ASEN/CSCI 5264: Decision Making under Uncertainty

Zachary Sunberg

Spring 2024

Prerequisites

- Basic familiarity with probability
- Fluency in a high level programming language and willingness to learn Julia.

Rough Schedule and List of Topics

(See Piazza for detailed and updated schedule.)

1. Probabilistic Models :
   - Probability
   - Conditional probability
   - Markov processes
   - Introduction to Bayesian networks
2. Markov Decision Processes :
   - Markov decision processes (MDPs)
   - Value iteration (contraction proof of convergence)
   - Policy iteration
   - Approximate dynamic programming
   - Online tree search
3. Reinforcement Learning :
   - Exploration and exploitation
   - Bandits
   - Model-free RL
   - Model-based RL
   - Deep Q learning
   - Policy gradient
   - Actor-critic
   - Entropy Regularization
4. POMDPs :
   - Hidden Markov models
   - Bayesian lters
   - Particle lters
   - Partially observable Markov decision processes (POMDPs)
   - Exact POMDP methods
   - O ine POMDP methods
   - Online POMDP methods
   - QMDP
5. Other Topics :
   - Games and multi-agent interaction
   - Meta and transfer learning
   - State of the art overview (e.g. Recent Deep RL Algorithms)

Websites

- Piazza will host course discussions, announcements, and host solutions that are not posted publicly. Students are encouraged to ask questions here. Rather than emailing questions to the teaching sta , I encourage you to post your questions on Piazza. The class signup link is at https://piazza.com/colorado/spring2024/asen5264 .
- Gradescope will be used for all assignments and exams.
- Github will be used to host all course materials.

Attendance and Participation

Learning is a collaborative e ort between the instructor and students. If students are registered for the in-person section, they are expected to attend class and participate in discussions and exercises. Remote students are expected to watch the recorded lectures, ask questions on the Piazza discussion board if there is confusion, and monitor course announcements delivered via Piazza or email.

Textbook

Mykel J. Kochenderfer, Tim A. Wheeler, and Kyle H. Wray, Algorithms for Decision Making . 2020. Available Online: http://algorithmsbook.com . $95.00.

Additional References

- Richard S. Sutton and Andrew G. Barto, Reinforcement Learning: An Introduction , 2nd Ed. MIT Press, 2018.$80.00, Available online: http://incompleteideas.net/book/the-book-2nd.html
- Dimitri P. Bertsekas, Dynamic Programming and Optimal Control, Athena Scienti c, 2012 (4th Ed.). $134.50
- Mykel J. Kochenderfer, Decision Making Under Uncertainty: Theory and Application, MIT Press, 2015. $70.00, Available online: https://ieeexplore.ieee.org/book/7288640
- Tom Kwong, Hands-On Design Patterns and Best Practices with Julia, Packt Publishing, 2020. $39.99
- Stefano Albrecht, Filippos Christianos, and Lukas Schafer, Multi-Agent Reinforcement Learning: Foundations and Modern Approaches Available online: https://www.marl-book.com/
- Laura Graesser, Wah Loon Keng, Foundations of Deep Reinforcement Learning: Theory and Practice in Python. Pearson Education, 2020.$50.00.

Assignments and Grading

- 40% Homework Assignments. There will be 6 large homework assignments, due approximately every two weeks. A typical assignment will consist of
  - { Several conceptual questions or exercises.
  - { One open-ended programming problem. You solution will be evaluated locally with obfuscated code and the score submitted to a leaderboard. The best performers will share their solution in class.
- 30% Exams. There will be three Exams consisting of several conceptual questions or exercises. Each exam will be taken remotely and timed for approximately 90 minutes. You will have a 24hr period within which to take the exam.
- 30% Final Project. A nal project chosen by the student that ideally connects to their research. Deliverable will be a 4-8 page report. Project may be completed in teams of up to 3.

As of the beginning of the course, participation is not expected to be a factor in assigning grades, however it may become a factor at the instructor's discretion. The class will be noti ed if participation from that point forward will be considered.

Late Policy

To ensure proper progression through the course, students are expected to begin assignments early and submit homework assignments on time. However, in order to provide for minor unforeseen events or responsibilities, students may turn in late homework assignments within 72 hours of the due date with a 10% penalty without any questions asked.

Exams must be turned in on time. If there is a technical error that causes you to miss the deadline, email me with images of the exam immediately so that I have a record of when you nished the exam. Penalties for missing an exam or nal project deadline will be determined on a case-by-case basis.

If a student has a special circumstance such as a major medical procedure, major family responsibility, or a religious observance that will prevent them from completing course work on time, this should be coordinated with the instructor before the due date.

Course Sta

Instructor : Professor Zachary Sunberg
AERO 263 zachary.sunberg@colorado.edu
O ce Hours : Posted on Piazza

Teaching Assistant : Ben Chupik
benjamin.chupik@colorado.edu
O ce Hours : Posted on Piazza

Meetings

T/TH 11:30-12:45, AERO 111 { Lecture video will automatically be posted online after class - see Piazza for link.

Additional Policies

Classroom Behavior

Students and faculty are responsible for maintaining an appropriate learning environment in all instructional settings, whether in person, remote, or online. Failure to adhere to such behavioral standards may be subject to discipline. Professional courtesy and sensitivity are especially important with respect to individuals and topics dealing with race, color, national origin, sex, pregnancy, age, disability, creed, religion, sexual orientation, gender identity, gender expression, veteran status, political a liation, or political philosophy.

For more information, see the classroom behavior policy, the Student Code of Conduct, and the O ce of Institutional Equity and Compliance.

Requirements for Infectious Disease

Members of the CU Boulder community and visitors to campus must follow university, department, and building health and safety requirements and all applicable campus policies and public health guidelines to reduce the risk of spreading infectious diseases. If public health conditions require, the university may also invoke related requirements for student conduct and disability accommodation that will apply to this class.

If you feel ill and think you might have COVID-19 or if you have tested positive for COVID-19, please stay home and follow the guidance of the Centers for Disease Control and Prevention (CDC) for isolation and testing. If you have been in close contact with someone who has COVID-19 but do not have any symptoms and have not tested positive for COVID-19, you do not need to stay home but should follow the guidance of the CDC for masking and testing.

Accommodation for Disabilities, Temporary Medical Conditions, and Medical Isolation

If you qualify for accommodations because of a disability, please submit your accommodation letter from Disability Services to your faculty member in a timely manner so that your needs can be addressed. Disability Services determines accommodations based on documented disabilities in the academic environment. Information on requesting accommodations is located on the Disability Services website. Contact Disability Services at 303-492-8671 or dsinfo@colorado.edu for further assistance. If you have a temporary medical condition, see Temporary Medical Conditions on the Disability Services website.

Students are expected to start on assignments early so that minor temporary medical conditions do not prevent them from turning assignments in on time. In addition, the late policy is designed to accommodate minor temporary medical conditions. If you have a major medical emergency that prevents you from completing an assignment, please contact the instructor as soon as possible to discuss accommodations.