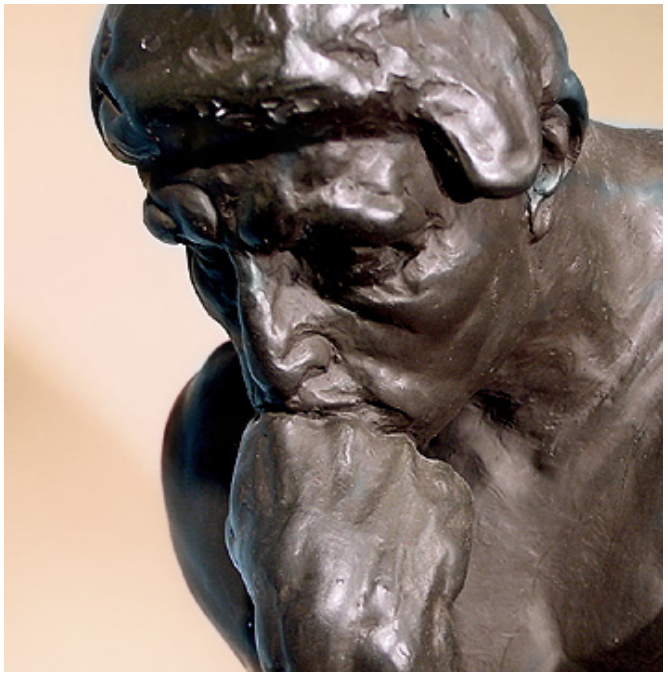
15-381
Artificial Intelligence

Drew Bagnell and Emma Brunskill

Fall 2013

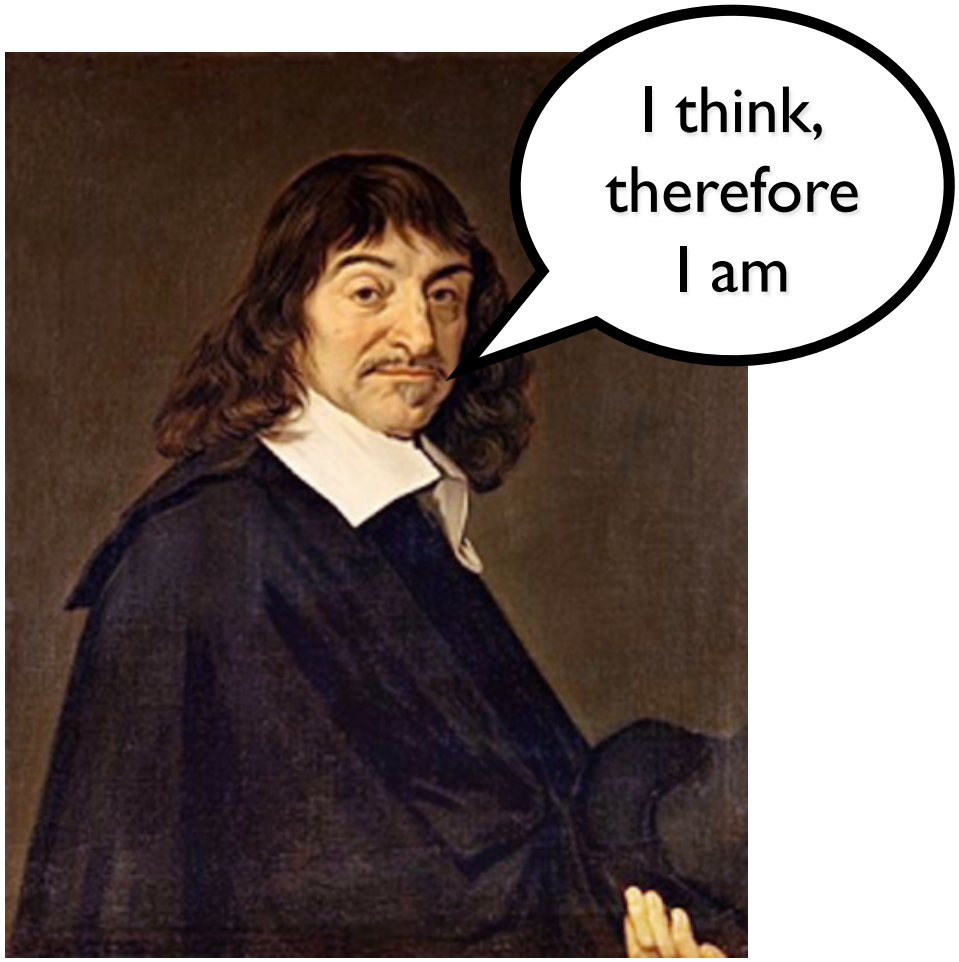
Multiple slides over course taken or adapted from Dan Klein, and past CMU 15-381 Instructors



Can Machines Think?

Alan Turing, “Computing Machinery and Intelligence,” *Mind*, 1950.

Mind-Body Dualism



The Astonishing Hypothesis

"You, your joys and your sorrows, your memories and your ambitions, your sense of personal identity and free will, are in fact no more than the behaviour of a vast assembly of nerve cells and their associated molecules"

--- Francis Crick, 1994

“You insist that there is something a machine cannot do. If you will tell me precisely what it is that a machine cannot do, then I can always make a machine which will do just that.”

--- John von Neumann, 1948

What is **intelligence**?

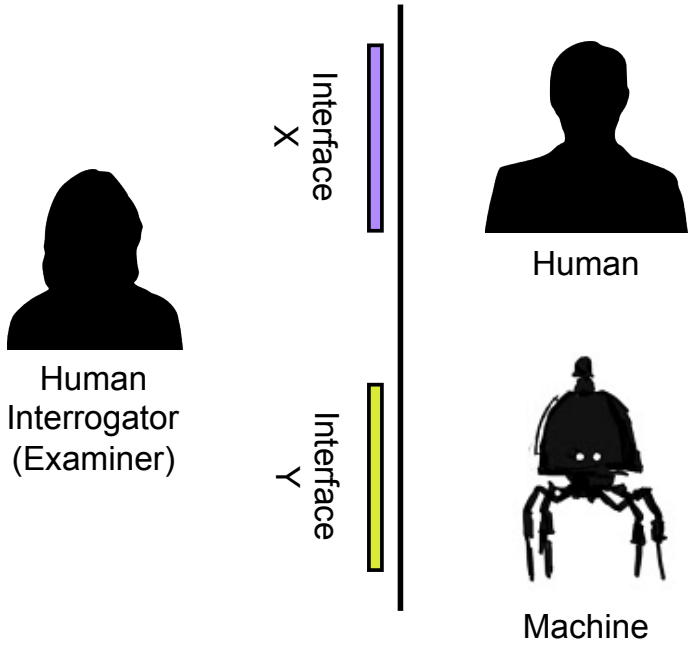
“...making a machine behave in ways that would be called intelligent if a human were so behaving.”

--- John McCarthy, 1955

“One might ... define thinking as consisting of those mental processes that we don't understand.”

--- Alan Turing

Imitation Game: Turing Test



Answer: X is a human and Y is a machine

Chinese Room

- Thought experiment proposed by Searle
- Suppose AI has produced a program that can pass the Turing Test in Chinese
- You have a handbook with its pseudocode
- You're in a closed room and receive Chinese characters through a slot
- You run the program's code manually and return the output
- Does this mean you *understand* Chinese?

Counterarguments

- Finding the mind: the whole system understands Chinese, the person is just a part of the system
- Redesigning the experiment: suppose the program simulates the actions of every neuron in the brain of a Chinese speaker

Counterarguments

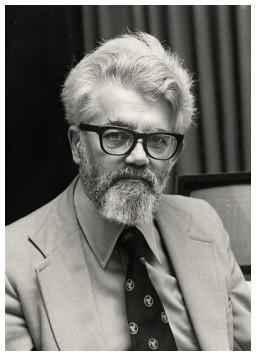
- Doubts about the intuition
  - Brain performs 100 billion operations per second, so it would take the person millions of years to simulate a simple answer
  - Churchland's Luminous Room: suppose you are standing in a dark room and quickly moving a magnet up and down, then by Maxwell's theory of artificial luminance it will be luminous. However, this requires 450 trillion movements per second

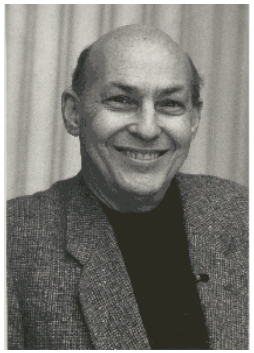
DARTMOUTH CONFERENCE (1956)
Founding of AI

"The study is to proceed on the basis of the conjecture that 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."

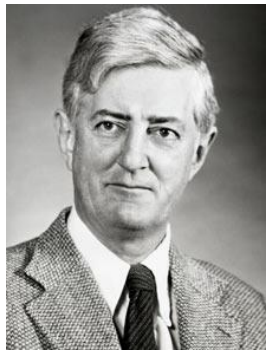
--- John McCarthy

DARTMOUTH CONFERENCE (1956)
Founding of AI


John McCarthy


Marvin Minsky

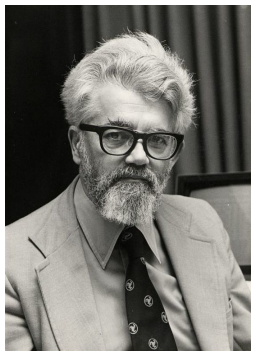

Claude Shannon


Oliver Selfridge

and “two vaguely known persons from RAND and Carnegie Tech... a significant afterthought.”
--- Pamela McCorduck, “Machines Who Think”

DARTMOUTH CONFERENCE (1956)

Founding of AI



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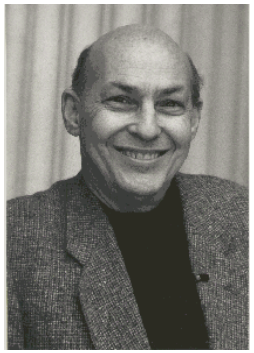

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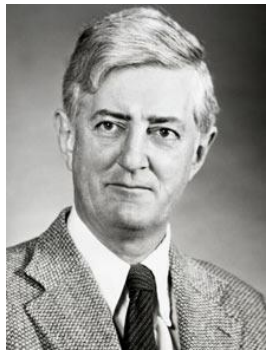
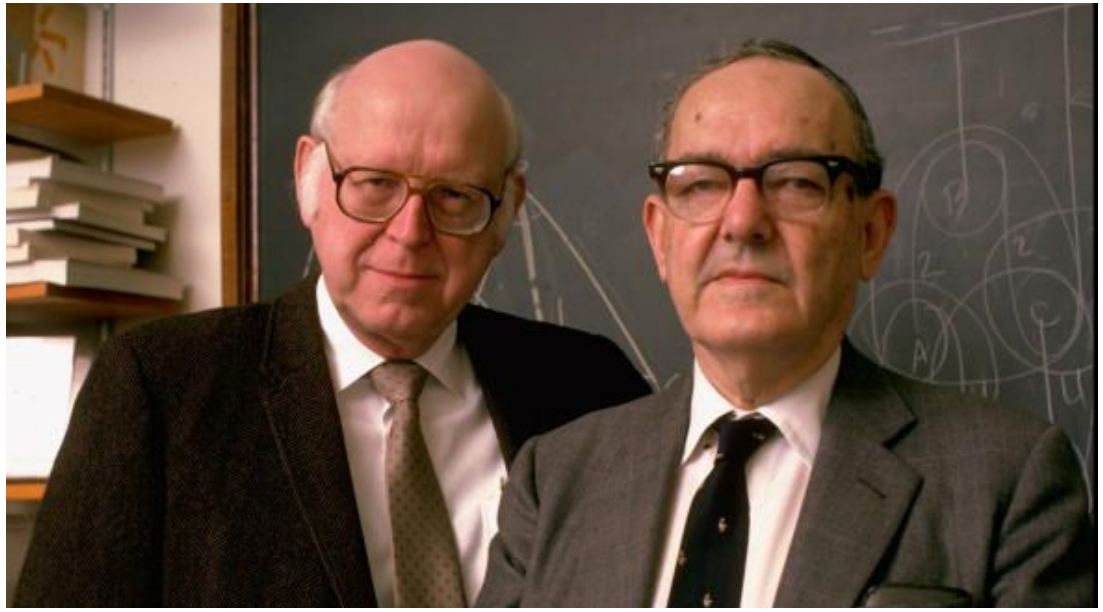


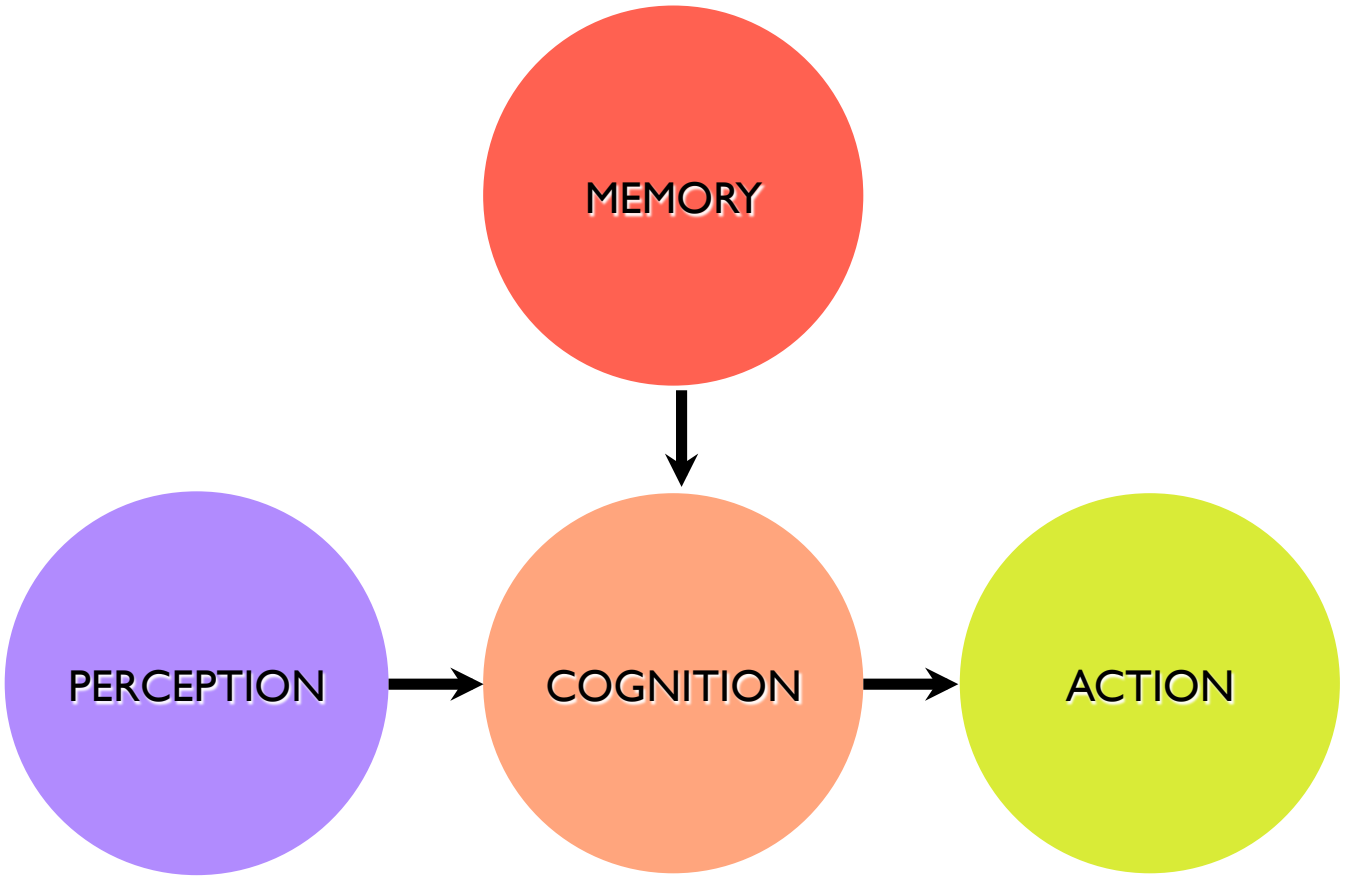
Oliver Selfridge



Alan Newell Herbert Simon

Act like a Human	Act Rationality

- **Rational**: Optimal decision making, given current information, towards achieving a goal.


MEMORY
PERCEPTION
COGNITION
ACTION

WHAT CAN AI DO NOW?

Play a decent game of table tennis?

WHAT CAN AI DO NOW?

- ✓ Play a decent game of table tennis?
- Drive safely along a curving mountain road?
- Drive safely along Forbes?
- Buy a week's worth of groceries on the web?
- Buy a week's worth of groceries at Giant Eagle?
- Discover and prove a new mathematical theorem?
- Converse successfully with another person for an hour?
- Fold laundry?
- Perform a complex surgical operation?
- Unload a dishwasher and put everything away?
- Translate spoken Chinese into spoken English in real time?
- Write an intentionally funny story?

WHAT CAN AI DO NOW?

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DARPA Urban Challenge

- 96 km urban area course, to be completed < 6 hours, took place in 2007
- Tartan Racing (CMU+GM) claimed the $2 million prize
- Challenge involves mission planning, motion planning, behavior generation, perception, world modeling
- http://www.youtube.com/watch?v=lULI63ERek0

Watson

- Watson defeated the two greatest-ever Jeopardy! champions
- Involves natural language processing, information retrieval, knowledge representation and reasoning, and machine learning
- http://www.youtube.com/watch?v=oUj9AzSE_9c

MORAVEC'S PARADOX

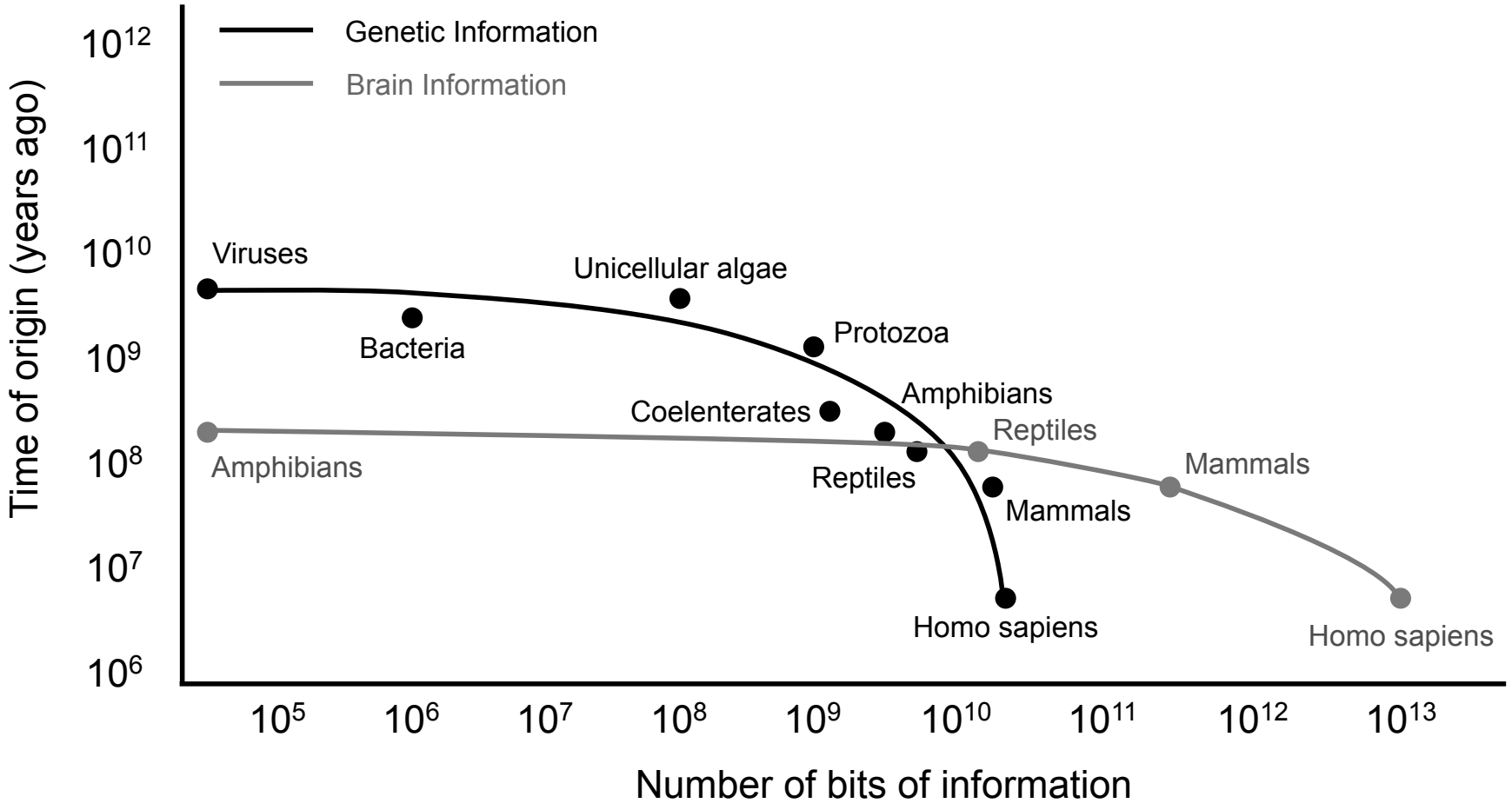
The main lesson of thirty-five
years of AI research is that
the hard problems are easy and
the easy problems are hard.

--- Steven Pinker

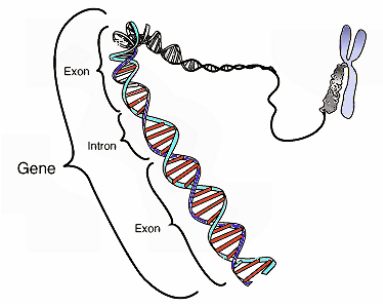
Evolution of Intelligence

- Human genes: 30 billion base pairs x 2 bits = 750 megabytes
- Human brain: 100 billion neurons x 1 bit = 12.5 gigabytes (a certain underestimate)
  - Better (but still under-) estimate
    - 10^14 synapses → 12,500 gigabytes (**G. Orr)**
- Internet? ~500 exabytes (IDC, 2009)

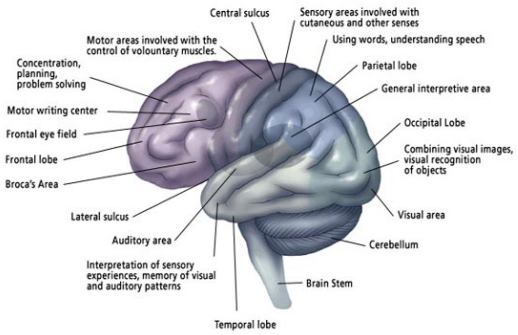
Biological Information Storage



Credit: Carl Sagan, *The Dragons of Eden,* 1977



Gene



Brain

Extrasomatic Knowledge

RAM

Hard drive

External Storage

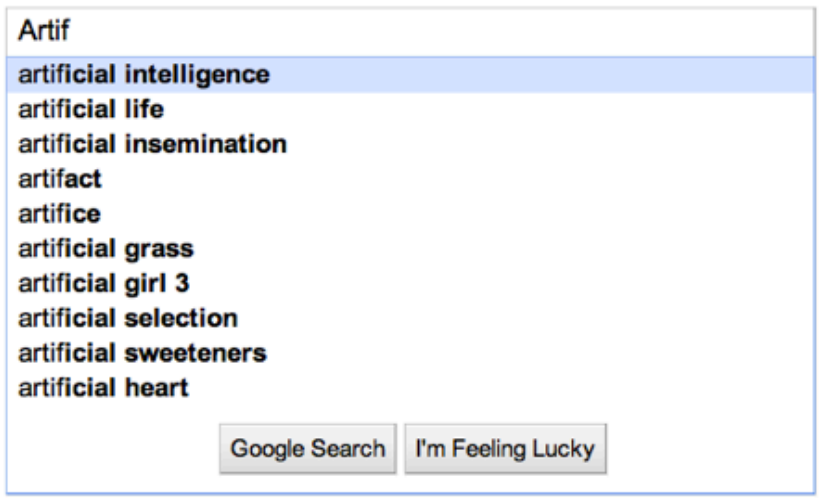
princetonbrainandspine.com

Biology vs Engineering

“AI in the **Postmodern** Age”

--- Alexei Efros

- All interesting questions have been asked
- **Intelligence**:
  1. Remember all questions, the best answers
  2. Match current question
  3. Look up the best answer



WolframAlpha computational knowledge engine

Enter what you want to calculate or know about:

What is the meaning of life

Examples Random

Assuming "What is the meaning of life" is a quantity | Use as referring to English words instead

Input interpretation:

Answer to the Ultimate Question of Life, the Universe, and Everything

Result:

42

(according to Douglas Adams' humorous science-fiction novel *The Hitchhiker's Guide to the Galaxy*)

Computed by Wolfram *Mathematica*

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Give us your feedback: send

WolframAlpha computational knowledge engine

log16(round((mass of the universe)/(protein of a large egg))) - 3

Examples Random

Assuming egg | Use raw egg instead

Assuming any type of egg | Use egg, fried or more instead

Input interpretation:

$$\log_{16}\left(\text{Round}\left[\frac{\text{mass of the observable universe}}{\text{egg} \mid \text{amount} \mid \text{1 large egg} \mid \text{protein}}\right]\right) - 3$$

$\log_b(x)$ is the base b logarithm »

Result:

Show details

42

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Artificial Artificial Intelligence

- Amazon mechanical turk
- Crowdsourcing
- But there also exists AI to improve artificial AI…

Representation

- All knowledge needs representation
  - Genetic Information
  - Behavioral Information
  - Audio Information
  - Visual Information
  - Textual Information

A major part AI is representing the problem space to allow efficient optimization for the best solution

Technological Singularity

- Emergence of superhuman intelligence
- Key idea: self-improvement
- Source of name: analogy between inability to predict events after the development of a superintelligence, and the space-time singularity beyond the event horizon of a black hole
- Some predict: this century
- Others argue: never

Understanding & creating intelligence
is the grand intellectual challenge of the century

Rene Descartes
Philosopher...

Aristotle
Philosopher...

Claude Shannon
Information Theorist

Warren McCulloch
Neurophysician

John
von Neumann
Mathematician...

Thomas Bayes
Reverend

Alan Turing
Computer Scientist

Francis Crick
Molecular Biologist

Herbert Simon
Economist...

Walter Pitts
Logician

Marvin Minsky
Cognitive Scientist

Alan Newell
Cognitive Psychologist

“AI still has openings
for a full-time Einstein”
--- Russell and Norvig

“If you invent a breakthrough in AI,
so machines can learn,
that is worth 10 Microsofts.”
--- Bill Gates

Our Expectations From You

AI COURSE TOPICS

- Making good decisions in deterministic worlds
  - Search
  - Constraint satisfaction
  - Optimization
- Handling Uncertainty
  - Bayes' nets
  - Machine learning
  - Decision making under uncertainty
- Beyond 1 mind: multi-agent AI
- Applications (robotics, vision…)

ARTIFICIAL INTELLIGENCE
Administration

- **Instructors**: Drew Bagnell and Emma Brunskill
- **Tas: Jesse Dunietz, Subhodeep Moitra, Danny Zhu**
- **Course Website**: : https://www.cs.cmu.edu/~15381/
- **Class Timing**: Tuesday and Thursday, noon-1:20pm
- **(Strongly) Recommended Book**: Artificial Intelligence: A Modern Approach (Russell and Norvig)
  - Will try to make copies available at library as well

ARTIFICIAL INTELLIGENCE

Administration

- **Reading: Expected to read in advance of lecture**
- **Question answering through Piazza**
- **Homework**: Can use 8 late days, at most 2 per homework
- **First homework will be due 9/10**
- **No laptops or cell phones**
  - **We expect total participation in class**
- **Extra credit:** Participation through
  - Clickers/question response
  - in-class question/answer

Background Calibration

- Rest of today: getting a sense of background
- We don't expect you to know all (or perhaps any) of these things
  - Very diverse background in class
- **Only graded on participation**
- Just gives us a better sense of everyone's background knowledge so we can consider recitations