICS

Preamble: Robotics as an application draws from many fields and allows the automation of products as diverse as cars, vacuum cleaners, and factories. This course is a challenging introduction to basic computational concepts used broadly in robotics. Topics include simulation, kinematics, control, optimization, and probabilistic inference.

Prerequisite: Multivariable calculus, linear algebra, introduction to computing, and Artificial Intelligence.

COURSE OUTCOMES & TAGGING

Course Outcomes		PO	PSO	CL	KC
CO1	Illustrate the evolution and technological advancements in Robotics	PO1	PSO6	U	C, P
CO2	Knowledge of the use of robotics and its type	PO1	PSO10	An	C, P
CO3	Demonstrate the working principle of robots	PO3	PSO5	An	C, P
CO4	Articulate the working of sensors for the success of a robot	PO4	PSO5	U, An	P, M
CO5	Describe the role of grippers in industrial robots	PO3	PSO11	Ap	P, C
CO6	Sketch the Kinematics of robots	PO5	PSO8	Ap	P
CO7	Outline the challenges and importance of robot programming	PO2	PSO7	U, An	C, P
CO8	Present applications areas of robotics	PO5	PSO11	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

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

MODULE II

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

MODULE III

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

MODULE IV

Grippers – Mechanical Gripper-Grasping force-Engel Berger-g-factors-mechanisms for actuation, Magnetic gripper, vacuum cup gripper-considerations in gripper selection & design. Industrial robots specifications. Selection based on the Application.

MODULE V

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

MODULE VI

Robot programming languages and systems – Levels of Robot Programming, Sample Application, Requirements of a Robot Programming Language, Problems peculiar to Robot Programming Language. Off-line programming systems

LEARNING RESOURCES

References

- Craig, John J. "Introduction to Robotics". Prentice Hall, 2017.
- "Industrial Robotics", Tata McGraw-Hill Education, 2012.
- Kevin M. Lynch, Frank C. Park, "Modern Robotics: Mechanics, Planning, and Control", Cambridge University Press, 2017
- Mordechai Ben-Ari, Francesco Mondada, "Elements of Robotics", Springer International Publishing, 2017
- Jazar, Reza N., "Theory of Applied Robotics", Springer Science & Business Media, 2010.
- Yang, Richard (Chunhui), et al. , "Robotics and Mechatronics", Springer, 2019.

Online Resources

- http://engineering.nyu.edu/mechatronics/ smart/ Archive/intro_to_rob/ Intro2Robotics.pdf
- http://www.mech.sharif.ir/c/document_library/get_file?uuid=5a4bb247- 1430-4e46-942c- d692dead831f& groupId=14040

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

GAME THEORY AND APPLICATIONS

Preamble: The 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 a specific emphasis on applications.

Prerequisite: Mathematical foundation in Artificial Intelligence

COURSE OUTCOMES & TAGGING

Course Outcomes		PO	PSO	CL	KC
CO1	Acquaint with the scope and applications of Game Theory	PO2	PSO2, PSO11	Ap, An	C, P, M
CO2	Exposes to the 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 a multi-agent environment	PO1	PSO7, PSO11	Ap, An	C, P
CO4	Present fundamental results for the 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 airlines, Premium pricing by hoteliers, taxi food aggregators etc.	PO3	PSO3, PSO4	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	PSO2, PSO3	U, Ap	C, P
CO7	Study Bayesian games and different equilibrium notions in Bayesian games such as Bayesian Nash equilibrium	PO5	PSO8, PSO 10	U, Ap	C, P
CO8	Introduce games with incomplete information, which is crucial to the theory of mechanism design	PO1	PSO7, PSO11	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	PSO 8, PSO 10	An, Ap	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 games Mixed 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, "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:CAI-DE-536(iii)	Credits: 3

SPEECH PROCESSING AND RECOGNITION

Preamble: The study and practice of speech signal processing is referred to as speech processing. Speech processing can be thought of as a special case of digital signal processing that is applied to speech signals as these signals are often treated in a digital representation. The course covers introduction to speech processing, synthesis, speech recognition, and acoustic phonetics, predictive strategies for speech coding and time and frequency domain methods for estimating speech parameters and Automatic Speech Recognition.

Prerequisite: Knowledge of NLP and Algorithms

COURSE OUTCOMES & TAGGING

Course Outcomes		PO	PSO	CL	KC
CO1	Explain Signal Processing models for speech perception	PO1	PSO1	U	C,P
CO2	Analyze the advantages and disadvantages of Feature Extraction Methods	PO3	PSO2	Ap, An	C,P
CO3	Explain the architecture of speech Recognition	PO4	PSO1	U	C,P
CO4	Analyze and evaluate metrics for Speech Recognition system	PO3	PSO6	An, E	C,P
CO5	Machine Learning approaches for Speech Processing	PO5	PSO4	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 speech processing – Historical of speech processing – Applications, Speech Production: Acoustic theory of speech production. Speech Analysis: Short-Time Speech Analysis, Time domain analysis (Short time energy, short time zero crossing Rate, ACF).

MODULE II

Speech Coding, Speech Enhancement, Speaker Verification, Language Identification. Signal Processing Models of Audio Perception: Basic anatomy of hearing System. Auditory Filter Banks, Psycho-acoustic analysis: Critical Band Structure, Absolute Threshold of Hearing, Simultaneous Masking, Temporal Masking, Quantization Noise Shaping, MPEG psycho-acoustic model.

MODULE III

Analysis and Synthesis of Pole-Zero Speech Models – Time-Dependent Processing, All-Pole Modeling of Deterministic Signals, Linear Prediction Analysis of Stochastic Speech Sounds, Synthesis Based on All-Pole Modeling. Short-Time Fourier Transform Analysis and Synthesis - Short-Time Analysis and Synthesis, Signal Estimation from the Modified STFT, Time-Scale Modification and Enhancement of Speech

MODULE IV

Speech Analysis: Features, Feature Extraction and Pattern Comparison Techniques: Speech distortion measures – mathematical and perceptual – Log Spectral Distance, Cepstral

Distances, Weighted Cepstral Distances and Filtering, Likelihood Distortions, Spectral Distortion using a Warped Frequency Scale, LPC, PLP and MFCC Coefficients, Time Alignment and Normalization – Dynamic Time Warping, Multiple Time – Alignment Paths.

MODULE V

Automatic Speech Recognition (ASR): Speech recognition architecture- Types of speech recognition-Issues in speech recognition - Performance evaluation of SR systems

MODULE VI

Speech recognition methodologies: Acoustic-phonetic approach, Pattern recognition approach: Template based approach-Dynamic Time Warping- Hidden Markov Model (HMM) -Vector Quantization – Support Vector Machine (SVM), Sequential data models. Speech Synthesis: Text-to-Speech Synthesis: Concatenative and waveform synthesis methods, subword units for TTS, intelligibility and naturalness – role of prosody, Applications and present status.

LEARNING RESOURCES

References

- Daniel Jurafsky, James H.Martin, "Speech and Language Processing", Prentice Hall, 2008.
- L. R. Rabiner, R. W. Schaffer, "Digital Processing of Speech signals", Prentice Hall, 1978.
- Jacob Benesty, M. Mohan Sondhi, Yiteng Huang "Springer handbook of speech Processing", Springer, 2007.
- Lawrence Rabinerand Biing-Hwang Juang, "Fundamentals of Speech Recognition", Pearson Education, 2003.
- Ben Gold and Nelson Morgan, Speech and Audio Signal Processing, John Wiley and Sons Inc. , Singapore, 2004.

Semester: 3	Course Code:CAI-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 bio-inspired computing fundamentals	PO2	PSO3	U	C, P
CO2	Explain optimization problems and their types	PO3	PSO8	U, An	C, P
CO3	Familiar with Genetic algorithms and their 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 the Particle swam optimization algorithm with an example	PO1	PSO3	AP	P
CO7	Compare different natural inspired computing algorithms	PO3	PSO1	An	C, P
CO8	Real world problems 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:CAI-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 of Internet and web technology.

COURSE OUTCOMES & TAGGING

Course Outcomes		PO	PSO	CL	KC
CO1	Compare Boolean and vector-space retrieval models	PO1	PSO1	An	C, P
CO2	Provide the ability to solve novel and practical information retrieval problems	PO2	PSO2	Ap	C, P
CO3	Illustrate the process of Document clustering in information retrieval	PO1	PSO9	U, An	C, P
CO4	Evaluate the information retrieval algorithms using precision and recall	PO4	PSO10	E	P, C
CO5	Implement Document ranking algorithm using TF-IDF algorithm	PO4	PSO7	An	P, C
CO6	Provide the knowledge of searching and indexing in information retrieval	PO2	PSO12	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:CAI-DE-537(i)	Credits: 3

AI PLANNING

Preamble: In this course, the challenges of building autonomous agents must continuously plan, execute their actions, and learn from their interactions with the environment. This course will cover in depth the main issues and algorithms in AI planning and learning, namely action and task modelling and representation, plan generation algorithms, heuristic learning and reuse of experience, and largely open research topics, such as dynamic integration of planning, scheduling, and execution, and multiagent planning.

Prerequisite: Linear algebra, introduction to computing and Artificial Intelligence.

COURSE OUTCOMES & TAGGING

Course Outcomes		PO	PSO	CL	KC
CO1	Knowledge in AI based plan design and execution	PO1	PSO3	U	C, P
CO2	Planning problems design using STRIPS, ADL, PDDL	PO3	PSO10	AN	C, P
CO3	Problems and solutions in HTN	PO4	PSO3, PSO4	Ap	C ,P
CO4	Knowledge of different types of planning	PO4	PSO5	U	P, M
CO5	Knowing the connection between Knowledge representation and planning approaches	PO5	PSO11	U	P, C
CO6	Control and search strategies in AI based planning	PO2	PSO3	An	P
CO7	Knowing the uncertainty principle in AI planning	PO2	PSO3	U,An	C, P
CO8	Real world problem solving by AI based planning	PO3	PSO1	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

Introduction to AI planning: Elements - States, goals, actions, plans. Situation calculus, representing change, STRIPS - Operators: preconditions, add and delete effects, planning as search - Means-ends analysis. Planning Problem - STRIPS, ADL, PDDL. Planning with State Space Search - Forward State Space Search, Backward State Space Search, Lifting, Sussman Anomaly

MODULE II

Planning approaches: Partial Order Planning, Planning Graphs, Hierarchical Planning, Plan generation and causal-link planning, Hierarchical task network (HTN) planning, Plan graph search, Skeletal planning, case-based planning, planning as constraint satisfaction, planning as satisfiability, Planning using temporal logics, Heuristic search planning, Reactive systems.

MODULE III

Plan Representations: Knowledge representation for planning, ontologies, description logics, Reasoning about time: temporal reasoning and scheduling

MODULE IV

Controlling Search: Complexity of planning problems, Abstraction, macros, hierarchical planning, Learning search control knowledge. Agent-Based Planning - Multi-agent planning architectures, reasoning about other agents, Learning from an external environment.

MODULE V

Planning under Uncertainty: Probabilistic planning, Decision theory, Markov decision processes. Making a single decision, Uncertainty in predictability, Uncertainty in sensing: The information space

MODULE VI

Planning in real world: Hierarchical Task Network example, PDDL: Planning Robot Moves, Piratical Planners, planning in space, Mixed-initiative planning, Planning in training simulation environments

LEARNING RESOURCES

References

- Nilsson, N. "Principles of Artificial Intelligence", Elsevier Science, 2014.
- Rich, E. and Knight, K. "Artificial Intelligence", McGraw Hill, 1991.
- Russell, S. and Norvig, P. "Artificial Intelligence: A Modern Approach", 4ed., Prentice Hall of India, New Delhi, 2020
- Vinod Chandra S S, Anand H S - "Artificial Intelligence: Principles and Applications", 2ed., Prentice Hall of India, New Delhi, 2020

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

METHODS FOR CAUSAL INFERENCE

Preamble: Students who successfully complete the course will show that they have a thorough understanding of the concepts of causal inference, including the frameworks of causal Bayesian networks and potential outcomes, as well as how these concepts are used in the data sciences. Students will comprehend how various causal inference methods are implemented, modified, and applied in a high-level programming language (such as Python). The ability to recognise, formulate, and resolve causal inference issues that crop up in the empirical sciences will be taught to students. The foundations and techniques for causal inference in data sciences and artificial intelligence will also be studied in depth by students who have the requisite computing and mathematical training.

Prerequisite: Probability, statistical inference and programming

COURSE OUTCOMES & TAGGING

Course Outcomes		PO	PSO	CL	KC
CO1	Ability to demonstrate a broad understanding of the principles of causal inference.	PO1	PSO2, PSO3	U,Ap	C,P
CO2	Understand the implementation, adaptation, and applications of several causal inference algorithms in a high-level programming language.	PO3	PSO5	U, Ap	C, P
CO3	Identify, formulate, and solve causal inference problems that arise in the empirical sciences.	PO2	PSO4, PSO5	U, An	C, P
CO4	Illustrate the different graphical representations of causal effects.	PO4	PSO6	U, Ap, E	C, P
CO5	Differentiate bias-based causal effects and their application	PO5	PSO5, PSO8	An, E	C, P
CO6	Demonstrate advanced Causal effect estimation techniques.	PO2	PSO10, PSO11	U,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: Need of causal inference study- Pitfalls of drawing conclusions from observational data; Simpson's paradox and its implications, Causal effect-Fundamental Problem of Causal Inference, Causation versus association, Individual causal effects, Average causal effects, Measures of Causal effects.

MODULE II

Randomized Experiments: Identification and estimation of Causal effects through randomization, conditional randomizations, standardization, inverse probability weighting, Randomization inference, and permutation testing.

MODULE III

Estimating causal effects from observational data: Identifiability conditions, Exchangeability, positivity, consistency, target trials, Effect modification: Need, Stratification, stratification and matching as a form of adjustment, effect modification, and adjustment methods.

MODULE IV

Causal interactions and Representing causal assumptions: Identification, counterfactual response types, and interactions, sufficient causes, sufficient cause interaction, sufficient component causes, Causal diagrams, syntax and semantics, interventions, counterfactuals.

MODULE V

Causal effect identifiability, Do-calculus, structure of confounding, front-door and back-door criteria, Selection and measurement bias , structure, selection bias and confounding, selection bias and censoring, adjusting for selection bias and measurement bias.

MODULE VI

Advanced Techniques for Causal Effects Estimation matching, inverse propensity weighting, representation learning, doubly robust estimation.

LEARNING RESOURCES

References

- Pearl, J., Glymour, M. and Jewell, N.P., 2016. Causal inference in statistics: A primer. John Wiley & Sons.
- Imai, Kosuke. Quantitative Social Science: An Introduction. Princeton University Press. 2017.
- Imbens, Guido W. and Donald B. Rubin. Causal Inference for Statistics, Social, and Biomedical Sciences. Cambridge University Press. 2010.
- Angrist, Joshua D., and Jorn-Steffen Pischke. Mostly Harmless Econometrics: An Empiricist's Companion. Princeton University Press. 2009.
- Morgan, Stephen L. and Christopher Winship. 2007. Counterfactuals and Causal Inference: Methods and Principles for Social Research. Cambridge University Press.

Semester: 3	Course Code:CAI-DE-537(iii)	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 deep architectures.	PO2	PSO1, PSO4	U	C, P
CO2	Use Deep learning for solving problems.	PO1	PSO3, PSO4	U,Ap	C,P
CO3	Familiar with DBN and CNN.	PO6	PSO4	U	C ,P
CO4	Familiar LSTM and RNN.	PO4	PSO4	U	C,P
CO5	Implement RNN, DBN and CNN.	PO5	PSO3, PSO4	U,Ap	C,P
CO6	Compare different Deep architectures and their learning models.	PO3	PSO4, PSO10	U, An,	C,P
CO7	Familiar with different deep frameworks like Tensorflow, Keras, Caffe, GAN. (Understand)	PO6	PSO4	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, Effective training 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): 3.
- Géron, Aurélien. Hands-on machine learning with Scikit-Learn, Keras, and TensorFlow. " O'Reilly Media, Inc.", 2022..
- Goodfellow, Ian, Yoshua Bengio, 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:CAI-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 of basic Artificial Intelligence, Machine learning

COURSE OUTCOMES & TAGGING

Course Outcomes		PO	PSO	CL	KC
CO1	Outline the basic concepts of Computational Creativity	PO2	PSO3	U	C
CO2	Analyse/critique developments in computational creativity like an expert	PO3	PSO11	U, An, Ap	C, P
CO3	Identify problems in addressing creative tasks	PO4	PSO3	U, An	C, P
CO4	Describe about creative machines and creative algorithms	PO1	PSO4	U, An	C, P
CO5	Design, develop, and document creativity tools from ideation to realization	PO3	PSO3	An, Ap	C, P
CO6	Differentiate creative artificial intelligence and architectural intelligence	PO5	PSO11	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- IFAIE_ Weak_ Strong_ Computational_ Creativity_ %28AAM%29_2014.pdf
- https://www.creativitypost.com/ science/what_is_ computational creativity

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

EVALUATION OF AI SYSTEMS

Preamble: Most AI applications deal the live data; hence validating the model is that much important as the design. A thoroughly evaluated model can perform in a more robust manner in any circumstance. This course is designed to impart the importance of evaluation and fine-tuning of AI models. Different evaluation matrices are covered in this course, along with the theoretical importance of each. A detailed study of the risks and remedies for the evaluation of AI systems should enrich the capability to design AI systems effectively.

Prerequisite: Machine Learning and Artificial Intelligence systems

COURSE OUTCOMES & TAGGING

Course Outcomes		PO	PSO	CL	KC
CO1	Summarise the importance of the evaluation of AI systems through a set of standardised matrices.	PO5	PSO1, PSO6	U	C
CO2	Differentiate the use of various evaluation matrices in AI systems	PO1	PSO2, PSO6	An	C, P
CO3	Identify various scenarios and their theory behind the various evaluation scenarios of AI systems.	PO5	PSO6	U, An	C, P
CO4	Justify the importance of the evolution of AI systems that deals with online data, by understudying their characteristics.	PO1	PSO4, PSO9	E	C, M
CO5	Formulate the risks of testing AI systems and the use of pre-trained nets in the applications	PO5	PSO11	An	C, M
CO6	Differentiate evaluation criteria in the different types of learning models.	PO5	PSO11	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

Variance, correlations and regression, usability, accessibility and learnability, guarantees regarding correctness, completeness, complexity, admissibility of heuristics, characteristics of non-testable systems and non-deterministic behavior of systems. Anomaly/Outliers Detection, Outliers Detection Techniques

MODULE II

Role of Metrics-Metrics for Supervised and Unsupervised Learning, Inertia and Adjusted Rand Score, Support, Confidence and Lift metrics, Confusion Matrix, Accuracy, Precision, Recall, Specificity and F1-Score, RMSE and R-Square.

MODULE III

Model Evaluation-Training, Validation and Testing Datasets, trade-off between bias and variance, Underfitting and Overfitting, Cross-validation methods, quality issues of machine learning system in terms of the training data, concept of drift in machine learning systems and its relationship with testing

MODULE IV

Online Testing of AI Systems-Architecture of an AI application, Components of an Intelligent Application and their Testing Needs, Interaction of AI and Non-AI Parts, Linguistic Analysis-Based Test Design,Testing AI systems, Test a Chatbot,No Free Lunch Theorem, "human-in-the-loop" systems

MODULE V

Explainable AI (XAI)-Explainable AI and its Need, LIME, CAM for Neural Networks. Risks in testing AI-Risks of Testing AI Systems, Risk of Using Pre-Trained Models, Risk of Concept Drift (CD), Challenges of AI Test Environment, Test Strategy for Testing AI Applications

MODULE VI

Comparison of evaluation matrices for supervised and un supervised learning models. Comparison of ground truth based evaluation matrices. Fine tuning the learning models and consistency of evaluation matrices.

LEARNING RESOURCES

References

- Nilsson, N. "Principles of Artificial Intelligence", Elsevier Science, 2014.
- Russell, S. and Norvig, P. "Artificial Intelligence: A Modern Approach", 4ed., Prentice Hall of India, New Delhi, 2020
- K. Murphy - "Machine Learning: a Probabilistic Perspective", MIT Press, 2012.
- M. Gopal, "Applied Machine Learning", McGraw-Hill Education, 2019
- David Forsyth, "Applied Machine Learning", Springer International Publishing, 2019
- Marc Peter Deisenroth, A. Aldo Faisal, Cheng Soon Ong, "Mathematics for Machine Learning", Cambridge University Press, 2020
- Elain Rich and Kevin Knight, "Artificial Intelligence", Tata McGraw-Hill, 2009
- Aggarwal, Charu C. "Neural networks and deep learning." Springer 10.978 (2018)
- Vinod Chandra S S, Anand H S - "Machine Learning: A Practitioners Approach", Prentice Hall of India, New Delhi, 2020
- C. Bishop - "Pattern Recognition and Machine Learning", Springer, 2007.

Semester: 3	Course Code: CAI-SE-4B3	Credits: 2

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	PSO8	Ap, An	C
CO2	Provide expertise in writing a research article	PO1	PSO12	Ap	C, P
CO3	Able to compare Copyright, Trademark and Patent	PO3	PSO6	An	C
CO4	Assess the quality of scientific publications	PO4	PSO8	An	C
CO5	Identify whether a journal is indexed in WoS and Scopus	PO5	PSO3	U, An	C, P
CO6	Understand the best practices followed for performing research	PO4	PSO4	U, Ap	C
CO7	Analyse the publication ethics practised in research	PO2	PSO8	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: CAI-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 help students to develop the skills needed for employability.

Prerequisite: Nil.

COURSE CONTENT

Massive Open Online Courses (MOOCs) are free online courses for anyone to enrol. MOOCs provide an affordable and flexible way to learn new skills, advance students' careers 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 Communication Technology (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 beginning of each Semester. 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

Online Resources

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

Semester: 3	Course Code: CAI-GC-4B1	Credits: 2

ARTIFICIAL INTELLIGENCE AND DAILY LIFE

Preamble: The Artificial Intelligence (AI) in Daily Life course aims to provide students with a comprehensive understanding of the practical applications and impact of AI in various aspects of everyday life. This course explores how AI technologies and algorithms are integrated into daily activities, products, and services, influencing decision-making processes, enhancing convenience, and transforming industries. Students will examine real-world examples, discuss ethical considerations, and explore the potential benefits and challenges associated with AI adoption.

Prerequisite: Nil.

COURSE OUTCOMES & TAGGING

Course Outcomes		PO	PSO	CL	KC
CO1	Demonstrate the fundamental understanding of the evolution of Artificial Intelligence (AI) and its foundations.	PO2	PSO1	U, Ap	F, C
CO2	Demonstrate awareness and a fundamental understanding of various applications of AI techniques in intelligent agents, Natural language Processing, and machine learning models.	PO1	PSO10	U	F, C
CO3	Demonstrate an ability to share in discussions applications of AI, its current scope and limitations.	PO2	PSO8	U	F, C
CO4	Apply basic principles of AI in solving daily life.	PO3	PSO7	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 Artificial Intelligence: Evolution of AI- Features of AI, Applications- AI domains, Intelligent agents, AI- Issues, Concerns and Ethical Considerations.

MODULE II

Impact of AI on Human Life: Strong AI and Weak AI, Importance of AI technologies, Impact of AI on Industry, Government and Society, Intelligent Agent System, Learning and Reasoning in AI.

MODULE III

Introduction to Machine Learning: Supervised and Unsupervised Algorithms- Reinforcement learning- Classification and Prediction models – Applications.

MODULE IV

Introduction to Game Theory: Two player game, Computer games-2D and 3D Games, Puzzle Games-Artificial Intelligence in Gaming.

MODULE V

Natural Language Processing: Natural Language Processing Tasks - NLP Applications, Text to Speech-Voice to Text Translators, Amazon Poly.

MODULE VI

Applications: Voice Assistance, Entertainment Streaming Apps, Personalized Marketing, Smart Input Device, Navigation Systems, Travel Recommender, Self-Driving Vehicles, Recognition Technology, Security and Surveillance, ADAS, Chat GPT, AI system for image generation.

LEARNING RESOURCES

References

- Russell, S., Norvig, P. Artificial Intelligence: A Modern Approach, Pearson,2020.
- Reese, B. The Fourth Age: Smart Robots, Conscious Computers and the Future of Humanity. Atria Books, 2018.
- Davenport, T. H. The AI Advantage: How to Put the Artificial Intelligence Revolution to Work, MIT Press, 2018.
- Russell, S. Human Compatible: Artificial Intelligence and the Problem of Control. Viking, 2015.
- Susskind, R., Susskind, D. The Future of the Professions: How Technology Will Transform the Work of Human Experts. Oxford University Press, 2015.
- Tegmark, M. Life 3.0: Being Human in the Age of Artificial Intelligence. Vintage, 2017.

Semester: 4	Course Code: CAI-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: CAI-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	PSO2, PSO10	An	C
CO4	Propose a new algorithm or design in the area of study	PO4	PSO5	An, Ap	C
CO5	Prepare a dissertation on the work done in the prescribed format	PO5	PSO3, PS06	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 Artificial Intelligence techniques. The courses up to the last semesters will give a comprehensive perspective of the theories and concepts of AI 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. Review
- 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: CAI-SE-4B5	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, PSO3	U, Ap	C,P
CO2	Establish goals by working with supervision to define work objectives for the internship experience	PO1	PSO4, PSO	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	PSO5, PSO6	An, Ap	P
CO5	Demonstrate effectively the ideas and solutions in the context of written, oral, and electronic media.	PO5	PSO7	U, An, Ap	C, P
CO6	Demonstrate and promote a proper work ethic.	PO4	PSO1O	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

Online Resources

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