Foundations of Artificial Intelligence
A3. Introduction: AI Past and Present

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Introduction: Overview

Chapter overview: introduction

- A1. Organizational Matters
- A2. What is Artificial Intelligence?
- A3. AI Past and Present
- A4. Rational Agents
- A5. Environments and Problem Solving Methods

A Short History of AI

Precursors (Until ca. 1943)

| 1950 | 1960 | 1970 | 1980 | 1990 | 2000 | ... |

Philosophy and mathematics ask similar questions
that influence AI.

- Aristotle (384–322 BC)
- Leibniz (1646–1716)
- Hilbert program (1920s)

Gestation (1943–1956)
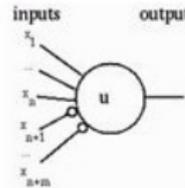
| 1950 | 1960 | 1970 | 1980 | 1990 | 2000 | ... |

Invention of electrical computers raised question:
Can computers mimic the human mind?

Gestation (1943–1956)

Artificial
Neurons

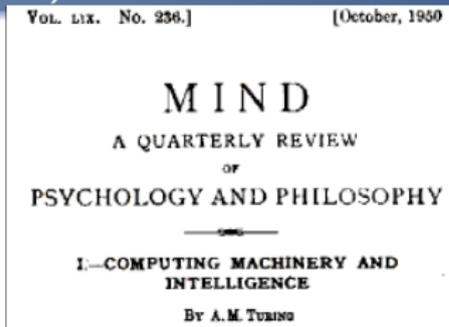**1950**   **1960**   **1970**   **1980**   **1990**   **2000**   **...**

W. McCulloch & W. Pitts (1943)
- first computational model of artificial neuron
- network of neurons can compute any computable function
- basis of deep learning

Gestation (1943–1956)

Artificial
Neurons

VOL. LIX. No. 236.]   [October, 1950

MIND

A QUARTERLY REVIEW

OF

PSYCHOLOGY AND PHILOSOPHY

I.—COMPUTING MACHINERY AND
INTELLIGENCE

BY A. M. TURING

1950   1960   1970   1980   1990   2000   ...

Turing Test

Computing Machinery and Intelligence (A. Turing, 1950)

- famous for introducing Turing test
- (still) relevant discussion of AI potential and requirements
- suggests core AI aspects: knowledge representation, reasoning, language understanding, learning

Gestation (1943–1956)

Artificial
Neurons

Dartmouth

| John MacCarthy | Marvin Minsky | Claude Shannon | Ray Solomonoff | Alan Newell |
| Herbert Simon | Arthur Samuel | Oliver Selfridge | Nathaniel Rochester | Trenchard More |

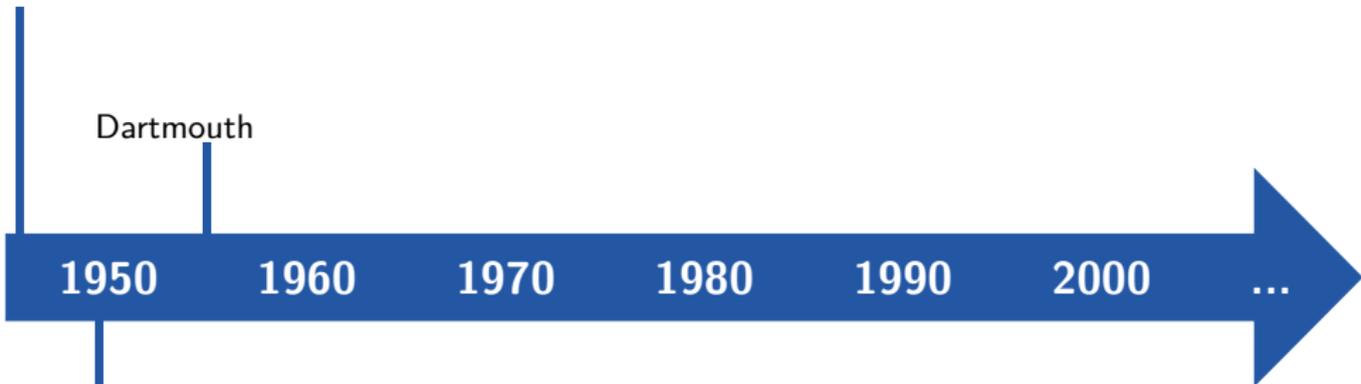**1950** **1960** **1970** **1980** **1990** **2000** **...**

Turing Test

Dartmouth workshop (1956)

- ambitious proposal: "An attempt will be made to find how to make machines use language, [...] solve kinds of problems now reserved for humans, and improve themselves."

- J. McCarthy coins term artificial intelligence

Early Enthusiasm (1952–1969)

Artificial
Neurons

Dartmouth

1950   1960   1970   1980   1990   2000   ...

Turing Test

early enthusiasm (H. Simon, 1957):
"[...] there are now in the world machines that think, that learn and that create. Moreover, their ability to do these things is going to increase rapidly until – in the visible future – the range of problems they can handle will be coextensive with the range to which the human mind has been applied."

Early Enthusiasm (1952–1969)

Artificial
Neurons

Dartmouth

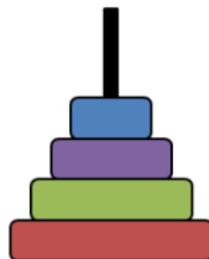**1950**   **1960**   **1970**   **1980**   **1990**   **2000**   **...**

GPS

Turing Test

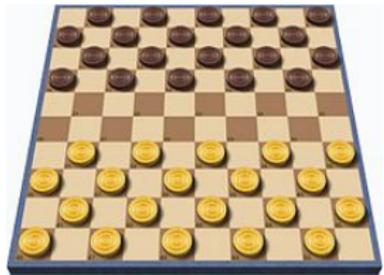General Problem Solver (H. Simon & A. Newell, 1957)

- universal problem solving machine
- imitates human problem solving strategies
- in principle able to solve every formalized symbolic problem
- in practice, GPS solves simple tasks like towers of Hanoi

Early Enthusiasm (1952–1969)

Artificial
Neurons

RL for
Checkers

Dartmouth

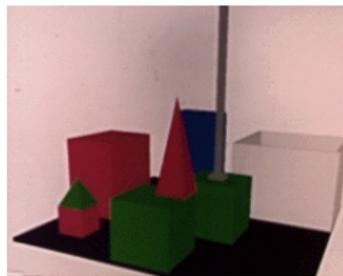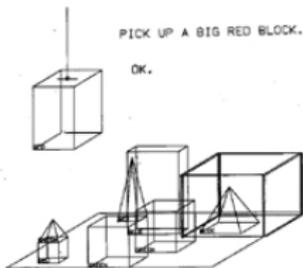| 1950 | 1960 | 1970 | 1980 | 1990 | 2000 | ... |

GPS

Turing Test

Checkers AI (A. Samuel, 1959)

- popularized term machine learning
- learned to play at strong amateur level
- uses ideas of reinforcement learning

Early Enthusiasm (1952–1969)

Artificial
Neurons

RL for
Checkers

Dartmouth

PICK UP A BIG RED BLOCK.

OK.

1950   **1960**   **1970**   **1980**   **1990**   **2000**   **...**

GPS

Microworlds

Turing Test

intelligence in microworlds, e.g. SHRDLU (T. Winograd, 1968)

- understands natural language
- communicates with user via teletype on blocks world
- graphical representation

A Dose of Reality (1966–1973)

Artificial
Neurons

RL for
Checkers

Dartmouth

Limitations

1950 · **1960** · **1970** · **1980** · **1990** · **2000** · **...**

GPS

Microworlds

Turing Test

- realization that unlimited computational power is illusion (birth of complexity theory, NP-completeness)
- AI systems (e.g., GPS, systems for micro worlds) fail to scale
- fundamental limitations on basic structures e.g., XOR problem of perceptrons

Expert Systems (1969–1986)

Artificial
Neurons

RL for
Checkers

Dartmouth

Limitations

DISTRIBUTE-MB-DEVICES-3

IF: the most current active context is distributing massbus devices
&   there is a single port disk drive that has not been assigned to a massbus
&   there are no unassigned dual port disk drives
&   the number of devices that each massbus should support is known
&   there is a massbus that has been assigned at least one disk drive and that should support additional
     disk drives
&   the type of cable needed to connect the disk drive to the previous device on the disk drive is known

THEN: assign the disk drive to the massbus

1950   **1960**   **1970**   **1980**   **1990**   **2000**   **...**

GPS

Microworlds

Expert
Systems

Turing Test

1980s: AI gold rush

- rule-based expert systems commercially successful

- (human) expert knowledge as input

- allows automatic reasoning on larger problems
  in narrower applications

- also: second heyday of neural networks

Expert Systems (1969–1986)

Artificial
Neurons

RL for
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Dartmouth

Limitations

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THEN: assign the disk drive to the massbus

| 1950 | 1960 | 1970 | 1980 | 1990 | 2000 | ... |

GPS

Microworlds

Expert
Systems

Turing Test

example: R1/XCON (J. McDermott, 1978)

- input: desired properties of a VAX computer system according to customer specifications
- output: specification of the computer system
- inference engine: simple forward chaining of rules

Expert Systems (1969–1986)

Artificial
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RL for
Checkers

Dartmouth

Limitations

DISTRIBUTE-MB-DEVICES-3

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GPS

Microworlds

Expert
Systems

AI Winter

Turing Test

end of 1980s: AI Winter

- **companies** failed to deliver promises
- expert systems difficult to maintain
- expert systems susceptible to uncertainty

Coming of Age (1990s and 2000s)

Artificial Neurons

RL for Checkers

Dartmouth

Limitations

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· · ·   · · ·   · · ·

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GPS

Microworlds

Expert Systems

AI Winter

Turing Test
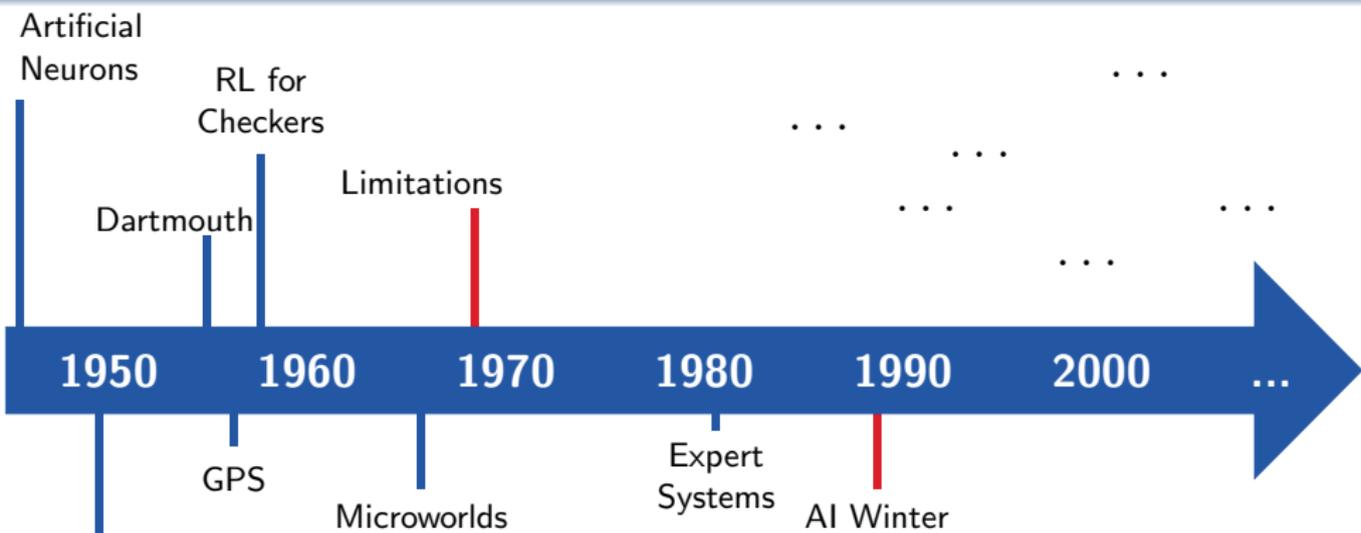
- advent of probabilistic methods
- formalization of AI techniques
- better understanding of theoretical complexity
- increased use of mathematical methods
- exploitation of large data sets (big data)

Broad Visibility in Society (Since 2010s)

Artificial Neurons

RL for Checkers

Dartmouth

Limitations

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AI Winter

Turing Test

well known systems and famous breakthroughs, e.g.,

- broadly used systems (e.g., virtual assistants)
- AI systems act in real-world (e.g., self-driving cars)
- systems outperform humans in hard tasks (e.g., AlphaGo)
- AI and human-written text hard to distinguish (ChatGPT)

Where are We Today?

AI Approaching Maturity

Russell & Norvig (1995)

Gentle revolutions have occurred in robotics, computer vision, machine learning, and knowledge representation.
A better understanding of the problems and their complexity properties, combined with increased mathematical sophistication, has led to workable research agendas and robust methods.

## Where are We Today?

- many coexisting paradigms
    - reactive vs. deliberative
    - data-driven vs. model-driven
    - often hybrid approaches
- many methods, often borrowing from other research areas
    - logic, decision theory, statistics, . . .
- different approaches
    - theoretical
    - algorithmic/experimental
    - application-oriented

Focus on Algorithms and Experiments

Many AI problems are inherently difficult (NP-hard),
but strong search techniques and heuristics often solve
large problem instances regardless:

- satisfiability in propositional logic
  - 10,000 propositional variables or more
    via conflict-directed clause learning
- constraint solvers
  - good scalability via constraint propagation
    and automatic exploitation of problem structure
- action planning
  - 10^{100} search states and more by search
    using automatically inferred heuristics

What Can AI Do Today?

https://kahoot.it/
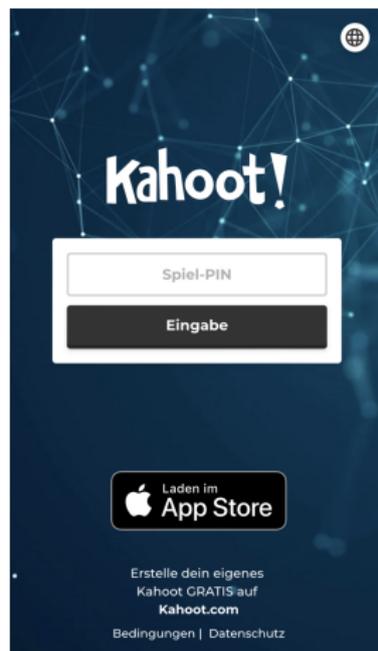
Summary

Summary

- 1950s/1960s: beginnings of AI; early enthusiasm
- 1970s: micro worlds and knowledge-based systems
- 1980s: gold rush of expert systems followed by "AI winter"
- 1990s/2000s: AI comes of age; research becomes more rigorous and mathematical; mature methods
- 2010s: AI systems enter mainstream