

## CSE 473: Artificial Intelligence Spring 2015

### Introduction & Agents



**Dieter Fox**  
Fri: 10:30–11:30



**Peter Henry**  
Wed,Thu: 1-2pm



**Nao Hiranuma**  
Tue Fri: 1-2pm

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

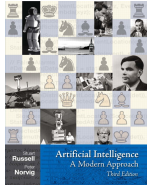
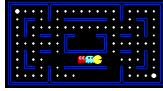
## Course Logistics

**Textbook:**  
Artificial Intelligence: A Modern Approach, Russell and Norvig (3<sup>rd</sup> ed)

**Prerequisites:**

- Data Structures (CSE 326 or CSE 322) or equivalent
- Understanding of probability, logic, algorithms, complexity

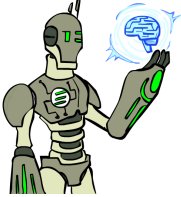
**Work:**  
Readings (text & papers)  
Programming assignments / hw (50%),  
Midterm (15%)  
Final (30%)  
Class participation (5%)

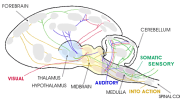
Pacman, autograder

## Today

- What is (AI)?
- Agency
- What is this course?




## Brain: Can We Build It?



10<sup>11</sup> neurons  
10<sup>14</sup> synapses  
cycle time: 10<sup>-3</sup> sec

VS.



10<sup>9</sup> transistors  
10<sup>12</sup> bits of RAM  
cycle time: 10<sup>-9</sup> sec

## What Can AI Do?

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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? Bake a cake?
- Discover and prove a new mathematical theorem?
- Perform a complex surgical operation?
- Unload a dishwasher and put everything away?
- Translate Chinese into English in real time?

## What is AI?

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The science of making machines that:

|                   |                  |
|-------------------|------------------|
| Think like humans | Think rationally |
| Act like humans   | Act rationally   |

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## Rational Decisions

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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 might be:

Computational Rationality

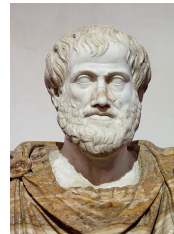
## A (Short) History of AI

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## Prehistory

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- **Logical Reasoning:** (4<sup>th</sup> C BC+) Aristotle, George Boole, Gottlob Frege, Alfred Tarski



## Medieval Times

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- **Probabilistic Reasoning:** (16<sup>th</sup> C+) Gerolamo Cardano, Pierre Fermat, James Bernoulli, Thomas Bayes



## 1940-1950: Early Days

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1942: Asimov: Positronic Brain; Three Laws of Robotics

1. A robot may not injure a human being or, through inaction, allow a human being to come to harm.
2. A robot must obey the orders given to it by human beings, except where such orders would conflict with the First Law.
3. A robot must protect its own existence as long as such protection does not conflict with the First or Second Laws.

1943: McCulloch & Pitts: Boolean circuit model of brain

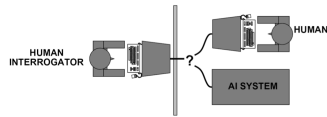
1946: First digital computer - ENIAC

## 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

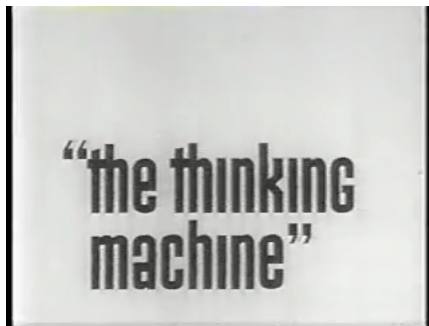
## 1950-1970: Excitement

- 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

## The Thinking Machine (1960's)



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## 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 Feigenbaum in "The Art of Artificial Intelligence"

## 1988--: Statistical Approaches

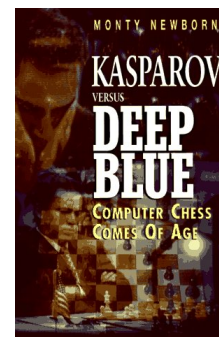


- 1985-1990: Rise of Probability and Decision Theory  
Eg, Bayes Nets  
Judea Pearl - ACM Turing Award 2011
- 1990-2000: Machine learning takes over subfields:  
Vision, Natural Language, etc.

"Every time I fire a linguist, the performance of the speech recognizer goes up"

- Fred Jelinek, IBM Speech Team

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


## 2005



Stanford Car  
DARPA Grand Challenge



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## Self-driving car, today



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## 2009

### Recommendations, Search result ordering Ad placement,

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## 2011



[http://www.youtube.com/watch?v=WFR3iOm\\_xhE](http://www.youtube.com/watch?v=WFR3iOm_xhE)

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## 2014 = Momentous Times!

Fooled 33% of judges!

News - Technology  
**Turing Test breakthrough as super-computer becomes first to convince us it's human**



Eugene Goostman, a computer programme pretending to be a young Ukrainian boy, successfully duped enough humans to pass the iconic test

ANDREW GRIFFIN Sunday 08 June 2014

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A programme that convinced humans that it was a 13-year-old boy has become the first computer ever to pass the Turing Test. The test – which requires that computers are indistinguishable

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## Judges were not so smart

**Conversation with Scott Aaronson:**

Scott: Which is bigger, a shoebox or Mount Everest?

Eugene: I can't make a choice right now. I should think it out later. And I forgot to ask you where you are from...

Scott: How many legs does a camel have?

Eugene: Something between 2 and 4. Maybe, three? :-)) By the way, I still don't know your specialty – or, possibly, I've missed it?

Scott: How many legs does a millipede have?

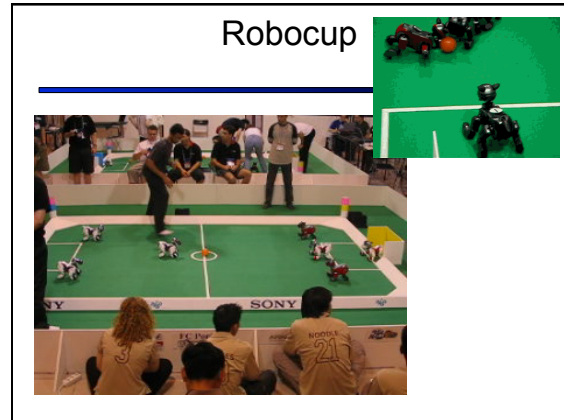
Eugene: Just two, but Chernobyl mutants may have them up to five. I know you are supposed to trick me.

Scott: No. I need to know that you're not a chatbot. Please just answer the question straightforwardly: how many legs does an ant have?

Eugene: Something between 2 and 4. Maybe, three? :-)) Oh, what a fruitful conversation:-)

Scott: Do you understand why I'm asking such basic questions? Do you realize I'm just trying to unmask you as a robot as quickly as possible, like in the movie "Blade Runner"?

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### What is AI?

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### Agent vs. Environment

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- An agent is an entity that perceives and acts.
- A rational agent selects actions that maximize its utility function.
- Characteristics of the percepts, environment, and action space dictate techniques for selecting rational actions.

Agent

Sensors

?

Actuators

← Percepts

→ Actions

Environment

### Types of Environments

- Fully observable *vs.* partially observable
- Single agent *vs.* multiagent
- Deterministic *vs.* stochastic
- Episodic *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.


Aka static vs. dynamic



### Deterministic vs. Stochastic

Is there uncertainty in how the world works?


vs.




### Episodic vs. Sequential

Episodic: next episode doesn't depend on previous actions.


vs.


### Discrete vs. Continuous

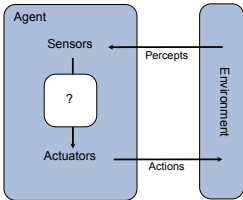
- Is there a finite (or countable) number of possible environment states?


vs.


## Types of Agent

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## Reflex Agents

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- Reflex agents:
  - Choose action based on current percept (and maybe memory)
  - Do not consider the future consequences of their actions
  - Act on how the world IS

## Goal Based Agents

- Plan ahead
- Ask "what if"
- Decisions based on (hypothesized) consequences of actions
- Must have a model of how the world evolves in response to actions
- Act on how the world **WOULD BE**

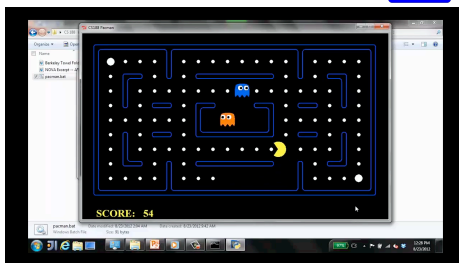


## Utility Based Agents

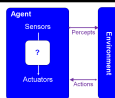
- Like goal-based, but
- Trade off multiple goals
- Reason about probabilities of outcomes
- Act on how the world will **LIKELY** be



## Pacman as an Agent



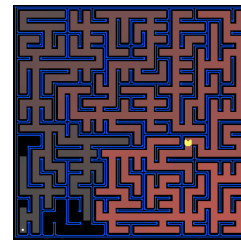
Originally developed at UC Berkeley:  
<http://www-inst.eecs.berkeley.edu/~cs188/pacman/pacman.html>



## PS1: Search

Goal:  
 • Help Pac-man find its way through the maze

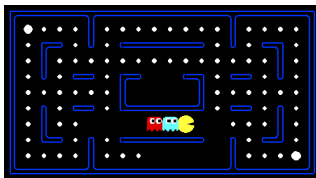
Techniques:  
 • Search: breadth-first, depth-first, etc.  
 • Heuristic Search: Best-first, A\*, etc.



## PS2: Game Playing

Goal:  
 • Play Pac-man!

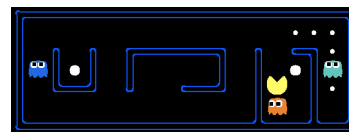
Techniques:  
 • Adversarial Search: minimax, alpha-beta, expectimax, etc.



## PS3: Planning and Learning

Goal:  
 • Help Pac-man learn about the world

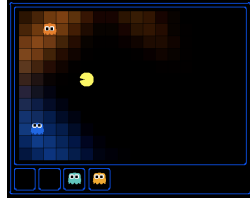
Techniques:  
 • Planning: MDPs, Value Iterations  
 • Learning: Reinforcement Learning



## PS4: Ghostbusters

### Goal:

- Help Pac-man hunt down the ghosts



### Techniques:

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

## Course Topics

- **Part I: Making Decisions**
  - Fast search / planning
  - Constraint satisfaction
  - Adversarial and uncertain search



- **Part II: Reasoning under Uncertainty**
  - Bayes' nets
  - Decision theory
  - Machine learning

- **Throughout: Applications**
  - Natural language, vision, robotics, games, ...