EE 67074 AI planning: from graph search to reinforcement learning

Course logistics

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Course webpage Canvas https://canvas.nd.edu/courses/80627
Course page https://www.mengxuehou.com/courses/2023fall/

Course schedule Tuesday/Thursday 12:30pm – 1:45pm
Course venue DeBartolo Hall room 205

Course information

Realizing the dreams of autonomy requires autonomous systems that learn to make good decisions. Decision-making is a fundamental challenge in an enormous range of tasks, including robotics, transportation systems, and smart manufacturing, etc. This class will provide a solid introduction to the field of AI planning and decision-making, with a focus on robotic applications. The lectures will start from AI planning methods for deterministic systems and approach to learning near-optimal decisions from past experiences in the real world full of uncertainty. This course is intended for graduate students interested in robotics, autonomy, control, and learning.

Course outline

- Deterministic decision-making: graph search, AI planning & automated planning, dynamic programming, model predictive control
- Decision-making under uncertainty: Markov Chain, Markov Decision Processes, Hidden Markov Chain, Partially Observable Markov Decision Processes
- Reinforcement Learning: model-based RL, policy gradients, value function based methods, actor-critic methods

We will cover these topics through a combination of lectures, assignments, and programming-based projects.

Textbooks:

(Recommended) Artificial Intelligence: A Modern Approach, Stuart J. Russell and Peter Norvig
(Recommended) Principles of Robot Motion: Theory, Algorithms, and Implementations, Howie Choset, Kevin Lynch, Seth Hutchinson, George Kantor, Wolfram Burgard
(Recommended) Reinforcement Learning: An Introduction, Sutton and Barto, 2nd Edition

Prerequisites for this class:

- Programming: all assignments will be in Python. If you have programming experiences but in different language, you will probably be fine.
- Calculus, Linear algebra: You should be comfortable understanding matrix operations and taking derivatives.
- Basic probability and statistics: you should know basics of probability, Bayesian updating law, etc.

Office hours

I will be very available during my office hours, and I encourage you to come and see me. I usually use office hours to answer any question you may have and work extra-problems with you. I kindly ask that you indicate your presence by sending me an email. I will cancel office hours if no student is booked 15 min before the office hour time.

My office hours will be held 2:00 pm on Thursday every week in Cushing Hall 226B.

Homework (40%)

There will be homework with due dates approximately every 2 weeks. You are expected to do all required assigned problems. Working through problems is a crucial part of the learning process and will have a major impact on your understanding of the material, which will in turn be reflected on your course grade. Every homework is expected to be finished in around 4 hours. Talk to me if you are taking far more than 4 hours to finish the homework.

We implement a positive reinforcement policy for returning assignments. Upon returning your assignment on time, you receive an automatic 3% bonus on top of our grade or a 100% grade, whichever is smaller. Such bonuses do not carry over to other assignments. You can submit your assignment up to 48 hours after the deadline by forfeiting the bonus, but no assignment will be accepted after that. In general, it is a good idea to start working on the homework early. You are also allowed (and encouraged) to ask me questions about homework during office hours, provided you have thought about the problems before. I will assume that you have worked and understood all homework problems when preparing the exams.

Homework must be turned in electronically on Canvas and your solutions are encouraged (but not required) to be typed in LATEX, which is the standard for technical documents.

The homework will consist of mathematical problems and programming problems. The programming assignments are an opportunity to explore more “hands-on” facets of AI and are equally important. The programming problems will be evaluated based on two criteria:

1. whether your code runs or not and whether it does what it is supposed to do;
2. the quality of your analysis of the simulation results; clarity and conciseness are extremely important.

It is essential that you properly reference your sources for your text, figures and tables, in your reports. Cases of plagiarism, such as unreferenced verbatim copying or paraphrasing from any source, will be referred to the Dean of Students for investigation and penalties. Exchange of source and LATEX code constitutes a case of plagiarism.

It is acceptable to work on problems in small groups, provided you turn in your own writeup.

Midterm Exam (30%)

There will be a midterm exam, tentatively scheduled on **Oct. 12, 2023** during class. The exam will be of theoretical and mathematical nature, and will consist in problems similar to those assigned in the homework. A **review class** will be held before the midterm to help you better prepare for it, tentatively scheduled on Oct. 10, 2023.

Final Project (30%)

There will not be a final exam in this class. But there will be a final project to be completed in teams of 3-4 students. Exact details will be provided in Oct., but the project essentially consists in of an in-depth study of a topic of your choosing: you may choose to center your project around a particular problem/dataset that you have encountered in your research or elsewhere online, you could do a more theoretical investigation of some aspect related to AI planning, or you might instead choose to do a more in-depth investigation of some area of robotics/control, or reinforcement learning not covered in this course. Please feel free to consult early and often with me regarding the choice of the project topic. The project deliverables will consist of a 1-page proposal, a final report, and a presentation.

Handouts and announcements

Handouts and announcements will be posted on Canvas, approximately 1 day prior to class.