COL778: Principles of Autonomous Systems

Semester II, 2023-24

Course Organization

Rohan Paul

Course Information

- Name
  - Couse Name: Principles of Autonomous Systems
  - Credits: 4
  - LTP: 3-0-2
- Timing
  - Slot: AA
  - Class Days: Mondays - Thursdays
  - Class Times: 2:00pm – 3:20pm
  - Room: LH421

Course Logistics

- Instructor
  - Prof. Rohan Paul
  - Email: rohan@cse.iitd.ac.in
  - Course webpage: https://www.cse.iitd.ac.in/~rohanpaul/teaching
- Teaching Assistant
  - Head TA: Namasivayam K (CSE PhD Student). Other TAs will be added when notified by the department.
- Communication
  - Formal communication will be on the course mailing list
    - 2302-COL778@courses.iitd.ac.in
  - Piazza forum will be setup for assignment related queries.

History

- This course is being offered the first time. Students may refer to the courses of study for the description of COL778.
- The course material will build on the COL864 course: Special Topics in AI that the instructor has taught a few times before. Students may refer to the course material for COL864 to get an idea.
- This 7xx level course will have a larger foundational material, and more practical component. The COL864 level course will remain as the research-oriented course.
- Students who have taken COL864 course in the last semester (Sem I for 2023-24) or before with me are not permitted to take the present COL778 course.

Teaching Mode

- Lectures
  - Any slide material will appear on the course webpage. Will be typically updated after the class.
  - Blackboard teaching will also take place.
  - Extra teaching days may be utilized (discretionary and with prior notification). Extra classes will be announced at least one day in advance.
  - Class participation is highly encouraged.

Who should take this course?

- Pre-requisites
  - Foundation course in AI or ML
    - Introduction to Artificial Intelligence (COL333-COL671) or Introduction to Machine Learning (COL774 or equivalent).
  - Others
    - Programming proficiency (Python and ability to install/work with external libraries/install and use a simulator on your own).
    - Good knowledge of probabilistic models, basic deep learning, basic search algorithms, Markov Decision Processes.
    - Prior experience in training neural networks using PyTorch etc. will be an advantage. A tutorial will be provided in the course for the concerned assignments.

Evaluation Criteria (tentative)

- Component I: Examination (theoretical aspects): 60%
  - Mid-term and Major Exam
- Component II: Assignments (practical aspects): 40%
  - Implementation and experimentation
- Margin: ~20% (discretionary)
  - Instructor's discretion as contingency.
  - This is for adjustments during the semester.

Other Policies

- Pass Criteria for Credit
  - 30% of the total score in the course
- Criteria for Audit Pass (NP)
  - Grade “B-” or higher AND at least 30% in each course component (examinations and assignment components individually).
- Institute guidelines will apply if announced by the Dean.

Examinations

- Standard offline mode.
- Information regarding exam logistics will be provided before the exam.

Assignments

- Detailed instructions will be provided for each assignment.
- Typically, assignments will be done individually. Some assignments may be allowed in groups and will be notified at the time of release of the assignment.
- Please ensure access to Moodle.
- Basic proficiency in Python/C++ and ability to install/work with external libraries if required for an assignment on your own.
- Typical assignment submission time will be 6pm. No deadline extensions please.
- Any delays beyond the submission time will result in late penalty of X% per day (from the submission day and time). Typically, X is 10%
- Any changes to the code or replacement of files after deadline are not permitted.

What is this course about?

- Autonomous Systems
  - A class of AI systems/applications called Embodied AI
  - Capacity of
    - Sensing, decision making and interacting with the physical world.
    - Physical interaction, exchange of energy with the physical environment.
  - Names: Intelligent Robotic Systems or Embodied AI (EAI).
  - Why now?
    - Advances in computing and sensing is making computing + AI systems pervasive.
    - We can start imagining a future where we can interact with such systems as we can now interact with other hardware.

- An Algorithmic Toolkit
  - Estimation
  - Planning
  - Decision-making under uncertainty. Learning.
  - Overlap with Learning/AI. Connections will be strengthened and in other cases new concepts will be introduced.

Topics

- Introduction
- State Estimation
- Classical State-space Planning
- Task Planning
- Decision-making under Uncertainty
- Reinforcement learning (relevant applications only)
- POMDPs
- Imitation Learning
- Deep Learning Applications
- Basics of Robot Perception
- The topic list is tentative and will be updated as the lectures are presented. Please see the previous offerings of the course to get a sense of the topics. These will be updated in this offering.

Review Before Class

- Please review the following specific topics before class as pre-requisites.
  - A* Search
  - Markov Decision Processes
  - Basic concept of Reinforcement Learning
  - Hidden Markov Models
  - Basics of Probabilistic Graphical Models
- Please refer to a standard AI textbook to refresh the above.

Books and References

- Primary resource is the **lecture material**.
- Books
  - Material is derived from various sources. The relevant sections will be indicated on the course webpage.
    - Artificial Intelligence: A Modern Approach (3rd Edition). Russell, Stuart J., and Peter Norvig. Link.
    - Sebastian Thrun, Wolfram Burgard and Dieter Fox. Probabilistic Robotics. MIT Press, 2005.
    - Reinforcement Learning (Second Edition). Richard Sutton and Andrew Barto. MIT Press. 2018. Online.
    - Deep Learning. Ian Goodfellow, Yoshua Bengio and Aaron Courville. Online.
    - Mykel Kochenderfer, Decision Making Under Uncertainty
    - Steven LaValle. Planning Algorithms. Cambridge University Press, 2006.
- Paper references
  - Any paper references mentioned will be provided on the course webpage.

Learning Objectives

- At the end of the course students will model a robotic system (e.g., a ground robot or manipulator) as a decision-making AI and Learning agent.
- Students will be able to formulate/solve relevant planning and estimation problems in this domain.
- Understand how to incorporate recent learning-based methods decision-making algorithms.
- Undertake independent project work in this area in future.
- Applicable to various industries:
  - The deal with noisy imperfect data from sensors.
  - Autonomous system, Robotics, applications are broad.
  - Industries that develop software for intelligent systems.
  - Academia and research labs.

Other Information

- This course will focus on AI aspects of autonomous systems.
- A robotic system (ground/air vehicle or manipulator) will be modeled as an AI agent capable of sensing and taking simple actions in the environment.
- The detail control and physical aspects of the system will be abstracted to a certain degree for the models discussed in the course.

Academic Integrity

- Please listen to your conscience. Please do not cheat.
- Please only submit the assignment only based on your own efforts.
  - Please write code or other written submissions from scratch independently. Sharing of code or parts of it or posting it online will constitute a violation of the honor code.
  - Do not look at or refer to code written by anyone else. You may discuss the problem, however the code implementation must be original. Discussion will not be grounds to justify software plagiarism.
  - Do not submit code copied from the internet or copied from students who have taken a related course earlier
  - If the assignment requires a report to be submitted, please write on your own based on your own understanding. Copying in the repot will also constitute as plagiarism.
  - Any mechanisms such as code similarity s/w or others can be used by the department to assess plagiarism.
- For fairness to honest students, plagiarism cases will be penalized with exclusion from assessment and additional penalties.

Honor Code Violations

- We are duty bound to follow the disciplinary procedures of the Department and the Institute in this regard.
  - Plagiarism in assignment/exam will result in zero in the assignment/exam and an additional penalty on an absolute scale (at least -10 absolute). Department and institute procedures such as DISCO and an F-grade will follow.
  - Copying or cheating in even a sub-part of an assignment or an exam will be counted as plagiarism in the whole assignment/exam. The whole assignment and exam will be made void with additional penalties and Dept. procedures.
  - In case an assignment allows working in pairs, both students will receive penalty even if only one student may be involved.
- Institute procedure will be followed
  - Dealing with plagiarism is part of the instructor's and the department's mandate. Please do not argue if you are found to be plagiarizing.
  - Any discussions will be at in the department committee. We will forward the names and the findings as per institute guidelines. Information will be shared with other faculty members for future courses and projects.

Other Emergencies

- Requests for late submissions or re-appearing in an exam on the grounds of medical emergencies must be accompanied with a medical certificate from a qualified doctor indicating that you were unwell in the period of submission and a proof of prescription.
- Provided to the TA before the submission deadline not afterwards.
- Any request to appear in the re-minor will require formal proof that you were unwell or exceptional circumstances prevailed during the minor due to which you could not appear. The proof will be used by the Department and the Dean to decide if a re-minor will be permitted on not.
- Follow institute guidelines for missing examinations.

Next Time

- This Class
  - Course Organization
- Next Class
  - Introduction