Statistical Techniques in Robotics (16-831) Spring 2019

[REV03] - Please check Piazza for up-to-date version

Days MW
Room NSH 3002
Time 10:30 - 11:50 AM
Lecturer Kris Kitani
TAs Rawal Khirodkar
Class Discussion and Slides `https://piazza.com/cmu/spring2019/16831/home`

Description
Probabilistic and learning techniques are now an essential part of building robots (or embedded systems) designed to operate in the real world. These systems must deal with uncertainty and adapt to changes in the environment by learning from experience (over time). Uncertainty arises from many sources: the inherent limitations in our ability to model the world, noise and perceptual limitations in sensor measurements, and the approximate nature of algorithmic solutions. Building intelligent machines requires that they adapt to their environment. Few things are more frustrating than machines that repeat the same mistake over and over again. We will explore (1) modern learning techniques that are effective at learning online, (2) reinforcement learning based techniques built to learn from expert demonstrations and (3) probabilistic inference algorithms for maintaining an estimate of itself despite uncertainty.

Prerequisites
Linear Algebra, Multivariate Calculus, Probability theory

Grading
(1) Programming and theory assignments: 70% (4 total), (2) Tutorial presentation:30% (one 30 minute group presentation). Grades determined on an absolute scale. 90% and above is A, 80% - 89% is B, 70% - 79% is C, 60% - 69%, 59% - 50% is D, 50% or below is R. There will be extra credit opportunities.

Late Submissions
3 late days total for the semester. You can use up to 2 late days on a single assignments. Submissions beyond the allowed late days will be penalized by a deduction in points by $33.\bar{3}\%$ per day.

Educational Outcomes
(1) Able to design, implement and prove the regret bounds of a Multiplicative Weights Algorithm.
(2) Apply concepts of online learning and understand the theoretical implication to incremental supervised learning algorithms.
(3) Implement and analyze the difference between linear programming, matrix games, quadratic programming and entropy maximization formulations of inverse reinforcement learning.
(4) Implement and analyze the optimality of multi-armed bandit problems given various environments.
(5) Design tutorial presentation to convey complex technical topics in easy-to-digest ways. Design theoretical and programming problems to reinforce ideas conveyed through the presentation. Improve verbal and visual presentation skills.

Academic Integrity
All encouraged to work together BUT you must do your own work (code and write up). If you work with someone, please include their name in your write up and inside any code that has been discussed. If we find highly identical write-ups or code without proper accreditation of collaborators, we will take action according to university policies. For tutorial presentations, you are encouraged to find pre-existing presentation material to aid your preparation. If you uses someone's material, please given them credit by including a citation where necessary.

Take Care of Yourself
Do your best to maintain a healthy lifestyle this semester by eating well, exercising, avoiding drugs and alcohol, getting enough sleep and taking some time to relax. This will help you achieve your goals and cope with stress. All of us benefit from support during times of struggle. You are not alone. There are many helpful resources available on campus and an important part of the college experience is learning how to ask for help. Asking for support sooner rather than later is often helpful. If you or anyone you know experiences any academic stress, difficult life events, or feelings like anxiety or depression, we strongly encourage you to seek support. Counseling and Psychological Services (CaPS) is here to help: call 412-268-2922 and visit their website at `http://www.cmu.edu/counseling/`. Consider reaching out to a friend, faculty or family member you trust for help getting connected to the support that can help.

Class Schedule

Date	Topic	Date	Topic
01-14	Learning Problems	01-16	PWEA (Greed, Majority)
01-21	No Class (MLK Day)	01-23	PWEA (Rand. Greedy, WMA)
01-28	PWEA/Classification (RWMA, Perceptron)	01-30	No Class (Polar Vortex)
02-04	Classification (Winnow)	02-06	Online ConvexOpt (Convexity, FRL)
02-11	Online ConvexOpt (FTRL), OGD	02-13	Online SVM, Boosting
02-18	AdaBoost, Bandits (Stochastic)	02-20	Bandits (Hoeffding's Ineq., Explore-Exploit)
02-25	Bandits (EXP3, EXP4)	02-27	Temporal Inference (Filtering, HMM, KF)
03-04	Temporal Inference (MEMM, CRF)*	03-06	Temporal Inference (GRU, LSTM)*
03-11	Spring Break	03-13	Spring Break
03-18	Decision Theory (MDP, RL-GPI)	03-20	Decision Theory (RL-PG) *
03-25	Decision Theory (RL-TD) *	03-27	Decision Theory (POMDP) *
04-01	Apprenticeship Learning (LP-IRL)	04-03	Apprenticeship Learning (Matrix game IRL)
04-08	Apprenticeship Learning (QP-IRL, MMP)	04-10	Apprenticeship Learning (MaxEnt-IRL)
04-15	Decision Theory (RL-A3C)*	04-17	Decision Theory (RL-TRPO,DDPG,PPO)*
04-22	Apprenticeship Learning (IL-GAIL)*	04-24	Apprenticeship Learning (IL-Deep Mimic)*
04-29	Multi-Player Game Survey*	05-01	Special Topic

* Topics with superscripts are student-led tutorials.

HW	Topic	Release Date	Submission Date	Editor
1	Weighted Majority Algorithm	01-23	02-06	-
2	Online Supervised Learning	02-11	02-25	-
3	Multi-Armed Bandit	02-27	03-18	-
4	Inverse Reinforcement Learning	04-01	04-15	-

Tutorial Guidelines

Each tutorial should be 30 minutes and each student in the team should present for roughly 10 minutes each. Each team will consist of 3 students. For each tutorial topic, there will be two teams presenting on the same topic and therefore there will be a repetition of ideas to reinforce learning objectives. Teams will be scored by Instructors and students.

Process:

1. Select desired tutorial topic, form a team, fill out Google form (3rd week of class)
2. Meet with your team early for coffee to discuss tutorial
3. Begin collecting resources and reading papers/books (ensure enough time to digest material)
4. Submit tutorial slides to Instructors (Lecturer and TA) at least 2 weeks before presentation. We will not be able to give feedback if you submit after this. Be sure to write your script in the presenter notes.
5. Improve slides based on comments.
6. Present tutorial on assigned date (please come 5 minutes early to make sure your computer connects)
7. Tutorial presentation (PDF) material made available to class on Piazza

Grade Breakdown (Total 30 pts)

- Submit tutorial slides to Instructors (Lecturer and TA) at least 2 weeks before presentation date. Get feedback and improve. (1 pt)
- Give oral presentation using slides (3 pts)
- Develop one theory problem and solution manual, submit to instructors **before** presentation (3 pts)
- Develop one programming problem and solution code, submit to instructors **before** presentation (3 pts)
- Audience score (10 pts). Weighted average score of the audience and instructors.
- Participation (10 pts). A half point for filling out a scoring form for each tutorial.