DS 598: Introduction to Reinforcement Learning

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Course Time & Location: Tue/Thu 12:30-1:45, EPC 204

Teaching Assistant: Gaurav Koley

Course Description

This course provides a gentle introduction to the field of Reinforcement Learning (RL). We will cover three main topics:

1. Basic concepts in RL, such as Markov Decision Processes (MDP), planning and learning in MDPs, and exploration & exploitation trade-off, etc.
2. Classic algorithms and algorithm design principles, including model-based learning, value-based learning and policy-based learning.
3. Modern challenges in RL, including exploration with nonlinear function approximations, multi-agent RL, and RL in partially observable environments.

The assessment tools consist of two parts:

1. Homeworks including both written problems and coding problems in Python, using Jupyter notebooks.
2. An RL competition lasting throughout the semester. More details below.

Prerequisites

Programming (DS 210 or equivalent), algorithms (DS 320 or equivalent) should be taken prior to this class. Introduction to ML (DS 340) should be taken prior to or simultaneously with this class. Students should be comfortable about the basics of probability and linear algebra, and experienced with programming in Python.

Textbook

We will primarily refer to the lecture notes, but occasionally we will refer to supplementary materials in the open-source textbook below.

- Alekh Agarwal Nan Jiang Sham M. Kakade Wen Sun. Reinforcement Learning: Theory and Algorithms.

Assignments and Grading

The main components of the course grade are:

- Assignments 40%
- Project 60%+
  - Midterm tournament: 15%(1) /10%(2-3) /5%(4-8)
  - Final tournament: 30%(1) /20%(2) /15%(3) /10%(4-8)
  - Least domain knowledge: 20%(1)
  - Tricks Sharing Presentation: 10%
  - Beating the baseline agent: 10%
  - Final Report: 30%

Tentative Schedule

Dates	Topics	Reading
Week 1	**Fundamentals**: Markov Decision Processes	AJKS: 1.1.1, 1.1.2

Week 2	**Fundamentals**: Markov Decision Processes	AJKS: 1.1.1, 1.1.2
Week 3	**Planning**: Value and Policy Iterations.	AJKS: 1.3.1, 1.3.2
Week 4	**Model-based RL**: Certainty Equivalence Learning	AJKS: 2.1, 2.3
Week 5	**Value-based RL**: Q-learning, DQN	AJKS: 4.1, 4.2
Week 6	**Policy-based RL:** Reinforce, PPO, DRPO	AJKS: 15.2, 15.4
Week 7	**Imitation Learning**: Behavior Cloning, Inverse RL	AJKS: 15.5
Week 8	**Exploration**: MAB and UCB	AJKS: 6.1.1
Week 9	**Exploration**: UCBVI	AJKS: 7.2
Week 10	**Multi-agent RL**: AlphaGo, Optimistic Nash-VI	TBD
Week 11	**Partially Observable MDPs**	TBD
Week 12	**Team Presentation**	TBD

Class and University Policies

Academic Code of Conduct: The BU Academic Code of Conduct is here: https://www.bu.edu/academics/policies/academic-conduct-code/. All students are required to familiarize themselves with this code, its definitions of misconduct, and its sanctions. Students should especially familiarize themselves with the section on plagiarism. On that topic:

Plagiarism: All written work in this course must be original to you. If you consult outside texts, or other forms of assistance, cite these sources in the proper format. This pertains to all external sources (books, journals, lectures, web sites, AI). We are required to report all suspected cases of plagiarism to the Academic Dean for review.

Academic integrity in computing coursework has some special aspects. Please review the examples of plagiarism as provided by the BU Computer

Science department.

Generative AI: All submitted work in this course must conform to the CDS GAIA policy.

Grade Cutoffs: I will determine grade cutoffs after all assignments and exams have been graded. Grade cutoffs will take into account my assessment of the difficulty level of the assignments and exams, and my assessment of what is expected for each letter grade.

Late Work: No late work will be accepted. You must submit all assignments by the designated deadline. Any work submitted after that time will **not** be considered. If you have outstanding circumstances that prevent you from completing the work by the assigned date, please consult with the professor.