Artificial Intelligence:
An Introduction

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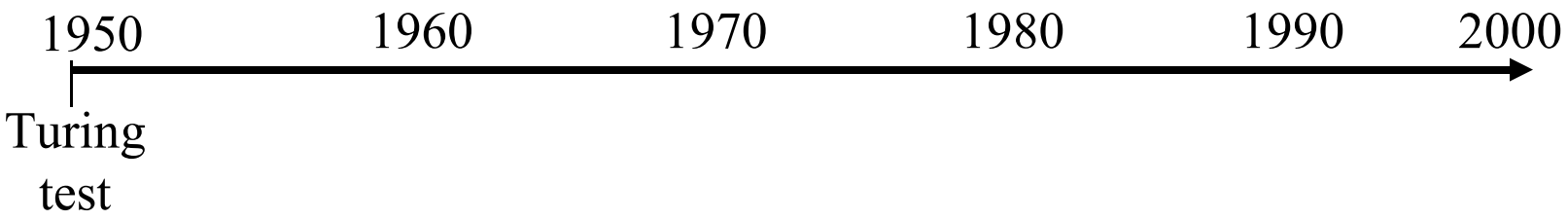
Strong AI

- **An autonomous self-moving machine that acts and reasons like a human**

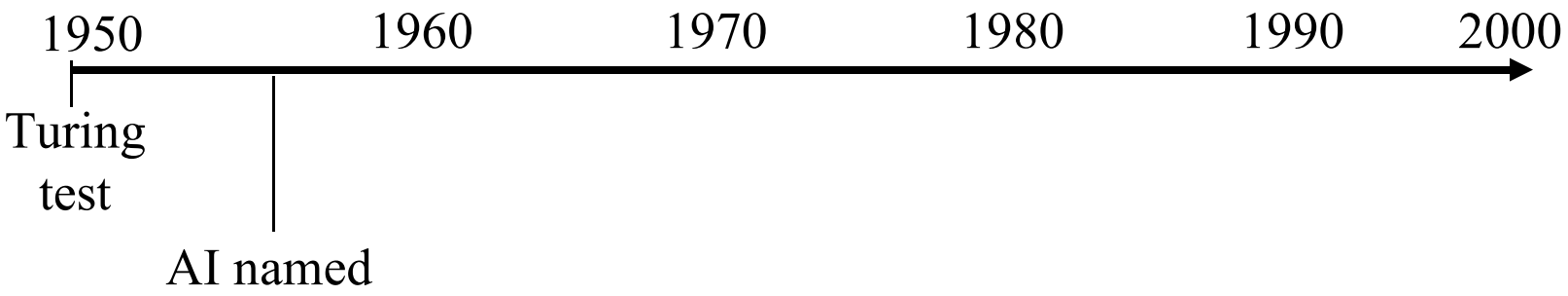
AI: a brief history

- 1950: Alan Turing. The Turing test.
  - Can machines think? → Can we tell it's a machine from conversation?
  - text in / text out
  - demo: A.L.I.C.E. (http://www.alicebot.org/)
  - Turing, A.M. (1950). Computing machinery and intelligence. Mind, 59, 433-460
  - it also contains things like genetic algorithm, human cloning …



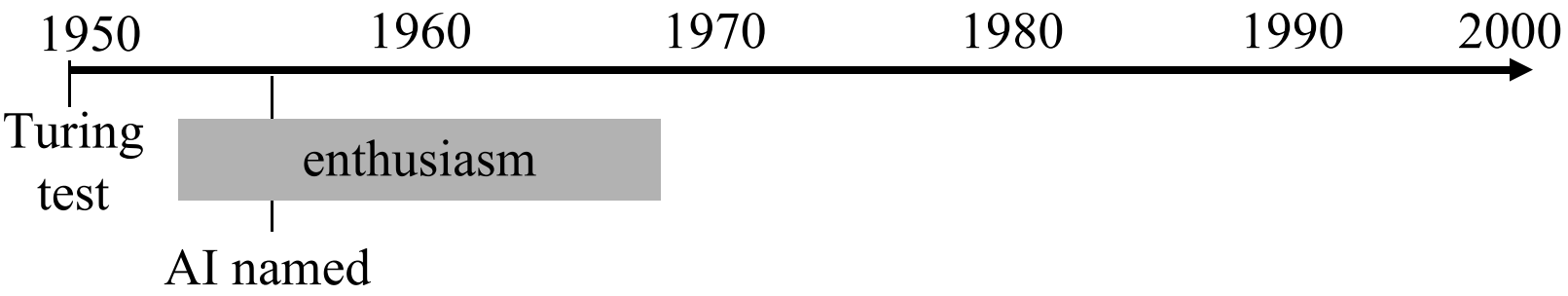
AI: a brief history

- 1956: Dartmouth summer workshop
  - AI named
  - big players introduced
    - John McCarthy, Marvin Minsky, Claude Shannon, Nathaniel Rochester, Trenchard More, Arthur Samuel, Ray Solomonoff, Oliver Selfridge, Allen Newell, Herbert Simon
  - no consensus



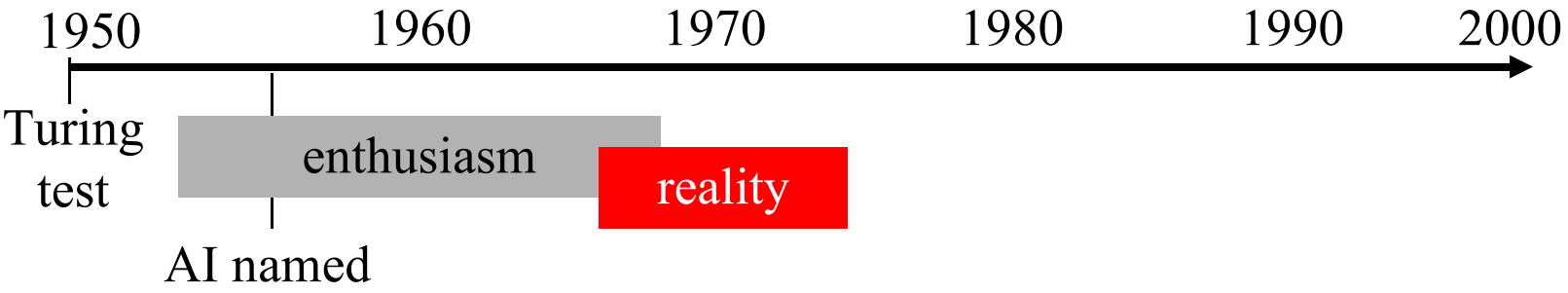
AI: a brief history

- 1952—1969: early enthusiasm: Computers can do X
  - X = solve puzzles, prove geometry theorems, play checker, Lisp, block world, ELIZA, perceptron…
  - but many are toy problems



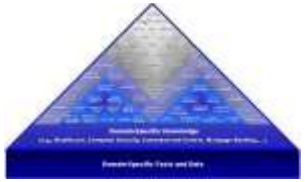
AI: a brief history

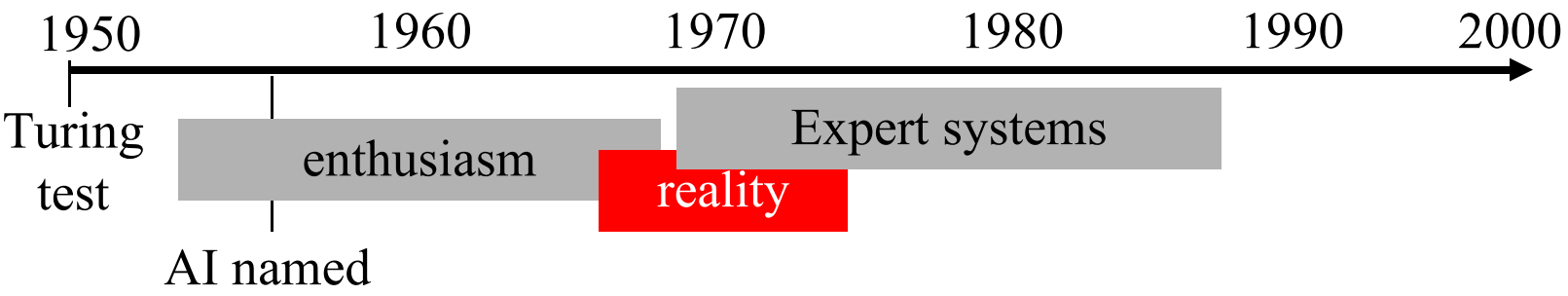
- 1966-1973: a dose of reality
  - syntactic without domain knowledge doesn't work
    - The spirit is willing but the flesh is weak
    - The vodka is good but the meat is rotten (US→RU→US)
    - US gov canceled funding for machine translation
  - intractability: exponential complexity
    - British gov ended AI support based on the Lighthill report
  - theoretic limit: perceptron can't do XOR
    - Neural network research halted



AI: a brief history

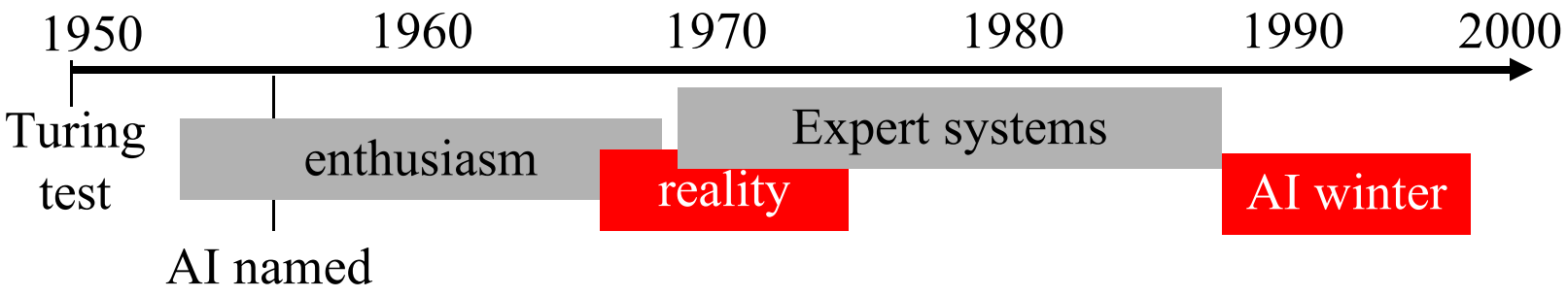
- 1969-1988: Knowledge-based systems
  - Add domain-specific knowledge to guide search
  - CYC: world = millions of rules. (cyc.com)
  - Expert systems commercialized in the 80's
    - One AI group in every major US company
    - Billions of $$$ industry





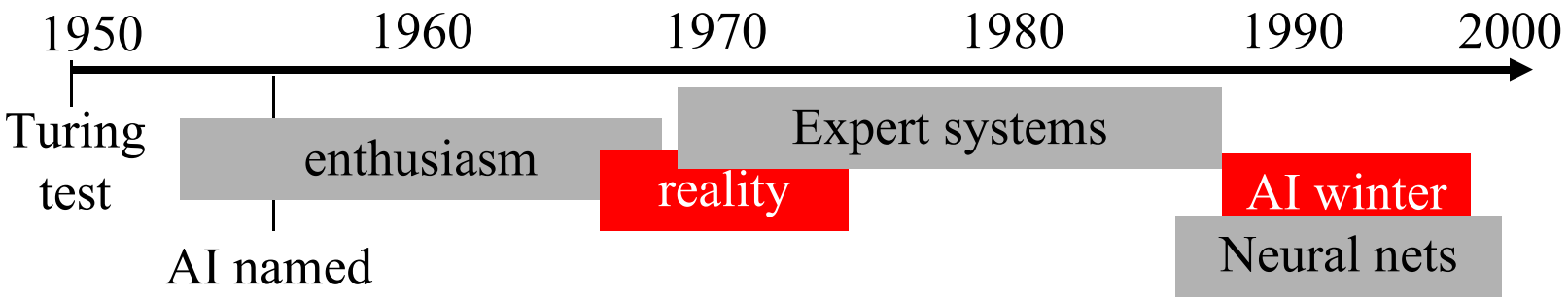
AI: a brief history

- 1988 – not long ago: AI winter
  - Expert systems
    - Massive investment from venture capitalists
    - Extravagant promises
  - Bubble burst
    - AI funding dried up
    - AI companies down



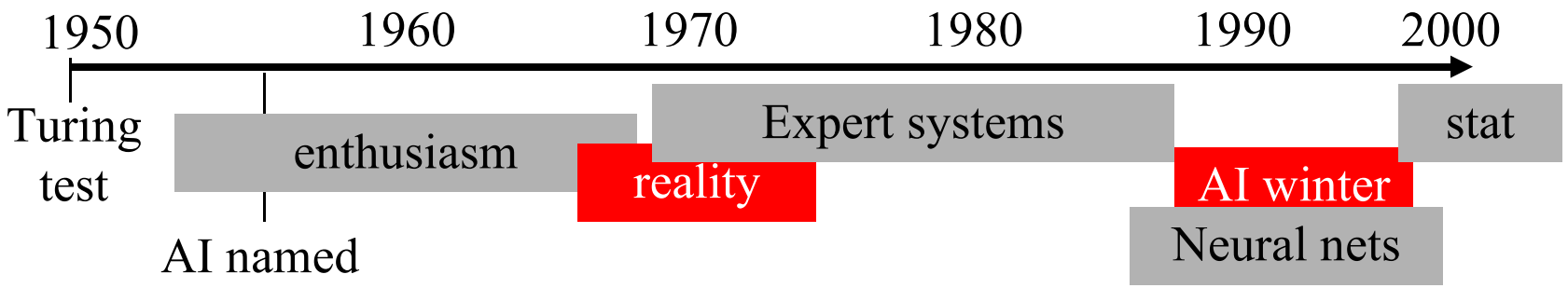
AI: a brief history

- 1986 – not long ago: neural networks
  - Multi-layer perceptron
  - Back propagation training algorithm rediscovered
  - Connectionists vs.
    - Symbolic models (Newell, Simon)
    - Logicist (McCarthy)
  - What it really is: statistical machine learning



AI: a brief history

- present: statistics
  - machine learning
    - Hidden Markov models (HMM), support vector machines (SVM), Gaussian processes, graphical models (Bayes networks, conditional random fields)
  - data mining



The Reality

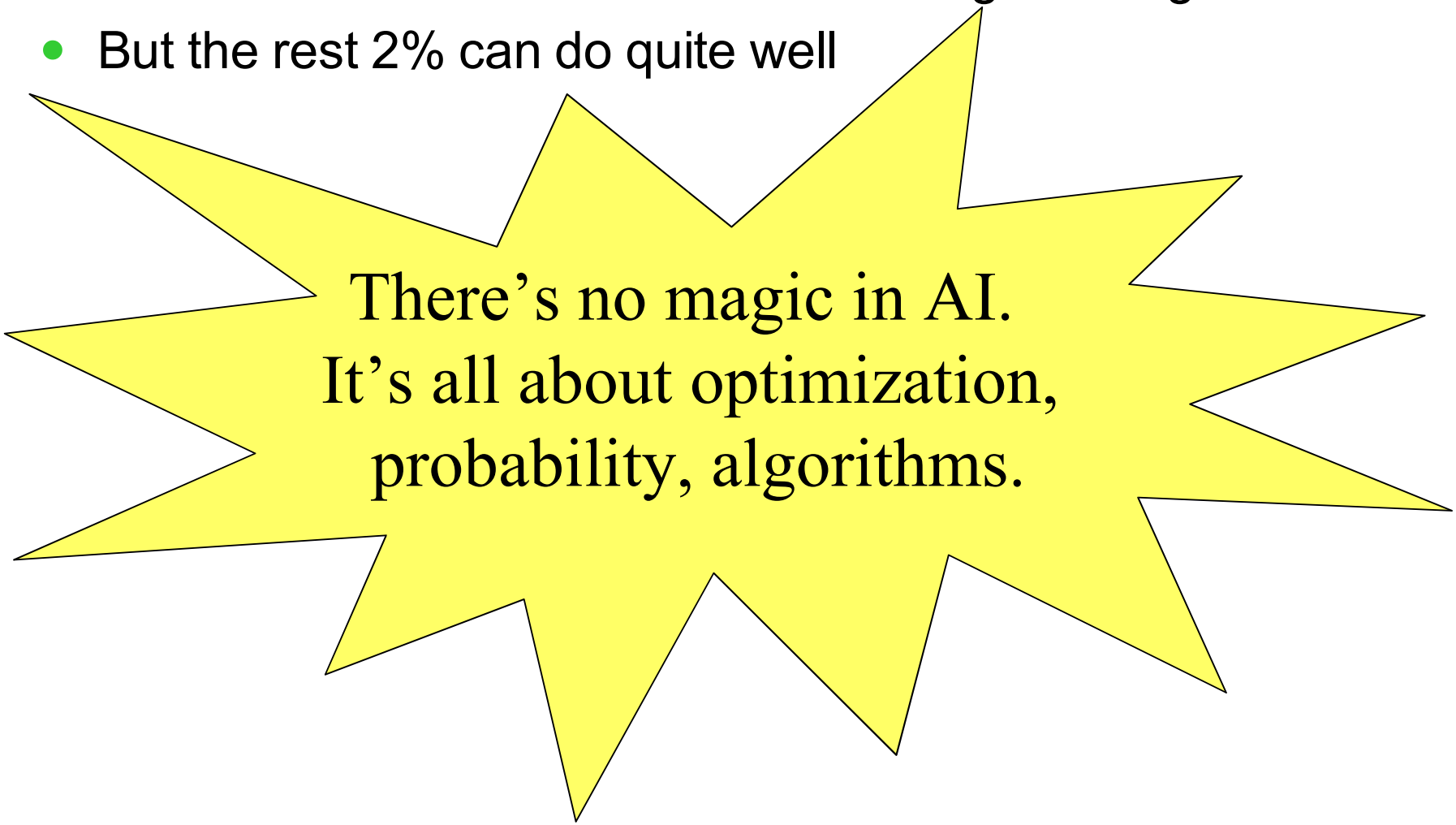
- In the early period of AI it seemed plausible that new forms of symbolic computation, e.g., frames and semantic networks, made much of classical theory obsolete. This led to a form of isolationism in which AI became largely separated from the rest of computer science. This isolationism is currently being abandoned. There is a recognition that machine learning should not be isolated from information theory, that uncertain reasoning should not be isolated from stochastic modeling, that search should not be isolated from classical optimization and control, and that automated reasoning should not be isolated from formal methods. **David McAllester 1998**

Weak AI

- **Machines *can* demonstrate intelligence, but do not necessarily have a mind, mental states or consciousness**
- **weak AI refers to the use of software to study or accomplish specific problem solving or reasoning tasks that do not encompass the full range of human cognitive abilities.**

AI today

- Don't know how to do 98% of the intelligent things
- But the rest 2% can do quite well

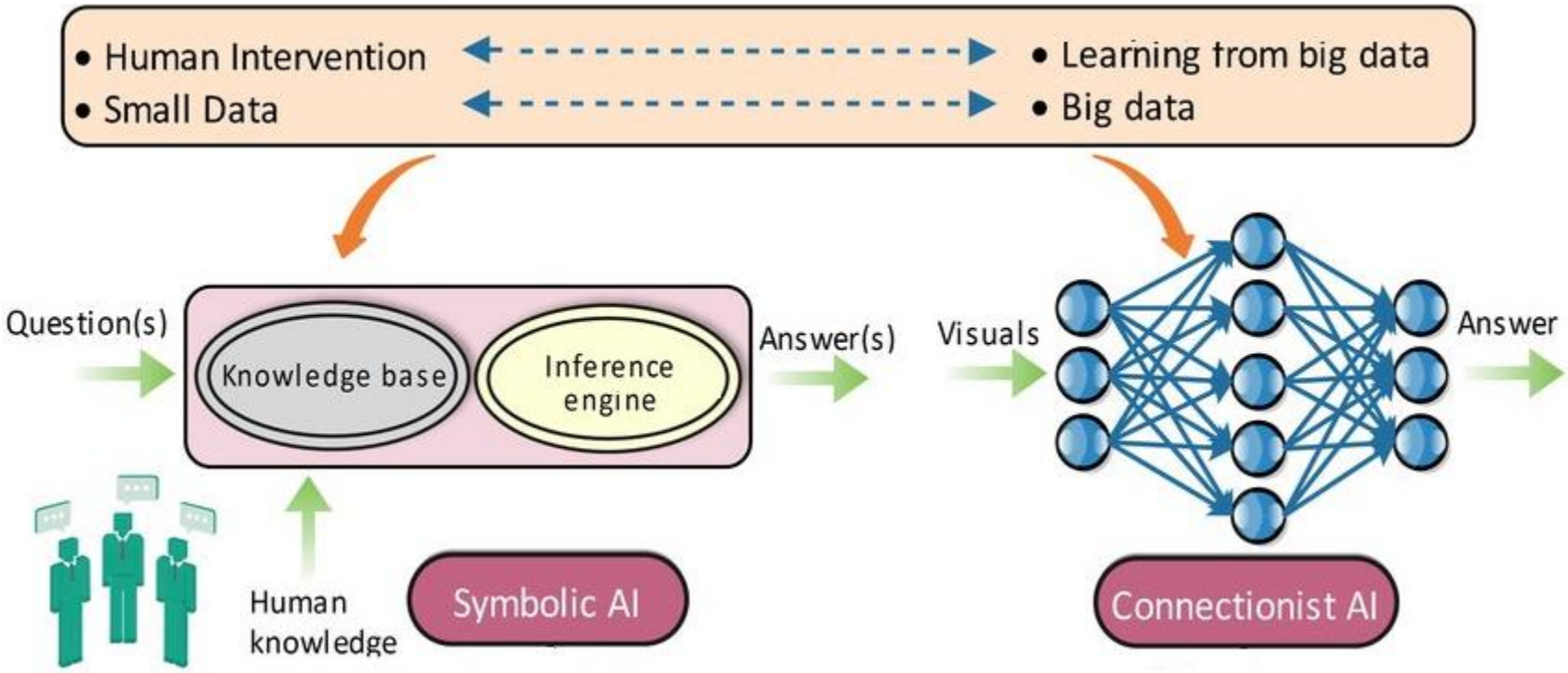


School of Thoughts

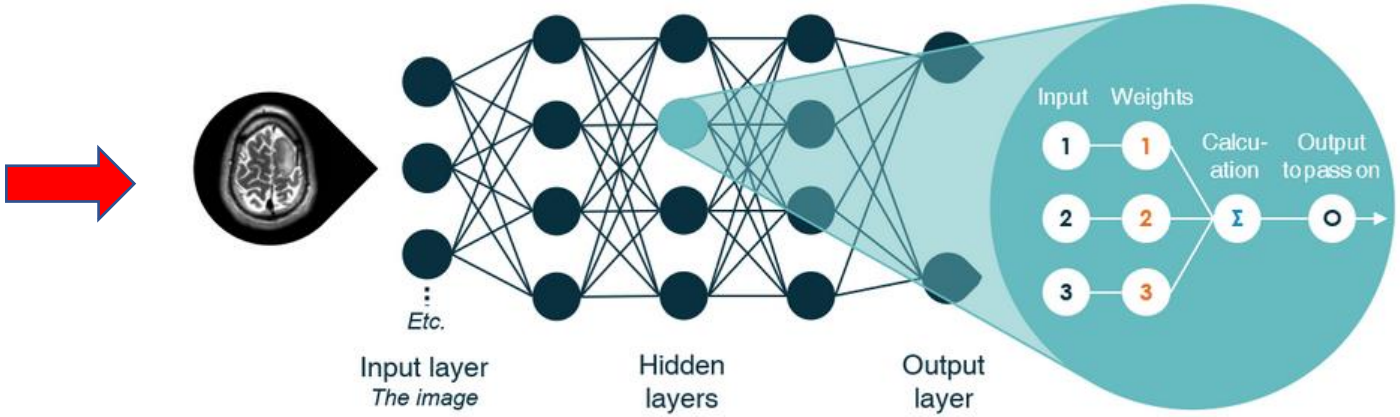
- **Symbolic AI (Classical AI or Good Old-Fashioned AI - GOFAI)**
  - **Core Idea**: Intelligence can be achieved by manipulating symbols and rules that represent knowledge.
  - **Examples**: Expert systems, theorem provers, and knowledge-based systems.

- **Connectionism (Neural Networks and Deep Learning)**
  - **Core Idea**: Intelligence emerges from the interaction of simple processing units (neurons) in a network, inspired by the human brain.
  - **Examples**: Deep learning models like convolutional neural networks (CNNs) and transformers (e.g., GPT, BERT).
- ……

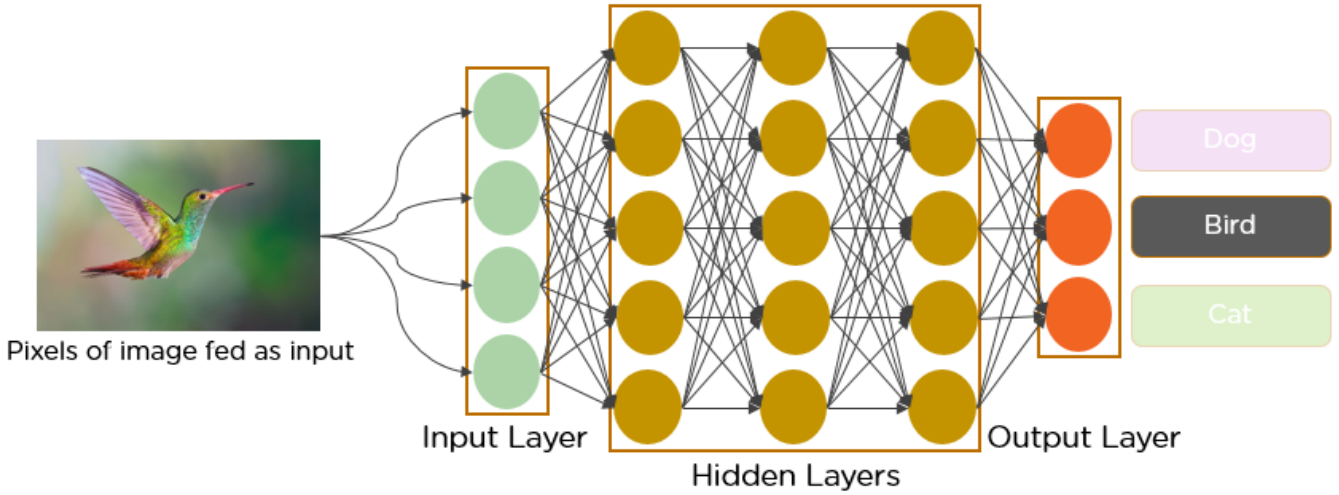
Connectionist vs Symbolic AI



From Physical to Artificial Neural Networks



Training Artificial NNs – Backpropagation



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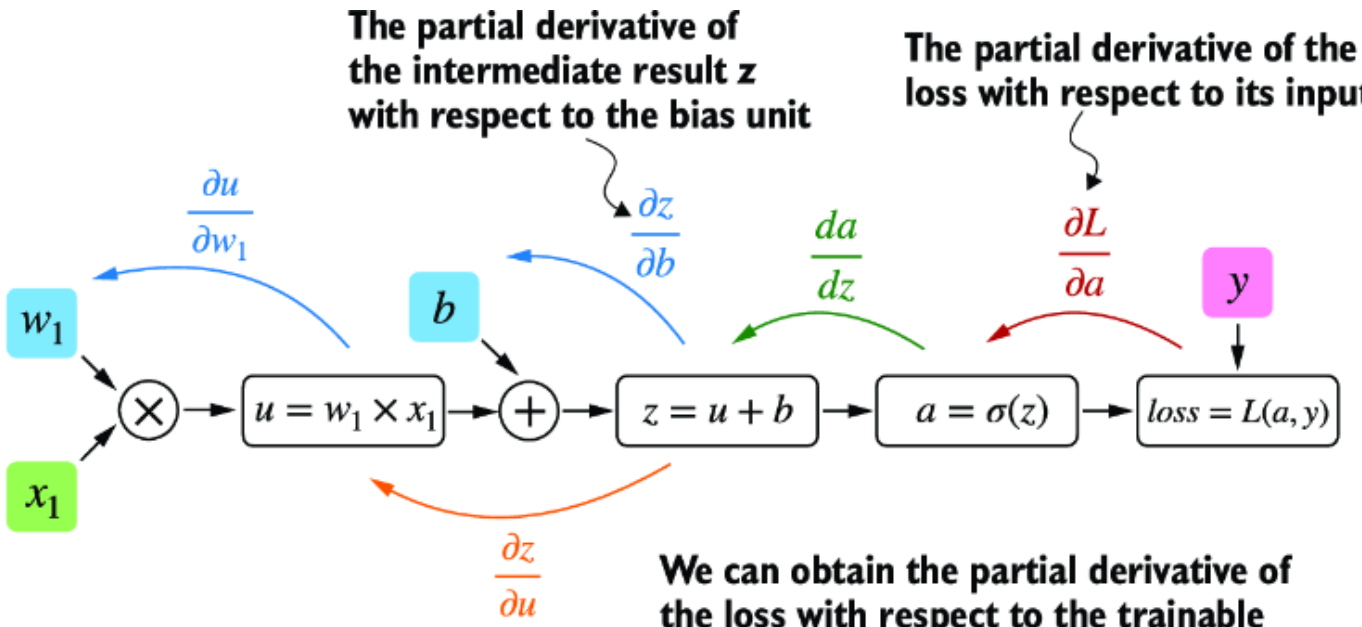

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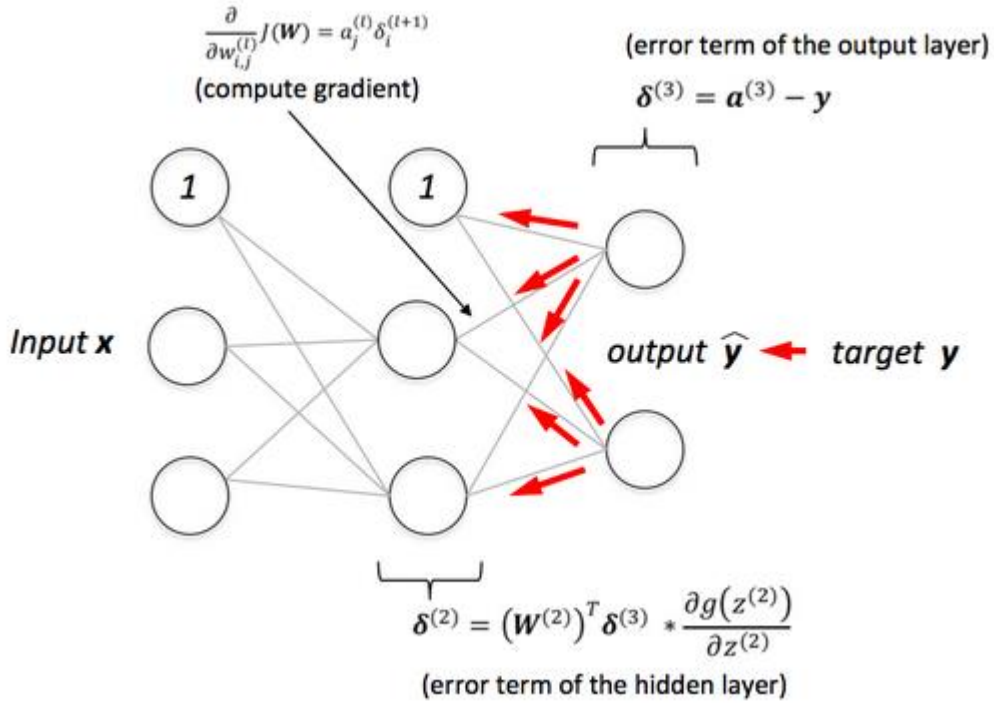
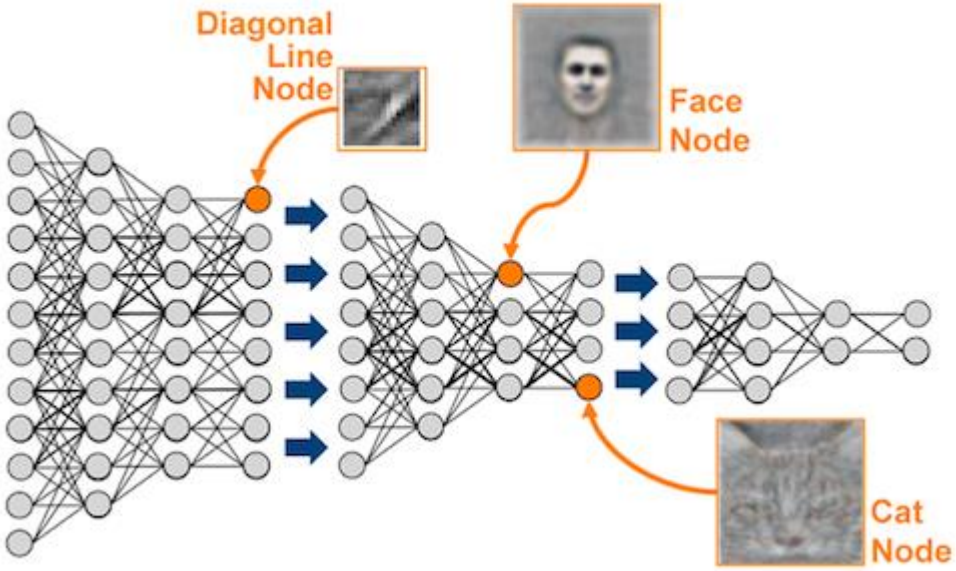


AI-revolutionary change- since 2010

- More computational power
  - Graphics processing unit – GPU
  - Clusters
- Better learning algorithms
  - Learning data representations;
  - Deep neural networks
  - Deep reinforcement learning



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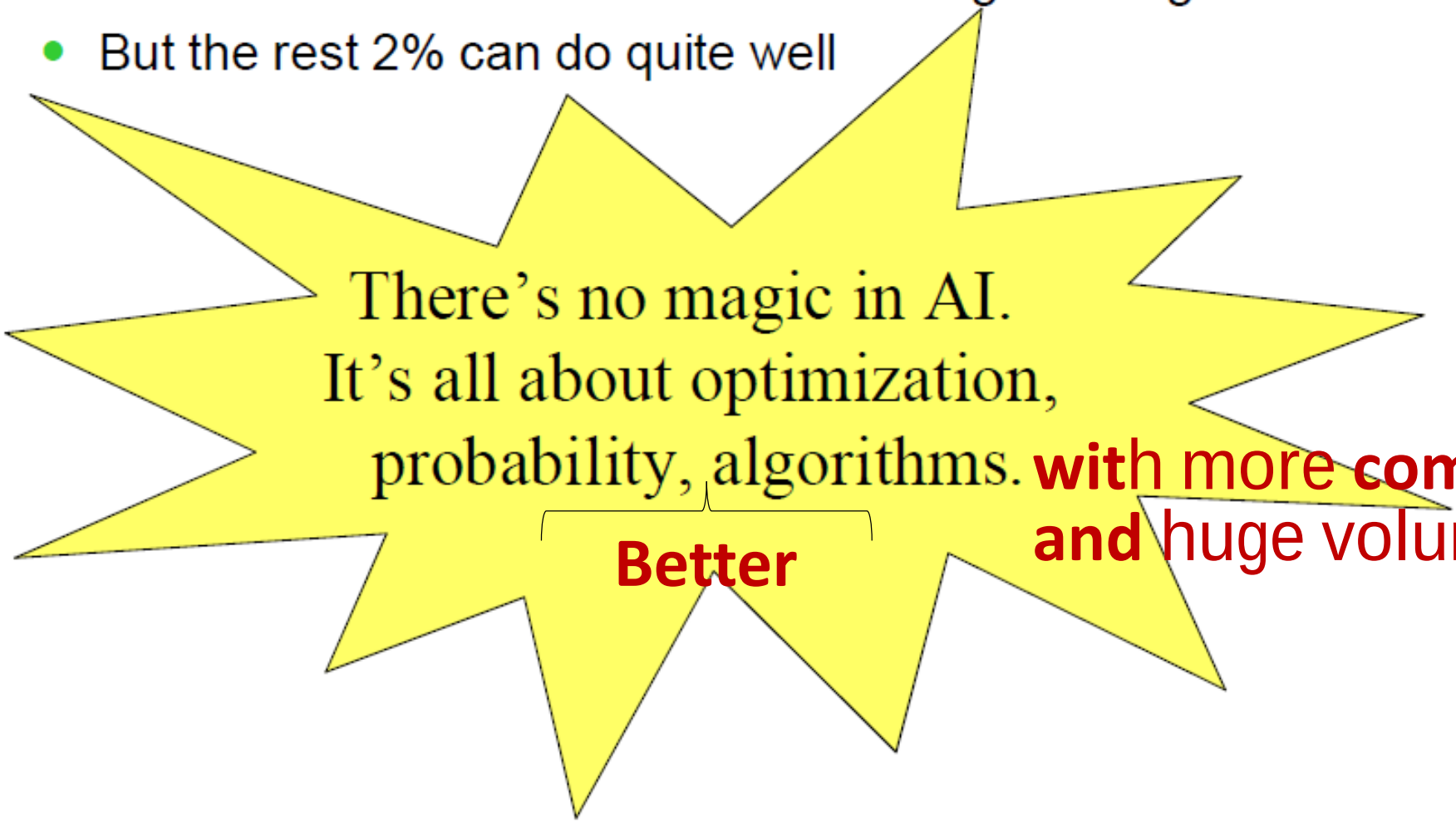


with more **computational power**
and huge volume of data

Why is it more important now?

- Flood of available data (especially with the advent of the Internet)
- Increasing computational power
- Growing progress in available algorithms and theory developed by researchers
- Increasing support from industries

AI today: natural language: chatbot

Valerie

Valerie: CMU Robot Receptionist in Newell-Simon hall.

ALICE: 2004 Loebner Prize winner

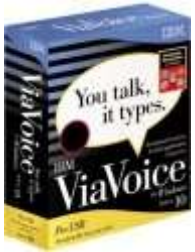
Whisper OpenAI

Automatic Speech Recognition (ASR)

Shallow?? natural language processing, pattern matching

AI today: natural language: speech recognition

- "speak or touch tone your card number" (tiny vocabulary, high accuracy needed)
- call routing: "how can I help you?" (large voc, low acc)
- dictation (large voc, high acc)



IBM
ViaVoice

Dragon
NaturallySpeaking

- Hidden Markov Model, A* search, …

AI today: natural language: machine translation

SYSTRAN
Language Translation Technologies

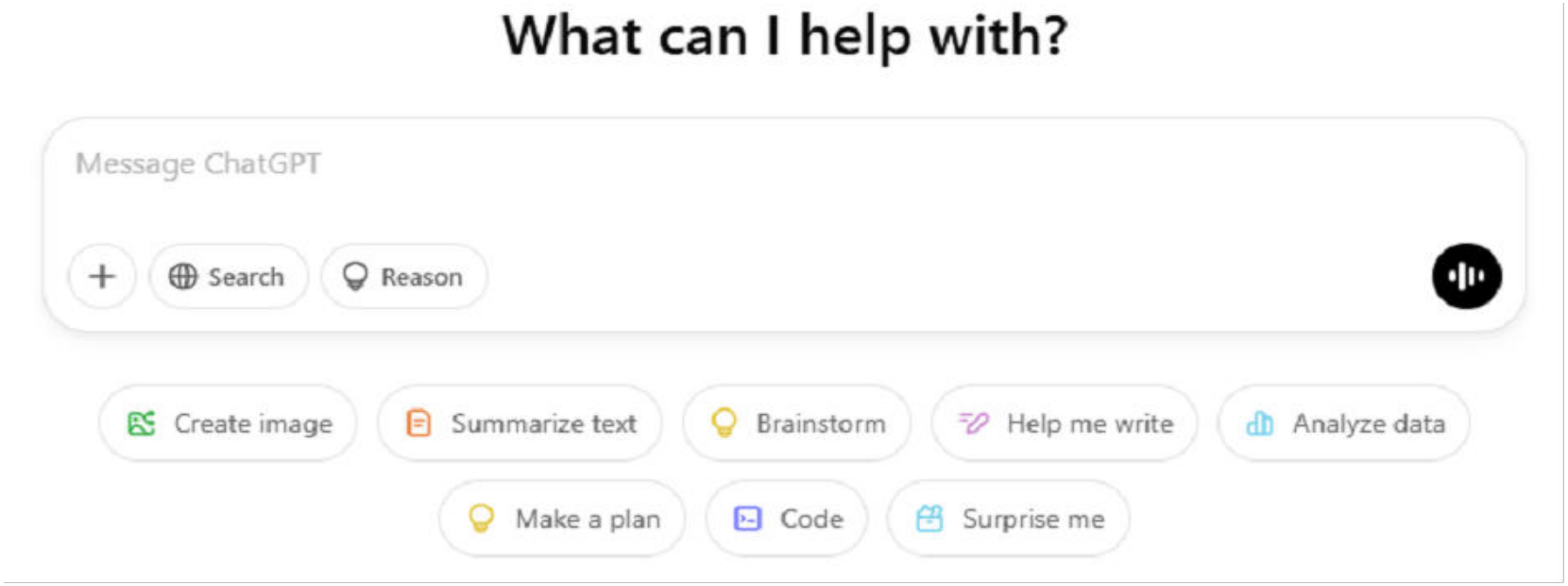
The spirit is willing but the flesh is weak. (2005/6/29)

Дух охотно готов но плоть слаба	Spirit is willingly ready but flesh it is weak
精神是愿意的但骨肉是微弱的	The spirit is wants but the flesh and blood is weak
精神は喜んでであるが、肉は弱い	Mind is rejoicing,, but the meat is weak
El alcohol está dispuesto pero la carne es débil	The alcohol is arranged but the meat is weak
الكحول مستعدّة غير أنّ اللحمة ضعيفة.	The alcohol is ready nevertheless the meat is weak.

- IBM statistical machine translation models
- US gov major consumer
  - Now? Neural Machine Translation

Use Foundation Models(like GPT or T5 Transformers)

AI today: natural language: question answering



AI today: game: from Chess to Go

- IBM Deep Blue vs. Kasparov, 1997/5
- 6 games: K, D, draw, draw, draw, D
- IBM stock up $18 billion.

- Search, two-player zero-sum discrete finite games and Deep Reinforcement Learning.

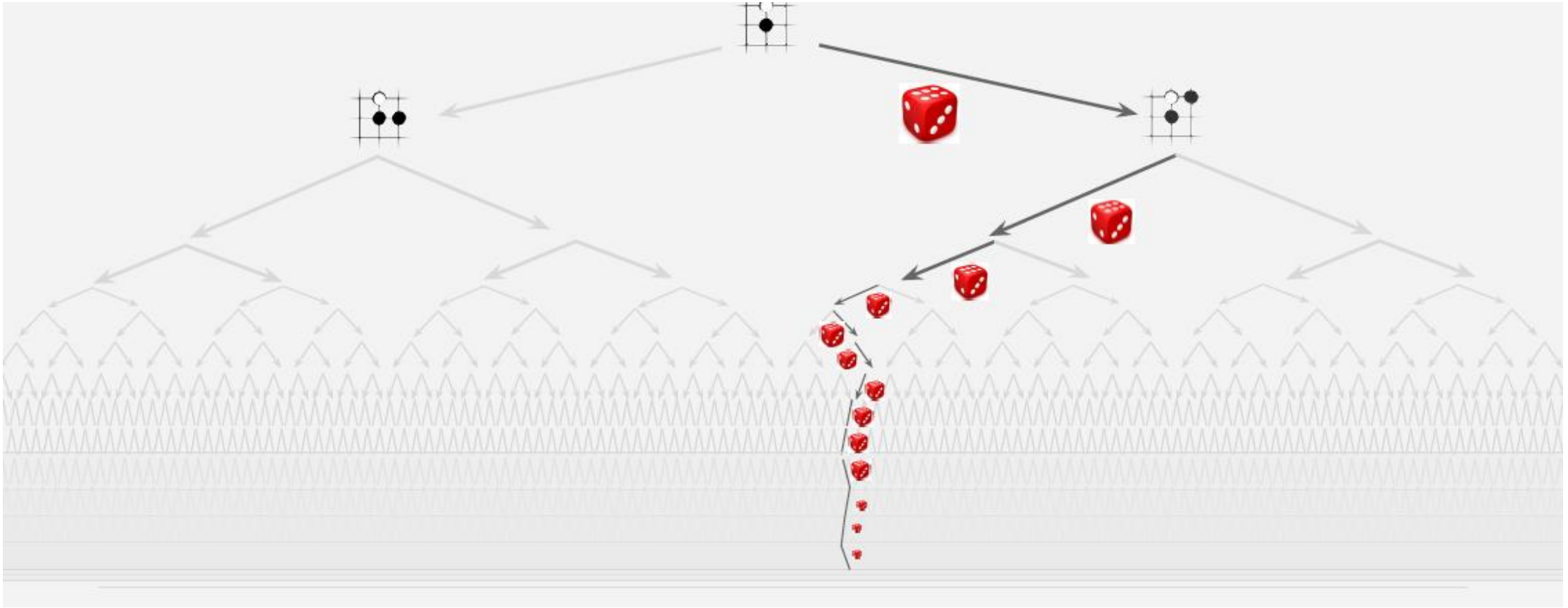
AlphaGo

Brute force search intractable:

1. Search space is huge
2. "Impossible" for computers to evaluate who is winning

Game tree complexity = b^d

AlphaGo



Deep Blue vs AlphaGo

Deep Blue	AlphaGo
Handcrafted chess knowledge	Knowledge learned from expert games and self-play
Alpha-beta search guided by heuristic evaluation function	Monte-Carlo search guided by policy and value networks
200 million positions / second	60,000 positions / second

Google DeepMind

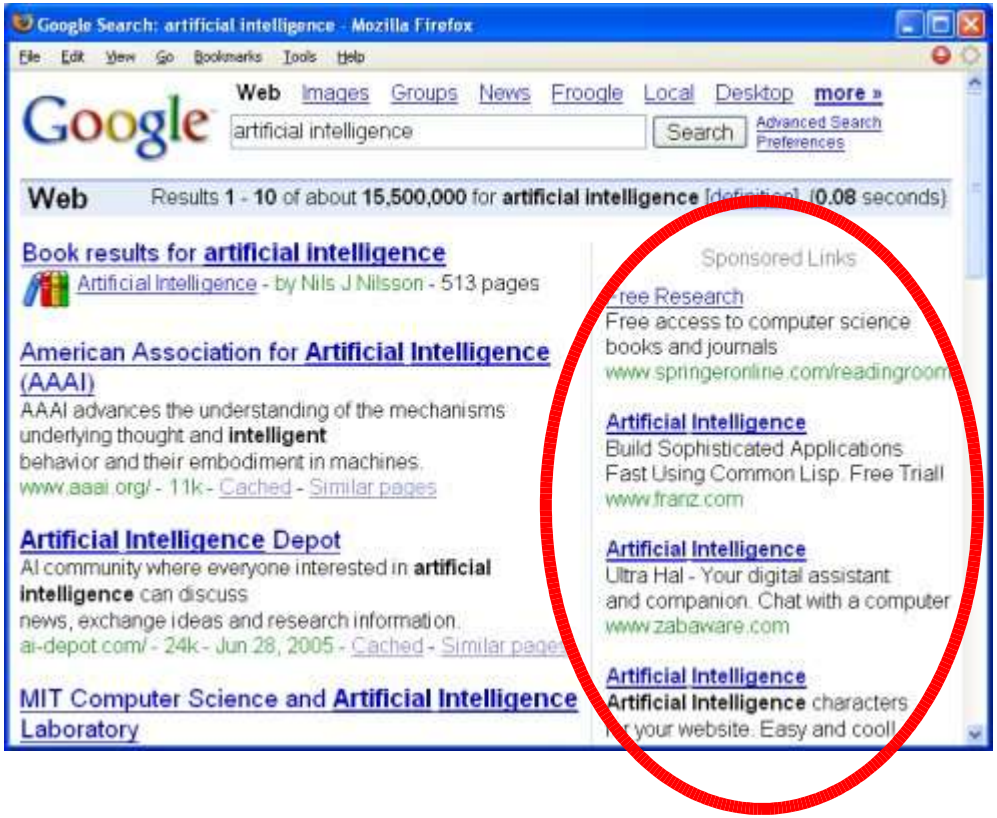
AI today: WWW: Google news

- Automatically selects / arranges news from multiple sources
- c.f. CNN

- Unsupervised machine learning: clustering

AI today: WWW: ad

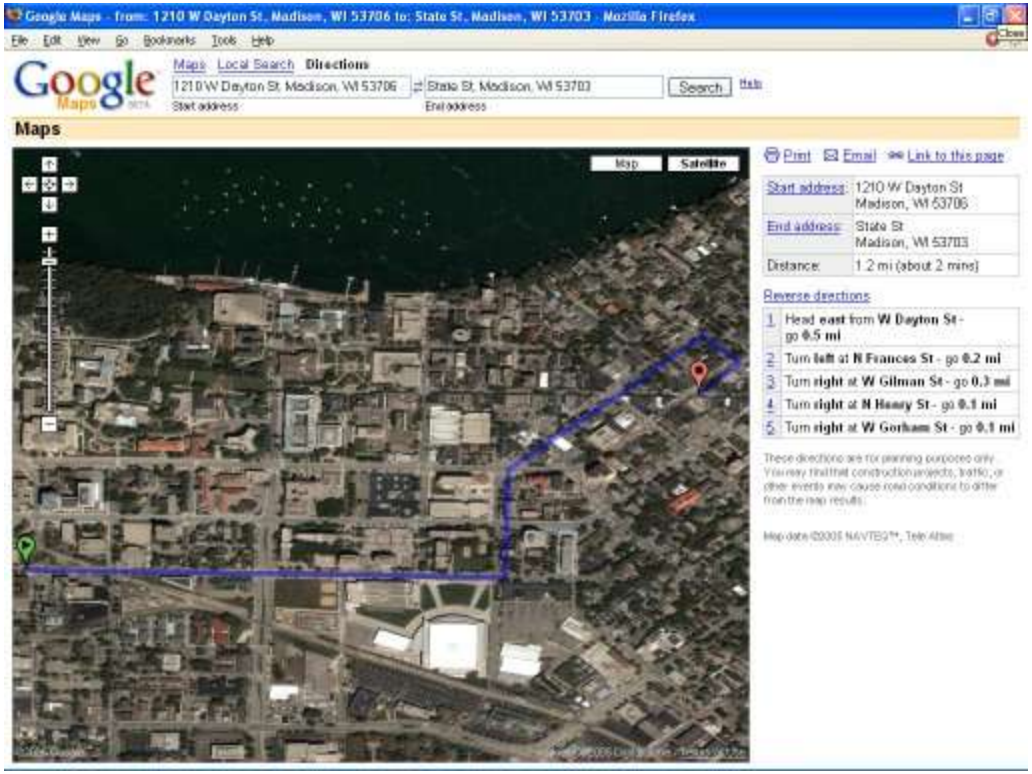
- "Sponsored links"
- Show ad based on relevance and money. Big business.



- Online algorithm, game, auction, multiple agents

AI today: WWW: driving directions

- From UW CS to state street



- search

AI today: WWW: collaborative filtering

- Recommendation based on other users' behavior
- e.g. Amazon.com

Availability: Usually ships within 24 hours. Ships from and so

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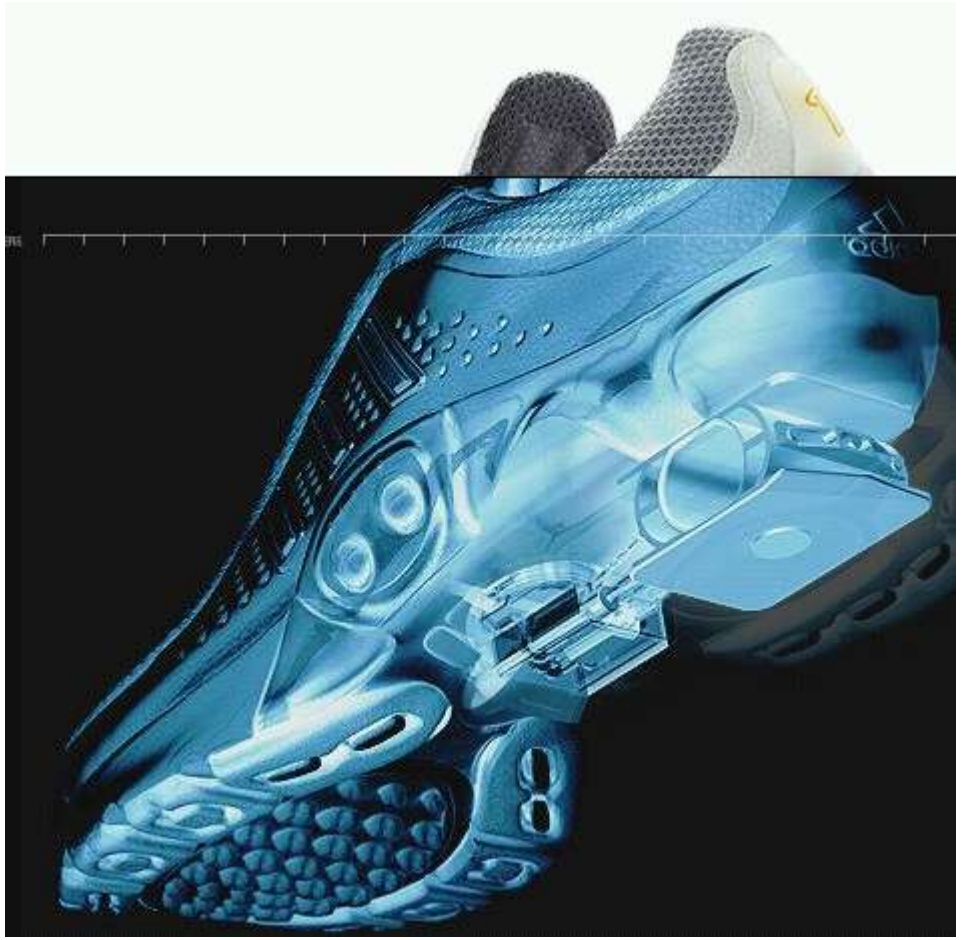
Explore Similar Items: in Books

- Unsupervised learning

AI today: robotics: 'intelligent' shoes

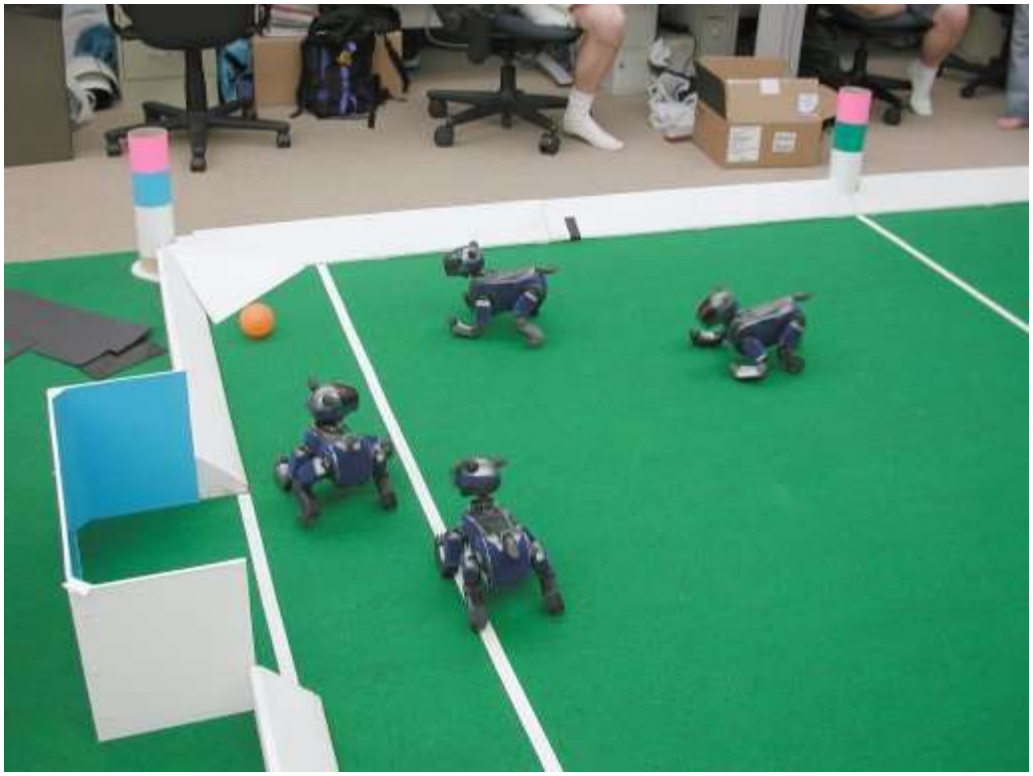
- Adjust cushioning by speed, road surface (adidas_1)



- Probably simple regression

AI today: robotics: robosoccer

- Robocup (http://www.robocup.org/)



- Markov decision process, reinforcement learning

AI today: robotics: humanoid

- Bipedal, human-like walking

Asimo (Honda)

QRIO (Sony)

AI today: robotics: Hubble telescope

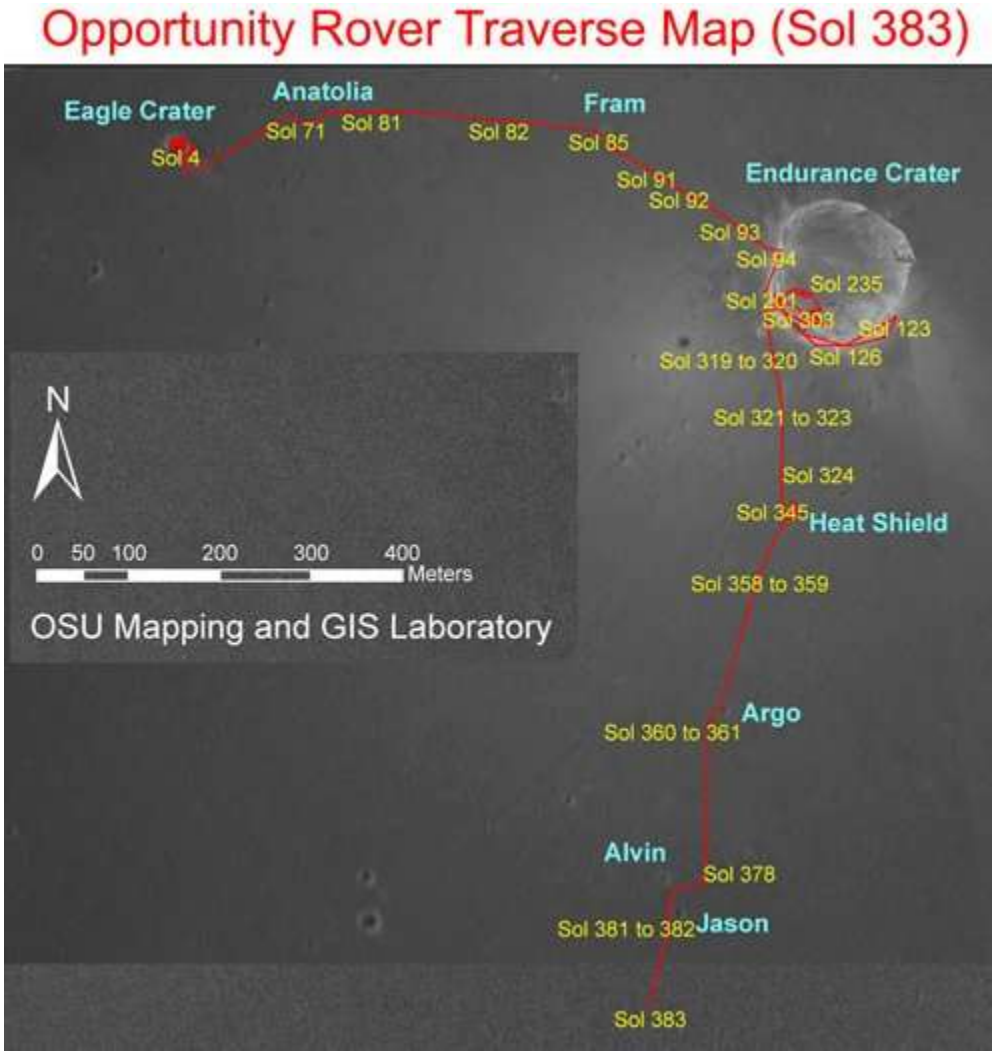
- Scheduling: who gets to see what when
  - 30,000 observations per year
  - Many constraints, including
    - Earth blocks view every 95 minutes
    - Halts when in South Atlantic Ocean radiation belt
    - Avoid bright Sun, Moon, illuminated Earth
    - Disruption of plan for e.g. a supernova
- Search: Constraint satisfaction problem

M. Johnston and G. Miller 1993
SPIKE: Intelligent Scheduling of Hubble Space Telescope Observations

AI today: robotics: Mars Rovers

- Autonomous driving on Mars (part time)
- Robot motion planning

not always autonomously…



AI Today

🚀 Generative AI – Tools like ChatGPT and MidJourney create human-like text, images, and even music.

🧠 Autonomous AI Agents – AI systems that can perform complex tasks with minimal human input.

🤖 AI in Work & Productivity – Automation is reshaping jobs, enhancing efficiency, and driving innovation.

🔬 Breakthroughs in Science & Medicine – AI accelerates drug discovery, medical diagnostics, and scientific research.

Are these intelligence?

AI defined

- Which one do you like?

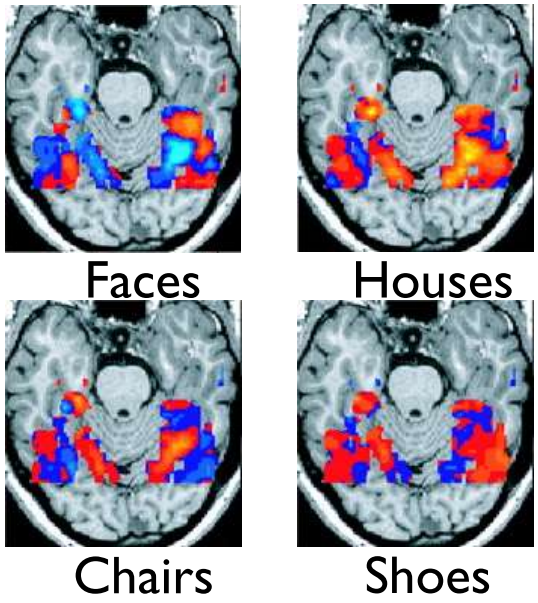
	act	think
humanly	e.g. Turing test 1990, 1991	How DO we think? 1985, 1978
rationally	agent 1998, 1998	Logic 1985, 1992

rational agent

- Sensors can be noisy or missing
- Actuators
  - may change the environment
  - can be inaccurate
- Performance measure
- Rational = optimize the performance measure
  - May not be perfect or even useful
  - e.g. “pick up as much dirt as possible”

How do we think? Mind reading

- Which picture is seen? high accuracy [Cox & Savoy, *Neuroimage* 2003]



[Haxby et al, *Science* 2001]

- Also word meaning, picture vs. sentence, sentence ambiguity

[Francisco Pereira, CMU Ph.D. thesis]