

Foundations of Artificial Intelligence

A3. Introduction: AI Past and Present

Malte Helmert

University of Basel

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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)

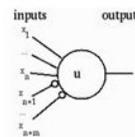
Gestation (1943–1956)

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 ...

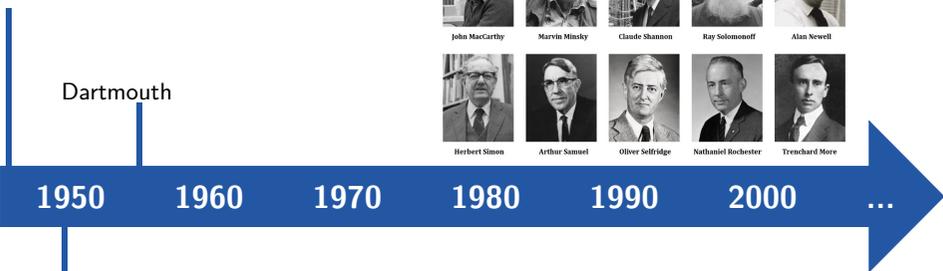
Turing Test

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

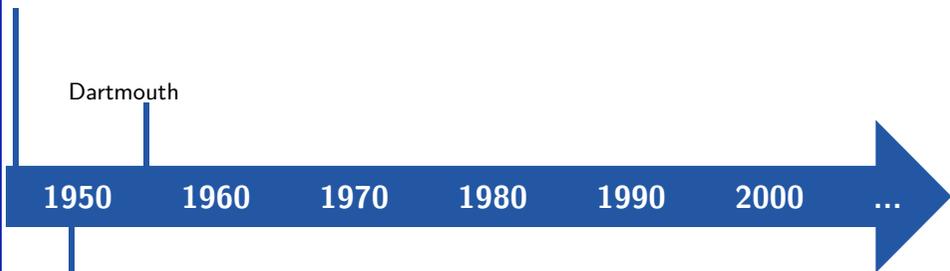


Dartmouth workshop (1956)

- ▶ 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

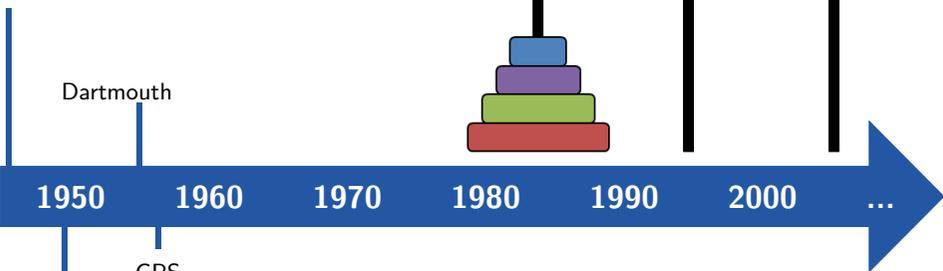
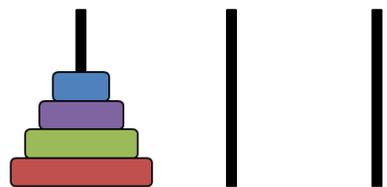


early enthusiasm (H. Simon, 1957):

“[...] 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



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

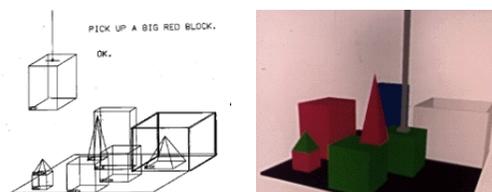


Checkers AI (A. Samuel, 1959)

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

Early Enthusiasm (1952–1969)

Timeline: 1950 (Turing Test), 1952 (Dartmouth), 1956 (Artificial Neurons), 1957 (RL for Checkers), 1960 (GPS), 1969 (Microworlds), 1970 (Limitations), 1980 (Expert Systems), 1990 (GPS), 2000 (GPS), ...



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)

Timeline: 1950 (Turing Test), 1952 (Dartmouth), 1956 (Artificial Neurons), 1957 (RL for Checkers), 1960 (GPS), 1969 (Microworlds), 1970 (Limitations), 1980 (Expert Systems), 1990 (GPS), 2000 (GPS), ...



- ▶ 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)

Timeline: 1950 (Turing Test), 1952 (Dartmouth), 1956 (Artificial Neurons), 1957 (RL for Checkers), 1960 (GPS), 1969 (Microworlds), 1970 (Limitations), 1980 (Expert Systems), 1990 (GPS), 2000 (GPS), ...

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 to 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

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)

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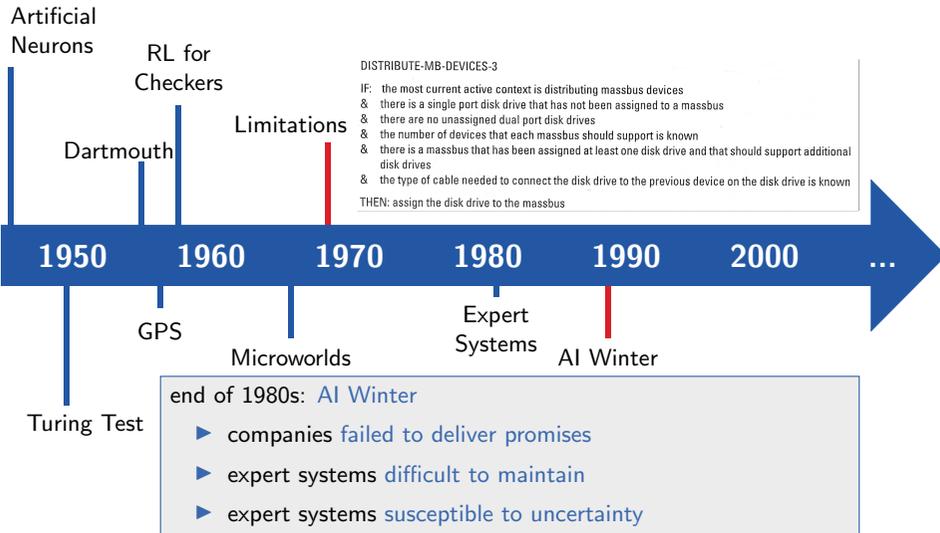
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example: **R1/XCON** (J. McDermott, 1978)

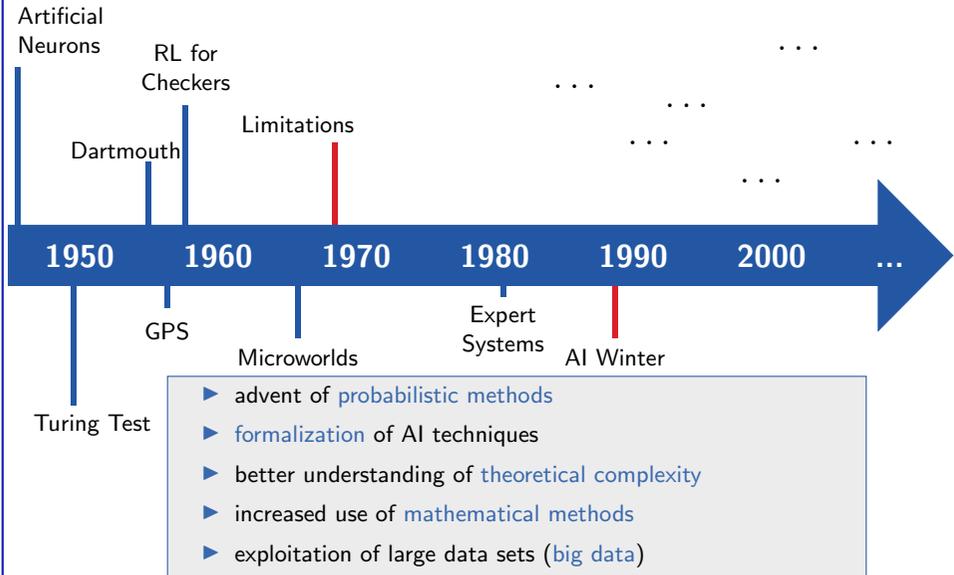
- ▶ **input**: desired properties of a VAX computer system according to customer specifications
- ▶ **output**: specification of the computer system
- ▶ **inference engine**: simple forward chaining of rules

Expert Systems (1969–1986)



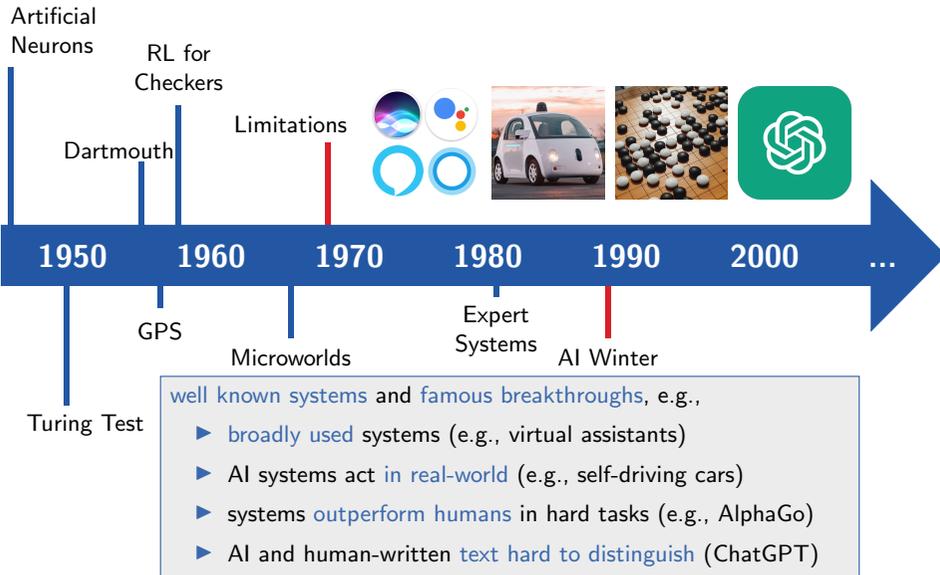
- end of 1980s: AI Winter
- ▶ companies failed to deliver promises
 - ▶ expert systems difficult to maintain
 - ▶ expert systems susceptible to uncertainty

Coming of Age (1990s and 2000s)



- ▶ 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)



- 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