INDIAN INSTITUTE OF TECHNOLOGY KHARAGPUR

Proposal for a new course in CAI

1	Name of the Department/Centre	**Centre for Artificial Intelligence**
2	Name of the Subject	**Artificial Intelligence: Foundations and Applications**
3	L-T-P and Credit	**3-1-0 (4 credit)**
4	Status of the subject	
	(a) Specify the Session, Semester, from which the subject is going to be offered (b) Please Specify the Level of the Subject (c) Whether the subject will be offered as compulsory or elective (d) The semester in which the subject will be offered (e) Name(s) of the Programme(s) in whose curricula this subject will be included	Autumn 2020-2021 **B. Tech, M. Tech, Integrated M.Sc, Ph. D**. **Elective (Core for Micro-Specialization in AI)** **To be decided** (1) Elective course for 5 year integrated M.Sc./B. Tech./Dual Degree students *in any discipline* (2) Elective Course for research scholars *in any discipline* (3) Elective course for M.Tech. students *in any discipline*
5	Prerequisite(s) for the subject, if any (Please give the subject numbers and names)	Programming and Data Structures

6	Objective and Contents (in 100 to 150 words)	The primary objective of this course is to indroduce the gamut of real-life problems where AI techniques can be successfully applied and detailing the necessary foundations to enable solving those practical problems. Hence, the contents of the course will revolve around several practical case-studies and provide foundational understanding to apply AI methods in solving them effectively. This course shall also provide necessary theoretical insights spanned across four layers – knowledge representation and logic; search and reasoning frameworks; ramifications of AI techniques under various scenarios/constraints; and observations/updations of methods from learning. These foundational and theoretical aspects will be enabled by suitable tools and appropriate communication interface designs, thereby bringing a holistic view of problem solving through applications of AI techniques.
7	Names of the faculty members of the Department/Center/School who have the necessary expertise and will be willing to teach the subject (Minimum two faculty members should be willing to teach the subject)	1. Partha Pratim Chakrabarti 2. Pallab Dasgupta 3. Sudeshna Sarkar 4. Pabitra Mitra 5. Adway Mitra 6. Jiaul Paik 7. Arijit Mondal (to join CAI on Dec-2019)
8	Do the contents of the subject have an overlap with any other subject offered in the Institute?	30% of Artificial Intelligence Course (CS60045) in CSE [Though there is some overlap, we expect that many students of various departments, centres and schools other than CSE will benefit from this course due to the demand on this topic]
9	Recommended Text-books/References	
	(a) Text-Books ========== (b) Reference	1. *Artificial Intelligence: A Modern Approach*, Stuart J. Russell and Peter Norvig, 3rd Edition, Prentice Hall, 2009. 2. *Principles of Artificial Intelligence*, Nils J. Nilsson, Morgan Kaufmann, 1982. ========== 3. *Artificial Intelligence: A New Synthesis*, Nils J. Nilsson, 1st Edition, Morgan Kaufmann, 1998. 4. *Heuristic Search: Theory and Applications*, Stefan

		Edelkamp and Stefan Schroedl, 1st Edition, Morgan Kaufmann, 2011. 5. *Heuristics: Intelligent Search Strategies for Computer Problem Solving*, Judea Pearl, Addison Wesley Longman Publishing Co., 1984. 6. *The Quest for Artificial Intelligence*, Nils J. Nilsson, Cambridge University Press, 2009. 7. *Logic in Computer Science: Modelling and Reasoning about Systems*, Michael Huth and Mark Ryan, 2nd Edition, Cambridge University Press, 2004. 8. *The Cambridge Handbook of Artificial Intelligence*, Keith Frankish and William M. Ramsey (ediitors), Cambridge University Press, 2014.
10.	Names of Departments/Centers/Schools/ Programmes whose students are expected to register for this subject	Any UG or PG student of any department / centre / school who has undergone a course on Programming and Data Structures or equivalent

Lecture-wise Topics: **52 lecture hours** including classes and tutorials

(1) Introduction to AI **(4 lectures)**

- (a) Historical Evolution and AI today
- (b) Architecture of AI Systems
  - i. Theory (Knowledge, Logic, Search, Reasoning, Planning, Learning)
  - ii. Tools and Applications
  - iii. Interface (Sensing, Actuation, Control)
- (c) Domains and Scope of AI Applications
  - i. Inter-disciplinary Problem Solving
  - ii. Intelligent/Expert Knowledge based Systems
  - iii. Case-studies and Success Stories

(2) Knowledge Representation Methods [Each sub-topic will have case studies]

- (a) State Space Representation **(2 Lectures)**
  - i. Graph Representation
  - ii. Constraint oriented Symbolic Representation
  - iii. Examples: Timetable building, Puzzle solving (Sudoku), Path finding, Scheduling
- (b) Logical Representations **(4 Lectures)**
  - i. Propositional, First-order Logic

ii. Descriptive Logic Representations (Prolog)
iii. Propositional Temporal Logic
iv. Modelling Examples

(c) Knowledge Graphs **(3 Lectures)**

i. Ontology Representation
ii. Semantic Graphs
iii. Representation and Access Mechanisms
- Tools: neo4j Graph Platform, Grakn knowledge graph

(3) Basic Artificial Intelligence Methods [Each sub-topic will have case studies]

(a) Heuristic Search **(3 Lectures)**

i. Solving: Backtracking and CSP Search
ii. Optimization: DFBB, Best-first Search / A* Search, IDA* search
iii. Search over Large Knowledge Graphs
- Examples: Puzzle solving, Airline Timetable/Scheduling, Path finding

(b) Reasoning & Deduction **(3 Lectures)**

i. Proof Techniques
ii. Tools: Coq prover, SAT/AMT solver (Zchaff/Z3)
iii. Examples: Program analysis, State reachability analysis

(c) Planning, Action, Control **(3 Lectures)**

i. Graph-plan, SAT-plan, Hierarchical-plan
ii. Case-study: Robot motion planning
iii. Tools: FeedForward-FeedDownward Planner, SATPlan/Simba

(d) Learning **(5 Lectures)**

i. Decision-tree learning
ii. Supervised and Unsupervised learning
iii. Classification and Regression
iv. Support Vector Machines
v. Neural Networks (Basics)
vi. Reinforcement Learning
vii. Tools: TensorFlow, MLFlow etc.

(e) Communication and Interaction **(4 lectures)**

i. Mode of communication (Language, Speech)
ii. Models of communication (Sensor, Actuator)
iii. Human-like interactions (Turing-test problem)
iv. Case-studies: Chatbot, Robotic-arm sensing/control/actuation

(4) Real-World Considerations [Each sub-topic will have case studies]

- (a) Time and Memory Constraints **(4 lectures)**
  - i. Contract search, Anytime search
  - ii. Memory-bounded search
  - iii. Search with Real-time adjustments
  - iv. Multi-objective Search
  - v. Case-study over large dynamic graphs
- (b) Uncertainty and Incomplete Information **(3 Lectures)**
  - i. Bayesian Network
  - ii. Probabilistic Reasoning and inference
  - iii. Markov models and reasoning
  - iv. Case-study: The Alarm Monitoring System
- (c) Environmental Models **(3 Lectures)**
  - i. Observability (full / partial)
  - ii. Information (known / unknown)
  - iii. State (deterministic / stochastic)
  - iv. Periodicity (discrete / continuous)
  - v. Adversarial Games
  - vi. Case-study involving agents, environment and games
- (d) Distributed, Multi-Agent Scenarios **(3 Lectures)**
  - i. Collaborative Problem Solving (Ex. Crowdsourced recommender)
  - ii. Competitive Problem Solving (Ex. Multi-player games)
  - iii. Utility based (dynamic) Problem Solving (Ex. Stock Market)

(5) Case Studies **(6 Lectures)**

- (a) Transportation
  - i. Dynamic vehicle routing, pick-up and drop
  - ii. On-demand high-capacity ride-sharing via dynamic assignment
  - iii. Optimal Pricing for Improving Efficiency of Taxi Systems
- (b) Game Design and Play: Alpha-beta pruning in Chess, Alphago
- (c) VLSI System Design: Specification, Validation, Synthesis
- (d) Socially and Globally Relevant: Weather forecasting

(6) Summary and Conclusions **(2 Lectures)**

- (a) Capabilities and Limitations
- (b) Impact on Society
- (c) AI of the Future