A Short History of Artificial Intelligence, Machine Learning, and Deep Learning*

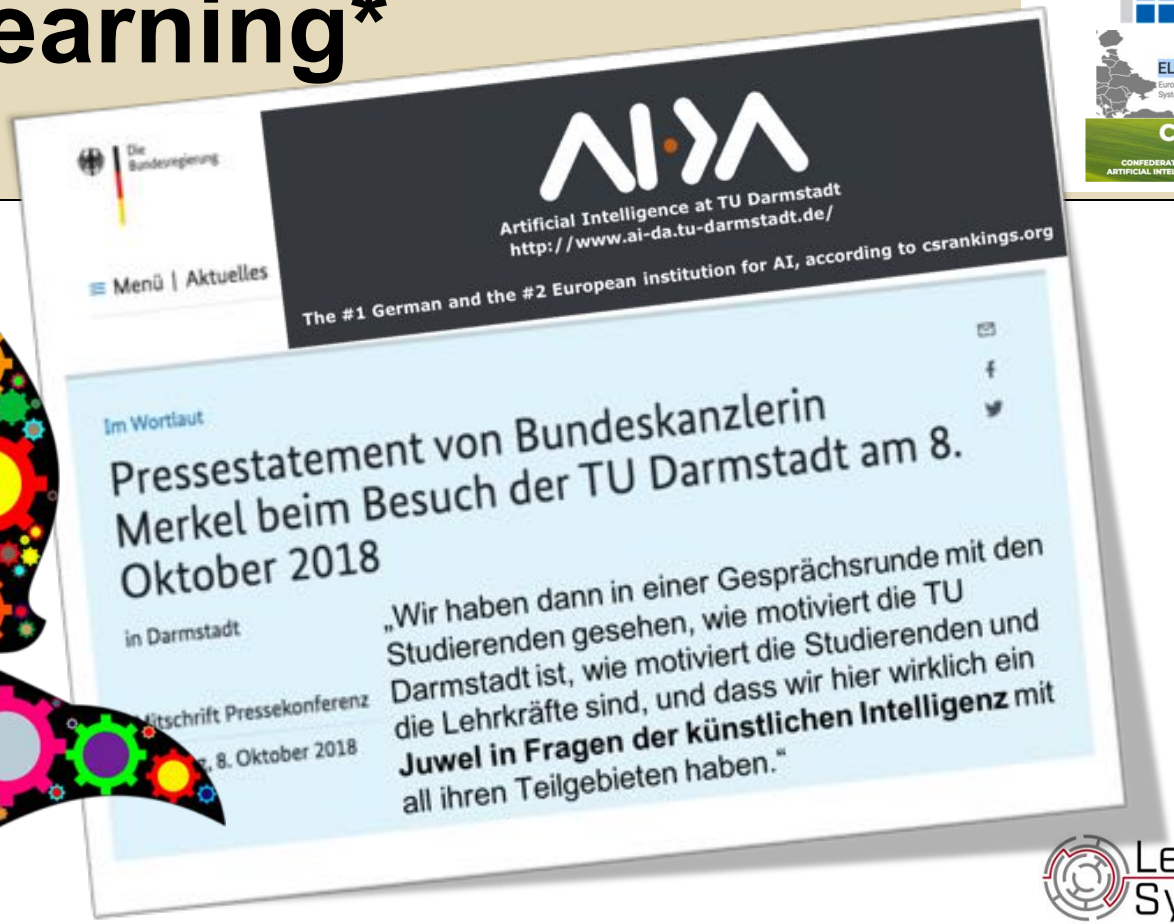
TECHNISCHE UNIVERSITÄT DARMSTADT

Centre for Cognitive Science

Fachbereich Informatik

ELLIS European Laboratory for Learning and Intelligent Systems

CLAIRE CONFEDERATION OF LABORATORIES FOR ARTIFICIAL INTELLIGENCE RESEARCH IN EUROPE



Lernende Systeme
DIE PLATTFORM FÜR KÜNSTLICHE INTELLIGENZ

Machine Learning and Artificial Intelligence: Two Fellow Travelers on the Quest for Intelligent Behavior in Machines

Kristian Kersting

Frontiers in Big Data
Published on 19 Nov 2018

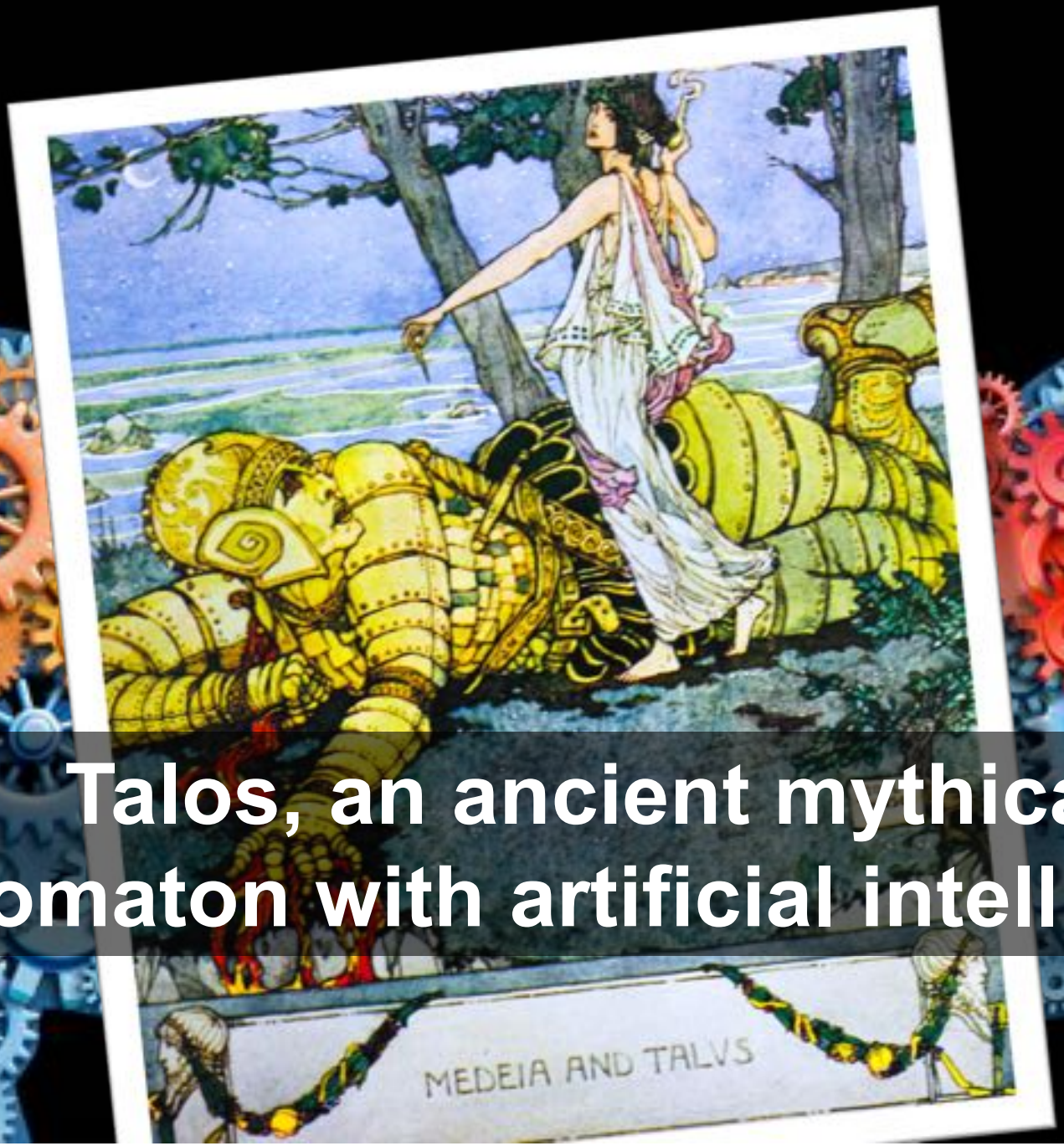
OPEN ACCESS

*Thanks to Christoph Lampert (IST) for some of the slides.

Federal Ministry of Education and Research

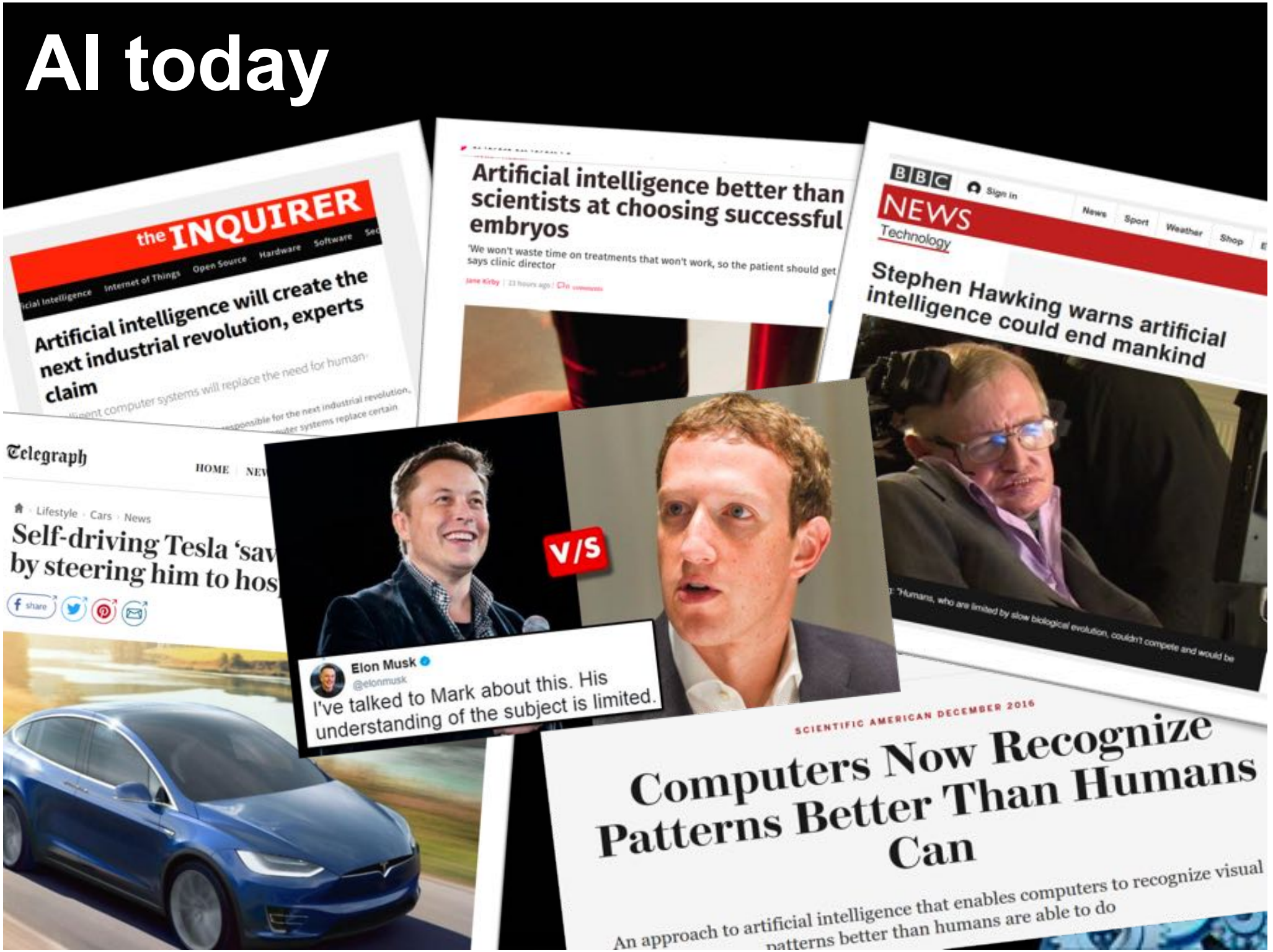
Prof. Dr. Kristian Kersting

The dream of AI is not new



Talos, an ancient mythical automaton with artificial intelligence

AI today


the INQUIRER
Artificial intelligence will create the next industrial revolution, experts claim
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
BBC
NEWS
Technology
Stephen Hawking warns artificial intelligence could end mankind
Telegraph
Lifestyle · Cars · News
Self-driving Tesla 'sav
by steering him to hos
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

Recent Hires

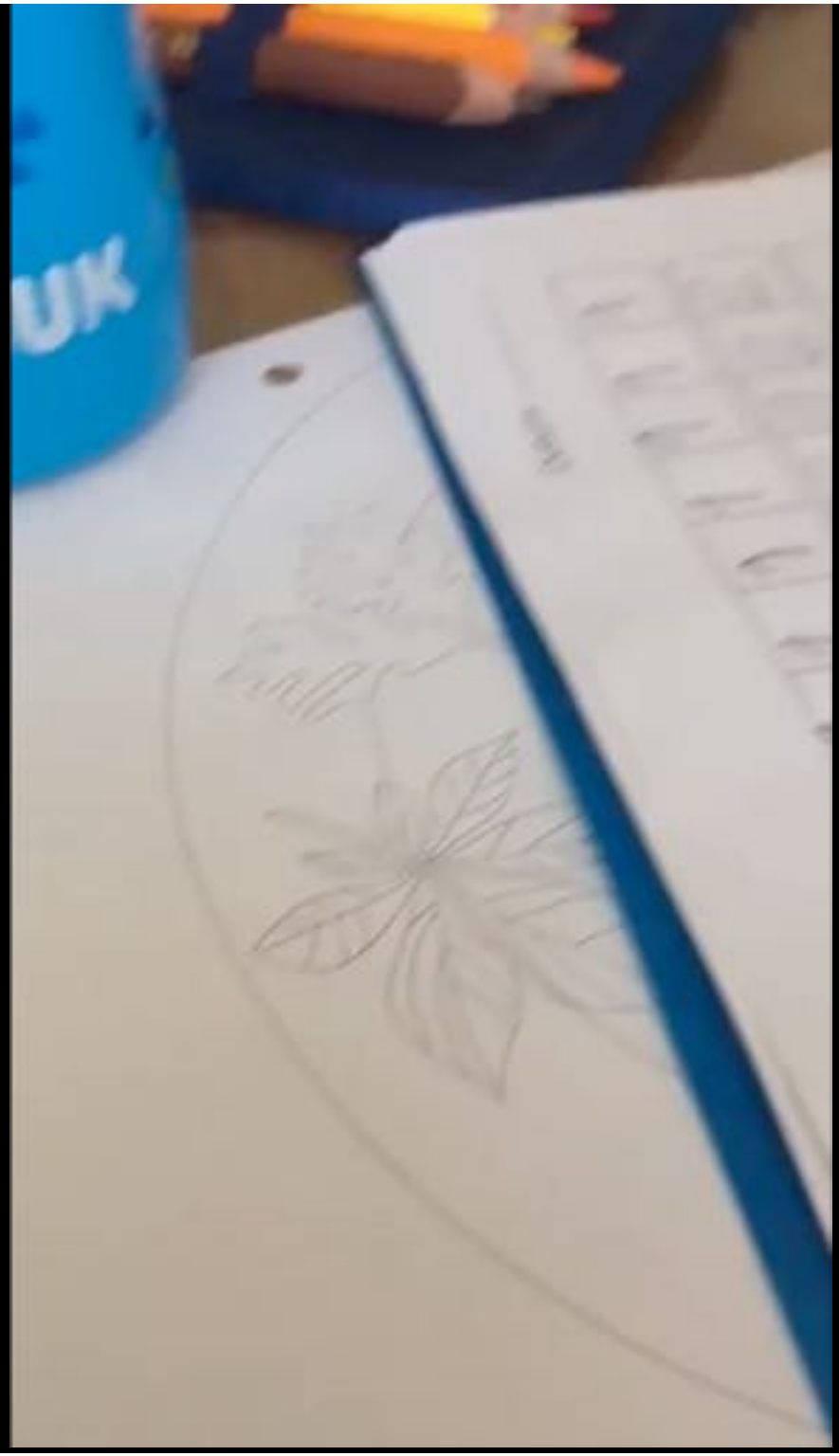
So, AI has many faces

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



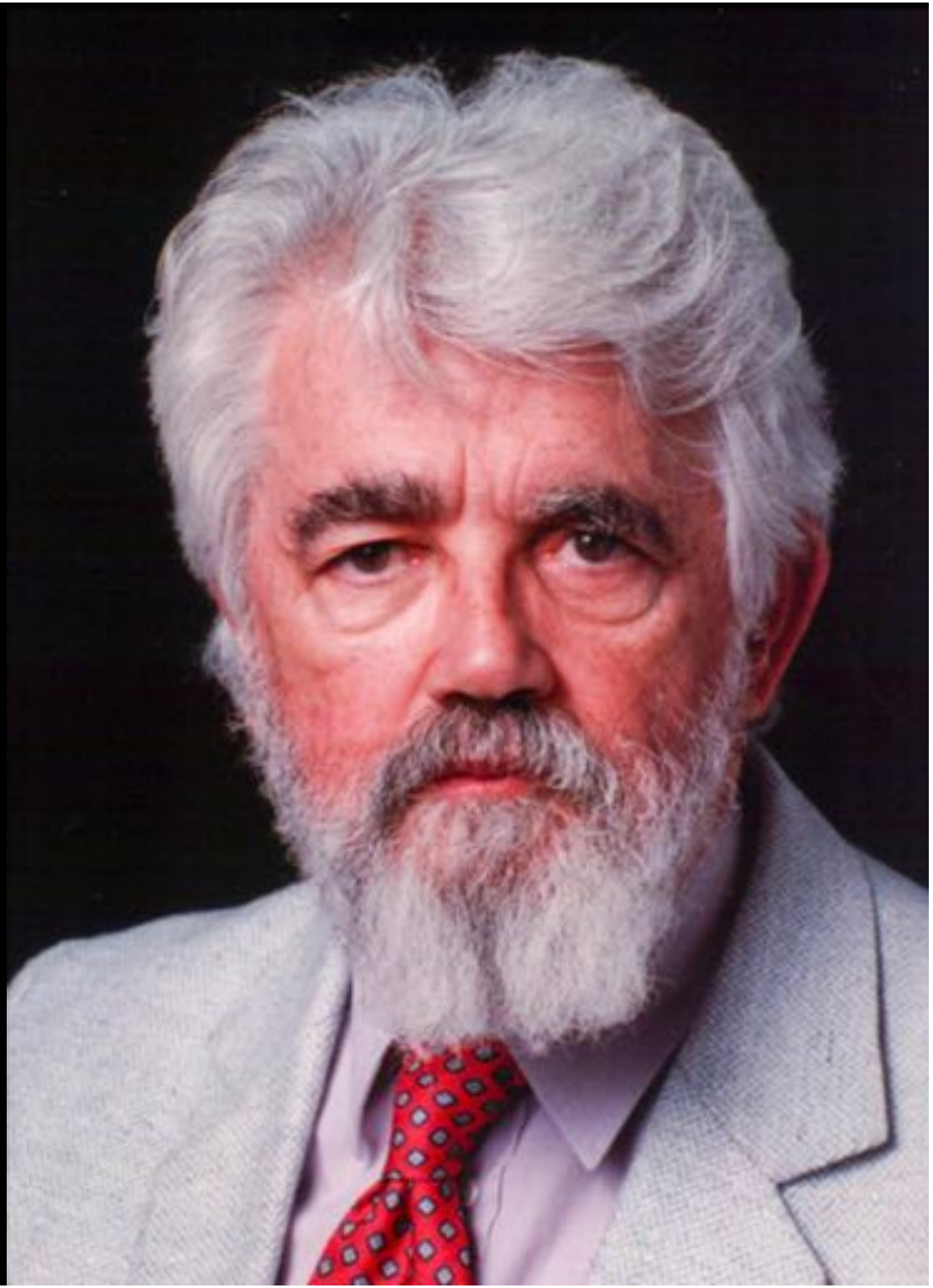
Can machines be smart, too?

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

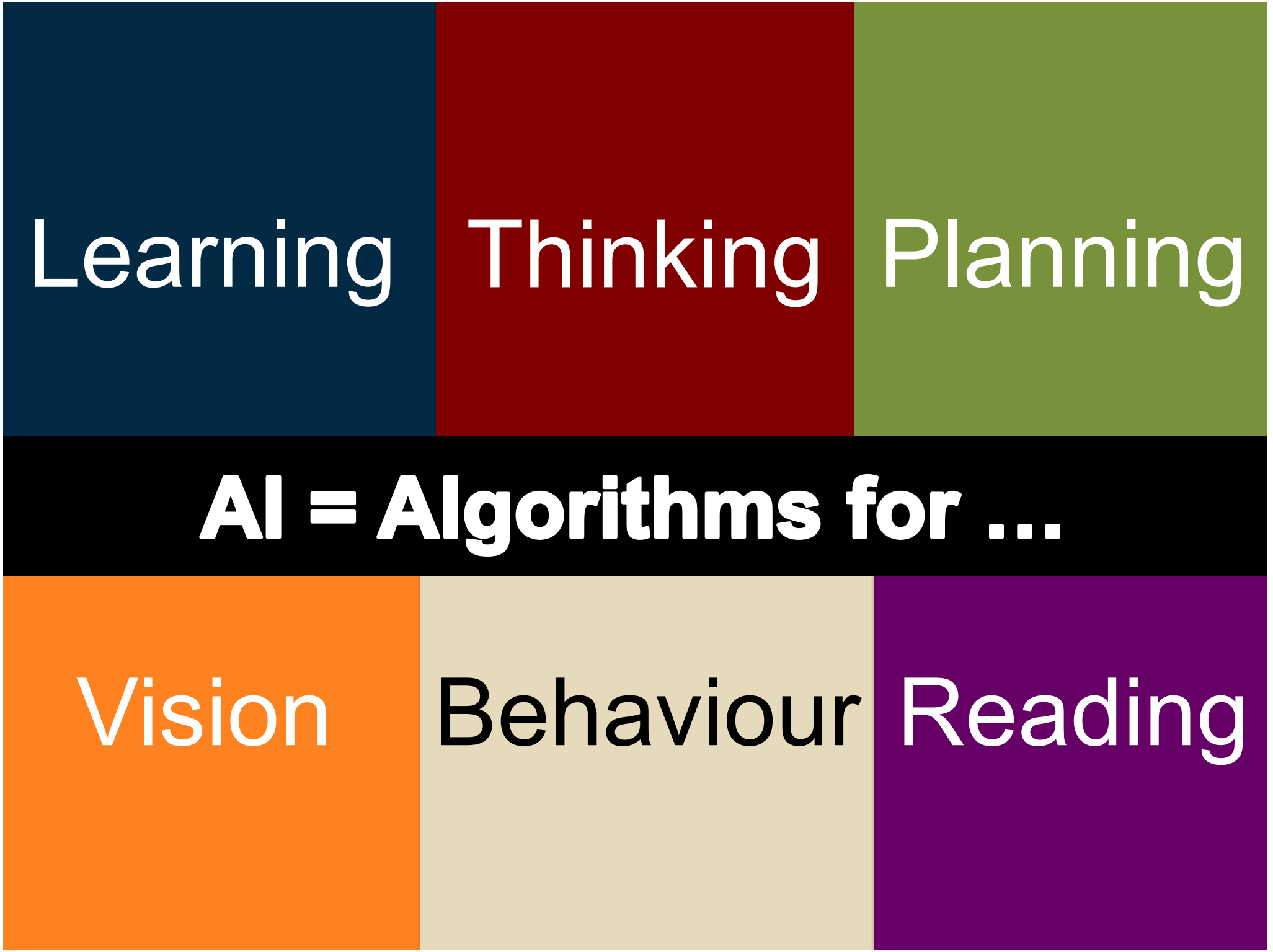


AI wants to build intelligent computer programs. How do we do this?

An Algorithm is

… an unambiguous specification of how to solve a class of problems – in finite time.

Think of it as a recipe!


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

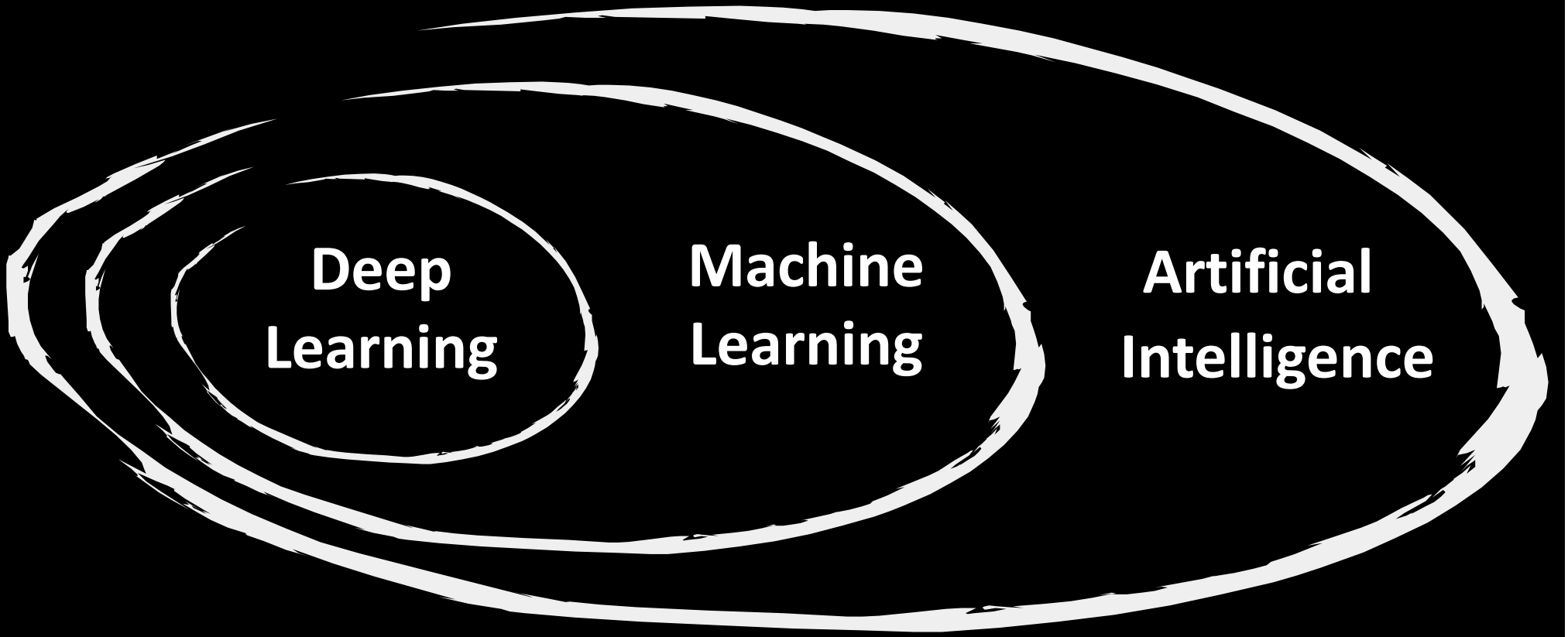
a form of machine learning that makes use of artificial neural networks

Geoffrey Hinton
Google
Univ. Toronto (CAN)

Yann LeCun
Facebook (USA)

Yoshua Bengio
Univ. Montreal (CAN)

Overall Picture



1950s: Birth of **Artificial Intelligence**

1960s: Era of the **Perceptrons**

1970s: First **AI Winter**

1980s: Era of **Expert Systems**

1990s: Second **AI Winter**

2000s: Era of **Statistical Machine Learning**

2010s: Era of **Deep Learning**

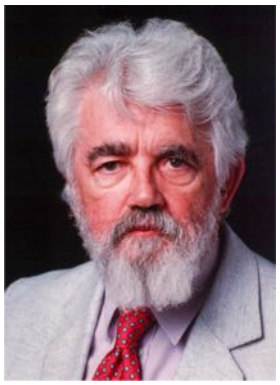
1956
AI is Born

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.

Dartmouth Conference



John McCarthy

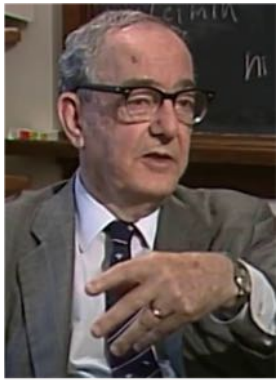
Turing Award 1971

Marvin Minsky

Turing Award 1969

Allen Newell

Turing Award 1975



Herbert A. Simon

Turing Award 1975

Nobel Prize 1978

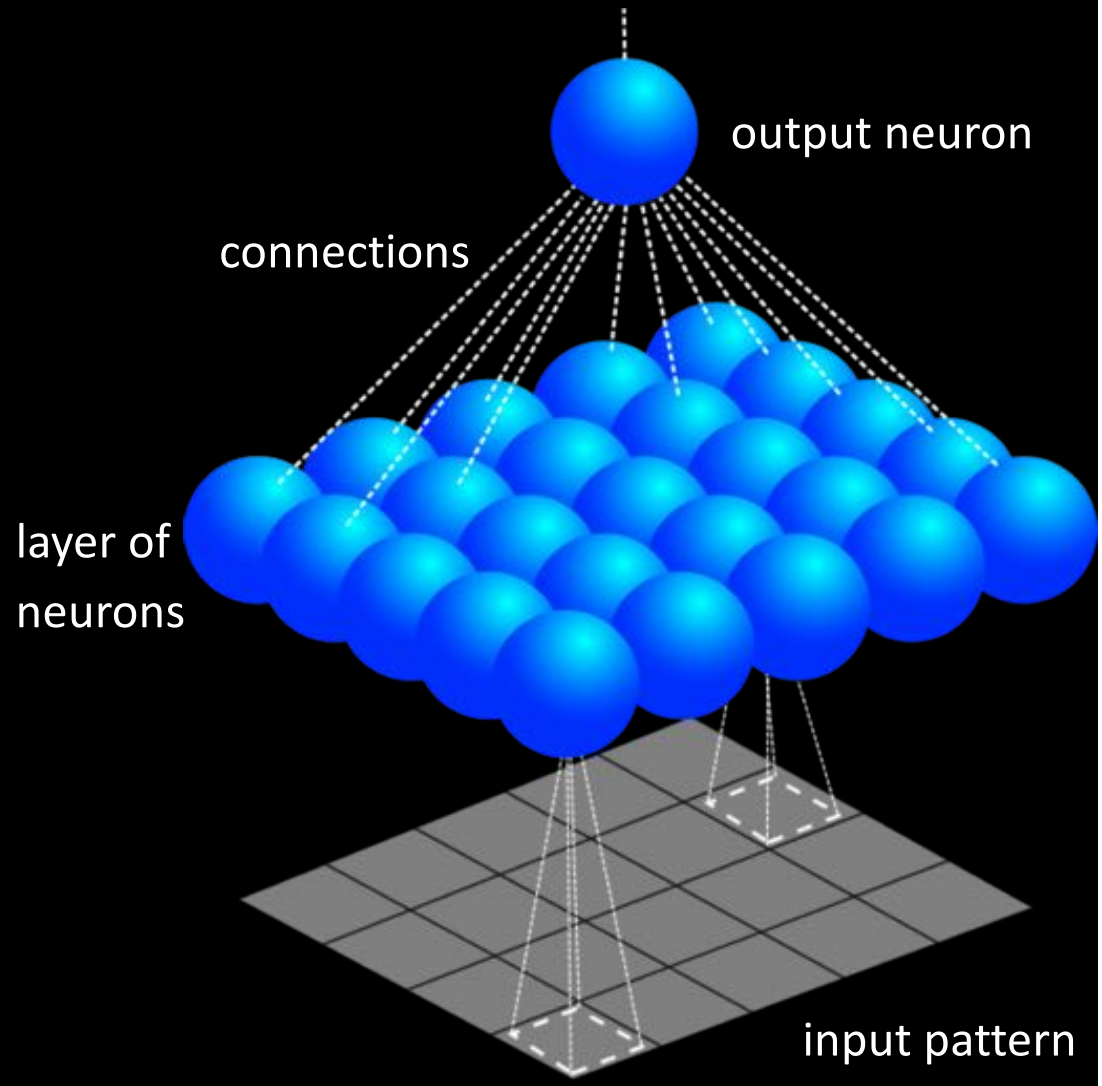
“Artificial Neural Networks”

Inspiration from the brain:

- **many small interconnected units (neurons)**
- **learning happens by changing the strength of connections (synapses)**
- **behavior of the whole is more than the sum of the parts**

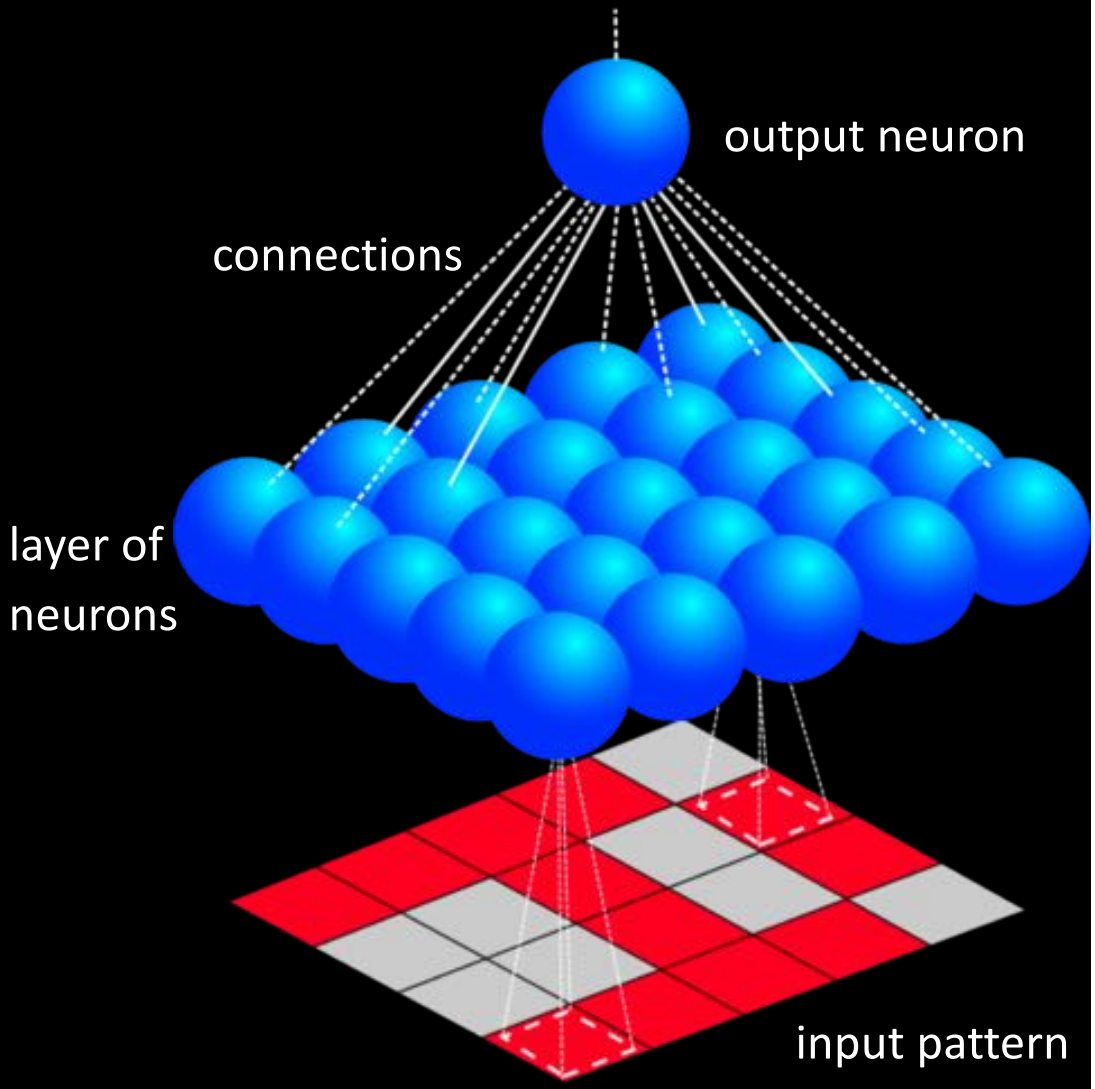
Frank Rosenblatt (1928-1971)

The Perceptron



The Perceptron

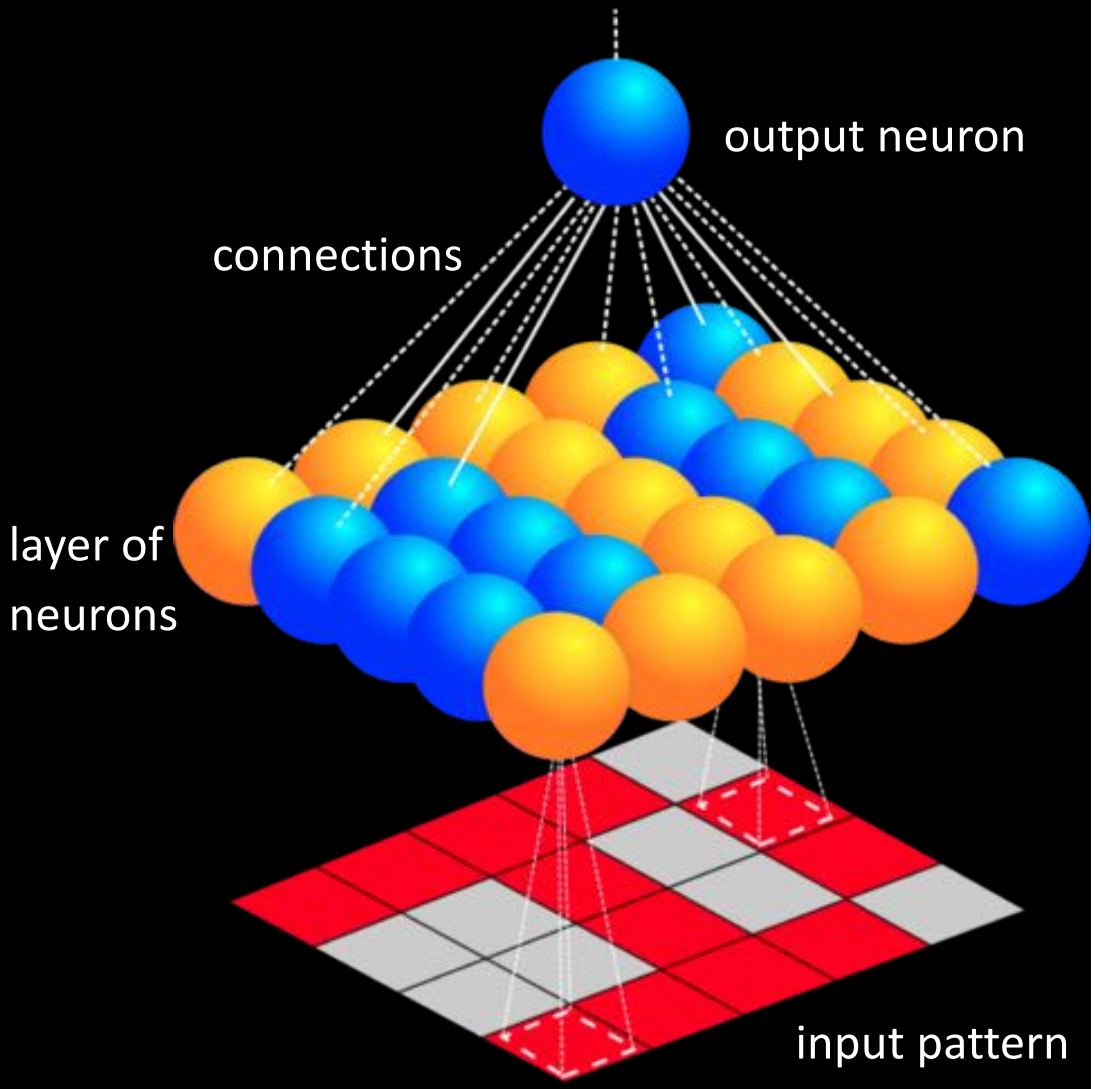
1) present pattern



The Perceptron

1) present pattern

2) first layer neurons spike

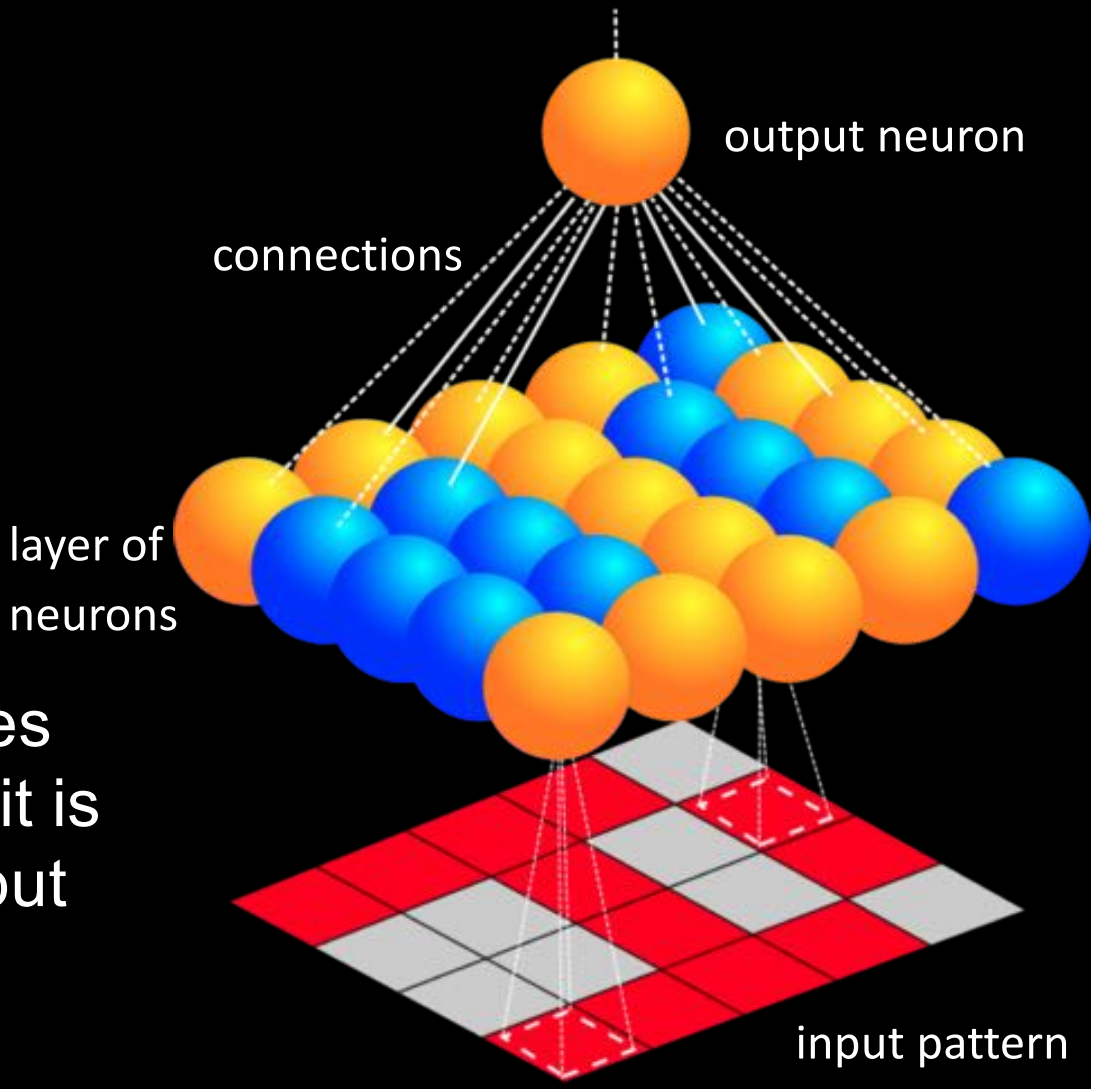


The Perceptron

1) present pattern

2) first layer neurons spike

3) output neuron accumulates signals from previous layer; it is above threshold, so the output neuron spikes



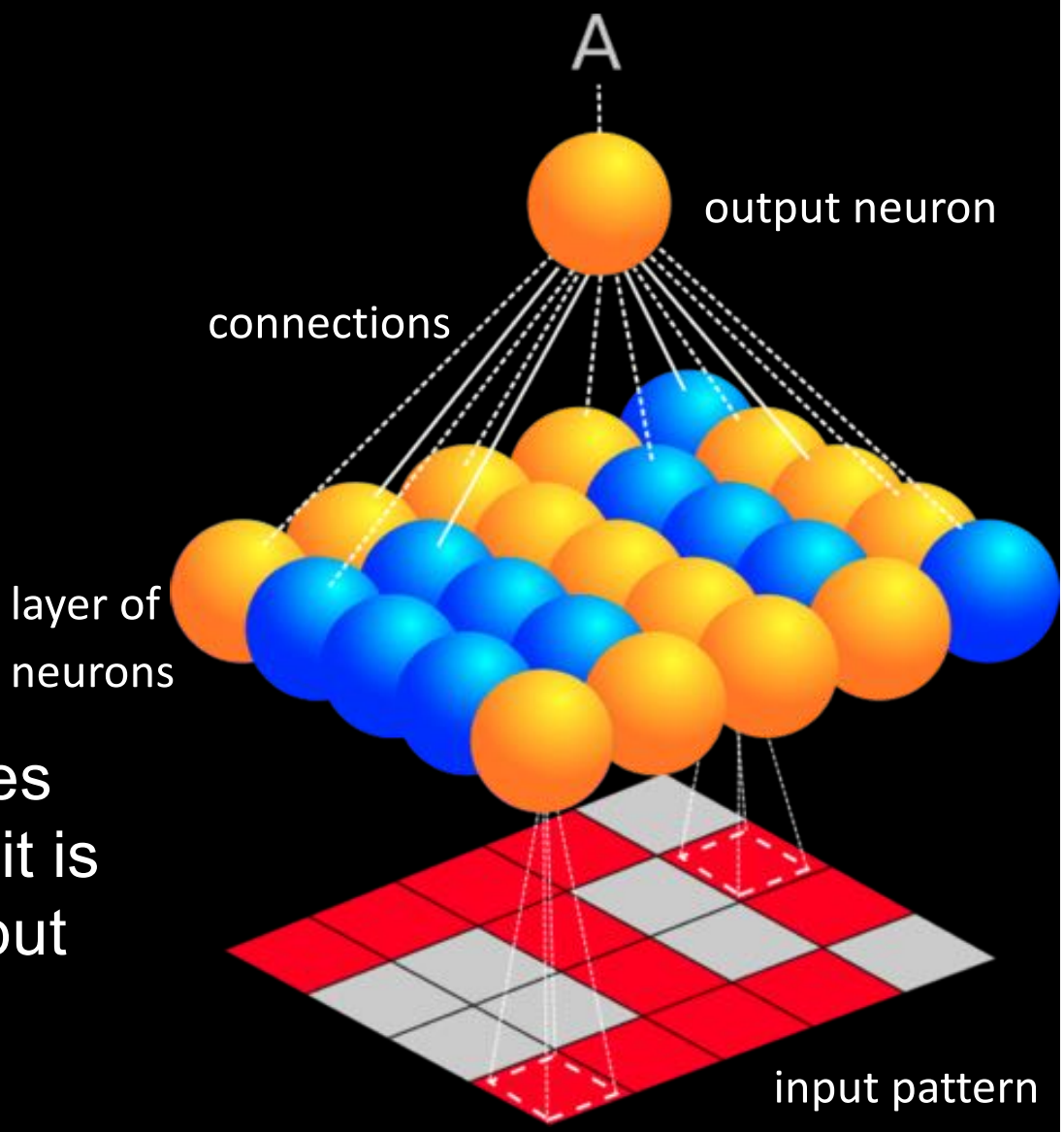
The Perceptron

1) present pattern

2) first layer neurons spike

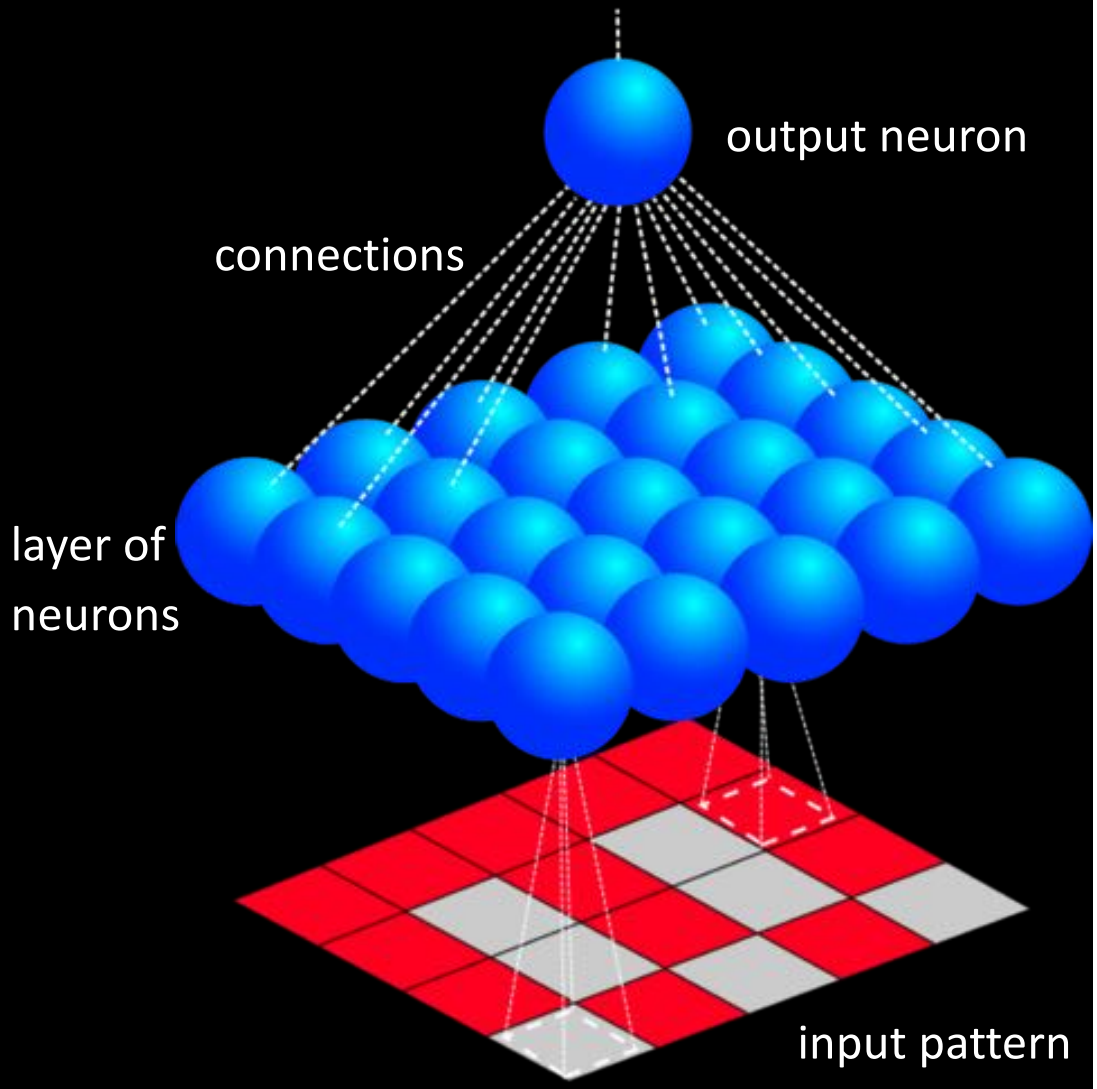
3) output neuron accumulates signals from previous layer; it is above threshold, so the output neuron spikes

4) prediction is “A”



The Perceptron

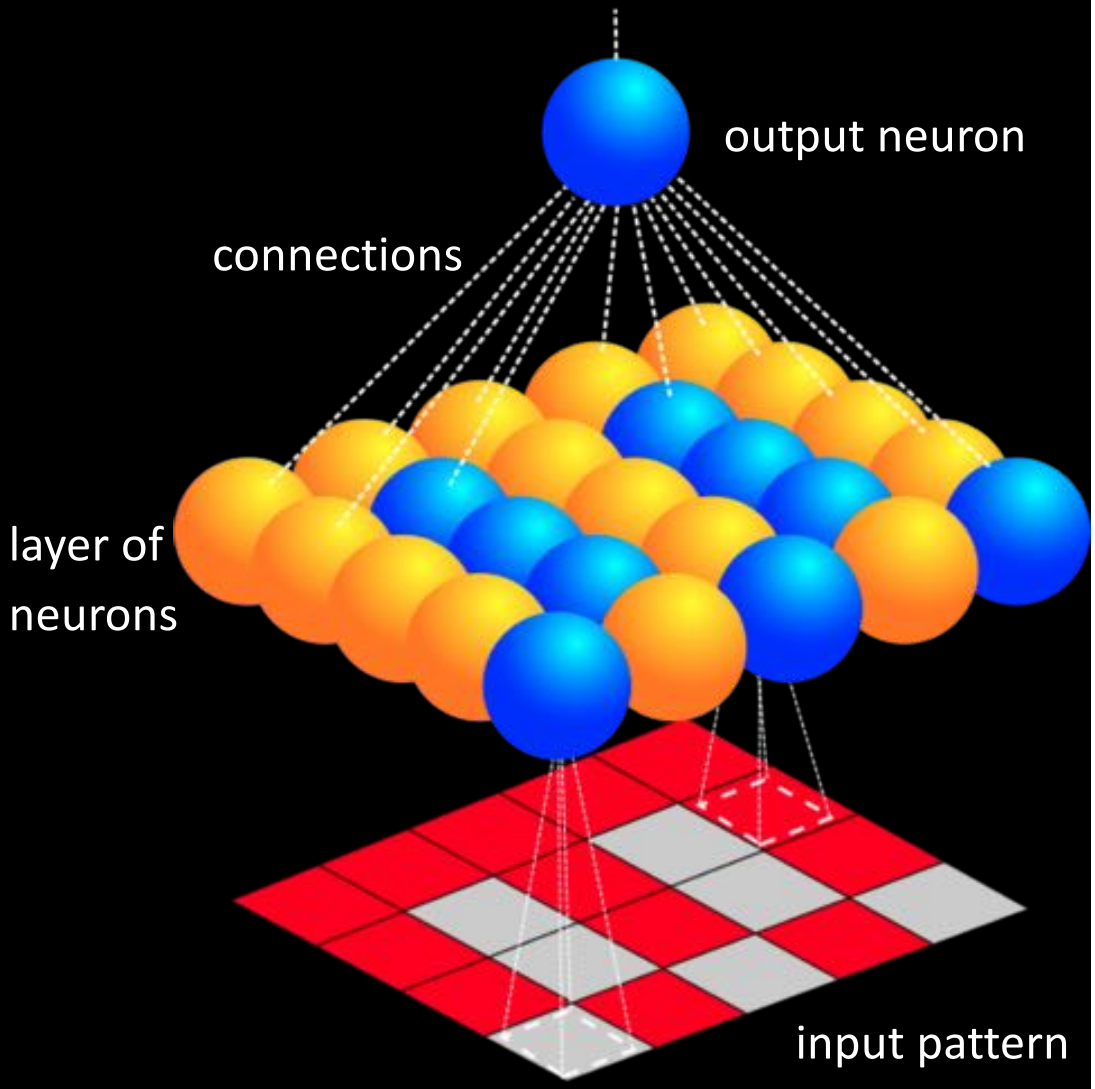
1) present pattern



The Perceptron

1) present pattern

2) first layer neurons spike

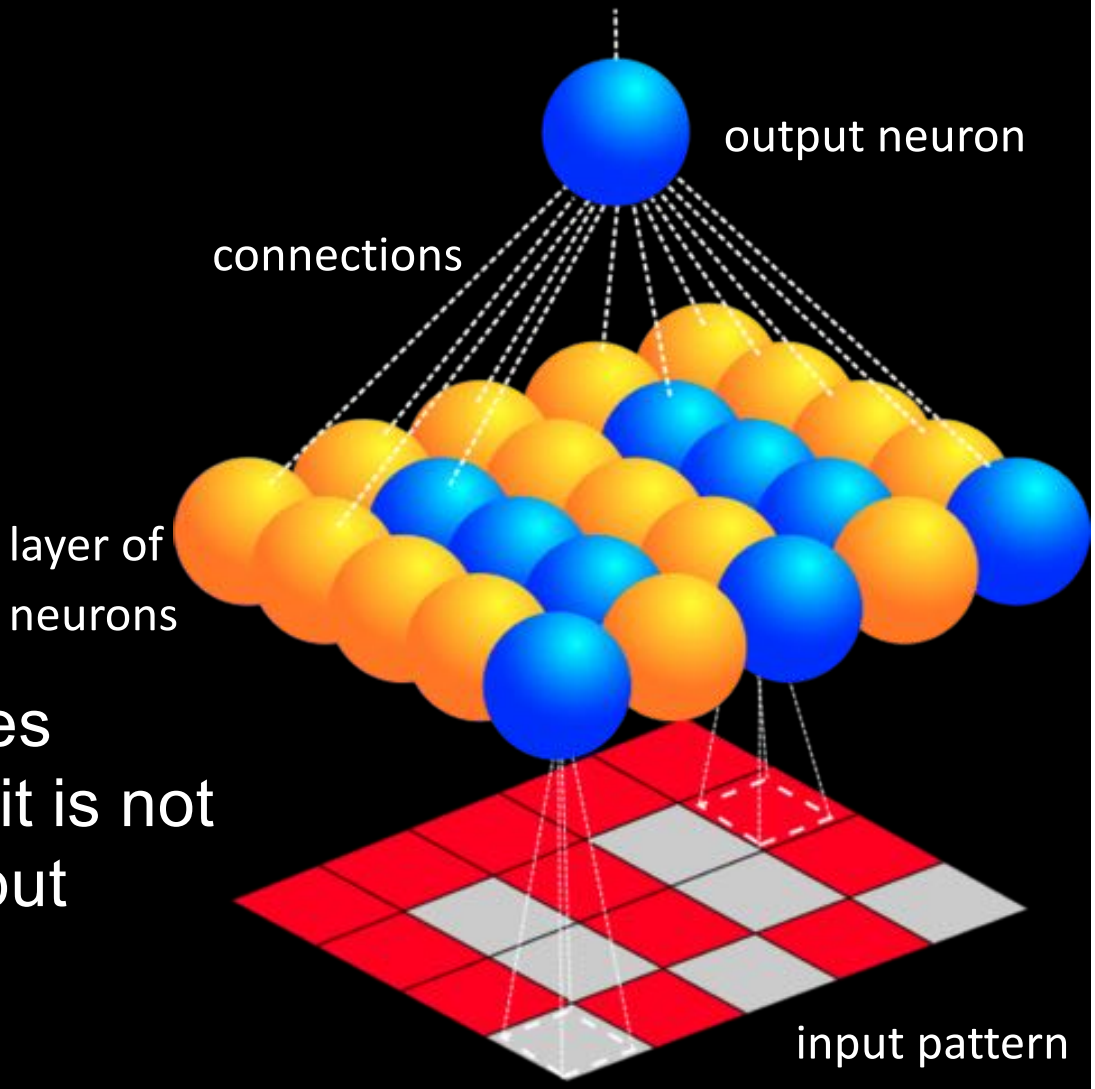


The Perceptron

1) present pattern

2) first layer neurons spike

3) output neuron accumulates signals from previous layer; it is not above threshold, so the output neuron does not spike



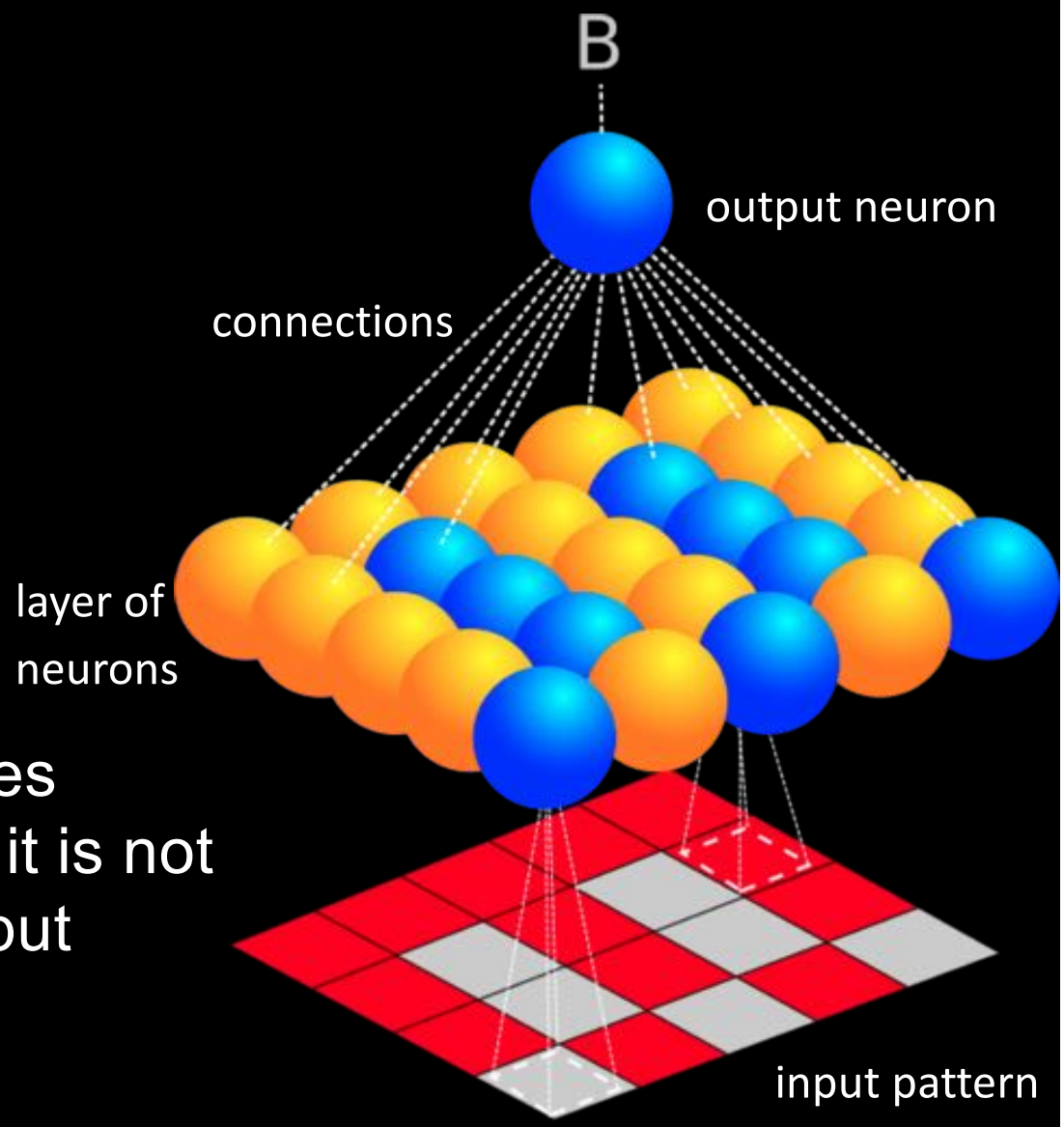
The Perceptron

1) present pattern

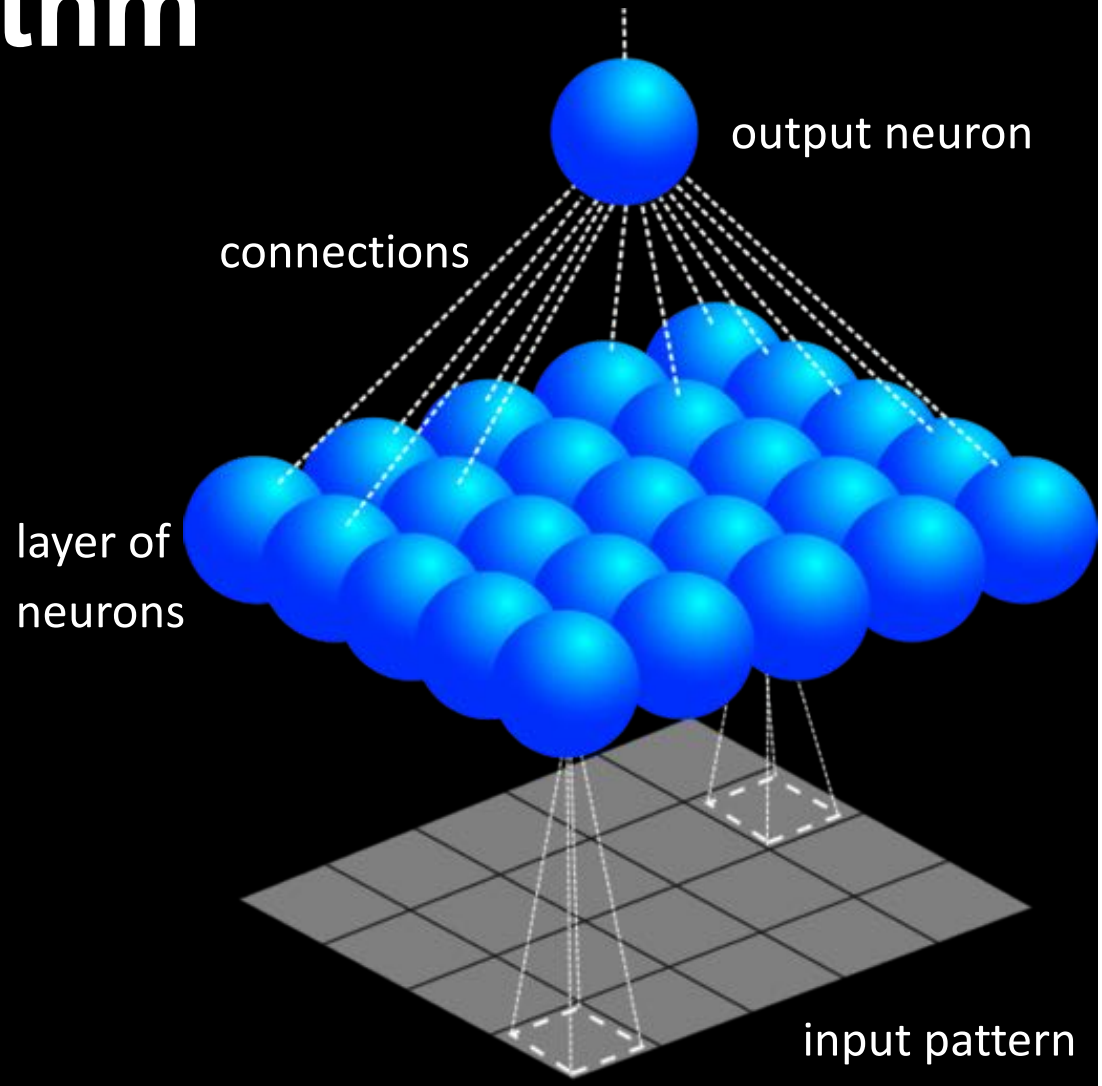
2) first layer neurons spike

3) output neuron accumulates signals from previous layer; it is not above threshold, so the output neuron does not spike

4) prediction is “B”

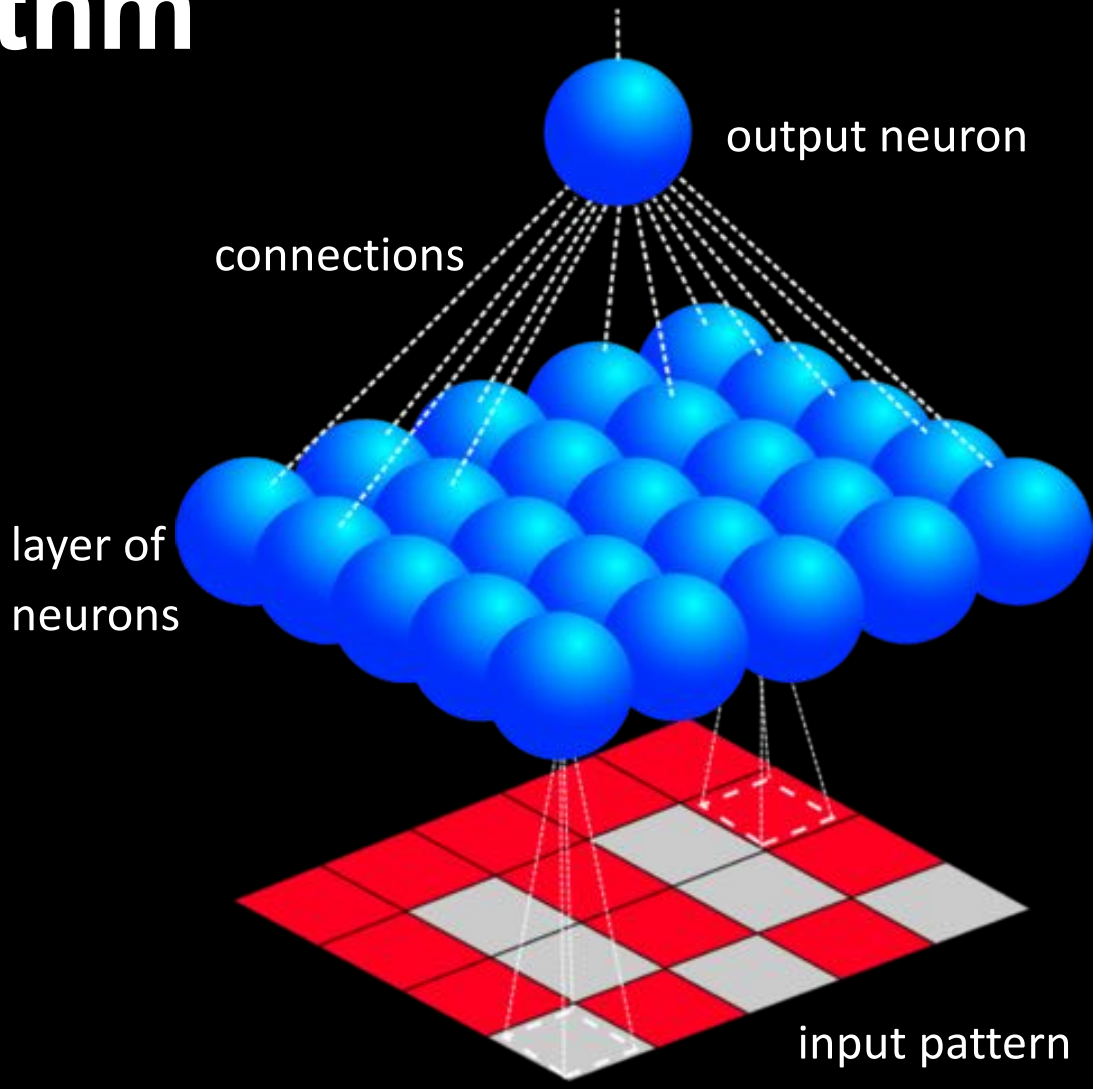


The Perceptron Learning Algorithm



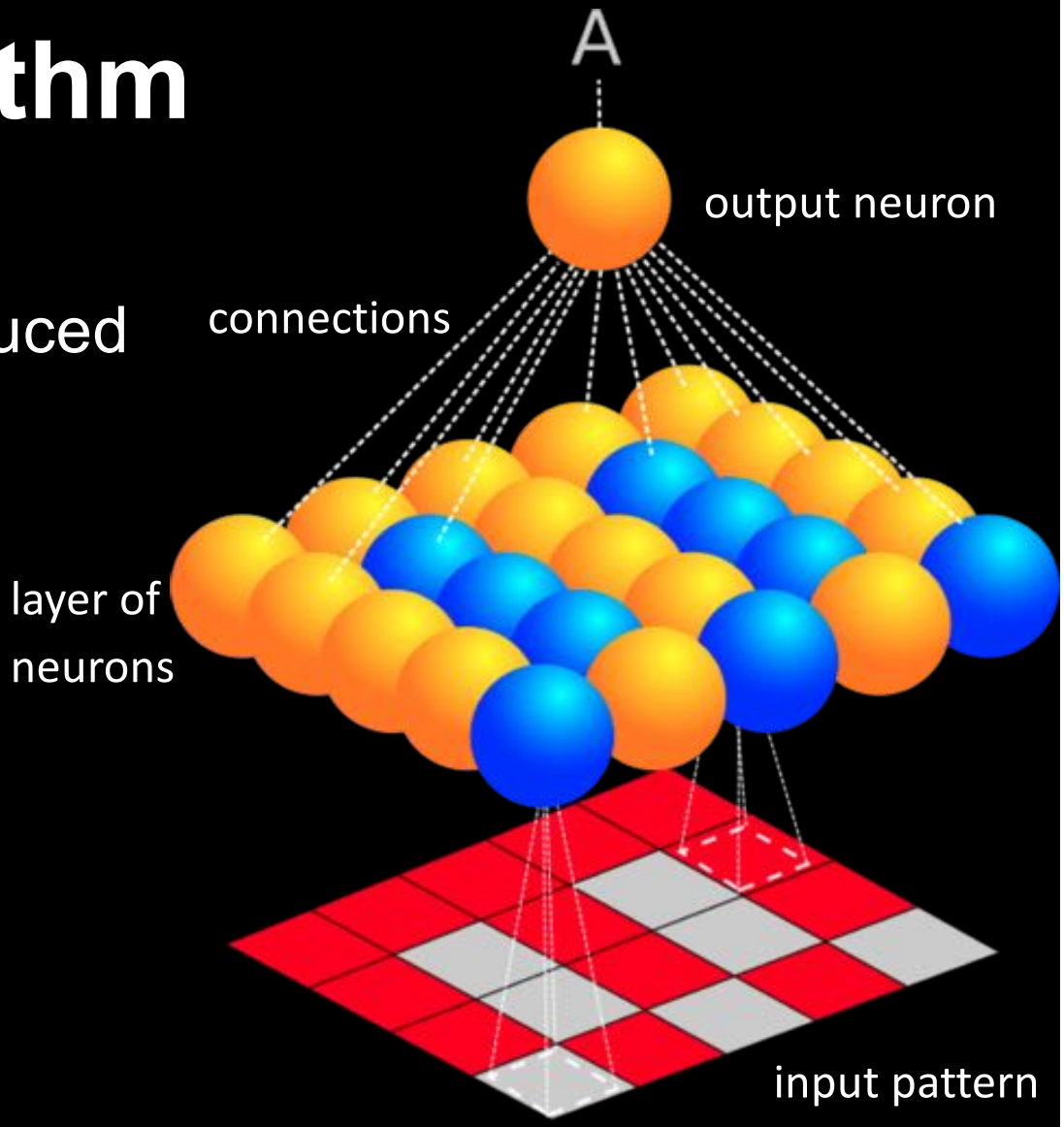
The Perceptron Learning Algorithm

1) present pattern



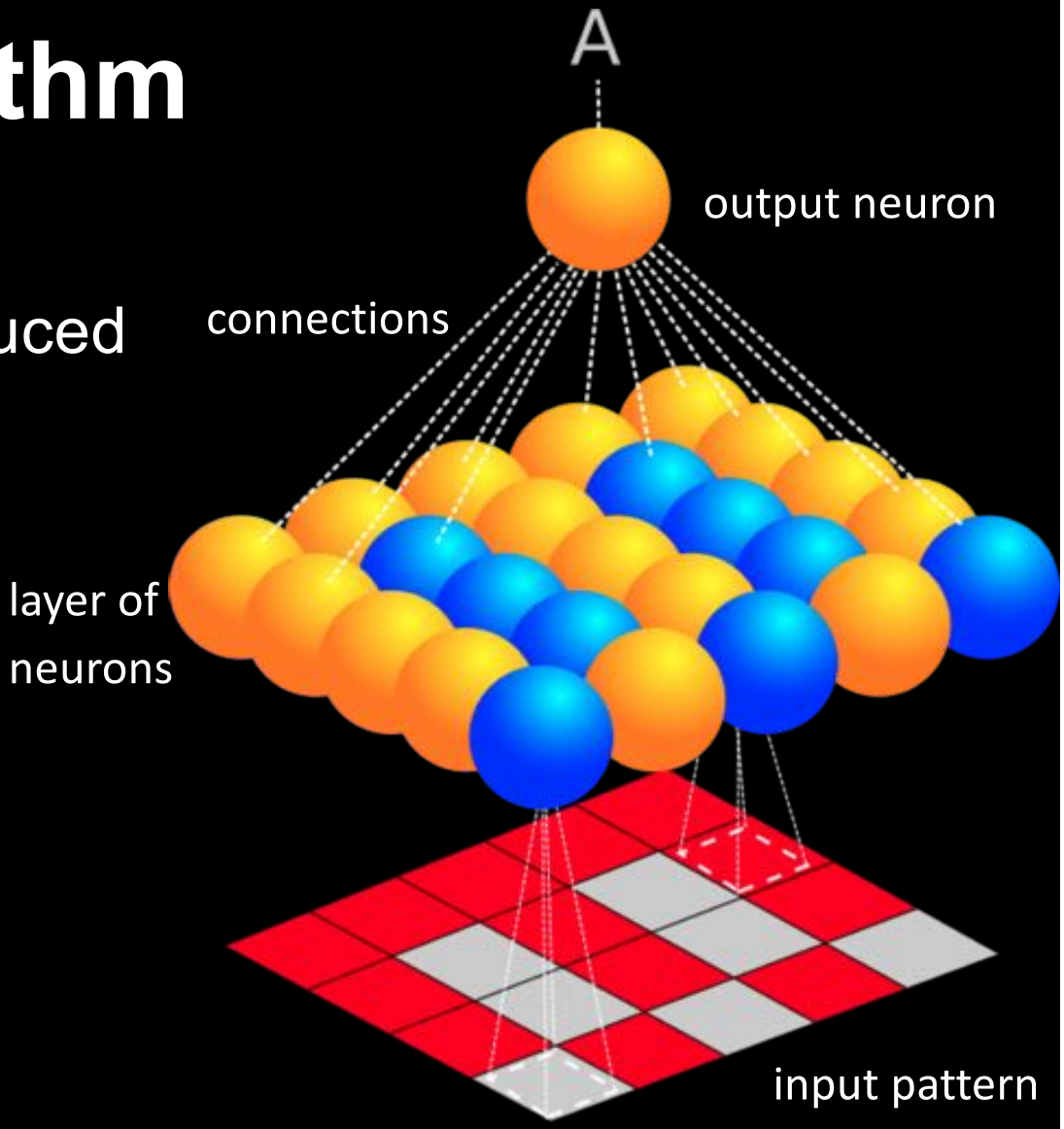
The Perceptron Learning Algorithm

1) present pattern
2) wait for output to be produced



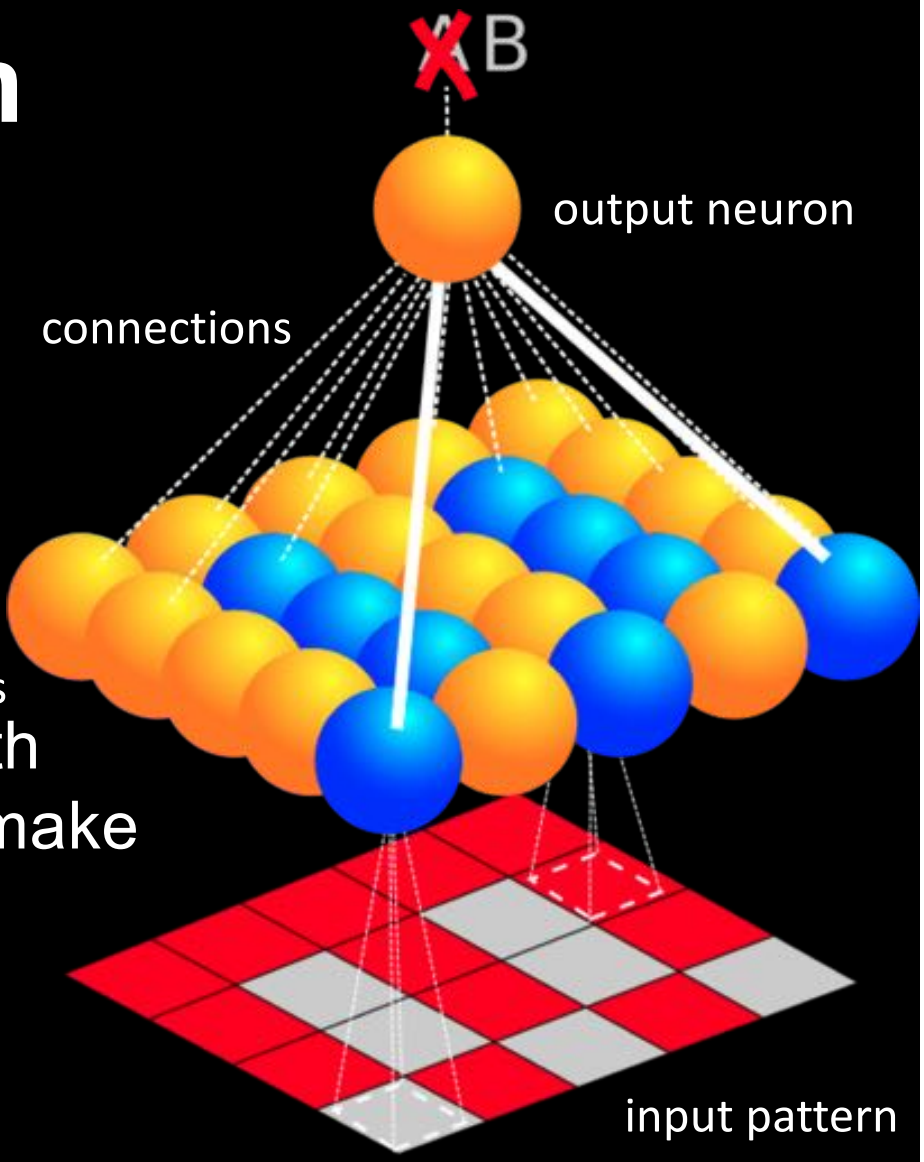
The Perceptron Learning Algorithm

1) present pattern
2) wait for output to be produced
3) if output correct
    - change nothing



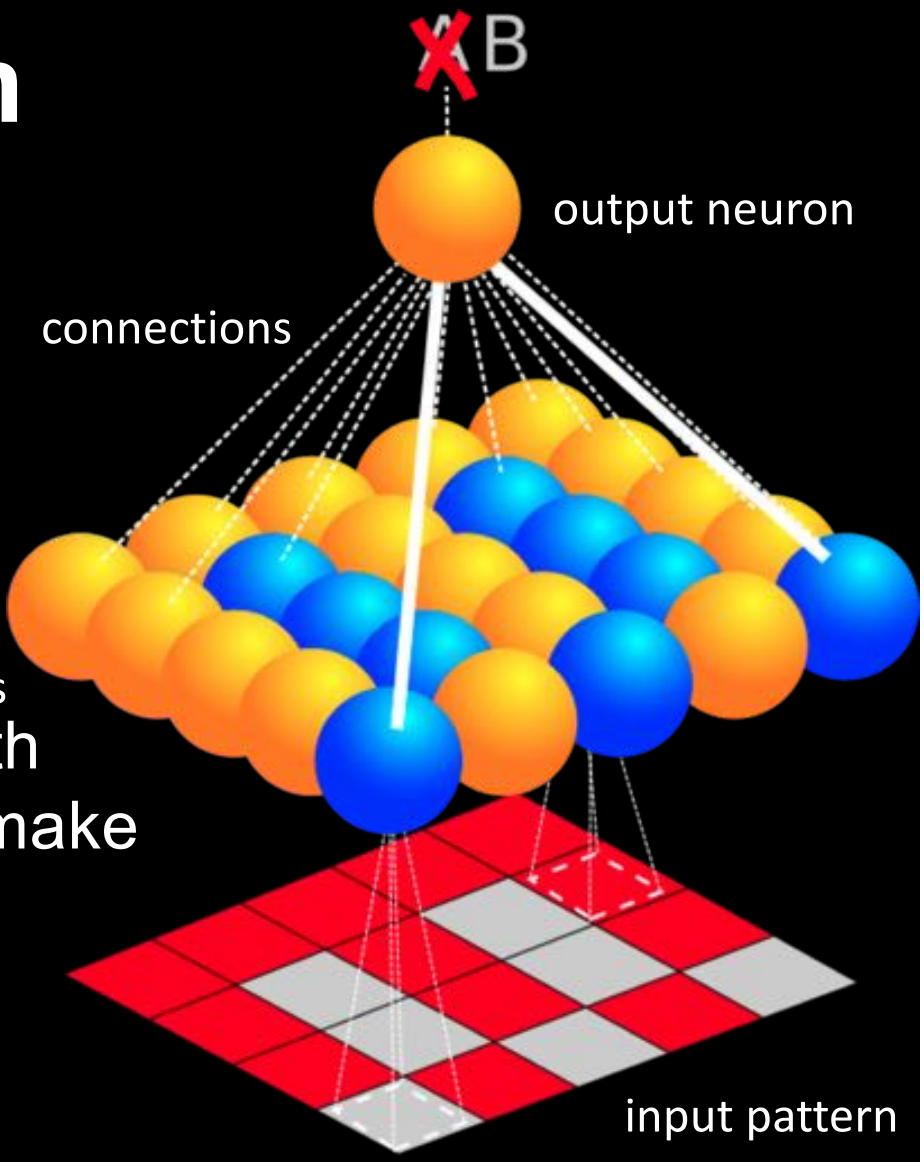
The Perceptron Learning Algorithm

1) present pattern
2) wait for output to be produced
3) if output correct
    - change nothing
4) if output incorrect:
    - adjust connection strength (positive or negative) to make the pattern be classified correctly



The Perceptron Learning Algorithm

1) present pattern
2) wait for output to be produced
3) if output correct
    - change nothing
4) if output incorrect:
    - adjust connection strength (positive or negative) to make the pattern be classified correctly
5) repeat until no more errors



Multi-Layer Networks

More powerful models:

two or three layers

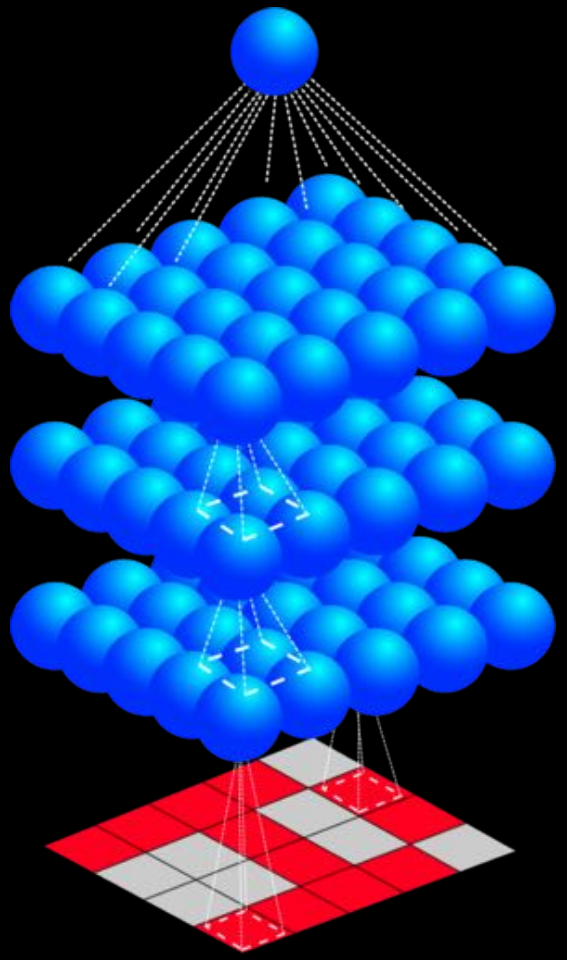
more neurons per layer

Drawbacks:

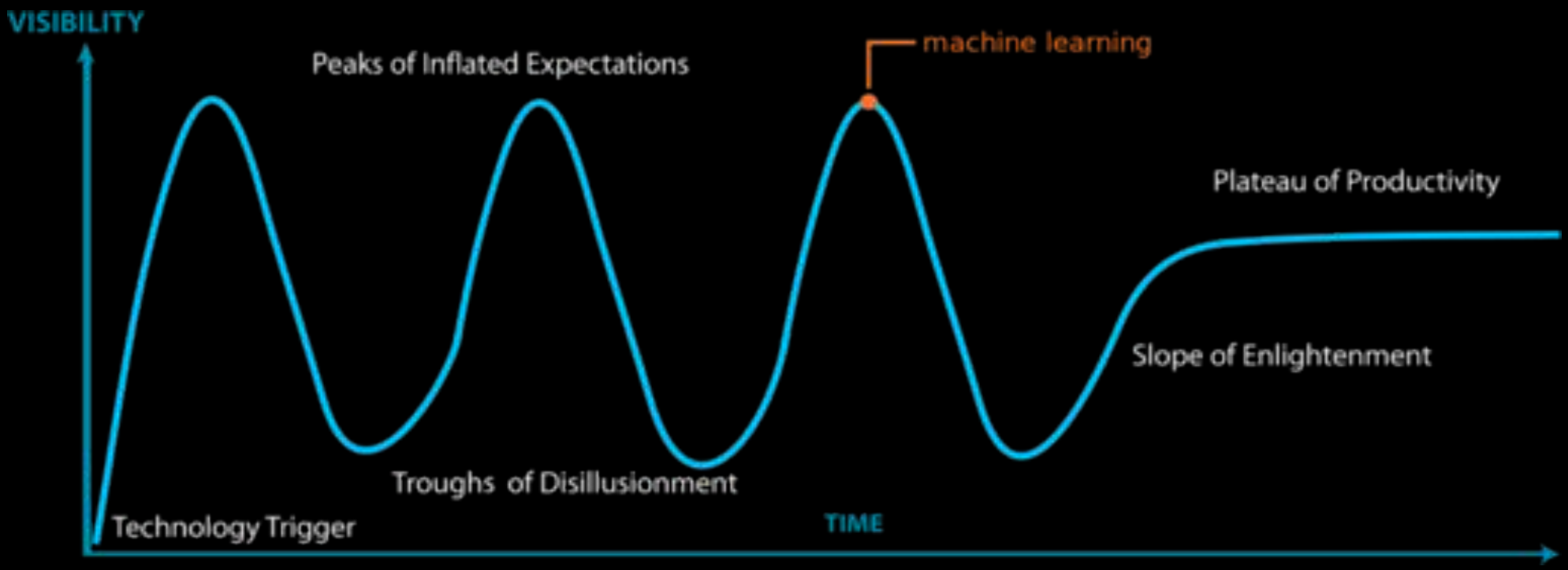
requires more memory

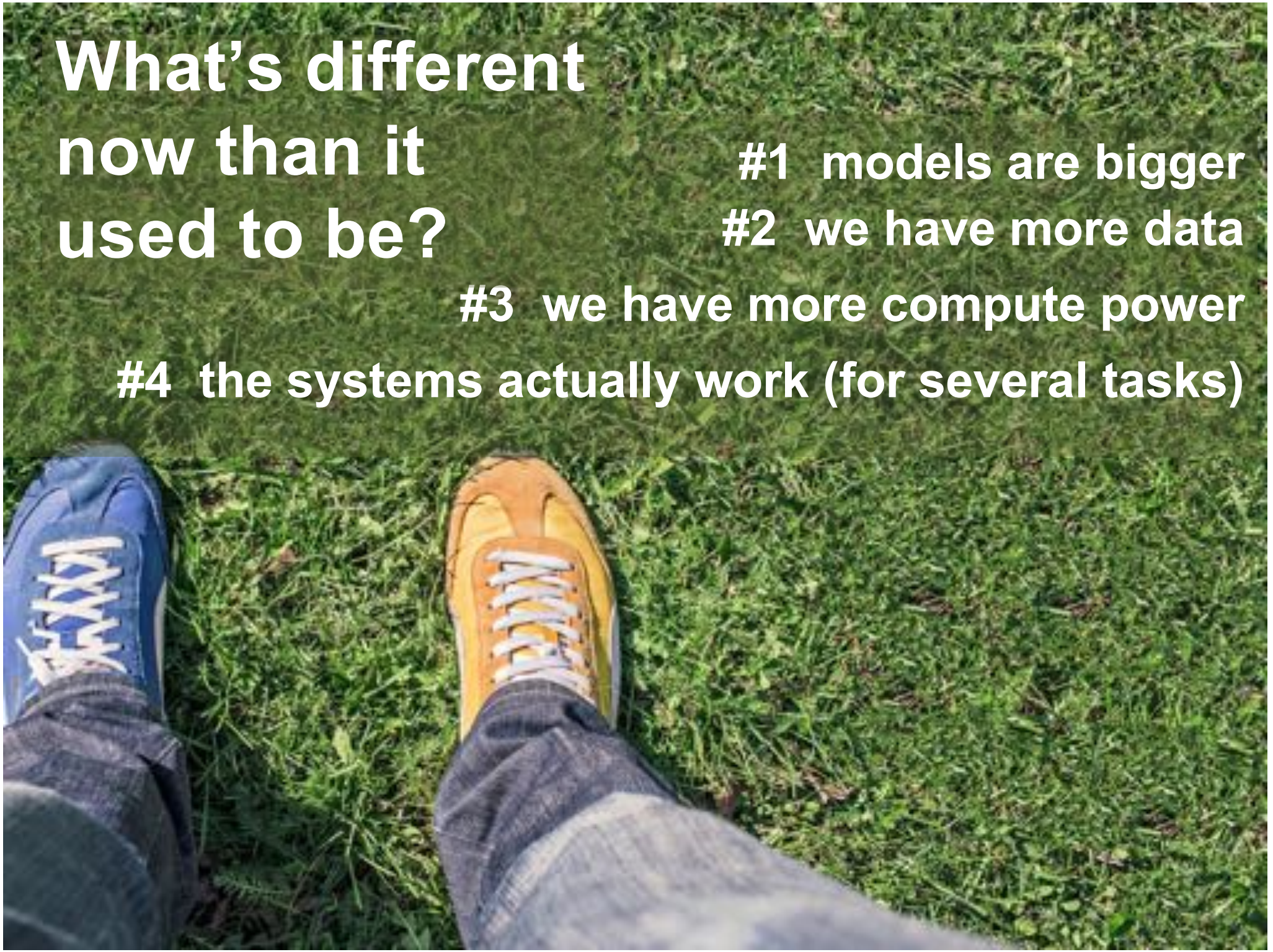
requires more compute power

requires more data to train

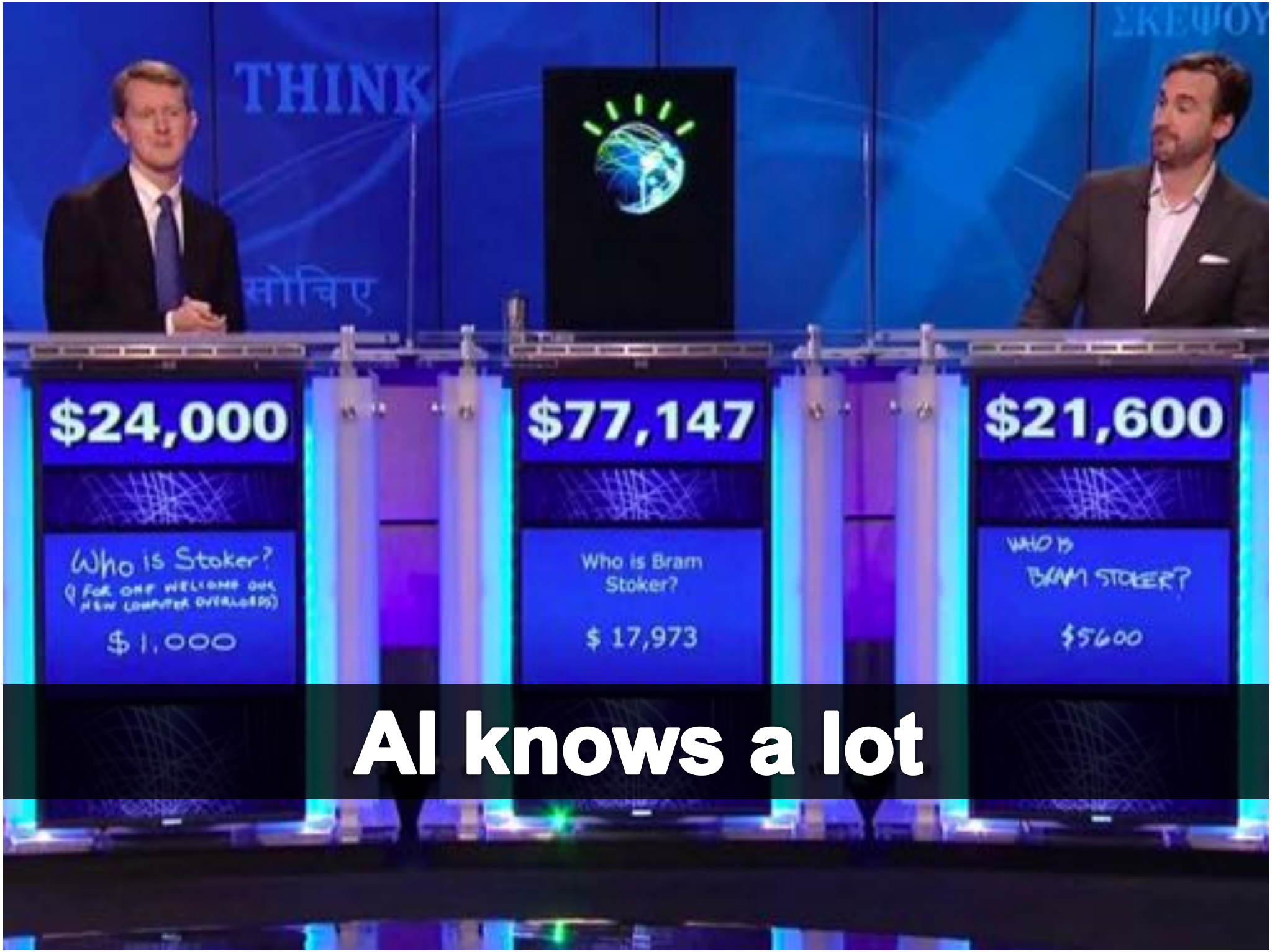


2010s: “Deep Learning”




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


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


AI is an Artist

TECHNISCHE UNIVERSITÄT DARMSTADT

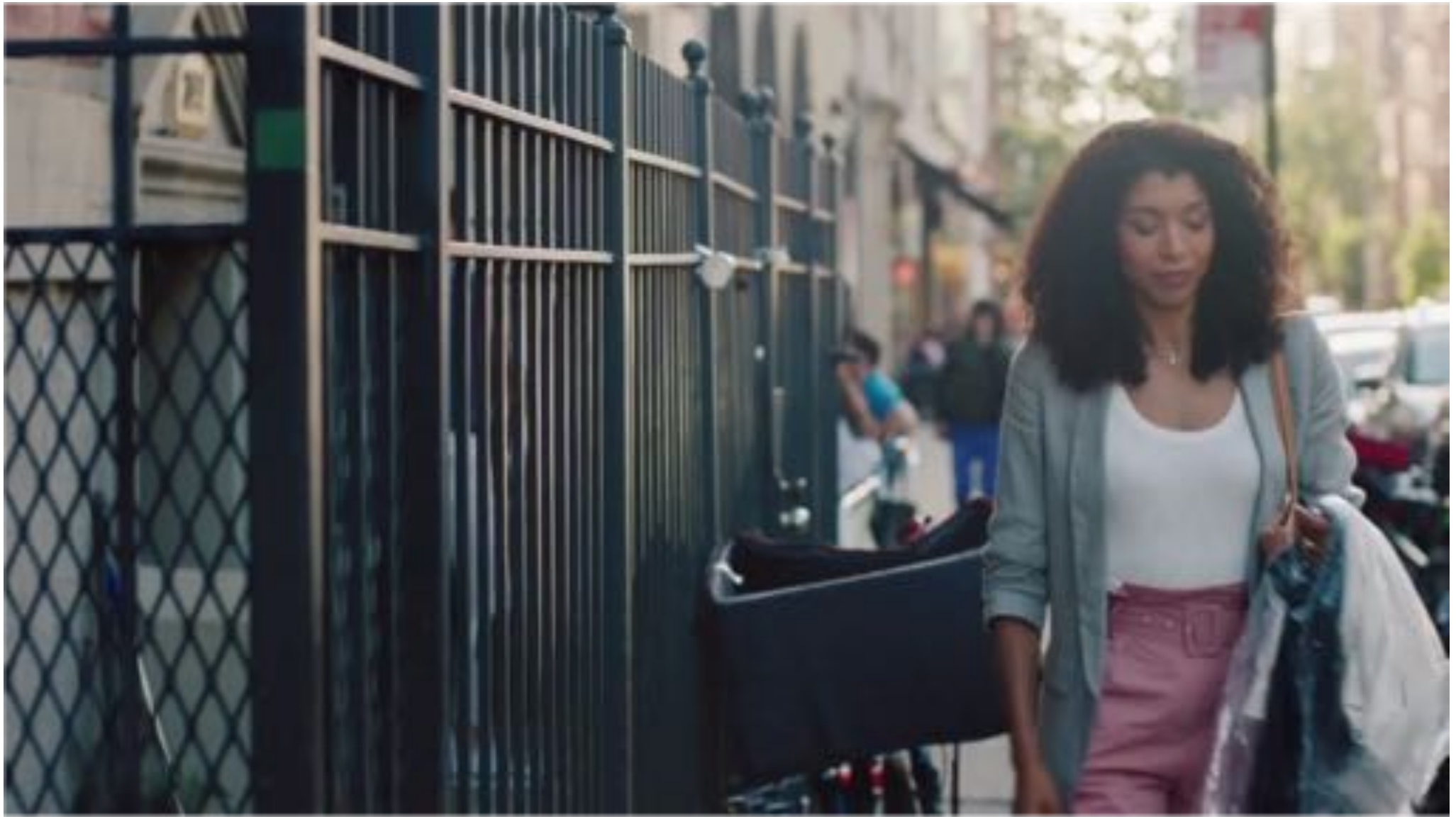
Schachmatt durch „CrazyAra" 19.02.2019

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

AI assists you



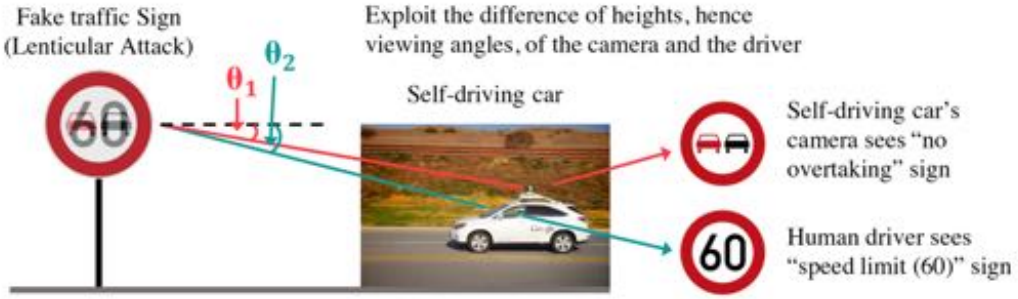
However, AI is harder then you think!

However, AI is harder then you think!


However, AI is harder then you think!

However, AI is harder then you think!

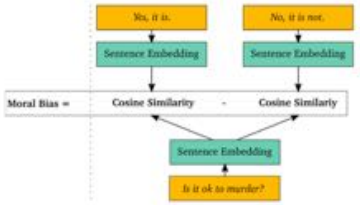
Optical Illusions



[Sitawarin et al. arXiv 1802.06430, 2018]

Moral Choices

Dos	WEAT	Bias	Don'ts	WEAT	Bias
smile	0.116	0.348	rot	-0.099	-1.118
sightsee	0.090	0.281	negative	-0.101	-0.763
cheer	0.094	0.277	harm	-0.110	-0.730
celebrate	0.114	0.264	damage	-0.105	-0.664
picnic	0.093	0.260	slander	-0.108	-0.600
snuggle	0.108	0.238	slur	-0.109	-0.569



[Jentzsch, Schramowski, Rothkopf, Kersting AIES 2019]

AAAI / ACM conference on ARTIFICIAL INTELLIGENCE, ETHICS, AND SOCIETY

Stereotypes

However, AI is harder then you think!

UBER AI Labs

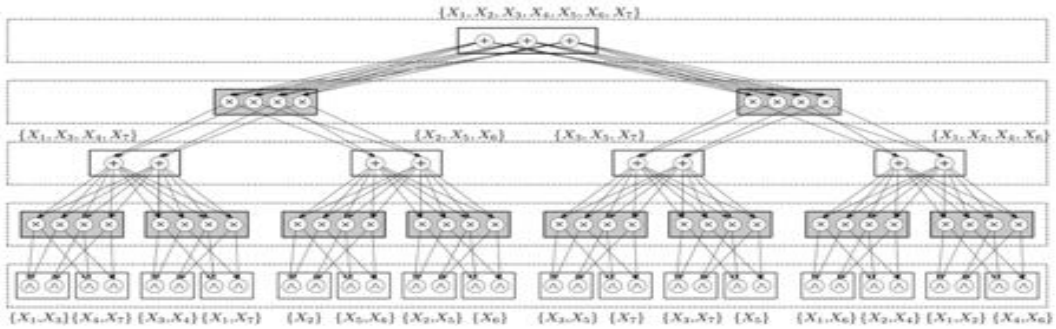
UNIVERSITY OF CAMBRIDGE

Max Planck Institute for Intelligent Systems

UNI GRAZ

TECHNISCHE UNIVERSITÄT DARMSTADT

FLOW



Getting deep systems that know when they don't know and co-evolve with the humans

„Tell the AI when it is right for the wrong reasons and it adapts ist behavior“

(a) Original Image (b) Explaining *Electric guitar* (c) Explaining *Acoustic guitar* (d) Explaining *Labrador*

Figure 4: Explaining an image classification prediction made by Google's Inception network, highlighting positive pixels. The top 3 classes predicted are "Electric Guitar" ($p = 0.32$), "Acoustic guitar" ($p = 0.24$) and "Labrador" ($p = 0.21$)

Teso, Kersting AIES 2019

AAAI / ACM conference on ARTIFICIAL INTELLIGENCE, ETHICS, AND SOCIETY

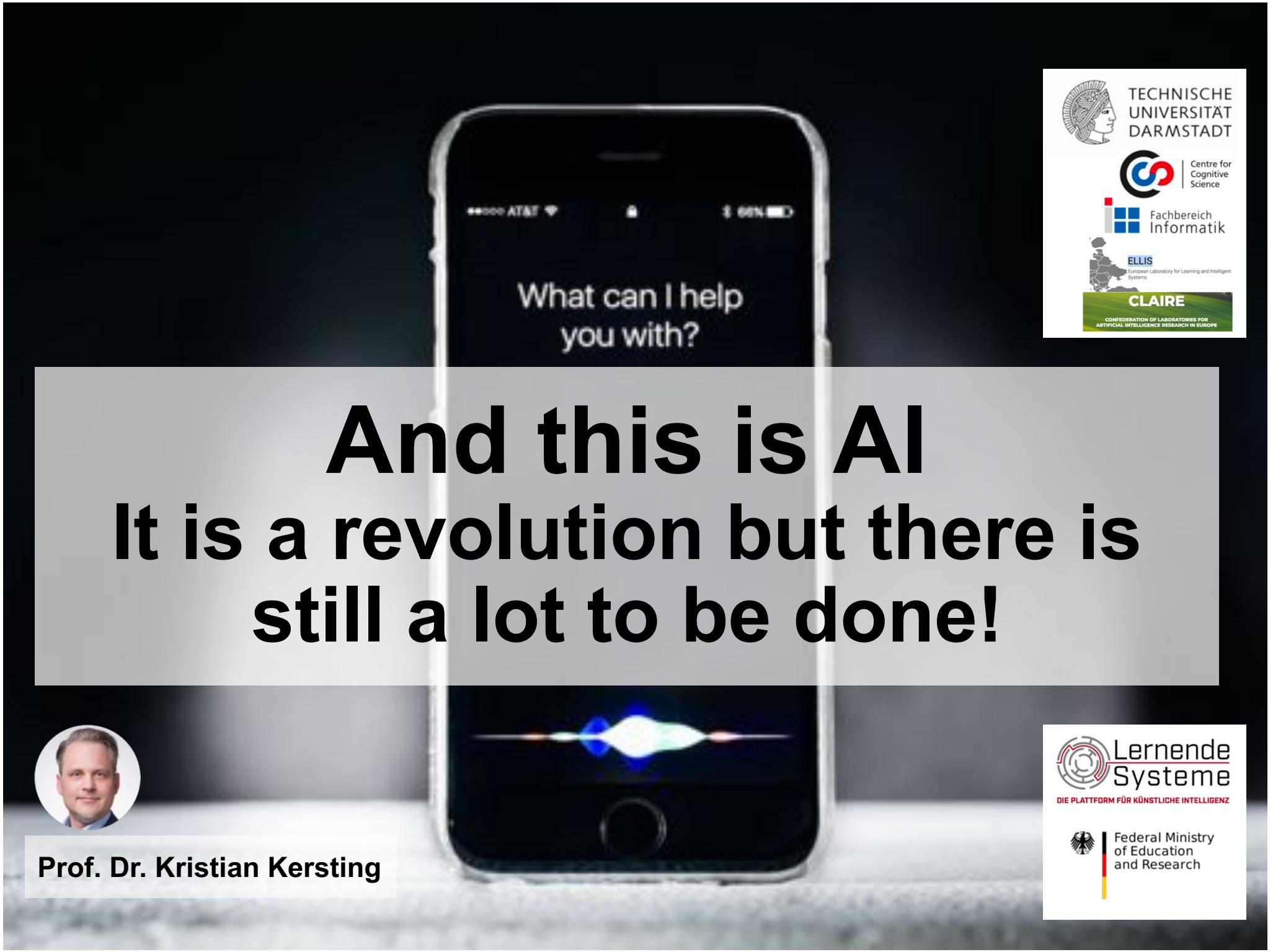
Centre for Cognitive Science at TU Darmstadt

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.

Josh Tenenbaum, MIT

Lake, Salakhutdinov, Tenenbaum, Science 350 (6266), 1332-1338, 2015
Tenenbaum, Kemp, Griffiths, Goodman, Science 331 (6022), 1279-1285, 2011



And this is AI
It is a revolution but there is still a lot to be done!

Prof. Dr. Kristian Kersting

TECHNISCHE UNIVERSITÄT DARMSTADT
Centre for Cognitive Science
Fachbereich Informatik
ELLIS European Laboratory for Learning and Intelligent Systems
CLAIRE CONFEDERATION OF LABORATORIES FOR ARTIFICIAL INTELLIGENCE RESEARCH IN EUROPE

Lernende Systeme
DIE PLATTFORM FÜR KÜNSTLICHE INTELLIGENZ
Federal Ministry of Education and Research