Introduction to Reinforcement Learning

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Summary
Reinforcement Learning is one of the hottest areas in machine learning. It is fundamentally different from supervised and unsupervised learning, as it allows an agent to learn by interacting with its environment. This allows for learning when the ground truth is unavailable, which is often the case. Even when ground truth is available, it often becomes outdated in a dynamic environment (think predicting Netflix usage before and during the pandemic). This workshop will introduce the elements of RL, k-armed bandits, Markov Decision Processes, value functions, Policy Gradients, Q-Learning and deep Q-Learning. The focus will be on computation and not theorem-proof (e.g., convergence guarantees).

Books

Reinforcement Learning 2nd edition. RS Sutton & AG Barto
The book is not necessary for the workshop but it is a classic in the field and highly recommended.

Topic List

• Foundations of Reinforcement Learning

• k-armed Bandit Problems

• Markov Decision Processes (MDPs)

• Approaches to solving MDPs:

> Dynamic Programming

> Monte Carlo

> Temporal-Difference Learning

• Q-Learning

• Deep Q-Learning (DQNs)

• Policy Gradients (PGs)

Learning Outcomes

• Understand the key elements of Reinforcement Learning

• Simulate a k-armed bandit problem with epsilon-greedy actions

• Understand the properties of Markov Decision Processes

- Understand, compute and improve value functions to optimize policy

- Study the Bellman optimality equations for estimating the optimal value functions

- Apply and contrast different methods for estimating value functions: dynamic programming, Monte Carlo simulation, temporal difference methods

- Explain how Q-Learning works and how it learns off policy

- Use Q-Learning to compute value functions

- Understand how to improve policy using Policy Gradients

- Compare the value-based approach to the Policy Gradient approach

Content Delivery

The content will be a set of detailed Jupyter notebooks containing background information, equations, illustrations, runnable code and exercises to critically examine and strengthen concepts. All notebooks will be provided to students and they will interact with the notebooks in JupyterLab; this application is installed with Anaconda, which is freely available for download.

A series of ten workshops of duration one hour each will be held.