# 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)


Philosophy and mathematics ask similar questions that influence AI.

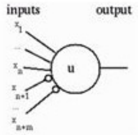
- Aristotle (384–322 BC)
- Leibniz (1646–1716)
- Hilbert program (1920s)

# Gestation (1943–1956)


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

# Gestation (1943–1956)

Artificial Neurons



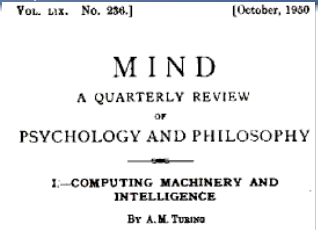

1950 1960 1970 1980 1990 2000 ...

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

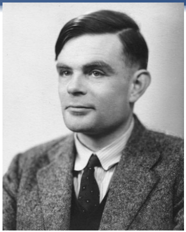
A QUARTERLY REVIEW

OF

PSYCHOLOGY AND PHILOSOPHY

I.—COMPUTING MACHINERY AND INTELLIGENCE

BY A. M. TURING



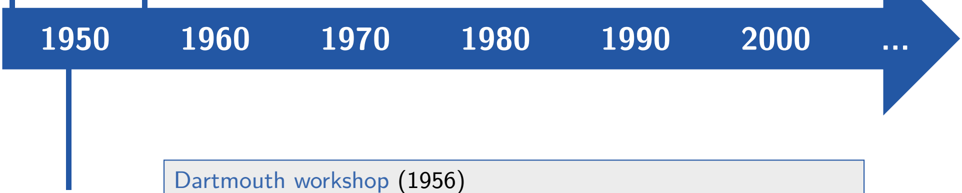
1950 1960 1970 1980 1990 2000 ...

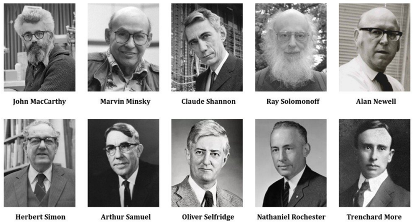
Turing Test

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)

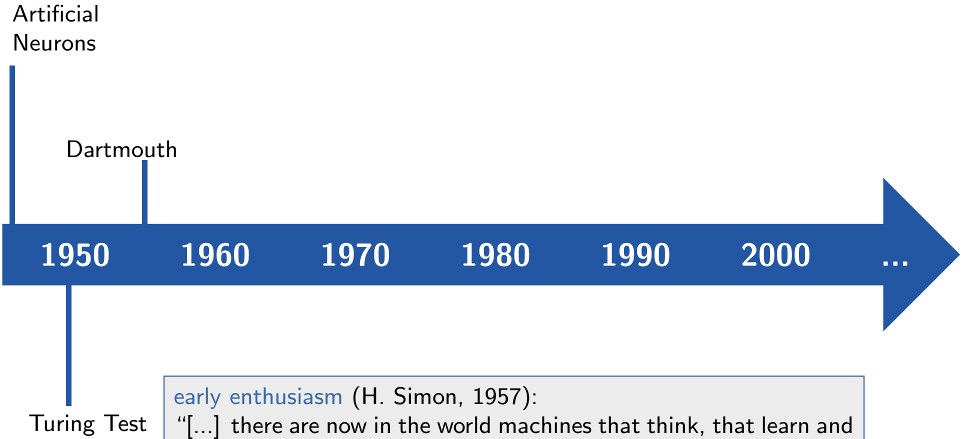



**Dartmouth workshop** (1956)

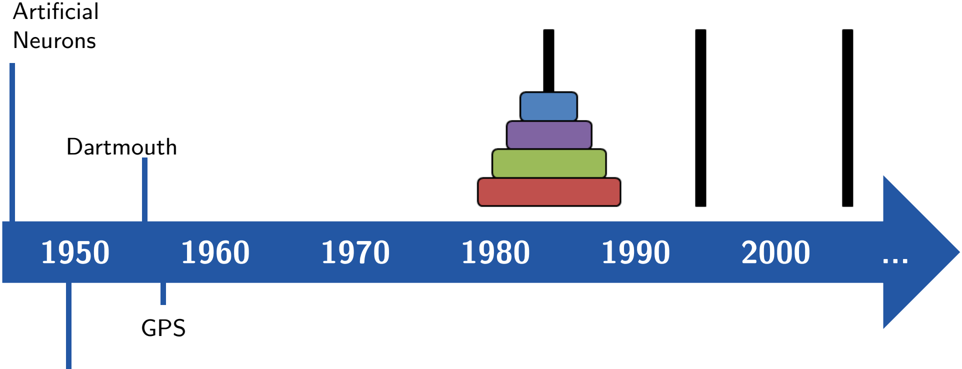
- ambitious proposal: "An attempt will be made to find how to make machines use language, [...] solve kinds of problems now reserved for humans, and improve themselves."
- J. McCarthy coins term artificial intelligence

# Early Enthusiasm (1952–1969)




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."

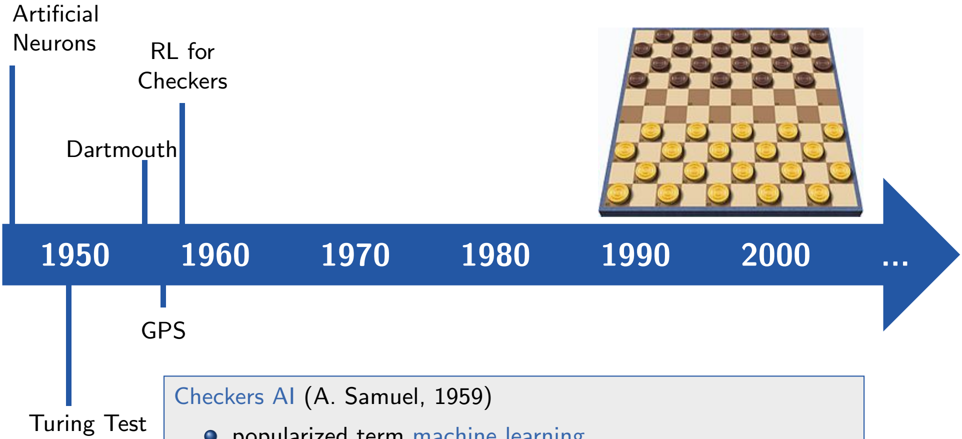
# Early Enthusiasm (1952–1969)




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)




**Checkers AI** (A. Samuel, 1959)

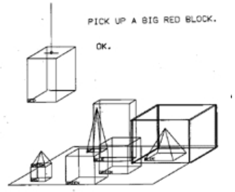
- popularized term machine learning
- learned to play at strong amateur level
- uses ideas of reinforcement learning

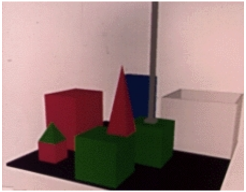
# Early Enthusiasm (1952–1969)

Artificial Neurons

RL for Checkers

Dartmouth



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

⇝ `https://hci.stanford.edu/winograd/shrdlu/`

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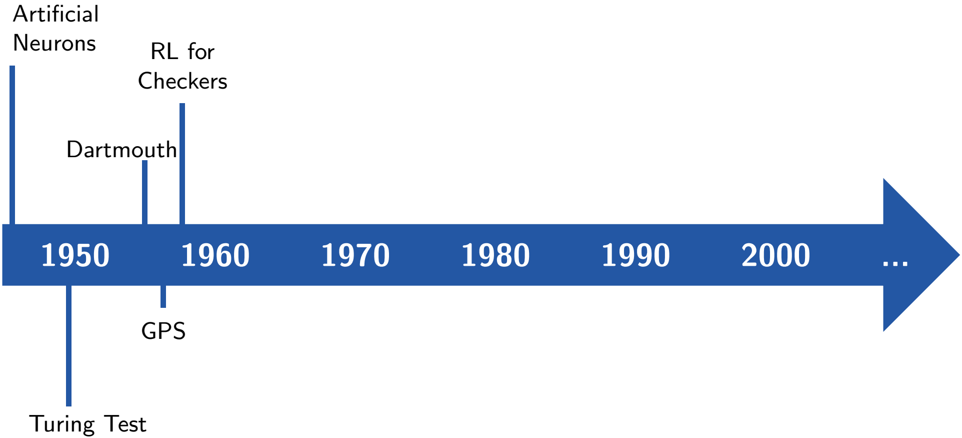
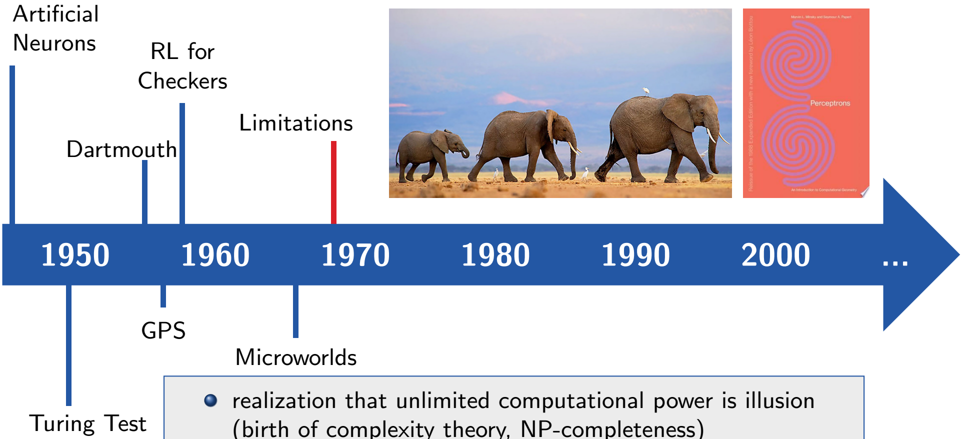
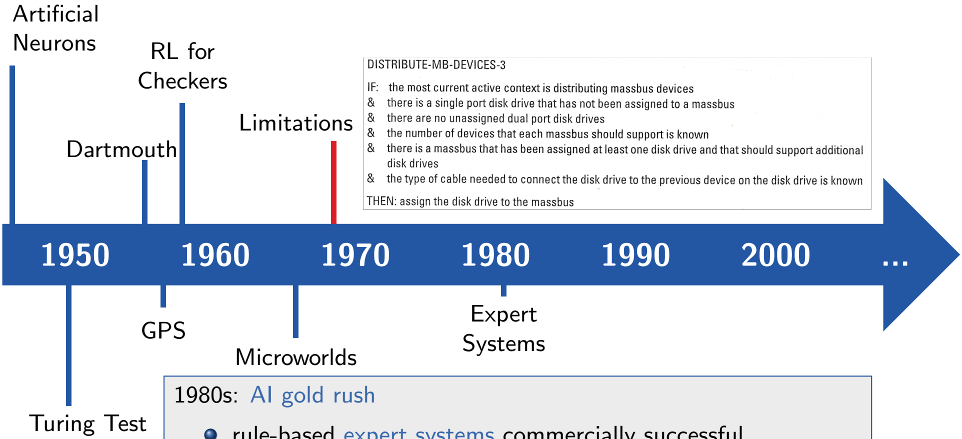


# A Dose of Reality (1966–1973)




- 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)




DISTRIBUTE-MB-DEVICES-3

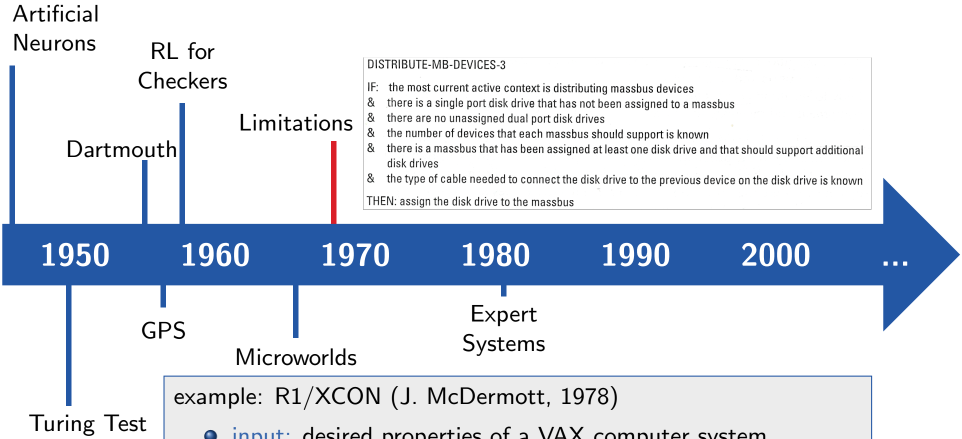
IF: the most current active context is distributing massbus devices
& there is a single port disk drive that has not been assigned to a massbus
& there are no unassigned dual port disk drives
& the number of devices that each massbus should support is known
& there is a massbus that has been assigned 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

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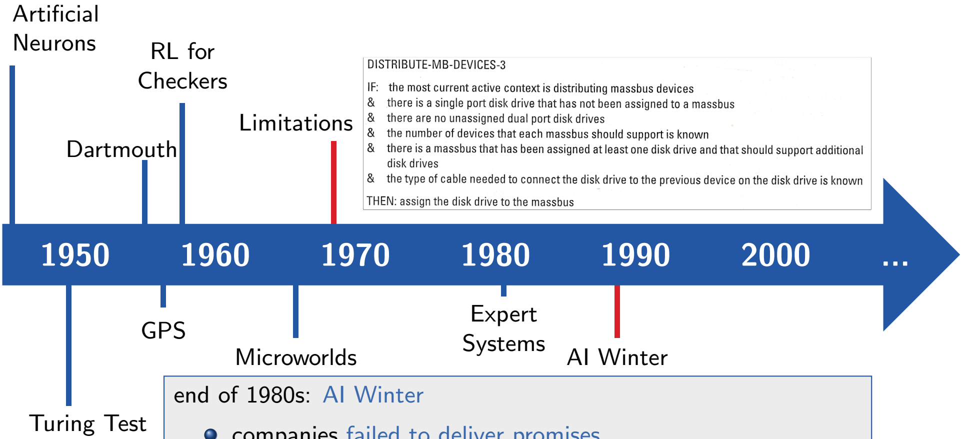
example: R1/XCON (J. McDermott, 1978)

- 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)

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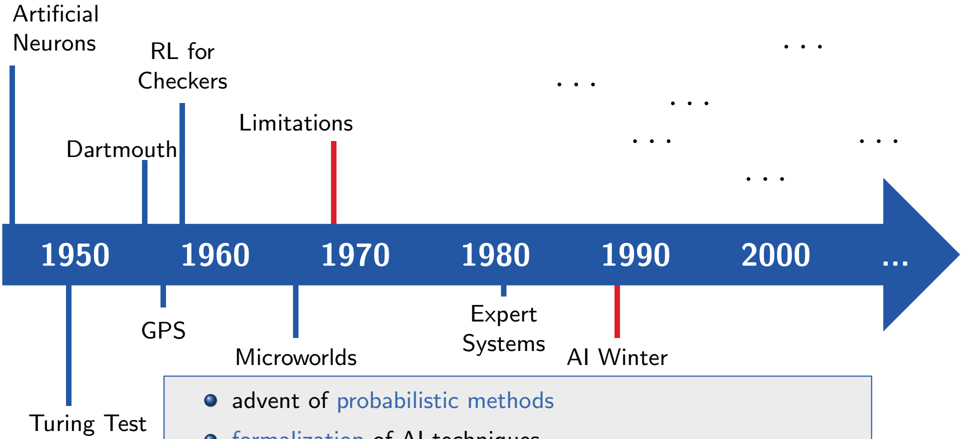
end of 1980s: AI Winter

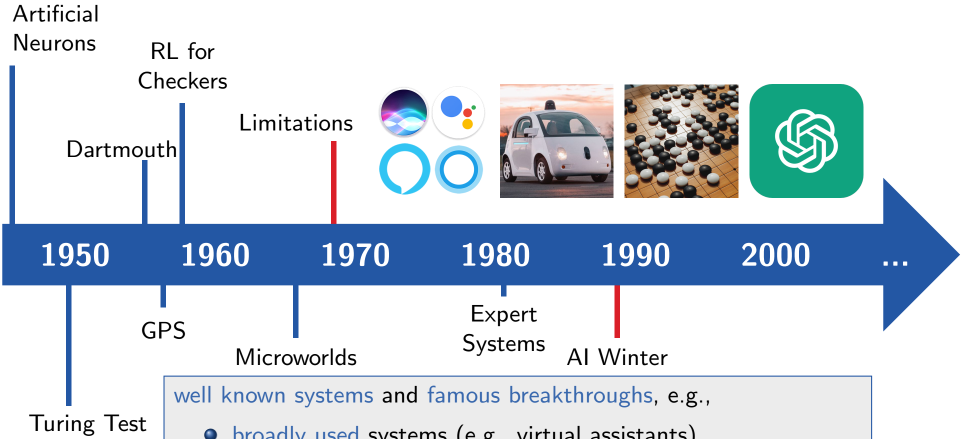
- companies failed to deliver promises
- expert systems difficult to maintain
- expert systems susceptible to uncertainty

# 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)

# 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?

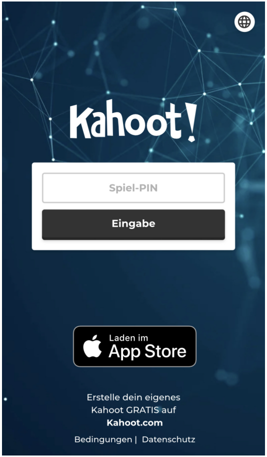

- many coexisting paradigms
  - reactive vs. deliberative
  - data-driven vs. model-driven
  - often hybrid approaches
- many methods, often borrowing from other research areas
  - logic, decision theory, statistics, ...
- different approaches
  - theoretical
  - algorithmic/experimental
  - application-oriented

# 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

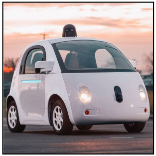
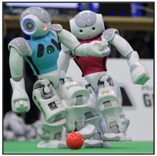
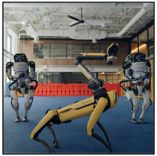
# What Can AI Do Today?



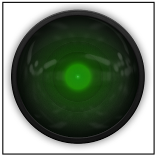

`https://kahoot.it/`

# What Can AI Do Today? – Videos, Articles and AIs



GitHub Copilot

# What Can AI Do Today?

results of our classroom poll:

- ✓ successfully complete an off-road car race
- ✗ beat a world champion table tennis player
- ✓ play guitar in a robot band
- ✓ do and fold the laundry
- ✓ drive safely in downtown Basel
- ✗ win a football match against a human team
- ✓ dance synchronously in a group of robots
- ✓ write code on the level of a CS student
- ✓ beat a world champion Chess, Go or Poker player
- ✓ create inspiring quotes
- ✓ compose music
- ✓ engage in a scientific conversation

# 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