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

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A3.1 A Short History of AI

A3.2 Where are We Today?

A3.3 Summary

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

A3.1 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)

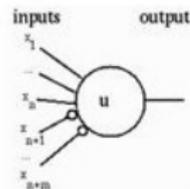| **1950** | **1960** | **1970** | **1980** | **1990** | **2000** | **…** |

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

Gestation (1943–1956)

Artificial
Neurons

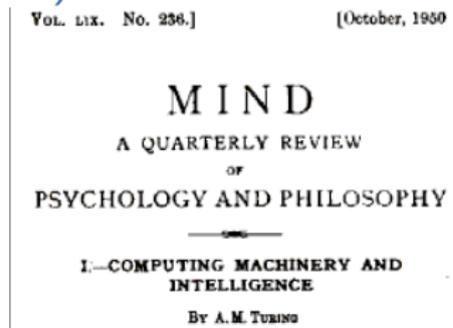| **1950** | **1960** | **1970** | **1980** | **1990** | **2000** | ... |

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

John MacCarthy — Marvin Minsky — Claude Shannon — Ray Solomonoff — Alan Newell

Herbert Simon — Arthur Samuel — Oliver Selfridge — Nathaniel Rochester — Trenchard More

Dartmouth

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
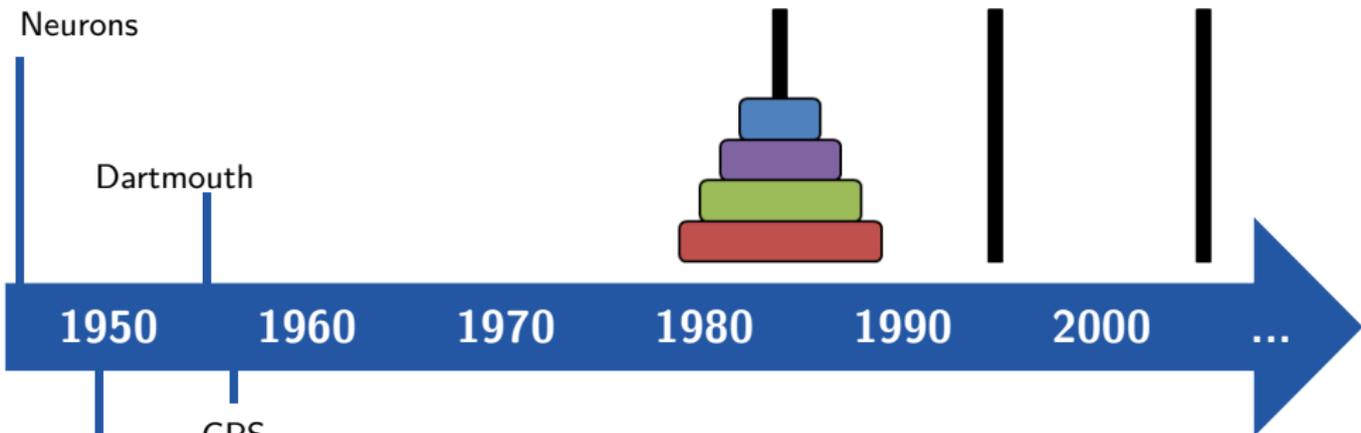
Turing Test

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

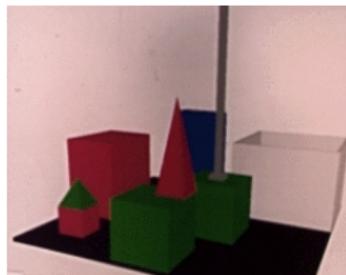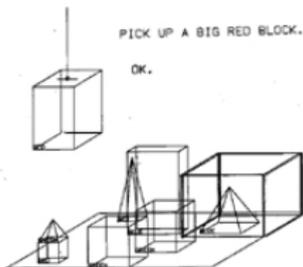| 1950 | 1960 | 1970 | 1980 | 1990 | 2000 | ... |

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
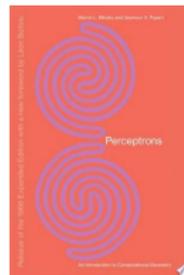- ▶ communicates with user via teletype on blocks world
- ▶ graphical representation

A Dose of Reality (1966–1973)

Artificial
Neurons

RL for
Checkers

Limitations

Dartmouth

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
Checkers

Dartmouth

Limitations

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　　 disk drives
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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
Neurons

RL for
Checkers

Dartmouth

Limitations

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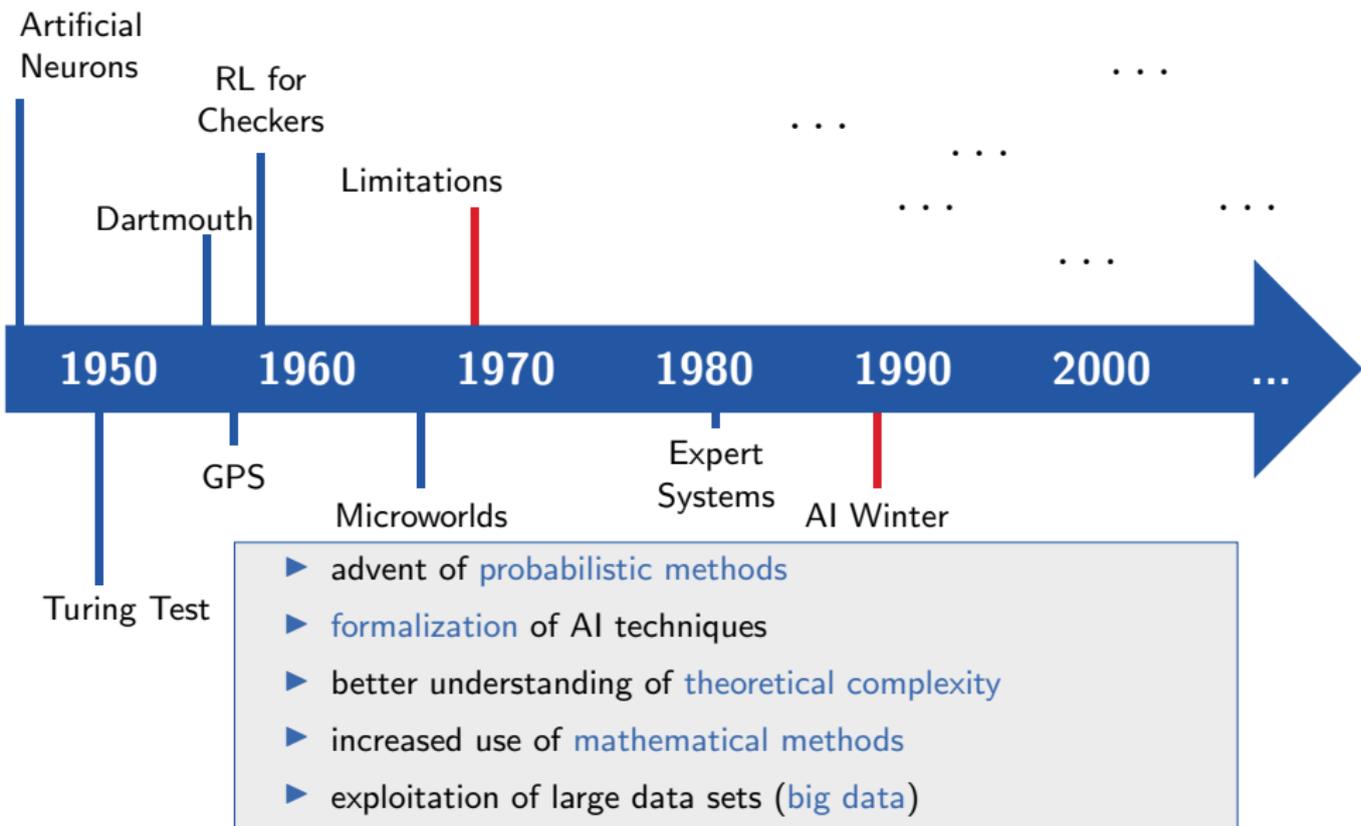| 1950 | 1960 | 1970 | 1980 | 1990 | 2000 | ... |

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

. . .

. . .

. . .

. . .

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

GPS

Expert
Systems

Microworlds

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

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

GPS

Microworlds

Expert Systems

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)

A3.2 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/
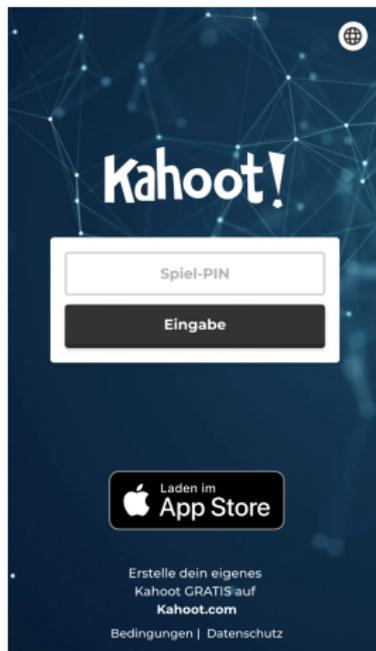
A3.3 Summary

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