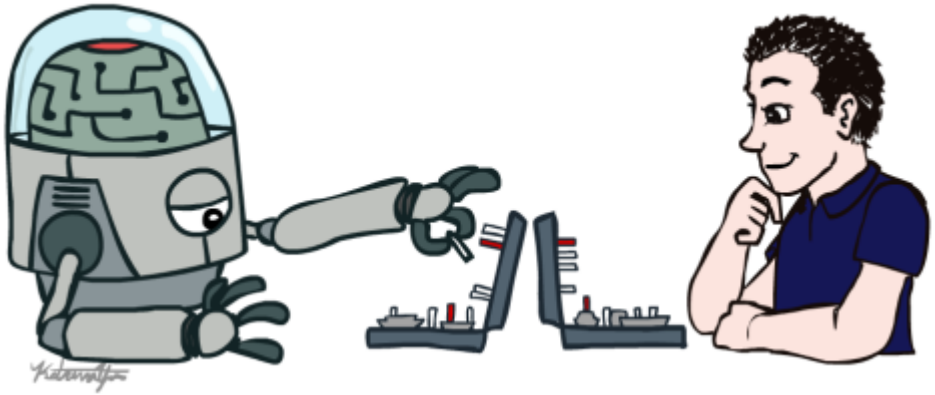
COMP3211
Fundamentals of Artificial Intelligence

Introduction

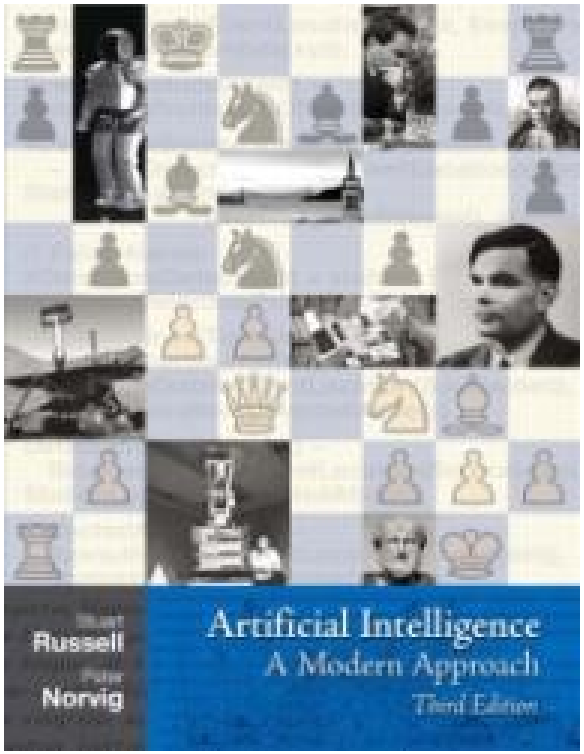


Logistics

- Instructor: Yangqiu Song
  - Email: yqsong@cse.ust.hk
- Office hours:
  - Tuesday and Thursday 4:30-6:00pm
  - Rm3518 (Lifts 25/26)
- Canvas
  - Syllabus
  - Lecture notes
  - Homework: submissions, gradings, etc.
  - Projects
  - Announcement
- TAs:
  - Yan Liang yliangav@connect.ust.hk
  - Ziqian Zeng zzengae@cse.ust.hk

Textbook

- Not required, but for students who want to read more we recommend
  - Russell & Norvig, AI: A Modern Approach, 3rd Ed.



  - Warning: Not a course textbook, so our presentation does not necessarily follow the presentation in the book.

Acknowledgements

- UC Berkeley Book Website
  - http://aima.cs.berkeley.edu/
- UC Berkeley CS188 Intro to AI
  - http://ai.berkeley.edu/home.html
- Stanford CS221: Artificial Intelligence: Principles and Techniques
  - http://web.stanford.edu/class/cs221

Course Information

- Prerequisites:
  - Data structures, programming (COMP 2011, 2012, 2012H …)
  - (optional) Discrete math (COMP 2711), Probability (MATH 2421), …
- Work:
  - Homework assignments (~30%)
  - Midterm (~10%)
  - Group project (~20%):
    - Software+Report (~10-15%)
    - Presentation (~5-10%)
  - Final exam (~40%)
  - Academic integrity policy
    - Late submission: score got reduced (time based)
      - Late within 1 day: get at most 80%
      - Late within 1 week: get at most 60%
      - Afterward: 0
    - Plagiarism: all involved parties will get zero

Grading Guidelines

- Homework:
  - TAs will grade homework assignments
- Final project (last year's example)
  - Final score=((sum(C2:G2)+H2)/2+average(I2:K2))/2

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1	group-id/name	pe	Readability	Runnable	Reproducibility	Documentat	Innovation	Workload(10	Reader-1	Reader-2	Reader-3		Remarks	YQ Remarks	Score
5	group1	P.	2	2	2	2	0	9	10	10	10		tabular q-learning		18.5
6	group2	JA	2	2	2	2	1	8	8	9	9		tabular q-learning		17.16666667
7	group3	LE	2	2	2	2	1	7	7	8	8.5		search		15.83333333
8	group4	Vi	2	2	2	2	0	6	7	8	8		search		14.66666667
9	group5	Ha	2	2	2	2	1	8	8	7.5	8.5		rnn; stock		16.5
10	group6	Ng	2	2	2	2	0	8	10	9.5	10		sentiment		17.83333333
11	group7	M	2	2	2	2	1	6	7	6.5	7		search		14.33333333
12	group8	Kv	2	2	2	2	0	7	10	9	8.5		sentiment		16.66666667
13	group9	Gl	2	2	2	2	1	8	9	9	10		dqn		17.83333333
14	group10	Sh	2	2	2	2	0	8	9	9.5	9.5		cnn; kaggle		17.33333333

  - This year: we will have presentations

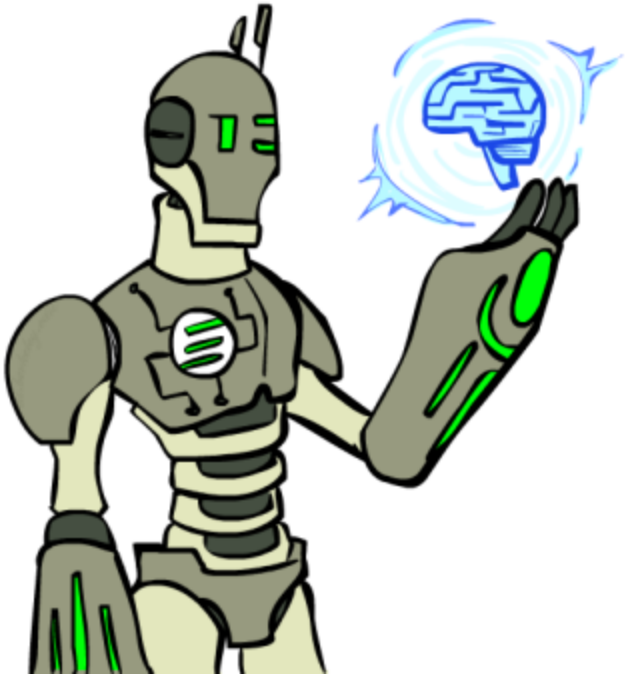
Exams and Final Grades

- Exams are related to the quiz, homework assignments
  - With a few difficult questions to distinguish the learning outcomes
- Final grades
  - With last year's experience

Earned Letter Grade	Percentage
A	~20-30%
B	~40-50%
C	~20-30%
D	~10-20%
F	~0-5%
Total	100%

Today

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

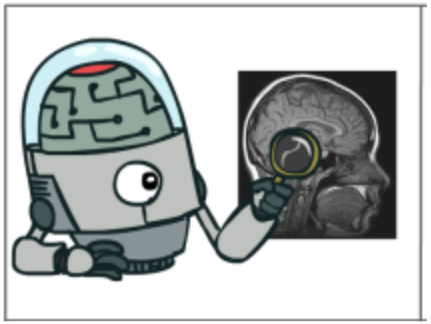


Sci-Fi AI?

What is AI?

The science of making machines that:

Think like people
cognitive
(neuro)science



Thinking like humans

- Scientific theories of internal activities of the brain
  - Cognitive Science– Predicting and testing behavior of human subjects (top down)
  - Cognitive Neuroscience– Direct identification from neurological data (bottom up)
  - Both approaches are now distinct from AI
  - Have this in common: All the available theories do not explain anything resembling human-level general intelligence

What Do We Know About the Brain?

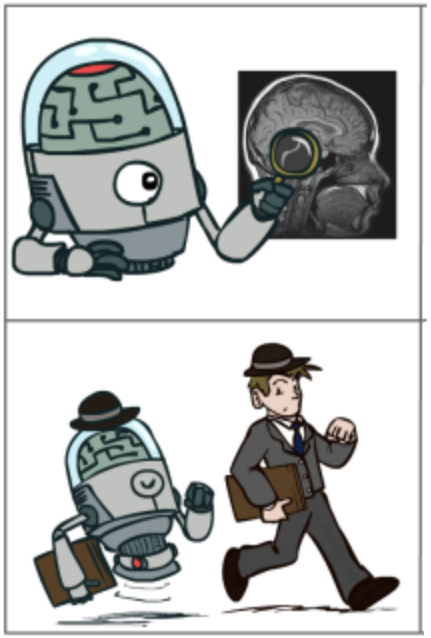
- Brains (human minds) are very good at making rational decisions, but not perfect
- Brains aren't as modular as software, so hard to reverse engineer!
- "Brains are to intelligence as wings are to flight"
- Lessons learned from the brain: memory and simulation are key to decision making

What is AI?

The science of making machines that:

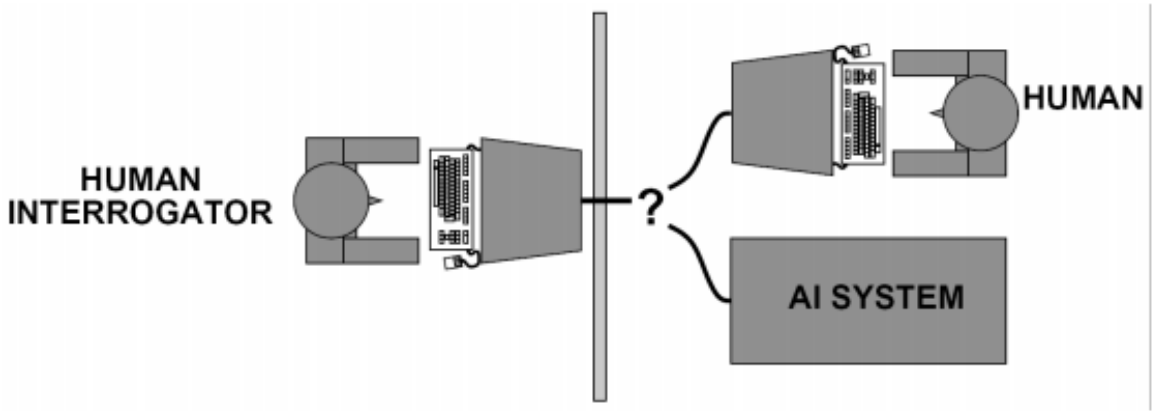
Think like people
cognitive (neuro)science

Act like people
actually very early definition, dating back to Alan Turing



Acting like humans

- Turing (1950) "Computing Machinery and Intelligence"
  - "Can machines think?" → "Can machines behave intelligently?"
  - Operational test for intelligent behavior: the Imitation Game (later dubbed "the Turing test")



  - Predicted by 2000, a 30% chance of fooling someone for 5 min
  - Anticipated major arguments against AI for the next 50 years
  - Suggested major components of AI: knowledge, reasoning, language understanding, learning
- Problem– Turing test is not reproducible or amenable to mathematical analysis

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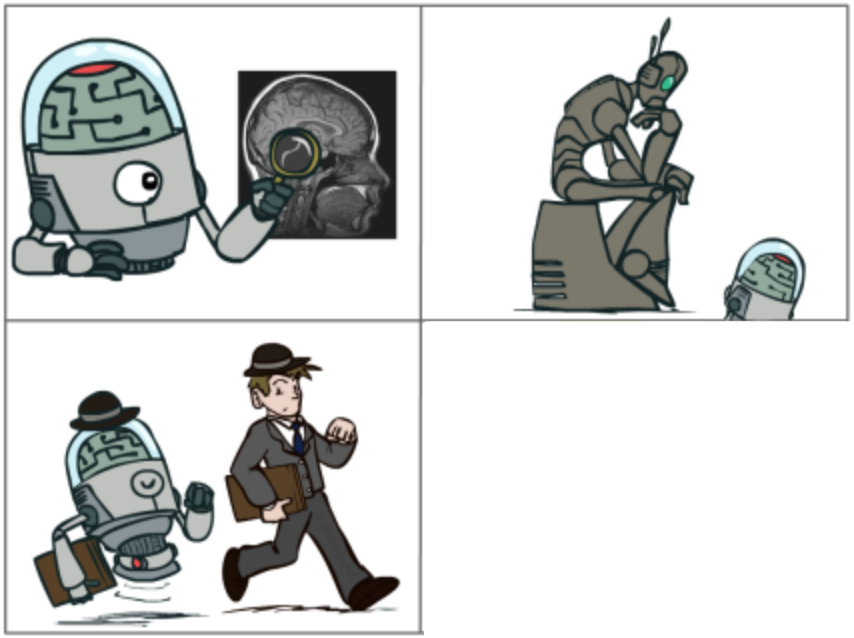

Think rationally
long tradition dating
back to Aristotle

Act like people
actually very early
definition, dating
back to Alan Turing

Thinking Rationally

- The “Laws of Thought” approach
  - What does it mean to “think rationally”?
  - Normative/prescriptive rather than descriptive
- Logicist tradition
  - Aristotle– What are the correct thought processes?
  - Logic– Notation and rules of derivation for thoughts
- Problems
  - Not all intelligent behavior mediated by logical deliberation
  - What is the purpose of thinking?
  - Logical systems tend to do the wrong thing in the presence of uncertainty

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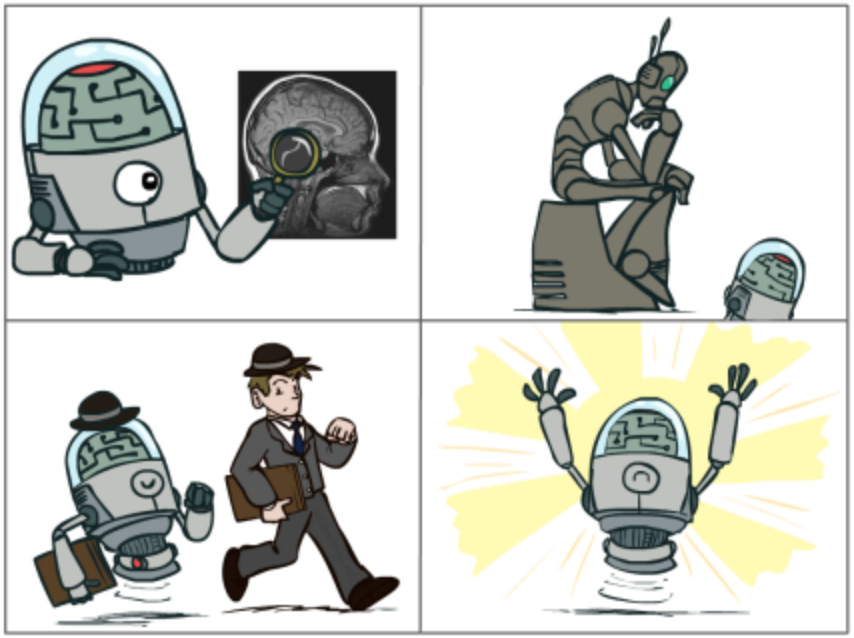


Think rationally
long tradition dating back to Aristotle

Act rationally
Our course's focus

Acting Rationally

- Rational behavior: Doing the "right thing"
  - The right thing: that which is expected to maximize goal achievement, given the available information
  - Entirely dependent on goals!
  - Irrational ≠ insane, irrationality is sub-optimal action
  - Rational ≠ successful
    - As human, we like money
    - We make it in the right way
- Our focus here: Rational agents
  - Systems which make the best possible decisions given goals, evidence, and constraints.
  - In the real world, usually lots of uncertainty and complexity
  - Usually, we are only approximating rationality

Rational Decisions

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

- Rational: maximally achieving pre-defined goals
- Goals are expressed in terms of the **utility** of outcomes
- Being rational means **maximizing your expected utility**

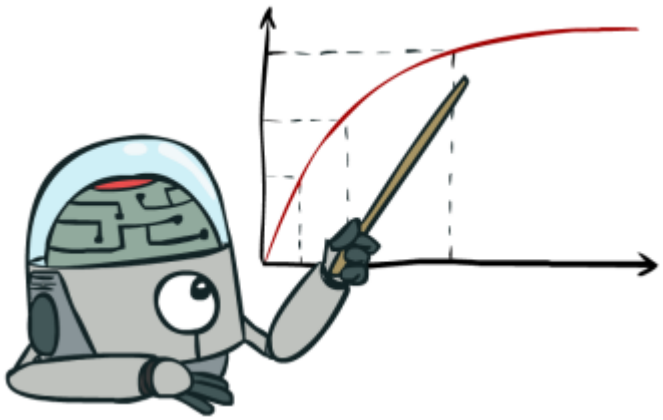
A better title for this course would be:

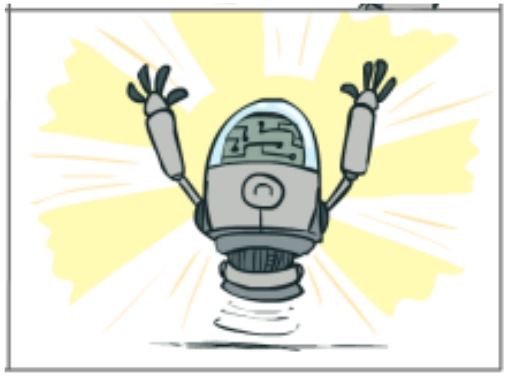
Computational Rationality

What is AI?

The science of making machines that:

Maximize Your Expected Utility



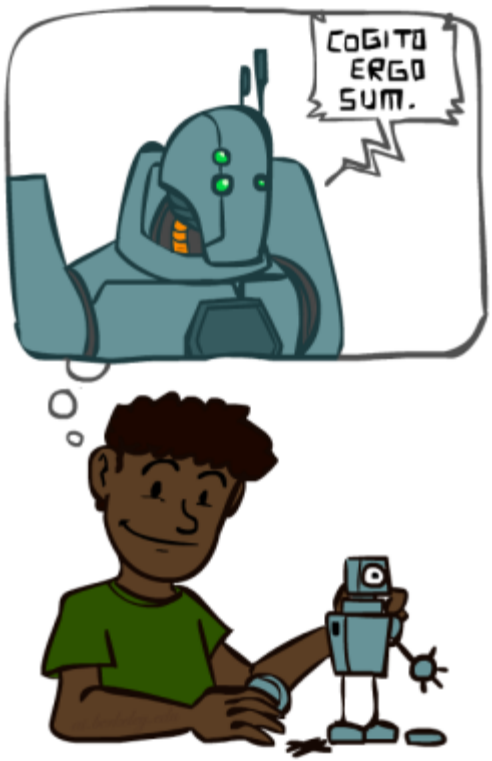


Act rationally

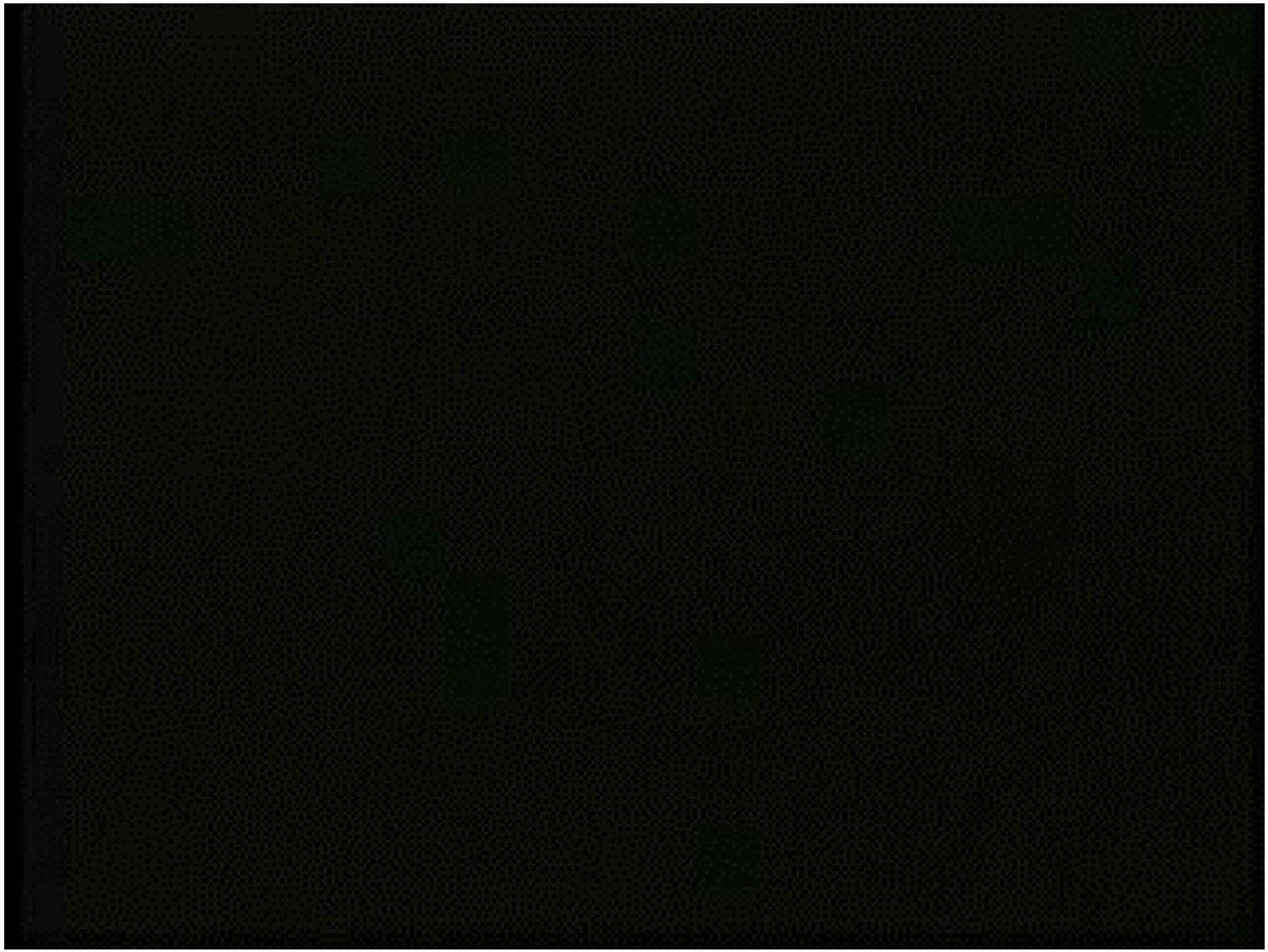
Designing Rational Agents

A (Short) History of AI

- 1940-1950: Early days
  - 1943: McCulloch & Pitts: Boolean circuit model of brain
  - 1950: Turing's "Computing Machinery and Intelligence"
- 1950-1970: Excitement: Look, Ma, no hands!
  - 1950s: Early AI programs, including Samuel's checkers progra Newell & Simon's Logic Theorist, Gelernter's Geometry Engin
  - 1956: Dartmouth meeting: "Artificial Intelligence" adopted
  - 1965: Robinson's complete algorithm for logical reasoning
- 1970-1990: 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"
- 1990-2010: Statistical approaches
  - Resurgence of probability, focus on uncertainty
  - General increase in technical depth
  - Agents and learning systems… "AI Spring"?
- 2010-: Return of neural networks
  - Deep learning
  - Big data



The Thinking Machine – MIT 1961



The AI Winter

- AI winter: 1974–80 and 1987–93
  - 1966: the failure of machine translation,
  - 1970: the abandonment of connectionism,
  - 1971–75: DARPA's frustration with the Speech Understanding Research program at Carnegie Mellon University,
  - 1973: the large decrease in AI research in the United Kingdom in response to the Lighthill report,
  - 1973–74: DARPA's cutbacks to academic AI research in general,
  - 1987: the collapse of the Lisp machine market,
  - 1988: the cancellation of new spending on AI by the Strategic Computing Initiative,
  - 1993: expert systems slowly reaching the bottom, and
  - 1990s: the quiet disappearance of the fifth-generation computer project's original goals.

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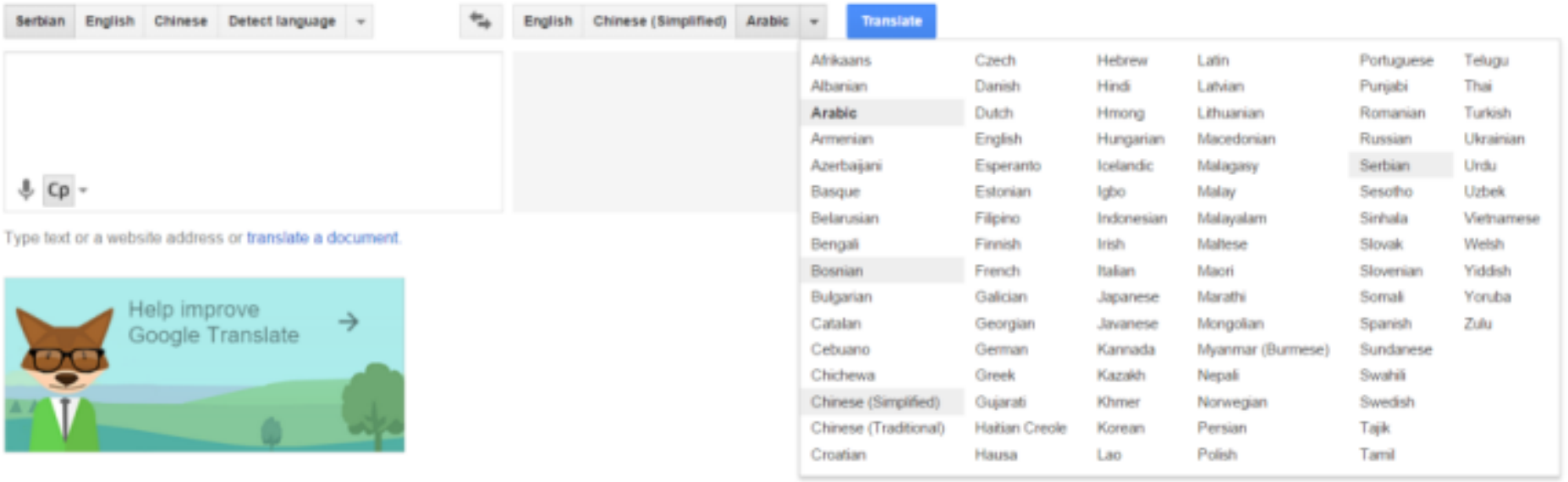
AI Enabled by Big Data

- 1966: the failure of machine translation
- Now: Google Translate
  - about 100 languages

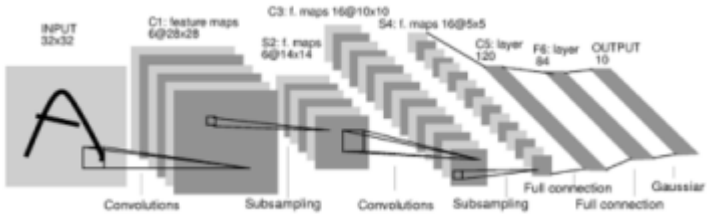


AI Enabled by Big Data

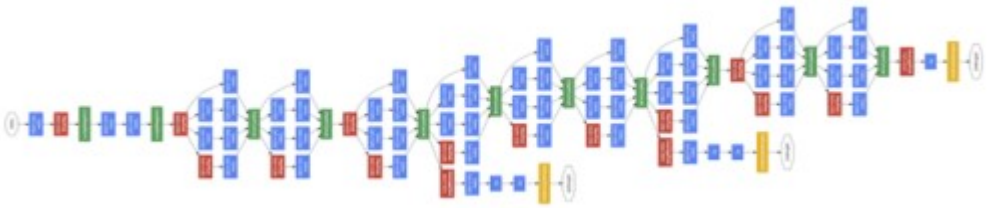
- Facebook

AI Enabled by Big Data

- 1970: the abandonment of connectionism
- Now: deep learning for image recognition
  - 1998 LeCun et al. CNN: 2 convolution layers



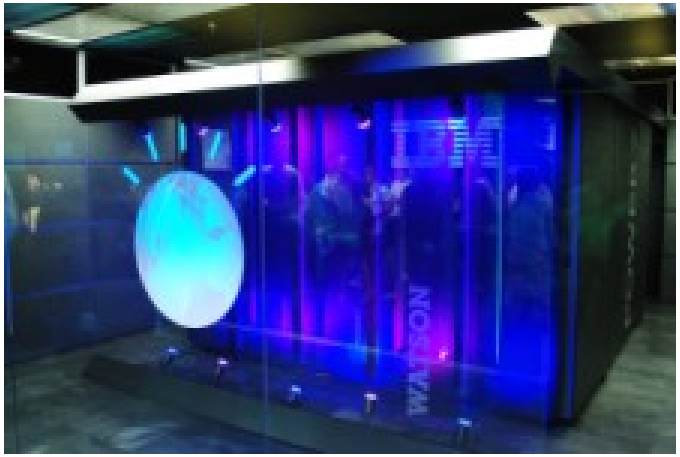
  - 2014 GoogleNet: 24 convolution layers (1,000 Objects)



  - Top 5: human error: 5.1% vs. GoogleNet error: 6.7%
  - Still improving: MSRA 150 layers; <5%
    - Could be more than 1,000 layers

AI Enabled by Big Data

- 1971–75: DARPA's frustration with the Speech Understanding
- "Watson is a question answering (QA) computing system that IBM built to apply advanced
  - natural language processing,
  - information retrieval,
  - knowledge representation,
  - automated reasoning, and
  - machine learning technologies
- to the field of open domain question answering."

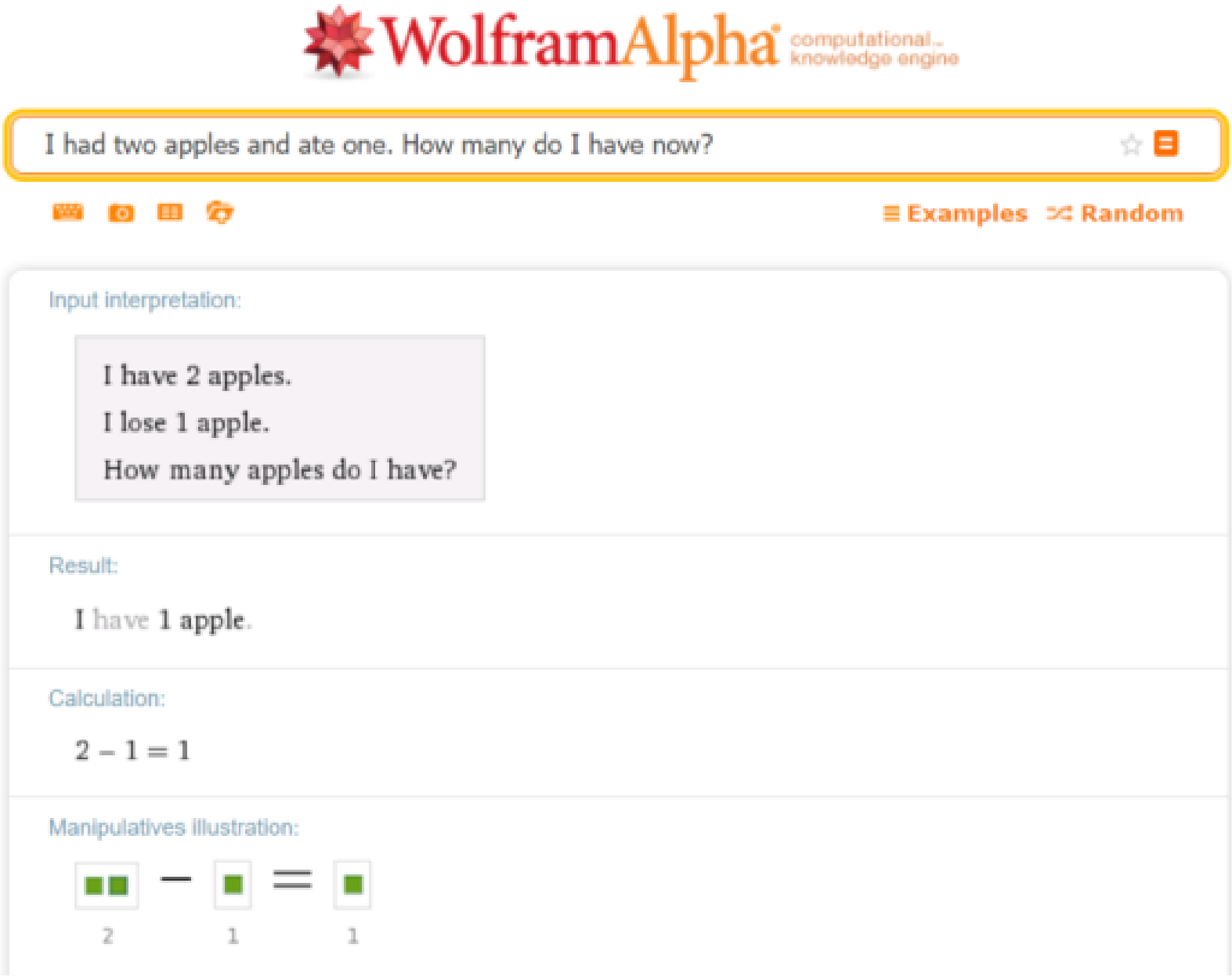


In 2011, Watson competed on Jeopardy! against former winners Brad Rutter and Ken Jennings. Watson received the first place prize of $1 million.

https://en.wikipedia.org/wiki/Watson_(computer)

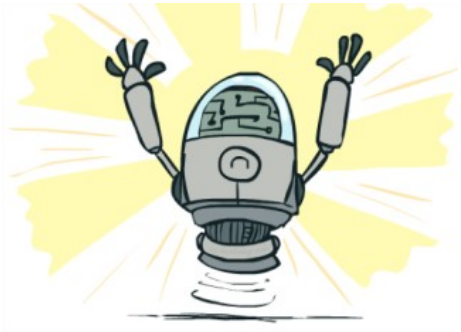
AI Enabled by Big Data

AI Enabled by Big Data



What Can AI Do? Quiz

Which of the following can be done at present?



- ✓ Play a decent game of table tennis?
- ✓ Play a decent game of Jeopardy?
- ✓ Drive safely along a curving mountain road?
- ? Drive safely along Queen's road?
- ✓ Buy a week's worth of groceries on the web?
- ✗ Buy a week's worth of groceries at ParkNShop?
- ? Discover and prove a new mathematical theorem?
- ✗ Converse successfully with another person for an hour?
- ? Perform a surgical operation?
- ✓ Put away the dishes and fold the laundry?
- ✓ Translate spoken Chinese into spoken English in real time?
- ✗ Write an intentionally funny story?

Natural Language, Vision, Robotics!

Natural Language

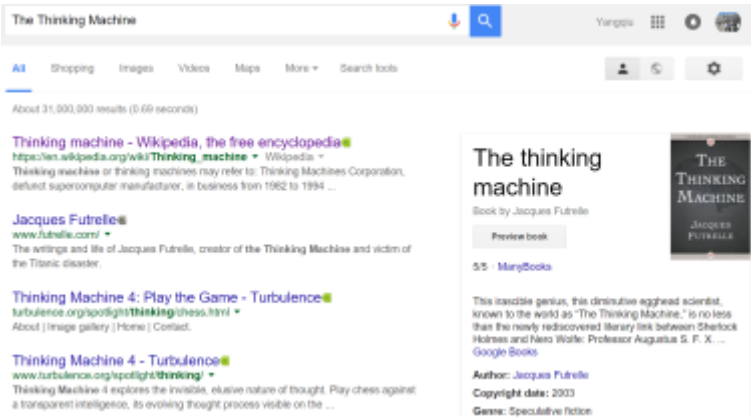
- Speech technologies (e.g. Siri)
  - Automatic speech recognition (ASR)
  - Text-to-speech synthesis (TTS)
  - +Dialog systems
  - +Translation https://www.youtube.com/watch?v=NhxCg2PA3ZI

Demo: NLP – ASR tvsample.avi

Natural Language

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

- Language processing technologies
  - Question answering
  - Machine translation
  - Web search
  - Text classification, spam filtering, etc…

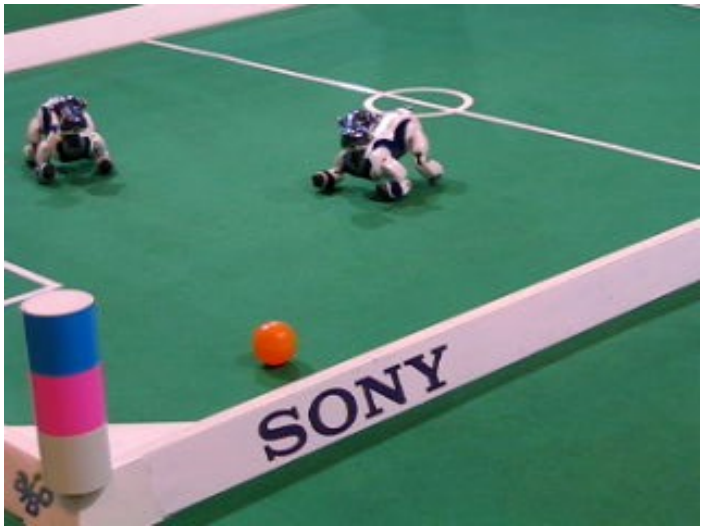


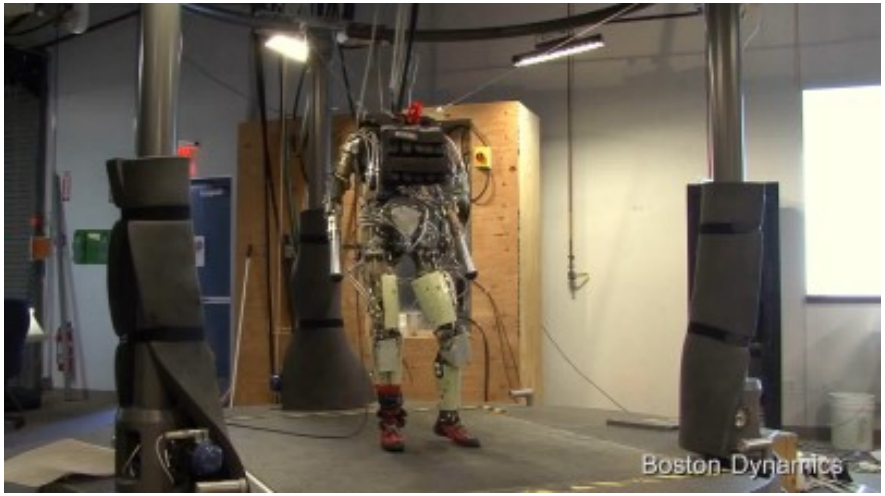
Vision (Perception)

- Object and face recognition
- Scene segmentation
- Image classification
- Tracking

https://www.youtube.com/watch?v=dAl2gimGIpU
https://www.youtube.com/watch?v=HJ58dbd5g8g (0:20)

Robotics





https://www.youtube.com/watch?v=rVlhMGQgDkY

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

Logic

- Logical systems
  - Theorem provers
  - Question answering
- Methods:
  - Deduction systems
  - Constraint satisfaction
  - Satisfiability solvers (huge advances!)

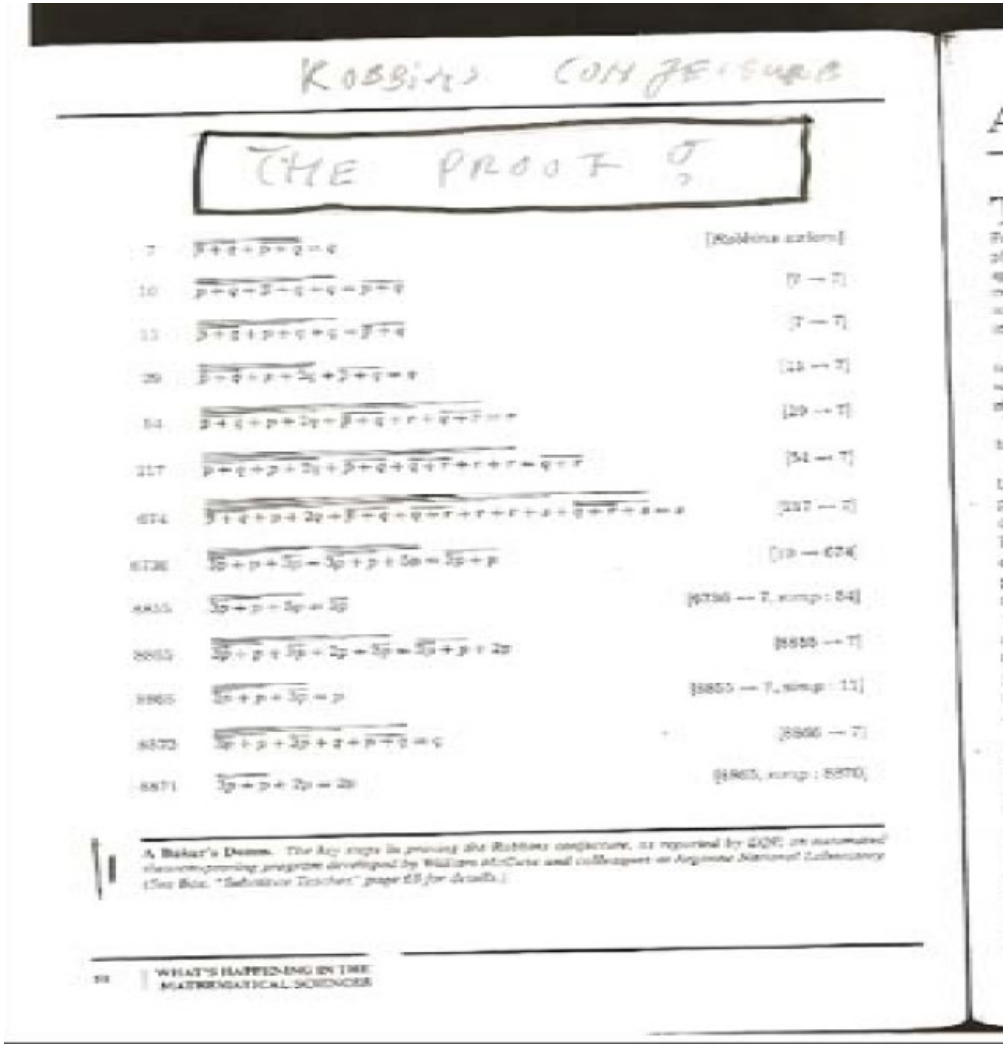


Image from Bart Selman

Game Playing

- 1996: Kasparov Beats Deep Blue

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

- 1997: Deep Blue Beats Kasparov

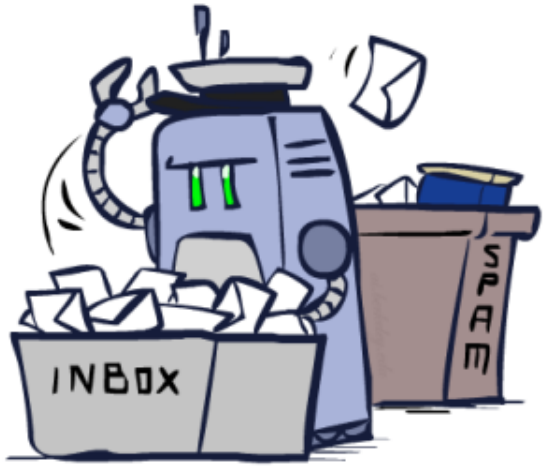
  “Deep Blue hasn't proven anything.”

- 2016：Huge game-playing advances recently, e.g. in Go!

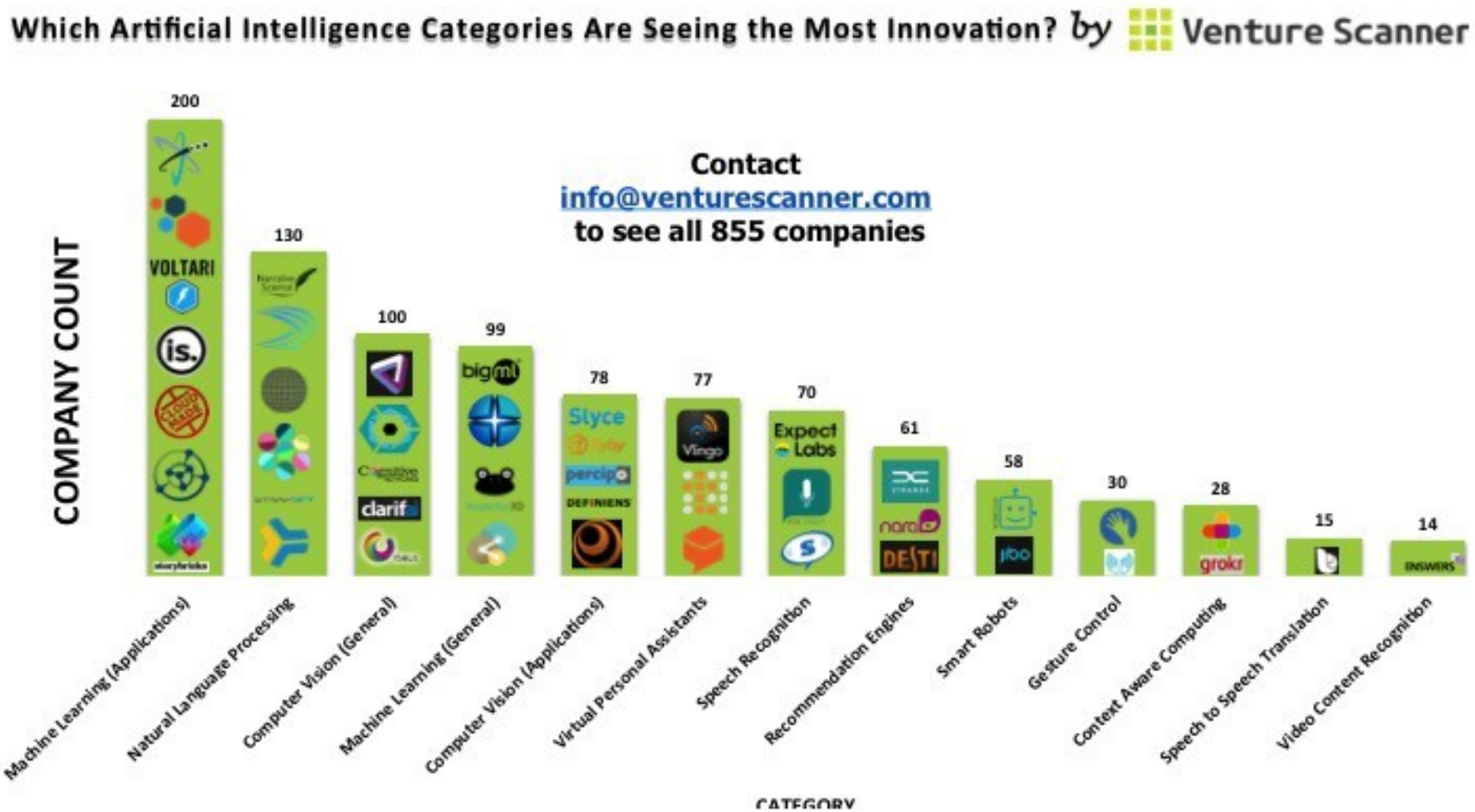
Text from Bart Selman, image from Wiki Deep Blue pages

Decision Making

- Applied AI involves many kinds of automation
  - Scheduling, e.g. airline routing, military
  - Route planning, e.g. Google maps
  - Medical diagnosis
  - Web search engines
  - Spam classifiers
  - Automated help desks
  - Fraud detection
  - Product recommendations
  - … Lots more!



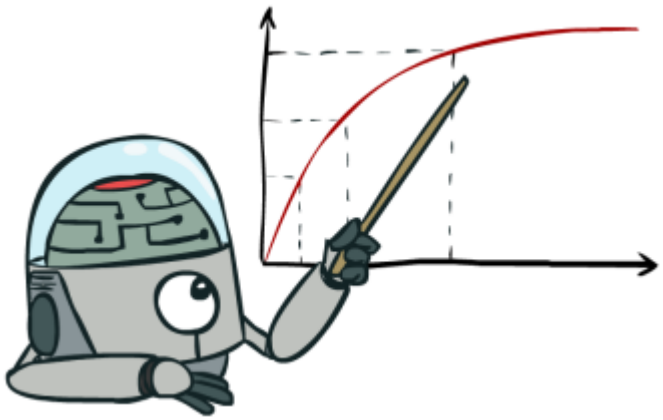
Startup Companies

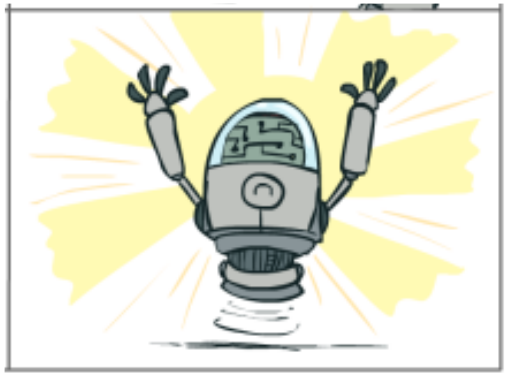


What is AI?

The science of making machines that:

Maximize Your Expected Utility



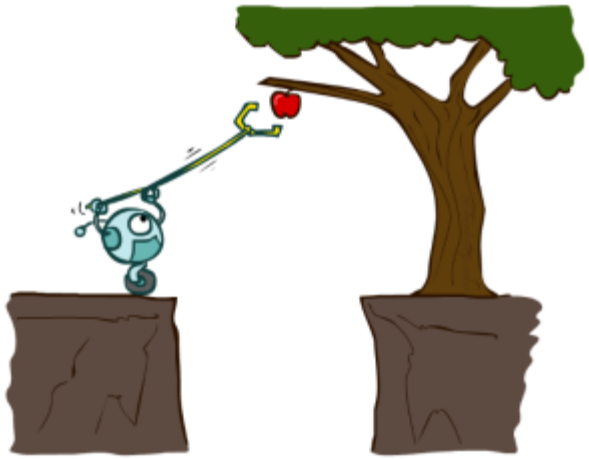


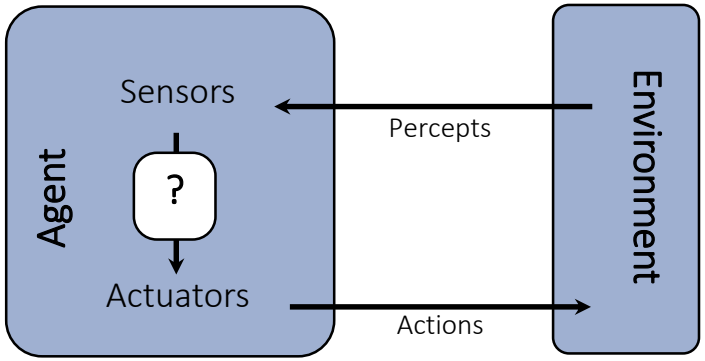
Act rationally

Designing Rational Agents

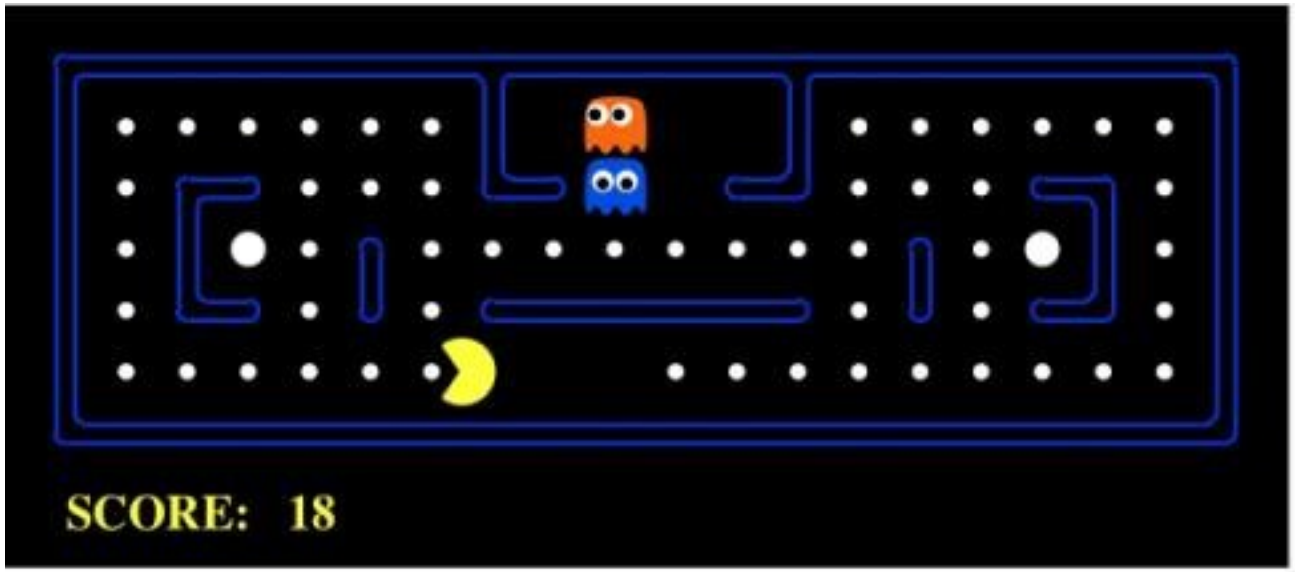
Designing Rational Agents

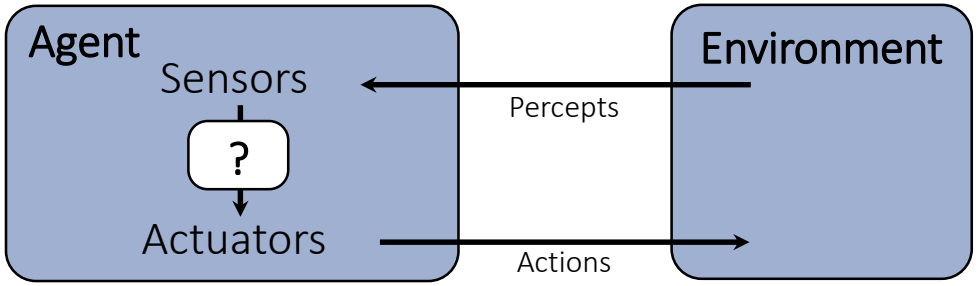
- An agent is an entity that *perceives* and *acts*.
- Characteristics of the percepts, environment, and action space dictate techniques for selecting rational actions
- A rational agent selects actions that maximize its (expected) utility.
- This course is about:
  - General AI techniques for a variety 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 or L1D2


CS188 Pacman
SCORE: 0
pacman.bat
Windows Batch File
Date modified: 8/23/2012 2:04 AM
Date created: 8/23/2012 9:42 AM
Size: 91 bytes
12:28 PM
8/23/2012

Course Topics

- Making Decisions
  - Search
  - Constraint satisfaction
  - Logic
- Reasoning under Uncertainty
  - Markov decision processes
  - Bayes' nets
  - Markov logics
- Throughout: Applications
  - Natural language , knowledge graph, vision, robotics, …

Search problems

Markov decision processes

Adversarial games

Constraint satisfaction problems

Bayesian networks

Reflex **States** **Variables** **Logic**

"Low-level intelligence" "High-level intelligence"

Machine learning