Foundations of Artificial Intelligence

2. Introduction: AI Past and Present

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February 22, 2023

Introduction: Overview

Chapter overview: introduction

- 1. What is Artificial Intelligence?
- 2. AI Past and Present
- 3. Rational Agents
- 4. Environments and Problem Solving Methods

A Short History of AI

Origins (Until ca. 1943)

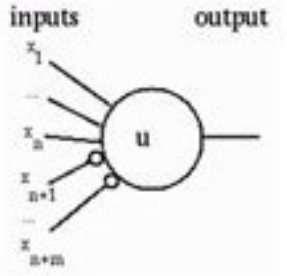
Philosophy, mathematics, psychology and linguistics asked similar questions that influence AI.

Inception (1943–1956)

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

Inception (1943–1956)

Artificial Neurons



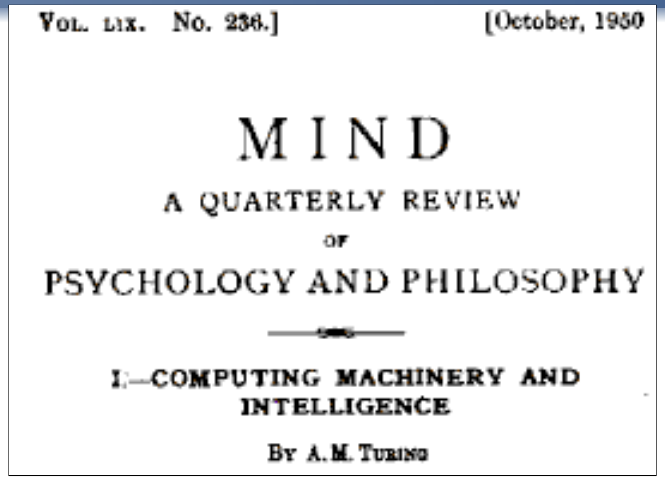
1950 1960 1970 1980 1990 2000 ...

W. McCulloch & W. Pitts (1943)

- first computational model of artificial neuron
- network of neurons can compute any computable function
- basis of deep learning

Inception (1943–1956)

Artificial Neurons


Vol. lix. No. 236.] [October, 1950

MIND

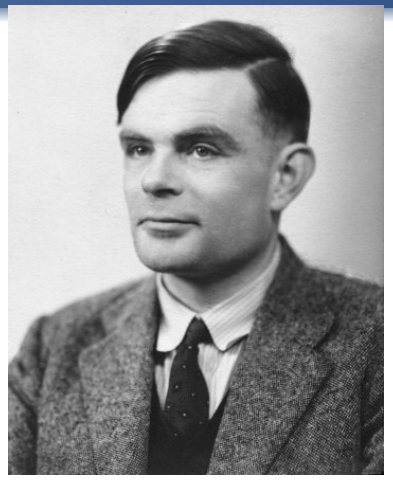
A QUARTERLY REVIEW

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)

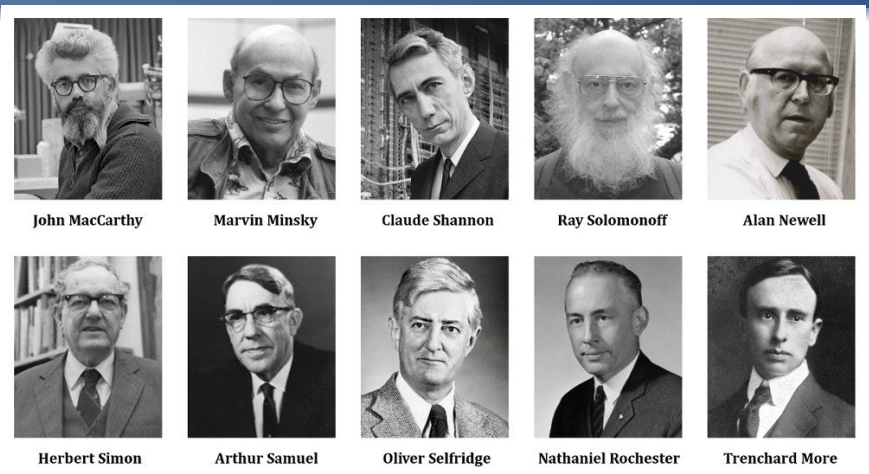
- famous for introducing Turing test
- (still) relevant discussion of AI potential and requirements
- suggests core AI aspects: knowledge representation, reasoning, language understanding, learning

Inception (1943–1956)

Artificial Neurons

Dartmouth

Turing Test

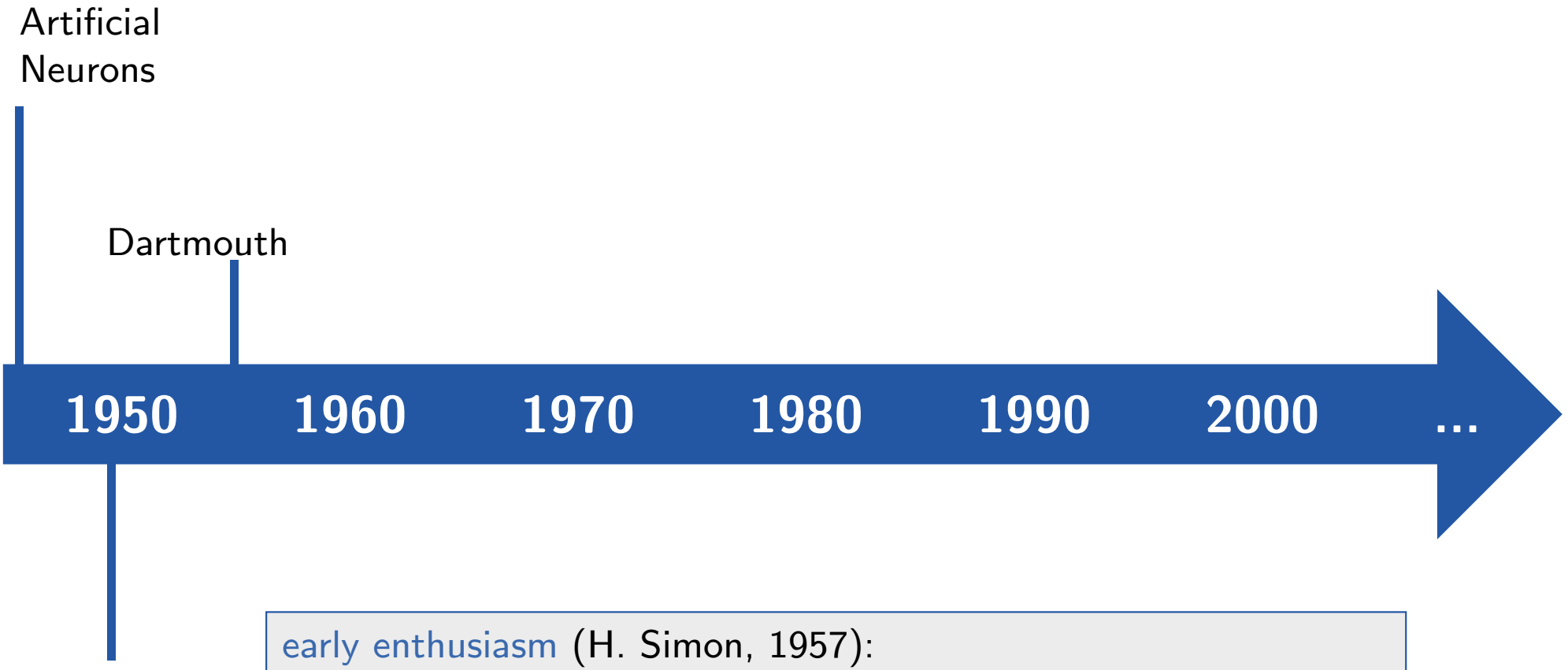


1950 1960 1970 1980 1990 2000 ...

Dartmouth workshop (1956)

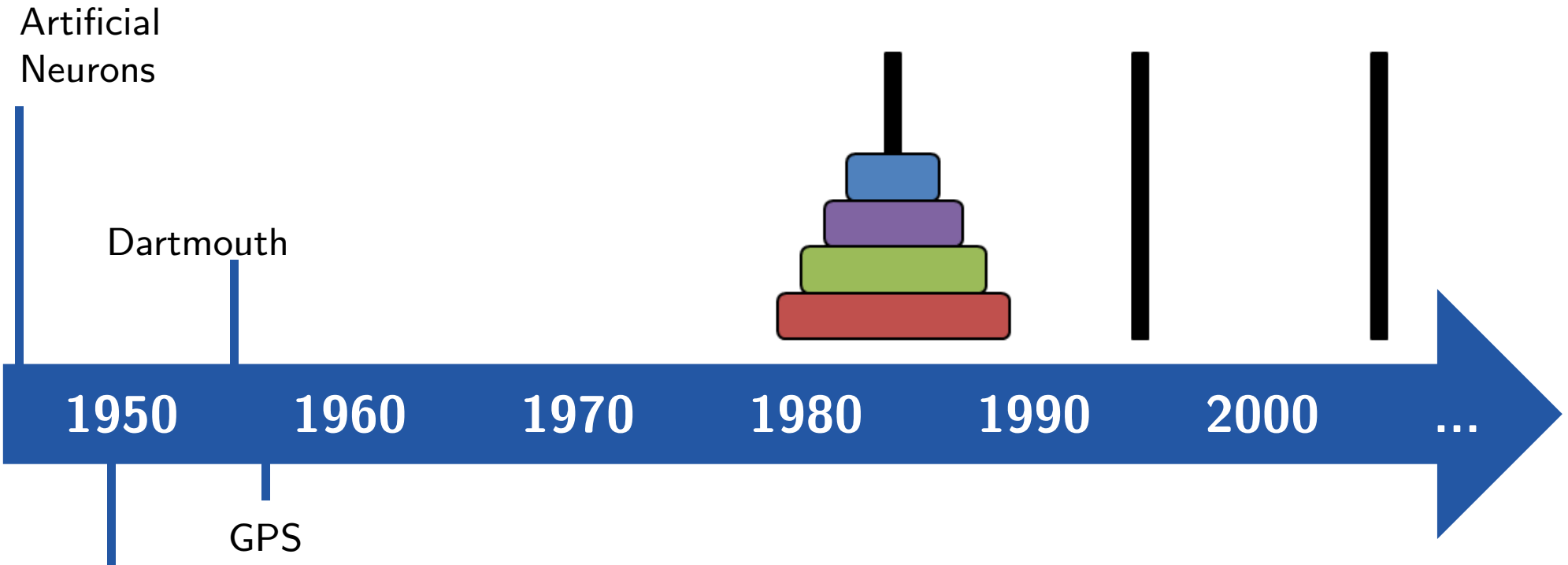
- ambitious proposal: "An attempt will be made to find how to make machines use language, [...] solve kinds of problems now reserved for humans, and improve themselves."
- no important breakthrough
- J. McCarthy coins term artificial intelligence

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."

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

Enthusiasm (1952–1969)

Artificial Neurons

RL for Checkers

Dartmouth

1950 1960 1970 1980 1990 2000 ...

GPS

Turing Test

Checkers AI (A. Samuel, 1959)

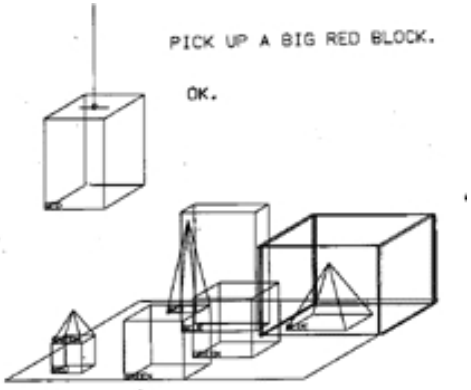
- popularized term machine learning
- learned to play at strong amateur level
- incorporates ideas of reinforcement learning

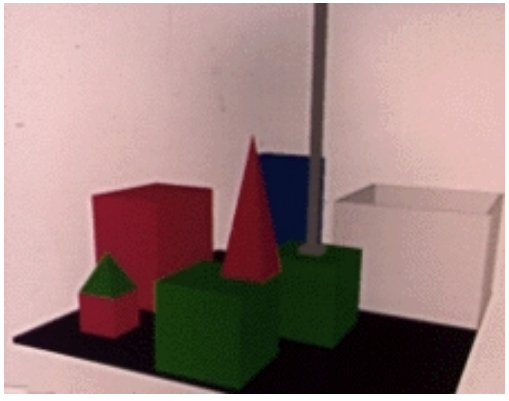
Enthusiasm (1952–1969)

Artificial Neurons

RL for Checkers

Dartmouth





1950 1960 1970 1980 1990 2000 ...

Turing Test

GPS

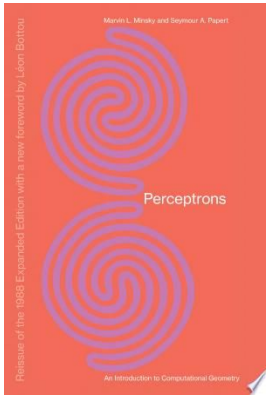
Microworlds

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

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

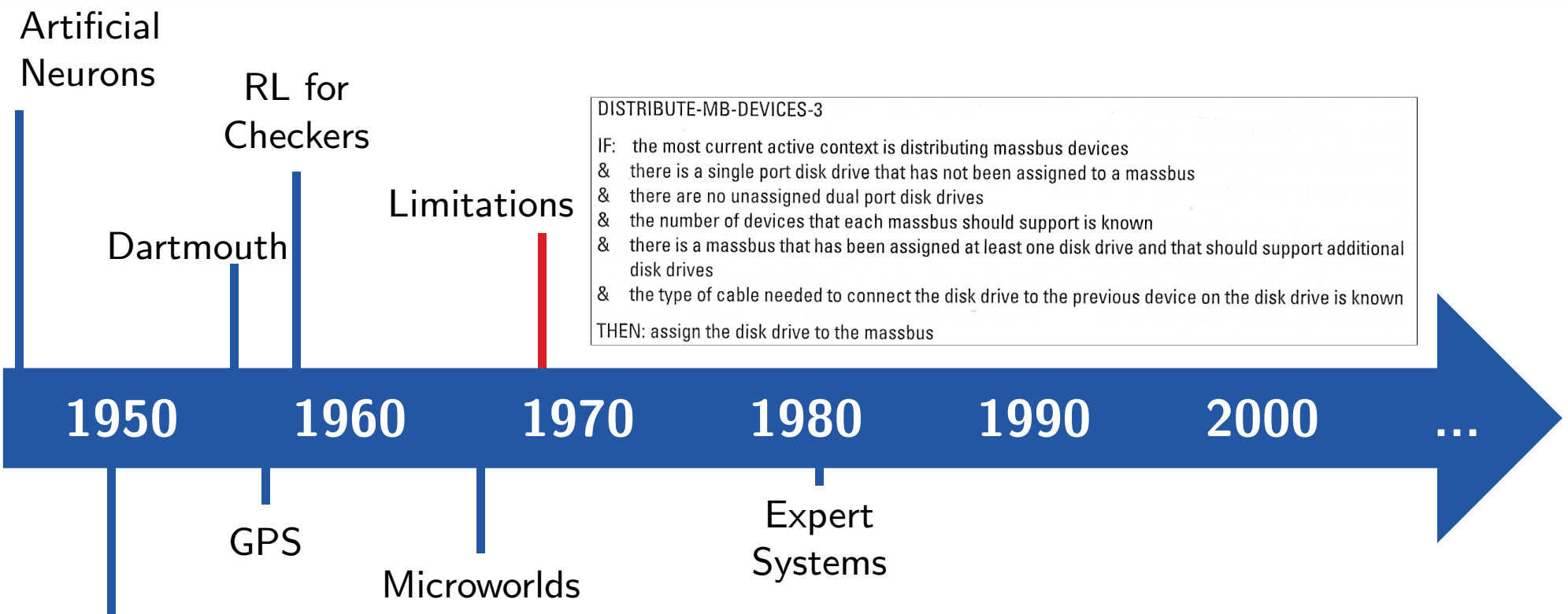
⇝ `http://hci.stanford.edu/~winograd/shrdlu/`

A Dose of Reality (1966–1973)



- realization that unlimited computational power is illusion
- 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)

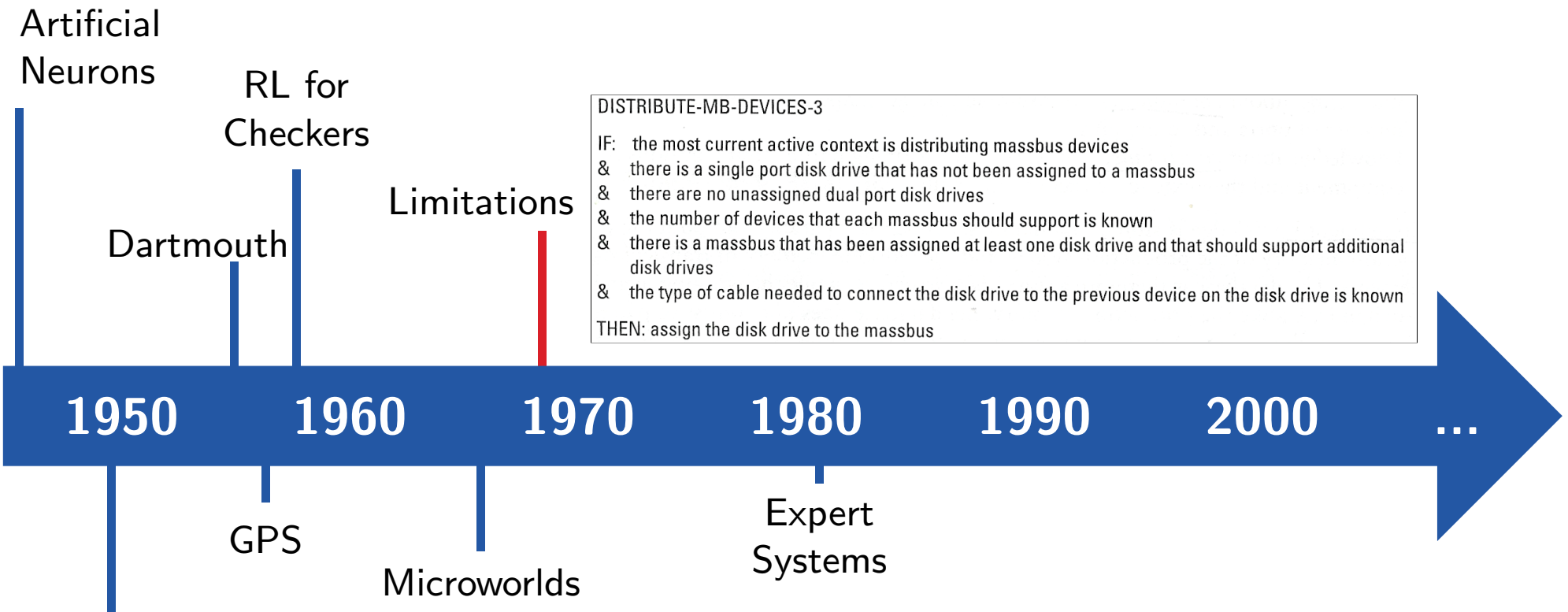


1980s: AI gold rush due to rule-based expert systems

- commercially successful
- (human) expert knowledge as input
- allows automatic reasoning on larger problems in narrower applications

$\rightsquigarrow$ enabled research boom

Expert Systems (1969–1986)



DISTRIBUTE-MB-DEVICES-3

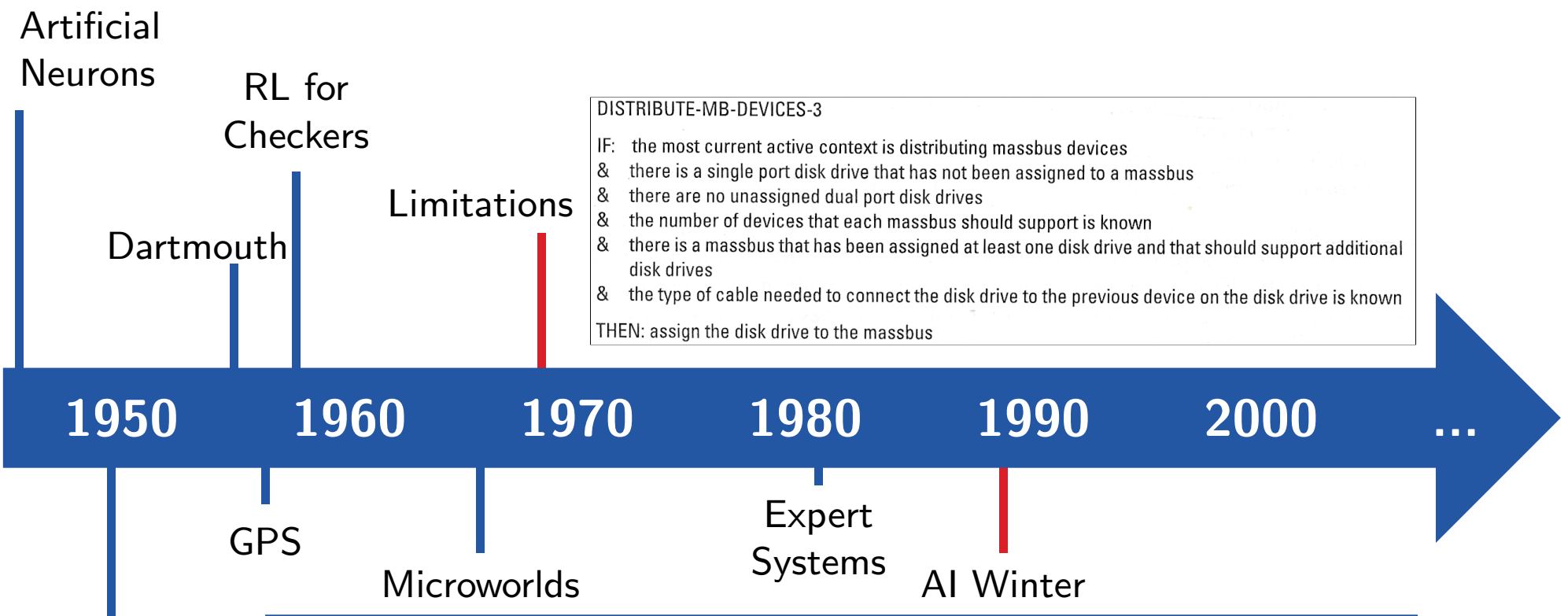
IF: the most current active context is distributing massbus devices
& there is a single port disk drive that has not been assigned to a massbus
& there are no unassigned dual port disk drives
& the number of devices that each massbus should support is known
& there is a massbus that has been assigned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

example: R1 (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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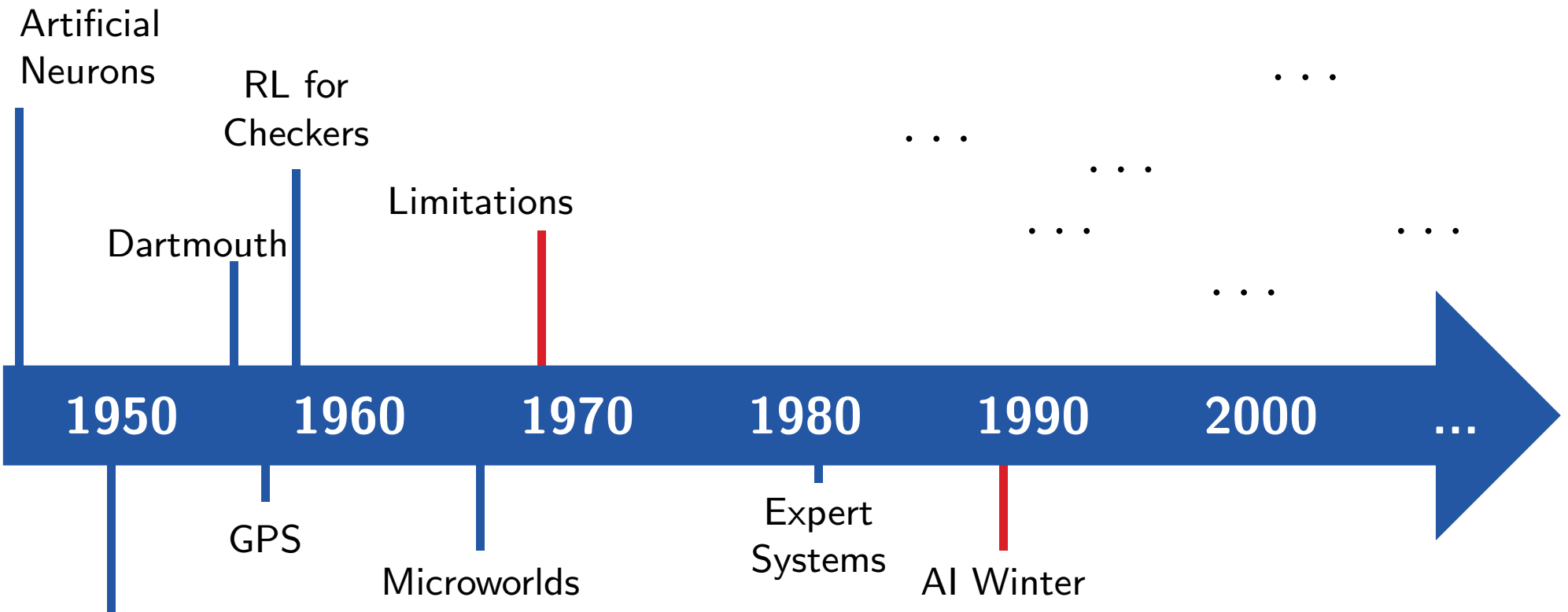
end of 1980s: AI Winter

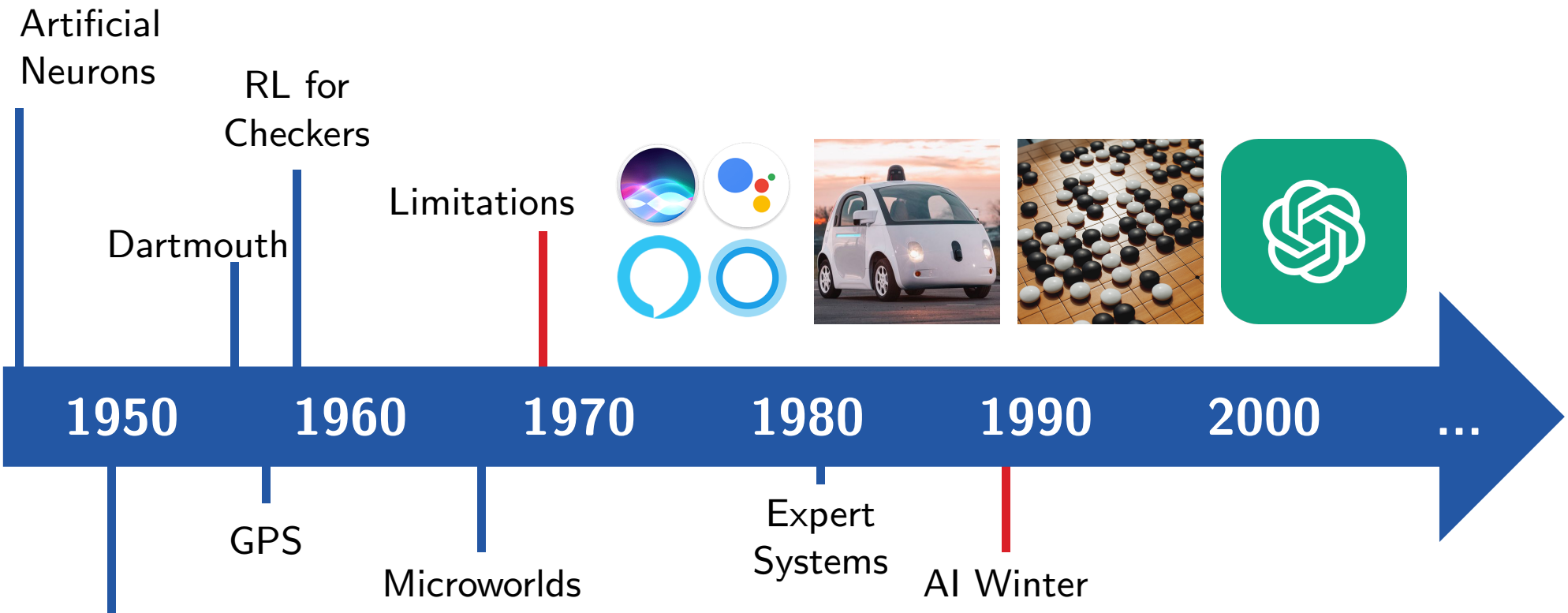
- companies failed to deliver promises
- expert systems difficult to maintain
- expert systems susceptible to uncertainty

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?

Where are we Today?

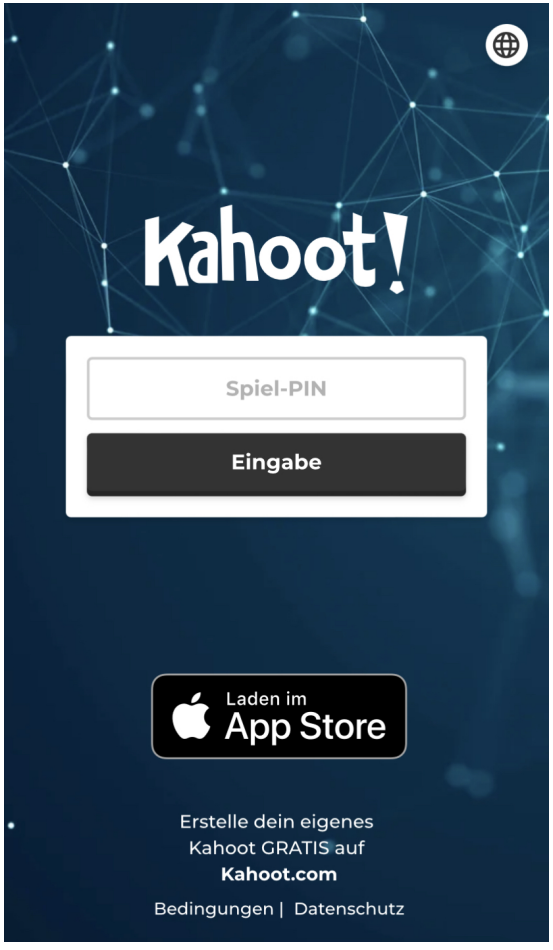
- many coexisting paradigms
  - reactive vs. deliberative
  - data-driven vs. model-driven
  - often hybrid approaches
- many methods, often borrowing from other research areas
  - logic, decision theory, statistics, ...
- different approaches
  - theoretical
  - algorithmic/experimental
  - application-oriented

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

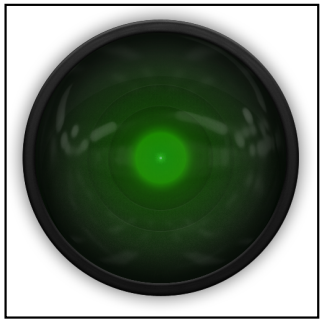
What can AI do Today?

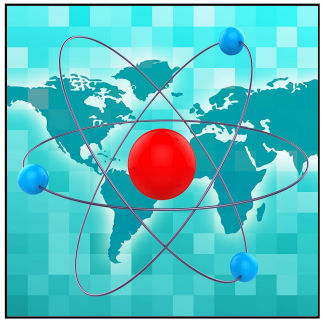


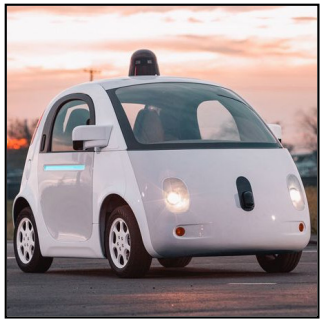
url: `https://kahoot.it/`

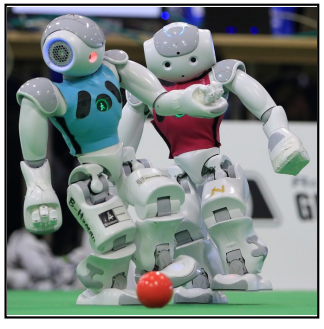
What can AI do Today? – Videos, Articles and AIs

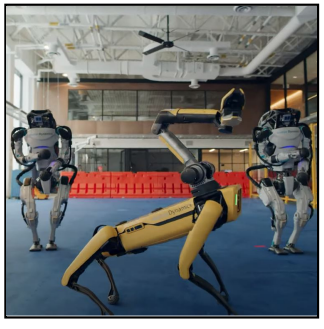
GitHub Copilot











What can AI do Today?

- ✓ successfully complete an off-road race
- ✗ beat a world champion table tennis player
- ✓ play guitar in a robot band
- ✓ do and fold the laundry
- ? 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
- ? drive safely in downtown Zürich
- ✗ win a football match against a human team
- ✓ dance synchronously in a group of robots

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