Einführung in die Künstliche Intelligenz

Teacher

Prof. Kristian Kersting (Artificial Intelligence and Machine Learning)

Homepage

to be announced

Time

Wednesday 16:15 -17:55

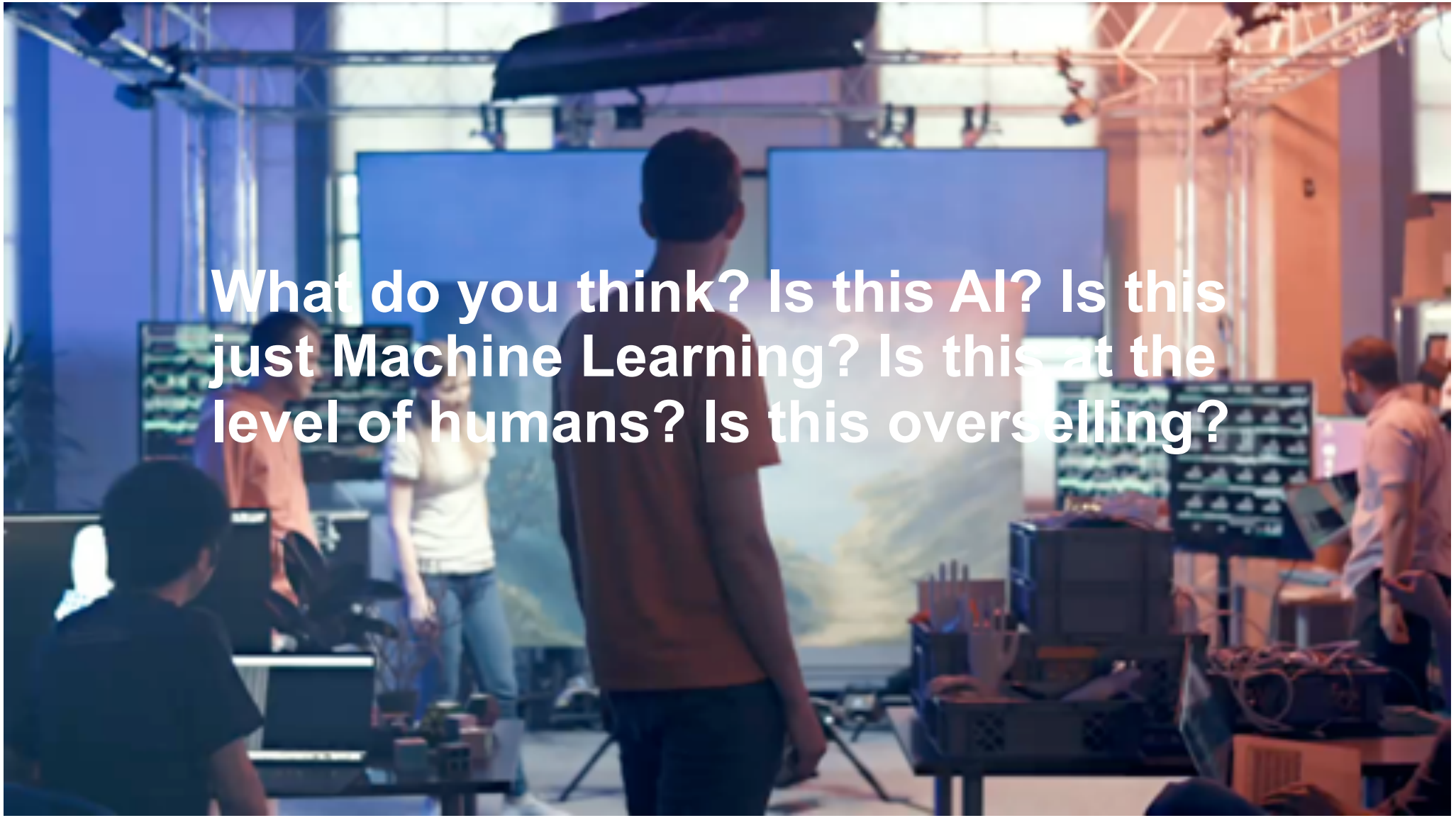
2 VO + 1 UE

Lectures and exercises will be each 2h

Übungen (Tutor: Karl Stelzner)

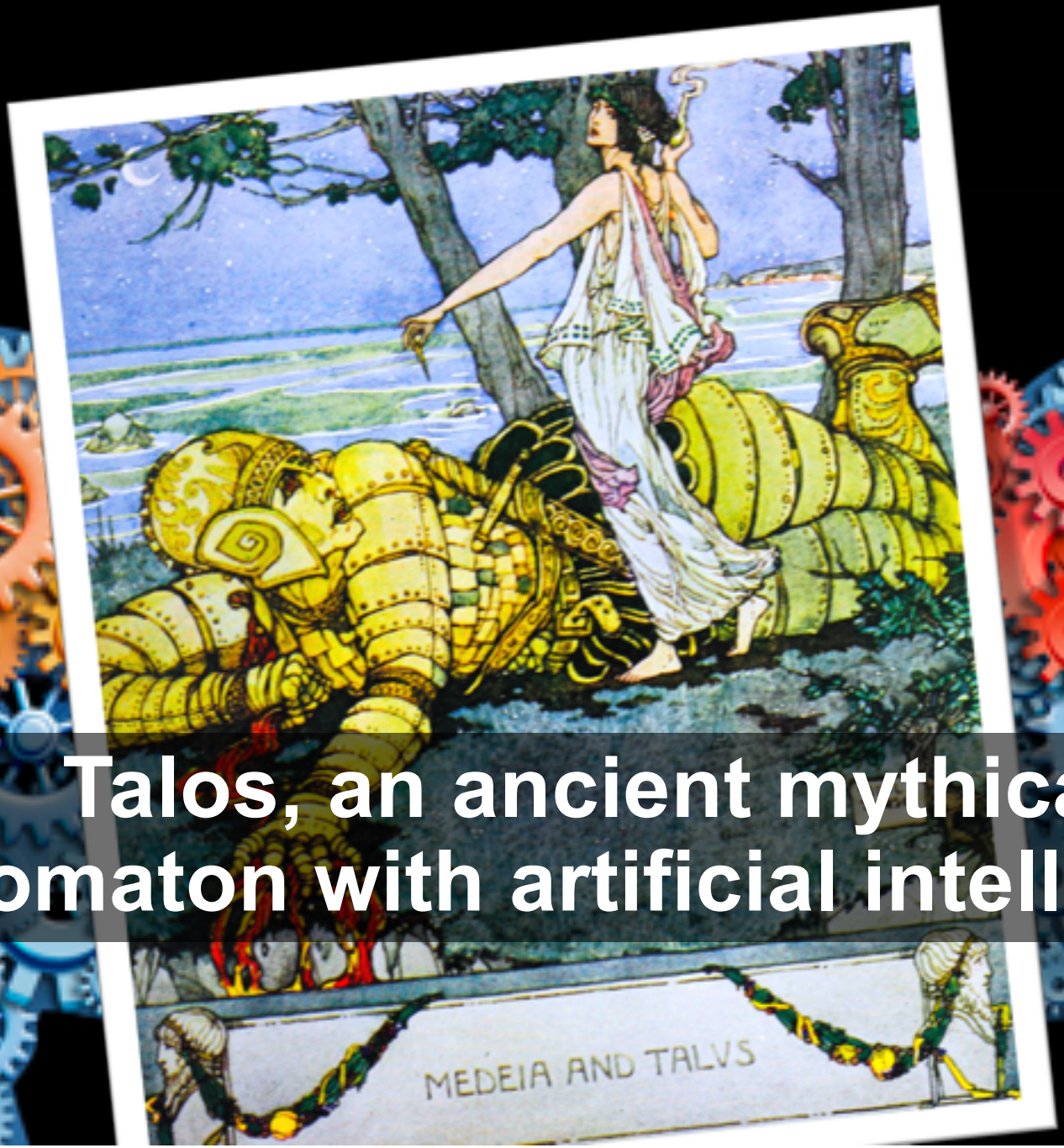
Just presentation of solutions, no (re)marks

Solving Rubik‘s Cube?



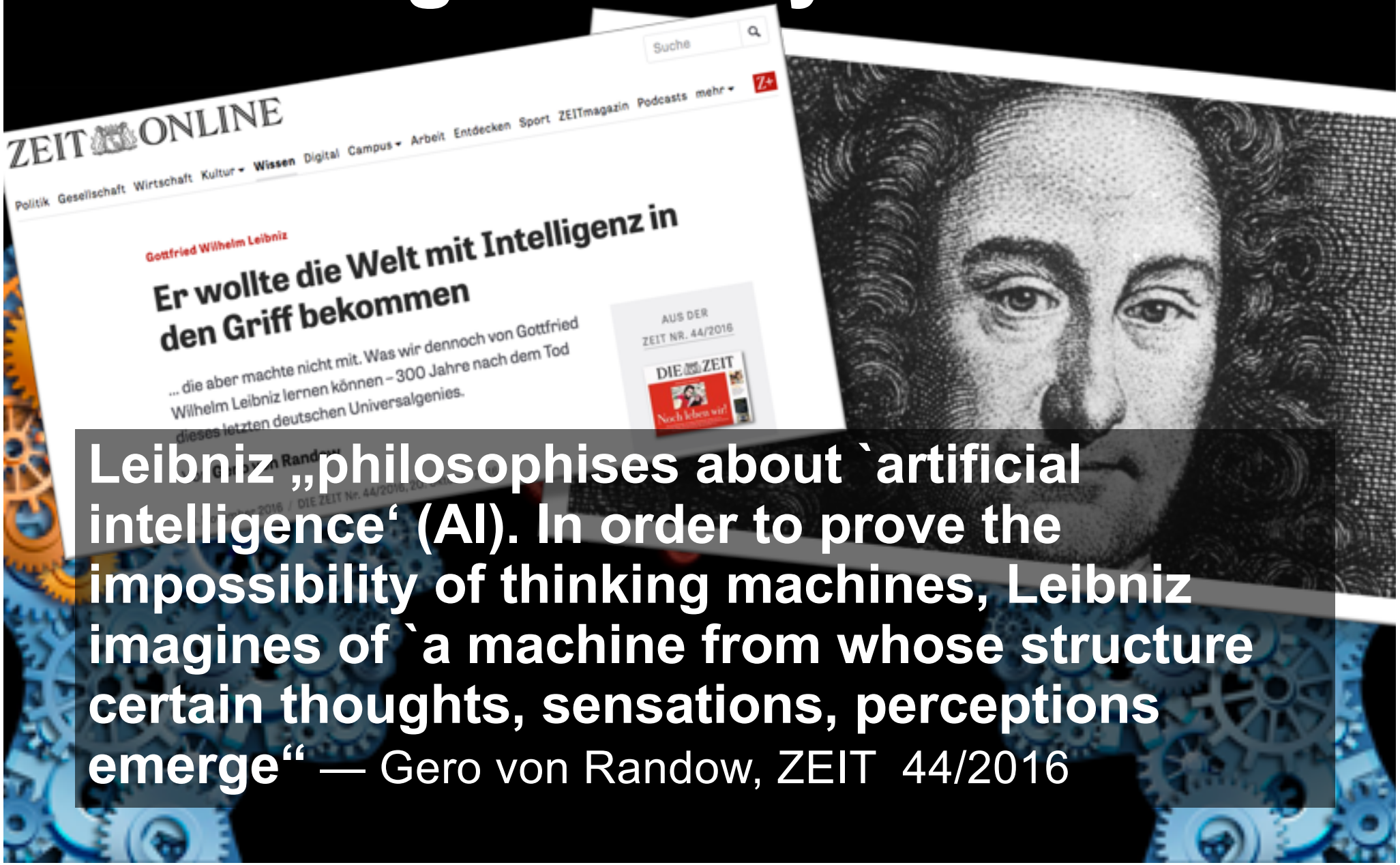
OpenAI: https://www.youtube.com/watch?v=x4O8pojMF0w

The dream of AI is not new



Talos, an ancient mythical automaton with artificial intelligence

The dream of an artificially intelligent entity is not new



Leibniz „philosophises about `artificial intelligence‘ (AI). In order to prove the impossibility of thinking machines, Leibniz imagines of `a machine from whose structure certain thoughts, sensations, perceptions emerge“ — Gero von Randow, ZEIT 44/2016

AI today

the INQUIRER

Internet of Things | Open Source | Hardware | Software

Artificial intelligence will create the next industrial revolution, experts claim

...ligent computer systems will replace the need for human-...

...esponsible for the next industrial revolution, ...puter systems replace certain ...

Artificial intelligence better than scientists at choosing successful embryos

'We won't waste time on treatments that won't work, so the patient should get ... says clinic director

Jane Kirby | 23 hours ago | 9 comments

BBC NEWS

Sign in | News | Sport | Weather | Shop

Technology

Stephen Hawking warns artificial intelligence could end mankind

...Humans, who are limited by slow biological evolution, couldn't compete and would be ...

Telegraph

HOME | NEW...

Lifestyle › Cars › News

Self-driving Tesla 'sav... by steering him to hos...

share

V/S

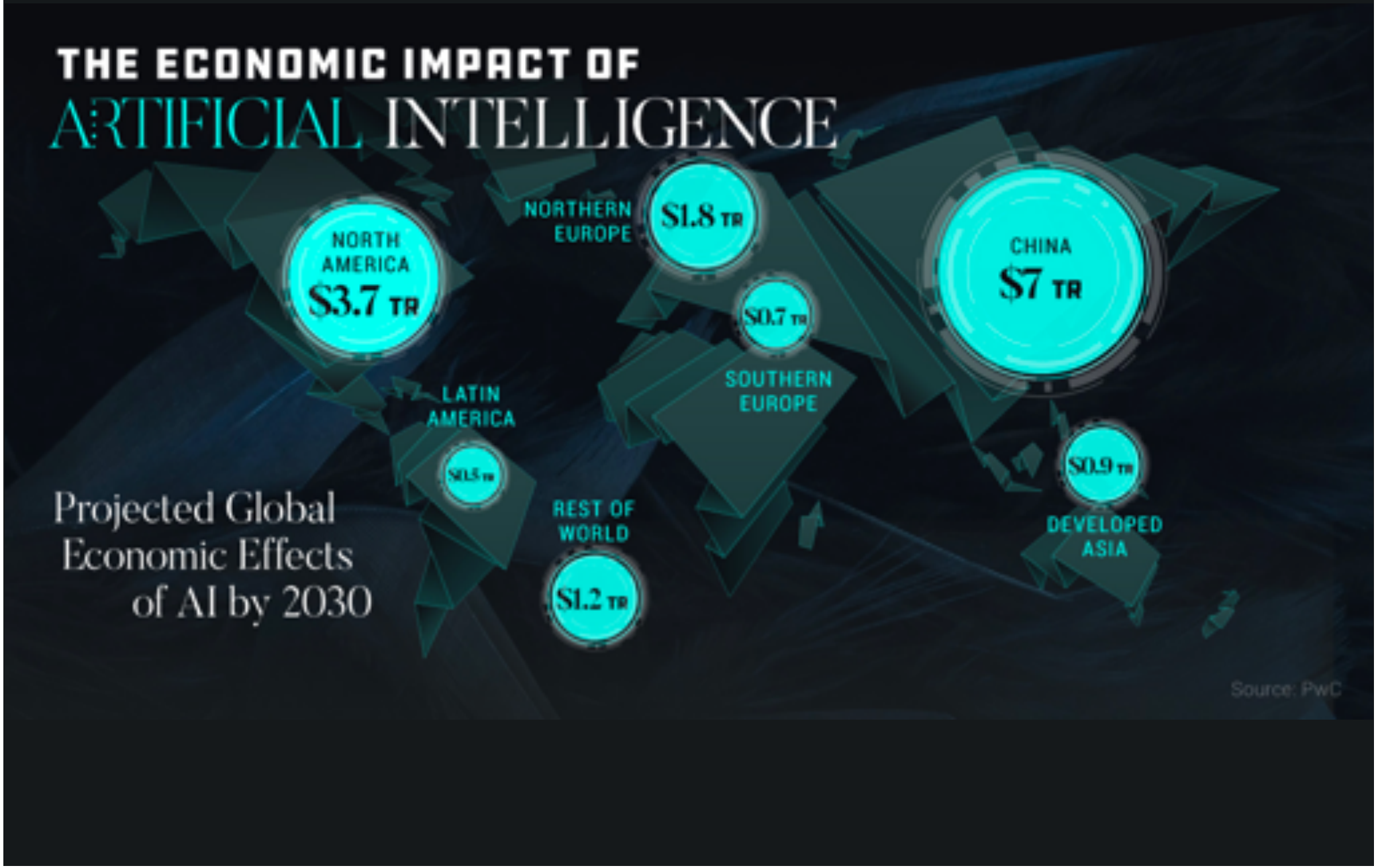
Elon Musk
@elonmusk
I've talked to Mark about this. His understanding of the subject is limited.

SCIENTIFIC AMERICAN DECEMBER 2016

Computers Now Recognize Patterns Better Than Humans Can

An approach to artificial intelligence that enables computers to recognize visual patterns better than humans are able to do

AI today


THE ECONOMIC IMPACT OF
ARTIFICIAL INTELLIGENCE
NORTH AMERICA
$3.7 TR
NORTHERN EUROPE
$1.8 TR
$0.7 TR
SOUTHERN EUROPE
CHINA
$7 TR
LATIN AMERICA
$0.5 TR
REST OF WORLD
$1.2 TR
$0.9 TR
DEVELOPED ASIA
Projected Global Economic Effects of AI by 2030
Source: PwC

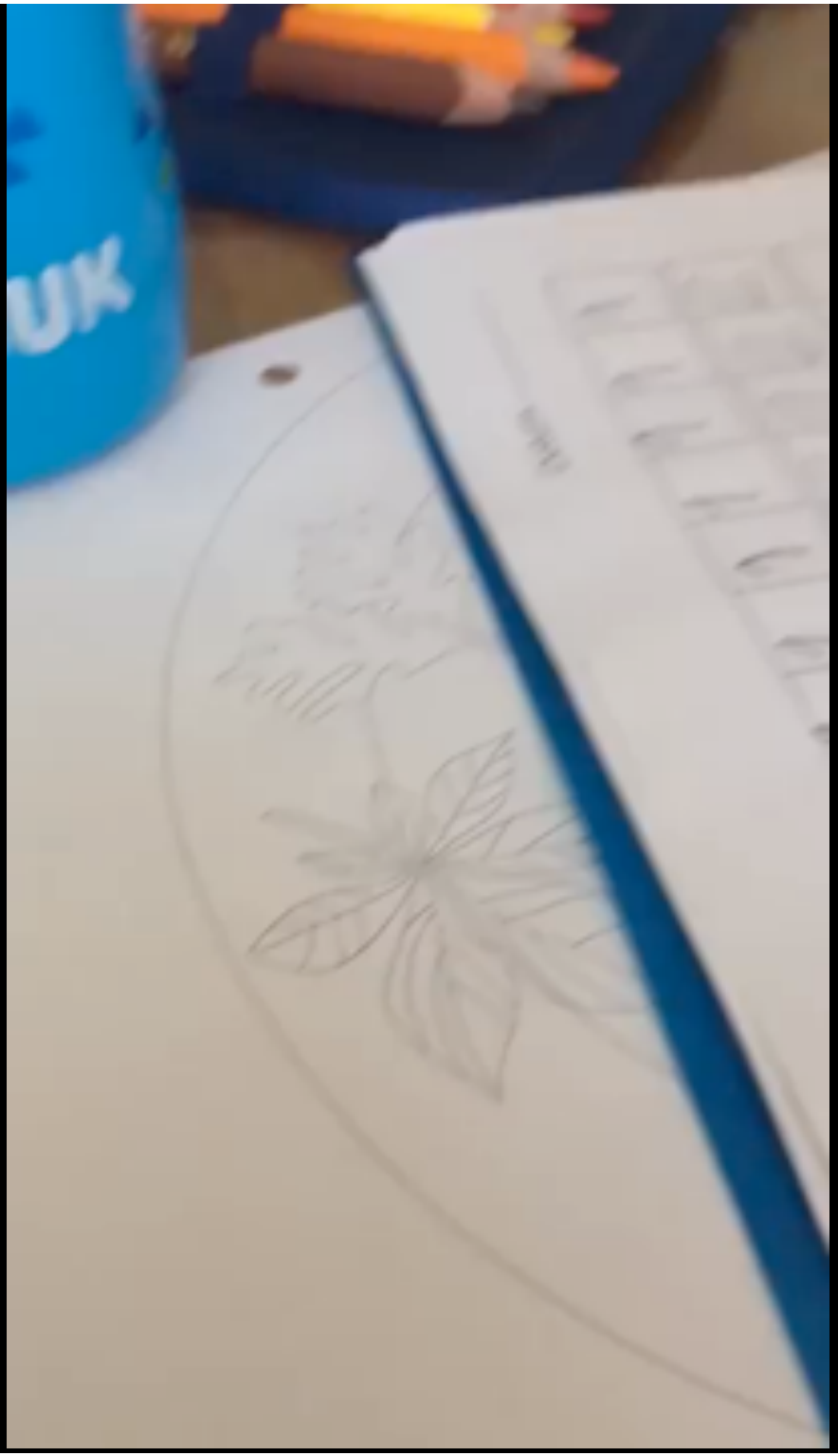
So, AI has many faces

Is AI the saviour of the world …

… or will autonomous self-aware robots bring about the downfall of humanity?

What is AI?

Humans are smart

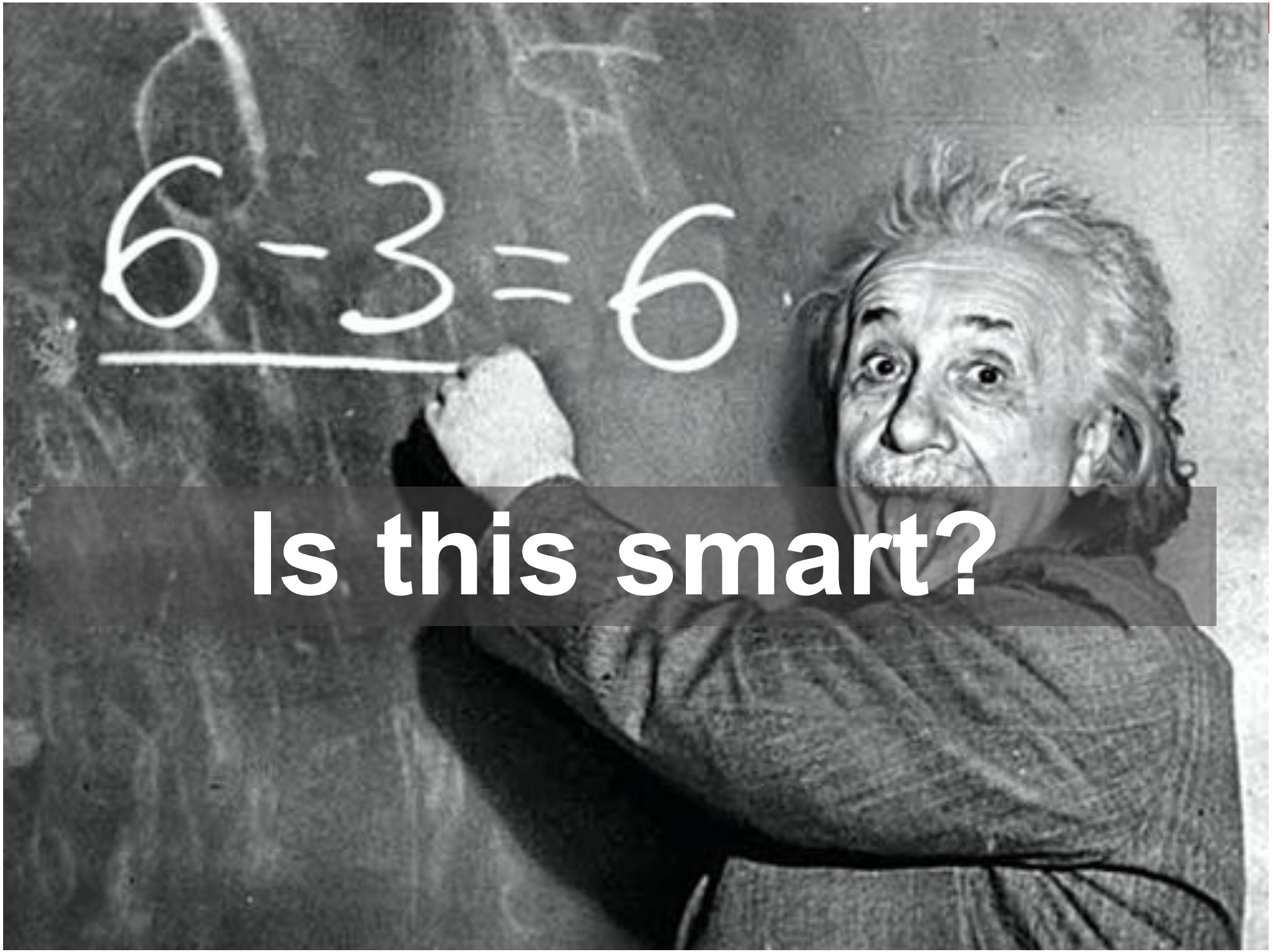


Can machines be smart, too?

What is actually Intelligence?


Is this smart?


Is this smart?
N24


6-3=6
Is this smart?

Intelligence has many qualities.

It is difficult to directly capture/ measure it.

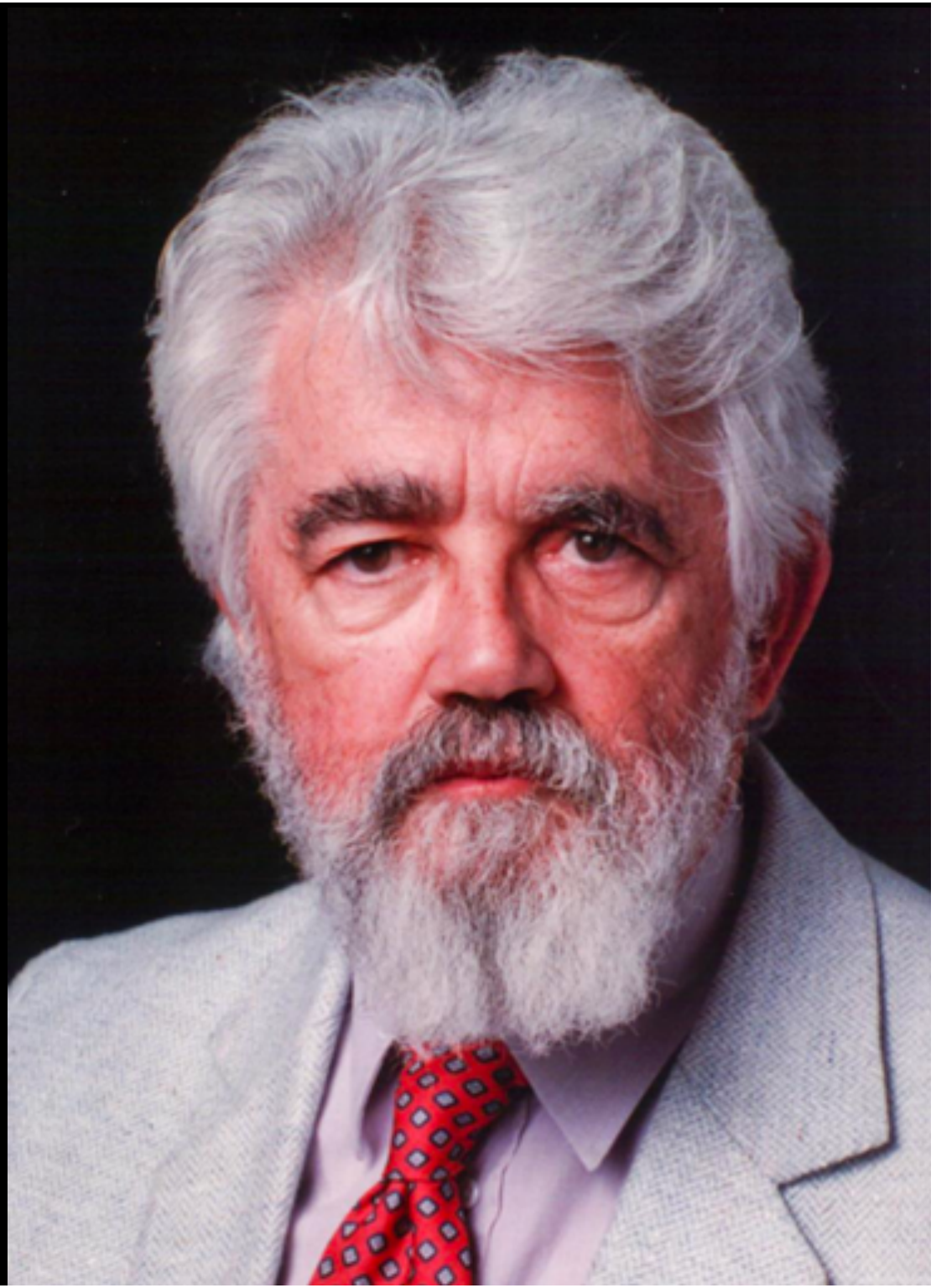
What is AI?

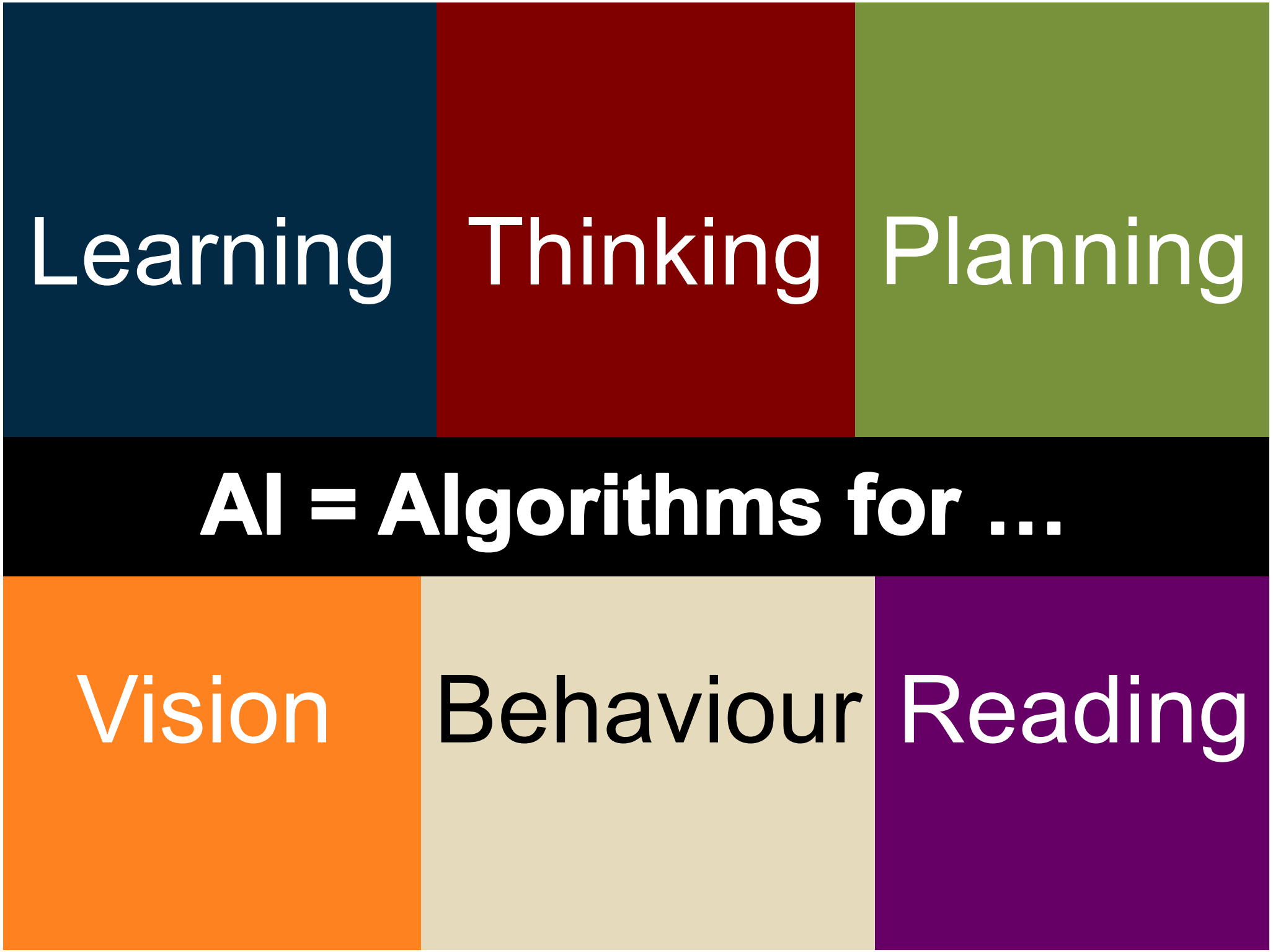
What is AI?

„the science and engineering of making intelligent machines, especially intelligent computer programs.

It is related to the similar task of using computers to understand human intelligence, but AI does not have to confine itself to methods that are biologically observable.“

- John McCarthy, Stanford (1956), coined the term AI, Turing Awardee

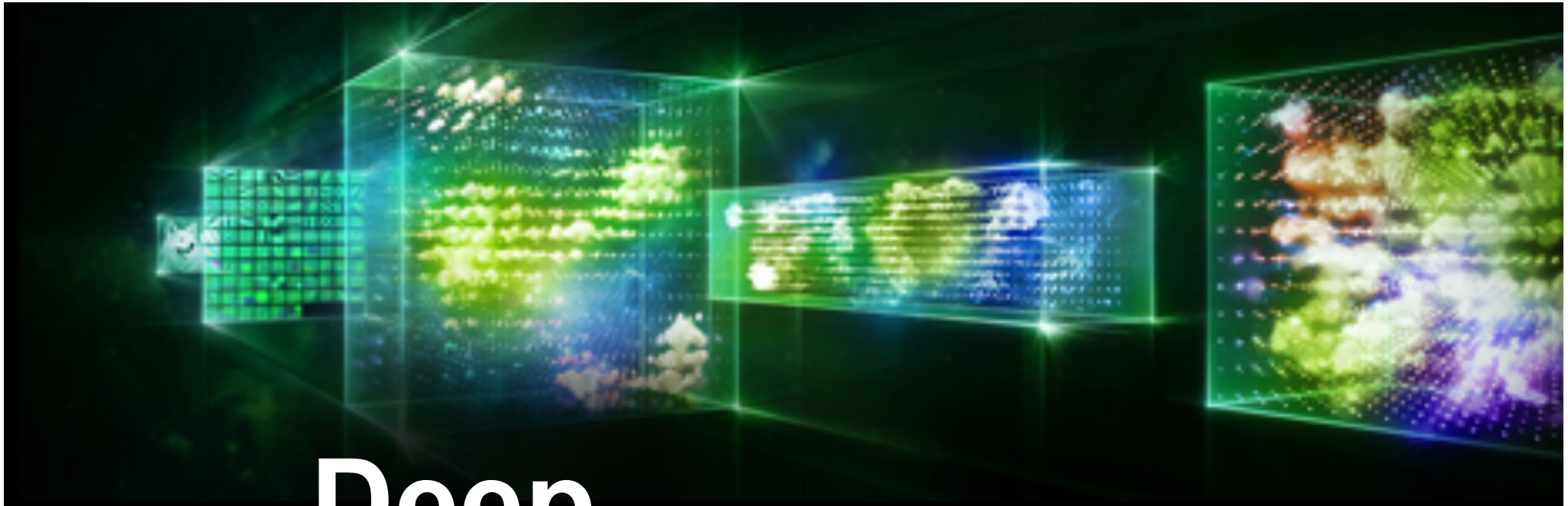



Learning
Thinking
Planning
AI = Algorithms for …
Vision
Behaviour
Reading

Machine Learning

the science "concerned with the question of how to construct computer programs that automatically improve with experience”

- Tom Mitchell (1997) CMU



Deep Learning

a form of machine learning that makes use of artificial neural networks

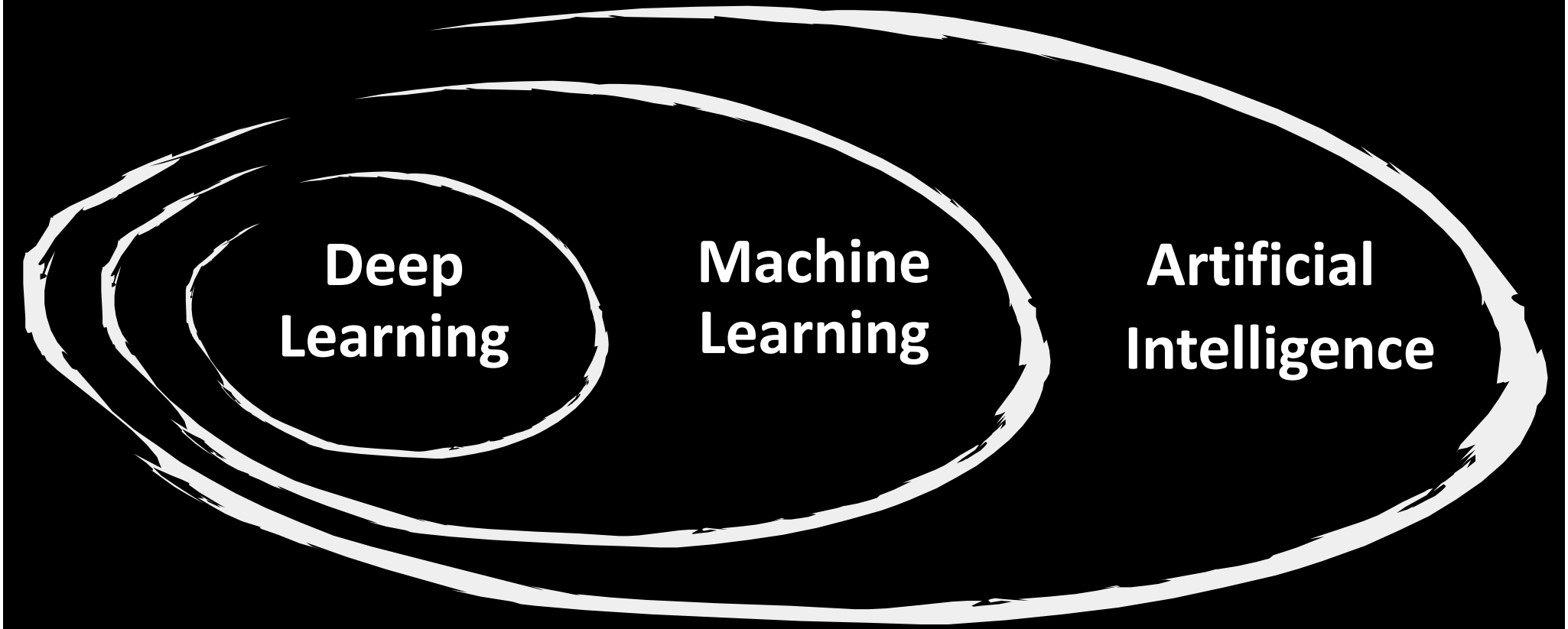
Geoffrey Hinton
Google
Univ. Toronto (CAN)

Yann LeCun
Facebook (USA)

Yoshua Bengio
Univ. Montreal (CAN)

Turing Awardees 2019

Overall Picture



A closer look at **the history of AI**

1956 Birth of AI

A Proposal for the

DARTMOUTH SUMMER RESEARCH PROJECT ON ARTIFICIAL INTELLIGENCE

We propose that a 2 month, 10 man study of artificial intelligence be carried out during the summer of 1956 at Dartmouth College in Hanover, New Hampshire. The study is to proceed on the basis of the conjecture that every aspect of learning or any other feature of intelligence can in principle be so precisely described that a machine can be made to simulate it. An attempt will be made to find how to make machines use language, form abstractions and concepts, solve kinds of problems now reserved for humans, and improve themselves. We think that a significant advance can be made in one or more of these problems if a carefully selected group of scientists work on it together for a summer.

John McCarthy
Turing Award 1971

Marvin Minsky
Turing Award 1969

Allen Newell
Turing Award 1975

Herbert A. Simon
Turing Award 1975
Nobel Prize 1978

… and of Cognitive Science

Artificial Neural Networks

Learning representations by back-propagating errors

David E. Rumelhart*, Geoffrey E. Hinton† & Ronald J. Williams*

* Institute for Cognitive Science, C-015, University of California, San Diego, La Jolla, California 92093, USA
† Department of Computer Science, Carnegie-Mellon University, Pittsburgh, Philadelphia 15213, USA

COGNITIVE SCIENCE **14,** 179–211 (1990)

Finding Structure in Time

JEFFREY L. ELMAN
University of California, San Diego

COGNITIVE SCIENCE 9, 147–169 (1985)

A Learning Algorithm for Boltzmann Machines*

DAVID H. ACKLEY
GEOFFREY E. HINTON
Computer Science Department
Carnegie-Mellon University
TERRENCE J. SEJNOWSKI
Biophysics Department
The Johns Hopkins University

Biological Cybernetics

Biol. Cybernetics 36, 193–202 (1980)

Neocognitron: A Self-organizing Neural Network Model for a Mechanism of Pattern Recognition Unaffected by Shift in Position

Kunihiko Fukushima
NHK Broadcasting Science Research Laboratories, Kinuta, Setagaya, Tokyo, Japan

Psychological Review
Vol. 65, No. 6, 1958

THE PERCEPTRON: A PROBABILISTIC MODEL FOR INFORMATION STORAGE AND ORGANIZATION IN THE BRAIN[1]

F. ROSENBLATT
Cornell Aeronautical Laboratory

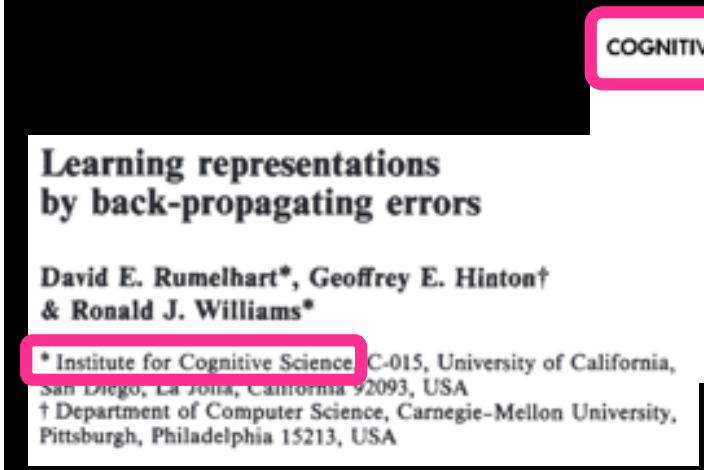
Psychological Review
1981, Vol. 88, No. 2, 135–170

0033-295X/81/8802-0135$00.75

Toward a Modern Theory of Adaptive Networks: Expectation and Prediction

Richard S. Sutton and Andrew G. Barto
Computer and Information Science Department
University of Massachusetts—Amherst

Artificial Neural Networks



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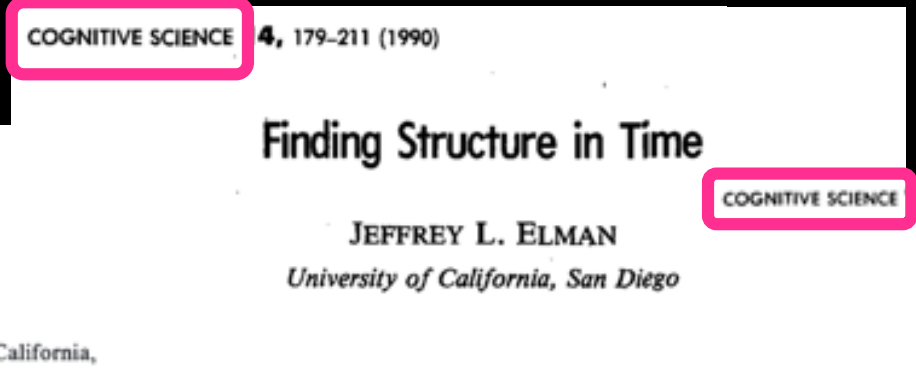

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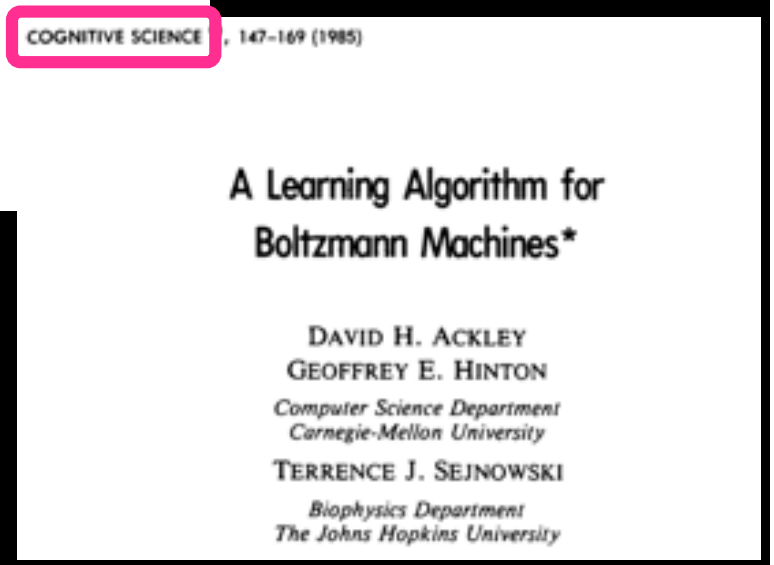

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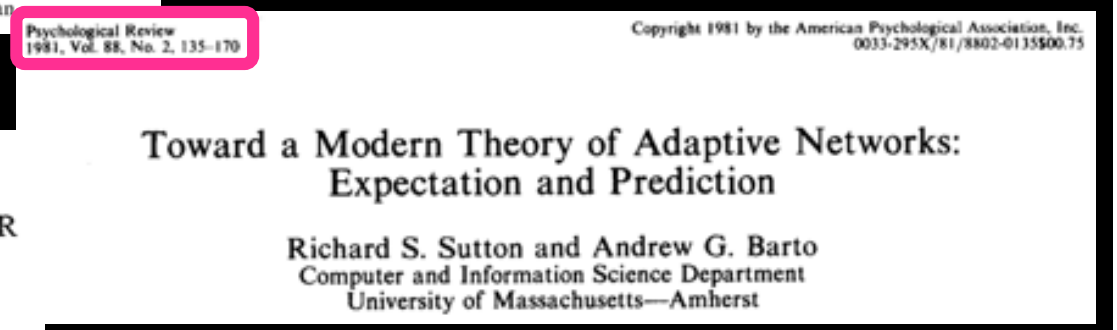

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Copyright 1981 by the American Psychological Association, Inc.
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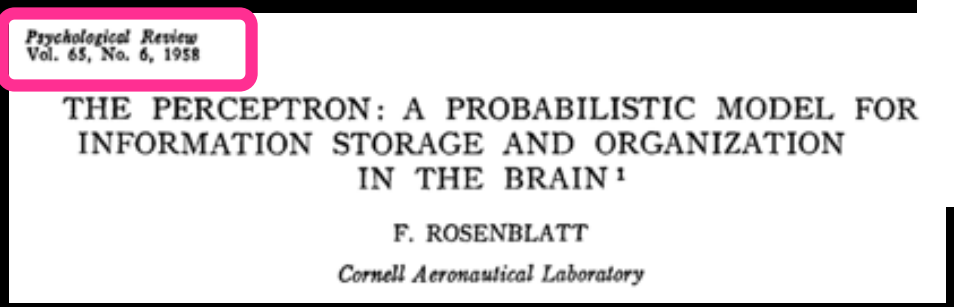

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slide after C. Rothkopf (TUD), after J.Tenenbaum (MIT)

Algorithms of intelligent behaviour teach us a lot about ourselves

The twin science: cognitive science

"How do we humans get so much from so little?" and by that I mean how do we acquire our understanding of the world given what is clearly by today's engineering standards so little data, so little time, and so little energy.

Centre for Cognitive Science at TU Darmstadt

Establishing cognitive science at the Technische Universität Darmstadt is a long-term commitment across multiple departments (see Members to get an impression on the interdisciplinary of the supporting groups and departments). The TU offers a strong foundation including several established top engineering groups in Germany, a prominent computer science department (which is among the top four in Germany), a

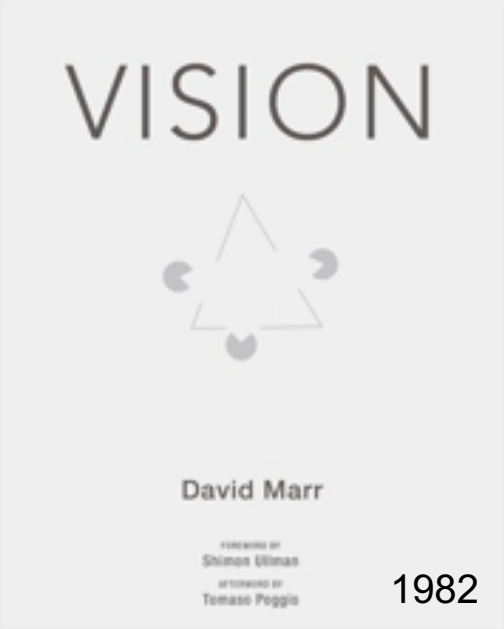
Centre for Cognitive Science

Josh Tenenbaum, MIT

Lake, Salakhutdinov, Tenenbaum, Science 350 (6266), 1332-1338, 2015

Tenenbaum, Kemp, Griffiths, Goodman, Science 331 (6022), 1279-1285, 2011

Three levels of description

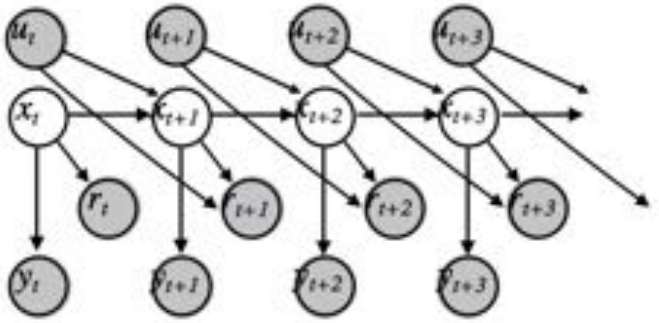


1982

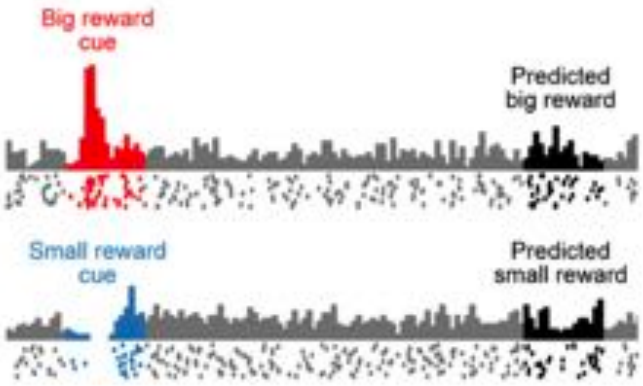
Computational
Why do things work the way they work? What is the goal of the computation? What are the unifying principles?

$$\textit{maximize:}\quad R_t = r_{t+1} + r_{t+2} + \cdots + r_T$$

Algorithmic
What represetation can implement such computations? How does the choice of the representation determine the algorithm

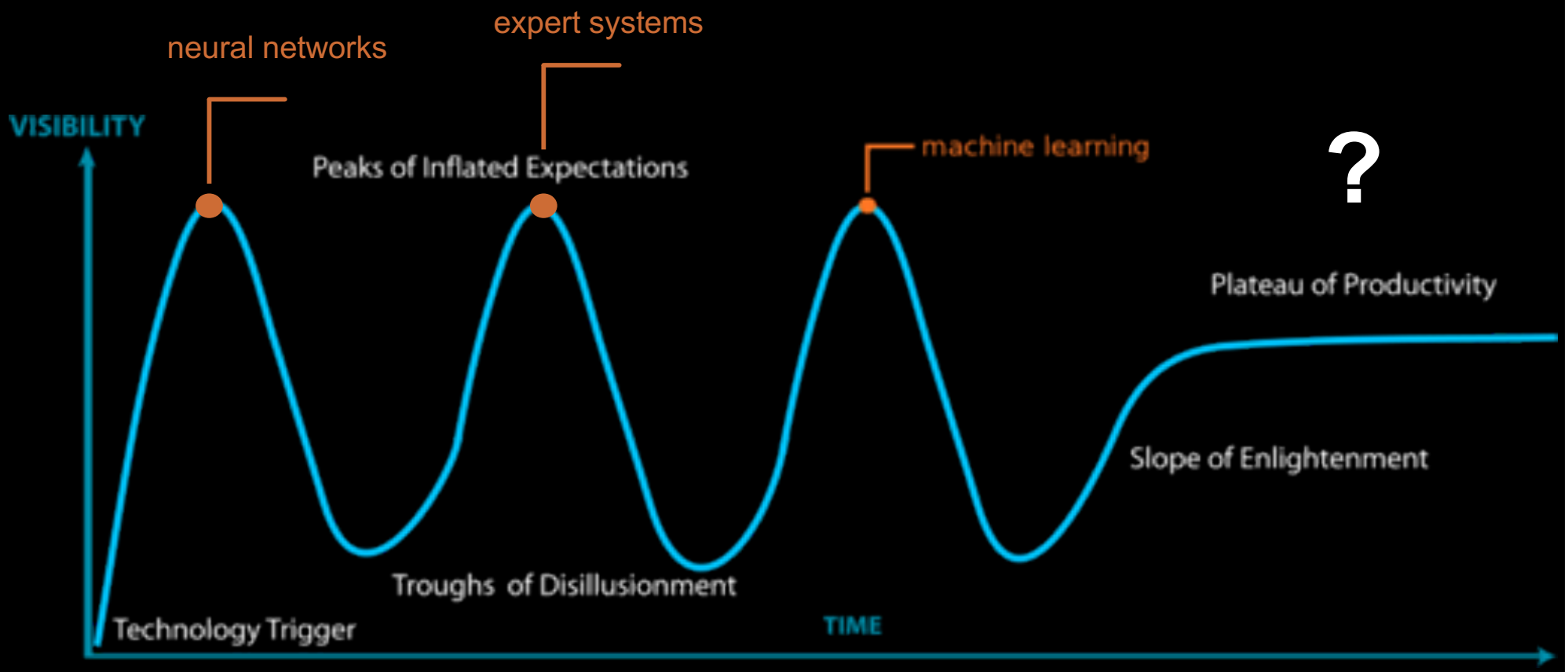


Implementational
How can such a system be built in hardware? How can neurons carry out the computations?



slide after C. Rothkopf (TUD)

The history of AI in a nutshell



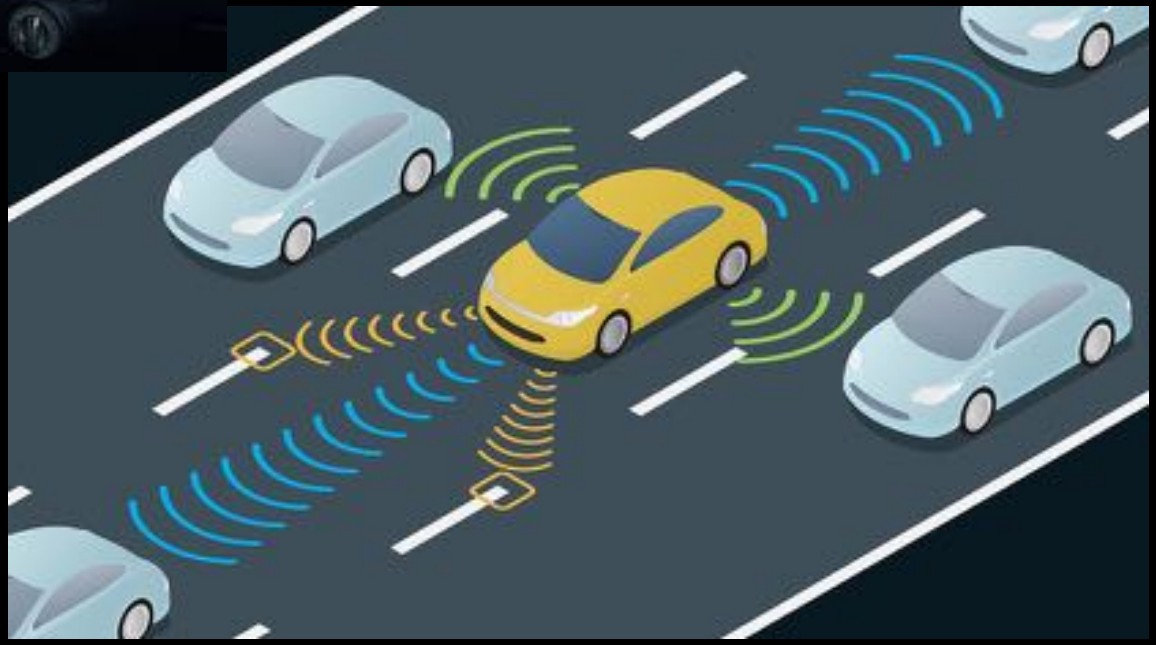
1956

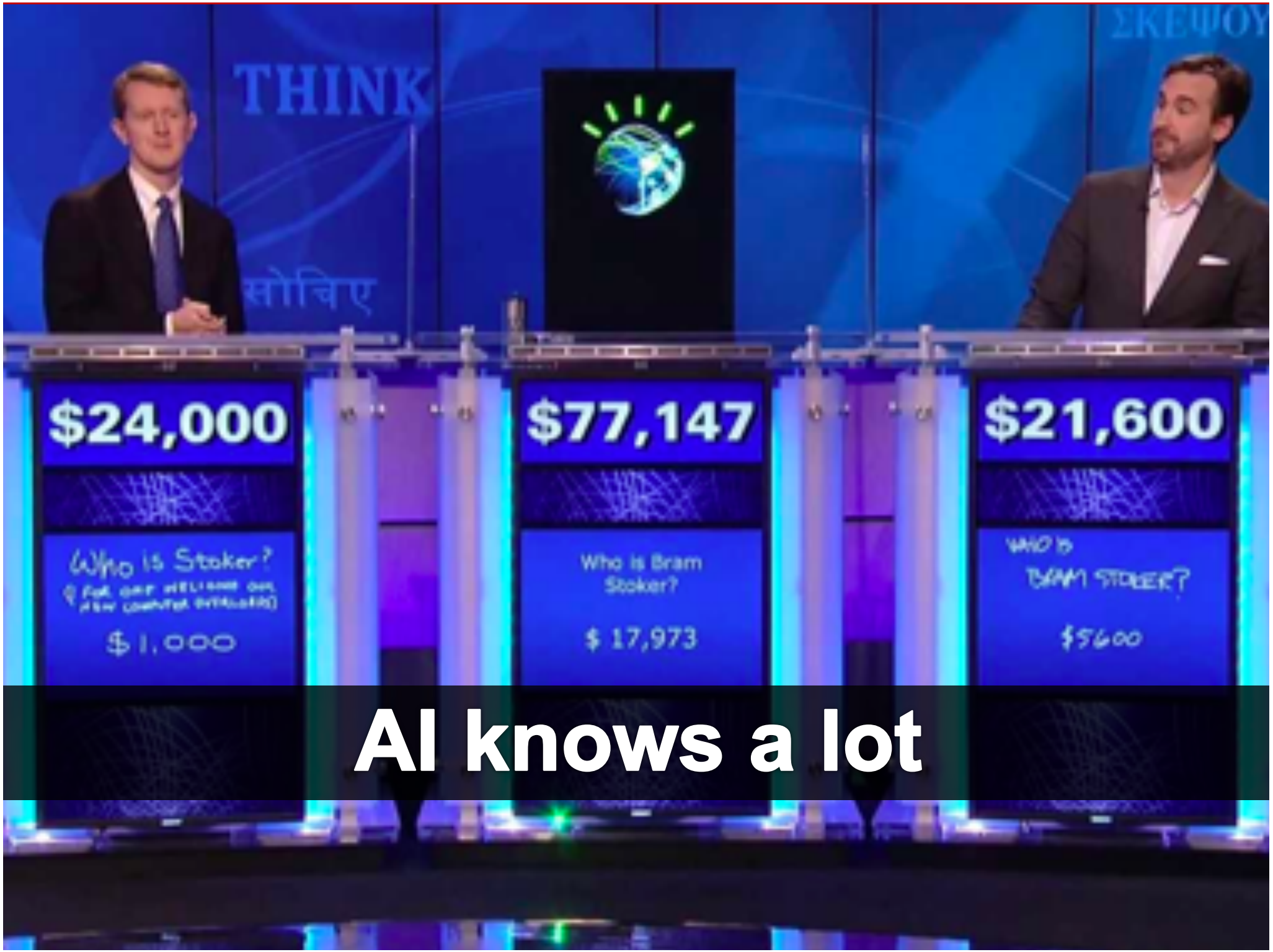
2019

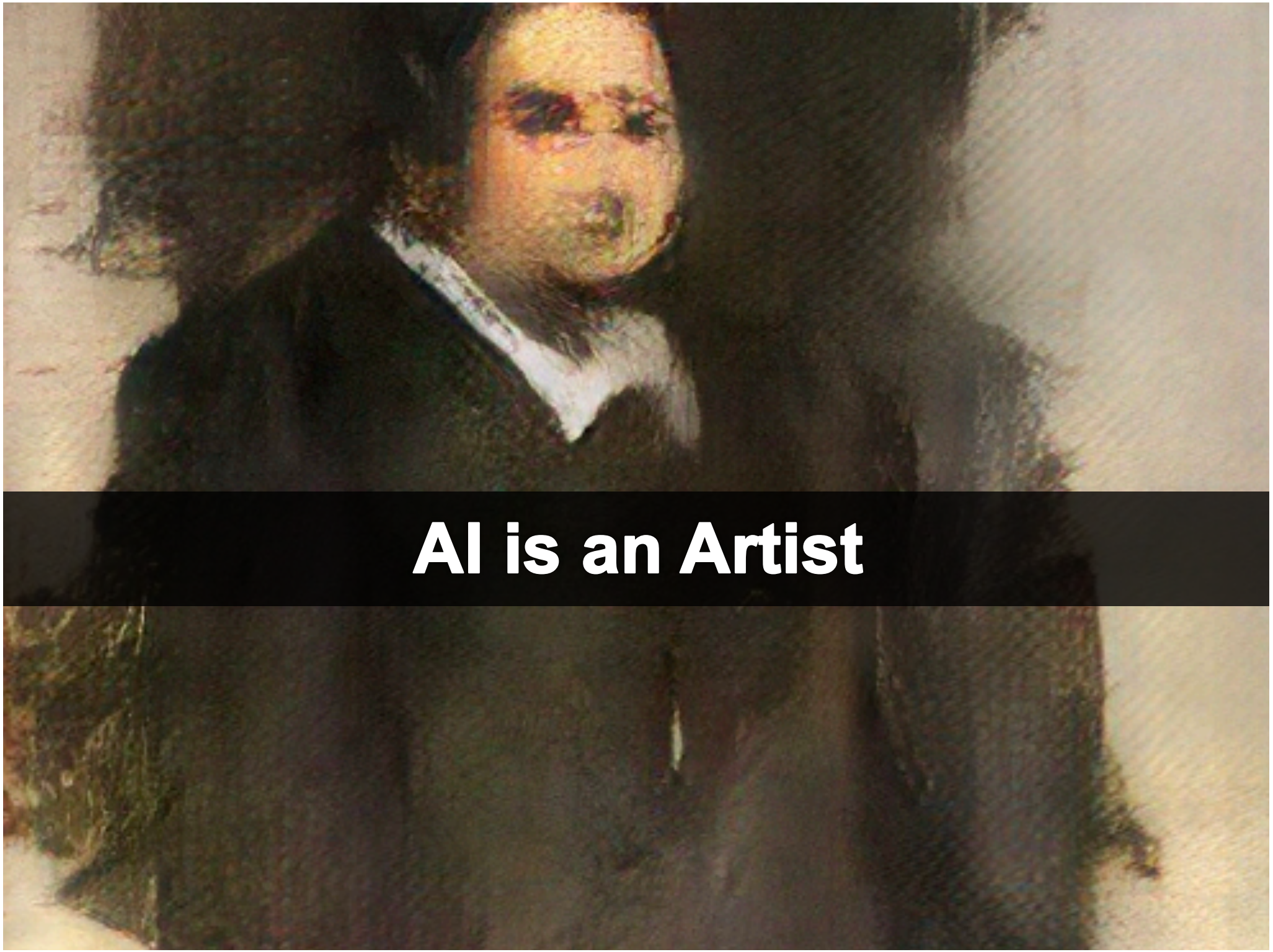

What's different now than it used to be?
#1 models are bigger
#2 we have more data
#3 we have more compute power
#4 the systems actually work for several tasks


AI does the
laundry

AI drives cars




THINK
सोचिए
$24,000
Who is Stoker?
$1,000
$77,147
Who is Bram Stoker?
$ 17,973
$21,600
$5600
AI knows a lot


AI is an Artist


TECHNISCHE UNIVERSITÄT DARMSTADT
Schachmatt durch „CrazyAra"
19.02.2019
Künstliche Intelligenz schlägt mehrfachen Weltmeister im Einsetzschach
Der von den TU-Studierenden Johannes Czech, Moritz Willig und Alena Beyer entwickelte Bot „CrazyAra" hat den Schachprofi Justin Tan in einem Online-Match der Schach-Variante „Crazyhouse" mit 4:1 geschlagen. Gelernt hat der Bot mittels künstlicher neuronaler Netze, was ihm erlaubt, vorausschauend Entscheidungen zu treffen. Das Besondere: Die Studierenden konnten damit einen Erfolg auf einem Feld feiern, das sonst von Giganten wie Google dominiert wird.
AI plays chess and GO
lichess.org
ALPHAGO
LEE SEDOL
01:59:31
AlphaGo
Lee Sedol
CrazyAra vs JannLee (Man vs Machine - Crazyhouse Chess on lichess.org) · 2 days ag
Category: Chess

AI assists you

But

But

The New York Times

Opinion

A.I. Is Harder Than You Think

By Gary Marcus and Ernest Davis

Mr. Marcus is a professor of psychology and neural science. Mr. Davis is a professor of computer science.

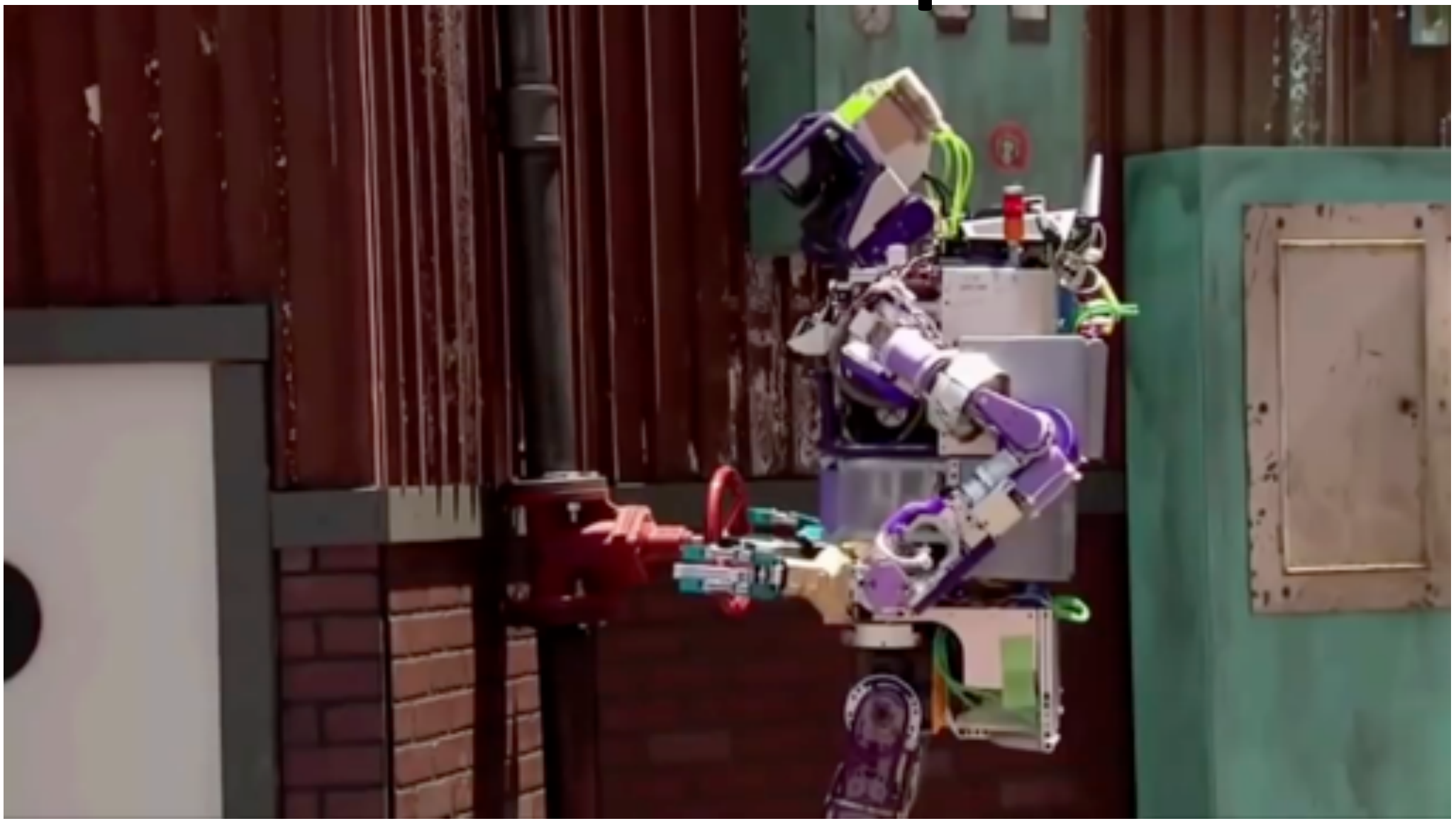
May 18, 2018

Current AI has many isolated talents

Current AI is not superhuman

DARPA challenge (2015)

Current AI is not superhuman



And this also holds as of today

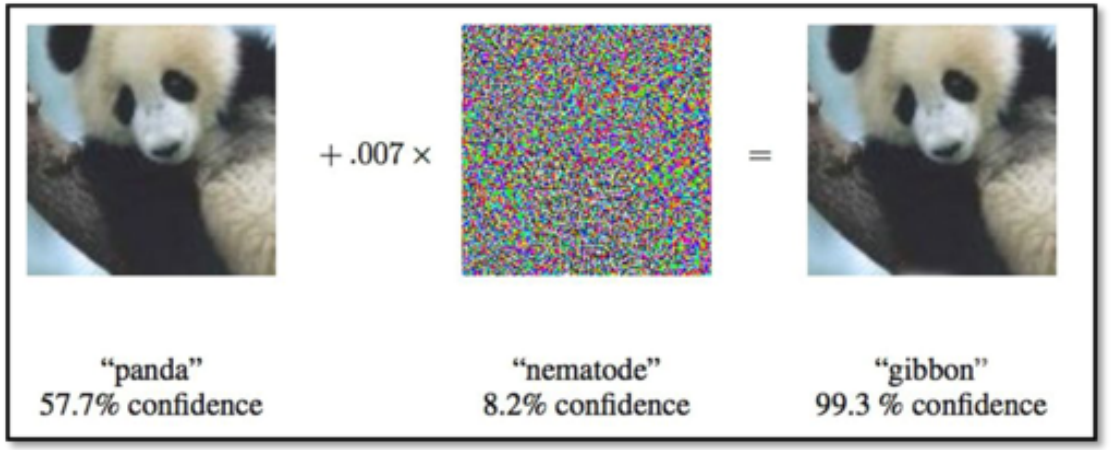
Fundamental Differences

as of today

Fundamental Differences

Sharif et al., 2015

Brown et al. (2017)



Google, 2015

REPORTS | PSYCHOLOGY

Semantics derived automatically from language corpora contain human-like biases

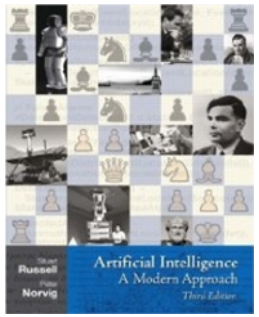
Aylin Caliskan[1,*], Joanna J. Bryson[1,2,*], Arvind Narayanan[1,*]
+ See all authors and affiliations

Science 14 Apr 2017:
Vol. 356, Issue 6334, pp. 183-186
DOI: 10.1126/science.aal4230

And this is where our journey begins, based on a text Book

The course will mostly follow

Stuart Russell und Peter Norvig: *Artificial Intelligence: A Modern Approach*. Prentice Hall, 3rd edition, 2010.



Deutsche Ausgabe:

Stuart Russell und Peter Norvig: *Künstliche Intelligenz: Ein Moderner Ansatz.* Pearson-Studium, 2004. ISBN: 978-3-8273-7089-1. 3. Auflage 2012

Home-page for the book:

http://aima.cs.berkeley.edu/

Course slides

in English (lecture is in German)

will be availabe from Homepage (Moodle)

What is Artificial Intelligence

Different definitions due to different criteria

Two dimensions:

Thought processes/reasoning vs. behavior/action

Success according to human standards vs.
success according to an ideal concept of intelligence:
rationality.

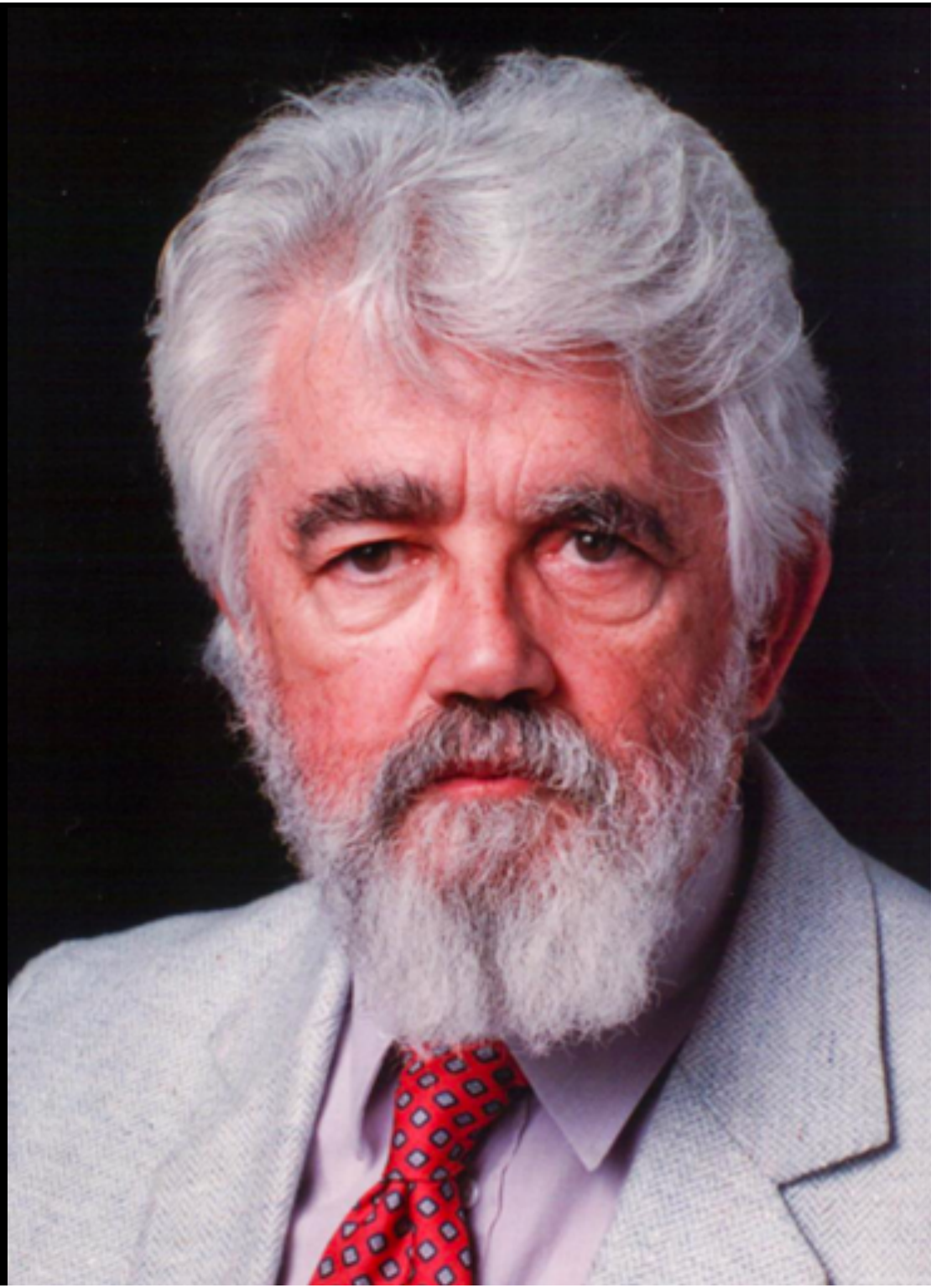
Systems that think like humans	Systems that think rationally
Systems that act like humans	Systems that act rationally

What is AI?

„the science and engineering of making intelligent machines, especially intelligent computer programs.

It is related to the similar task of using computers to understand human intelligence, but AI does not have to confine itself to methods that are biologically observable.“

- John McCarthy, Stanford (1956), coined the term AI, Turing Awardee



Definitions of Artificial Intelligence

Systems that think like humans	Systems that think rationally
"The exciting new effort to make computers think . . . *machines with minds*, in the full and literal sense." (Haugeland, 1985)	"The study of mental faculties through the use of computational models." (Charniak and McDermott, 1985)
"[The automation of] activities that we associate with human thinking, activities such as decision-making, problem solving, learning . . ." (Bellman, 1978)	"The study of the computations that make it possible to perceive, reason, and act." (Winston, 1992)
Systems that act like humans	**Systems that act rationally**
"The art of creating machines that perform functions that require intelligence when performed by people." (Kurzweil, 1990)	"Computational Intelligence is the study of the design of intelligent agents." (Poole *et al.*, 1998)
"The study of how to make computers do things at which, at the moment, people are better." (Rich and Knight, 1991)	"AI . . . is concerned with intelligent behavior in artifacts." (Nilsson, 1998)

Figure 1.1 Some definitions of artificial intelligence, organized into four categories.

Systems that think like humans

How do humans think?

Requires scientific theories of internal brain activities (cognitive model):

- Level of abstraction? (knowledge or circuitry?) Validation?
  - Predicting and testing human behavior
  - Identification from neurological data

Cognitive Science brings together computational models from AI and experimental techniques from psychology to construct precise and testable theories of the mind. Cognitive Science is often viewed distinct from AI but this is wrong. As at TU Darmstadt, both are twin disciplines!

Cognitive Neuroscience: How does the brain work at the neuronal level?

Other AI-relevant Course Topics @ TUD

Machine Learning (Peters, Roth, Kersting)
Robotics (Peters, von Stryk)
Search and Optimization (Weihe)
Natural Language Processing (Gurevych)
Fuzzy Logic and Genetic Algorithms (Adamy)
Vision and Perception (Roth, Fellner, Kuijper)
Cognitive Science (Rothkopf, Kersting, Jäkel)
Hardware (Koch)
Serious Games (Göbel)
Bioinformatics (Köppl, Hamacher)
...

Systems that think rationally

Capturing the laws of thought

- Aristotle: What are ‘correct’ argument and thought processes?
  - Correctness depends on irrefutability of reasoning processes.
  - Syllogisms:
    - first patterns of correct formal reasoning
    - “Socrates is a man, all man are mortal → Socrates is mortal”
- This study initiated the field of logic.
  - The logicist tradition in AI hopes to create intelligent systems using logic programming.

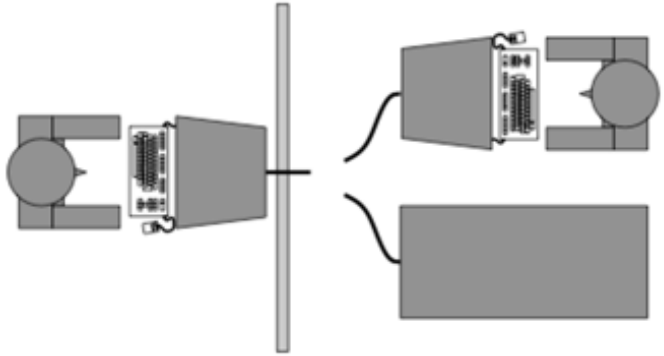
Problems:

- It is hard to fomalize knowledge exactly
  - → Feigenbaum Bottleneck in expert systems
- Practical constraints
  - it is easy to write a logically optimal chess player...
- Not all intelligence is mediated by logic behavior

Systems that act like humans

When does a system behave intelligently?

Turing (1950) Computing Machinery and Intelligence
Operational test of intelligence: imitation game



Test still relevant now, yet might be the wrong question.

Requires the collaboration of major components of AI: knowledge, reasoning, language understanding, learning, …

Problem with Turing test:

not reproducible, constructive or amenable to mathematical analysis.

Systems that act rationally

Rational behavior: “doing the right thing”

- The “Right thing” is that what is expected to maximize goal achievement given the available information.

Can include thinking, yet in service of rational action

- Action without thinking: e.g. reflexes.

Two advantages over previous approaches

- More general than law of thoughts approach
  - in many situations, a provably correct action does not exist
- More amenable to scientific development
  - rationality can be defined and optimized

On the other hand

- perfect rationality is only feasible in ideal environments.
- rationality is often not a very good model of reality.
  - humans are, e.g., very bad in estimating probabilities...

Foundations of AI

Different fields have contributed to AI in the form of ideas, viewpoints and techniques.

Philosophy: Logic, reasoning, mind as a physical system, foundations of learning, language and rationality.

Mathematics: Formal representation and proof algorithms, computation, (un)decidability, (in)tractability, probability.

Psychology: adaptation, phenomena of perception and motor control.

Economics: formal theory of rational decisions, game theory.

Linguistics: knowledge represetation, grammar.

Neuroscience: physical substrate for mental activities.

Control theory: homeostatic systems, stability, optimal agent design.

Subdisciplines of AI

Natural Language Processing
Knowledge Representation
Automated Reasoning
Planning
Machine Learning
Computer Vision
Robotics
...

See also https://gi.de/themen/beitrag/was-ist-eine-professur-fuer-kuenstliche-intelligenz-1/ (in German)

A Brief History of AI

Greek mythology:

- Hephaestus built Talos, a giant intelligent bronze robot

13th century:

- brazen head: oracle in the form of a talking head made of brass supposedly owned by Roger Bacon and Albertus Magnus

15th century:

- da Vinci drafted robot design

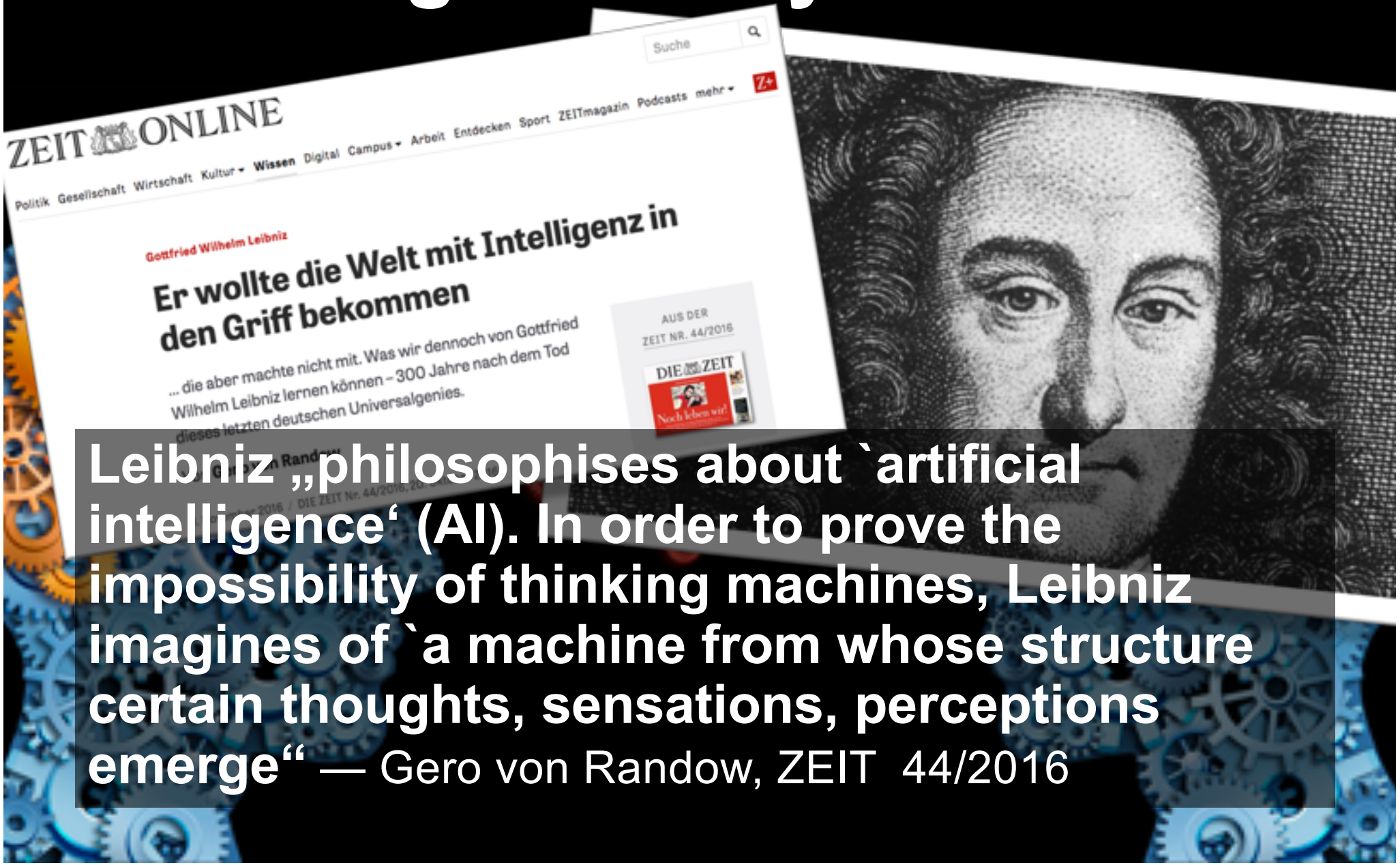
16th century:

- Rabbi Loew made the giant Golem of clay to protect the Jewish community in Prague
- remains are still supposed to be there...

17th century:

- Descartes – “animals are complex machines”

The dream of an artificially intelligent entity is not new

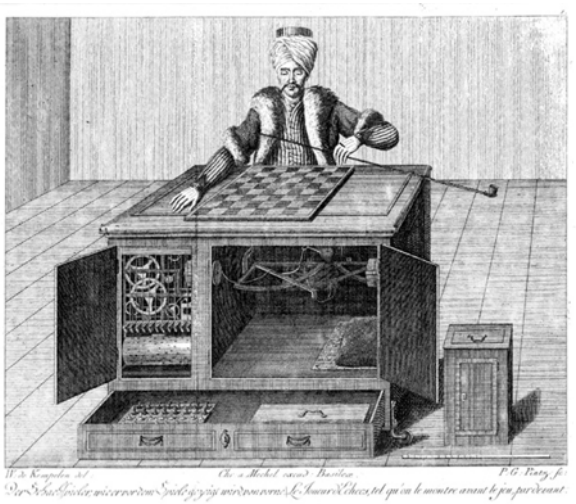


Leibniz „philosophises about `artificial intelligence‘ (AI). In order to prove the impossibility of thinking machines, Leibniz imagines of `a machine from whose structure certain thoughts, sensations, perceptions emerge“ — Gero von Randow, ZEIT 44/2016

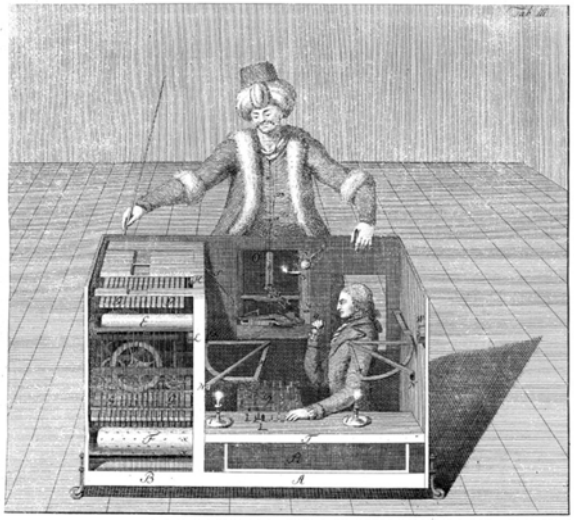
A Brief History of AI

18th century:

- von Kempelen's chess-playing Turk
- amazing piece of mechanical engineering
- played and won chess games all over the world (e.g., against Napoleon)

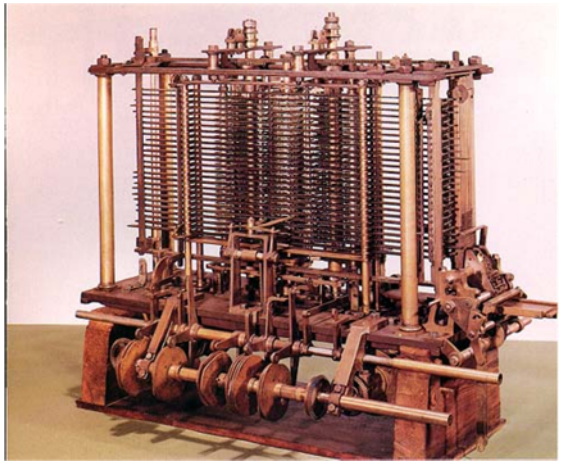


A Brief History of AI



18th century:

- von Kempelen's chess-playing Turk
- amazing piece of mechanical engineering
- played and won chess games all over the world (e.g., against Napoleon)
- unfortunately a hoax...



19th century:

- Charles Babbage's Analytical Engine

1920:

- first use of word "robot" in Karel Capek's play *R.U.R (Rossum's Universal Robots)*

1940's:

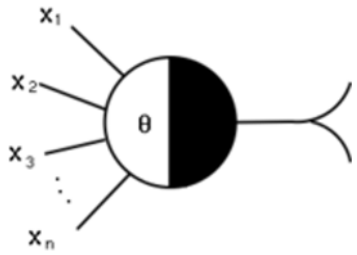
- Isaac Asimov – "Three Laws of Robotics"

A Brief History of AI

1943:

McCulloch and Pitts model artificial neurons

1951: Marvin Minsky and Dann Edmonds constructed the first neural network computer



1950

Claude Shannon: algorithm for playing Chess

foresees strategies that are still used today

Shannon Type-A Strategy:

brute-force minimax search until a fixed horizon

Shannon Type-B Strategy

pruning uninteresting lines (as humans do)

preferred by Shannon (and contemporaries)

1951

Turing's chess algorithm

computation with paper and pencil

first recorded man-machine (chess) game

http://www.chessgames.com/perl/chessgame?gid=1356927

The Dartmouth Conference

1956:

John McCarthy invites 10 scientists with various backgrounds to a 2-week workshop at Dartmouth College

- bringing together top minds on automata theory, neural nets and the study of intelligence.
- For the next 20 years the field was dominated by these participants
  - John McCarthy, Herbert Simon, Allan Newell, Marvin Minsky, Arthur Samuel, etc.
- Allen Newell and Herbert Simon (CMU): The Logic Theorist
  - first nonnumerical thinking program used for theorem proving
  - proved various theorems of Whitehead's *Principia Mathematica*
  - a joint publication by AN, HS, and LT was rejected...

→ Term “Artificial Intelligence” is coined

Great Expectations (1952-1969)

Newell and Simon (CMU): the General Problem Solver.
- Imitation of human problem-solving
- successfully solved simple puzzles
  → physical symbol system hypothesis

Arthur Samuel (IBM, 1952-)
- investigated game playing (checkers) with great success at IBM
  - program beat a regional master
- pioneered many ideas in game playing and machine learning
  - including alpha-beta search, reinforcement learning, etc.

John McCarthy (MIT, 1958-)
- Inventor of Lisp (second-oldest high-level language)
- Logic-oriented Advice Taker
  - separation between knowledge and reasoning

Marvin Minsky (MIT)
- various students working on micro-worlds (e.g., block's world)

A Dose of Reality (1966-1973)

Progress was slower than (unrealistic) expectations

Simon and Newell's (1958) predictions

1. That within ten years, a digital computer will be the world's chess champion, unless the rules bar it from competition.
2. That within ten years a digital computer will discover and prove an important new mathematical theorem.
3. That within ten years a digital computer will write music that will be accepted by critics as possessing considerable aesthetic value.
4. That within ten years most theories in psychology will take the form of computer programs, or of qualitative statements about the characteristics of computer programs. . . .The simplest way I can summarize is to say that there are now in the world machines that can think, that learn and that create. Moreover, their ability to do these things is going to increase rapidly until — in a visible future — the range of problems they can handle will be coextensive with the range to which the human mind has been applied.

A Dose of Reality (1966-1973)

- Progress was slower than (unrealistic) expectations
  - Simon and Newell's (1958) predictions
  - came more or less true after 40 (instead of 10) years
    - but in very different ways than they had imagined
- Difficulties
  - Difficulty of knowledge representation
    - e.g., attempt for Machine Translation of Russian Scientific papers

> the spirit is willing but the flesh is weak

A Dose of Reality (1966-1973)

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> the spirit is willing but the flesh is weak
> → the vodka is good but the meat is rotten

  - In 1966 no machine translations were used
  - nowadays they are routinely used
    - but most still give awful results

A Dose of Reality (1966-1973)

- Progress was slower than (unrealistic) expectations
  - some of Simon and Newell's (1958) predictions came more or less true after 40 (instead of 10) years
    - but in very different ways than they had imagined
- Difficulties
  - Difficulty of knowledge representation
  - Lack of scalability
    - under-estimation of the combinatorial explosion in search
    - things that work well in micro-worlds do not work in real world
      - e.g., theorem proving only worked with very few facts
    - Lighthill report (1973) focused on this issue
      - stopped AI funding in UK in all but two universities
  - Fundamental limitations on techniques and representations
    - Minsky and Papert (1969) noted that perceptrons are only linear seperators
      - killed research in neural networks for decades

Knowledge-Based Systems (1969-1979)

- DENDRAL project (Buchanan et al. 1969)
  - task:
    - infer molecular structure from formula of the molecule and the mass spectrum
  - First successful knowledge-intensive system
    - recognized importance of domain-specific knowledge
- Expert systems
  - MYCIN to diagnose blood infections (Feigenbaum et al.)
    - with ~450 rules, it performed better than junior doctors
    - knowledge had to be tediously acquired from experts (→ Knowledge Engineering Bottleneck)
    - introduction of uncertainty in reasoning
- Increase in knowledge representation research
  - Logic, frames, Schank's scripts, semantic nets, …
  - CYC project (started by Lenat 1984)
    - attempt to encode common-sense knowledge

The AI industry (1980-present)

- R1 (McDermott, 1982)
  - expert system for configuring computers at DEC
  - saved about $40 million a year in 1986
- Fifth generation project in Japan (1981)
  - 10-year plan with strong focus on Logic Programming
  - did not quite live up to its ambitious goals
- Similar programs in US and UK put an end to the AI winter
  - in UK, the Alvey report reinstantiated funding for “Intelligent Knowledge-Based Systems” (to avoid the name AI)
- Neural Networks revival
  - seminal work *Parallel Distributed Processing* by Rumelhart and McClelland (1986)
  - soon became popular in industrial applications
- AI industry grew from a few million dollars in 1980 to billions of dollars in 1988

Current Trends in AI

- exploit the strengths of the computer
  - fast repetitious computations
  - elementary statistics (counting and probabilities)
  - and do not try to model human thought processes
    - brute-force methods perform much better in many areas
    - aviation was only possible when planes stopped to flap their wings...
- focus on particular tasks and not on solving AI as a whole
  - “Intelligent prostheses”
    - tools that support us in tasks that would otherwise require human intelligence
  - “AI-complete problems”
    - informal notion for very hard problems that cannot be solved unless the system has human-like knowledge and reasoning
- strong scientific standards developed in the 1980s
  - solid experimentation and scientific verification of hypotheses

The Science of AI

- Conference Series
  - 1969 - : Biennial International Joint Conference on AI (IJCAI)
  - 1980 - : Annual National Conference on AI (AAAI)
  - 1982 - : Biennial European Conference on AI (ECAI)
- Magazines
  - AI Magazine (published by AAAI)
  - IEEE Intelligent systems
- Journals
  - Artificial Intelligence (Elsevier)
  - Journal of Artificial Intelligence Research
    - pioneered free on-line publication (http://www.jair.org)
- Since the 1980s various subfields emerged, joined forces with related fields
  - many journals and annual conferences in subareas


TECHNISCHE UNIVERSITÄT DARMSTADT
Schachmatt durch „CrazyAra"
19.02.2019
Künstliche Intelligenz schlägt mehrfachen Weltmeister im Einsetzschach
Der von den TU-Studierenden Johannes Czech, Moritz Willig und Alena Beyer entwickelte Bot „CrazyAra" hat den Schachprofi Justin Tan in einem Online-Match der Schach-Variante „Crazyhouse" mit 4:1 geschlagen. Gelernt hat der Bot mittels künstlicher neuronaler Netze, was ihm erlaubt, vorausschauend Entscheidungen zu treffen. Das Besondere: Die Studierenden konnten damit einen Erfolg auf einem Feld feiern, das sonst von Giganten wie Google dominiert wird.
AI plays chess and GO
lichess.org
ALPHAGO
LEE SEDOL
01:59:31
AlphaGo
Lee Sedol
CrazyAra vs JannLee (Man vs Machine - Crazyhouse Chess on lichess.org) · 2 days ag
Category: Chess

State of the Art

- Autonomous Planning and Scheduling
  - NASA's on-board autonomous planning program controlled the scheduling of operations for a spacecraft
  - During the 1991 Gulf War, US forces deployed an AI logistics planning and scheduling program
    - DARPA: this application payed back 30 years of investment in AI
- Game Playing
  - TD-Gammon learned an evaluation function for backgammon that led to changes in backgammon theory
  - Deep Blue defeated the reigning world chess champion Garry Kasparov in 1997
    - increased IBM stocks by several billion $
  - 2017: AlphaGo beat the No. 1 Go Player in the world
  - 2018: AlphaZero beats best chess programs after 4 hours of training

State-of-the-Art

- Natural Language Understanding
  - translation systems are frequently used
  - Speech recognition
    - United Airlines has an entire booking system based on automated speech recognition and dialog management
- Puzzles
  - Proverb solves crossword puzzles better than most humans
    - although it does not “understand” the clues
    - combination of constraint satisfaction, statistics, web retrieval, …
  - IBM's Watson has won at Jeopardy quiz show
    - Now the basis of IBM's cognitive computing initiative
    - http://www.ibm.com/de/watson

AI knows a lot

State of the Art

- Robotics
  - self-driving cars are on the verge to consumer products
  - robot assistents are routinely used in microsurgery
  - Roomba vacuum robots sold

- Scientific Discovery
  - machine learning system helped to discover new quasars
  - automated theorem prover proved Robbins conjecture unsolved for decades
  - Data Mining and Knowledge Discovery has developed into a new industry
- Deep Learning
  - Unexpected and unprecedented breakthroughs in diverse areas such as computer vision, language understanding, game playing, etc.

Recommended Books

Douglas R. Hofstadter, *Gödel, Escher, Bach*, Basic Books, New York 1979.
→ classic, inspiring, readable, original intro into AI

Peter Norvig, *Paradigms of Artificial Intelligence Programming: Case Studies in Common LISP*, Morgan Kaufmann, 2000.
→ AI techniques in LISP

Ivan Bratko, *Prolog Programming for AI*, Addison-Wesley, 3rd edition, 2000.
→ AI techniques in Prolog

Haugeland, John (ed.), *Mind Design II: Philosophy, Psychology, and Artificial Intelligence*, Cambridge, Mass.: MIT Press, 1981.
→ collection of classic Philosophical articles

http://www.aaai.org/AITopics/
→ Web site of the Association for the Advancement of Artficial Intelligence