Artificial and Computational Intelligence - HO - Mtech-AIML (6)

Artificial Intelligence (Birla Institute of Technology and Science, Pilani)

BIRLA INSTITUTE OF TECHNOLOGY & SCIENCE, PILANI WORK INTEGRATED LEARNING PROGRAMMES

Digital Learning
Part A: Content Design

Course Title	**Artificial and Computational Intelligence**
Course No(s)	**AIML**ZG557**
Credit Units	**5**
Credit Model	**1.25 - 1.5 - 2.25** **1.25 unit for class room hours, 1.5 unit for Tutorial,** **2.25 units for student preparation.** **1 unit = 32 hours**
Course Authors	**S.P.Vimal, Rajavadhana P**
Version No	**4.0**
Date	**Aug 12, 2022**

Course Objectives

No	Course Objective
CO1	To provide a solid foundation for designing intelligent agents
CO2	Learn the representation and use of knowledge in inference-based problem solving approaches
CO3	Learn to apply probability theory to describe and model agents operating in uncertain environments
CO4	Learn the optimization models of computation and processing in real world application of intelligent agents

Text Book(s)

T1	Stuart Russell and Peter Norvig, "Artificial Intelligence – A Modern Approach", Third Ed, Pearson Education, 2010

Reference Book(s) & other resources

R1	Ryszard S. Michalski, Jaime G. Carbonell and Tom M. Mitchell, "Machine Learning: An Artificial Intelligence Approach", Elsevier, 2014
R2	Dan W Patterson, "Introduction to AI and Expert Systems", Prentice Hall of India, New Delhi, 2010
R3	Elaine Rich and Kevin Knight, "Artificial Intelligence", Tata McGraw Hill Publishing Company, New Delhi, 2003

Modular Content Structure

0. Introduction
    - **a.** Artificial Intelligence: Foundations, Overview of Modern AI & Application Domains.
1. Introduction to Intelligent Agents: Notion of Agents and Environments, Rationality, Nature of Environments, Structure of Agents
2. Problem Solving Agent using Search:
    - **a.** Problem Formulation, Uninformed Search Algorithms: Uniform cost Search, Depth Limited Search, Iterative Deepening Search – Informed Search Algorithms:
      Notion of Heuristics, Greedy best first search, A* search, Optimality of A*
    - **b.** Heuristic Functions: Heuristic Accuracy & Algorithm performance, Admissible heuristics from relaxed problems, pattern databases & Experience
    - **c.** Local Search Algorithms & Optimization Problems: Hill Climbing Search, Simulated Annealing, Local Beam Search, Evolutionary Algorithms - Genetic Algorithm, Ant Colony Optimization, Particle Swarm Optimization
3. Game Playing:
    - **a.** Searching to play games: Minimax Algorithm, Alpha-Beta Pruning
    - **b.** Making imperfect real time decisions
4. Knowledge Representation using Logics:
      (**Pre-Reading:** Logics- Propositional, Predicate, TT-Entail, Theorem Proving)
    - **a.** Logic Representation of a sample agent, Proof by resolution, DPLL Algorithm, Agents based on Propositional logic
    - **b.** Overview of First Order Logic semantics, Example representation, Unification & Lifting, forward chaining, Backward Chaining, Resolution
5. Probabilistic Representation and Reasoning
    - **a.** Inference using full joint distribution & Example, Knowledge representation using Bayesian Networks, semantics of Bayesian Networks, Representation of Conditional Independence using Bayesian Networks
    - **b.** Exact Inference - by enumeration and variable elimination, Need for Approximate Inference - Direct Sampling
6. Reasoning over time
    - **a.** Time and Uncertainty, Inference in temporal models
    - **b.** Hidden Morkov Models, Algorithms: Filtering, Smoothing, Finding the most likely sequence, EM algorithms for Learning the parameters of HMM
7. Ethics in AI
    - **a.** Explainable AI- Logically Explained Network, Explainable Bayesian Network

Learning Outcomes:

No	Learning Outcomes
LO1	Understand the environment and process of development to build intelligent agents
LO2	Identify heuristics to pursue goals in exponentially large search spaces.
LO3	Represent problem and derive reasoning using logical inferences
LO4	Apply probability theory to describe and model agents operating in uncertain environments
LO5	Analyze ways for agents to learn and improve their behavior.

Part B: Course Handout

Academic Term	**First Semester, 2022-23**
Course Title	**Artificial and Computational Intelligence**
Course No	**DSE**ZG557**
Lead Instructor	

Session #	List of Topic Title (from content structure in Part A)	References
1	(1) What is Artificial Intelligence: Acting Humanly, Thinking humanly, Thinking rationally, Acting Rationally (2) Foundations of AI (3) Brief Overview of Modern AI & Application Domains.	T1: 1.1 T1: 1.2, 1.4
2	(1) Intelligent Agents: Notion of Agents and Environments, Rationality (2) Nature of Environments, Structure of Agents	T1: Chapter 2
3	Problem Solving Agent: (1) Problem Formulation - Examples (2) Uninformed Search Algorithms: Uniform cost Search, Depth Limited Search, Iterative Deepening Search. (3) Notion of Heuristics (4) Informed Search Algorithms : Greedy best first search, A* search	T1: Chapter 3.1-3.4, 3.5.1, 3.5.2

4	Problem Solving Agent using Informed Search: (1) Optimality of A* Heuristic Functions: (1) Heuristic Accuracy & Algorithm performance (2) Admissible heuristics from relaxed problems, pattern databases. & Experience	T1: Chapter 3.5.2, 3.6
5	Local Search Algorithms & Optimization Problems (1) Hill Climbing Search (2) Simulated Annealing, (3) Local Beam Search	T1: Chapter 4.1
6	Local Search Algorithms & Optimization Problems (1) Genetic Algorithm	T1: Chapter 4.1, Research papers & web resources
7	Local Search Algorithms & Optimization Problems (1) Ant Colony Optimization (2) Particle Swarm Optimization	Research papers & web resources
8	Searching to play games: (1) Minimax Algorithm (2) Alpha-Beta Pruning (3) Making imperfect real time decisions	T1: Chapter 5.1 to 5.4
9	Logical Agent: (1) Logic Representation of a sample agent (2) DPLL Algorithm, Agents based on Propositional logic (3) Overview of First Order Logic semantics, Example representation	T1: Chapter 7.1, 7.2, 7.5.2, 7.5.3, 7.6.1, 8.1, 8.3.4
10	Inference in First Order Logic (1) Unification & Lifting (2) Forward chaining (3) Backward Chaining	T1: Chapter 9
11	Inference in First Order Logic (1) Resolution Probabilistic Representation and Reasoning (1) Inference using full joint distribution & Example (2) Knowledge representation using Bayesian Networks	T1: Chapter 9, 13, 14.1

12	Probabilistic Representation and Reasoning (1) Semantics of Bayesian Networks (2) Representation of Conditional Independence using BN	T1: 14.2, 14.3
13	Probabilistic Representation and Reasoning (1) Exact Inference - by enumeration and variable elimination (2) Need for Approximate Inference - Direct Sampling	T1: 14.4, 14.5
14	Reasoning over time (1) Time and Uncertainty (2) Inference in temporal models	T1: Chapter 15.1, 15.2
15	Reasoning over time (1) Hidden Markov Models (2) Learning HMM Parameters using EM Algorithm (3) Applications of HMM	T1: Chapter , 15.3, 20.3-20.3.3
16	Ethics in AI: (1) Explainable AI- Logically Explained Network, Explainable Bayesian Network	Research papers & web resources

Detailed Plan for Lab work/Design work

Lab No	Lab Objective	Lab Sheet Access URL	Content Reference
1	Implementing Uninformed Search Algorithms	NA	Module #2
2	Implementing Informed Search Techniques	NA	Module #2
3	Implementing Local Search Techniques	NA	Module #2
4	Implementing adversarial search techniques	NA	Module #3
5	Representing knowledge using logics and performing reasoning	NA	Module #4
6	Experimenting with Bayesian Networks and Inferencing	NA	Module #5
7	Experimenting with HMM	NA	Module #6

Case studies: Detailed Plan

Case study No	Case study Objective	Case study Sheet Access URL
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Evaluation Scheme:
Legend: EC = Evaluation Component; AN = After Noon Session; FN = Fore Noon Session

No	Name	Type	Duration	Weight	Day, Date, Session, Time
EC-1	Quiz-I	Online	-	5%	TBA
	Assignment -1	Take-Home	-	13%	TBA
	Assignment -2	Take-Home	-	12%	TBA
EC-2	Mid-Semester Test	Open/Closed Book	1.5 hours	30%	TBA
EC-3	Comprehensive Exam	Open/Closed Book	2.5 hours	40%	TBA

Note:
Syllabus for Mid-Semester Test (Open/Closed Book): Topics in Contact Sessions: 1 to 8
Syllabus for Comprehensive Exam (Open/Closed Book): All topics

Important links and information:
Elearn portal: https://elearn.bits-pilani.ac.in
Students are expected to visit the Elearn portal on a regular basis and stay up to date with the latest announcements and deadlines.
Contact sessions: Students should attend the online lectures as per the schedule provided on the Elearn portal.
Evaluation Guidelines:

1. EC-1 consists of two Assignments and one Quiz. Students will attempt them through the course pages on the Elearn portal. Announcements will be made on the portal, in a timely manner.
2. For Closed Book tests: No books or reference material of any kind will be permitted.
3. For Open Book exams: Use of books and any printed / written reference material (filed or bound) is permitted. However, loose sheets of paper will not be allowed. Use of calculators is permitted in all exams. Laptops/Mobiles of any kind are not allowed. Exchange of any material is not allowed.
4. If a student is unable to appear for the Regular Test/Exam due to genuine exigencies, the student should follow the procedure to apply for the Make-Up Test/Exam which will be made available on the Elearn portal. The Make-Up Test/Exam will be conducted only at selected exam centres on the dates to be announced later.

It shall be the responsibility of the individual student to be regular in maintaining the self-study schedule as given in the course handout, attend the online lectures, and take all the prescribed evaluation components such as Assignment/Quiz, Mid-Semester Test and Comprehensive Exam according to the evaluation scheme provided in the handout.