ASEN 6519-007: Decision Making under Uncertainty

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Prerequisites

1. Fluency in a high level programming language and willingness to learn a new one (any language will be allowed on assignments, but some Julia, up to the level of writing functions, will be required)
2. Basic knowledge of applied probability

Rough Schedule and List of Topics

(See Canvas for detailed schedule.)

1. **Probabilistic Models [1/16 - 1/23]**:
   - Probability
   - Conditional probability
   - Bayesian networks
   - Markov processes
2. **Problems with Outcome Uncertainty [1/28 - 2/13]**:
   - Markov decision processes (MDPs)
   - Value iteration (contraction proof of convergence)
   - Policy iteration
   - Approximate dynamic programming
   - Online tree search
3. **Problems with Model Uncertainty [2/18 - 3/5]**:
   - Reinforcement learning (RL)
   - Exploration and exploitation
   - Bandits
   - Model-free RL
   - Model-based RL
   - Deep Q learning
   - Policy gradient
   - Actor-critic
4. **Problems with State Uncertainty [3/10 - 4/2]**:
   - Hidden Markov models
   - Bayesian filters
   - Particle filters
   - Partially observable Markov decision processes (POMDPs)
   - Exact POMDP methods
   - Convexity of POMDP value functions
   - Offline POMDP methods
   - Online POMDP methods
   - QMDP
5. **Other Topics [4/7-4/30]**: Alpha Go, Alpha Star, D-separation of Bayesian networks, Bayesian network parameter and structure learning, games, alternative optimization objectives (risk averse, robust, constrained), ρ-POMDPs, meta-learning, how to review academic publications

Learning Technology

Canvas will be the main hub for the course. A detailed schedule and assignments will be posted here.
Piazza will host course discussions. Students are encouraged to ask questions here.
RedPen.jl will be used to submit solutions to the open-ended homework assignments.

Assignments and Grading

60% Homework Assignments. There will be 6 large homework assignments, due approximately every two weeks. Each assignment will consist of

- Several conceptual questions
- Two or three exercises that will require some programming or math
- One open-ended 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.

35% Final Project. A final project chosen by the student that ideally connects to their research. Deliverable will be a 6 page report. Project may be completed in teams of up to 3.
5% Peer Review. You will be assigned 2 project reports from other teams in the class to write peer reviews for.

Late Policy

For **homework**, there will be a **20% penalty for every late day**. For the **final project** and **peer review**, there will be a **20% penalty for every late *hour*** (due to the need for quick turnaround). Please use your knowledge of decision making under uncertainty to include appropriate contingency in your plans to avoid these penalties.

Textbook

Mykel J. Kochenderfer, Decision Making Under Uncertainty: Theory and Application, MIT Press, 2015. $70.00, Available online: `https://ieeexplore.ieee.org/book/7288640`

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 Scientific, 2012 (4th Ed.). $134.50

Instructor Contact

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Teaching Assistant

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Meetings

T/TH 10-11:15 am AERO 114