ECE 590D-001, Reinforcement Learning at Scale

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Geometric Data Analytics

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Description

This course consist of three parts. The first part will focus on machine learning at scale using modern tools such as Docker, GitLab with CI/CD, cloud computing, and Kubernetes. The second part will focus on reinforcement learning (RL) for single- and multi- agent environments and include topics such as Q-learning, policy gradients, and their deep learning extensions. The third part will combine the first two topics and focus on scaling DeepRL methods to attack large problems such as the Atari-57 benchmark and the StarCraft Multi-Agent Challenge.

Details

- The Syllabus.
- Other resources:
  - Lecture notes
  - Bibliography (including books, articles, lecture notes from other course, projects)
- How I'm approaching this course as an instructor:
  - Collect and distill resources that allow students to understand recent advances in RL. To this end I will make connections with applications.
  - Develop experiments that illustrate the execution of recent advances in RL.
  - I am interested in the technical details (mathematician), but I think intuition about the field as a whole is more valuable.
  - I think problems and their solution is the best way to develop theory.

- How I'd like you to approach this course as a student:
  - Be curious—there will ample additional reading beyond what I can cover in-class.
  - Try things—learning by doing is critical and there many exciting places to apply RL.
  - Realize that the programming and implementation parts are likely as valuable (if not more) than the theory. It's essentially like steady hands in the lab.
- Caveat Lector
  - I try to clarify which statements are my opinions and which I can support by data or proof. *I will not always succeed at this.*
  - These notes are essentially a draft and will like contain typos, errors, and other forms of mis-information. I'd rather they not, so please send corrections and comments to me via email.
  - I will be version controlling the notes via git+github.

Some very brief history (more in later lectures)

- Reinforcement learning is other than you might think; it starts with Bellman in the 1950s (if not Von Neumann). Here the approach was using dynamic programming (DP) to solve exactly (by specifying a policy or value function). DP does not scale well.
- *Reinforcement learning*, *Approximate dynamic programming*, *and Neuro-dynamic programming* are all essentially interchangeable and try to solve the same problem, but by approximate policy or value functions.
- A number of advances were made in the 1980s and 1990s, but were limited by computational power. See also the Wikipedia article on *AI Winters*.

Some very brief history (more in later lectures)

- One way to approximate a policy or value function is using an *deep neural network*—this is part of the recent surge of research activity in RL.
- RL will often contain a generative component that can be sampled in a parallel or distributed sense. The price, availability, and user tools for distributed computing have also driven the RL surge.
- As a result of using new approximation methods (or practicality of such methods), new RL updates are currently active research topic.

Where to start ...

- There are some very nice books (see the Syllabus).
- There are also piles of journal articles (bibliography forthcoming).
- **There is also digging into code!**
  - Spinning Up: Docs, Code
  - Ray: Docs, Code
  - ChainerRL: Docs, Code
  - Horizon: Docs, Code
  - Open AI Baselines and stable baselines: Docs, Code

Spinningup

- Spinning Up is an introductory guide to (deep) reinforcement learning written by Joshua Achiam (OpenAI Research Scientist).
  - Gets to the good stuff quick and mixes theory and implementation well.
  - Uses standard tools (python, tensorflow, mpi)
  - Open-ended and flexible—we'll mix it together with other resources.

Docker

- De facto standard for containerization
- Starting place for rapidly building distributed architectures with orchestration like Kubernetes.
- Starting place: containerize requirements and code for Spinning Up (this will be written formally as a homework assignment).
- **¡¡demo!!**