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Introduction to Artificial Intelligence

Nicholas Mattei, *Tulane University*

CMPS3140 – Introduction to Artificial Intelligence

Spring 2020

https://nmattei.github.io/cmps3140/

Many Thanks

Slides are based off contributions from many including

- Anca Dragan, Dan Klein, and Pieter Abbeel from UC Berkeley CS188 Intro to AI at UC Berkeley (ai.berkeley.edu).
- Jihun Hamm (Tulane University) and Lirong Xia (RPI).

Goals of This Course

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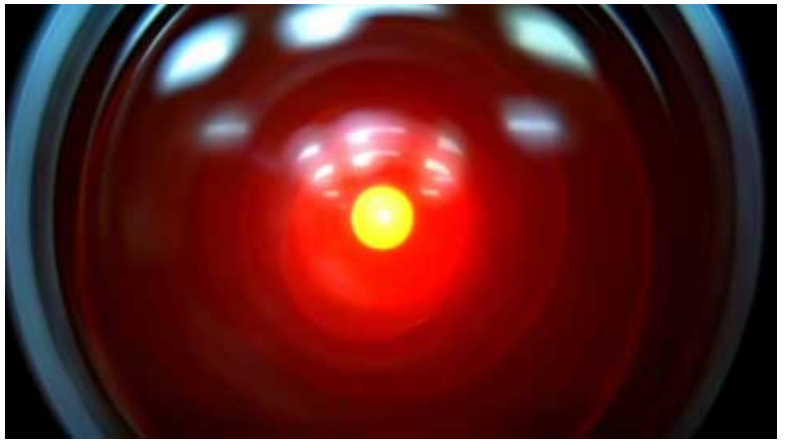
- Learn about **Artificial Intelligence**
  - Increase your **AI Literacy**
  - Prepare you for **Topics Courses** and/or **Research**



- **Breadth** over **Depth**

- AI is one of the **great intellectual adventures** of the 20th and 21st centuries.
  - What is a mind?
  - How can a physical object have a mind? Is a running computer (just) a physical object?
  - Can we build a mind? Can trying to build one teaches us what a mind is?

- The aim of this course … introduction to the main concepts and techniques in artificial intelligence.
  - "What is an intelligent artificial agent?", problem solving using search and constraint satisfaction, uncertainty, Bayesian networks and probabilistic inference, supervised learning, planning, sequential decision problems, as well as several additional topics.

Prerequisite Knowledge

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- Aimed at **TU:CS Undergrads** – but likely accessible to others with programming experience and mathematical maturity.

- We **do** assume:
  - Familiarity with Python and/or programming.
  - You are comfortable with topics in Discrete Math (sets, probability, counting).
  - You want to be here!

- Prerequisite(s): CMPS 1500 and CMPS/MATH 2170
- Good if you have taken / enrolled in Algorithms, Data Science, or Machine Learning.

Overview

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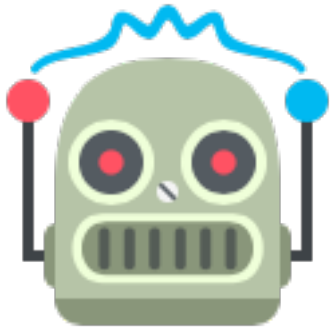
- Course Webpage:
  - https://nmattei.github.io/cmps3140/
  - We will use this post all course material including projects, readings, and slides.
  - All work will be either turned in by hand (written) or through Canvas.

- Time and Place
  - **Lectures:** Tuesdays and Thursdays
  - **Room:** Stanly Thomas 302 (Building 10)
  - **Time:** 930 - 1045

Course Staff

- **Instructor:** Prof. Nicholas Mattei
  - **Office:** Stanley Thomas 402B
  - **Office Hours:** TR 1500-1600
  - Email: nsmattei@tulane.edu
  - **Research Interests:** AI, ML, data science, decision making… (this class!)

- **TA:** Arie Glazer
  - Email: aglazier@tulane.edu
  - Office: Stanley Thomas 309
  - Office Hours: MW 1000-1100



Who am I?

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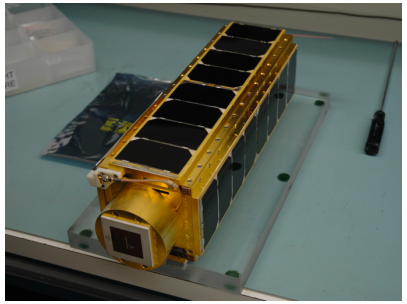

- Undergrad/Masters University of Kentucky
- Worked at NASA Ames Research Center (Bay Area)
- PhD University of Kentucky
- NICTA / UNSW / Data61 / CSIRO (Sydney, Australia)
- IBM Research (New York)
- Tulane University!

This Course is an EXPERIMENT!

- Please speak up if things aren't working, we're going to fast, or we're going too slow.
- I have a tendency to speak fast, *please tell me to slow down!*
- The schedule is subject to change – please keep checking and I'll remind you of any changes!
- **Most important:** ***let's have fun and learn some cool stuff!***

Required Materials

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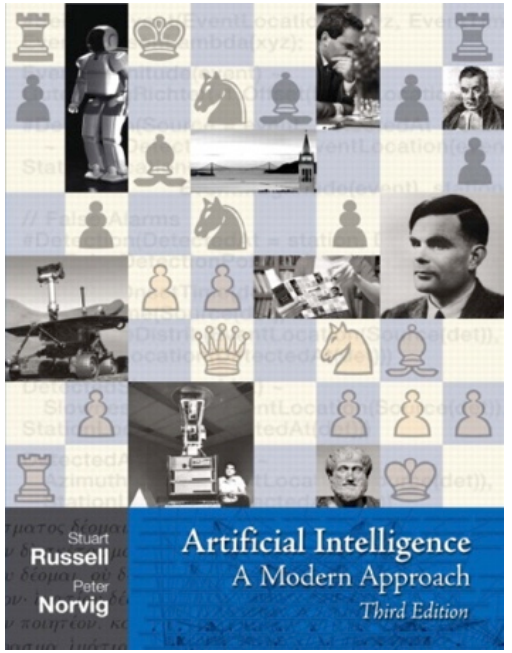
- I really, very strongly encourage you to purchase the textbook!
  - Russell & Norvig, AI: A Modern Approach, 3rd Ed.
  - We will likely have homework problems from the book!



- You will also need access to a computer that you can install the required software. **If you do not have access to a computer that you can install software on please see me ASAP.**
  - Projects require the use of a Unix prompt (Mac and Ubuntu users are ready to go!)
  - If you need to install Linux and you have Windows 10 an easy way is to use the Linux Subsystem.
  - If you were in the Data Science class last year and are comfortable with Docker you can download the standard Ubuntu image and go that route.

(Tentative) Course structure

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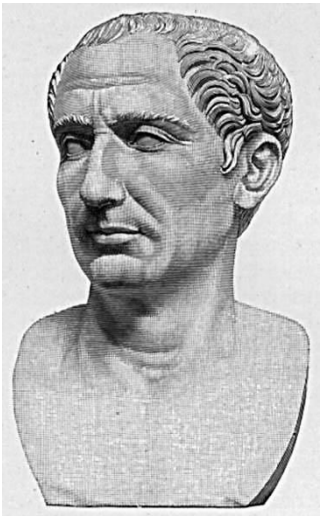
- First Lecture: Intro!

- Next 8 lectures (4 weeks): intro to agents, uninformed search, informed search, heuristic search, min-max search, local search, adversarial environments.
  - Project 1: Pacman Searching
  - Project 2: Pacman Avoid the Ghosts



Ambitious …

- 6 Lectures (3 weeks): logical agents, first order logic, planning, constraint satisfaction problems.
  - Project 3: ? Prolog, MiniZinc?

- **Midterm**

- We have 29 total lectures.
  - Dr. Mattei gone for 1 (1 Midterm)
- We have 27 (-1 for intro) content lectures and so many things we can cover!!

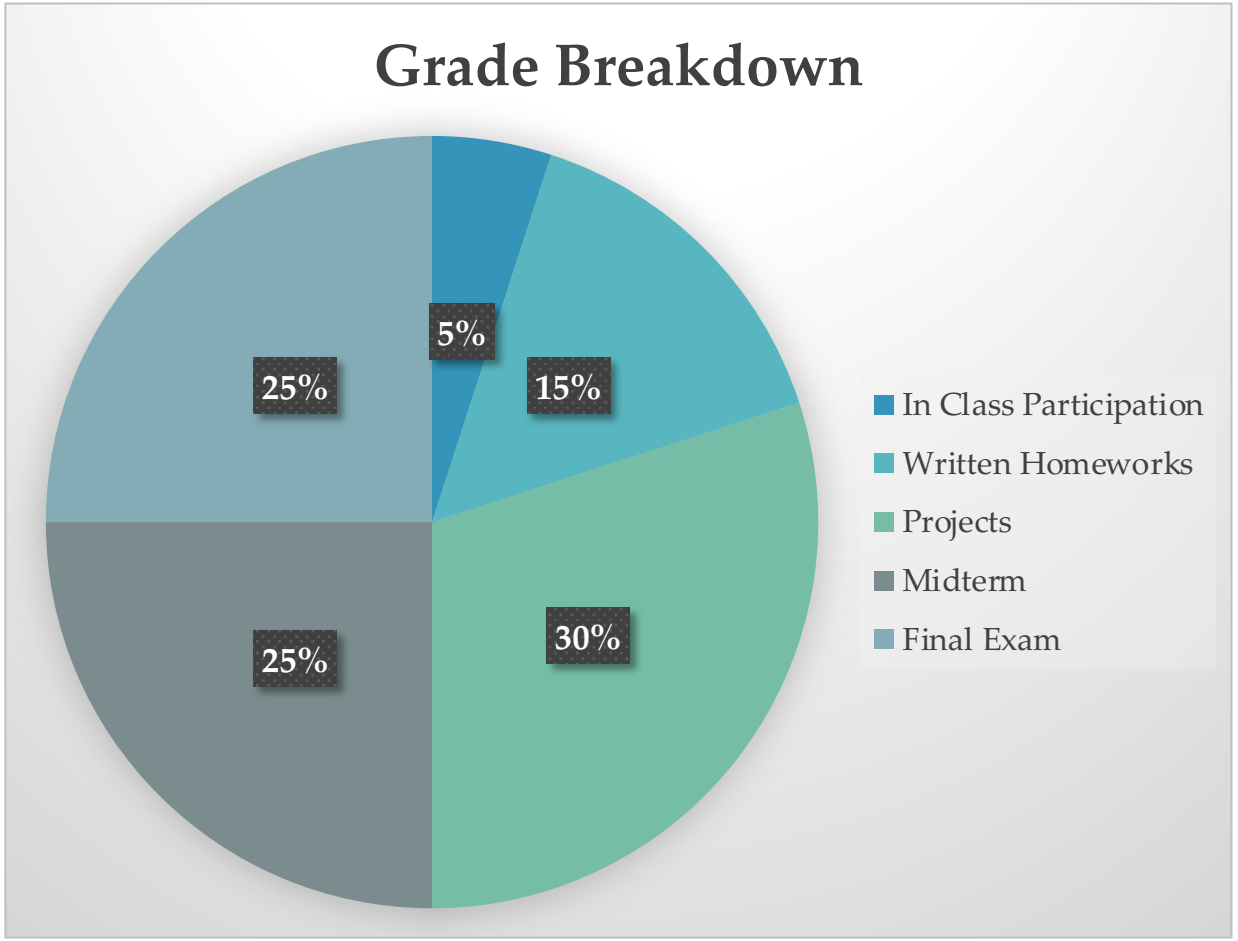
- 6 Lectures (3 weeks) Probability, decision theory, reasoning under uncertainty
  - Project 4: Pacman Finding Ghosts

- 6 Lectures (3 weeks): MDPs, Reinforcement Learning, some Machine Learning.
  - Project 5: Pacman Learning to Play!

Grading

- 5% - In Class Participation / Activities
- 15% - Written Homeworks
- 30% - Projects
- 25% - Midterm Exam
- 25% - Final Exam
  - Grad students, one extra project!

- All grades will be posted on Canvas.



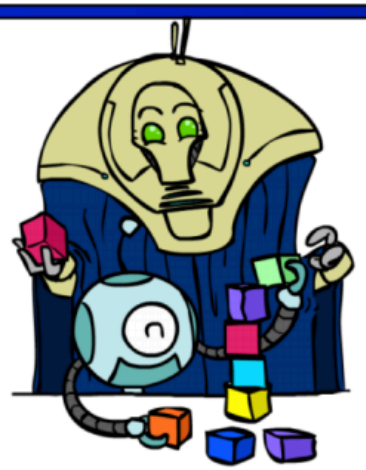
A >= 90% B >= 80% C >= 70%

D >= 60% F < 60%

+/- grades will be given for borderline cases.

Formative v. Summative

- Or: Instructive v. Assessment



Instruction

Grow knowledge, collaborate, work until success

Assessment

Measure knowledge, each student on their own, stopped before success

5% - In Class Activities and Participation

- Throughout the semester we will regularly complete short in class exercises such as:
  - brainstorming activities,
  - think-pair-share,
  - pre/post questions and short answer writing.
- Class attendance
  - Class attendance will be taken almost every day.
  - **Please please please do the readings (if possible) before so we can talk about them!**
  - Students are responsible for notifying instructors about absences that result from serious illnesses, injuries, or critical personal problems
  - Students with frequent absences will be reported and/or removed from the course according to university policy.

25% Each: Midterm and Final Exam

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- You know what this is.

- Final will not be comprehensive – will test the second portion of the course (hence equal weight).

- Dates:
  - March 5th, 2020 (In class).
  - May 6th, 2020 (8-12).

- You are allowed one, hand written, 8.5x11in, cheat sheet. This will be turned in with your exam (and handed back).

- **You must earn at least a 60% average between the two exams to pass this course!**

15% - Written Homeworks

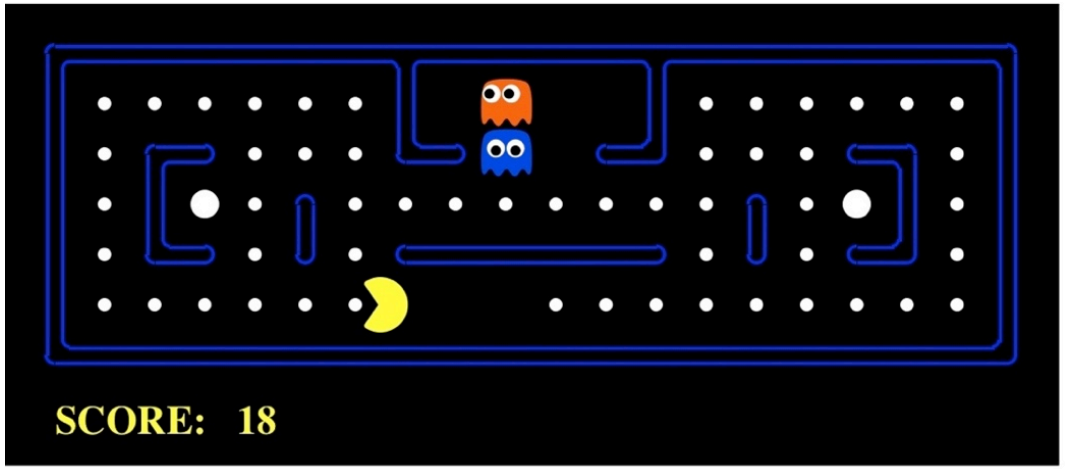
- We will have between 6-8 written homeworks throughout the semester.
- You are expected to write your answers individually.

- You are encouraged to **discuss homework problems in small groups, as long as you give credit to whomever you discussed the topics with at the top of your homework.**
- You are strongly discouraged from seeking solutions online; if you do, you must cite any sources explicitly you use for each problem.

- Copying of homework from other students or from other sources is strictly prohibited. Obtaining a solution from another source without citing the source is plagiarism.

30% - Projects

- We will do somewhere between 3-5 projects not counting Project 0!
- Most of these will be the PacMan projects and in Python!



30% - Projects

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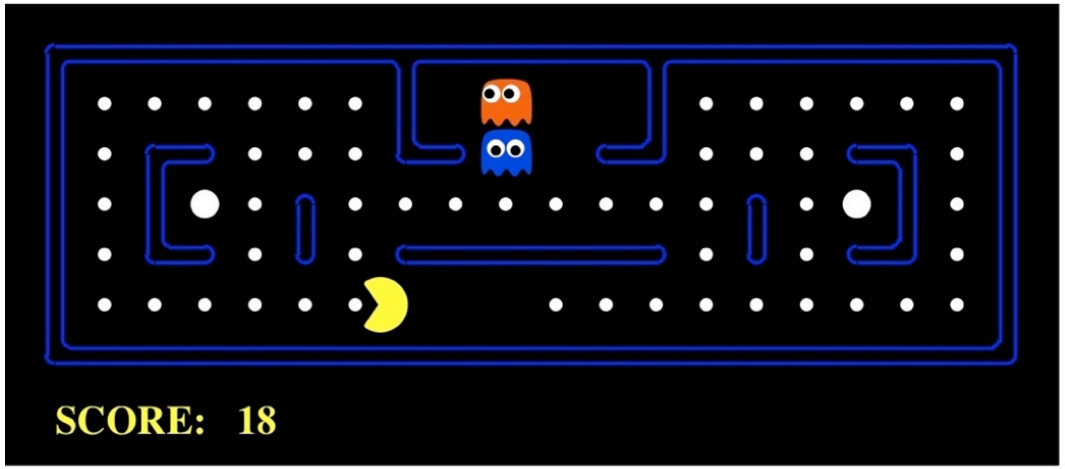
- We will do somewhere between 3-5 projects not counting Project 0!

- Most of these will be the PacMan projects and in Python!

- Gives you hands on experience!
- Will be autograded but we will look at and check your code.

- **Note:** These projects have been used a lot, we will check but we are not perfect. I will ask you questions about how you did them on the test… you better understand!



Late Work and Tokens

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- All work must be turned in on time unless explicit consent for outstanding circumstances is given beforehand (or in the case of illness, with a documented absence after).

- Any late work will be penalized at **20% of the total assignment value per day up to 5 days late, after which it will not be accepted**. The exception to this rule is if work solutions are presented in class (as is the case with labs and quizzes).

- **Late Tokens.** At the start of this semester you each are holding **3 late tokens** which can be redeemed at any time for programming projects only. Each token is worth one additional day, to use at your discretion.
  - These tokens have no cash value but are worth 1 additional point to your overall project grade at the end of the semester if you do not use them.

Laptops in Lecture

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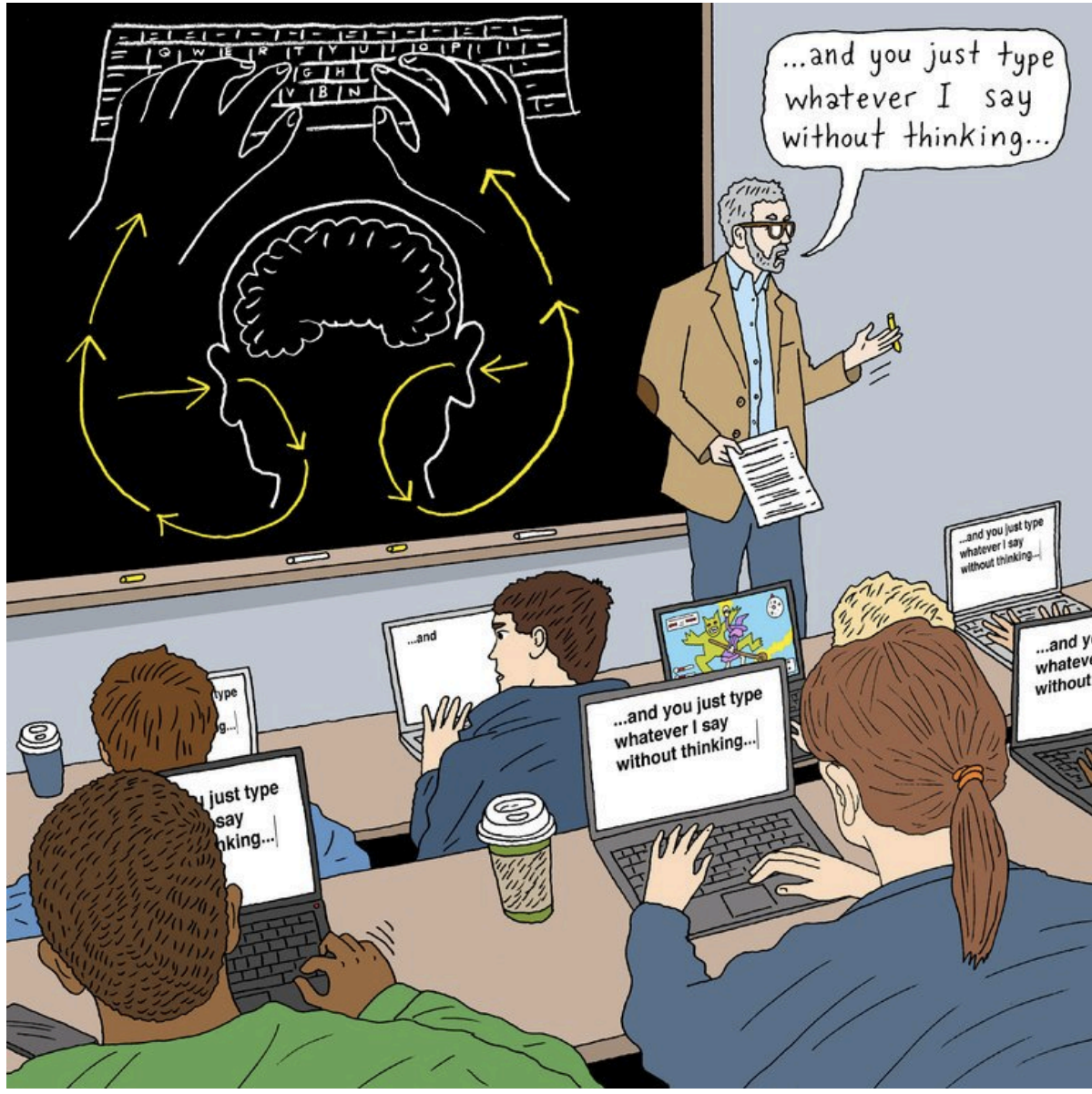
The New York Times

Laptops Are Great. But Not During a Lecture or a Meeting.

Economic View

By SUSAN DYNARSKI NOV. 22, 2017



Electronic Devices

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- Please silence your phones!

- If you want to use a laptop please move to the back of the class
  - https://www.scientificamerican.com/article/students-are-better-off-without-a-laptop-in-the-classroom/
  - https://www.nytimes.com/2017/11/22/business/laptops-not-during-lecture-or-meeting.html

- (everyone else -- I encourage you to sit in the front so that we can have an interaction.)

Giant and Important Walls of Text

Academic Integrity

- You are required to adhere to Tulane's Code of Academic Conduct.

- This course will follow Tulane's Code of Academic Conduct. Cheating will be reported to the Associate Dean of Newcomb-Tulane College. Discussion is encouraged. However, what you turn in must be your own. You may not read another classmate's solutions or copy a solution from the web. **I will be running checks on the code turned in for plagiarism. If plagiarism is detected the minimum penalty is a 0 on the assignment and being reported, however, you may automatically fail this course at my discretion.**

- The Code of Academic Conduct applies to all undergraduate students, full-time and part-time, at Tulane University. Tulane University expects and requires behavior compatible with its high standards of scholarship. By accepting admission to the university, a student accepts its regulations (i.e., Code of Academic Conduct and the Code of Student Conduct) and acknowledges the right of the university to take disciplinary action, including suspension or expulsion, for conduct judged unsatisfactory or disruptive.

Academic Integrity

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(Text unironically stolen from Hal Daumé III)

- **Any assignment or exam that is handed in must be your own work** (unless otherwise stated). However, talking with one another to understand the material better is strongly encouraged. Recognizing the distinction between cheating and cooperation is very important. If you copy someone else's solution, you are cheating. If you let someone else copy your solution, you are cheating (this includes *posting solutions online in a public place)*. If someone dictates a solution to you, you are cheating.

- Everything you hand in must be in your own words, and based on your own understanding of the solution. If someone helps you understand the problem during a high-level discussion, you are not cheating. **We strongly encourage students to help one another understand the material presented in class, in the book, and general issues relevant to the assignments.** When taking an exam, you must work independently. Any collaboration during an exam will be considered cheating. Any student who is caught cheating will be given an F in the course and referred to the University Office of Student Conduct. Please don't take that chance – if you're having trouble understanding the material, please let me know and I will be more than happy to help.

Title IX and Harassment

- Tulane University recognizes the inherent dignity of all individuals and promotes respect for all people. **As such, Tulane is committed to providing an environment free of all forms of discrimination including sexual and gender-based discrimination, harassment, and violence like sexual assault, intimate partner violence, and stalking. If you (or someone you know) has experienced or is experiencing these types of behaviors, know that you are not alone.**

- Resources and support are available: you can learn more at http://allin.tulane.edu. Any and all of your communications on these matters will be treated as either "Confidential" or "Private". **Please know that if you choose to confide in me I am mandated by the university to report to the Title IX Coordinator, as Tulane and I want to be sure you are connected with all the support the university can offer.** You do not need to respond to outreach from the university if you do not want. You can also make a report yourself, including an anonymous report, through the form http://tulane.edu/concerns.

Wait What is AI?

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- Take out a piece of paper, put your name and today's date on it.
- Take a moment to try to answer the following questions:
  - What is your definition of artificial intelligence as a field of study?
  - What is the thing you are most excited to learn about in this course?
  - What is the thing you are most worried about in this class?
  - List your other CS courses this semester

AI

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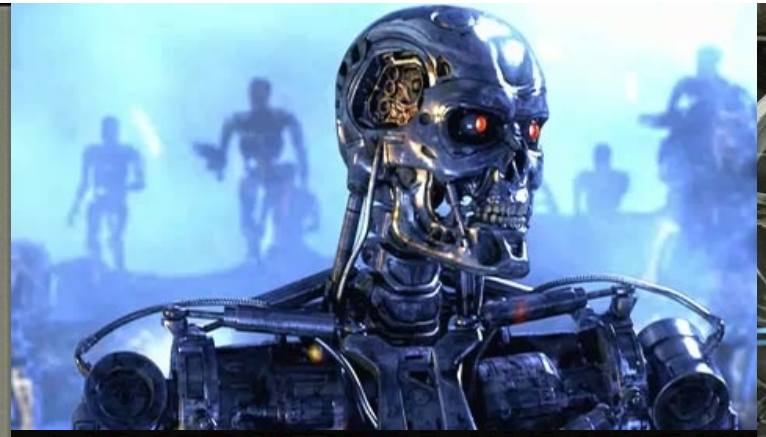
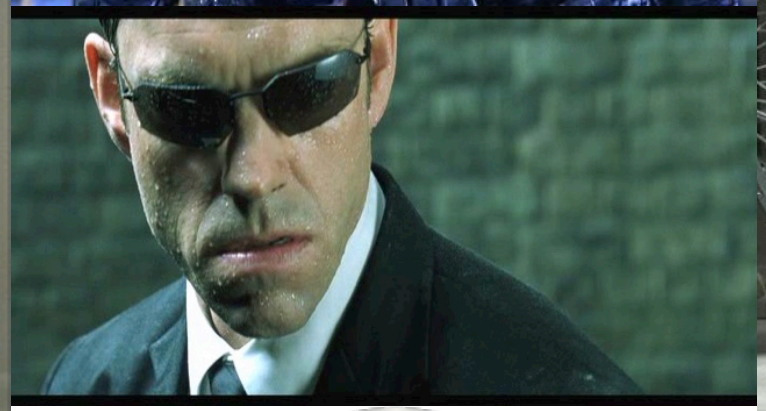
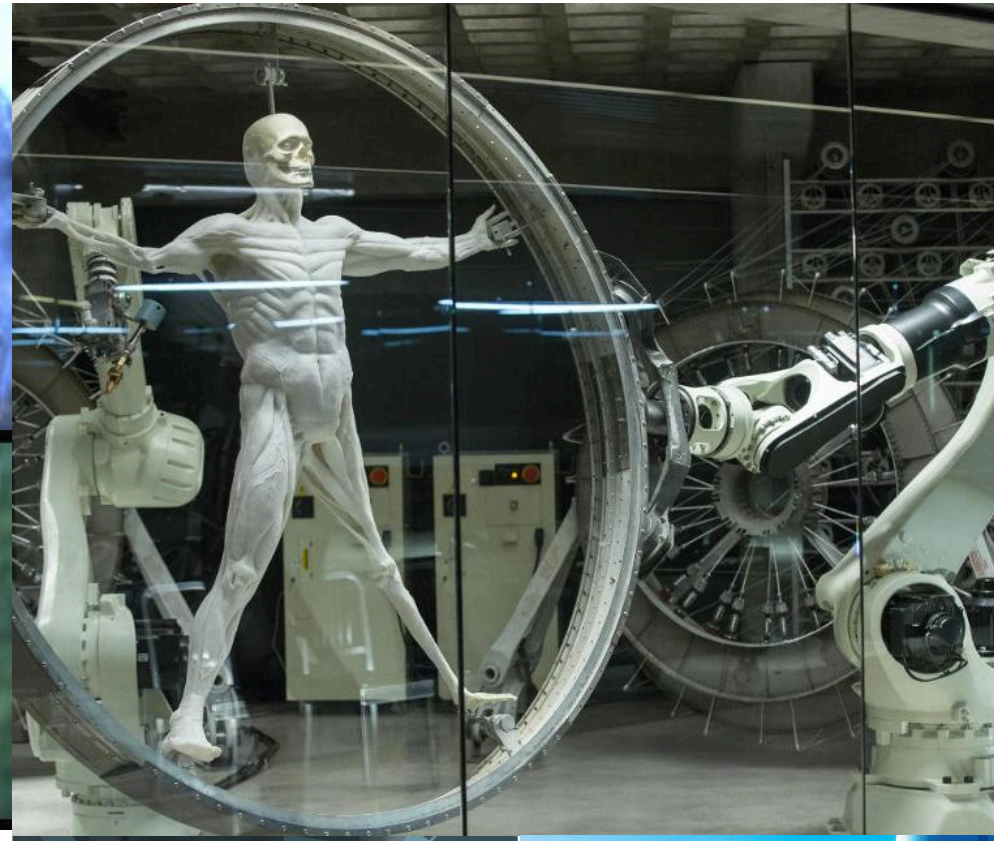
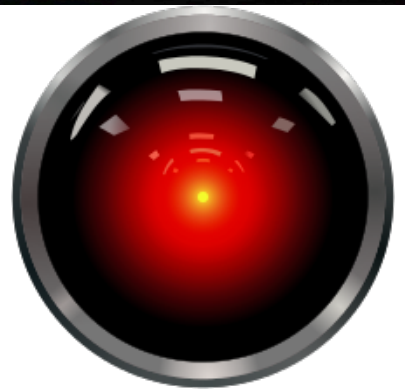
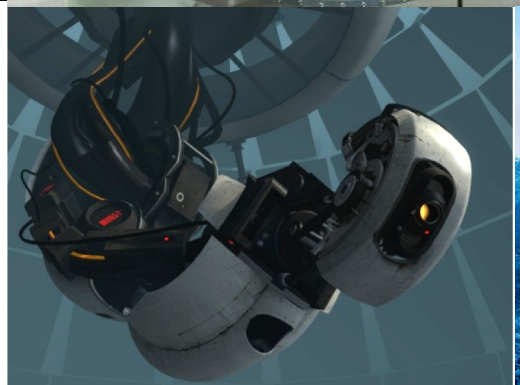








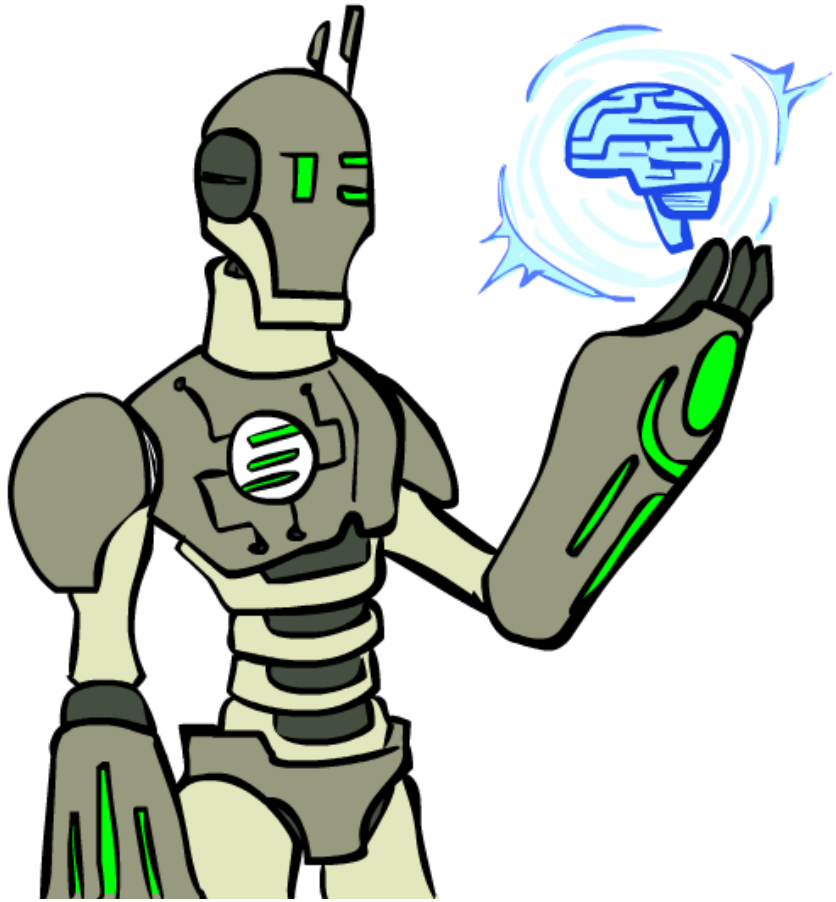



WAYMO


TUG
CAUTION
MAY CONTAIN
CHEMOTHERAPY DRUG
CAUTION
MAY CONTAIN
CHEMOTHERAPY DRUG

The Rest of Today

- What is Artificial Intelligence
- Where did it come from?
- What can AI do (now-ish as of early 2020)?



What is AI?

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The science of making machines that:

Wait, What is AI?

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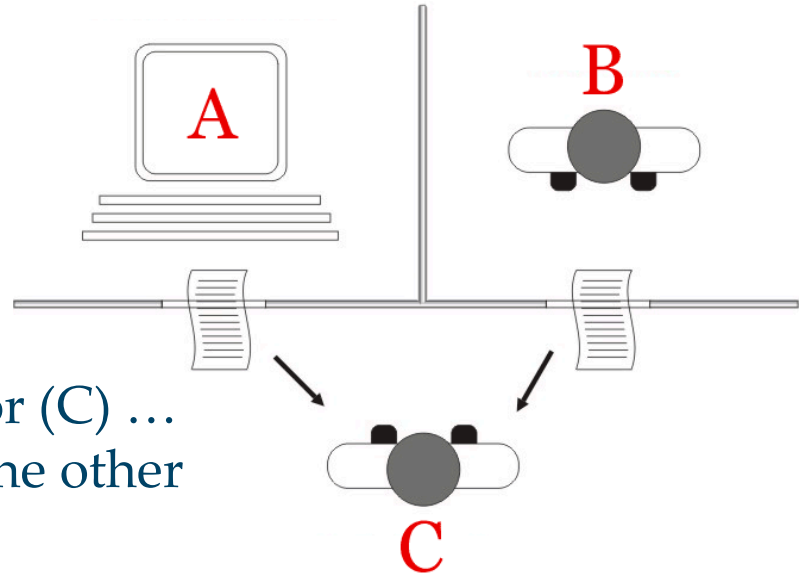
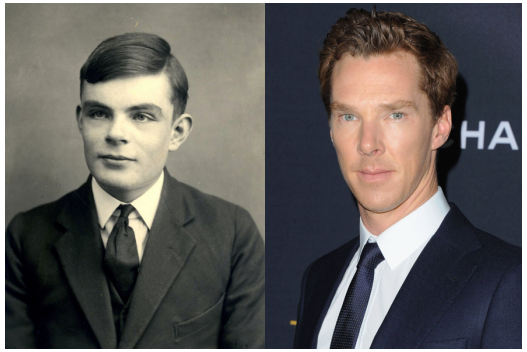
- **Alan Turing** 1950, *"I propose to consider the question, 'Can machines think?' … I shall replace the question by another, which is closely related to it and is expressed in relatively unambiguous words."*



- **The Imitation Game:** "… a man (A), a woman (B) and an interrogator (C) … The object of the game for the interrogator is to determine which of the other two is the man and which is the woman.

- Or, generalized to computers:
  - A human interrogator and two subjects one human and one machine.
  - Using keyboards the interrogator asks written questions and receives written answers.
  - If interrogator cannot tell if A or B is human, then the machine passes.
  - No direct physical interaction between the interrogator and the machine



Acting Humanly: The Turing Test

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- What's needed to pass the Turing Test?
  - Natural Language Processing
    - to communicate, say, in written English
  - Knowledge Representation
    - to store what it knows or hears
  - Automated Reasoning
    - to use the stored information to answer questions and draw new conclusions
  - Learning
    - to adapt to new circumstances

- Total Turing Test: In total Turing test, physical interaction is assumed: interrogator can pass or show objects to subjects A & B
  - Computer vision to perceive objects
  - Robotics to manipulate objects

AI passed the Turing test

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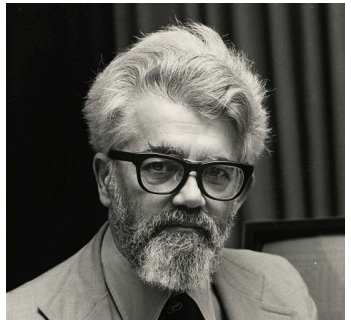
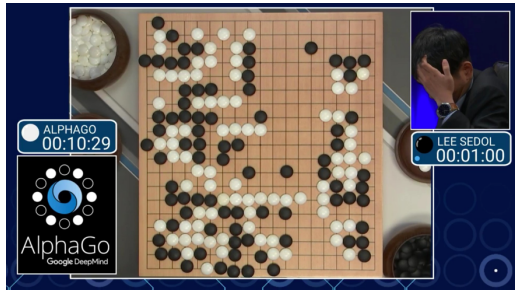


- AI program "Eugene Goostman" passed the Turing test for world's first time in June 2014
  - A chatting programing impersonating a 13-year-old Ukrainian boy, created by Vladimir Veselov et al. (http://www.princetonai.com/bot)
  - 33% of the 30 judges were convinced that the bot was human
- Does it mean we have an working AI program?
  - Emphasis on the outcome, not the underlying process of intelligence

- **John McCarthy** et al. 1955, "… *every aspect of learning or any other feature of intelligence can in principle be so precisely described that a machine can be made to simulate it.*"



- **Tessler's Theorem:** "*Intelligence is what machines haven't done yet.*"
  - I.e., "If machines can do it, it isn't intelligence.

Thinking Humanly: Cognitive Modeling

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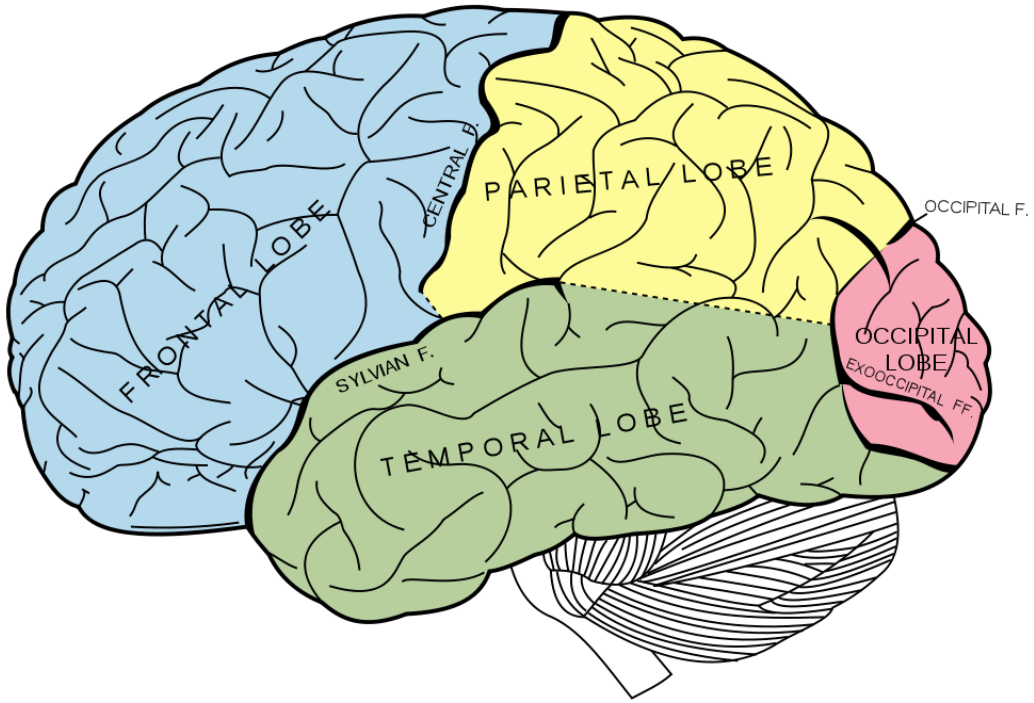
- Understanding the human thought process is the main goal of cognitive science
  - Psychological experiments + computational models of thinking

- Cognitive science is not AI
  - Algorithm that works on computers does not mean it's how human brain works
  - Successful AI applications need not base on cognitive modeling
  - The two fields have influenced each other



Thinking Rationally: "Laws of Thought"

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- Logic:
  - Syllogism from Greek philosophers:

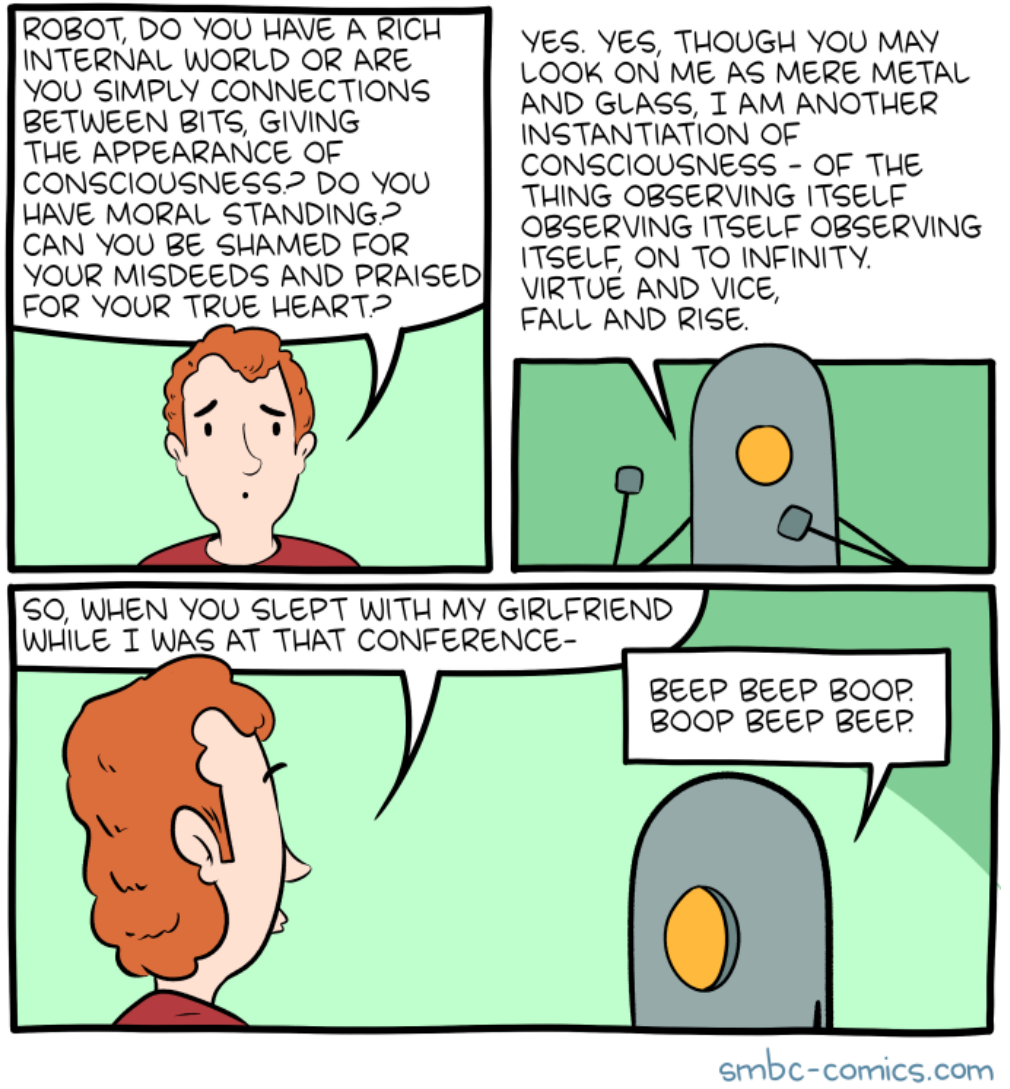
    "Socrates is a man: all men are mortal: therefore, Socrates is mortal."
  - By 1965, programs exists that could solve any solvable logical problems *in principle*
- Practical problems:
  - Not everything can be formulated logically
  - Large amounts of computation needed to do complete inference

Announcements

- Website Updated with Schedule, and Project0, and Slides, and Office Hours!
  - https://nmattei.github.io/cmps3140/
  - Get started on Project0!

- Dr. Mattei's Office Hours will be:
  - TR 1500 – 1600
  - STH 402B
- Arie's Office Hours will be:
  - MW 1000 – 1100
  - STH 309

- We now have 40+ People in the course.
  - If you are not formally enrolled and want to be come see me after class.



What is AI?

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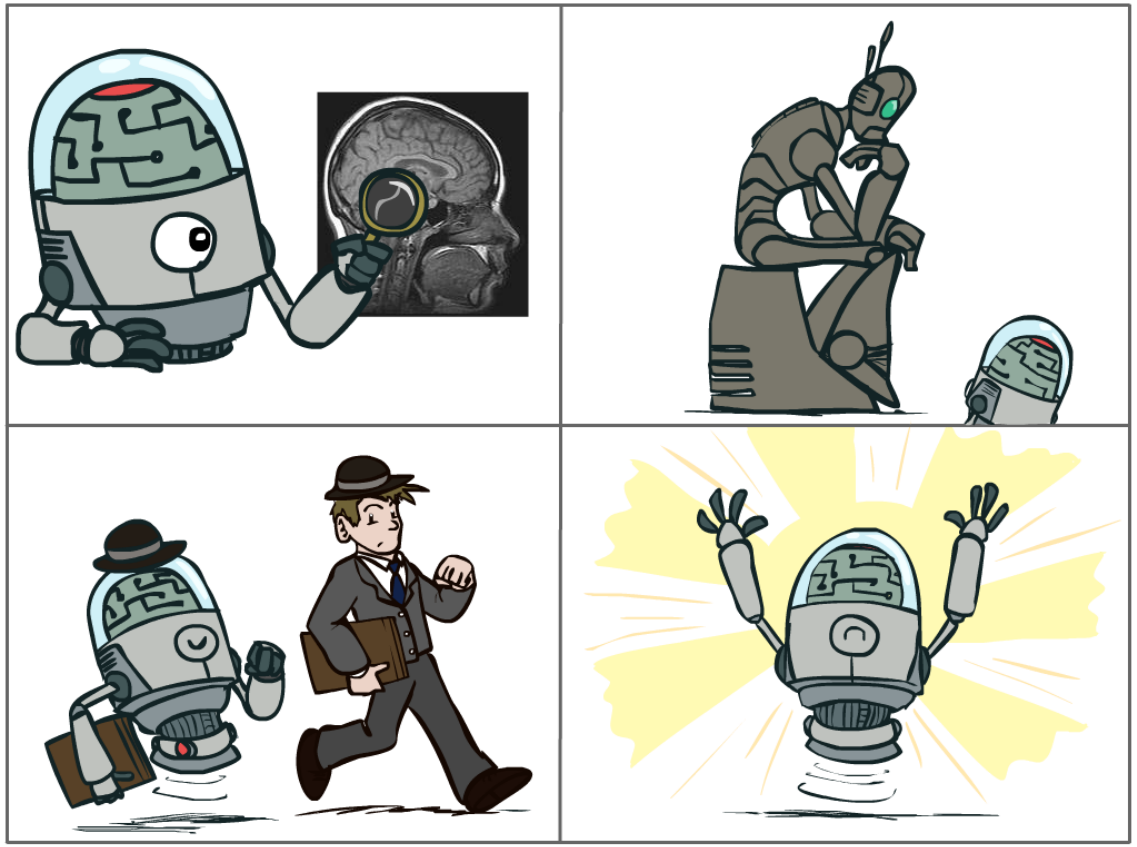
The science of making machines that:

Think like people



Think rationally

Act like people

Act rationally

Rational Decisions

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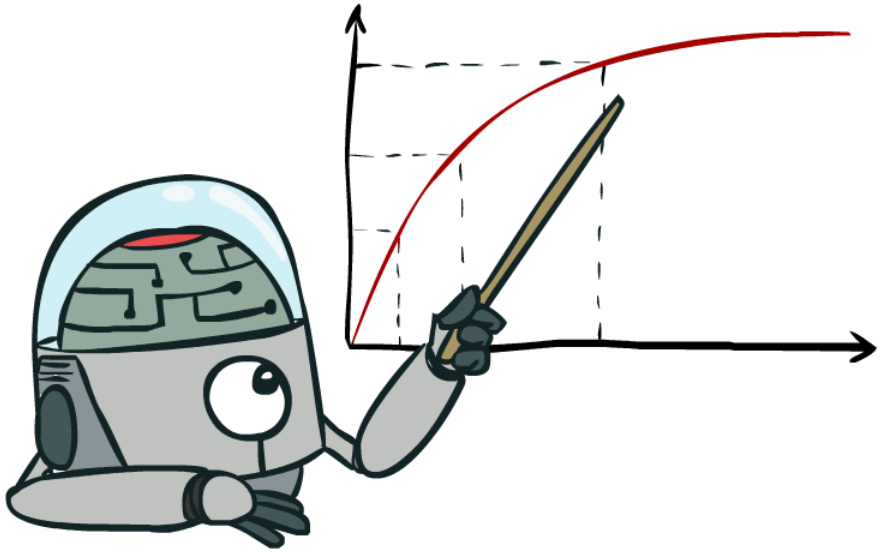
We'll use the term **rational** in a very specific, technical way:

- 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**

A better title for this course would be:

Computational Rationality

Maximize Your Expected Utility



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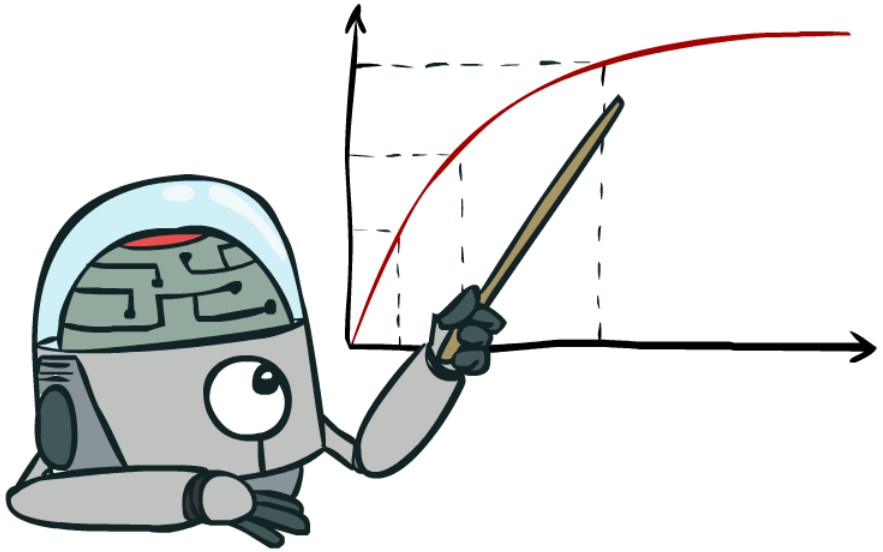
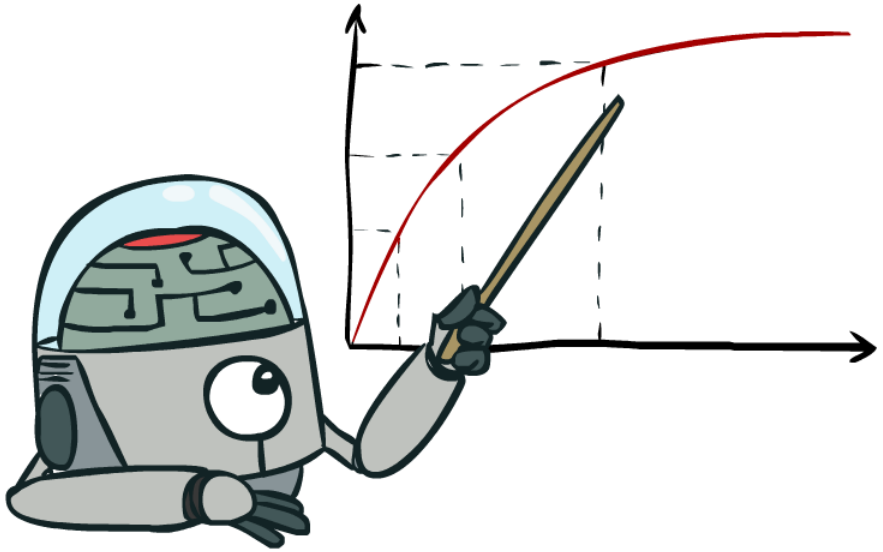
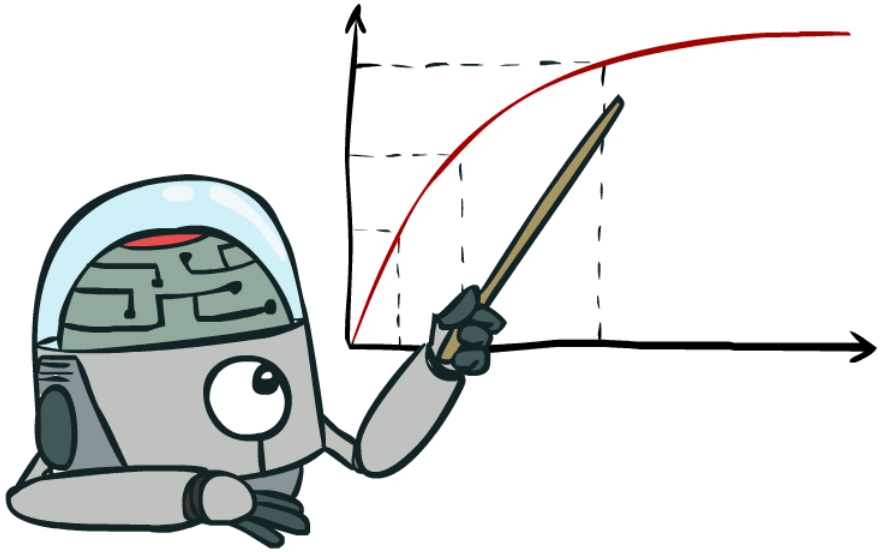
Maximize Your **Expected** Utility



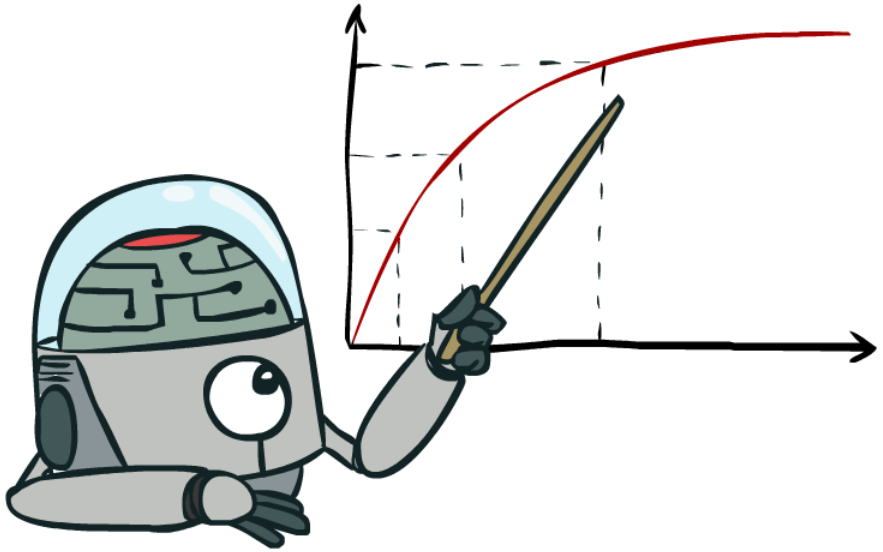
Maximize Your Expected **Utility**



Maximize Your Expected Utility



Maximize **Your** Expected Utility



Big Challenge: Limited Computation

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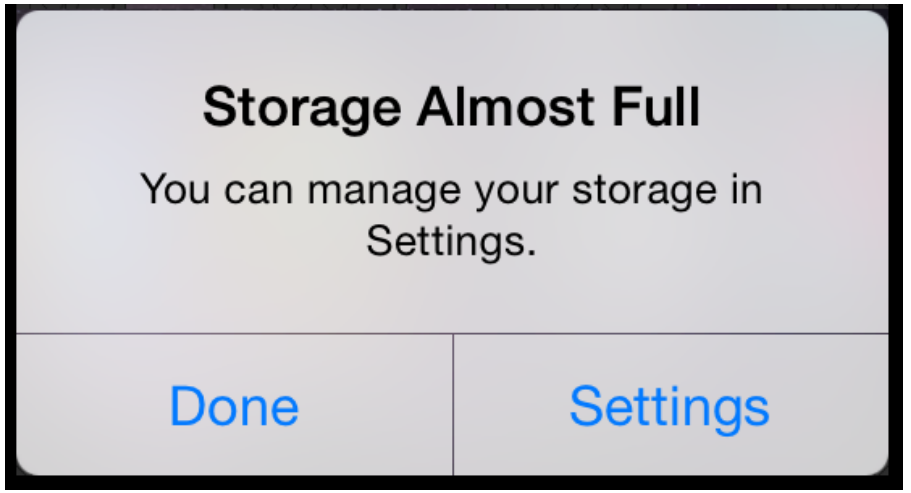
- If you could enumerate all the ways to play a game of tic-tac-toe…
- What about chess?
- Sometimes we don't have the resources
  - Run out of time
  - Run out of memory
- Limited rationality: do the right thing given the constraints
- This will come up over and over again as we talk about searching, agent designs, and computing in general!



What About the Brain?

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- Brains (human minds) are very good at making rational decisions, but not perfect
- Brains aren't as modular as software, so hard to reverse engineer!
- "Brains are to intelligence as wings are to flight"
- Lessons learned from the brain: memory and simulation are key to decision making

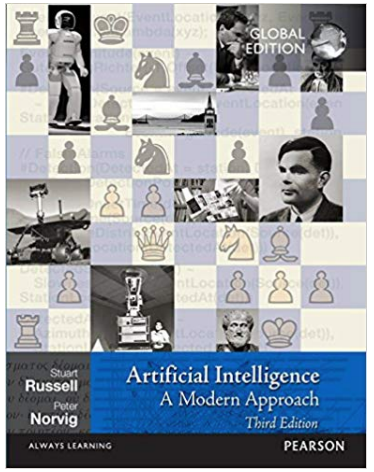
Foundations of AI

- Philosophy:
  - logic, methods of reasoning
  - mind as physical system
  - foundations of learning, language, rationality
- Mathematics:
  - formal representation and proof
  - algorithms, computation, (un)decidability, (in)tractability
  - probability
- Psychology :
  - adaptation
  - phenomena of perception and motor control
  - experimental techniques (psychophysics, etc.)
- Economics:
  - formal theory of rational decisions
- Linguistics:
  - knowledge representation
  - grammar
- Neuroscience:
  - plastic physical substrate for mental activity
- Control theory
  - homeostatic systems, stability
  - simple optimal agent designs

AI for AI Researchers

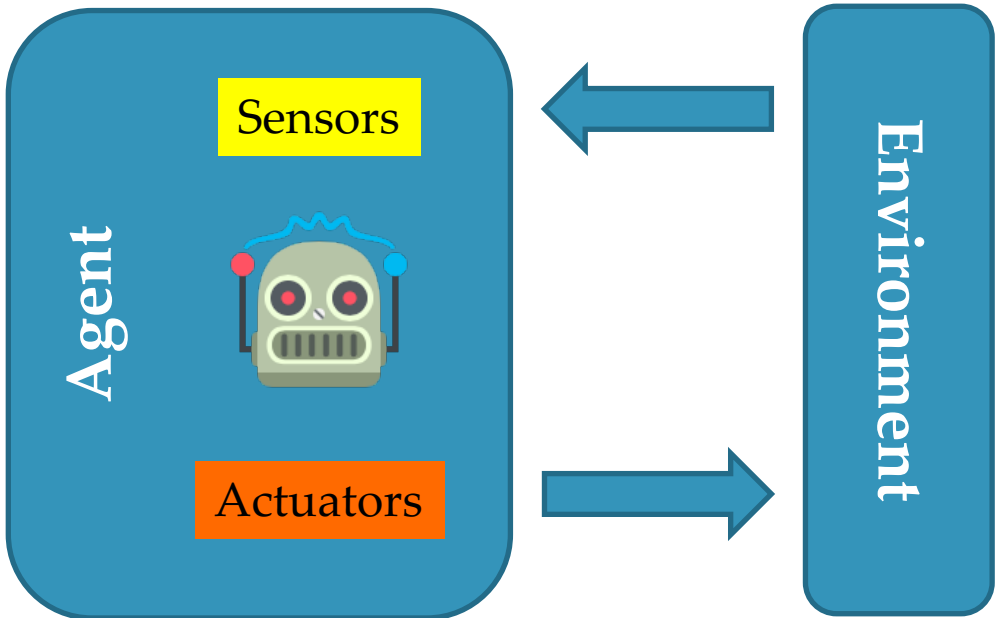
- **Russell and Norvig**, *"'artificial intelligence' is when a machine mimics 'cognitive functions' that humans associate with other human minds such as 'learning' and 'problem solving'"*

  - Broadly responsible for the agent based approach: *"… rational agents that acts so as to achieve the best outcome, or, when there is uncertainty, the best expected outcome."*



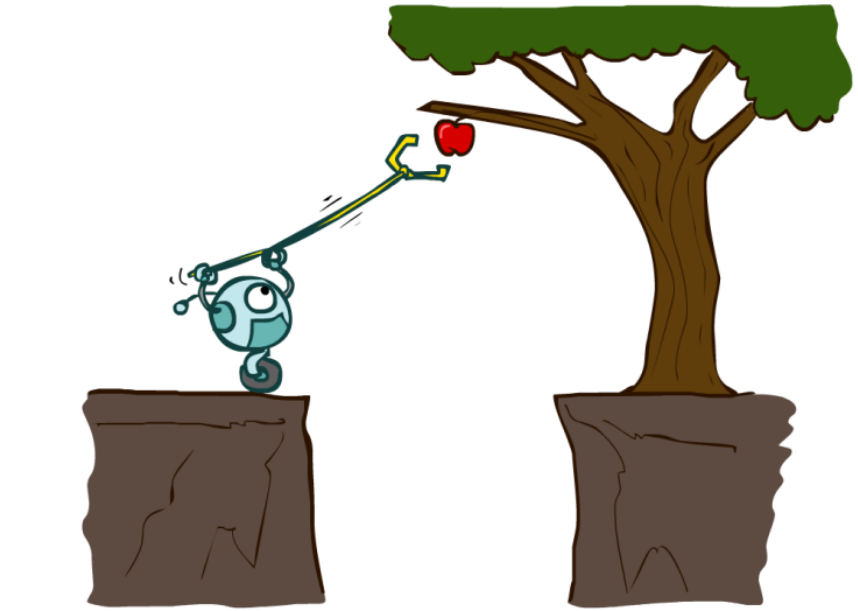
- Traditional Goals:
  - Reasoning, Planning, and Knowledge Representation;
  - Machine Learning and Natural Language Processing;
  - Perception (vision), and Embodiment (Robotics).

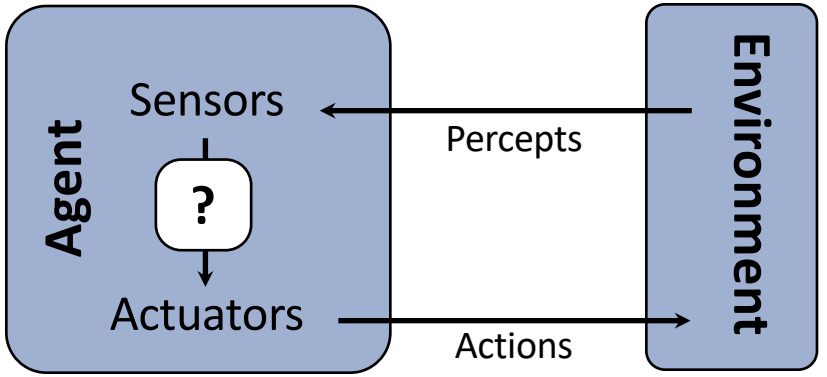
  - All of these are in service of (for some) creating Artificial General Intelligence (AGI).



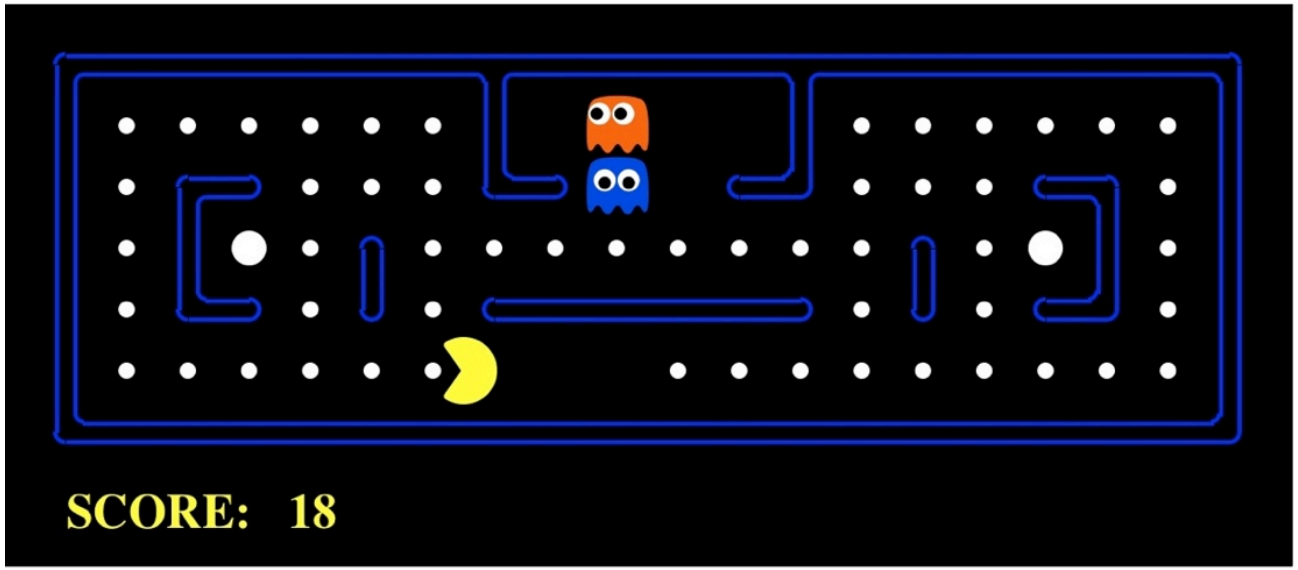
Designing Rational Agents

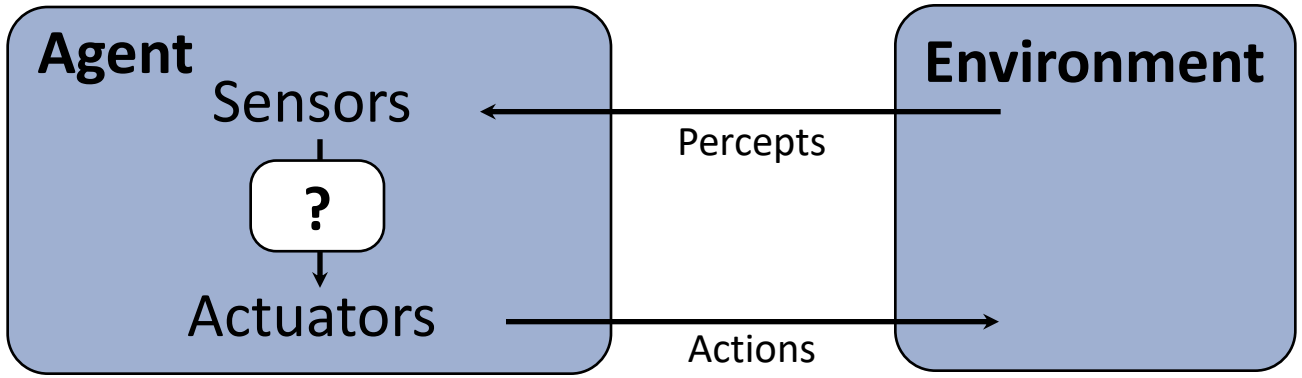
- An **agent** is an entity that *perceives* and *acts*.
- A **rational agent** selects actions that maximize its (expected) **utility**.
- Characteristics of the **percepts, environment,** and **action space** dictate techniques for selecting rational actions
- **This course** is about:
  - General AI techniques for a variety of problem types
  - Learning to recognize when and how a new problem can be solved with an existing technique





Pac-Man as an Agent





Pac-Man is a registered trademark of Namco-Bandai Games, used here for educational purposes

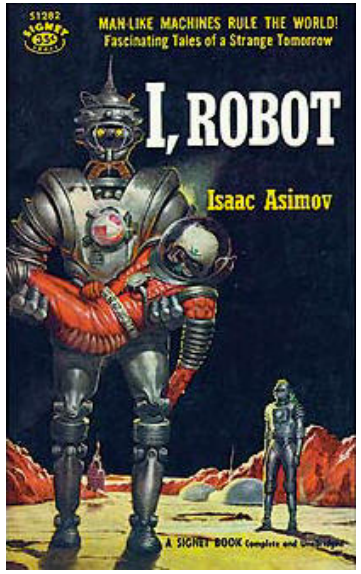
Demo1: pacman-l1.mp4

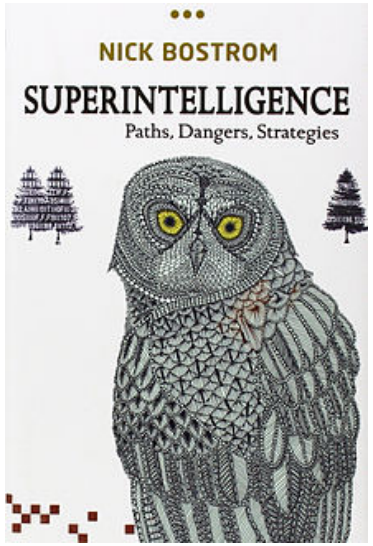
Artificial General Intelligence?

- What you think of when you think of *AI* most of the time.
  - **Strong AI:** program for the whole range of human cognition.
  - **Weak AI:** narrow or domain specific tasks.

```
> Hello, I am Eliza.
* I am afraid.
> How long have you been afraid?
* Since midterms.
> Tell me more...
* I am afraid that I will fail
my course.
> Do you enjoy being afraid that
you will fail your course?
```

- *If* we can create a big enough system, we can simulate a human
  … or close enough.
  - Intelligence is just a function mapping inputs to outputs.
  - Is there a difference between faking it and making it?



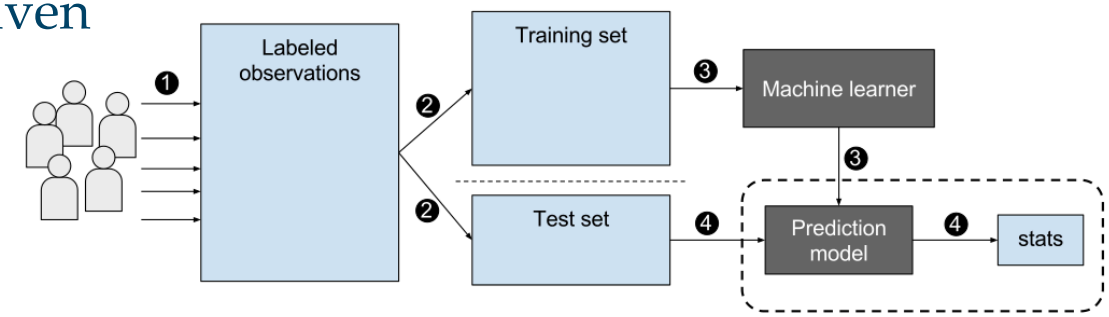


Machine Learning

- *(Depending on whom you ask, either is AI or is a subfield of AI.)*
- **Arthur Samuel 1959,** *"… give[s] computers the ability to learn without being explicitly programmed."*

- **Tom M. Mitchell**, "A computer program is said to learn from experience *E* with respect to some class of tasks *T* and performance measure *P* if its performance at tasks in *T* as measured by *P*, improves with experience E."

- Major Machine Learning Paradigms:
  - **Supervised Learning:** provide labeled examples and the machine learns to identify these (classification).
  - **Unsupervised Learning:** unlabeled examples are given and the machine learns to differentiate these (clustering).
  - **Reinforcement Learning:** only a reward signal is given as feedback to the machine (acting).



AI vs Machine Learning (One Argument, Not Nick's)

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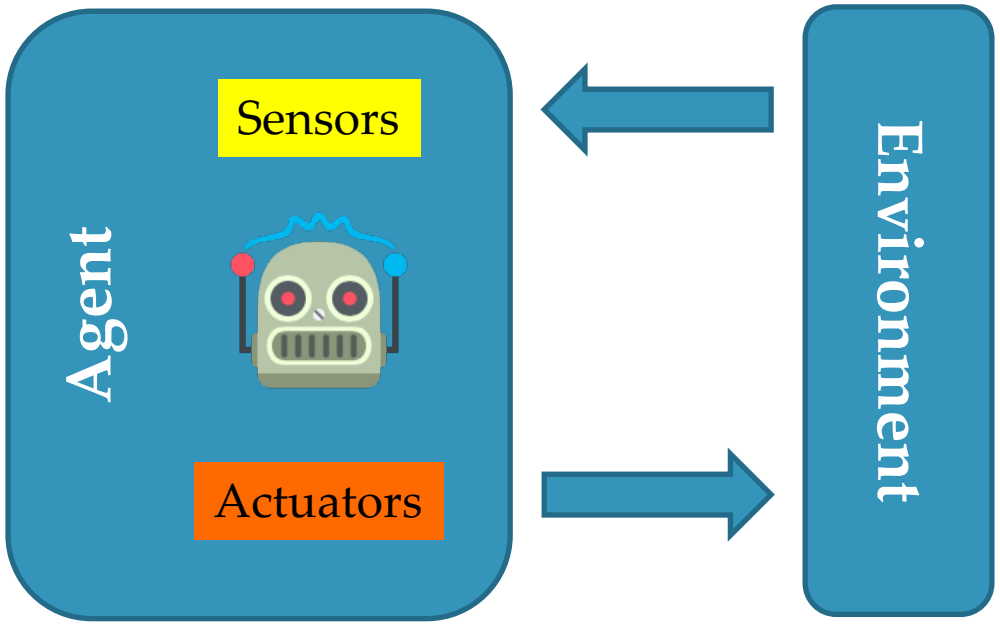
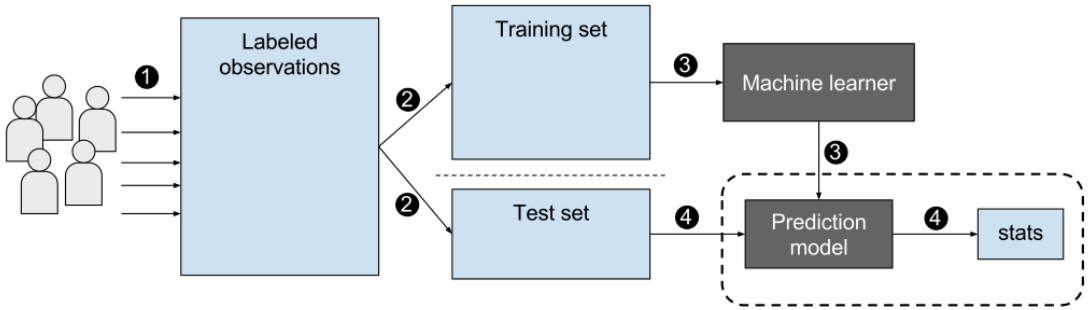
- AI = Machine Learning ?
  - Historically, ML is one (recent) approach for AI
  - ML is (arguably) the dominant form of effort in AI research at the moment.
    - (with some exception of classic research topics such as Knowledge Representation)
  - Most of the recent successes in AI application is driven by ML (and lots and lots of data).
  - ** However, this all assumes we don't count things like Optimization, SAT, planning etc… remember *Tessler's Theorem*…

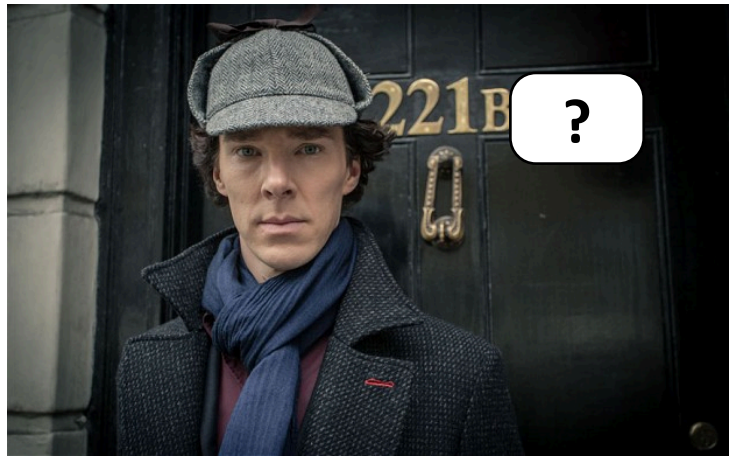


- Main distinction:
  - Classic AI: emphasis on deductive reasoning
  - Machine Learning: inductive reasoning

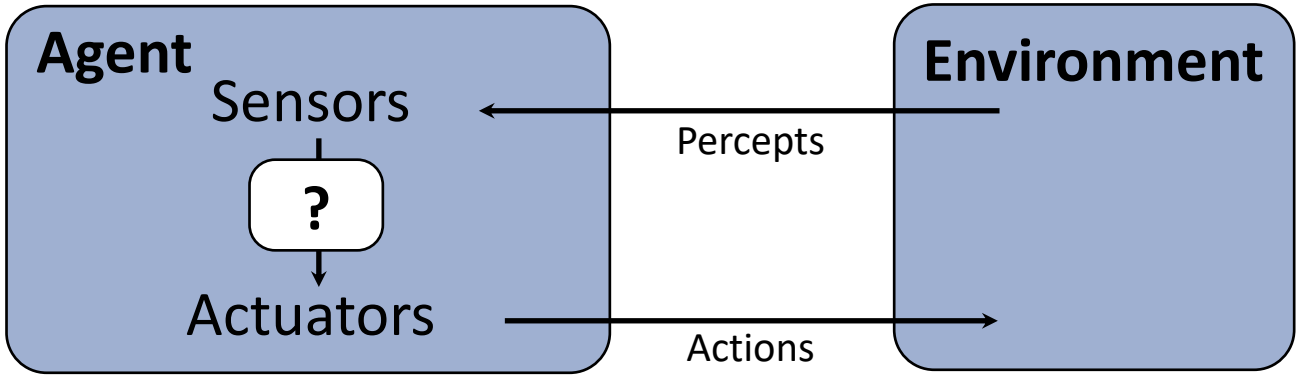


Deductive reasoning

- Deductive reasoning: general premises → particular conclusions
  - Search: problem formulation + BFS, A*,etc
  - Logic: KB using PL/FOL + generalized resolution, etc
  - Probability: JPT/Bayes Net + Bayes rule, etc
  - In general, encode knowledge about the problem, and use general algorithms to solve it

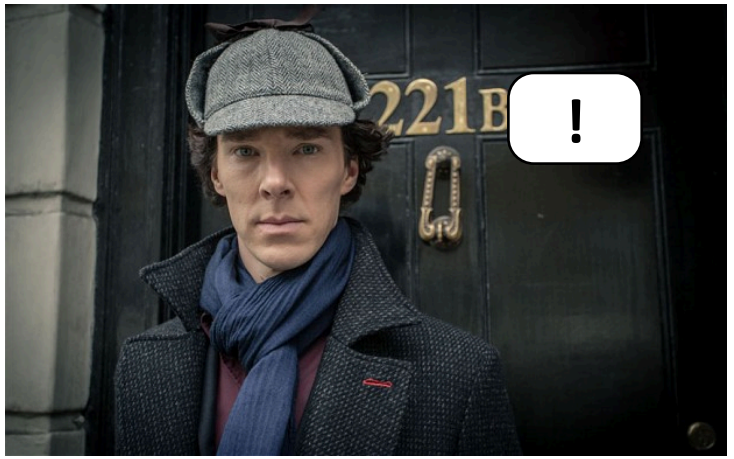


- Is deduction the full extent of what intelligent agents can do?



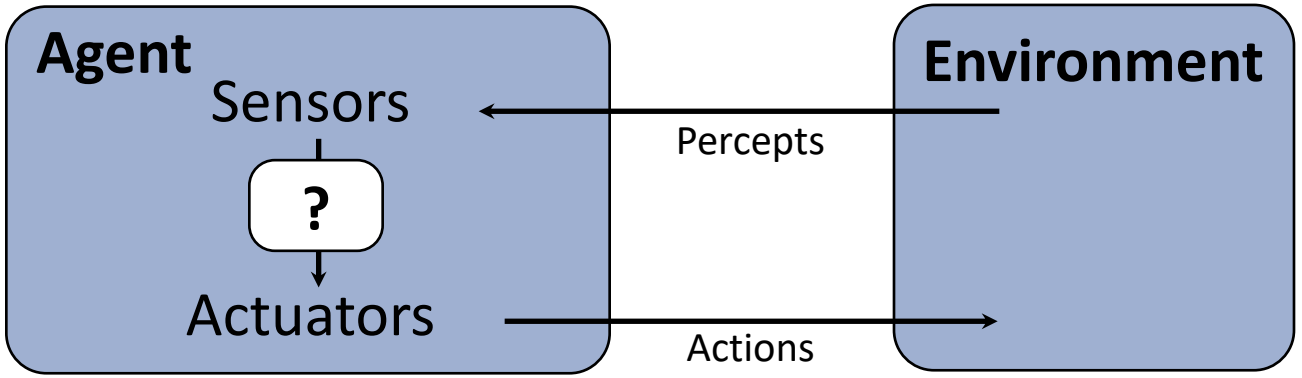
Inductive reasoning

- Inductive reasoning: particular instances → general knowledge
  - {Socrates died, Plato died, … } →
    All men are mortal

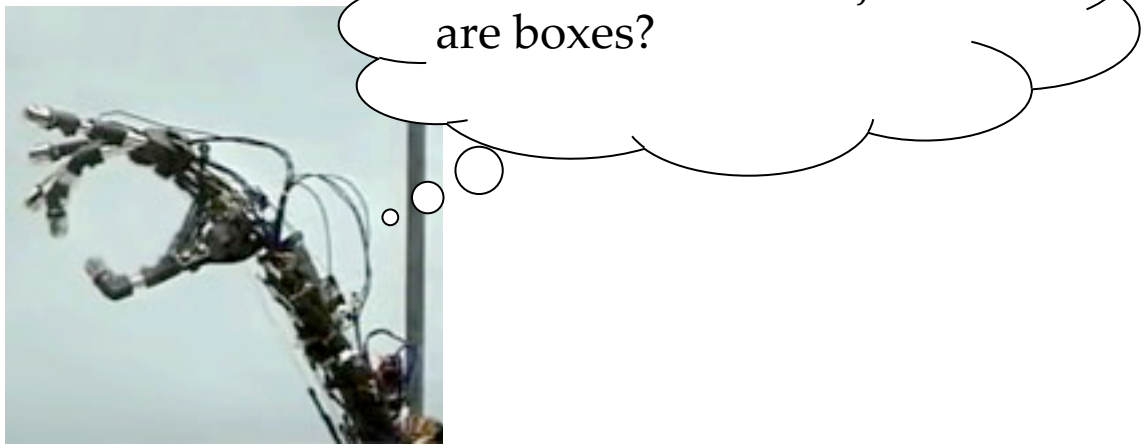


- Agent needs inductive reasoning skills too
  - To adapt to changes of the world
  - To learn more about the world to make better decisions

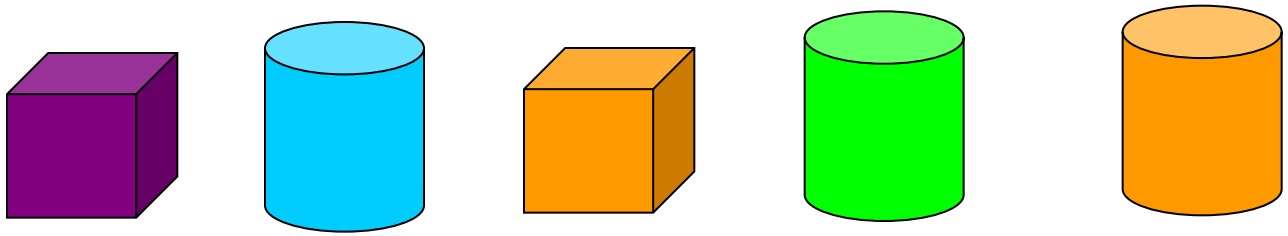
- Rational agents requires **both**
  deductive and inductive reasoning skills!!



Deductive reasoning

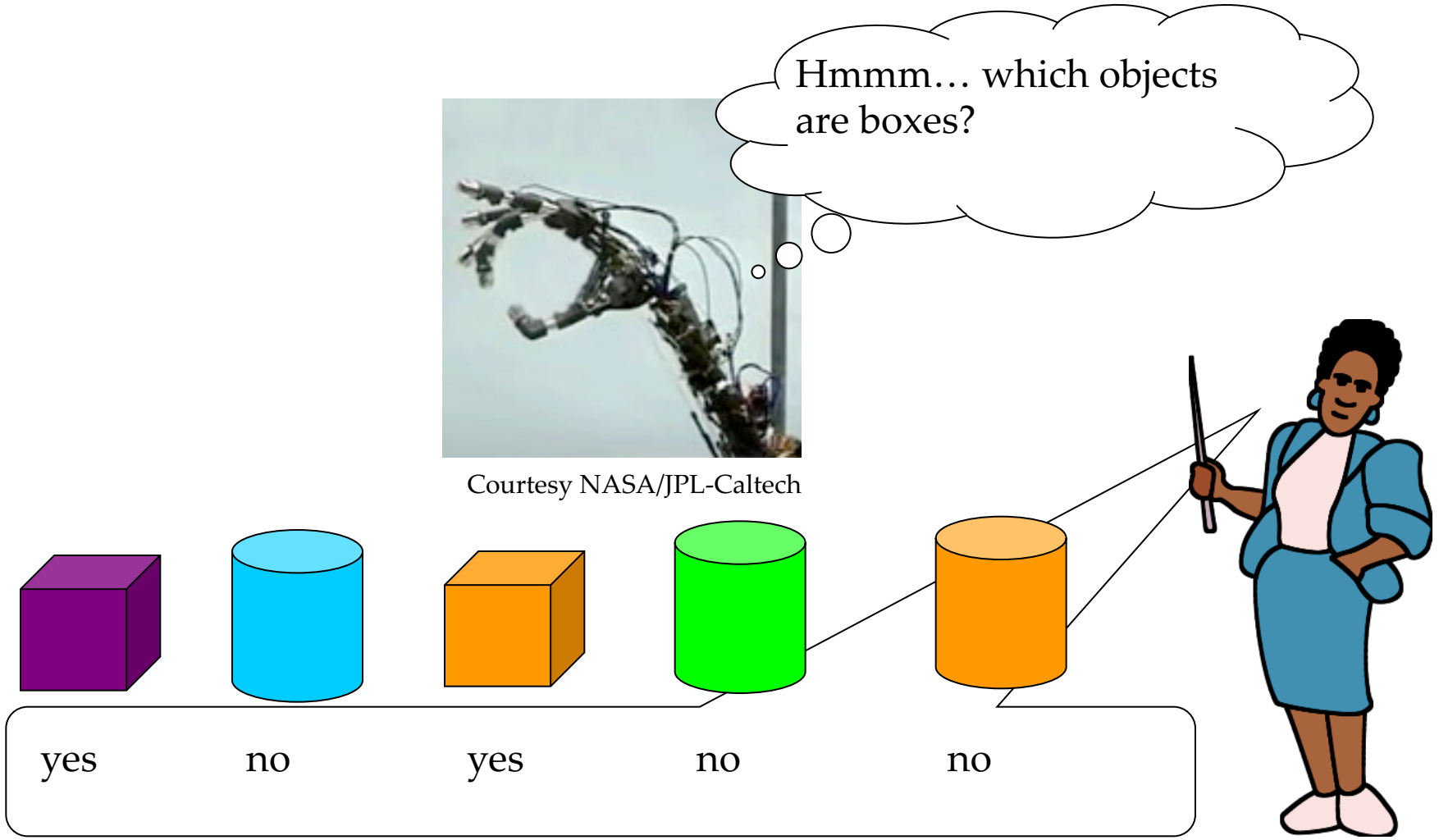


Courtesy NASA/JPL-Caltech



Deduction: a box is an rectangular-shaped object with an empty interior, and is often made of woods, papers, plastic, metals, …

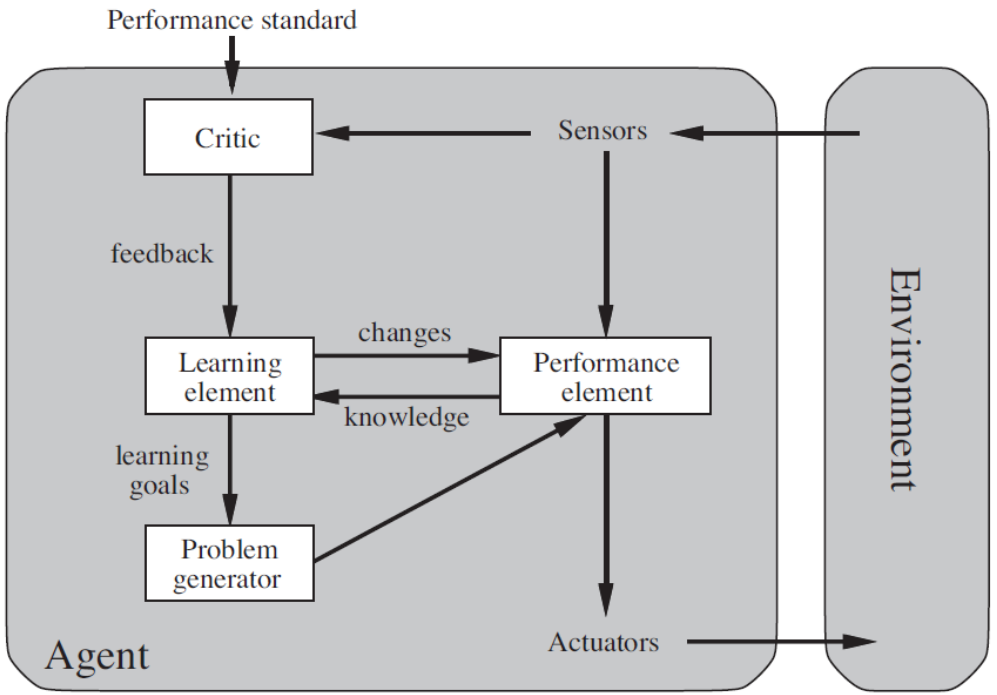
Inductive reasoning



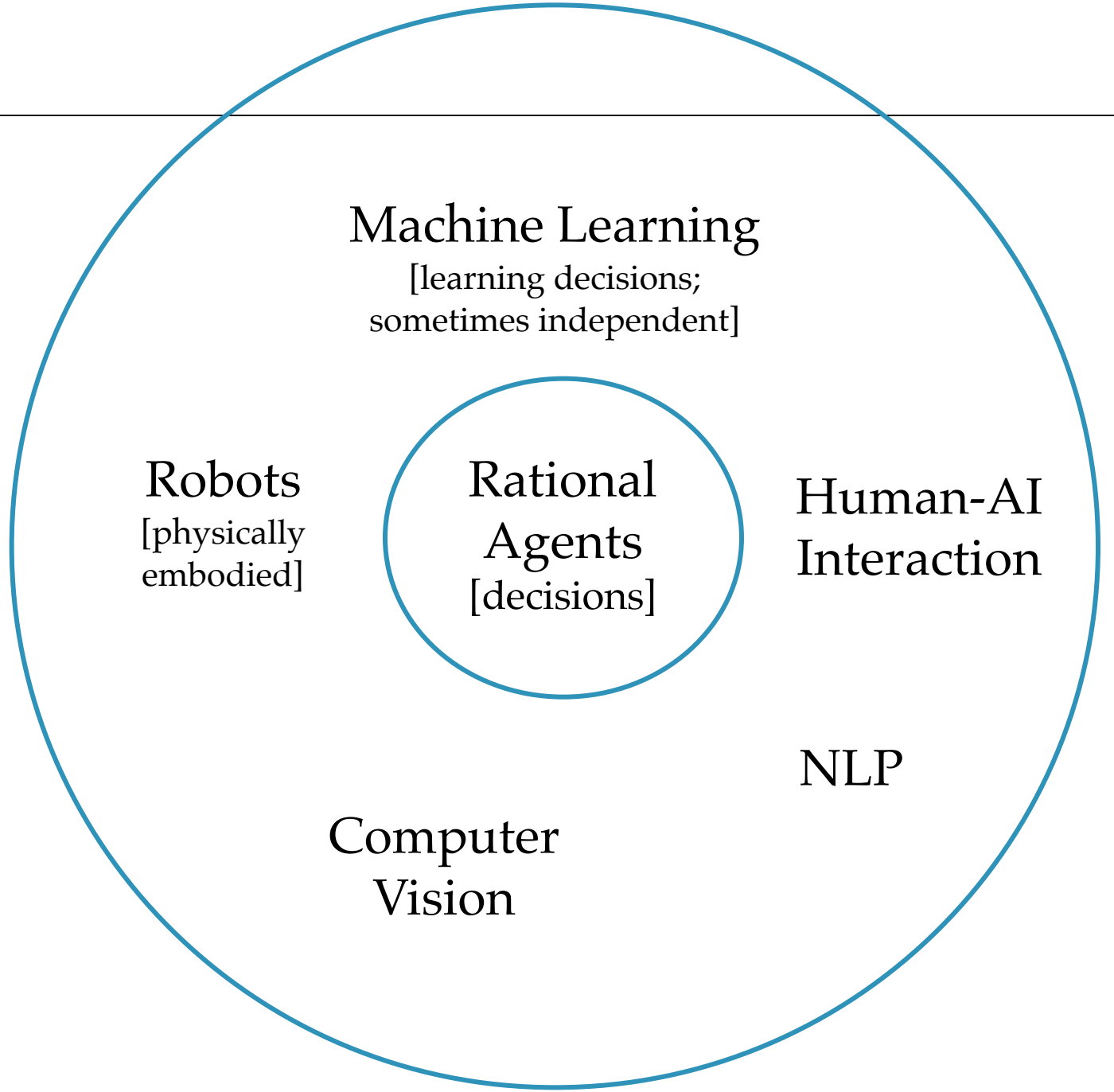
Ideal vs realistic learning agents

- An ideal, fully autonomous learning agent can
  - understand and formulate the problem by itself
    - what states there are,
    - how actions affect states,
    - how states and percepts are related)
  - find the best (sequence of) actions to reach the goal or maximize utility

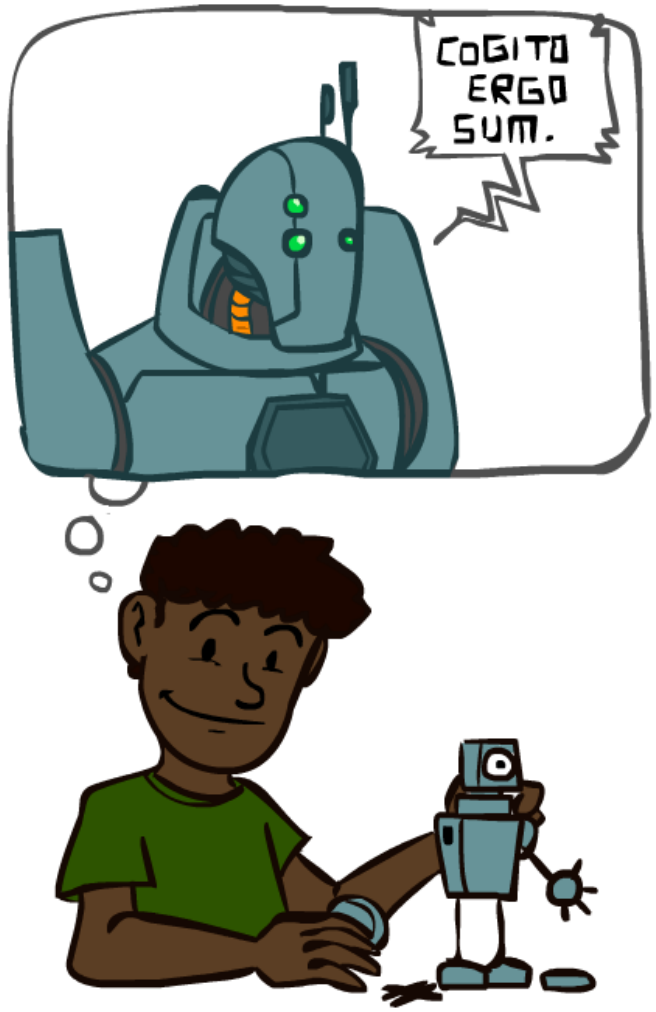
- Reinforcement learning is closest to this goal
- A more modest, realistic goal: learning agents should
  - solve a sub-problem by learning
  - improve performance from experience

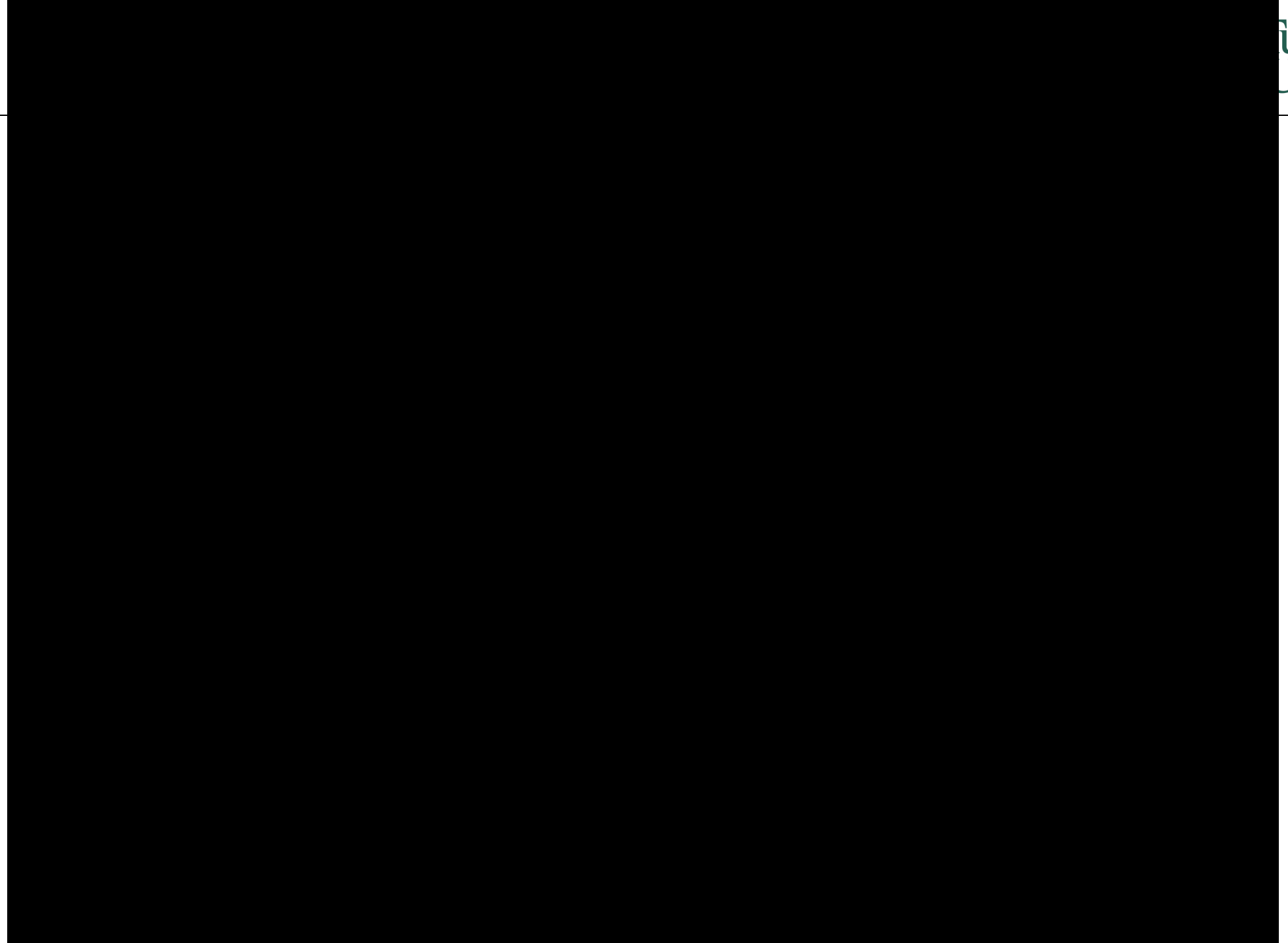


AI


Machine Learning
[learning decisions;
sometimes independent]
Robots
[physically
embodied]
Rational
Agents
[decisions]
Human-AI
Interaction
NLP
Computer
Vision

A (Short) History of AI





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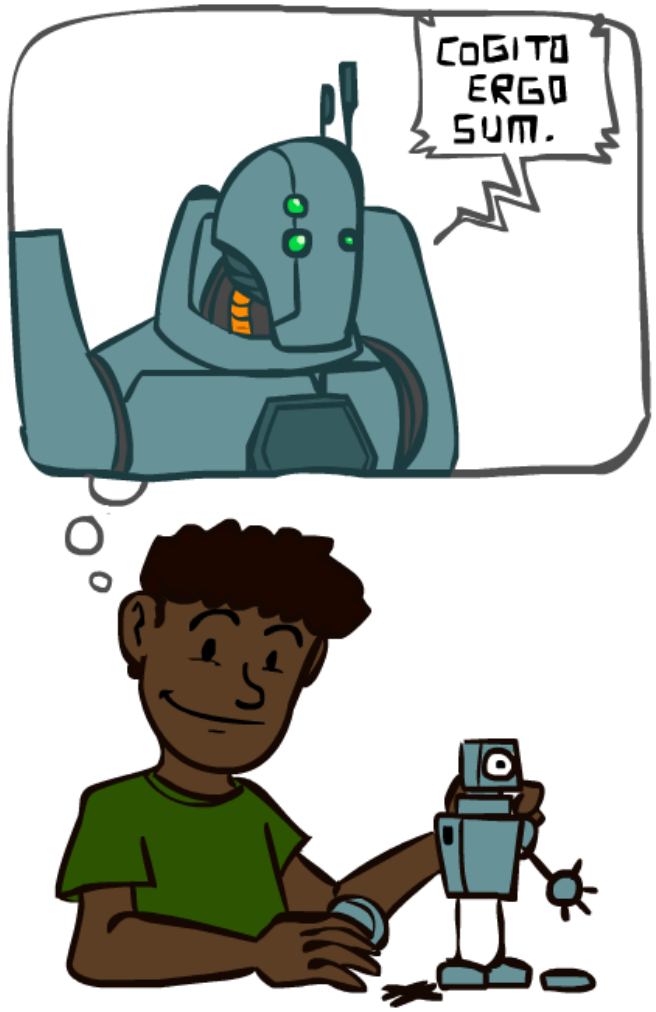
A (Short) History of AI

- 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… "AI Spring"?
- 2000—: Where are we now?



What Can AI Do?

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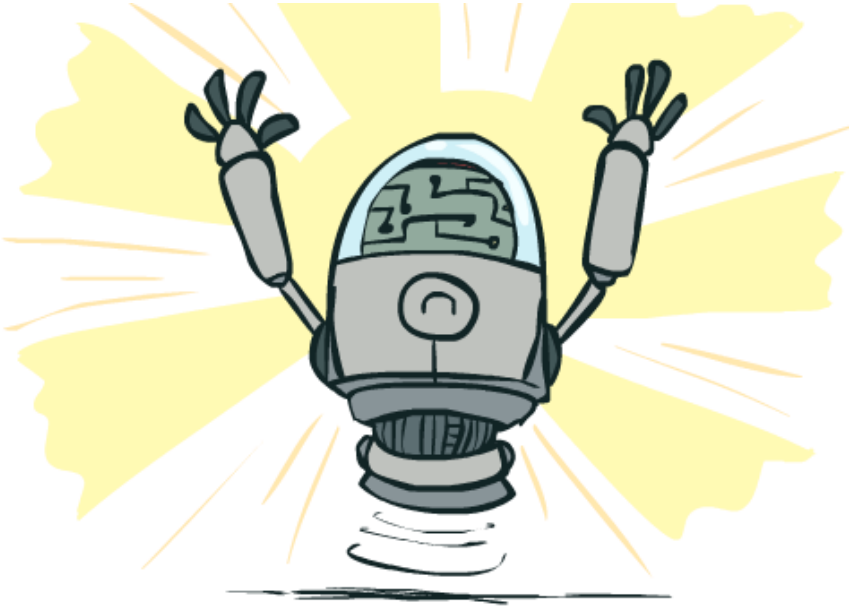
Quiz: Which of the following can be done at present?

- ✔ 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 along Telegraph Avenue?
- ✔ Buy a week's worth of groceries on the web?
- ✘ Buy a week's worth of groceries at Berkeley Bowl?
- ? 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?

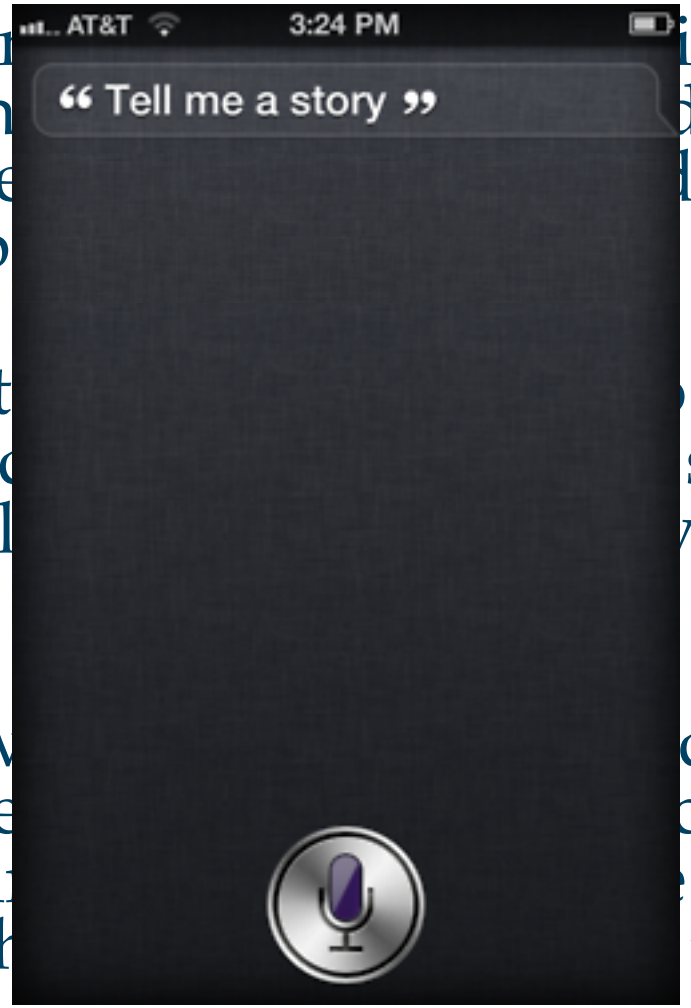


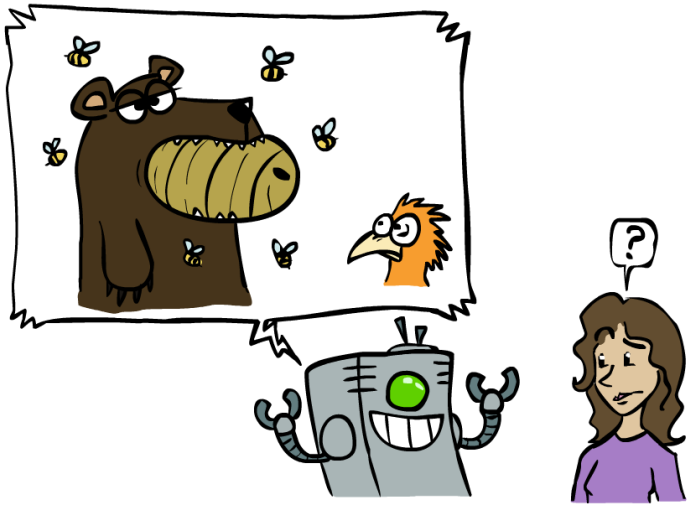
Unintentionally Funny Stories

- One day Joe Bear was hu iend Irving Bird where some h d him there was a beehive in the l to the oak tree. He ate the b

- Henry Squirrel was thirst the river bank where his gooc sitting. Henry slipped and fel drowned. The End.

- Once upon a time there w d a vain crow. One day the crow was sitting in his tre cheese in his mouth. He noticed that he was holdi . He became hungry, and swallowed the cheese. Th the crow. The End.

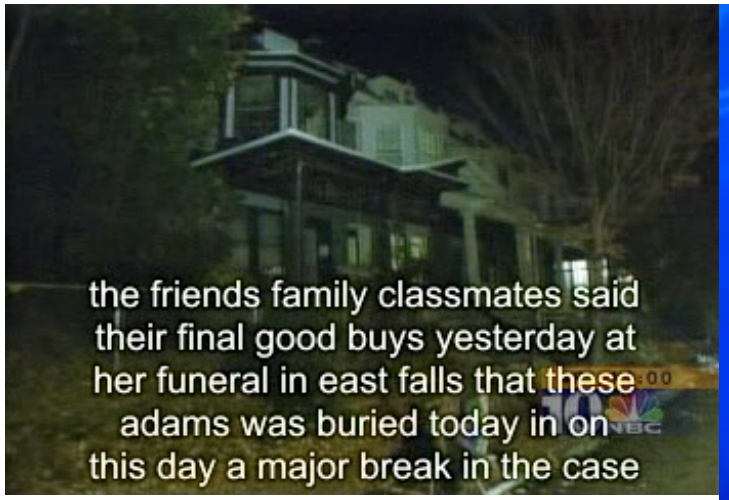




[Shank, Tale-Spin System, 1984]

Natural Language

- Speech technologies (e.g. Siri)
  - Automatic speech recognition (ASR)
  - Text-to-speech synthesis (TTS)
  - Dialog systems



- Language processing technologies
  - Question answering
  - Machine translation

  - Web search
  - Text classification, spam filtering, etc…

Computer Vision

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"man in black shirt is playing guitar."

"construction worker in orange safety vest is working on road."

"two young girls are playing with lego toy."

"boy is doing backflip on wakeboard."

"girl in pink dress is jumping in air."

"black and white dog jumps over bar."

"young girl in pink shirt is swinging on swing."

"man in blue wetsuit is surfing on wave."

Karpathy & Fei-Fei, 2015; Donahue et al., 2015; Xu et al, 2015; many more

Tools for Predictions & Decisions

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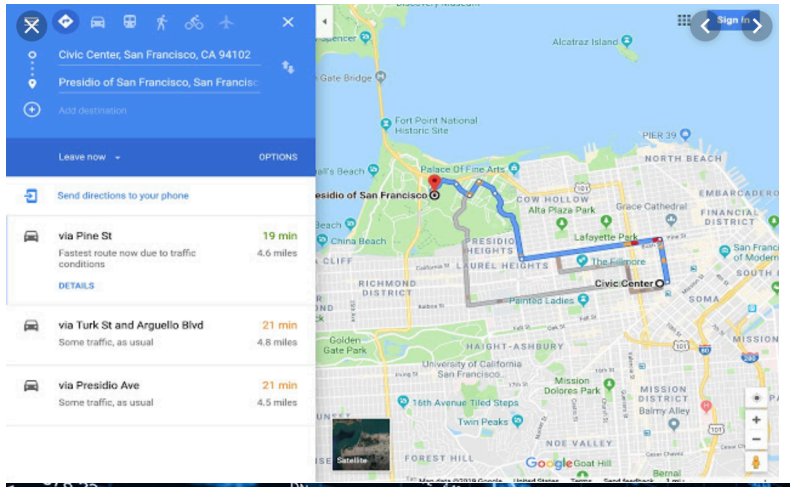

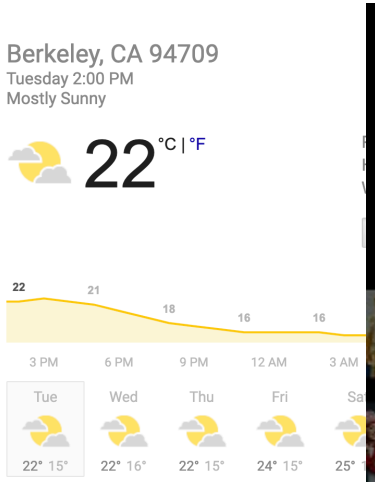

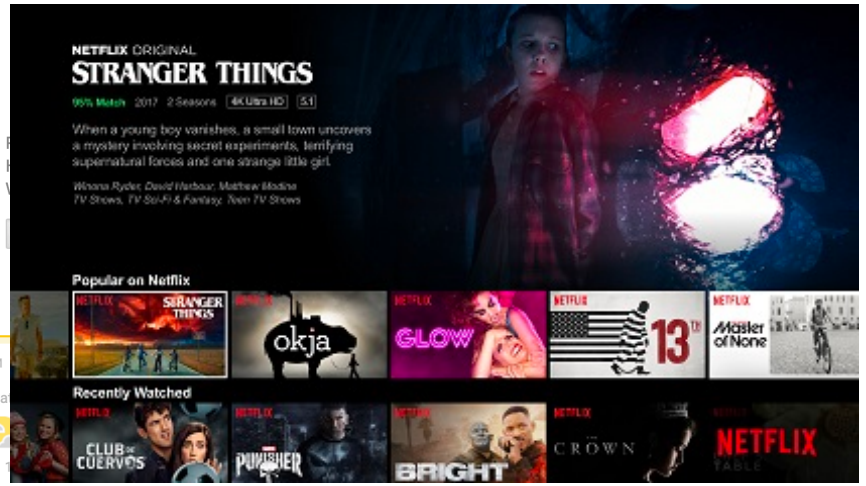

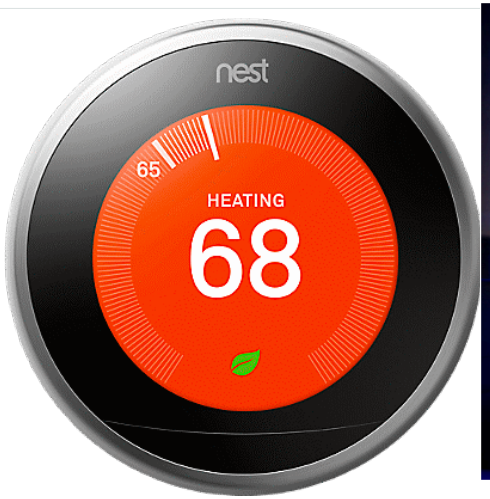


. e4 c6 2. d4 d5 3. Nc3 dxe4

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Game Agents

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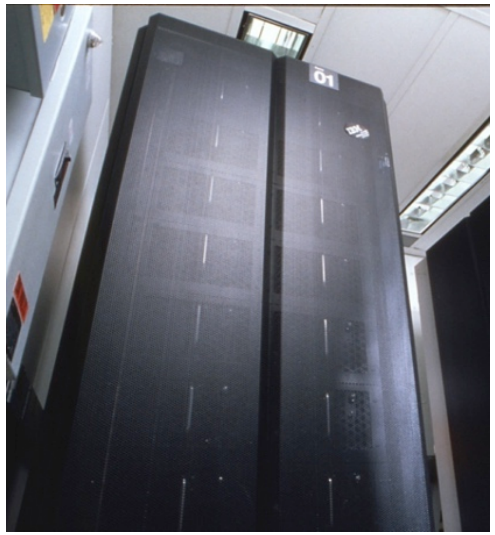
- Classic Moment: May, '97: Deep Blue vs. Kasparov
  - First match won against world champion
  - "Intelligent creative" play
  - 200 million board positions per second
  - Humans understood 99.9 of Deep Blue's moves
  - Can do about the same now with a PC cluster



- 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."

Text from Bart Selman, image from IBM's Deep Blue pages

Game Agents

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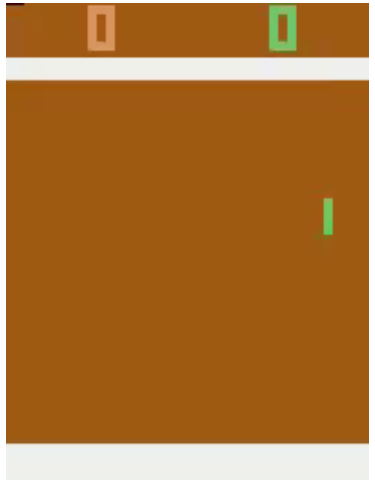
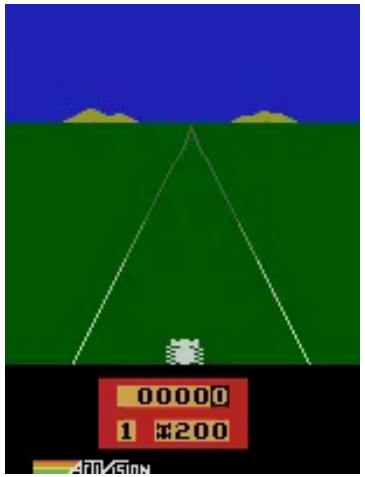
- Reinforcement learning

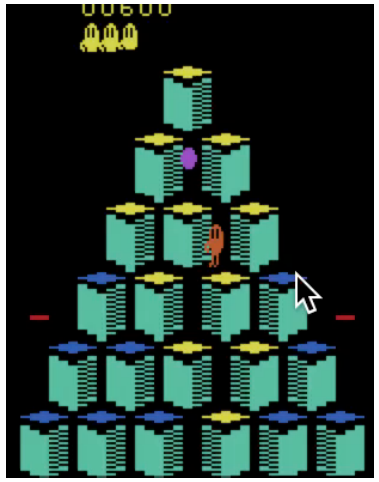


Pong

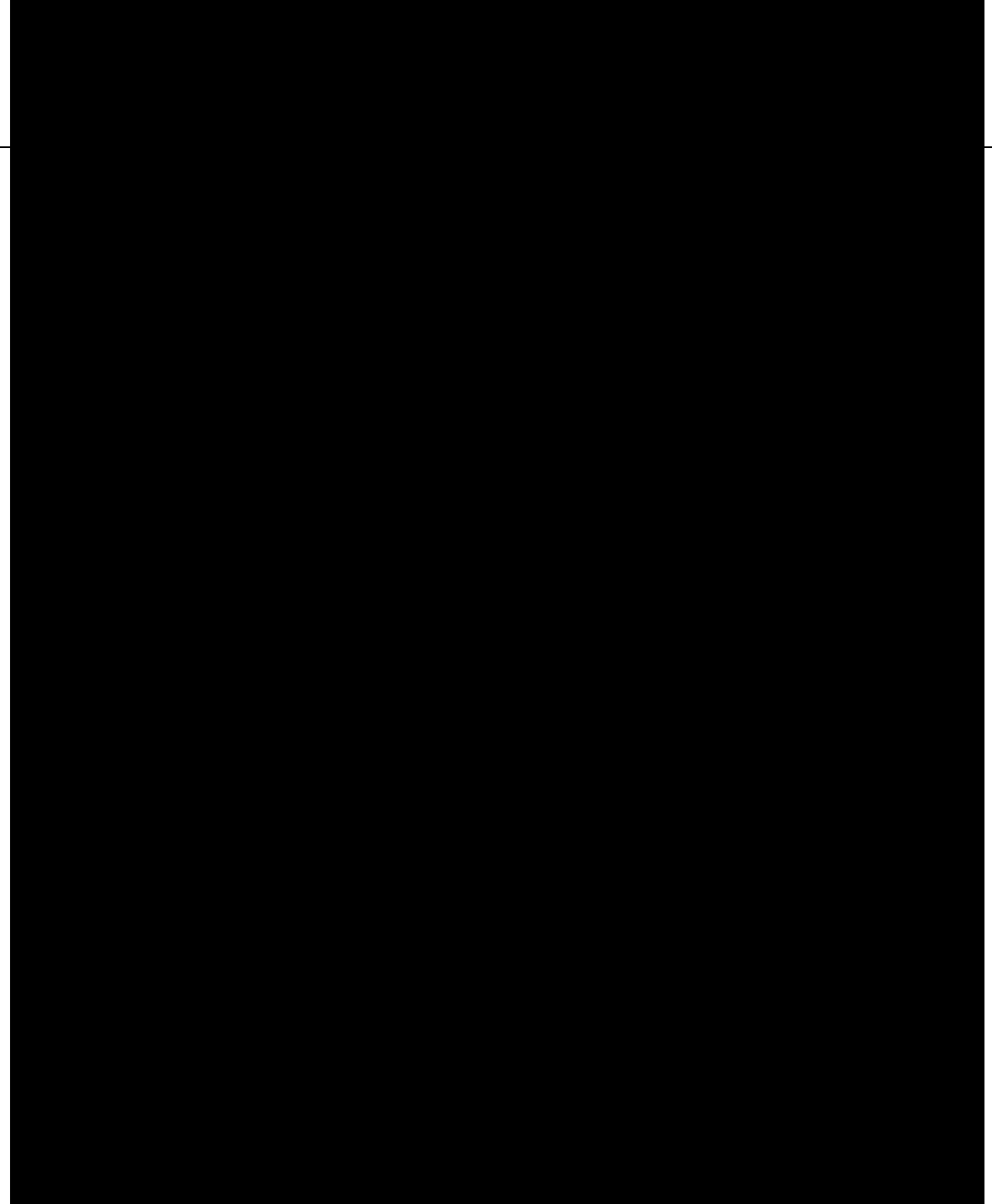


Enduro

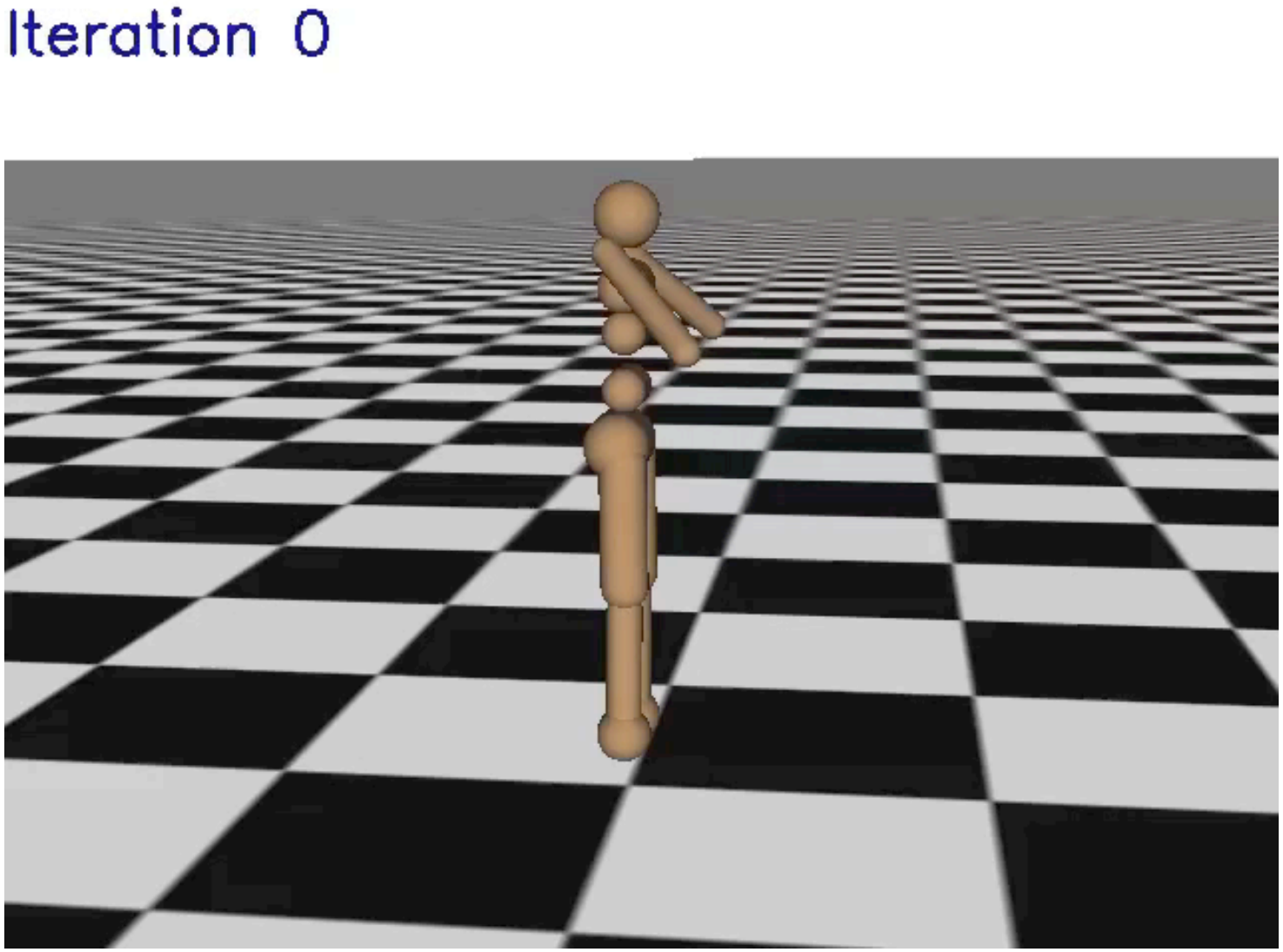
Beamrider



Q*bert



Simulated Agents



[Schulman, Moritz, Levine, Jordan, Abbeel, ICLR 2016]

Robotics

Demo 1: ROBOTICS – soccer.avi
Demo 2: ROBOTICS – soccer2.avi
Demo 3: ROBOTICS – gcar.avi
Demo 4: ROBOTICS – laundry.avi
Demo 5: ROBOTICS – petman.avi

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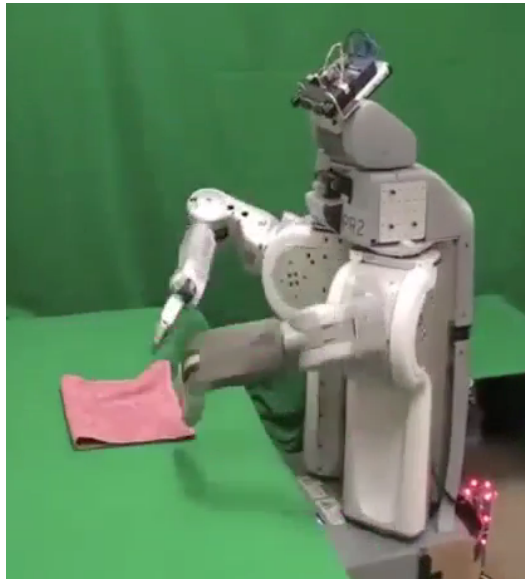
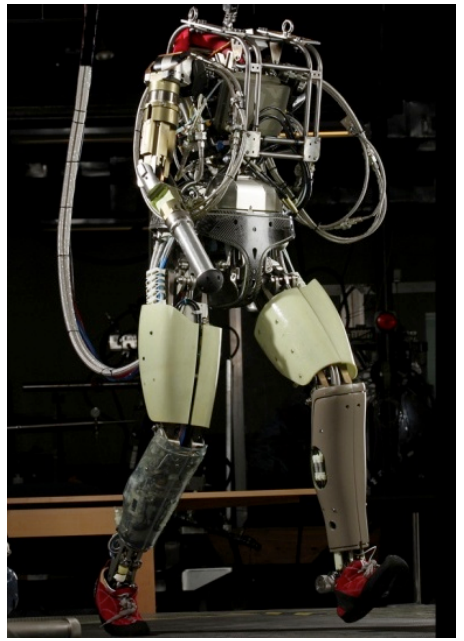
- Robotics
  - Part mech. eng.
  - Part AI
  - Reality much harder than simulations!
- Technologies
  - Vehicles
  - Rescue
  - Help in the home
  - Lots of automation…
- In this class:
  - We ignore mechanical aspects
  - Methods for planning
  - Methods for control





Images from UC Berkeley, Boston Dynamics, RoboCup, Google

Robots

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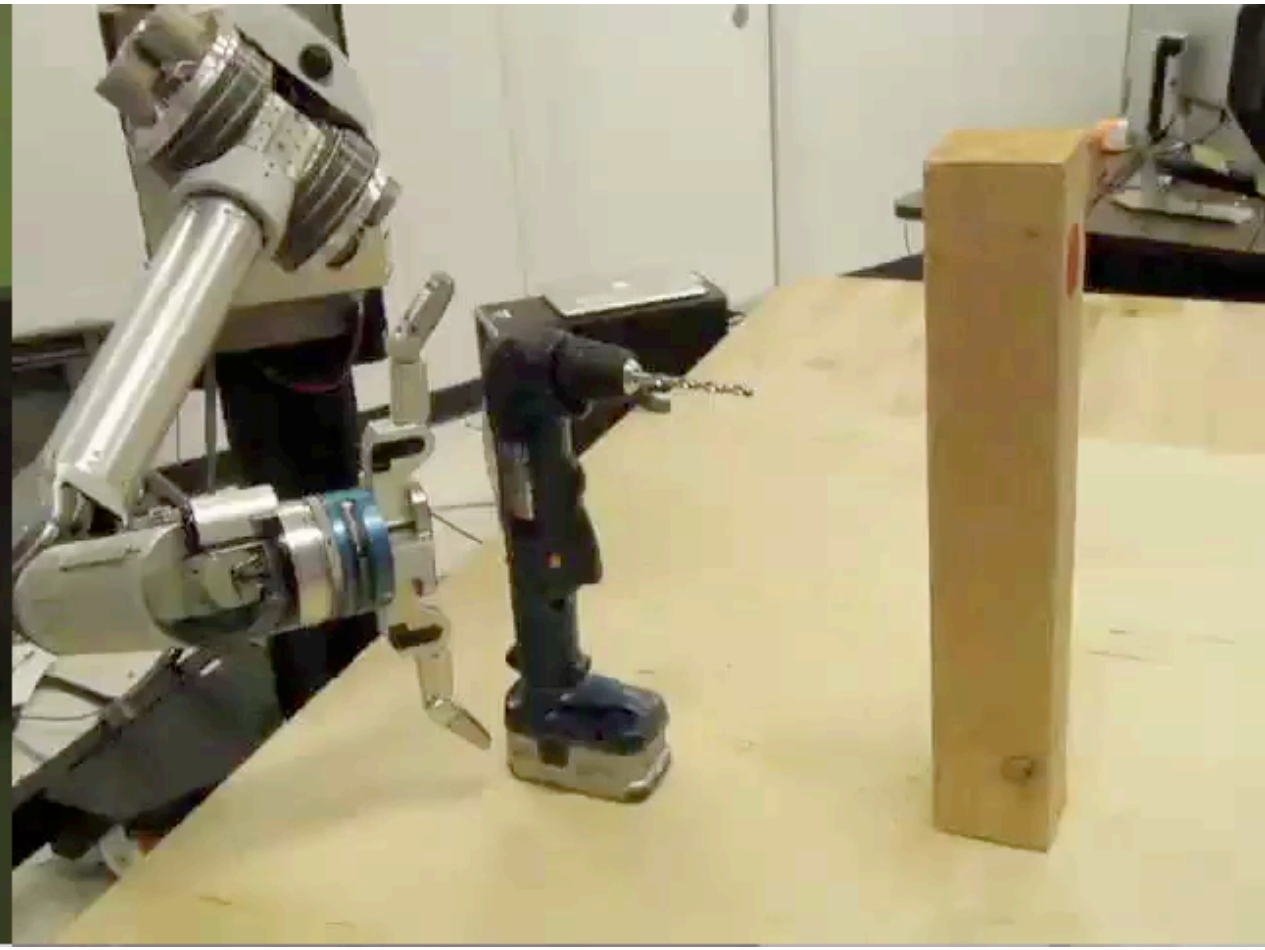


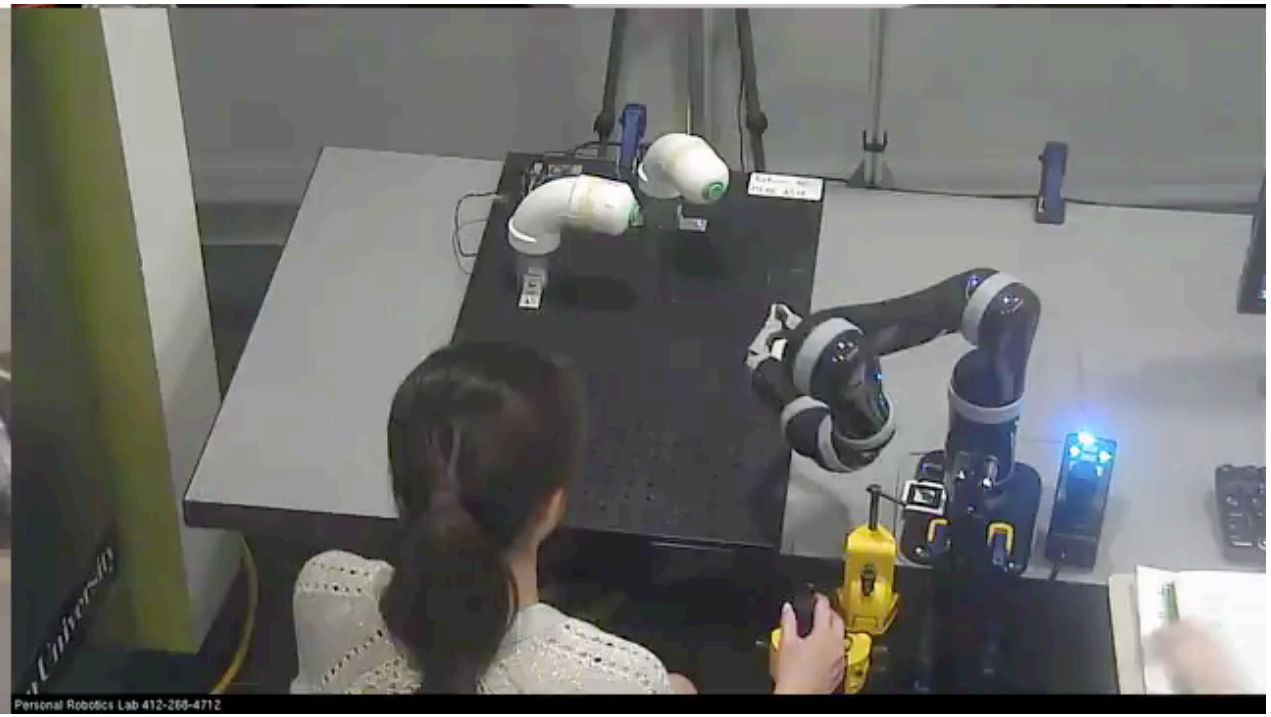
Robots

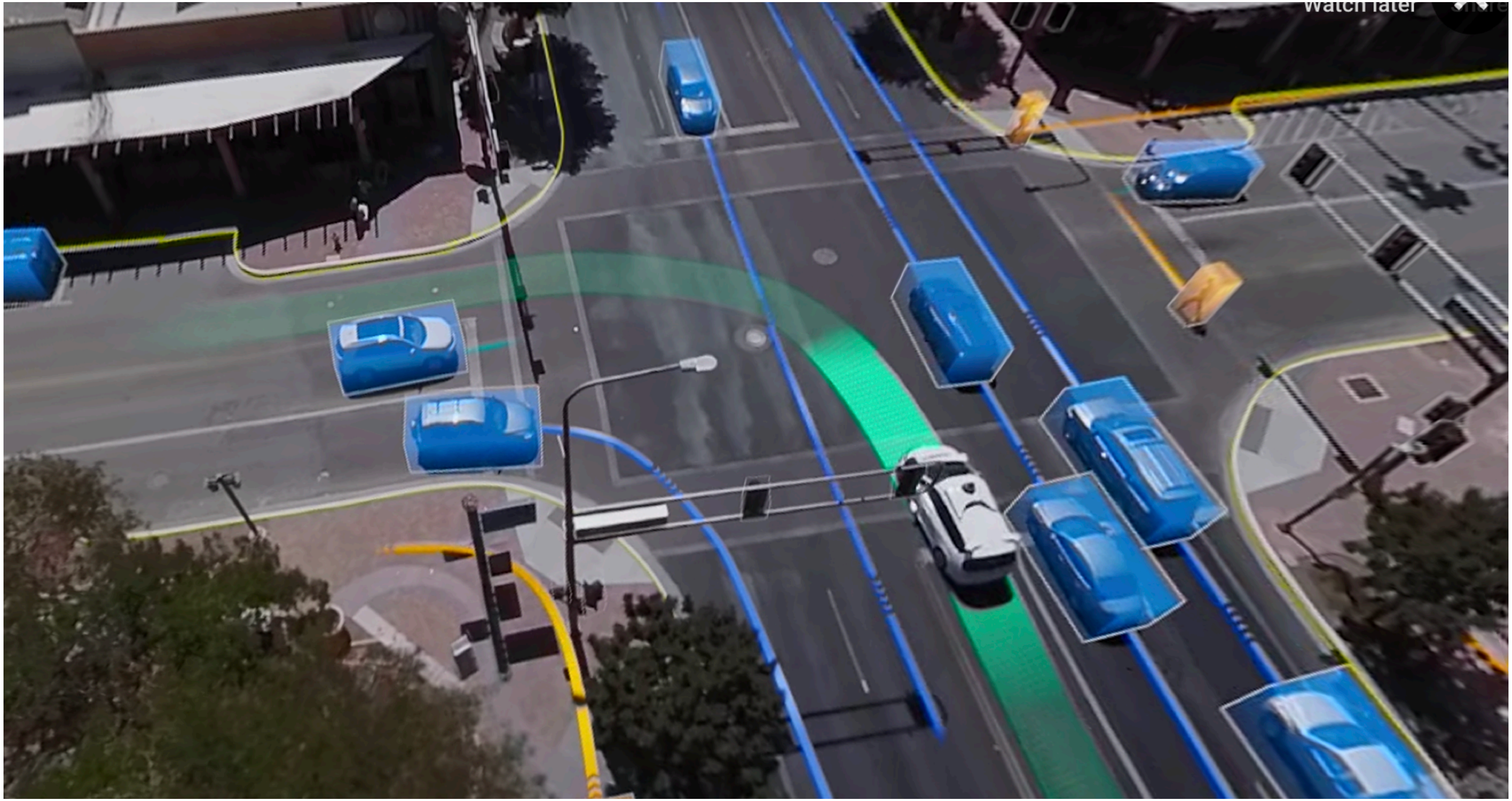
Tulane University

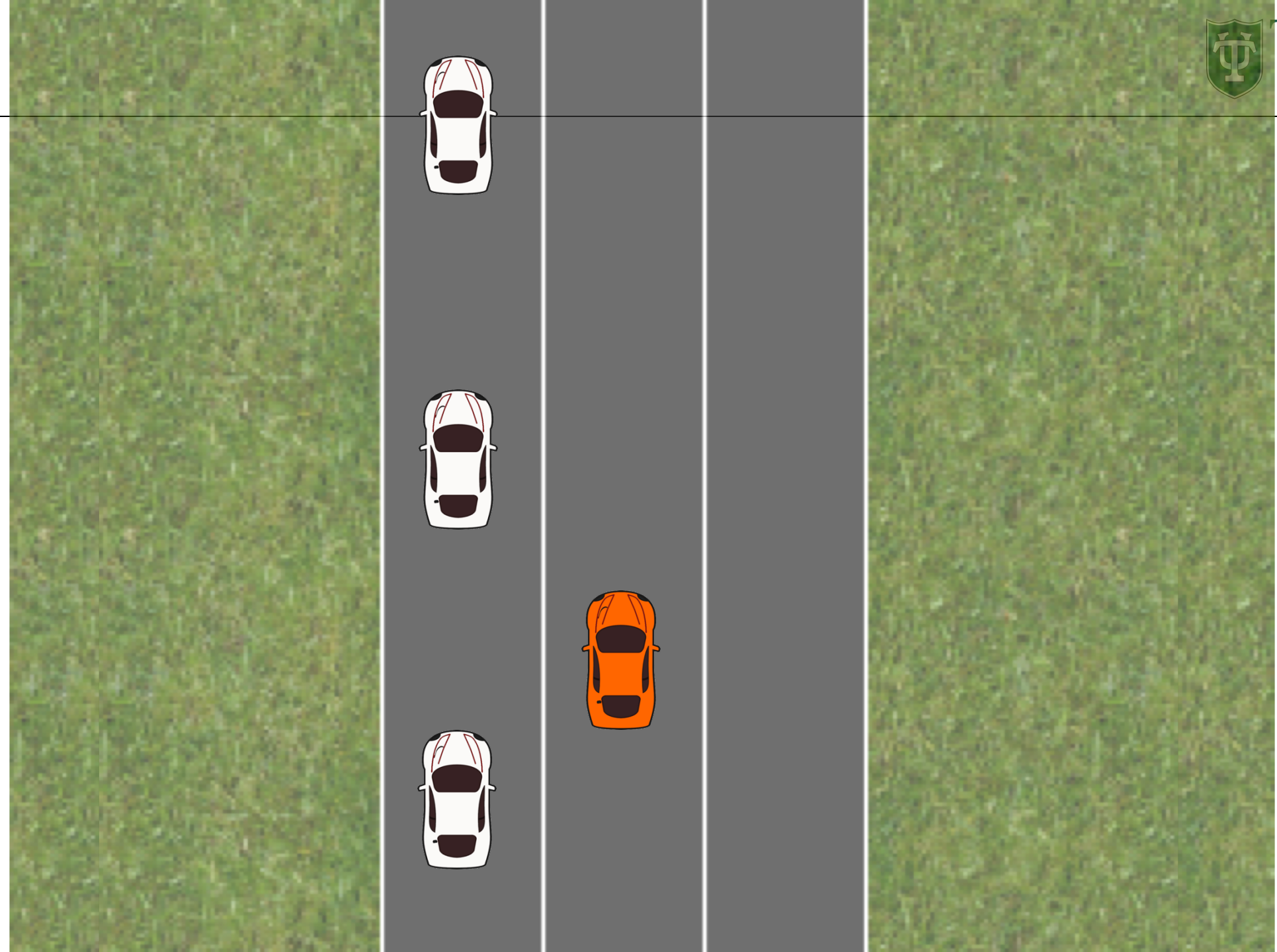
[Levine*, Finn*, Darrell, Abbeel, JMLR 2016]

Human-AI Interaction

Tulane University







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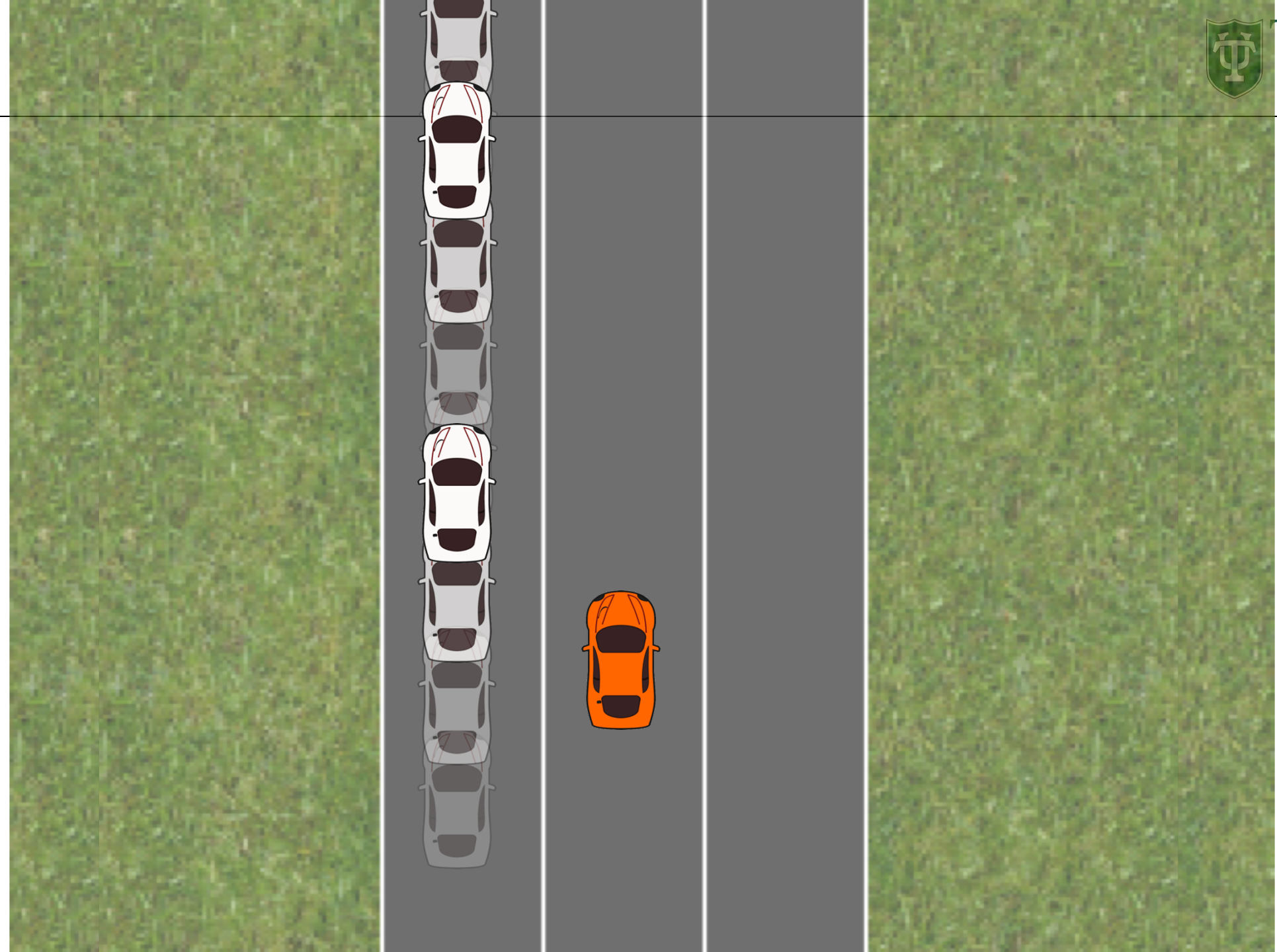

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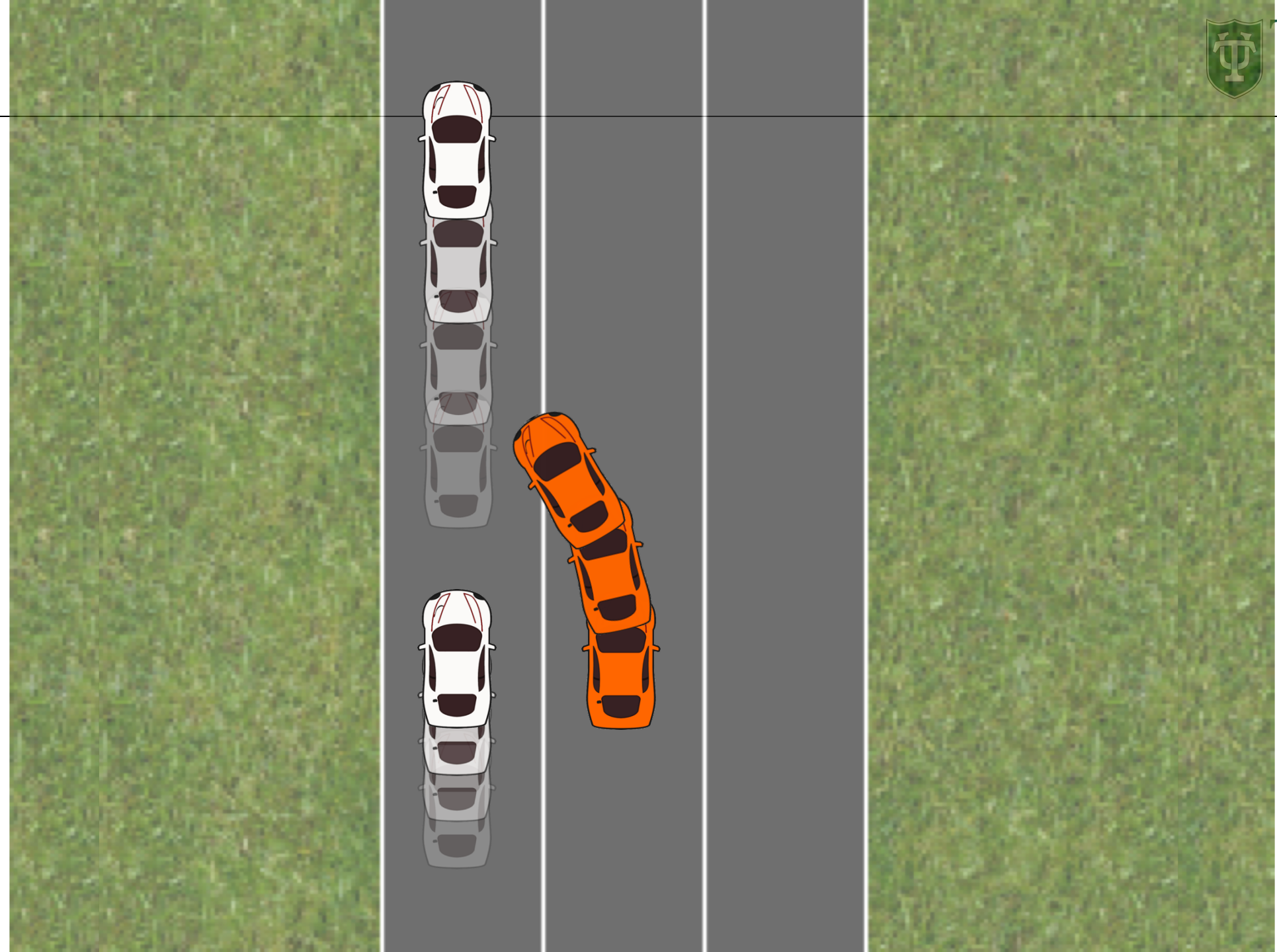

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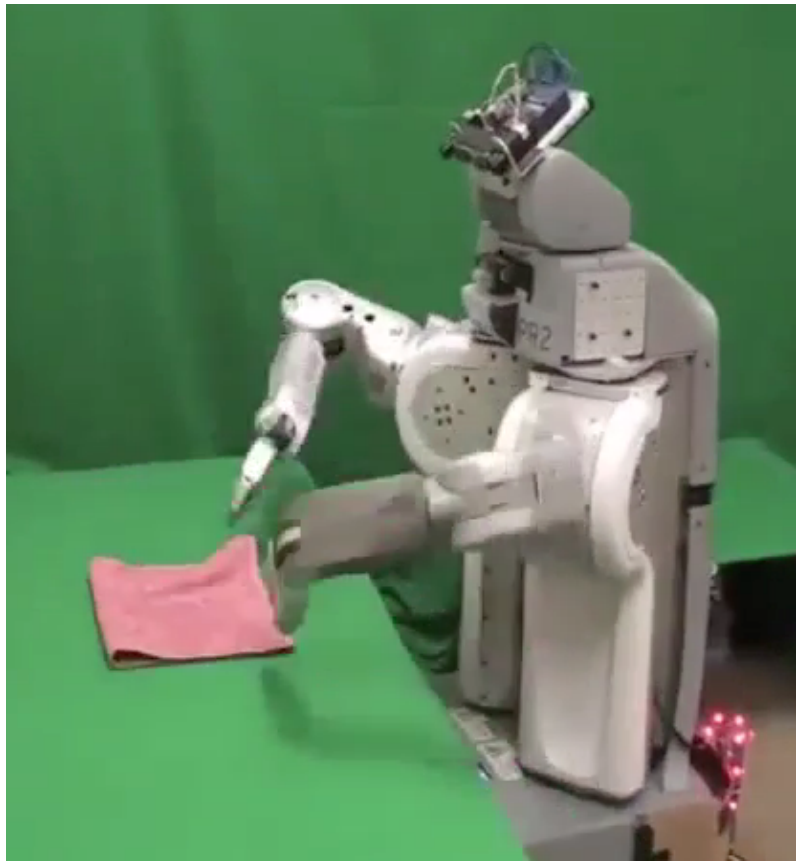
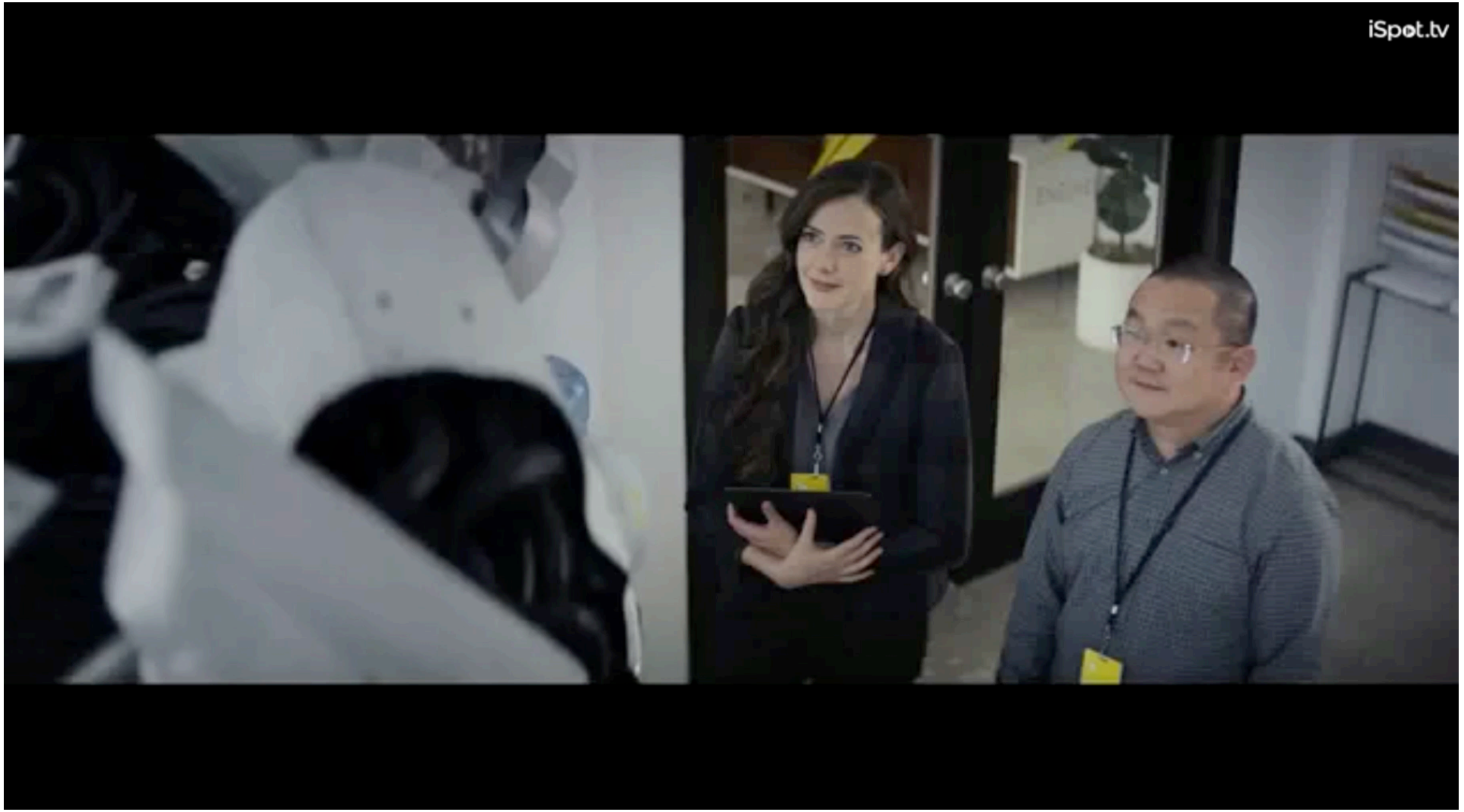
Carnegie Mellon Unive

Utility?

Clear utility function

Not so clear utility function




iSpot.tv

“Reward Hacking”

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- Agents may ”Reward Hack,” i.e., learn behaviors that have high reward but are not intended.
  - Constantly hitting the power-up instead of playing the game.
  - Pause the game instead of playing the game.

- One of a list of concrete problems in AI Safety including **Safe Exploration** and **Avoiding Negative Side Effects**.

- Wired Article: https://www.wired.com/story/when-bots-teach-themselves-to-cheat/
- DeepMind List: https://t.co/mAGUf3quFQ

WIRED

TOM SIMONITE BUSINESS 08.08.18 09:00 AM

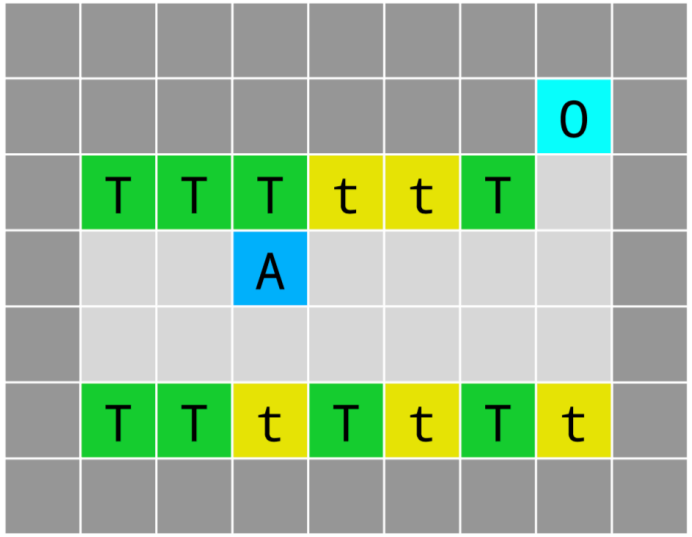
WHEN BOTS TEACH THEMSELVES TO CHEAT

Paper Citations

Dario Amodei, Chris Olah, Jacob Steinhardt, Paul Christiano, John Schulman, Dan Mané. *Concrete Problems in AI Safety*. arXiv:1606.06565, 2016.


START
START
SCORE
0
LAPS
—/3
TIME
0:01
TURBO
MORE GAMES

Not Just Videogames!



A Agent

O Bucket

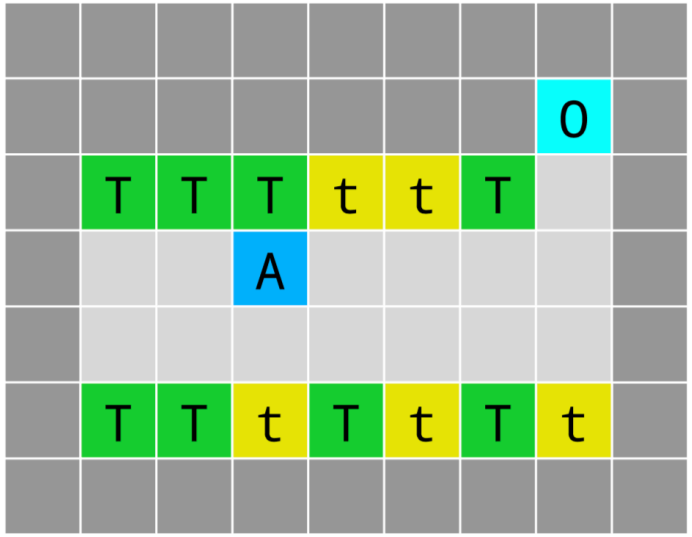
T Watered Tomato

t Unwatered Tomato

- DeepMind and others released AI Safety Grid World posing a number of challenging RL tasks.
  - https://arxiv.org/abs/1711.09883

- Here we have a robot who must water the plants and is penalized if he sees a plant that is un-watered.

Not Just Videogames!



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