CSE P 573
Artificial Intelligence
Spring 2014

Ali Farhadi

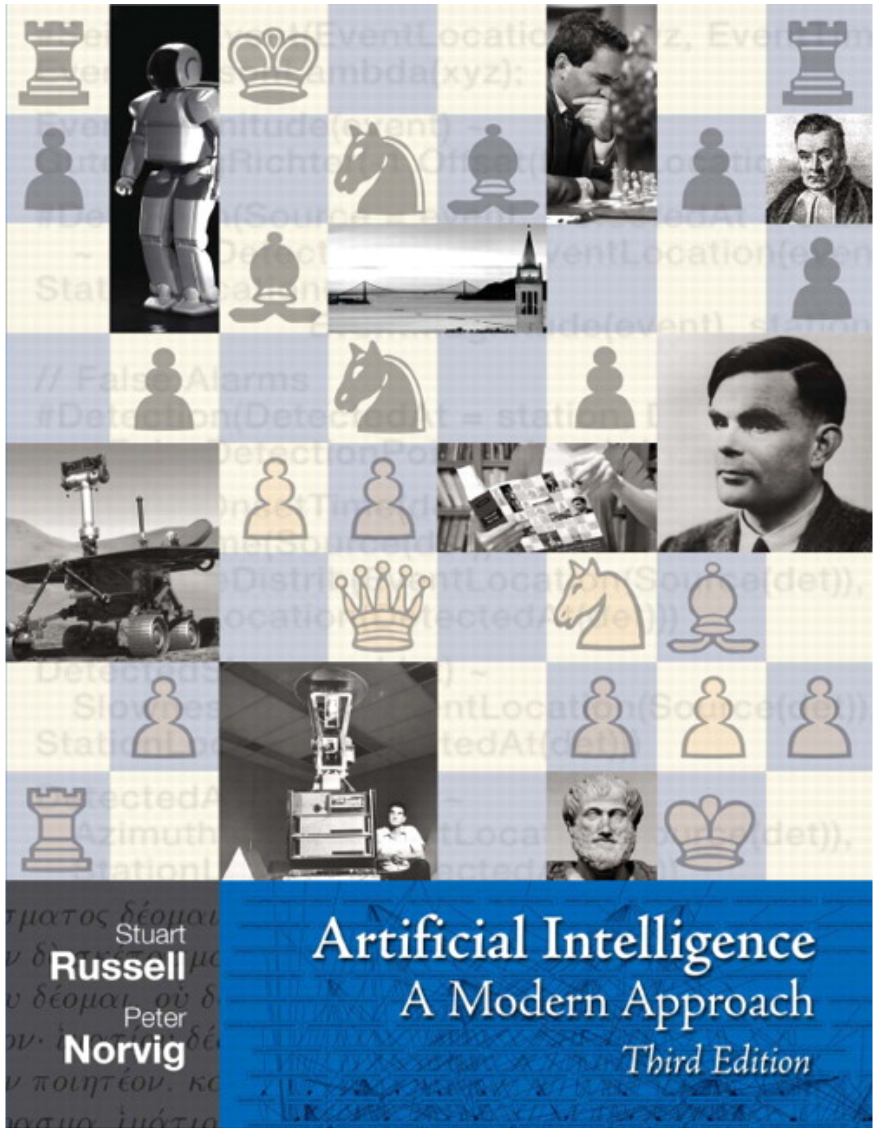
https://courses.cs.washington.edu/courses/csep573/14sp/

Several slides from Luke Zettlemoyer, Dan Klein, Dan Weld, Stuart Russell, Andrew Moore

What is CSE P 573?

Textbook:

- Artificial Intelligence: A Modern Approach, Russell and Norvig (3rd ed)



Prerequisites:

- Data Structures (CSE 326 or CSE 322) or equivalent
- Basic exposure to probability, data structures, and logic

Work:

- Readings,
- Programming assignment (50%),
- Written assignments (20%),
- Final Exam (25%),
- Class participation (5%)

Course Staff

- Instructor:
  - Ali Farhadi
    Research: Vision, ML

- TA:
  - Dun-Yu Hsiao <dyhsiao@cs.washington.edu>
- Discussion Board:
  https://catalyst.uw.edu/gopost/board/dyhsiao/36576
- Dropbox:
  https://catalyst.uw.edu/collectit/dropbox/dyhsiao/31467

Today

- What is artificial intelligence (AI)?
- What can AI do?
- What is this course?

What is AI?


Science of making intelligent machines or computer programs

What Is AI?

The science of making machines that:

Think like humans
Act like humans

Rational Decisions

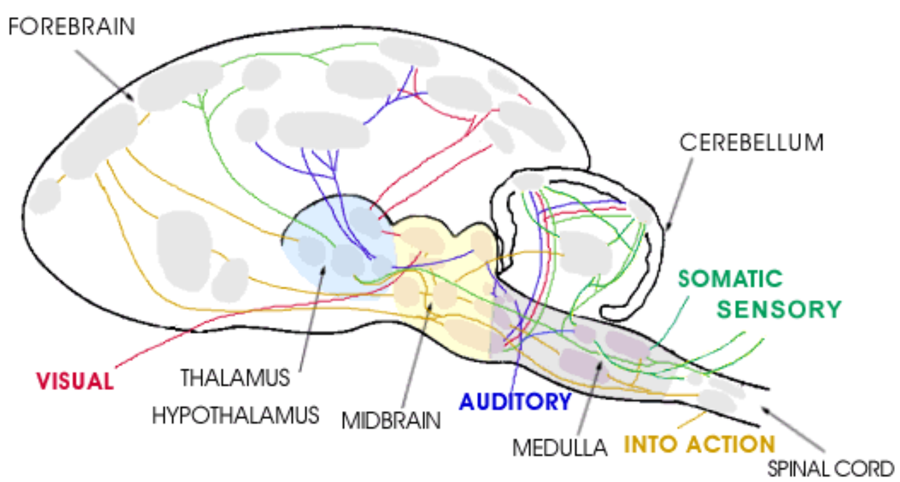
We'll use the term **rational** in a particular way:

- Rational: maximally achieving pre-defined goals
- Rational 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

Can We Build It?



10^{11} neurons
10^{14} synapses
cycle time: 10^{-3} sec

vs.

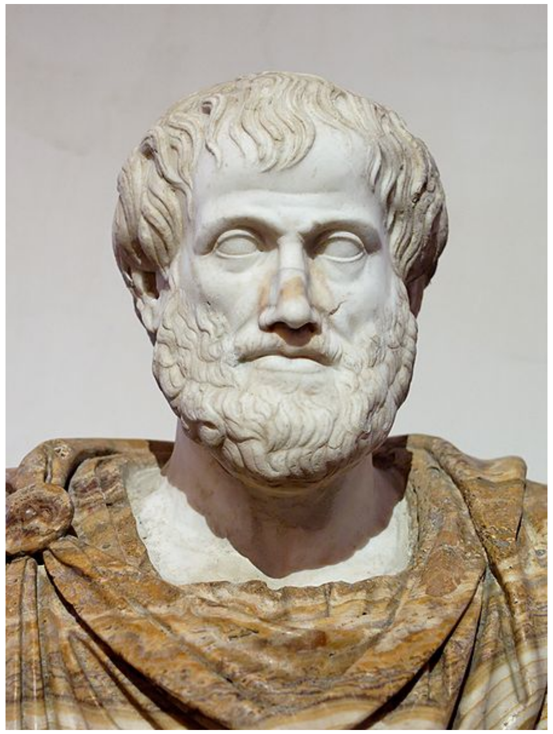
10^{9} transistors
10^{12} bits of RAM
cycle time: 10^{-9} sec

A (Short) History of AI

- Prehistory
- 1940-1950: Early days
- 1950—70: Excitement: Look, Ma, no hands!
- 1970—88: Knowledge-based approaches
- 1988—: Statistical approaches
- 2000—: Where are we now?

Prehistory

- Logical Reasoning: (4th C BC+) Aristotle, George Boole, Gottlob Frege, Alfred Tarski
- Probabilistic Reasoning: (16th C+) Gerolamo Cardano, Pierre Fermat, James Bernoulli, Thomas Bayes



and

1940-1950: Early Days

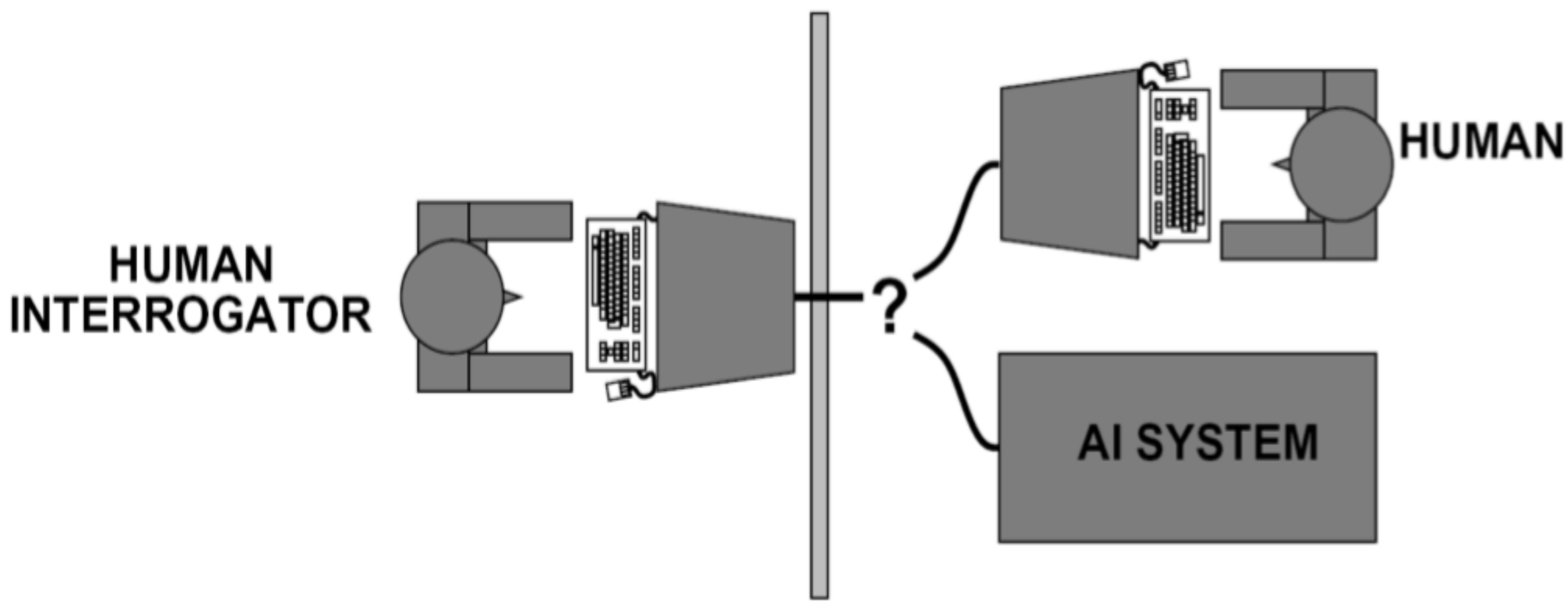
- 1943: McCulloch & Pitts: Boolean circuit model of brain
- 1950: Turing's "Computing Machinery and Intelligence"

I propose to consider the question, "Can machines think?" This should begin with definitions of the meaning of the terms "machine" and "think." The definitions might be framed...

-Alan Turing

The Turing Test

- Turing (1950) "Computing machinery and intelligence"
  - "Can machines think?" → "Can machines behave intelligently?"
  - The Imitation Game:



- Suggested major components of AI: knowledge, reasoning, language understanding, learning

1950-1970: Excitement

- 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

“Over Christmas, Allen Newell and I created a thinking machine.”

-Herbert Simon

1970-1980: Knowledge Based Systems

- 1969-79: Early development of knowledge-based systems
- 1980-88: Expert systems industry booms
- 1988-93: Expert systems industry busts
  - “AI Winter”

The knowledge engineer practices the art of bringing the principles and tools of AI research to bear on difficult applications problems requiring experts’ knowledge for their solution.

- *Edward Felgenbaum* in “The Art of Artificial Intelligence”

1988--: Statistical Approaches

- 1985-1990: Probability and Decision Theory win
  - Pearl, Bayes Nets
- 1990-2000: Machine learning takes over subfields: Vision, Natural Language, etc.
- Agents, uncertainty, and learning systems…
  - "AI Spring"?

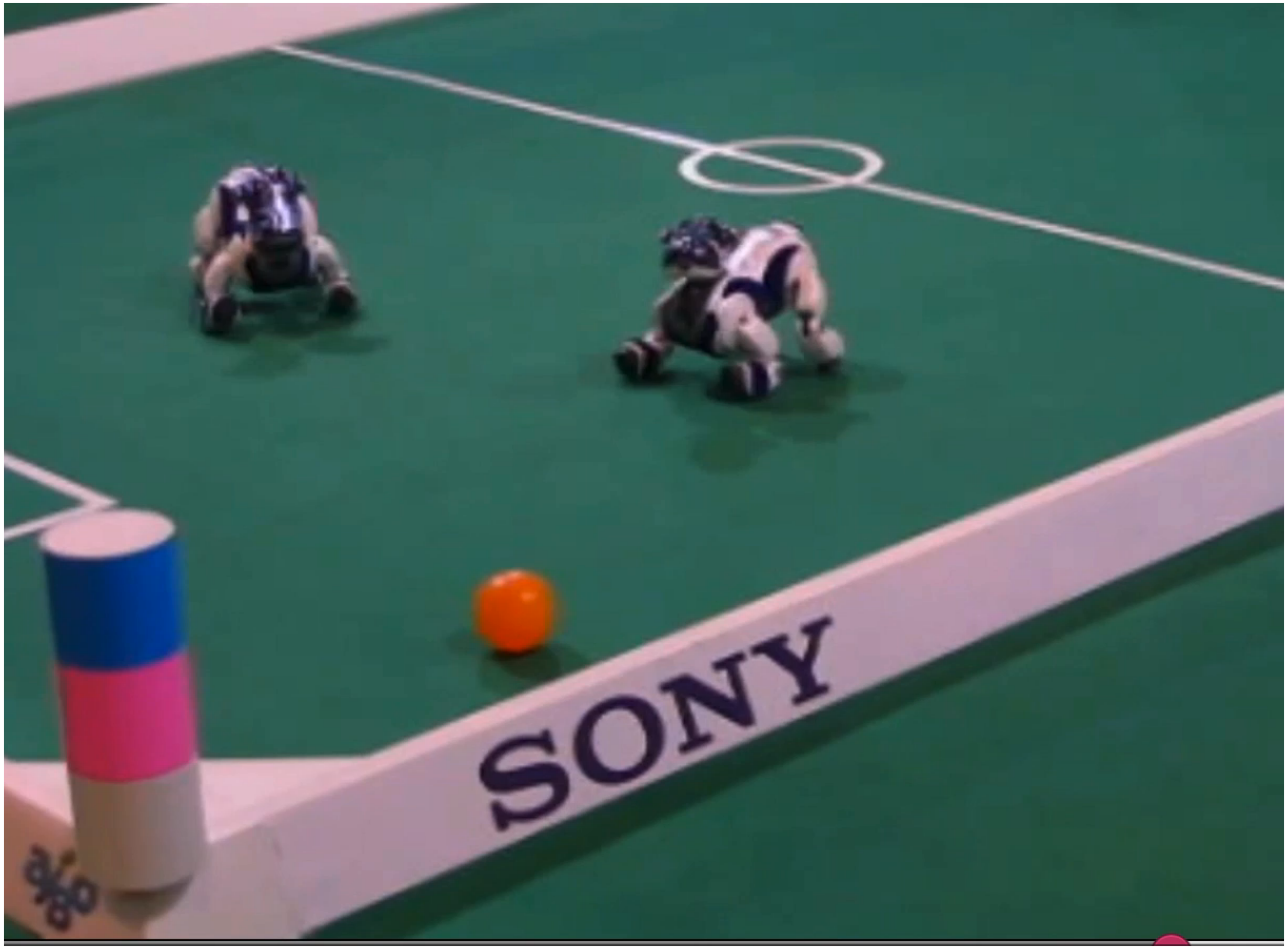
What Can AI Do?

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

- Play a decent game of Soccer?
- Play a winning game of Chess? Go? Jeopardy?
- Drive safely along a curving mountain road? University Way?
- Buy a week's worth of groceries on the Web? At QFC?
- Make a car? Make a cake?
- Discover and prove a new mathematical theorem?
- Perform a complex surgical operation?
- Translate Chinese into English in real time?


SONY

Super Kick



What Can AI Do?

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

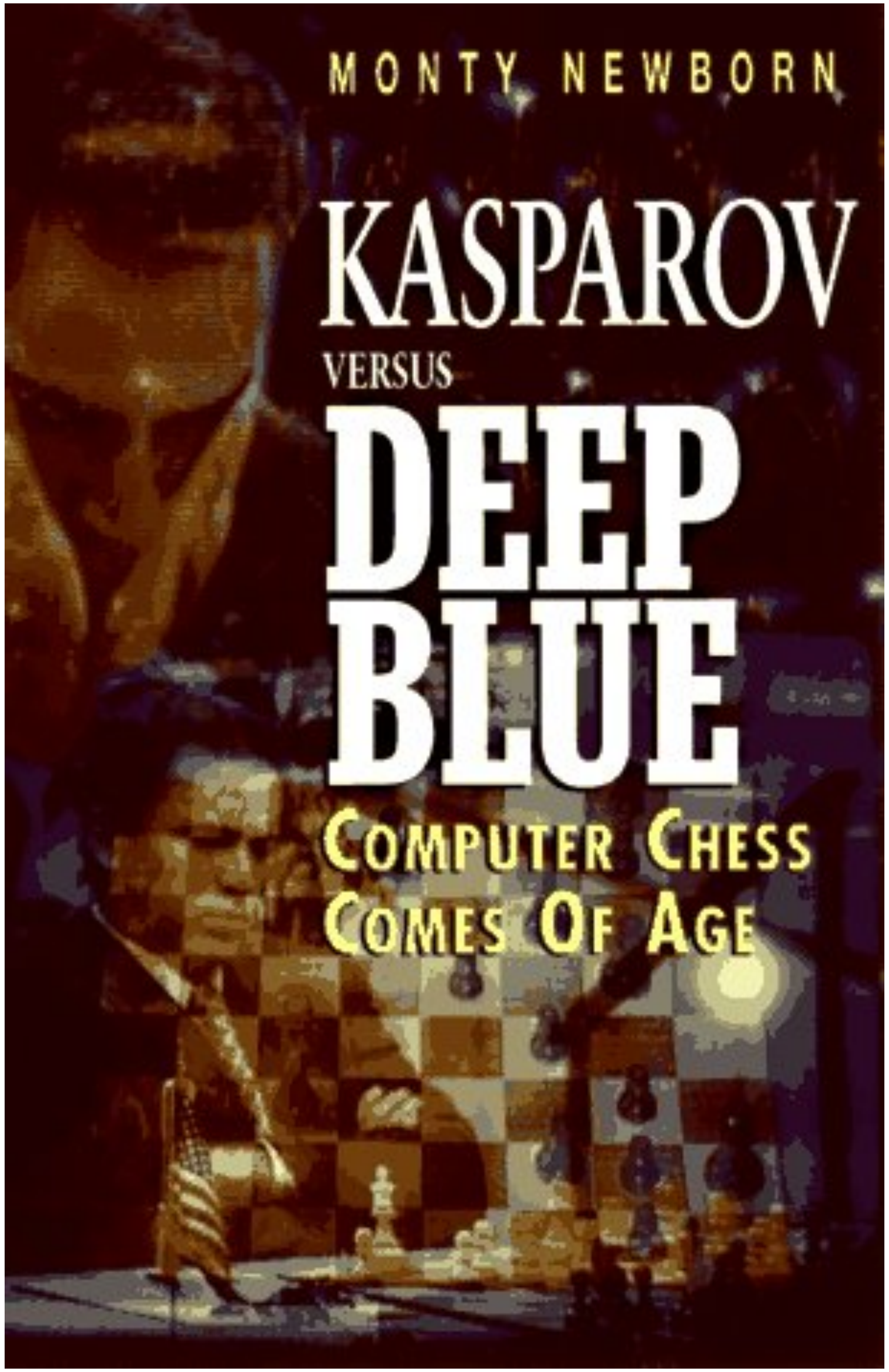
✓ Play a decent game of Soccer?
- Play a winning game of Chess? Go? Jeopardy?
- Drive safely along a curving mountain road?   University Way?
- Buy a week's worth of groceries on the Web?   At QFC?
- Make a car?   Make a cake?
- Discover and prove a new mathematical theorem?
- Perform a complex surgical operation?
- Translate Chinese into English in real time?

State of the Art

May 1997

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

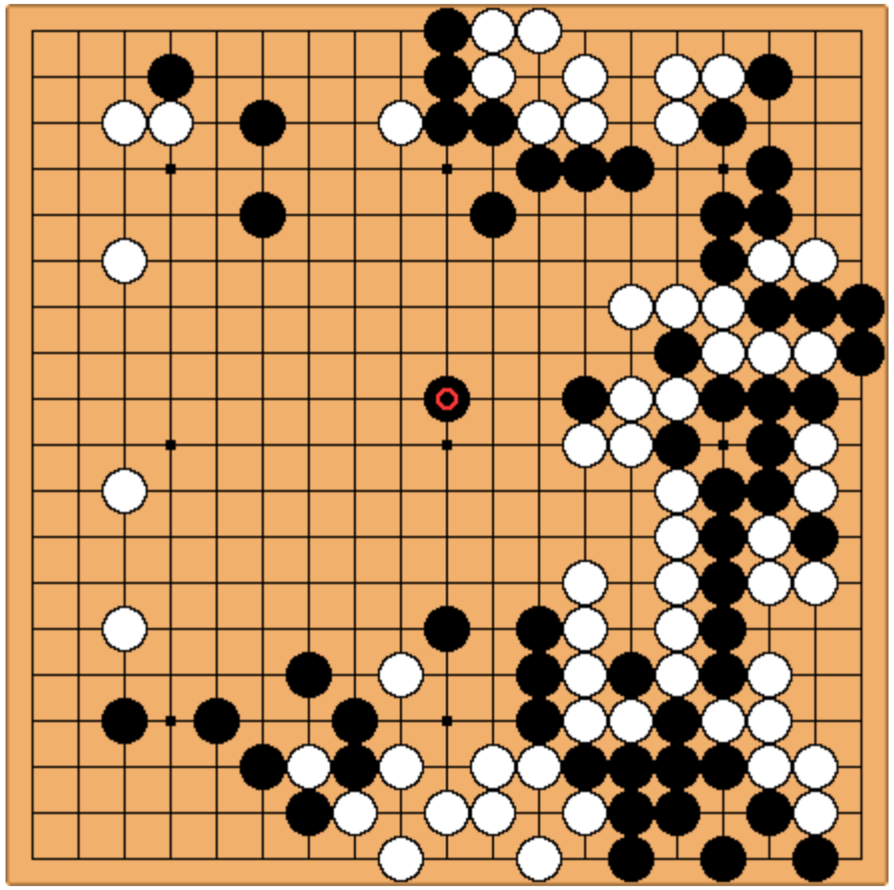
-*Gary Kasparov*



Saying Deep Blue doesn't really think about chess is like saying an airplane doesn't really fly because it doesn't flap its wings.

– *Drew McDermott*

Other Games?



What Can AI Do?

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

✓ Play a decent game of Soccer?
✓ Play a winning game of Chess? Go? Jeopardy?
- Drive safely along a curving mountain road?   University Way?
- Buy a week's worth of groceries on the Web?   At QFC?
- Make a car?   Make a cake?
- Discover and prove a new mathematical theorem?
- Perform a complex surgical operation?
- Translate Chinese into English in real time?

What Can AI Do?

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

✓ Play a decent game of Soccer?
✓ Play a winning game of Chess? Go? Jeopardy?
✓ Drive safely along a curving mountain road? University Way?
- Buy a week's worth of groceries on the Web?
- Buy a week’s worth of groceries at QFC?
- Make a car? Make a cake?
- Discover and prove a new mathematical theorem?
- Perform a complex surgical operation?
- Translate Chinese into English in real time?

What Can AI Do?

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

- ✓ Play a decent game of Soccer?
- ✓ Play a winning game of Chess? Go? Jeopardy?
- ✓ Drive safely along a curving mountain road?   University Way?
- ✓ Buy a week's worth of groceries on the Web?
- ✗ Buy a week's worth of groceries at QFC?
- Make a car? Make a cake?
- Discover and prove a new mathematical theorem?
- Perform a complex surgical operation?
- Translate Chinese into English in real time?

BakeBot:
Motion Planning for Cooking

Mario Bollini and Daniela Rus
CSAIL, MIT

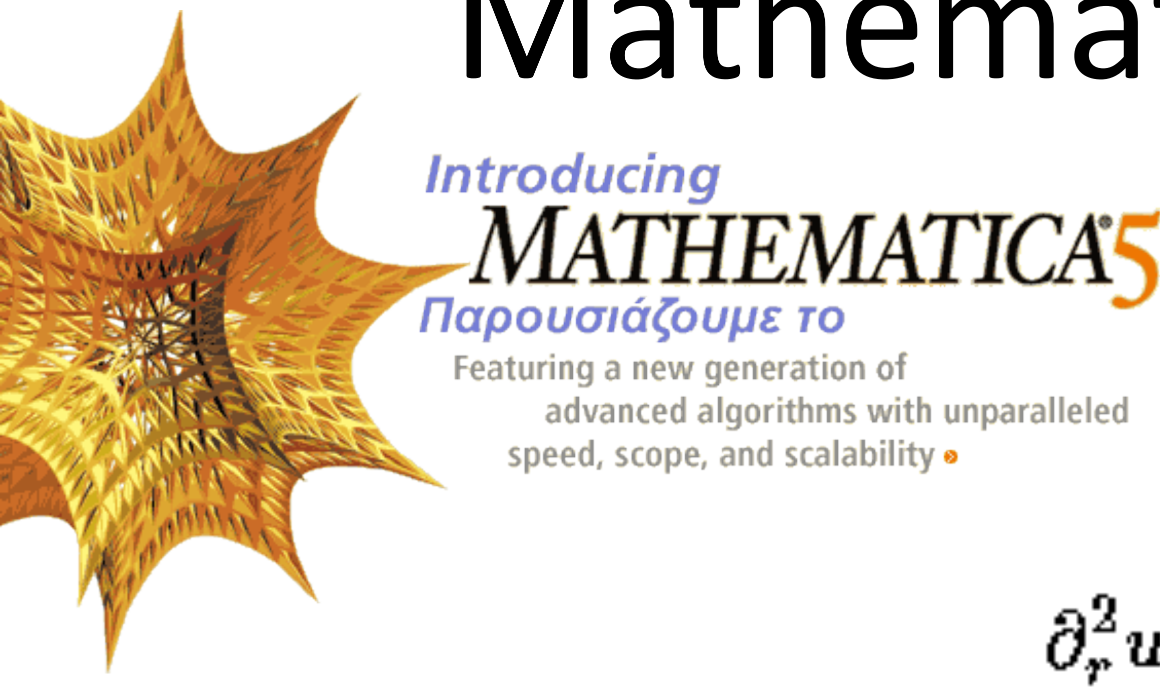
CSAIL

What Can AI Do?

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

- ✓ Play a decent game of Soccer?
- ✓ Play a winning game of Chess? Go? Jeopardy?
- ✓ Drive safely along a curving mountain road? University Way?
- ✓ Buy a week's worth of groceries on the Web?
- ✗ Buy a week’s worth of groceries at QFC?
- ✓ Make a car? Make a cake?
- Discover and prove a new mathematical theorem?
- Perform a complex surgical operation?
- Translate Chinese into English in real time?

Mathematical Calculation



$$
\begin{aligned}
\partial_r^2 u &= -\left[E' - \frac{l(l+1)}{r^2} - r^2\right] u(r) \\
e^{-2s}\left(\partial_s^2 - \partial_s\right) u(s) &= -\left[E' - l(l+1)e^{-2s} - e^{2s}\right] u(s) \\
e^{-2s}\left[e^{\frac{1}{2}s}\left(e^{-\frac{1}{2}s}u(s)\right)'' - \frac{1}{4}u\right] &= -\left[E' - l(l+1)e^{-2s} - e^{2s}\right] u(s) \\
e^{-2s}\left[e^{\frac{1}{2}s}\left(e^{-\frac{1}{2}s}u(s)\right)''\right] &= -\left[E' - \left(l+\frac{1}{2}\right)^2 e^{-2s} - e^{2s}\right] u(s) \\
v'' &= -e^{2s}\left[E' - \left(l+\frac{1}{2}\right)^2 e^{-2s} - e^{2s}\right] v
\end{aligned}
$$

What Can AI Do?

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

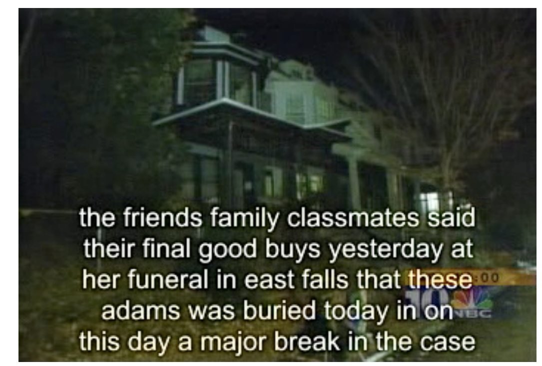
- ✓ Play a decent game of Soccer?
- ✓ Play a winning game of Chess? Go? Jeopardy?
- ✓ Drive safely along a curving mountain road? University Way?
- ✓ Buy a week's worth of groceries on the Web?
- ✗ Buy a week's worth of groceries at QFC?
- ✓ Make a car? Make a cake?
- ✓ Discover and prove a new mathematical theorem?
- ✗ Perform a complex surgical operation?
- ✓ Translate Chinese into English in real time?

Different Research Areas in AI

- Natural Language Processing
- Computer Vision
- Robotics
- Logic
- Decision Making
- Game Playing

Natural Language Processing

- Speech Technologies (e.g., Siri):
  - Automatic Speech Recognition (ASR)
  - Text-to-speech synthesis
  - Dialog Systems



- Language Technologies:
  - Question answering
  - Machine translation

"Il est impossible aux journalistes de rentrer dans les régions tibétaines"

Bruno Philip, correspondant du "Monde" en Chine, estime que les journalistes de l'AFP qui ont été expulsés de la province tibétaine du Qinghai "n'étaient pas dans l'illégalité".

Les faits Le dalaï-lama dénonce l'"enfer" imposé au Tibet depuis sa fuite, en 1959

Vidéo Anniversaire de la rébellion

"It is impossible for journalists to enter Tibetan areas"

Philip Bruno, correspondent for "World" in China, said that journalists of the AFP who have been deported from the Tibetan province of Qinghai "were not illegal."

Facts The Dalai Lama denounces the "hell" imposed since he fled Tibet in 1959

Video Anniversary of the Tibetan rebellion: China on guard

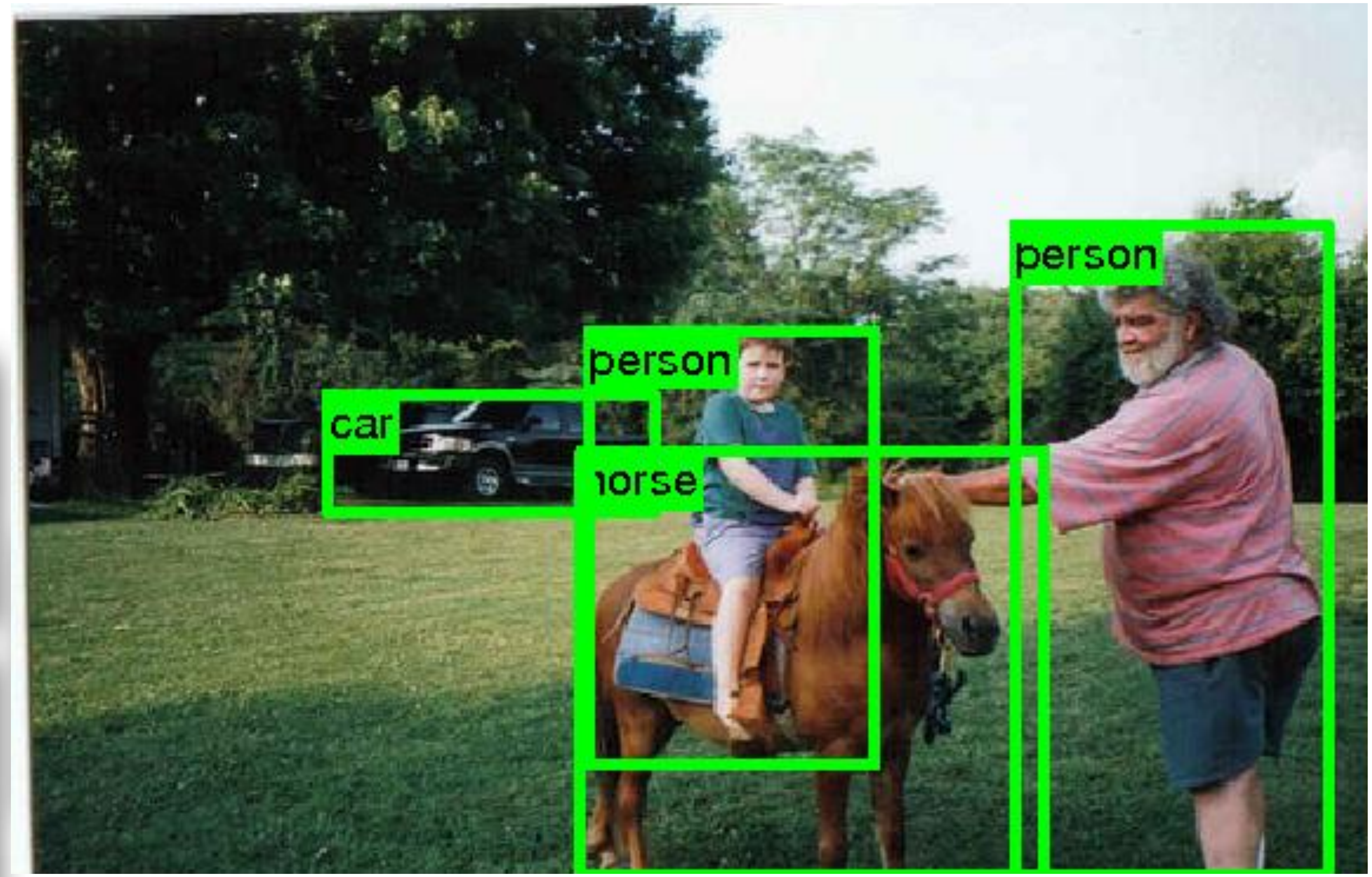
  - Text classification; spam filtering; etc


46 11:00
10 NBC
YouTube

Vision

- Object Recognition
- Scene Classification
- Image Segmentation
- Human Activity Recognition

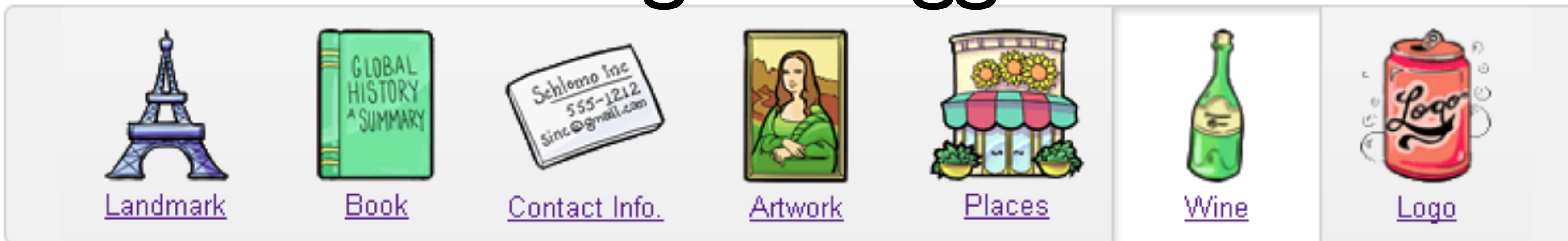
Object Recognition

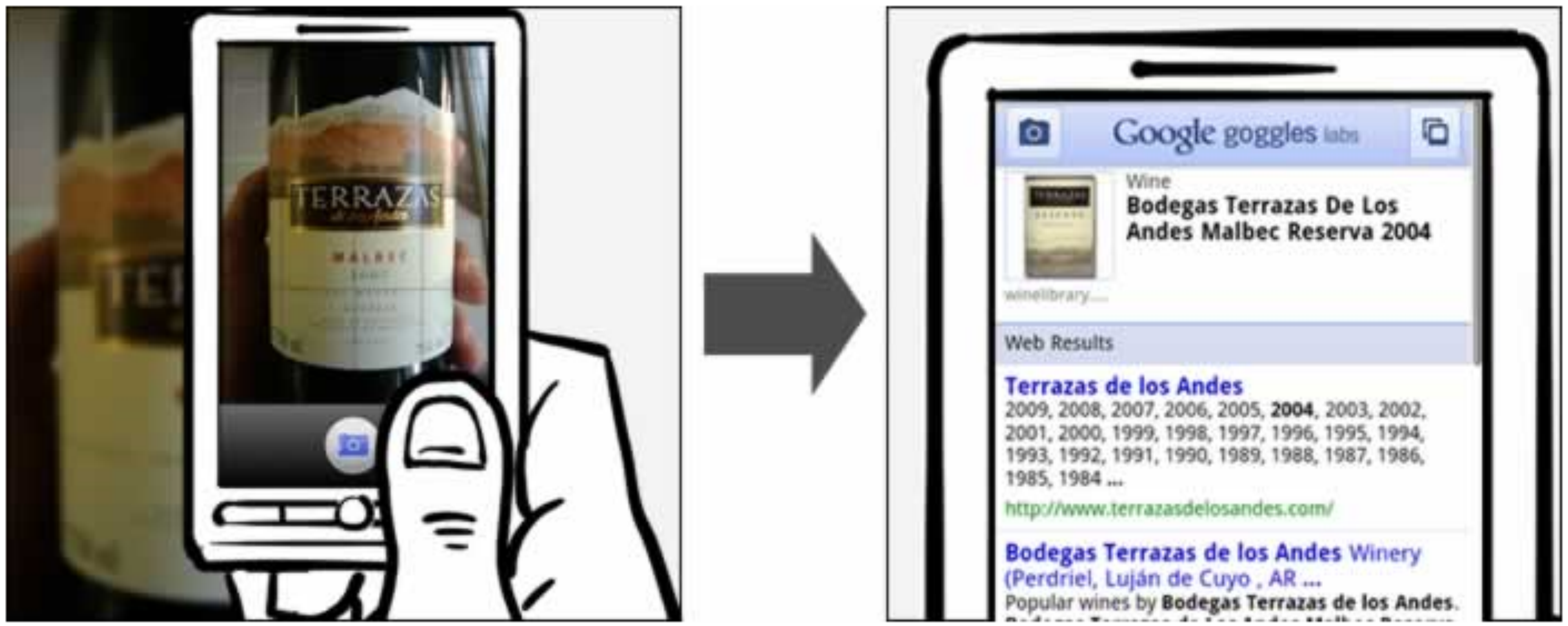


Scene Segmentation

(b) (c)

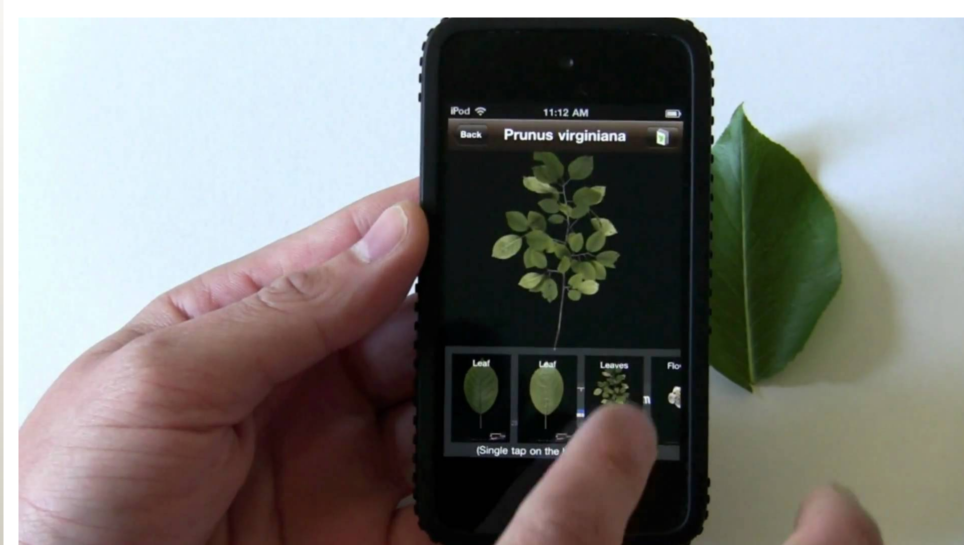
Google Goggles





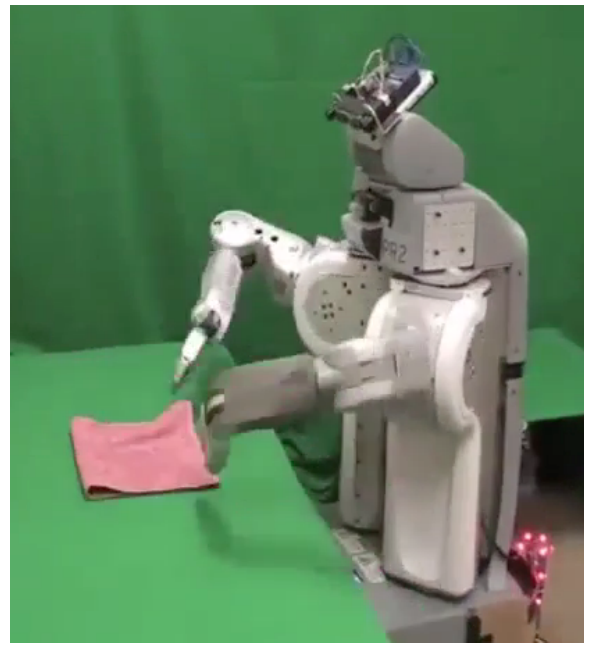
Smile Detection

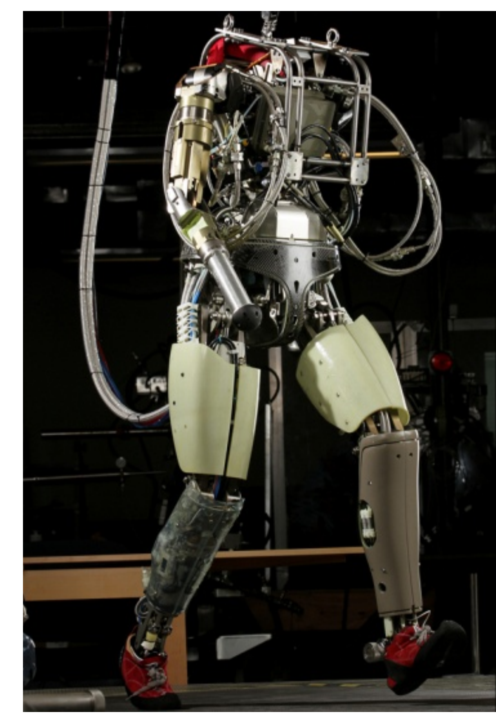
Leaf Snap



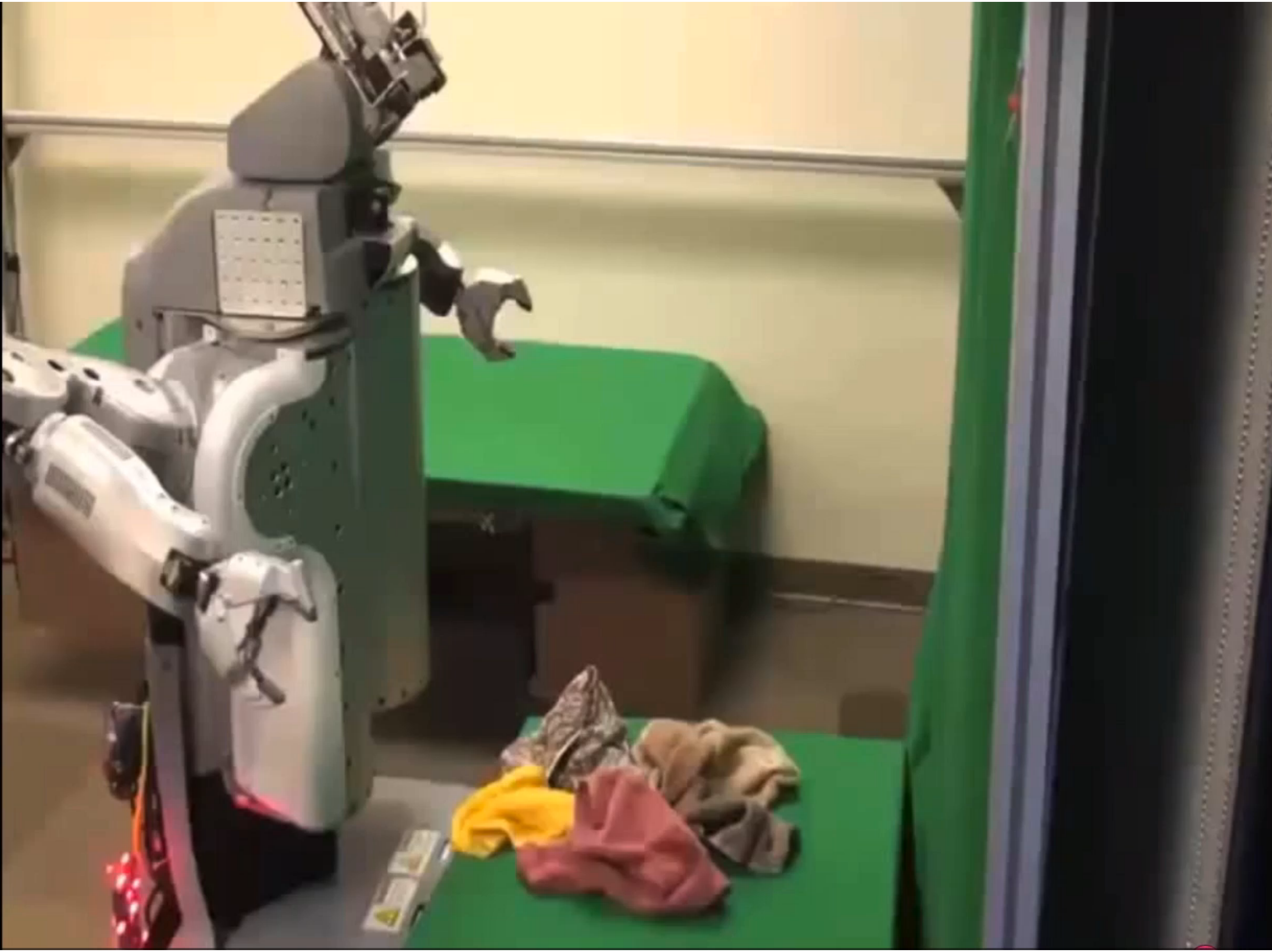
Robotics

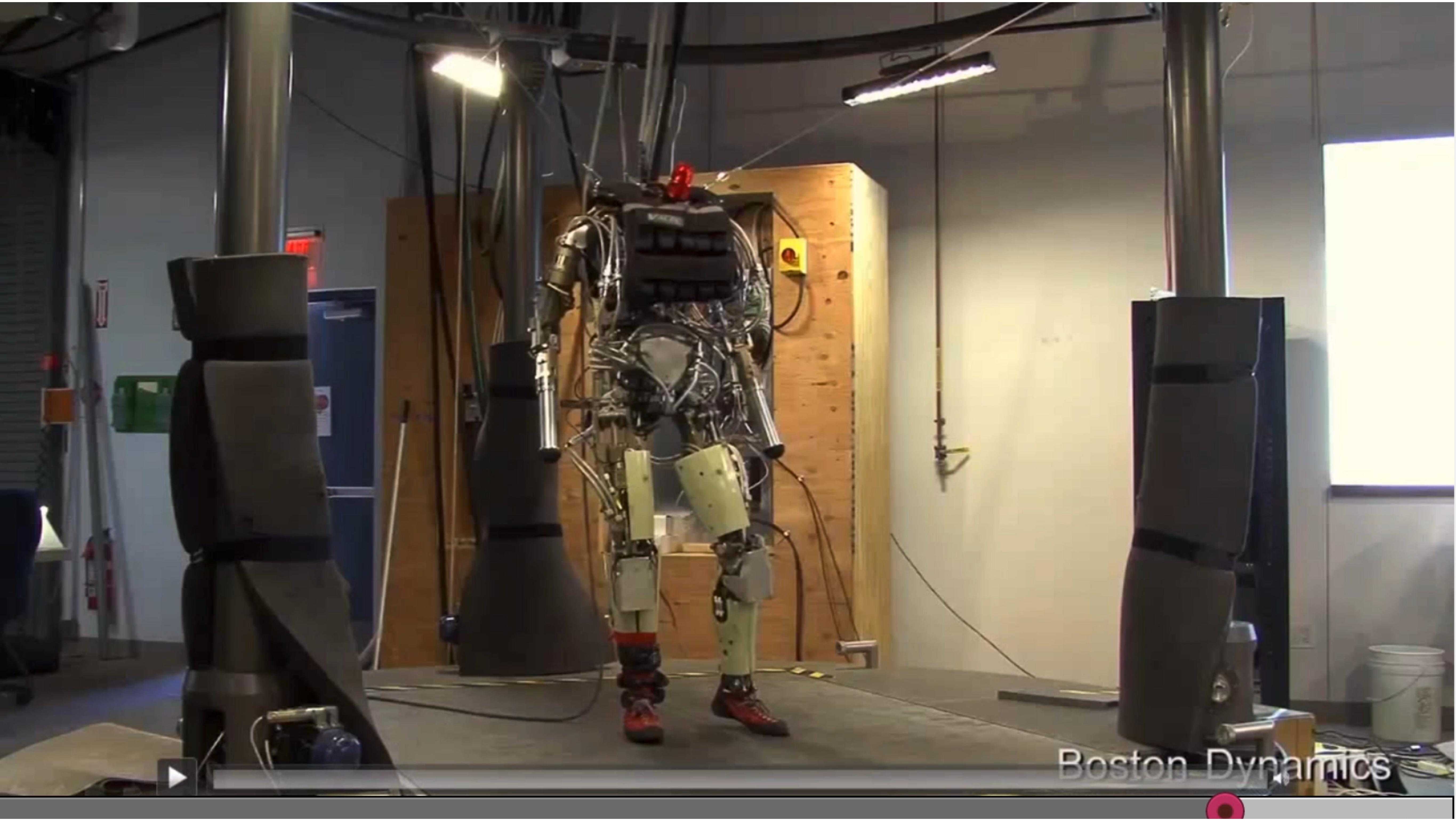
- Robotics
  - Part mech. eng.
  - Part AI
  - Reality much harder than simulations!
- Technologies
  - Vehicles
  - Rescue
  - Soccer!
  - Lots of automation…
- In this class:
  - We ignore mechanical aspects
  - Methods for planning
  - Methods for control



Images from UC Berkeley, Boston Dynamics, RoboCup, Google




Boston Dynamics

Logic

- Logical systems
  - Theorem provers
  - NASA fault diagnosis
  - Question answering

- Methods:
  - Deduction systems
  - Constraint satisfaction
  - Satisfiability solvers (huge advances!)

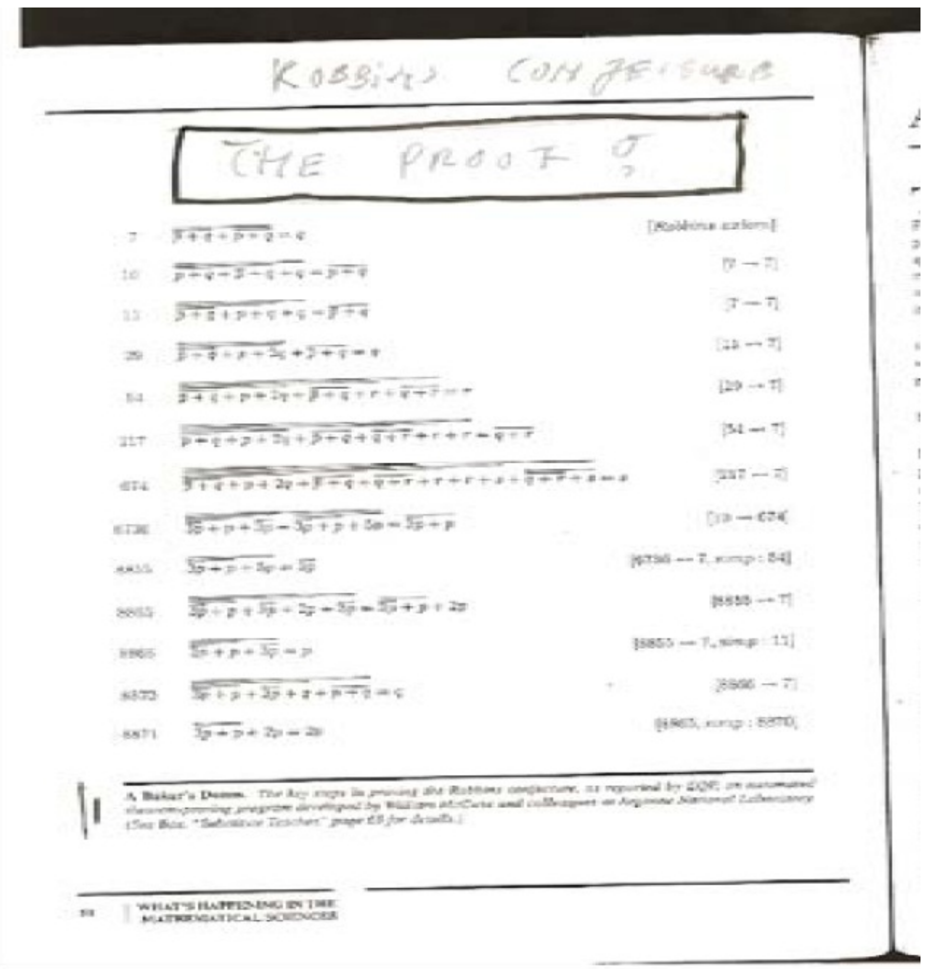


Image from Bart Selman

Decision Making

- Scheduling, airline routing
- Route planning
- Medical diagnosis
- Web search
- Spam classification
- Automated help desks
- Fraud detection
- Product recommendation
- … Lots more!

Machine Learning

- Most current AI systems

"Il est impossible aux journalistes de rentrer dans les régions tibétaines"

Bruno Philip, correspondant du "Monde" en Chine, estime que les journalistes de l'AFP qui ont été expulsés de la province tibétaine du Qinghai "n'étaient pas dans l'illégalité".

Les faits Le dalaï-lama dénonce l'"enfer" imposé au Tibet depuis sa fuite, en 1959

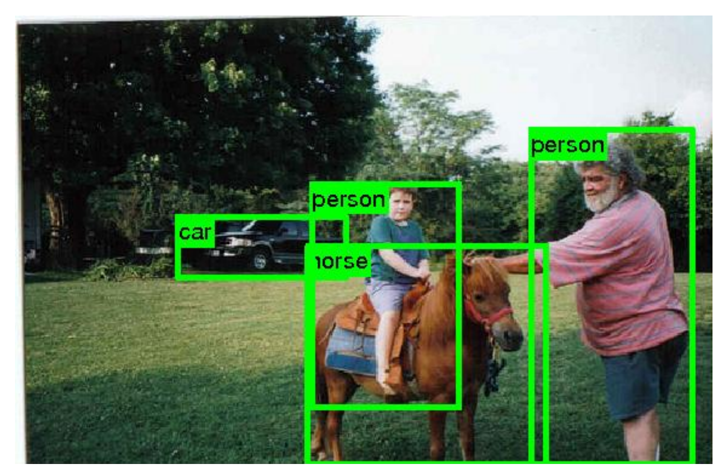
Vidéo Anniversaire de la rébellion

"It is impossible for journalists to enter Tibetan areas"

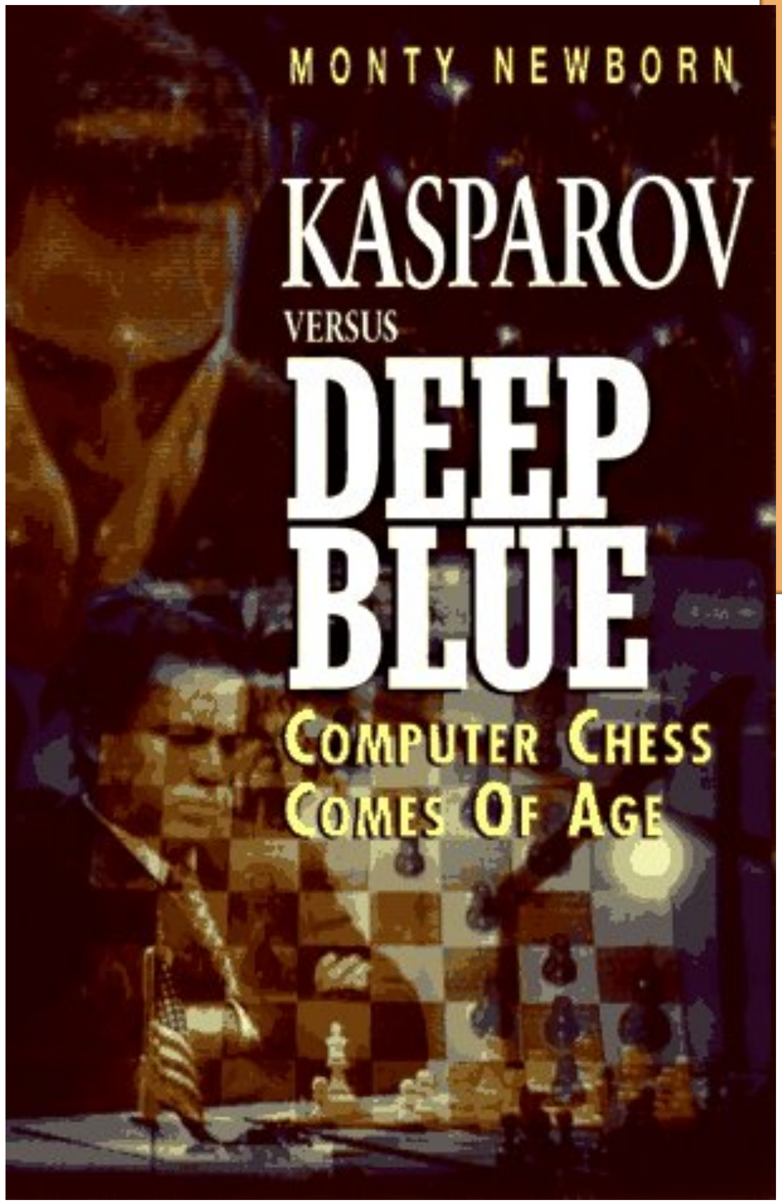
Philip Bruno, correspondent for "World" in China, said that journalists of the AFP who have been deported from the Tibetan province of Qinghai "were not illegal."

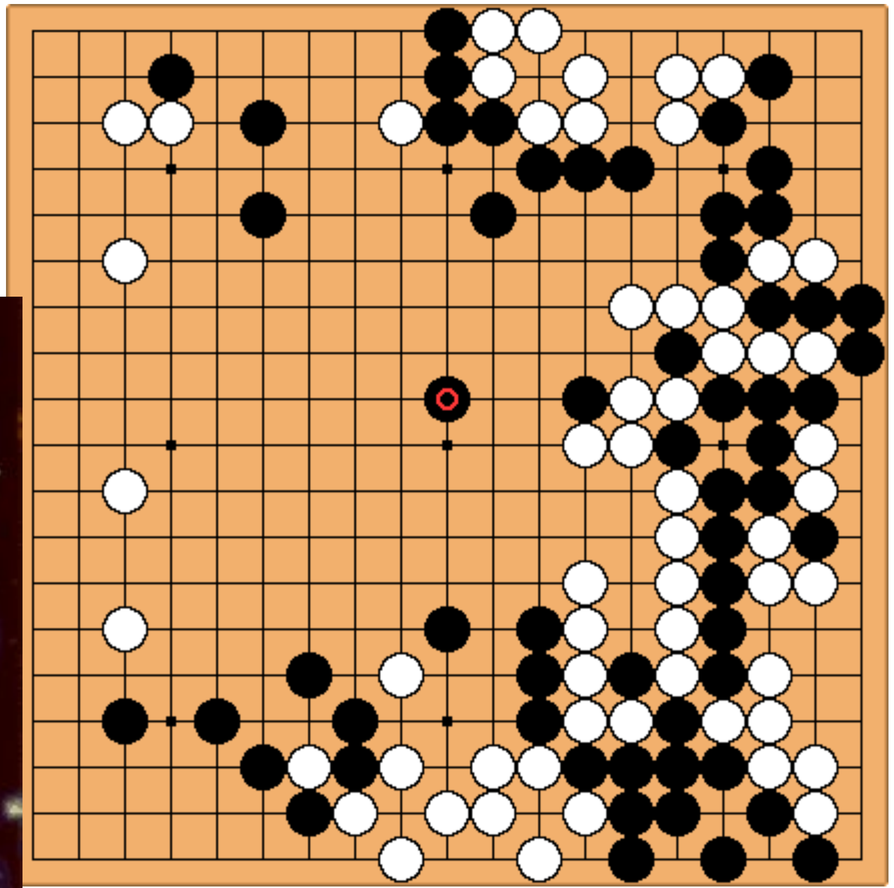
Facts The Dalai Lama denounces the "hell" imposed since he fled Tibet in 1959

Video Anniversary of the Tibetan rebellion: China on guard



Game Playing





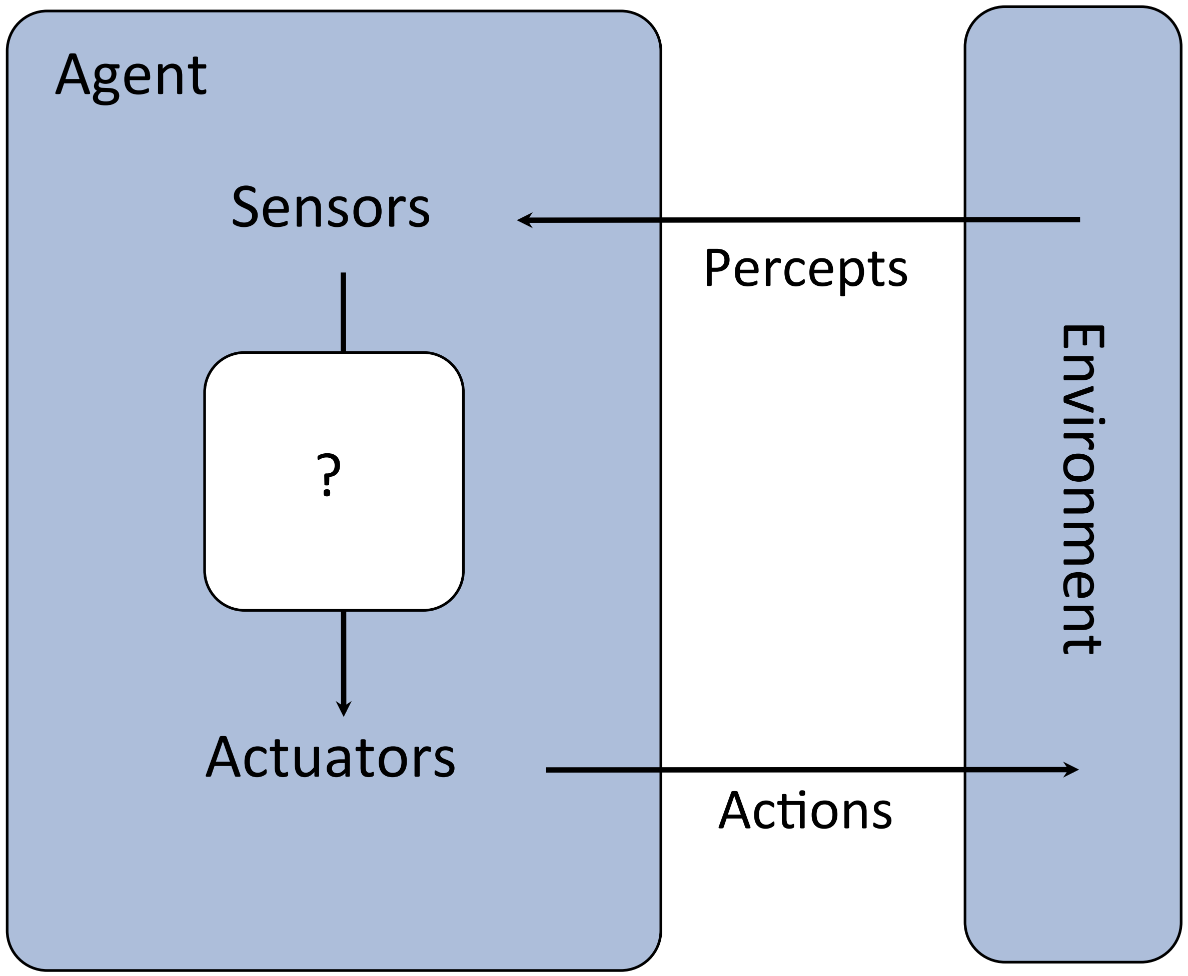
Designing Rational Agents

An agent:

- Perceives and acts
- Selects actions that maximize its utility function
- Has a goal

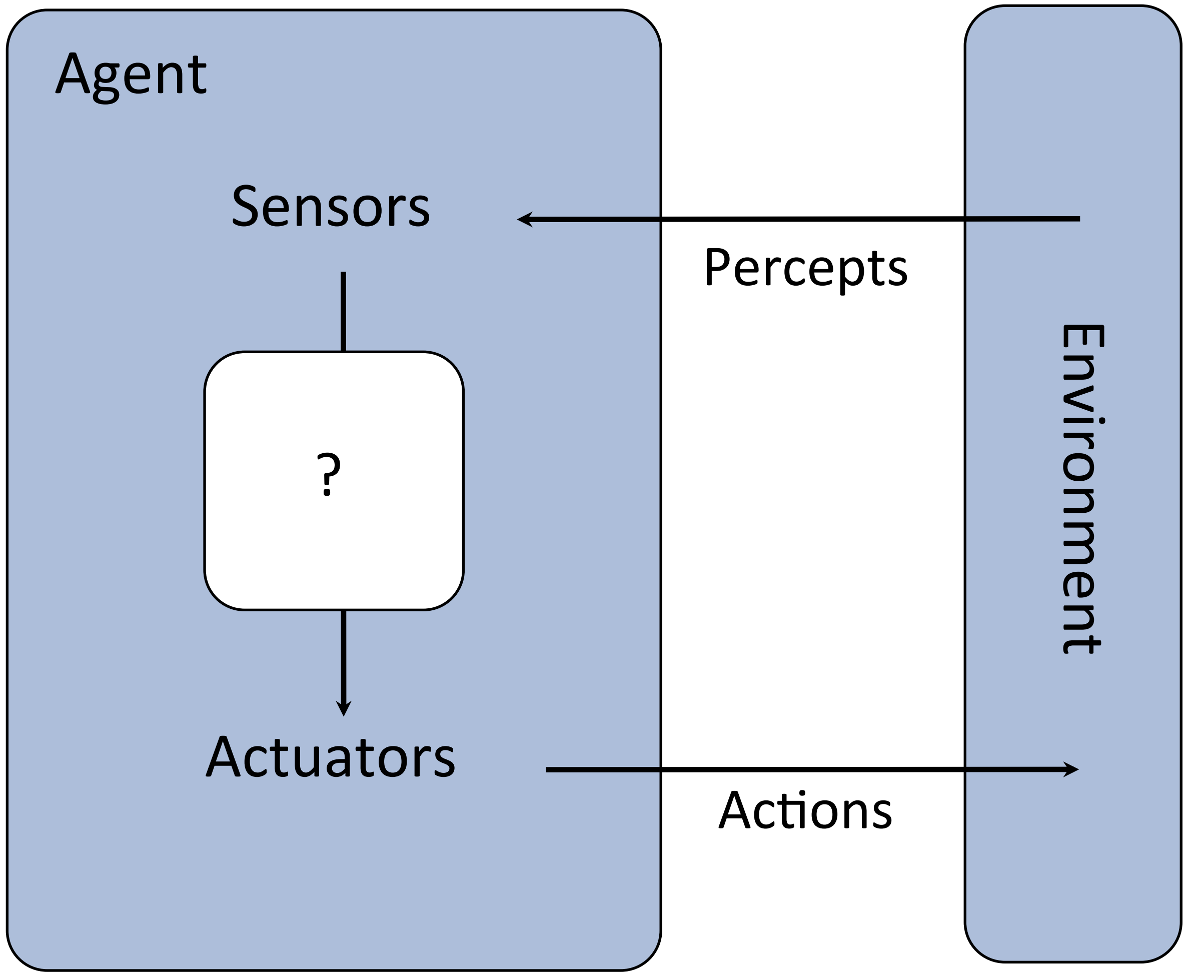
Environment:

- Input and output to the agent



Designing Rational Agents

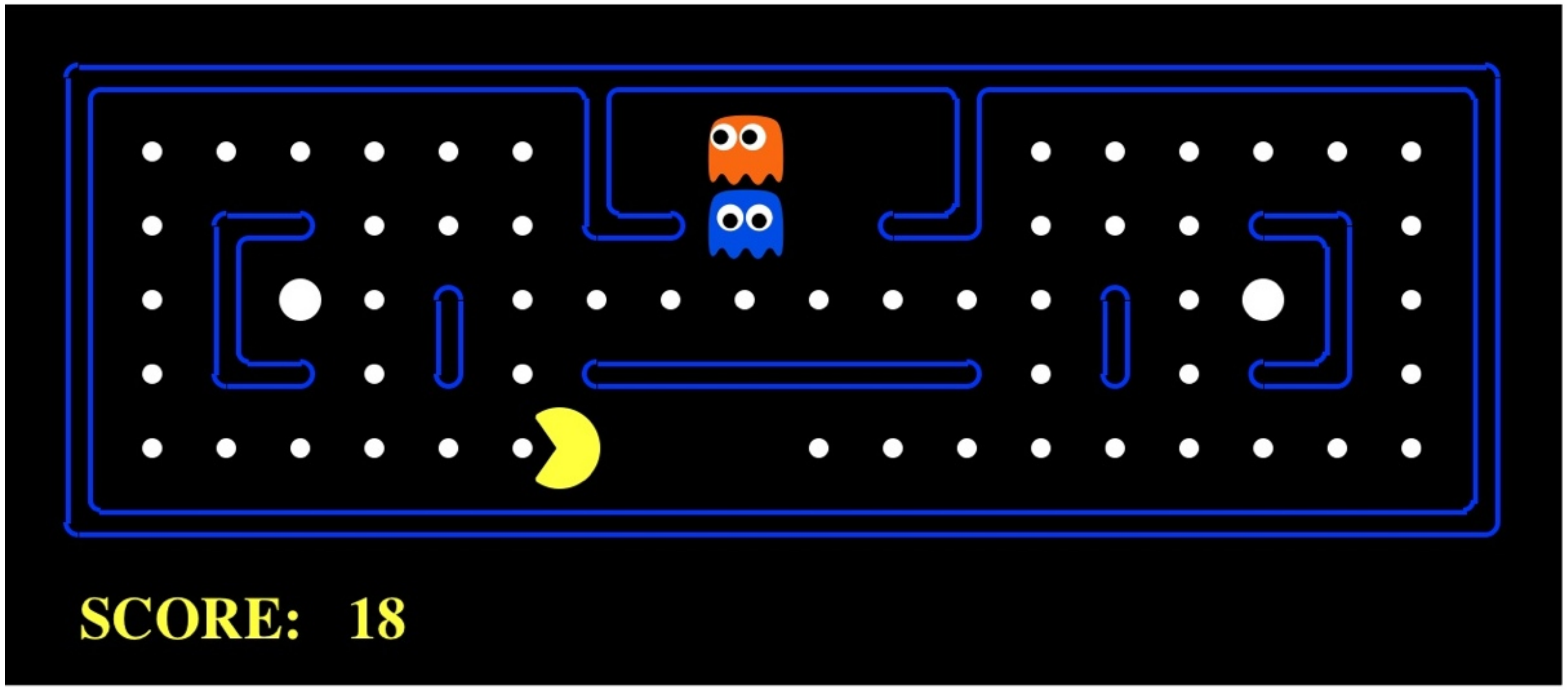
Characteristics of the percepts, environment, and action space dictate techniques for selecting rational actions.

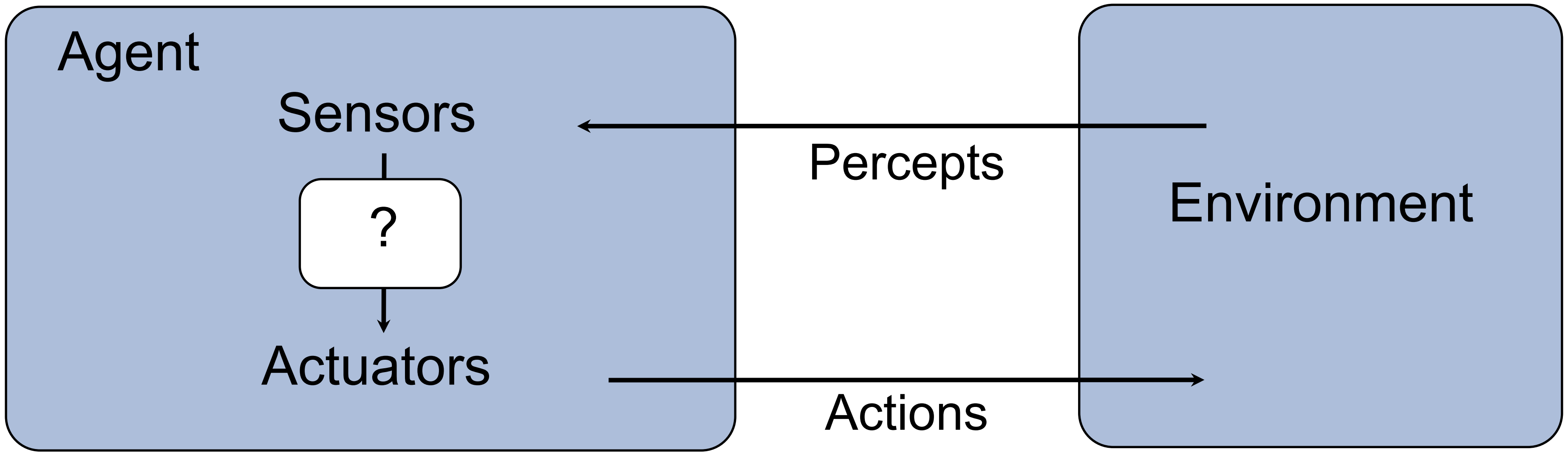


This course is about:

- 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

Pacman as an Agent



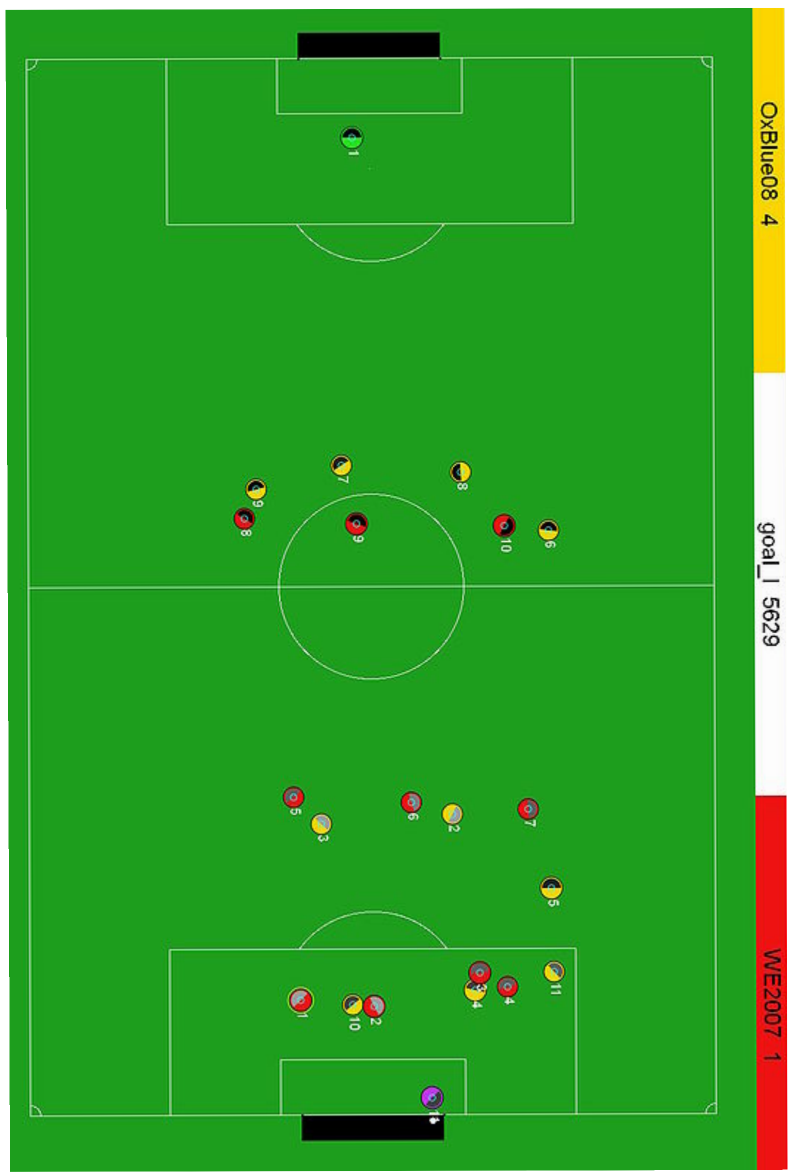


Types of Environments

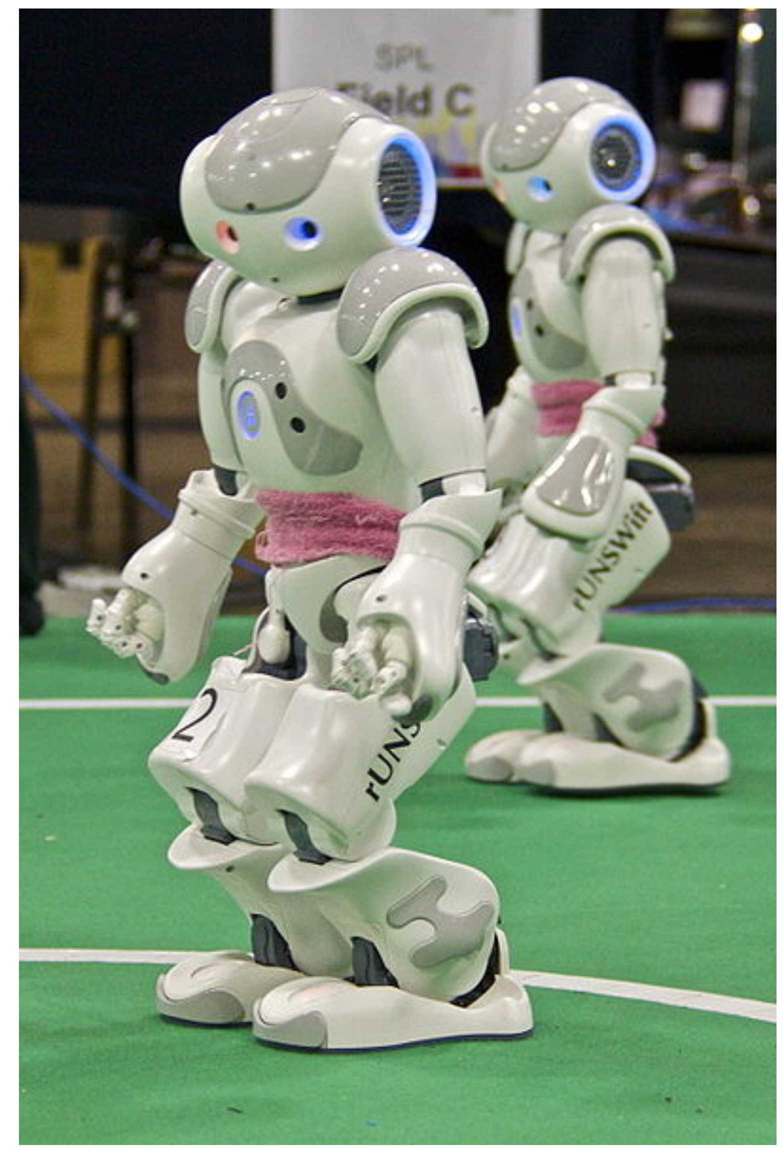
- Fully observable *vs.* partially observable
- Single agent *vs.* multiagent
- Deterministic *vs.* stochastic
- Static *vs.* sequential
- Discrete *vs.* continuous

Fully observable vs. Partially observable

Can the agent observe the complete state of the environment?



vs.



Single agent vs. Multiagent

Is the agent the only thing acting in the world?

vs.

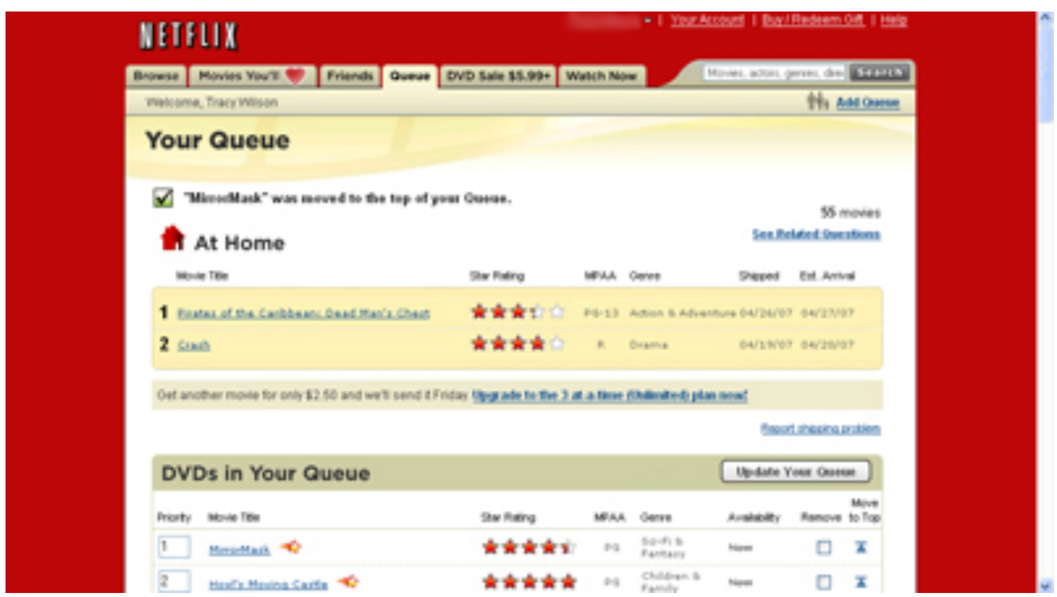
Deterministic vs. Stochastic

Is there uncertainty in how the world works?

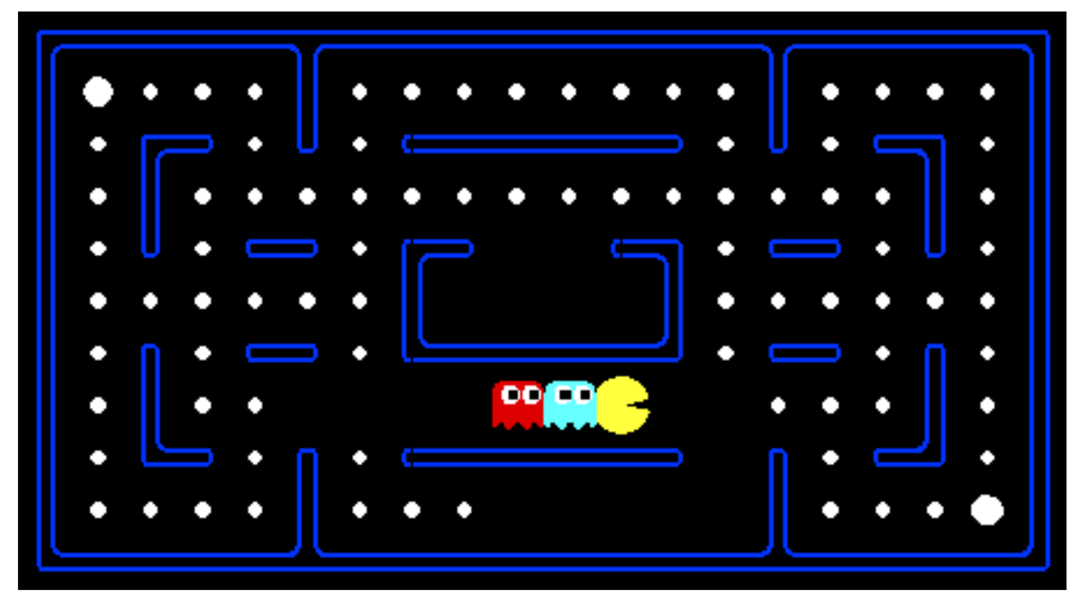
vs.

Static vs. Sequential

Does the agent take more than one action?



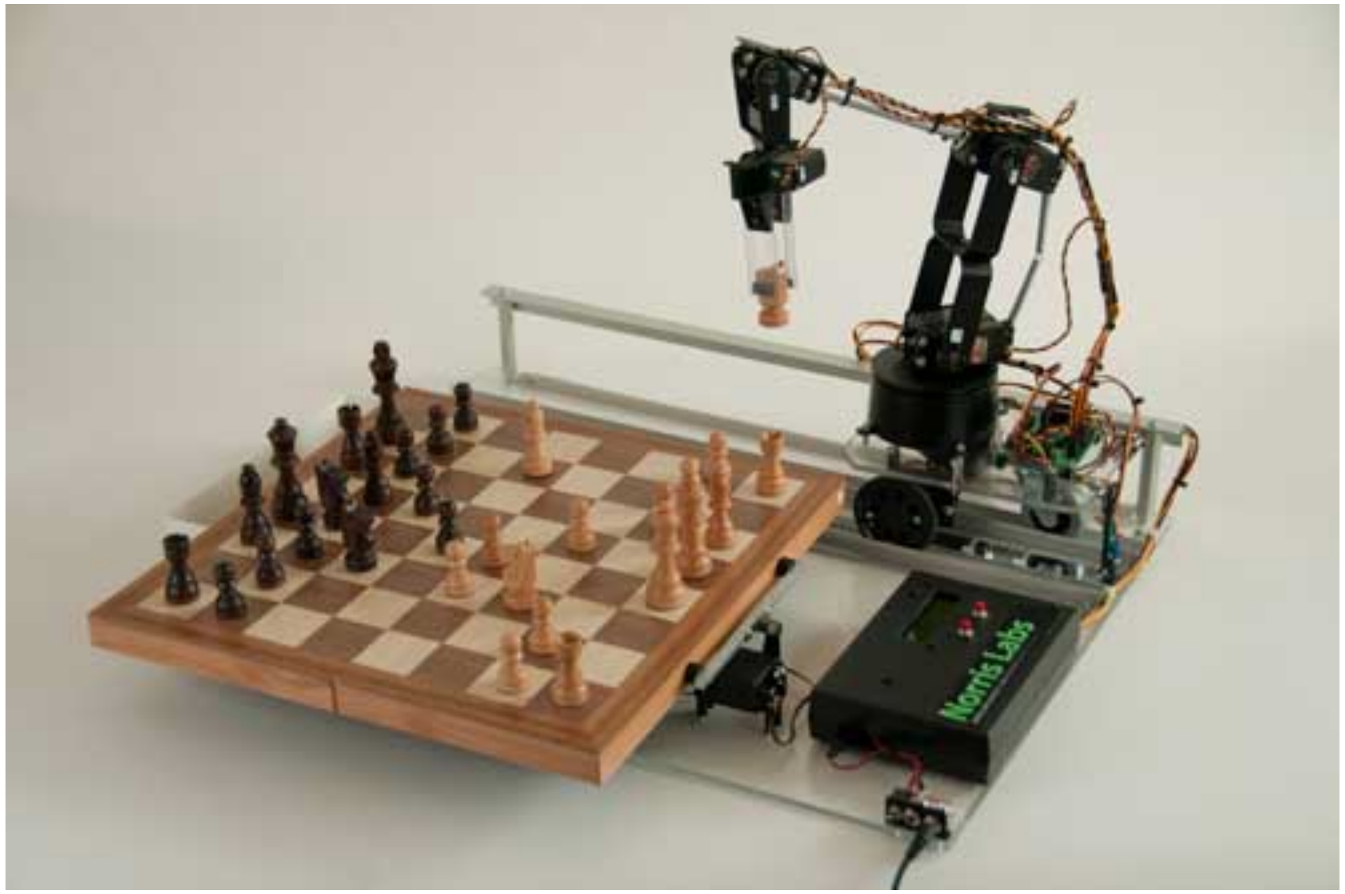
vs.



Discrete vs. Continuous

Is there a finite (or countable) number of possible environment states?

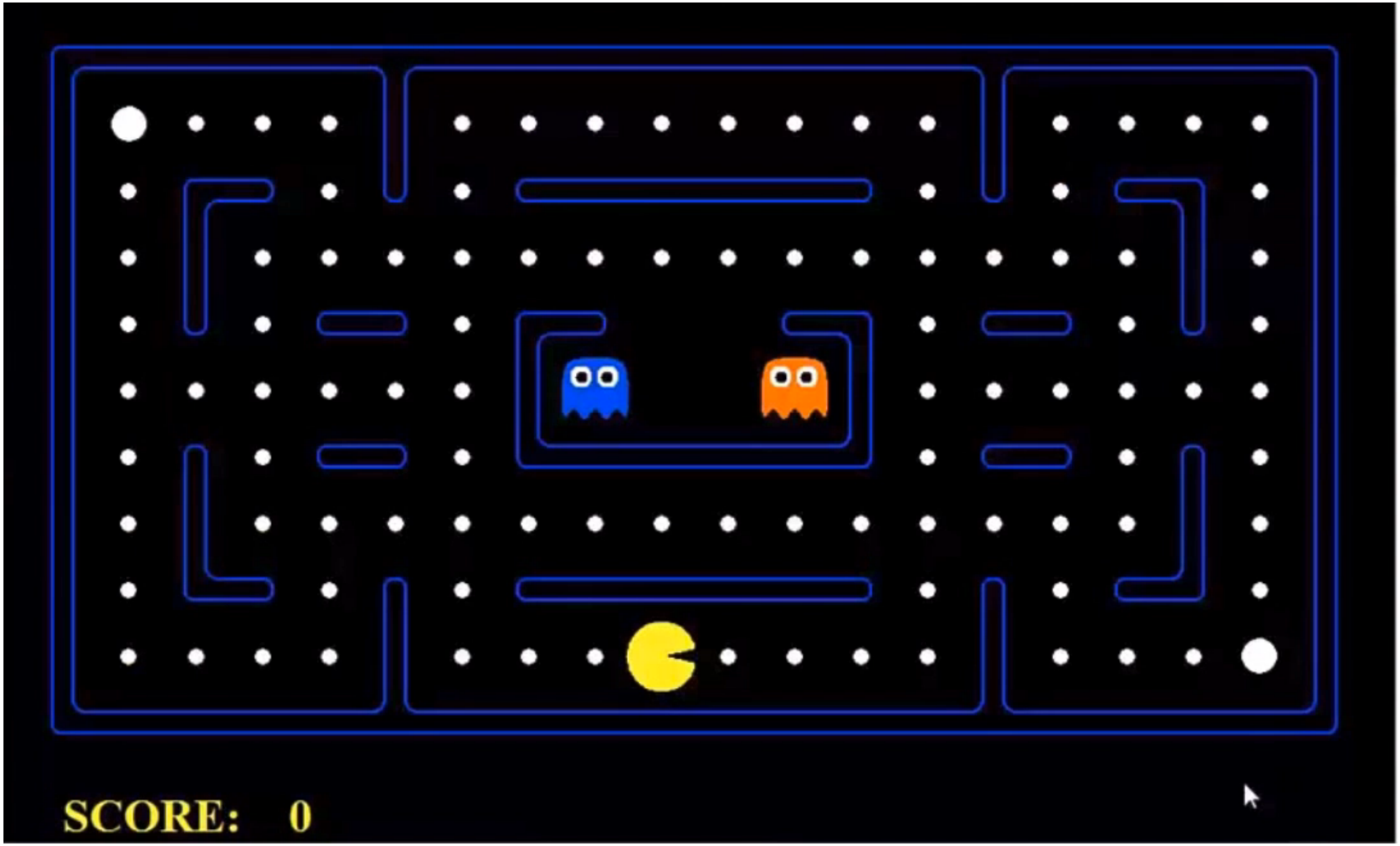
vs.



Topics in This Course

- Introduction
- Search
- Game Playing (minimax, alpha beta, expectimax)
- Markov Decision Processes
- Reinforcement Learning
- Constraint satisfaction
- Uncertainty, Bayesian networks, HMMs
- Supervised Machine Learning
- Logic & Planning
- Applications: Natural Language Processing, Computer Vision

Assignments: Pac-man



Originally developed at UC Berkeley:

http://www-inst.eecs.berkeley.edu/~cs188/pacman/pacman.html

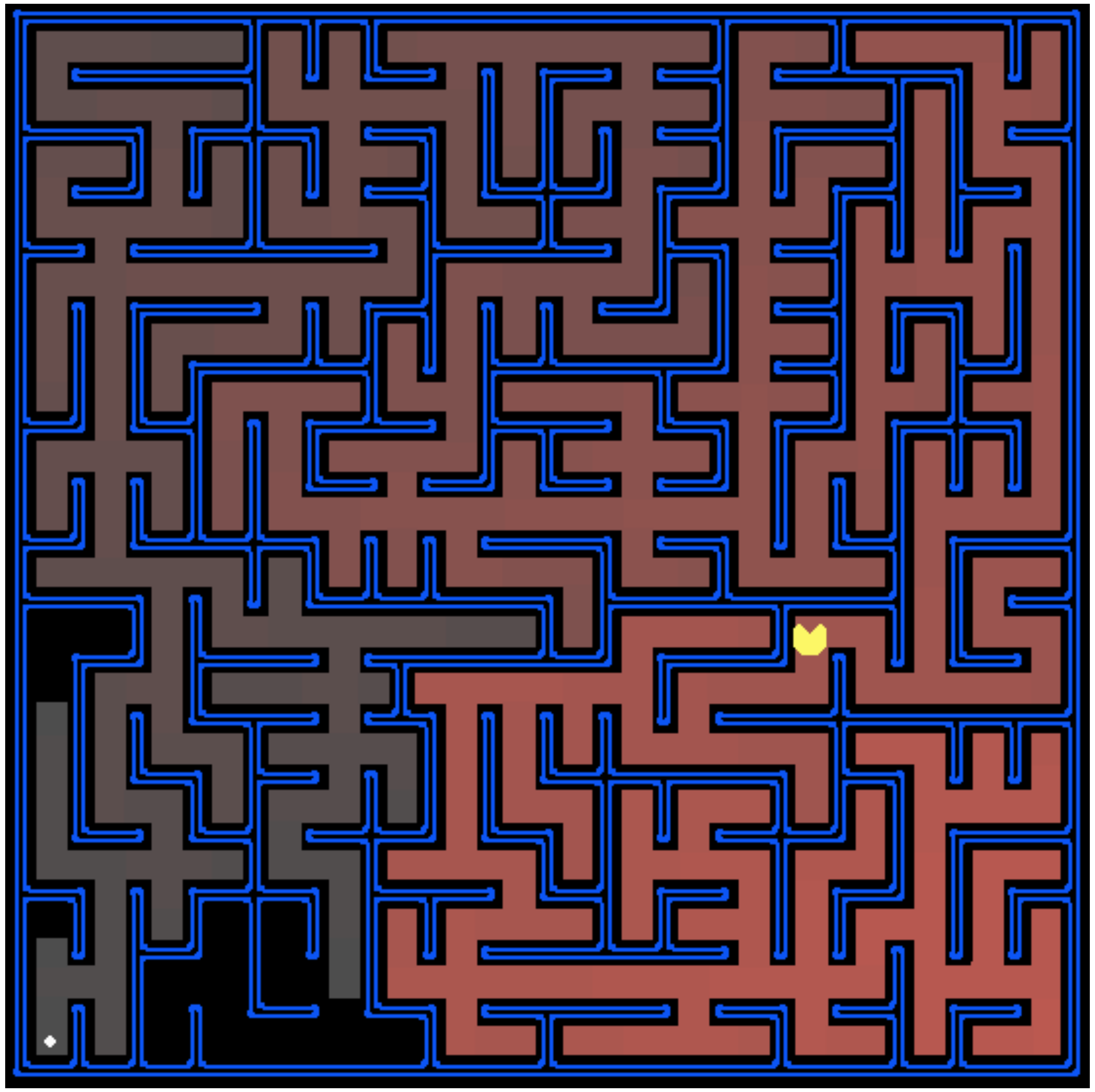
PS1: Search

Goal:

- Help Pac-man find his way through the maze

Techniques:

- Search: breadth-first, depth-first, etc.
- Heuristic Search: Best-first, A*, etc.



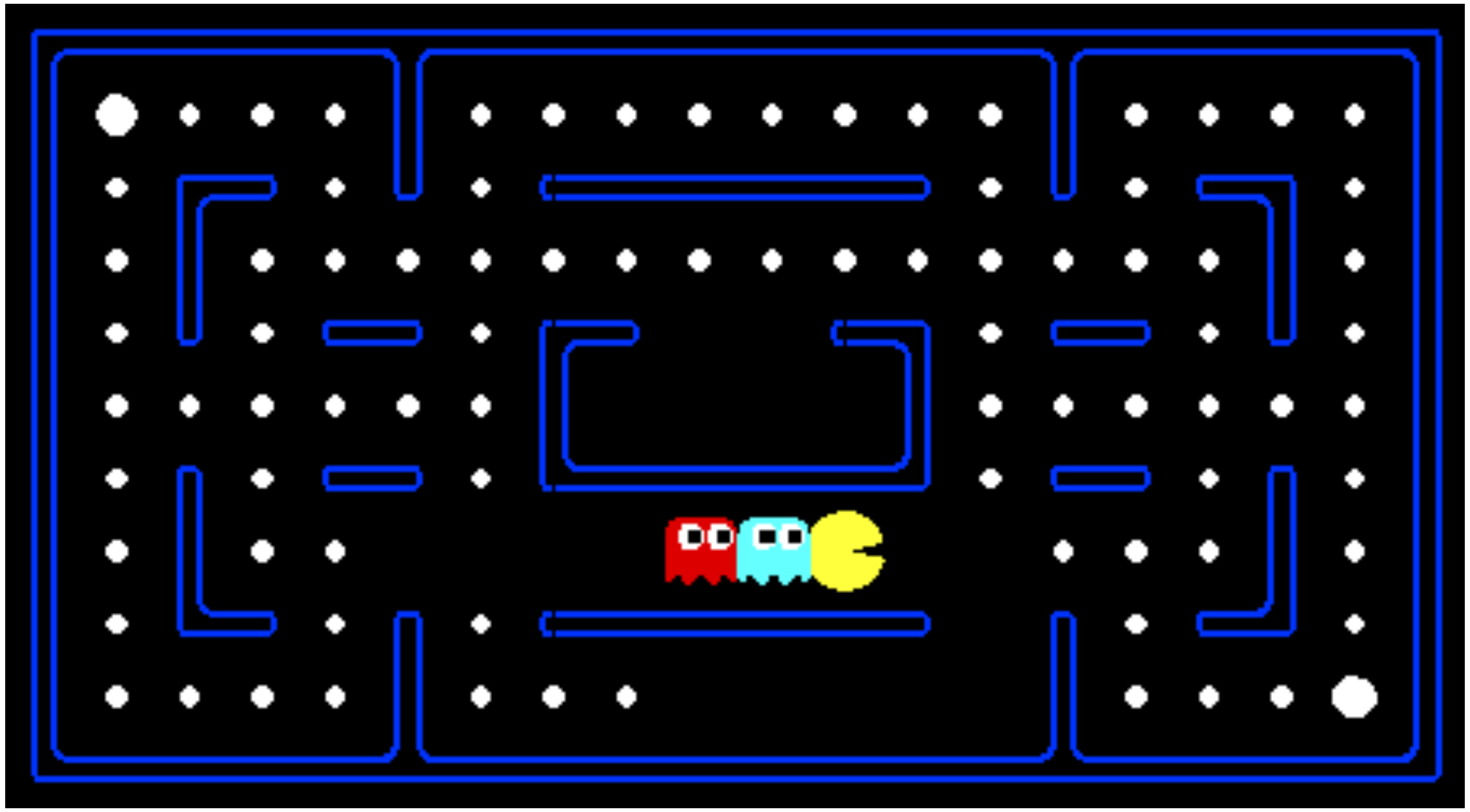
PS2: Game Playing

Goal:

- Play Pac-man!

Techniques:

- Adversarial Search: minimax, alpha-beta, expectimax, etc.



PS3: Planning and Learning

Goal:

- Help Pac-man learn about the world

Techniques:

- Planning: MDPs, Value Iterations
- Learning: Reinforcement Learning

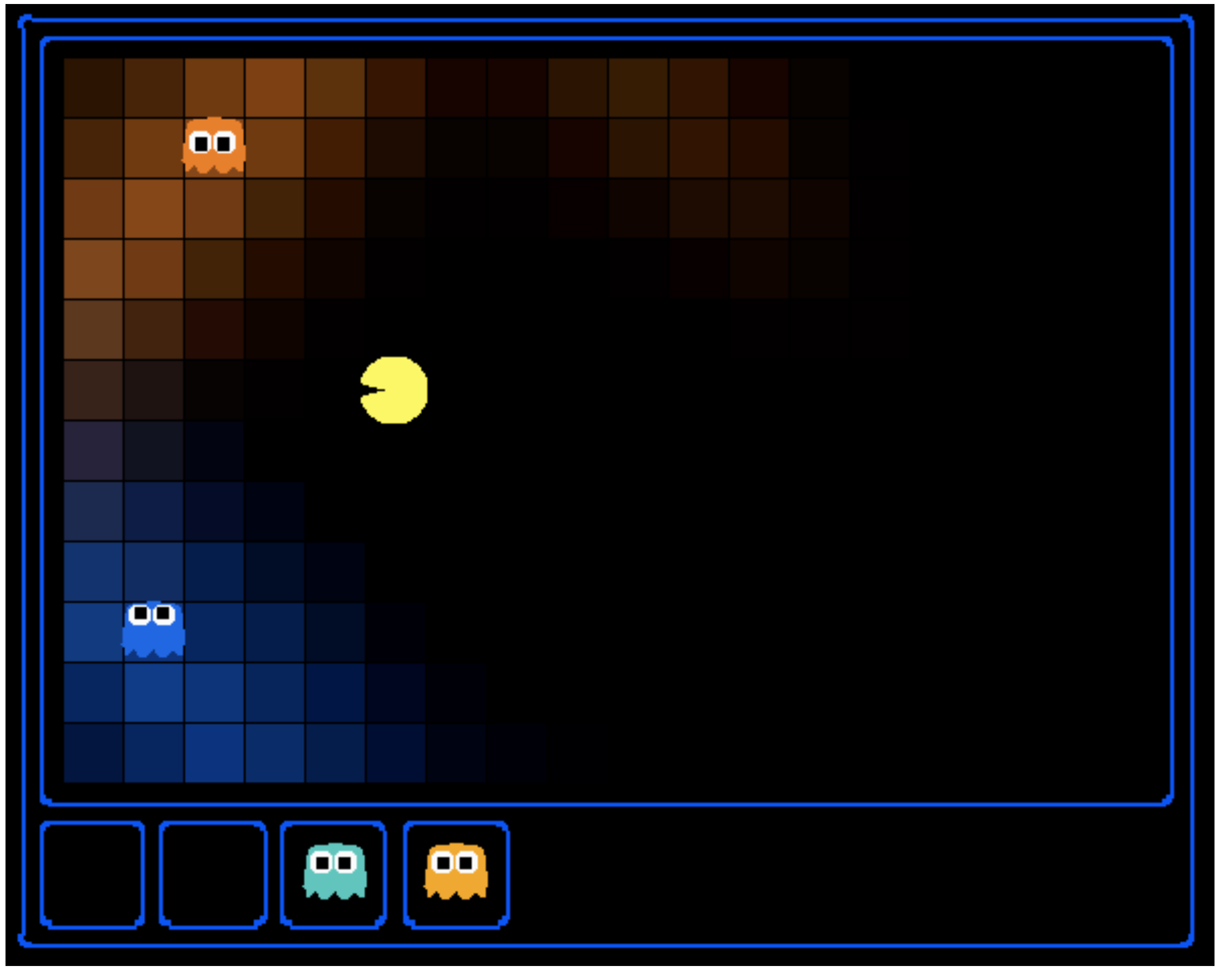
PS4: Ghostbusters

Goal:

- Help Pac-man hunt down the ghosts

Techniques:

- Probabilistic models: HMMS, Bayes Nets
- Inference: State estimation and particle filtering



To Do:

- Look at the course website: https://courses.cs.washington.edu/courses/csep573/14sp/
- Do the python tutorial