MA 59800, Fall 2021 Syllabus

Course:	Mathematical Theory and Applications of Deep Reinforcement Learning
Location/Time:	TTh at 10:30 - 11:45 in REC 309
Instructor:	Haizhao Yang, haizhao@purdue.edu, Math. Bld. Room 402 Office hours, Tuesday, 3:00 PM-5:00 PM in **Zoom**, meeting ID: 99654019488, and meeting password: 447709.
Description:	Credit Hours: 3.00. • Learning Outcome 1: Stdents understand basic deep learning and know how to apply deep learning to solve supervised learning problems. • Learning Outcome 2: Students understand the most basic reinforcement learning model: tabular solution methods. • Learning Outcome 3: Students understand an advanced reinforcement learning model: approximate solution methods. • Learning Outcome 4: Students undersand basic deep reinforcement learning and can apply it to several applications. • Learning Outcome 5: Students understand basic deep reinforcement learning theory.
Course Materials:	• Textbook - *Deep Learning* by Ian Goodfellow, Yoshua Bengio, and Aaron Courville. Go to `https://www.deeplearningbook.org/` for a free online textbook. • Textbook - *Reinforcement Learning - An Introduction* by Richard S. Sutton and Andrew G. Barto. Second edition.
Important prerequisites:	Students must review basic numerical linear algebra, differential equations, probability, and optimization by themselves.
Approximate Schedule:	• LO 1.1 Students understand the definition and examples of unsupervised, supervised, semi-supervised, and reinforcement learning • LO 1.2 Deep neural networks • LO 1.3 Students know how to use optimization algorithms for deep learning in supervised learning • LO 1.4 Students understand the generalization of deep learning in supervised learning and know how to use it to explain learning performance

- LO 2.1 Students understand multi-armed bandits
- LO 2.2 Students understand finite Markov decision process
- LO 2.3 Students understand dynamic Programming
- LO 2.4 Students understand Monte Carlo methods
- LO 2.5 Students understand temporal difference learning
- LO 3.1 Students understand on-poicy prediction with approximation
- LO 3.2 Students understand on-policy control with approximation
- LO 3.3 Students understand off-polcy methods with approximation
- LO 3.4 Students understand policy gradient methods
- LO 4.1 Students understand neural architecture search and know how to use deep reinforcement learning to design network structures for deep learning
- LO 4.2 Students understand the application of deep reinforcement learning in scientific computing and implement some examples
- LO 4.3 Students understand how to apply deep reinforcement learning to control problems
- LO 5.1 Students understand approximation theory
- LO 5.2 Students understand optimization theory
- LO 5.3 Students understand generalization theory

GRADING:

▶ **Attendance** – No requirement

▶ **Homework** – Weekly optional assignments for reading or coding

▶ **Class project** – Students are required to conduct a class project. You are welcome to do the class project in a team but the maximum number of team members is 3. You can choose a purely theoretical project, a purely experimental project, or the combination of them. Each team needs to make a presentation during Week 8 to 12 and submit a report by December 5th. The report and presentation must include a statement clearly describing the contribution of each team member. Final grade will be made based on the presentation and report.

NOTES/ EXPECTATIONS:

• Missed course work is officially accommodated in the following three circumstances:

1. Illness or other extraordinary personal circumstance.

2. Religious observance
3. Varsity athletic participation

• This is an advanced course with high expectations. Your submitted work should reflect your best effort. Students who obtain state-of-the-art computational results or deeper understanding of the theoretical results in the class project will be given A+ or A; students who can prove or present known theories in a neat and simplified setting will be given A- or B+; students who can reproduce deep learning applications with comparable results will be given A- or B+ under the condition that no known implementation is available online or your results contain substantially new examples; students who can understand and present a theoretical paper, or tun and test available deep learning codes to reproduce results can get B or B-.
• The Protect Purdue Plan, which includes the Protect Purdue Pledge, is campus policy and as such all members of the Purdue community must comply with the required health and safety guidelines. Required behaviors in this class include: staying home and contacting the Protect Purdue Health Center (496-INFO) if you feel ill or know you have been exposed to the virus, wearing a mask in classrooms and campus building, at all times (e.g., no eating/drinking in the classroom), disinfecting desk/workspace prior to and after use, maintaining proper social distancing with peers and instructors (including when entering/exiting classrooms), refraining from moving furniture, avoiding shared use of personal items, maintaining robust hygiene (e.g., handwashing, disposal of tissues) prior to, during and after class, and following all safety directions from the instructor.

• Students who are not engaging in these behaviors (e.g., wearing a mask) will be offered the opportunity to comply. If non-compliance continues, possible results include instructors asking the student to leave class and instructors dismissing the whole class. Students who do not comply with the required health behaviors are violating the University Code of Conduct and will be reported to the Dean of Students Office with sanctions ranging from educational requirements to dismissal from the university.

• Any student who has substantial reason to believe that another person in a campus room (e.g., classroom) is threatening the safety of others by not complying (e.g., not wearing a mask) may leave the room without consequence. The student is encouraged to report the behavior to and discuss next steps with their instructor. Students also have the option of reporting the behavior to the Office of the Student

Rights and Responsibilities. See also Purdue University Bill of Student Rights.

• Purdue University strives to make learning experiences accessible to all participants. If you anticipate or experience physical or academic barriers based on disability, you are encouraged to contact the Disability Resource Center at: drc@purdue.edu or by phone: 765-494-1247. In this mathematics course accommodations are managed between the instructor, the student and DRC Testing Center. If you have been certified by the Disability Resource Center (DRC) as eligible for accommodations, you should contact your instructor to discuss your accommodations as soon as possible. Here are instructions for sending your Course Accessibility Letter to your instructor: https://www.purdue.edu/drc/students/course-accessibility-letter.php