The City College of New York

CSC 36000:
Modern Distributed Computing *NextGen with AI Agents*

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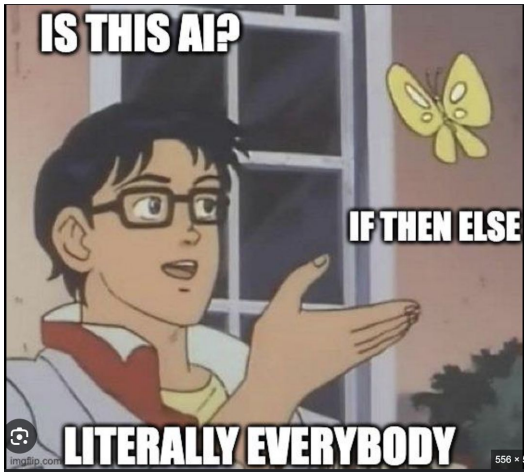
About Me

- PhD in Computer Science from the University of Maryland, College Park in Summer 2025
- Recent PhD Student Researcher at Google AI AR and Google DeepMind and as an AI Resident at Google X
- Lead PhD Researcher in a DoD LTS project
- Tenure-Track Assistant Professor of Computer Science at the City College of New York beginning Fall 2025

Research Interests

- AI Agents
  - Improving capabilities of AI Agents
    - Real World Applications in Climate Conservation, Supply Chain Orchestration, Multimodal Agents, LLM Agents, Recommender Systems, Economics, AI Privacy etc
- Distributed Training (we know it as Modern Distributed Computing)
- Multimodal Deep Learning
  - Interpretable Semantic Understanding across Image, Text, Video, Audio modes
- AI Alignment
  - Human-AI collaboration; Fixing Mistakes of Humans/other AI Agents; Explainable AI
- AI Agents Seminar Series: (go.umd.edu/marl)



About You

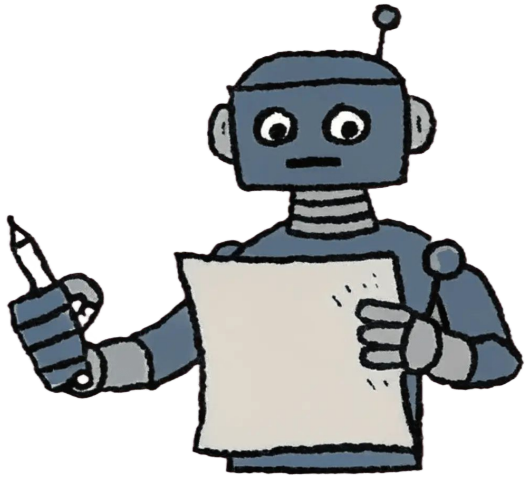
- What programming background do you have?
- What are you most excited to learn?
- What do you dream to do after graduation?
- What is your expectations from this course?

About this Course

- Website: https://saptab.github.io/modern-distributed-computing-with-AI-Agents/
- Syllabus: https://saptab.github.io/modern-distributed-computing-with-AI-Agents/static_files/Syllabus.pdf
- Programming Language: Python
- We will be learning about distributed computing architectures with a focus on real-world applications like AI Agents
  - Federated Learning
  - Decentralized Learning
  - Parallel Processing
  - LLM/VLM Agents
- At the end of the semester you will be able to understand these systems and implement them in a real-world context

Grading Structure

- Four programming assignments (18%)
- Four written homework assignments (18%)
- Classroom Participation (6%)
- Midterm Exam (12%)
- Group Project (27%)
- Final Exam (19%)



How to Reach Me

- Email: sbandyopadhyay@ccny.cuny.edu
- Office: NAC 7/244 (Being set up by CUNY Facilities right now)
  - Temporary office in NAC 8/206 Chair's office
- Office Hours: Monday 4 to 5 pm in NAC 8/206 temporarily (by appointment via email or class)

This Lecture

- Motivation of Distributed Computing
- Overview of Machine Learning, AI Agents, and their applications

Why Distributed Computing?

Why not use one GIANT computer?

- Every second, Google handles 100,000+ searches
- Netflix is streaming video to 270 million subscribers all over the world
- Using a single computer to this is IMPOSSIBLE

Physics and Money

- Putting that many transistors on a chip would literally cause them to melt
- The speed of light introduced delays that can’t be overcome, no matter how clever we are
- It would cost way too much!

AI Agents: Overview and Applications

What is Machine Learning?

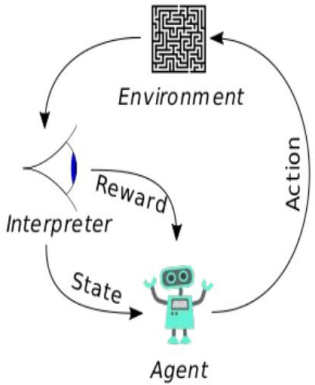
- Algorithms that help to automatically perform tasks
- Fundamental concepts involve High School Mathematics
  - y = f(x)
- Data may be texts, images, videos, audios etc. So embeddings are used to convert them to numbers for numerical operations

Multi-Agent Reinforcement Learning

- Evolving area of Machine Learning (specially since 2018)
- Multiple autonomous agents can interact with each other to foster competition and cooperation among humans and autonomous agents
- These agents try to maximize their individual interests while optimizing the greater good.
- E.g. 2 or more self-driving cars would try to reach their respective destinations at the earliest but would want to stop allowing the other car to pass in order to avoid accidents.

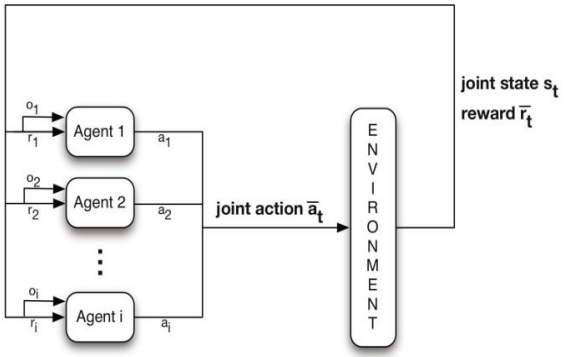
Single-Agent vs. Multi-agent RL (DeepMind, 2019)

Traditional (Single-Agent) RL



Source: Wikipedia

Multiagent Reinforcement Learning



Source: Nowe, Vrancx & De Hauwere 2012

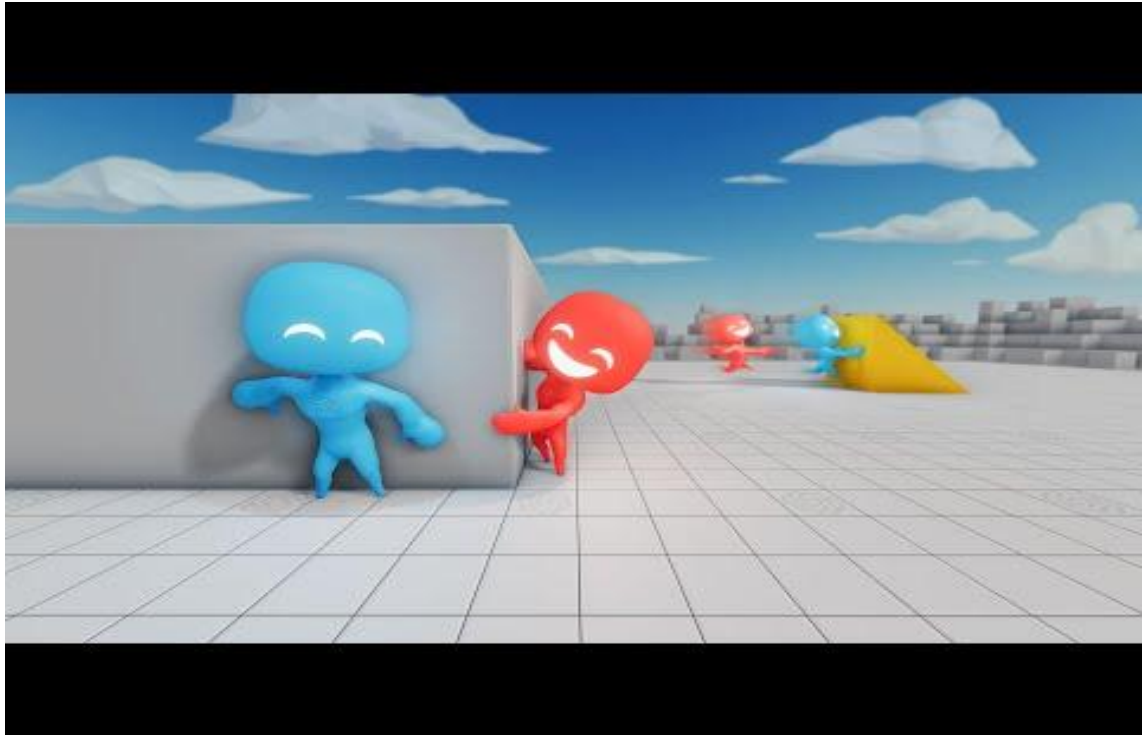
Motivation from Game Theory

- Studying strategic interaction of rational agents to achieve a goal(s)
- Stackelberg games: Attackers try to gain control of secure targets protected by defenders
- Interdiction games: Extension of Stackelberg security games where attacks are constrained by a path on a graph interdiction environment G = (V,E) where V=#vertices; E =#edges
- $V = S \cup T$ where S is a set of vertices for sources and T is a set of vertices for targets
- Nash Equilibrium: Each player knows the equilibrium strategies of the other player. Players have no incentives to deviate from their strategies unilaterally
- Multi-agent Reinforcement Learning research is inspired by Game Theory work

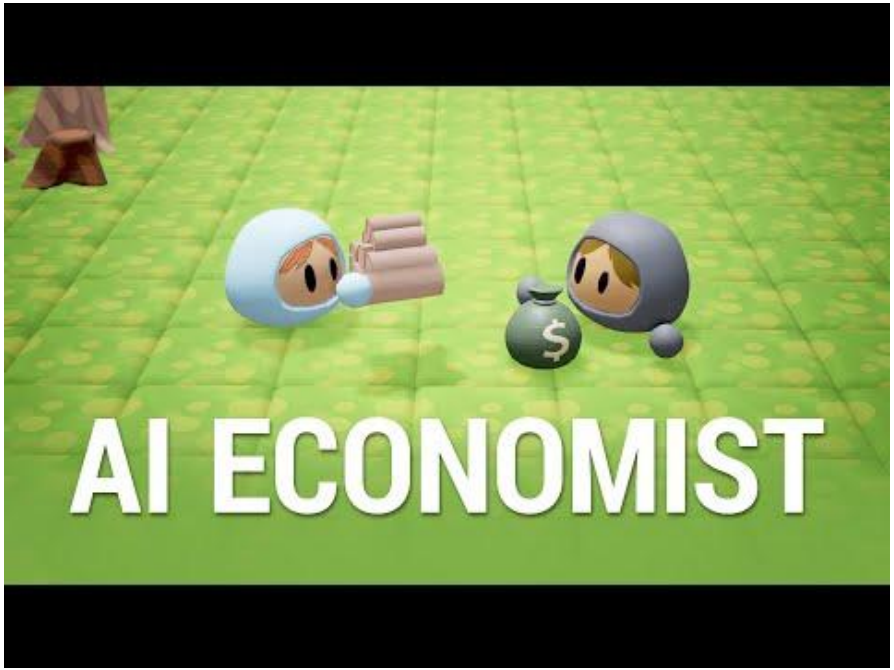
Some Applications

- Game theory problems
- Discovering, analyzing and disrupting illicit networks
  - Arms
  - Humans
  - Wildlife
  - Deforested trees
  - Drugs
  - Counterfeit goods
- War games and strategies (nuclear arms race, world wars)
- Equitable markets
- International relations like peace treaty negotiations
- Robust and Fair Management/Governance
- Fair tax policies
- Climate change
- Existential disasters like pandemics
- Swarm robotics
- Internet of Things (IoT)

Multi-agent RL for Hide-and-Seek (OpenAI, 2019)



Tax Policy with Multi-agent RL (Zheng et. al, 2020)



Questions?