

Northeastern University
Department of Electrical and Computer Engineering
EECE 5698 - ST: Reinforcement Learning Syllabus

Semester:

Spring 2023

Course:

EECE 5698 – ST: Reinforcement Learning

Tuesdays and Fridays 9:50 am – 11:30 am

Hayden Hall #221

Instructor: Prof. Mahdi Imani, Assistant Professor, Electrical and Computer Engineering

Email: m.imani@northeastern.edu

Students are encouraged to utilize the class meeting time and Canvas to ask their questions, so the entire class benefits from them.

TA:

Begum Taskazan (taskazan.b@northeastern.edu)

Office hours:

Wednesdays, 12 pm – 1 pm (in-person, Location: Snell Library Colab T (1st Floor))

Fridays, 12 pm – 1 pm (<https://northeastern.zoom.us/j/93538769254>)

Other office hours: By appointments

Course Description:

Covers fundamentals of reinforcement learning. Begins with multi-arm bandit problems and the basics of exploration and exploitation. Relates the key concepts of control theory to dynamic programming and reinforcement learning. Discusses well-known off-policy and on-policy temporal difference learning methods. Covers large-scale learning methods, including deep value-based and deep policy-based methods. Discusses basics of inverse reinforcement learning and imitation learning methods and their connections to inverse optimal control problems.

Corequisite:

Introduction to Machine Learning and Pattern Recognition (EECE 5644)

Student Learning Outcomes:

At the end of the course, the student will be able to:

1. define the key features that distinguish reinforcement learning (RL) from artificial intelligence and non-interactive machine learning;

2. understand RL algorithms and build RL models for sequential decision-making;
3. understand how to formulate a task as an RL problem and how to begin implementing a solution;
4. understand how RL fits under the broader umbrella of machine learning and how it complements deep learning, supervised and unsupervised learning.

Topics, Exams, Projects, and HWs

Date	Topics	HWs/Projects	Ref
L1-Jan 13	Introduction to Reinforcement Learning		
L2-Jan 17	Multi-Armed Bandit	HW1	Ref [1]-Chap 2
L3-Jan 20	Multi-Armed Bandit	Project 1	Ref [1]-Chap 2
L4-Jan 24	Reinforcement Learning Preliminaries		Ref [1]-Chap 3
L5-Jan 27	Reinforcement Learning Preliminaries	<u>HW1 Due</u>	Ref [1]-Chap 3
L6-Jan 31	Bellman Equation and Optimality		Ref [1]-Chap 3
L7-Feb 3	Bellman Equation and Optimality		Ref [1]-Chap 3
L8-Feb 7	Dynamic Programming – Policy Iteration	HW2 <u>P1 Due</u>	Ref [1]-Chap 4
L9-Feb 10	Dynamic Programming – Value Iteration	Project 2	Ref [1]-Chap 4
L10-Feb 14	Policy Iteration – Matrix Form		Ref [1]-Chap 5
L11- Feb 17	Value Iteration – Matrix Form	<u>HW2 Due</u>	Ref [1]-Chap 5
L12- Feb 21	Exam 1		
L13- Feb 24	Approximate Dynamic Programming	HW3	Ref [1]-Chap 5
L14- Feb 28	Monte Carlo Learning		Ref [1]-Chap 6
L15-March 3	Temporal Difference Learning	<u>P2 Due</u>	Ref [1]-Chap 6
L16-March 14	On-Policy Learning	Project 3	Ref [1]-Chap 7
L17- March 17	Off-Policy Learning	HW4 <u>HW3 Due</u>	Ref [1]-Chap 7
L18- March 21	Off-Policy vs. On Policy		Literature
L19- March 24	TD Variations		Literature
L20- March 28	Function Approximations Methods in RL	HW5	Literature
L21- March 31	Least Square Policy Iteration and Neural Fitted Q-Iteration	<u>HW4 Due</u>	Ref [3]-Chap 4
L22-April 4	Exam 2		
L23-April 7	Deep Q Networks		Ref [3]-Chap 4
L24-April 11	DQN Variations: Double, Dueling, Prioritized	<u>HW5 Due</u>	Ref [3]-Chap 5
L25-April 14	Policy Gradient Methods	<u>P3 Due</u>	Ref [3]-Chap 5
L26-April 18	Review Session		

Textbook (s):

The course primary textbook is

- [1] Richard S. Sutton, and Andrew G. Barto. Reinforcement learning: An introduction. MIT press, 2nd Edition, 2018.

Other Reference Texts:

- [2] Csaba. Szepesvári "Algorithms for reinforcement learning." Synthesis lectures on artificial intelligence and machine learning 4.1 (2010): 1-103.
- [3] Vincent François-Lavet, Peter Henderson, Riashat Islam, Marc G. Bellemare, and Joelle Pineau. "An introduction to deep reinforcement learning." Foundations and Trends® in Machine Learning 11, no. 3-4 (2018): 219-354.
- [4] Alberto Leon-Garcia, Probability and Random Processes for Electrical Engineering, Third Edition, Addison- Wesley, 2008

Lecture notes: All handouts, including homework, will be posted in the course learning module (<https://canvas.northeastern.edu>):

Course Name: EECE5698.37044.202330

Lecture Mode: The class will have only in-person mode (with no recording or zoom link); attendance is expected and mandatory.

Exams: There will be no make-up for the exams. Both exams will be closed book.

HWs and Projects: We expect you to turn in all completed problem sets on time. Late submissions will not be accepted unless there is a prior arrangement with the TA/instructor. For project implementation, students are highly encouraged to use Python. For other programming languages, students need to discuss them with the instructor/TA.

Grading: Exam 1: 15%, Exam 2: 15%; HWs: 20%; Project 1: 10%; Project 2: 20%; Project 3: 20%.

Collaboration policy: We encourage working together whenever possible: in sharing your idea/knowledge and general discussions of the materials, HWs and projects. Keep in mind, however, that for the HWs and project, the solutions you hand in should reflect your own implementations and should be written solely by you. It is not acceptable to copy a solution/code that somebody else has written.

Academic Honesty

There is no restriction on discussions, use of texts, or use of library materials while learning how to do any assignment. Indeed students are encouraged to help each other learn! If a solution to a problem is found in the literature, you must provide correct citations. For homework, every student is expected to work through their own analysis

or modeling and to submit their own work. It is not permissible to present another student's work as one's own, nor to copy computer code. With computer programming, there can at times be a fine line between collaboration and copying/duplication of work. However although this line may be fine, it is generally pretty easy to tell where it is. Ultimately you are responsible for any work you hand in, so do not hand in anything you do not understand! In the case of improper collaboration, penalties may be assessed to all students involved. Plagiarism and cheating will be dealt with under the policies described in the student handbook. If you are tempted to cheat, it probably means that you are not ready to carry out the required activity and in that case you should talk to the instructor/TAs about the material, rather than attempting to bluff your way through by cheating. If you have doubts in a specific situation about what level of collaboration is acceptable, ask!

Northeastern University expects students to complete all examinations, tests, papers, creative projects, and assignments of any kind according to the highest ethical standards, as set forth either explicitly or implicitly in this Code

Go to <http://www.northeastern.edu/osccr/academic-integrity-policy/> (Links to an external site.) to access the full academic integrity policy.

Student Accommodations

Northeastern University and the Disability Resource Center (DRC) are committed to providing disability services that enable students who qualify under Section 504 of the Rehabilitation Act and the Americans with Disabilities Act Amendments Act (ADAAA) to participate fully in the activities of the university. To receive accommodations through the DRC, students must provide appropriate documentation that demonstrates a current substantially limiting disability.

For more information, visit <http://www.northeastern.edu/drc/getting-started-with-the-drc/> (Links to an external site.).

Diversity and Inclusion

Northeastern University is committed to equal opportunity, affirmative action, diversity and social justice while building a climate of inclusion on and beyond campus. In the classroom, members of the University community work to cultivate an inclusive environment that denounces discrimination through innovation, collaboration and an awareness of global perspectives on social justice.

Please visit <http://www.northeastern.edu/oidi/> (Links to an external site.) for complete information on Diversity and Inclusion.

TITLE IX

Title IX of the Education Amendments of 1972 protects individuals from sex or gender-based discrimination, including discrimination based on gender identity, in educational programs and activities that receive federal financial assistance.

Northeastern's Title IX Policy prohibits Prohibited Offenses, which are defined as sexual harassment, sexual assault, relationship or domestic violence, and stalking. The Title IX Policy applies to the entire community, including male, female, transgender students,

faculty, and staff.

In case of an emergency, please call 911.

Please visit www.northeastern.edu/titleix for a complete list of reporting options and resources both on- and off-campus