

CS 3317: Artificial Intelligence

Introduction

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(slides adapted from UC Berkeley CS188)

Who am I?

- I am an tenure-track associate professor
 - Qing Yuan Research Institute, School of EIEE
- Bachelor's degree on math
 - Chu Kochen Honors College of Zhejiang University
- PhD degree on robotics
 - Nanyang Technological University, Singapore
- Postdoc training on robot intelligence
 - National University of Singapore, Singapore

How am I related to AI?

- Research area: robot intelligence
 - Theory: robot planning and robot learning
 - Practice: autonomous driving and household robots
- I publish papers in major robotics conferences and journals
 - IJRR, T-RO, RSS, RAL, ICRA, CoRL, IROS, ...
- I am active in the robotics & AI community
 - Associate editor of ICRA 2023 on robot learning
 - Main organizer of a RSS workshop
 - PC member of RSS, CoRL, ICAPS, ...

Q: Your impression on AI?

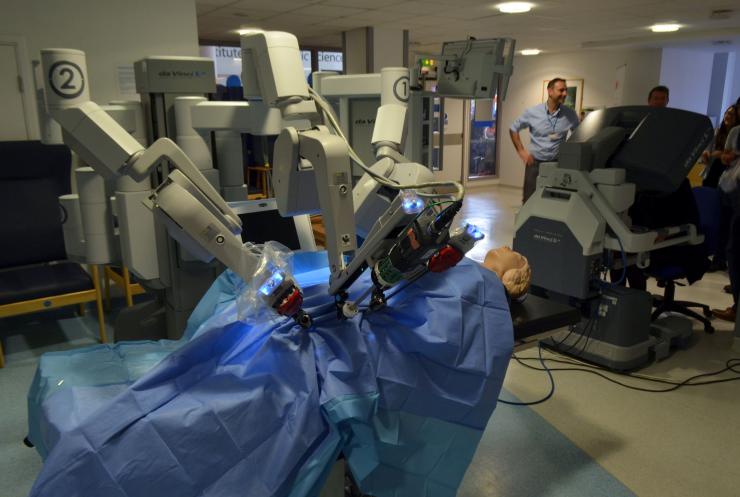
Impression of AI – Good Ones



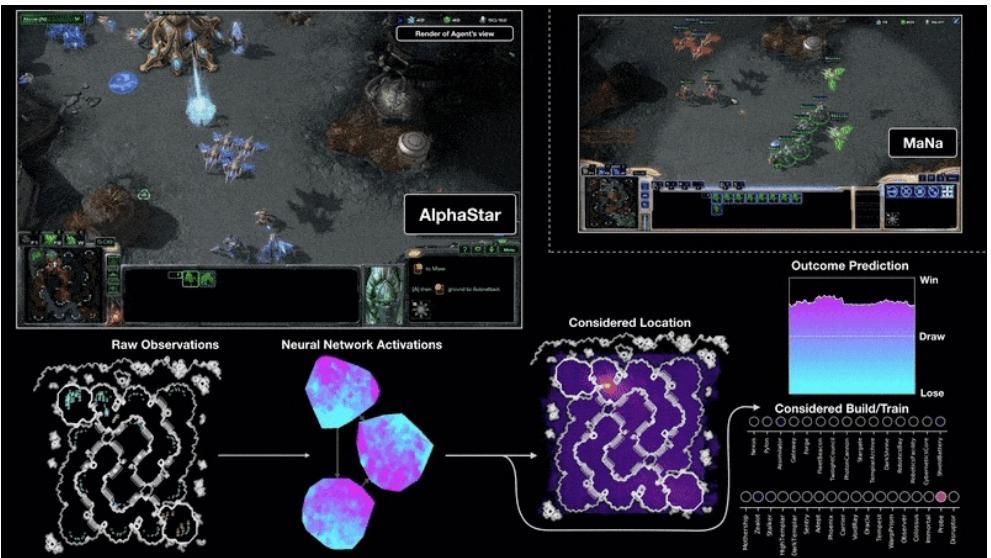
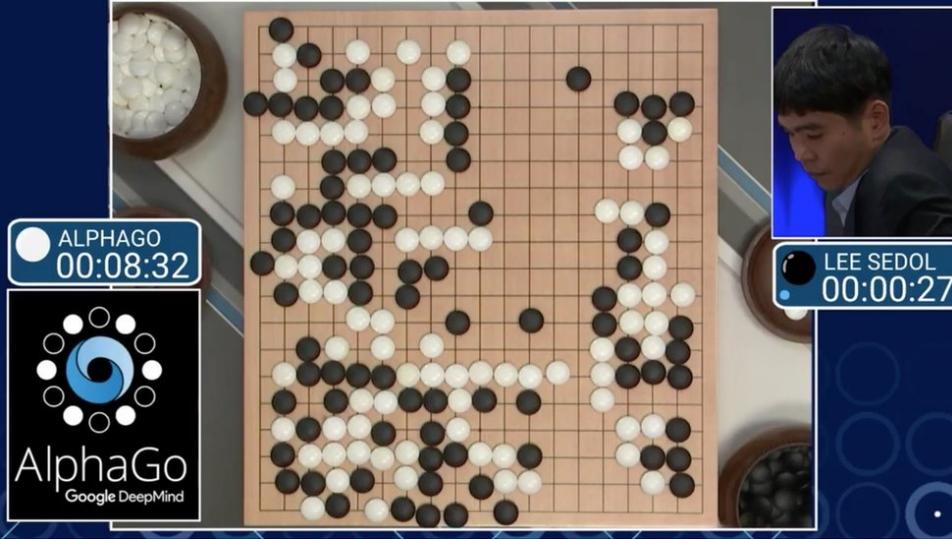
Impression of AI – Bad Ones



Real AI – What we really want

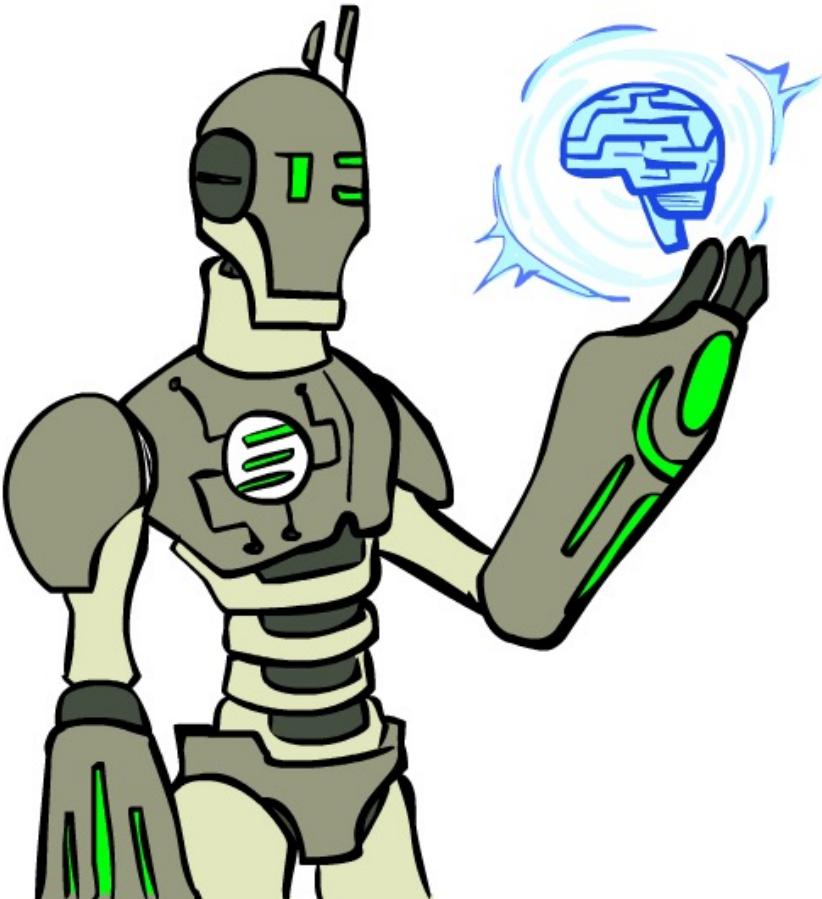


Real AI – what it is good at



In the following slides...

- What is artificial intelligence?
- Where did it come from/What can AI do?
 - What should we and shouldn't we worry about?
- Overview of the Course



What is AI?

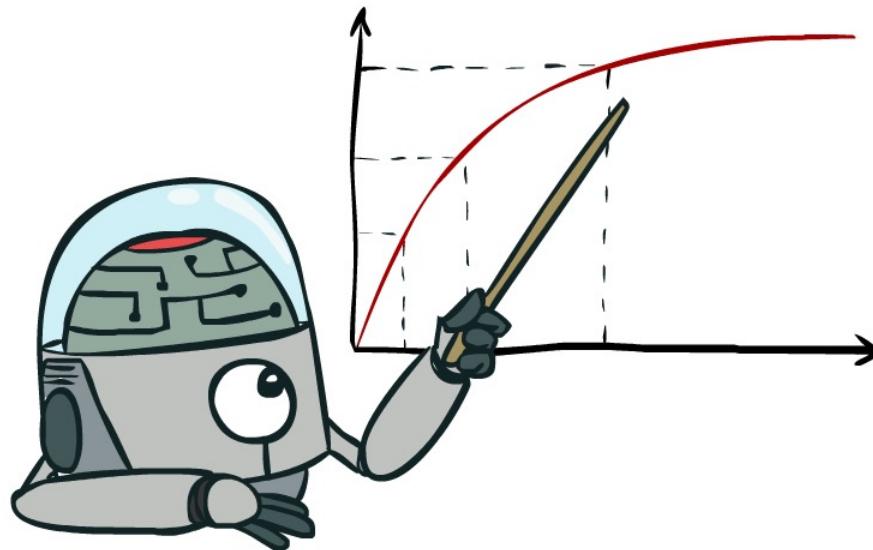
The science of making machines that:

Rational Decisions

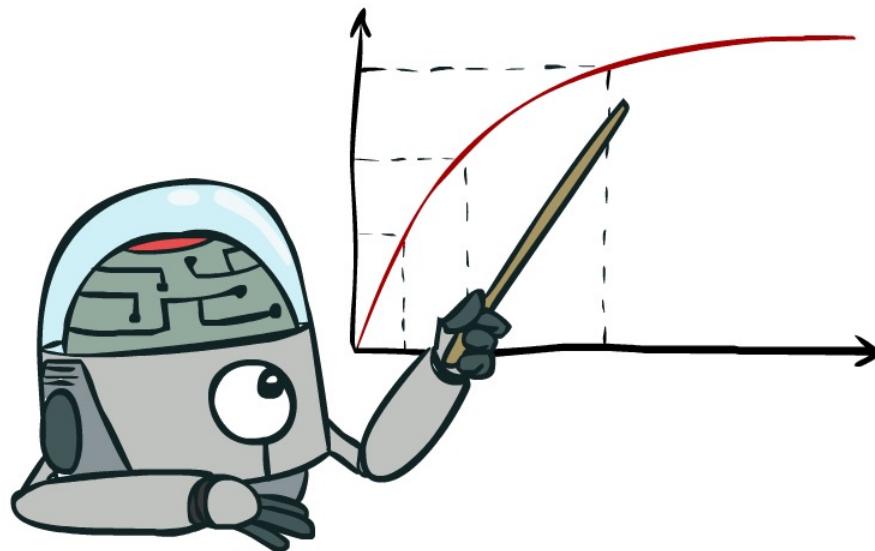
We'll use the term **rational** in a very specific, technical way:

- Rational: maximally achieving pre-defined goals
- Rationality only concerns what decisions are made
(not the thought process behind them)
- Goals are expressed in terms of the **utility** of outcomes
- Being rational means **maximizing your expected utility**

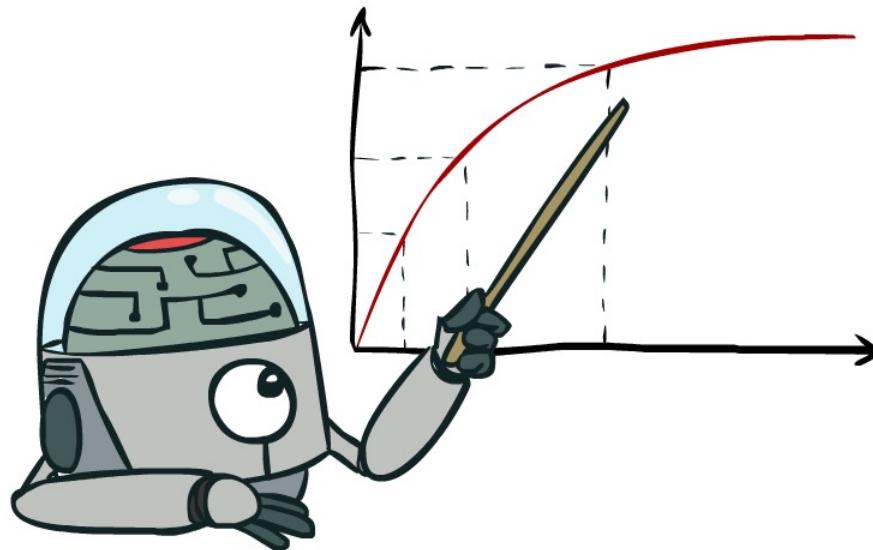
Maximize Your Expected Utility



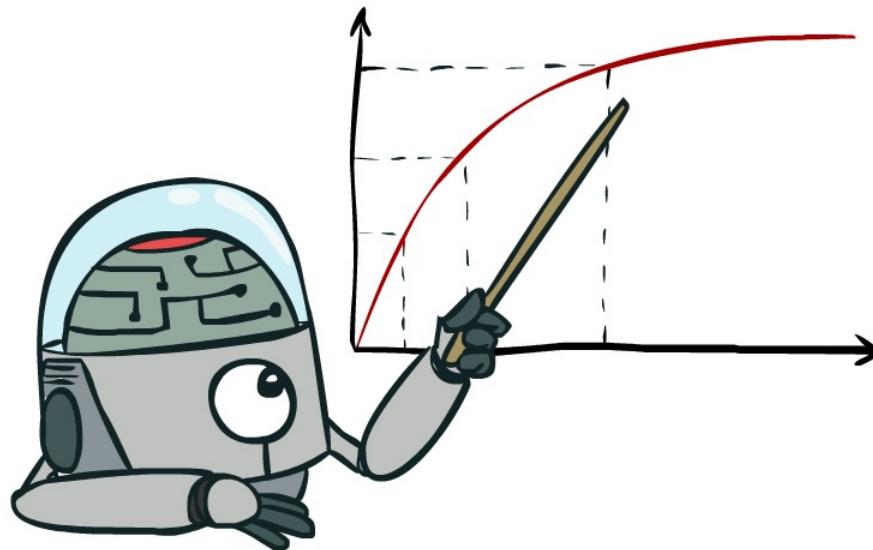
Maximize Your Expected Utility



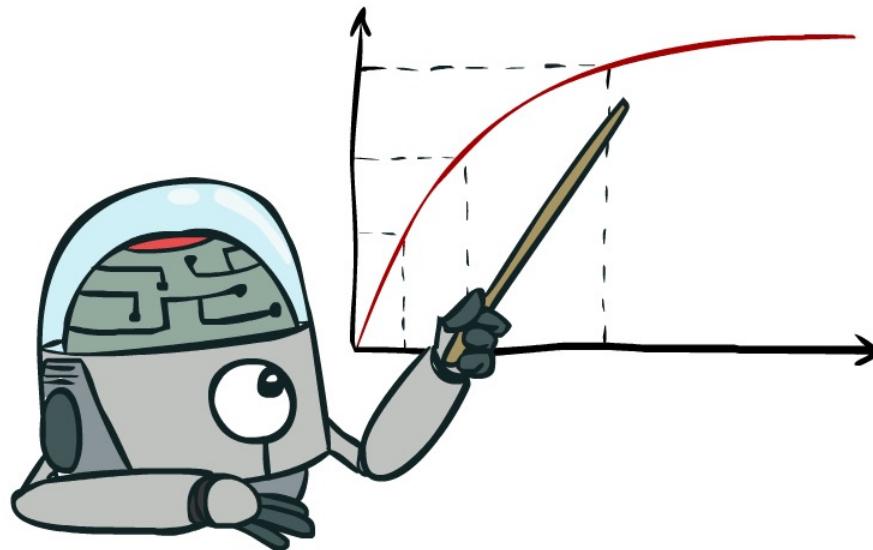
Maximize Your Expected Utility



Maximize Your Expected Utility



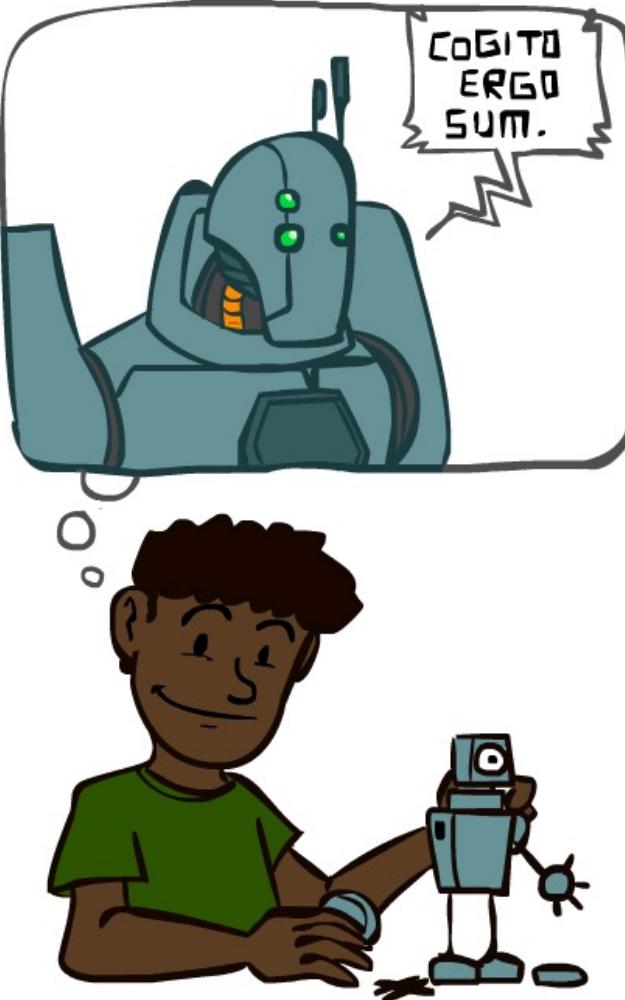
Maximize Your Expected Utility



Brain vs. AI

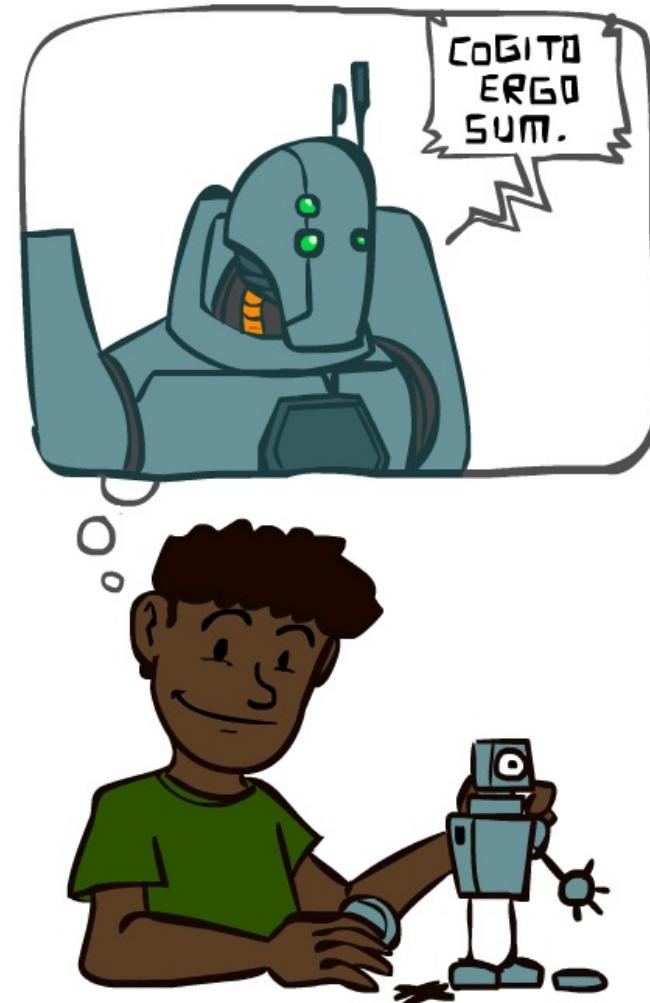
- Brains are very good at reflex and intuition and adapts fast to new situations
- Brains are good at making rational (but not perfect) decisions , but struggles to scale.
- Brains aren't as modular as software, so hard to reverse engineer!
- AI is good at math, logical reasoning and combinatorial optimization, but struggles to adapt to new situations
- AI can easily making complex decisions for structured problems
- Modularity is the basic principle of AI.

A (Short) History of AI



A (Short) History of AI

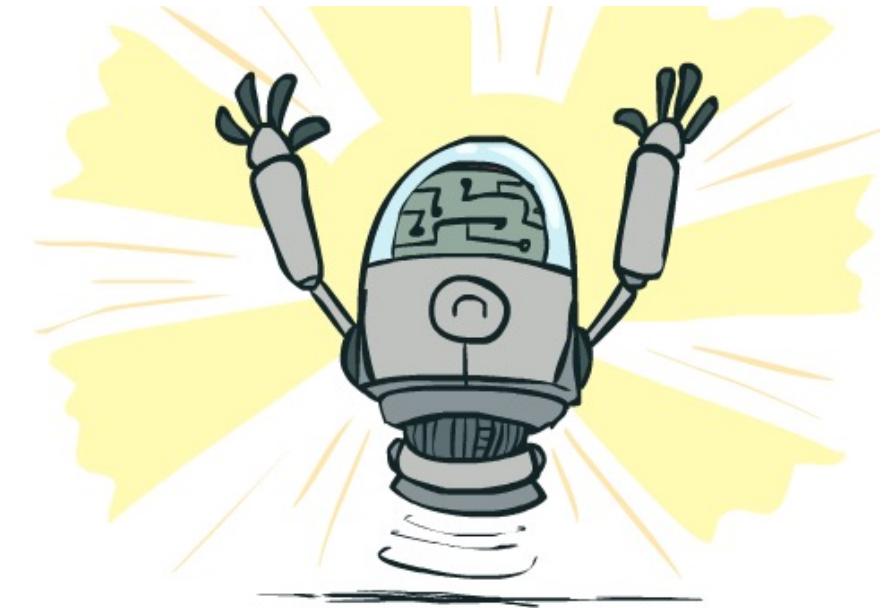
- 1940-1950: Early days
 - 1943: McCulloch & Pitts: Boolean circuit model of brain
 - 1950: Turing's "Computing Machinery and Intelligence"
- 1950—70: Excitement: Look, Ma, no hands!
 - 1950s: Early AI programs, including Samuel's checkers program, Newell & Simon's Logic Theorist, Gelernter's Geometry Engine
 - 1956: Dartmouth meeting: "Artificial Intelligence" adopted
 - 1965: Robinson's complete algorithm for logical reasoning
- 1970—90: Knowledge-based approaches
 - 1969—79: Early development of knowledge-based systems
 - 1980—88: Expert systems industry booms
 - 1988—93: Expert systems industry busts: "AI Winter"
- 1990—: Statistical approaches
 - Resurgence of probability, focus on uncertainty
 - General increase in technical depth
 - Agents and learning systems
- 2010—: Deep learning and big data
 - Deep neural networks ... "AI Spring"
 - ChatGPT, foundation models ... Summer is coming?
- Where are we now?



What Can AI Do?

Quiz: Which of the following can be done at present?

- Play a decent game of Jeopardy?
- Win against any human at chess?
- Win against the best humans at Go?
- Play a decent game of tennis?
- Grab a particular cup and put it on a shelf?
- Unload any dishwasher in any home?
- Drive safely along the highway?
- Drive safely in the busiest area of your hometown city?
- Buy a week's worth of groceries on the web?
- Buy a week's worth of groceries at a supermarket?
- Discover and prove a new mathematical theorem?
- Perform a surgical operation?
- Unload a know dishwasher in collaboration with a person?
- Translate spoken Chinese into spoken English in real time?
- Write an intentionally funny story?



Historical AI

Game Agents: Deep Blue by IBM

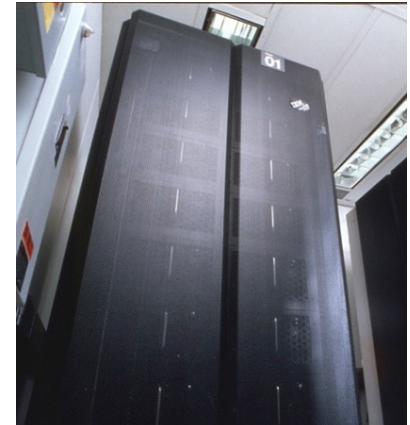
- Search Algorithms

- 1996: Kasparov Beats Deep Blue

"I could feel --- I could smell ---
a new kind of intelligence across the table."

- 1997: Deep Blue Beats Kasparov

"Deep Blue hasn't proven anything."



Computer Vision

- Large datasets and Deep learning
 - Datasets: ImageNet, ...
 - Neural networks: ResNet, ...



Atari Games

- Reinforcement learning (RL)
 - Deep Q-Networks (DQN)



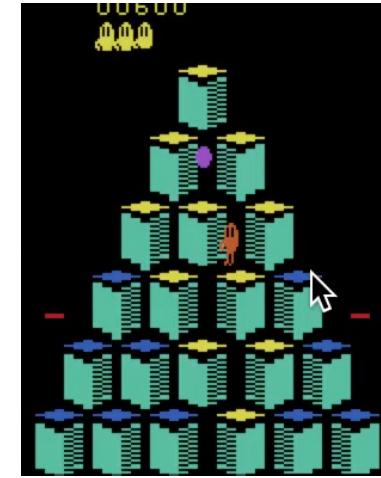
Pong



Enduro



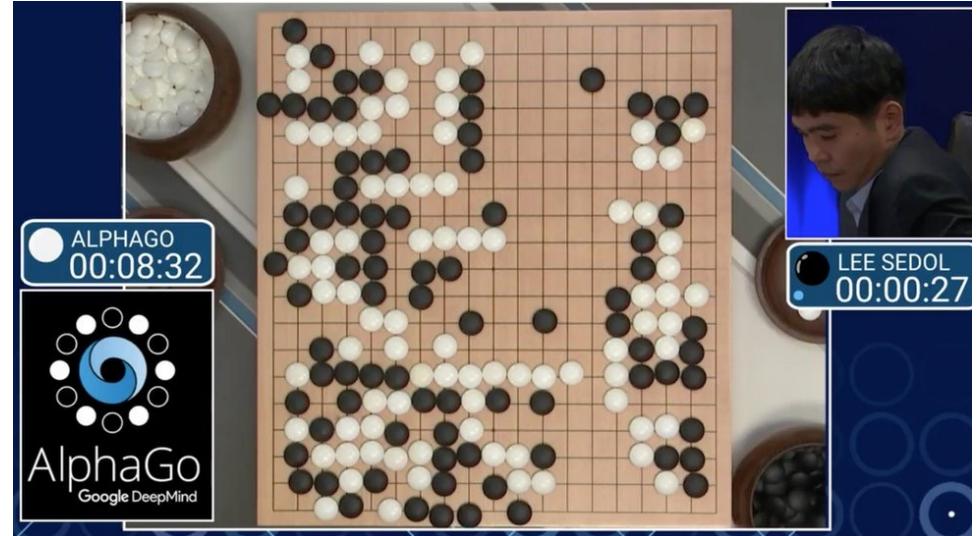
Beamrider



Q*bert

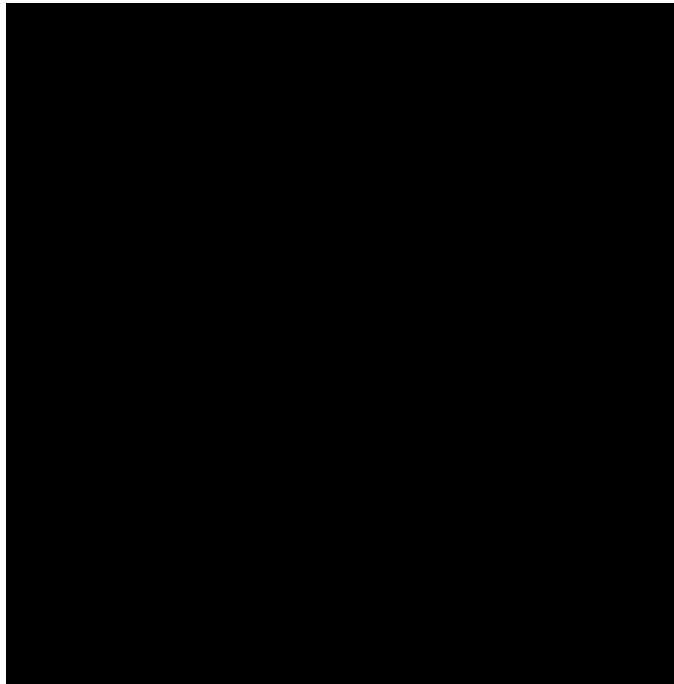
Game Agents: AlphaGo by DeepMind

- Search + RL
- 2015: AlphaGo Beats Fang Hui
 - “It’s not a human move. I’ve never seen a human play this move.”
- 2016: AlphaGo Beats Lee Sedol
 - “AlphaGo played consistently from beginning to the end while I, as I am a human, showed some mental vulnerability.”
- 2017: AlphaGo beats Ke Jie
 - “the god of Go”
 - AlphaGo Zero published on Nature

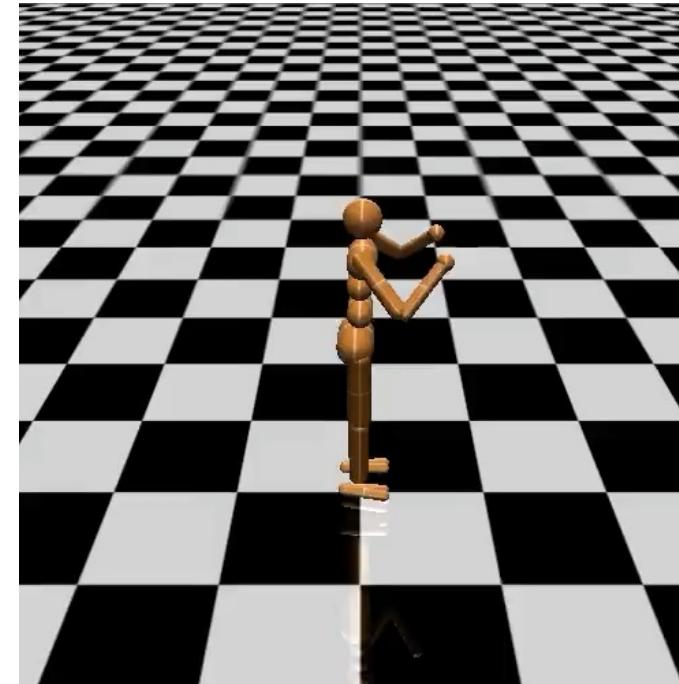


High-Dimensional Control

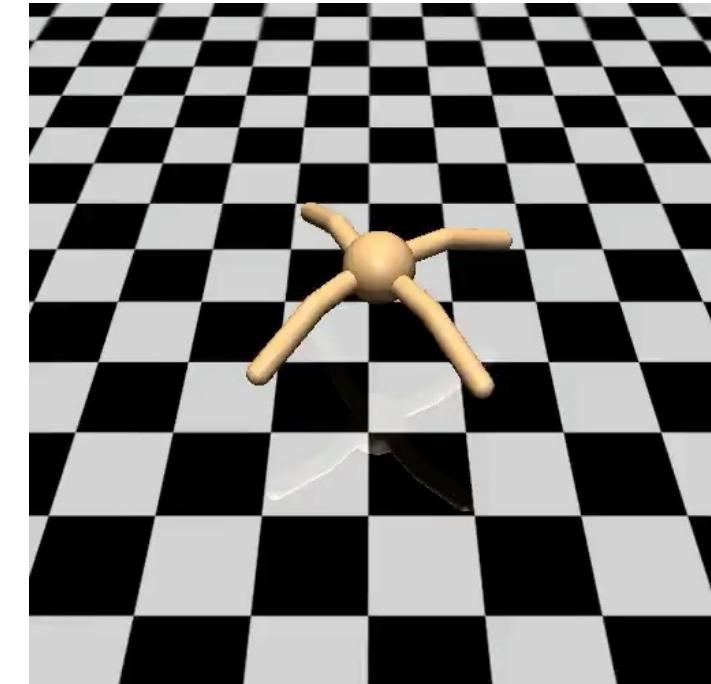
- Reinforcement learning
 - New generation: Policy Gradient



Walker



Humanoid



Ant

Autonomous driving

- Modular AI systems



Waymo's
self-driving car [2018]



Driving in a crowd [Cai et al., IJRR 2018]



Driving in complex traffic [Cai et al., T-RO 2022]

Robotics



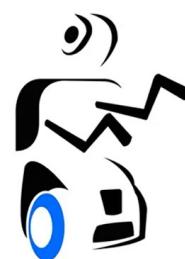
Robot control [Boston Dynamics 2020]



Robot motion planning [Lu et al., 2023]



Robot manipulation [OpenAI 2019]



Autonomous Robot Feeding
with Assistive Dexterous Arm
(ADA)

Natural Language

○ ChatGPT [OpenAI 2022]

cc

Introduce yourself.



Certainly! I'm ChatGPT, a sophisticated AI language model created by OpenAI. My primary function is to assist you by providing information, answering questions, and engaging in conversations on a wide range of topics. I've been trained on a vast dataset of text from the internet, books, and other sources up until my knowledge cutoff date in September 2021.

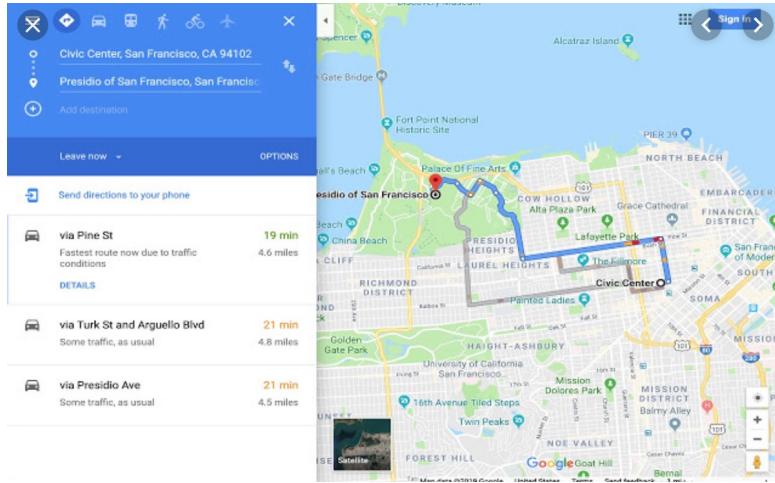


I'm here to help you with any inquiries or tasks you may have, whether it's learning something new, brainstorming ideas, writing content, or simply engaging in a friendly conversation. Feel free to ask me anything, and I'll do my best to provide you with accurate and helpful responses. How can I assist you today?

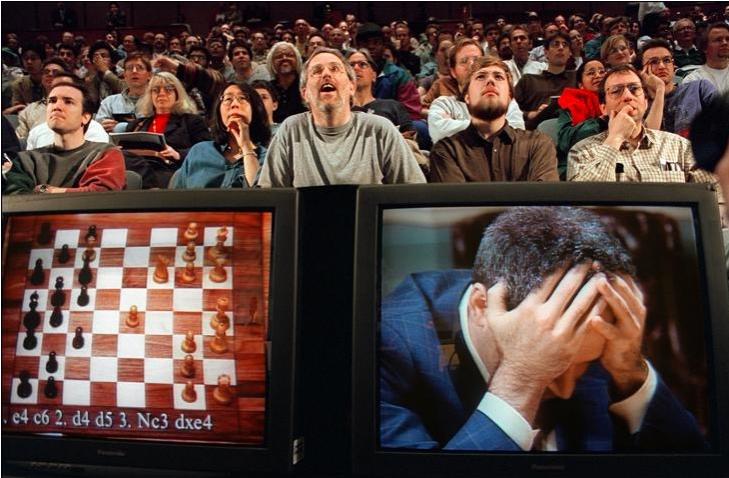
Topics

- Utilities and Rationality
- Search algorithms and Planning
- Constraint Satisfaction Problems
- Game Trees, Minimax, Pruning, Monte-Carlo Tree Search
- Probabilistic Inference, Bayesian Networks, Markov Models
- Decision Networks and Value of Perfect Information
- Markov Decision Processes and Reinforcement Learning
- Survey of Modern Problems and Topics (Guest Lectures!)
- Note: this course is not about neural networks!

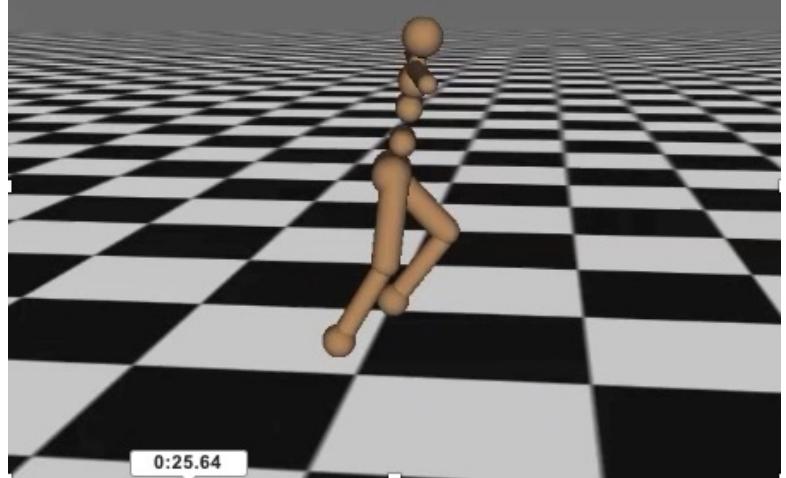
The kinds of AI problems in CS 3317



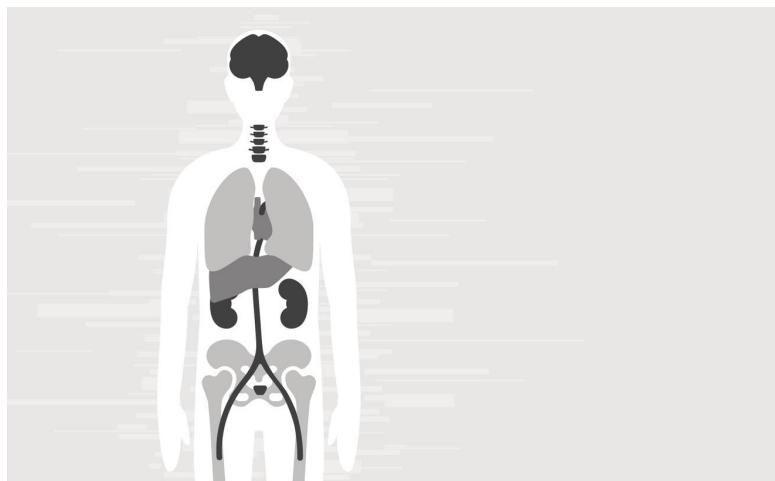
Navigation systems



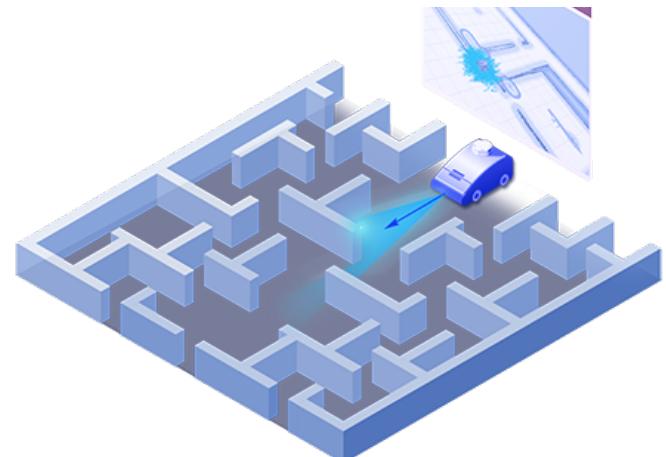
Game agents



RL agents



Medical diagnosis systems



Robot localization systems



Decision making under uncertainty

Overview of the Course

- Team
- Course Website, Gradescope, Canvas
- Homework
- Project
- Exams
- Office Hours

Team

- Lecturer: Panpan Cai
 - Associate professor, QingYuan Research Institute
- Co-Lecturer: Shuai Li
 - Associate professor, John Hopkins Center
- Teaching Assit.: Wenjing Tang, Haoming Ye
 - Graduate students

Website

- Website: roboticsjtu.github.io/CS3317/index.html
 - Contact information
 - Tentative schedule
 - Lecture slides and notes
 - Course policies, etc.

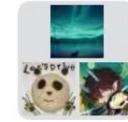
Communication

- Canvas:

- Announcements of homework and the project
- Ask questions in the forum
- Help each other via the forum!

- WeChat group:

- Other communication matters, e.g., look for project members



群聊: CS3317 Fall 2023



该二维码 7 天内 (9月16日前) 有效，重新进入将更新

Course Format

- (Weeks 1-8) Lectures on Mon (8 am)
- (Week 9-16) Lectures on Mon (8 am) and Wed (10 am)
- Please show up and actively engage
 - You are encouraged to ask questions!
- Lectures are recorded
 - Posted on Canvas after lecture
 - Slides posted after lecture

Evaluation

- Homework (40%)
 - There will be 8 homework
 - Get you comfortable with the basic concepts
 - Deepen your understanding on the theories
 - Exercise the application of the taught algorithms
 - Due dates to be released on the corresponding lectures

Evaluation (continued)

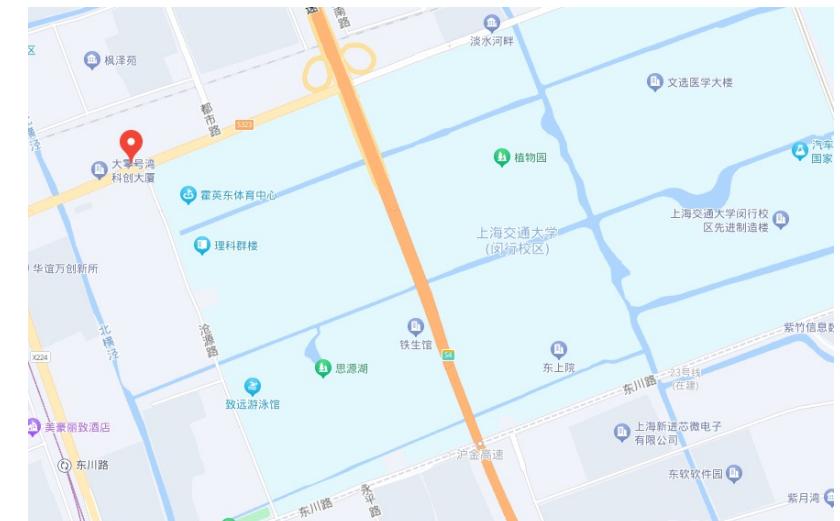
- The final project (30%)
 - Practice advanced applications of the taught algorithms
 - Work as groups of 3 and submit together
 - Academic integrity! Plagiarism of code is easy to catch
 - Score = 0 if plagiarism is caught
 - Python auto-grading (20%) + presentation (10%)
 - Rank top 3 on performance to get 100% score on auto-grading
 - Exceed my expectation to get 100% score on presentation
 - Presentations will happen on Week 16
 - To be released on week 4 (tentative)
 - Start early, iterate your solution until satisfactory
 - Submit on time! Late submissions lose 20% scores per day

Evaluation (continued)

- Exams (30%)
 - Final-exam: Week 17 or 18
- **Both projects and exams are hard! To prepare for them**
 - Make good use of discussion sessions!
 - Hosted by TAs
 - 18:55, Every Thursday
 - Location: Dong Xia Yuan 205

Office hours

	name	email	office hour
Instructor	<u>Panpan Cai</u>	cai_panpan@sjtu.edu.cn	Fri 10-11 AM Online
Assistant Instructor	<u>Shuai Li</u>	shuaili8@sjtu.edu.cn	Mon 2-3 PM Rm 1406-2, Software College
TA	Wenjing Tang	applesoup@sjtu.edu.cn@sjtu.edu.cn	Thu 7-9 PM Online
	Haoming Ye	butterflyprimo@sjtu.edu.cn	Tue 7-9 PM Online

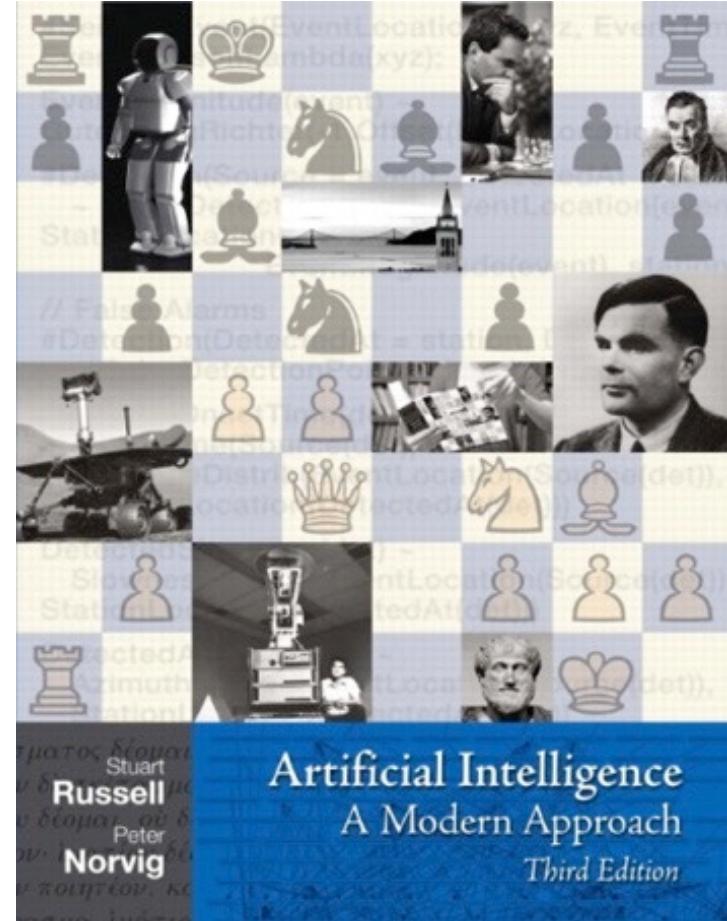


Prerequisites

- Math
 - Discrete Math
 - Probability Theory
- Programming
 - Basic Python (learn the syntax if you don't know it already)
 - Understanding of Data Structures, Object Oriented Programming, etc.

References

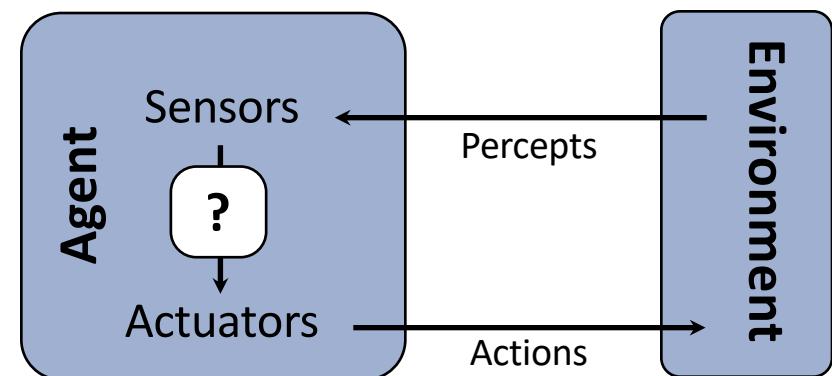
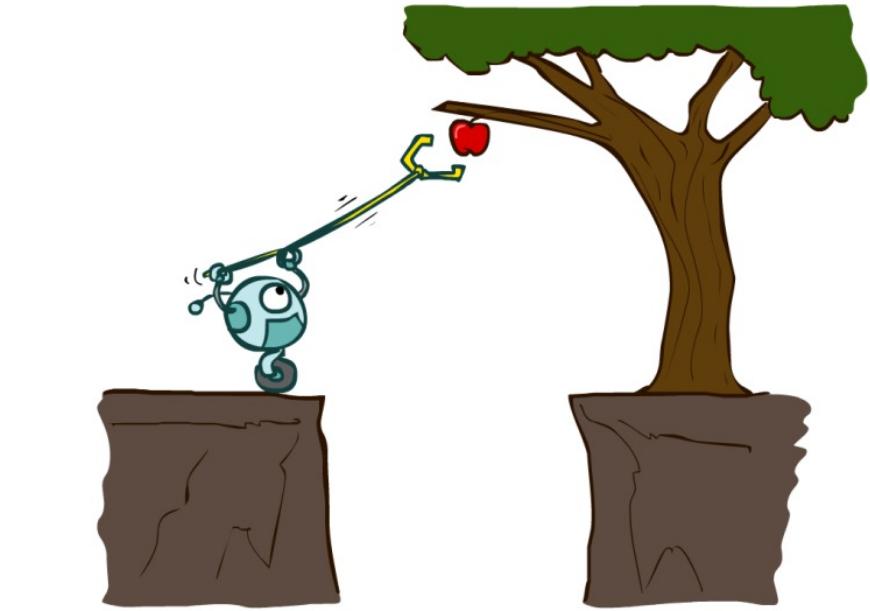
- Recommended book
 - Russell & Norvig, AI: A Modern Approach



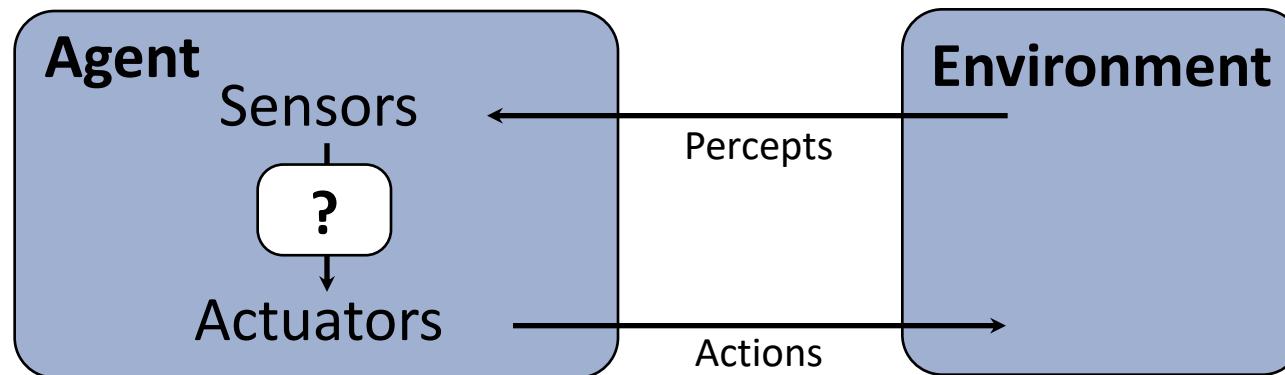
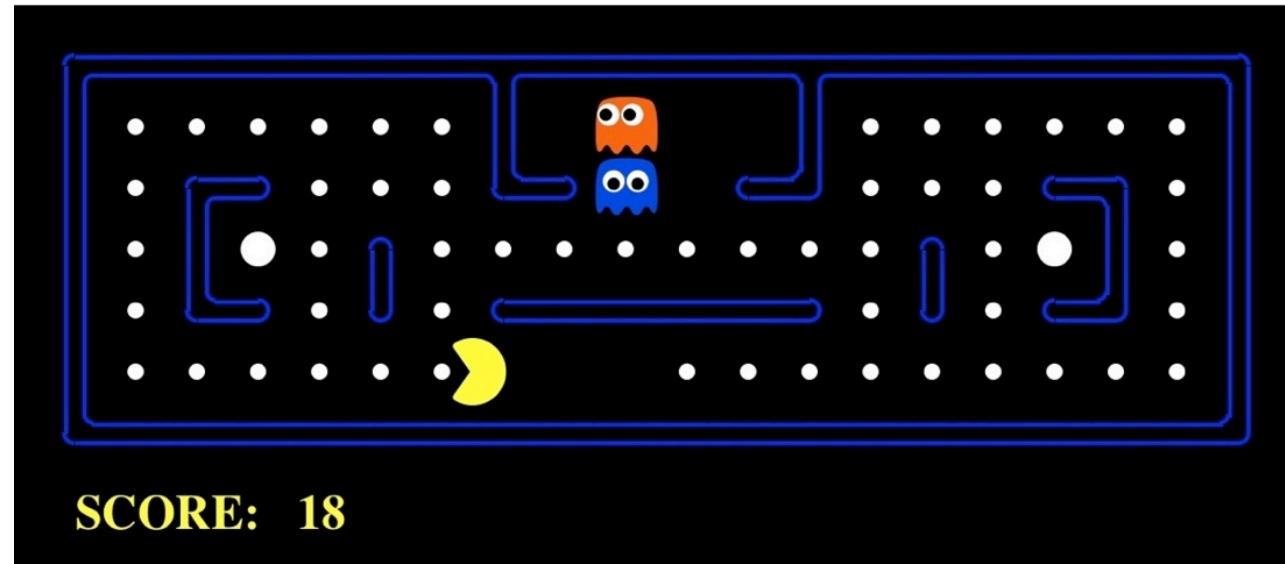
Next Lecture

Designing Rational Agents

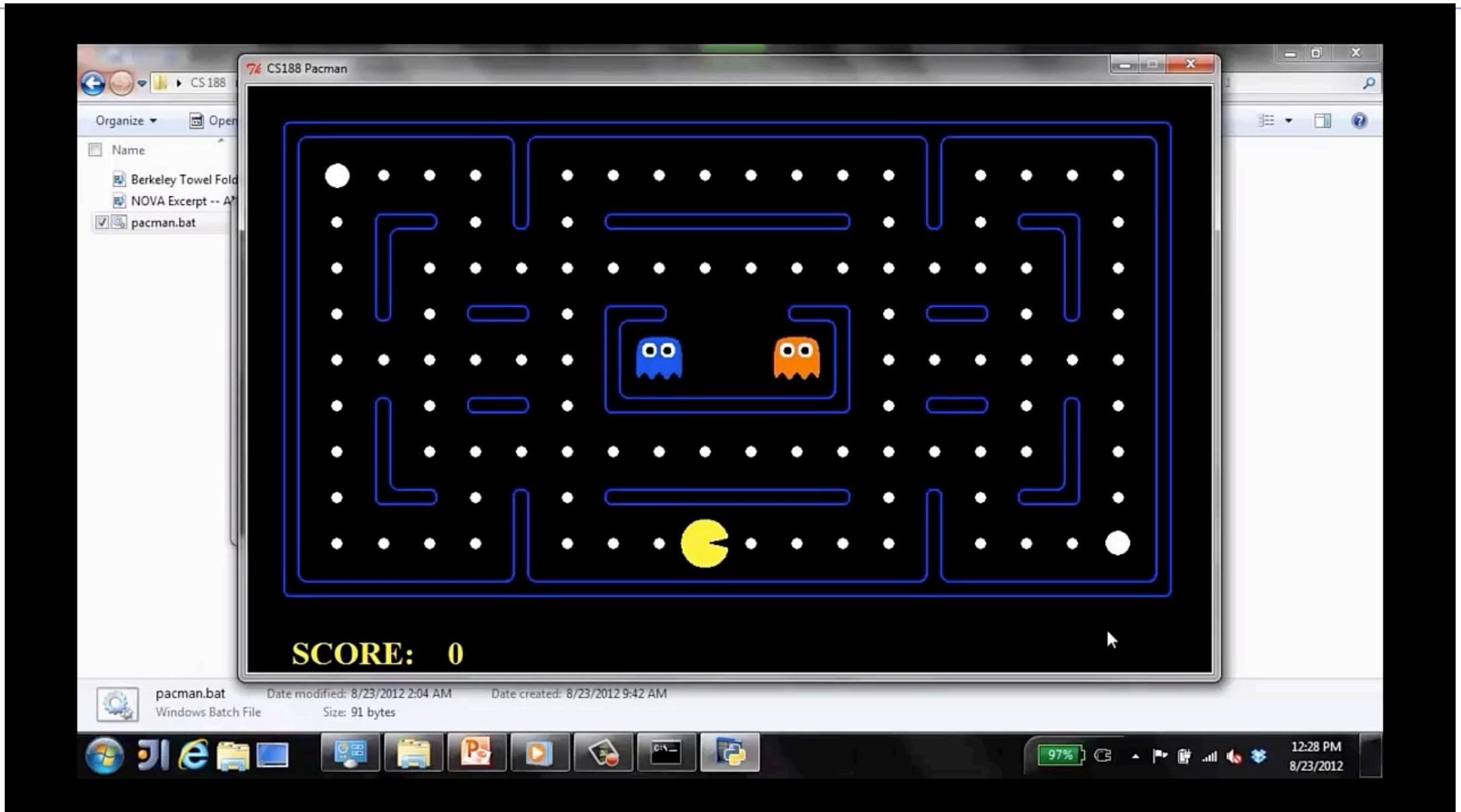
- An **agent** is an entity that *perceives* and *acts*.
- A **rational agent** selects actions that maximize its (expected) **utility**.
- The **selection of rational actions** is dictated by characteristics of the **percepts, environment, and action space**



Pac-Man as an Agent



A human agent in Pacman



The task environment - PEAS

- Performance measure
 - -1 per step; + 10 food; +500 win; -500 die;
+200 hit scared ghost
- Environment
 - Pacman dynamics (incl ghost behavior)
- Actuators
 - Left Right Up Down or NSEW
- Sensors
 - Entire state is visible (except power pellet duration)



PEAS: self-driving taxi

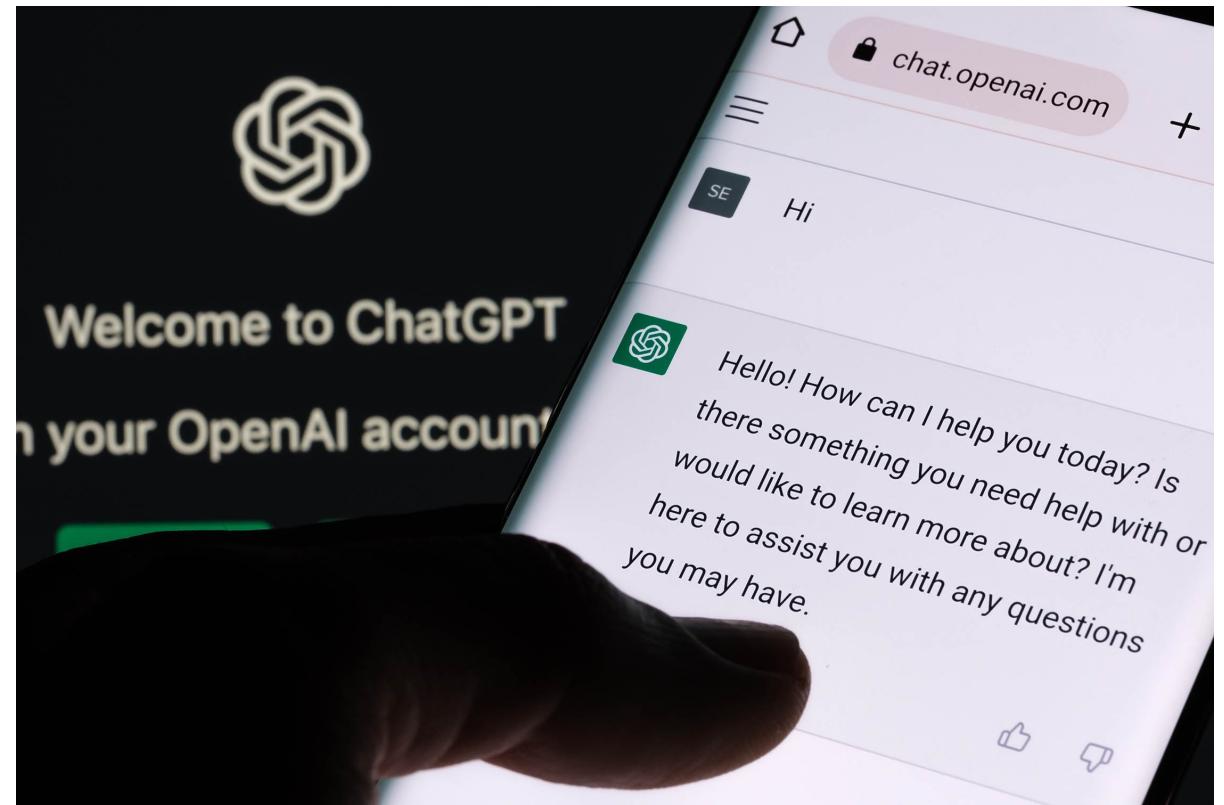
- Performance measure
 - Income, happy customer, vehicle costs, fines, insurance premiums
- Environment
 - Shanghai streets, other drivers, customers, weather, police...
- Actuators
 - Steering, brake, gas, display / speaker
- Sensors
 - Camera, Lidar, GPS, accelerometer, engine sensors, microphone



Image: <http://nypost.com/2014/06/21/how-google-might-put-taxi-drivers-out-of-business/>

PEAS: ChatGPT

- Performance measure
 - Precision of prediction
 - Satisfaction of the user
- Environment
 - The user
- Actuators
 - Output text
- Sensors
 - Input text



Environment types

	Pacman	Taxi	ChatGPT
Fully or partially observable			
Single-agent or multiagent			
Deterministic or stochastic			
Static or dynamic			
Discrete or continuous			
Known physics?			
Known perf. measure?			

Agent design

- The environment type largely determines the agent design
 - *Partially observable* => agent requires *memory* (internal state)
 - *Stochastic* => agent may have to prepare for *contingencies*
 - *Multi-agent* => agent may need to behave *randomly*
 - *Static* => agent has time to compute a rational decision
 - *Continuous time* => continuously operating *controller*
 - *Unknown physics* => need for *exploration*
 - *Unknown perf. measure* => observe/interact with *human principal*