Applied Deep Learning

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What is deep learning all about?

"In the early days of [AI], the field rapidly tackled and solved problems that are intellectually difficult for human beings but relatively straightforward for computers […] The **true challenge** to [AI] proved to be solving the tasks that are easy for people to perform but hard for people to describe formally – **problems that we solve intuitively**, that feel automatic, like recognizing spoken words or faces in images.

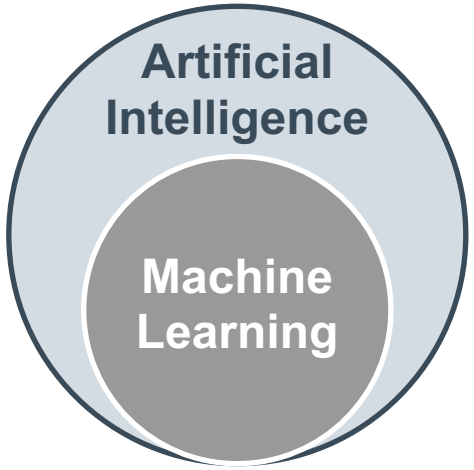
"[**Deep learning**] is about a **solution to these more intuitive problems**."

– Goodfellow et al., 2016

Machine learning and Artificial intelligence

Machine Learning (ML):
Well-defined concept. Set of algorithms (i.e., procedures) that take data as an input and learn patterns or predictions from this data without being told explicitly how to build these patterns or predictions.

Artificial Intelligence (AI):
Not as clear. Typically set of tasks performed by a computer that are commonly associated with intelligent beings (includes interaction with environment and making decisions to maximize goals)



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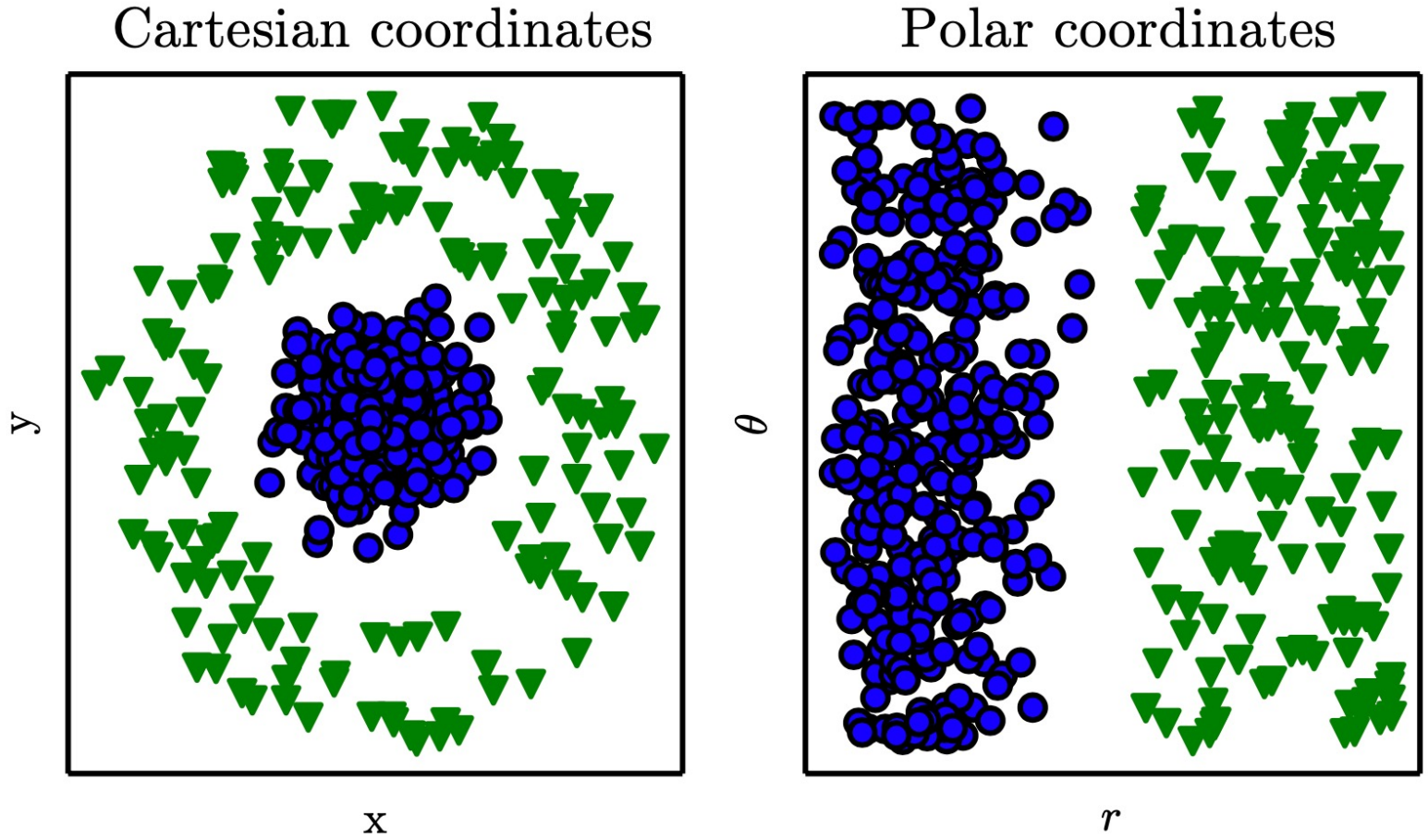
The importance of representations

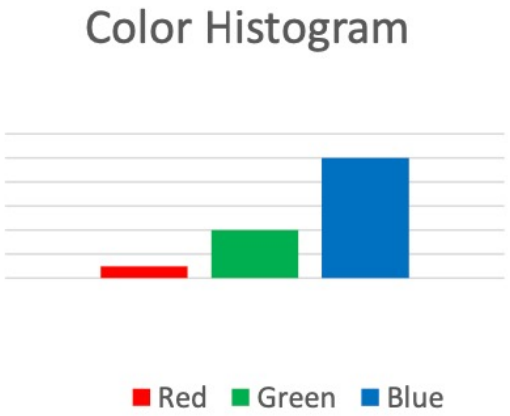


Source: Goodfellow et al.

The traditional way of extracting features: pre-defined representations

x

Extract features



build hypothesis

$$y = w^T \phi(x)$$

Source: Liang

Representation learning: learning the features to extract

x

Learn $\phi(x)$

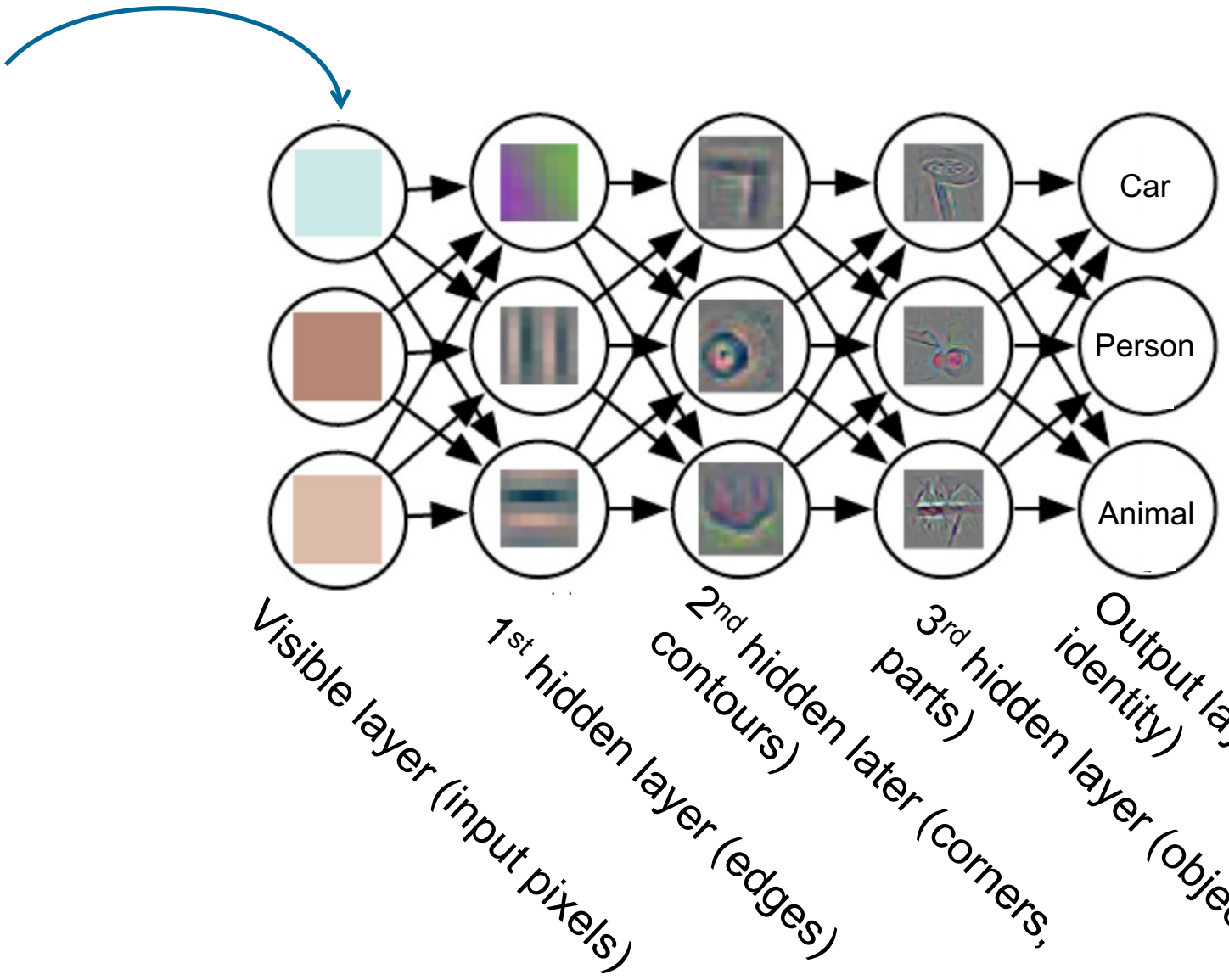
$\phi(x)$

Learn w

$y = w^T \phi(x)$

Source: Liang

What is the magic behind deep learning?



Source: Goodfellow et al.

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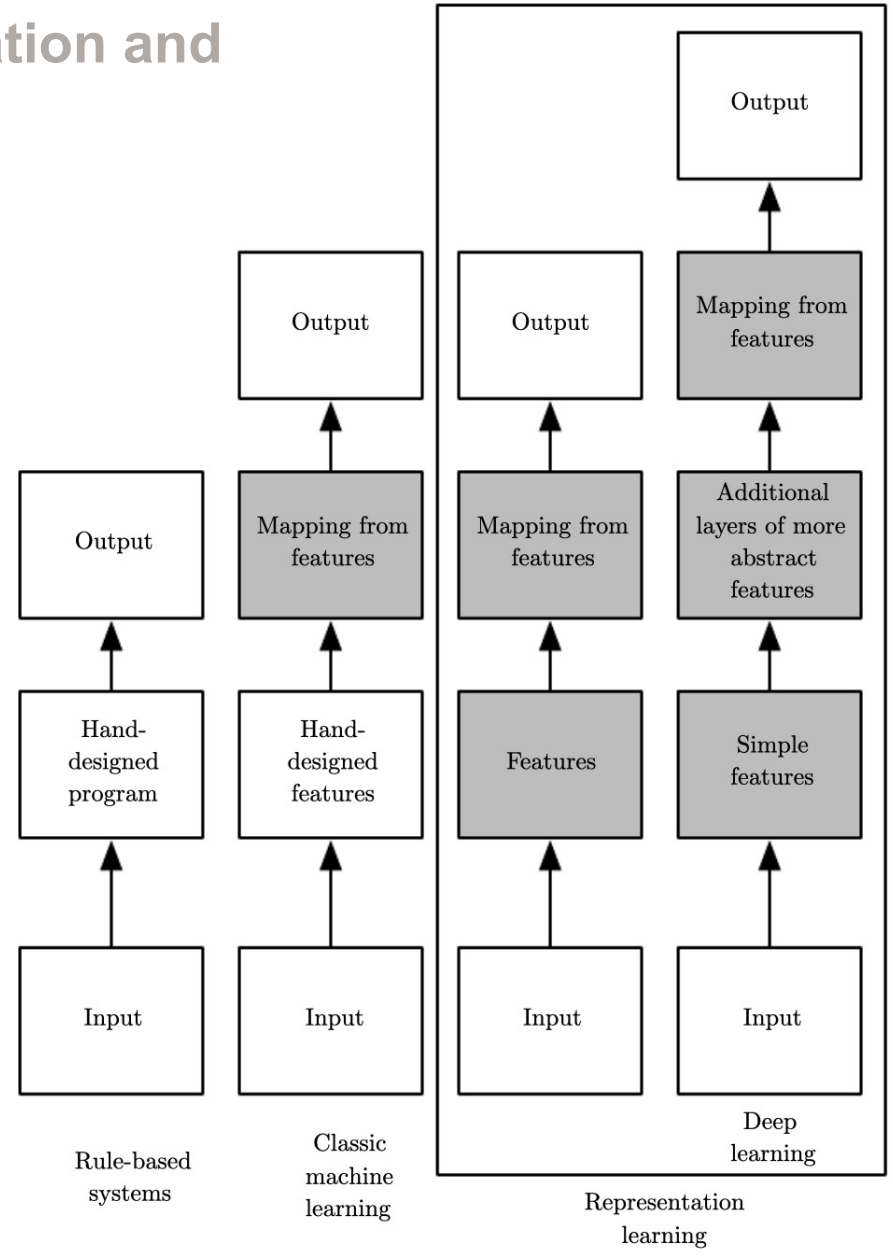
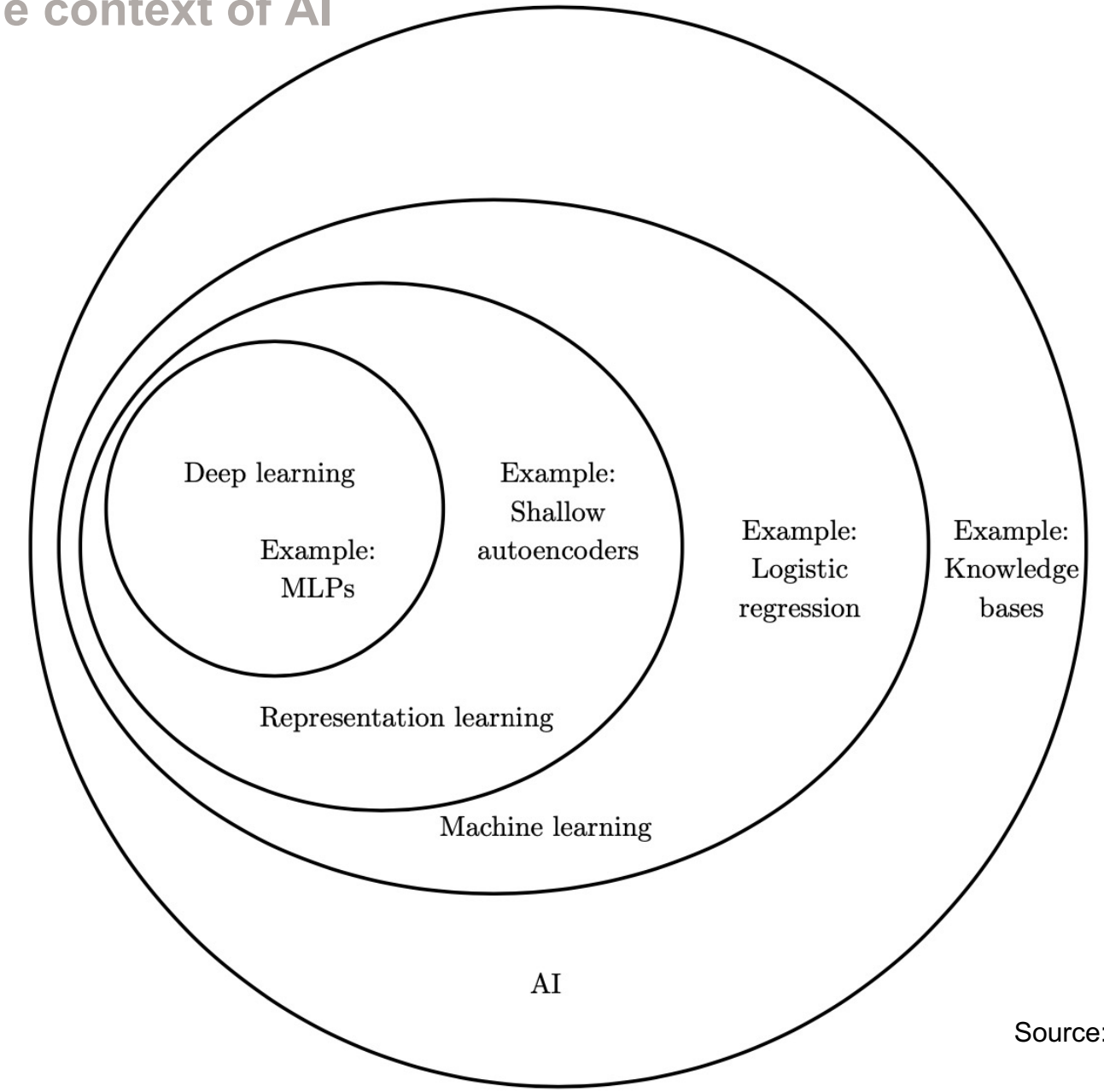
What we learn in representation and deep learning



Source: Goodfellow et al.

Deep learning in the context of AI



Source: Goodfellow et al.

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Supervised and unsupervised deep learning

Supervised learning

Data is labeled: (x,y)

Goal:

- Learn a function f, such that f(x) = y

Examples:

- *Feed-forward network:* Given product and customer features, how likely is it that the customer will click on an ad?
- *Convolutional neural network:* Does the image contain a car?

Unsupervised learning

Data is unlabeled: (x)

Goal:

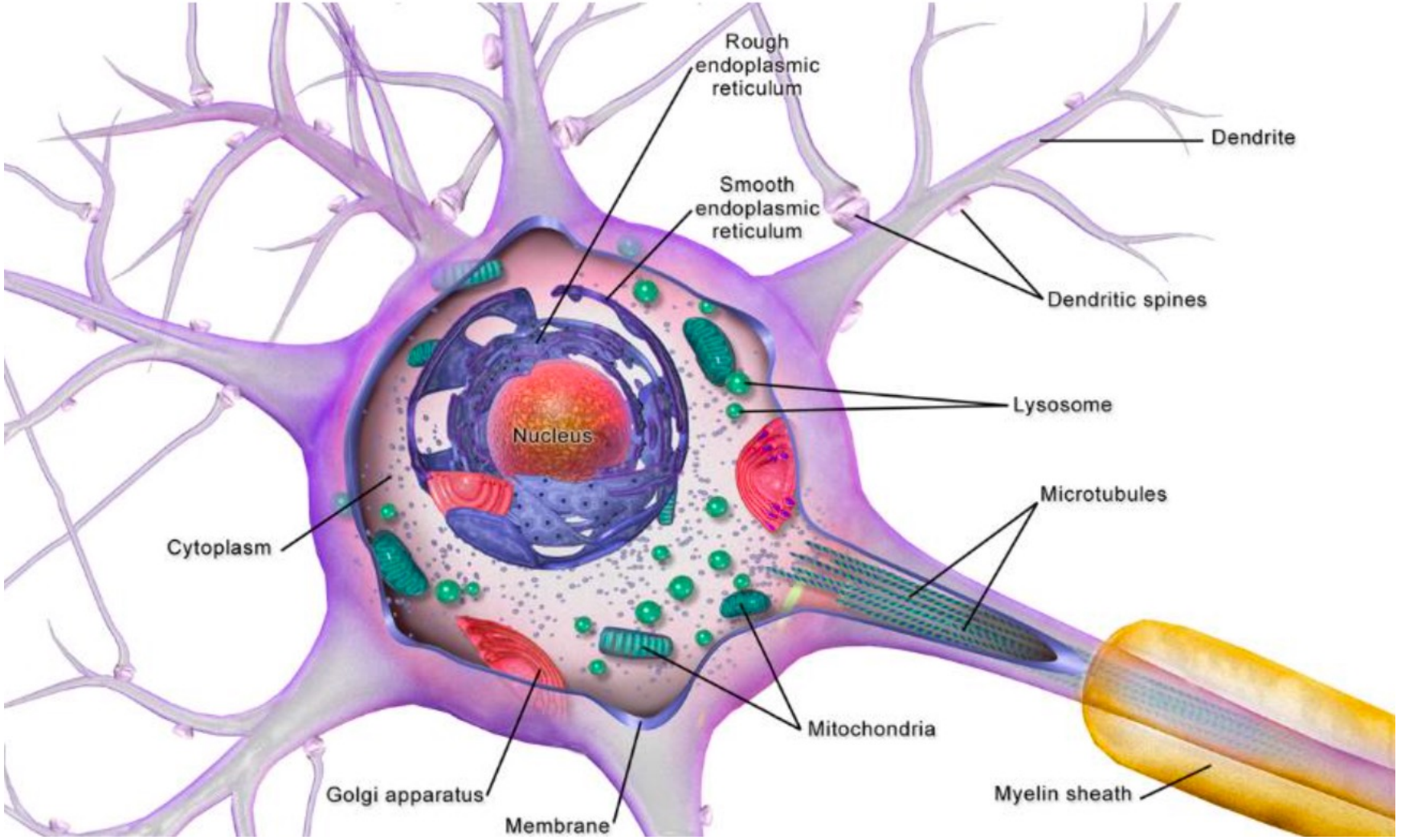
- Learn a function f

Examples:

- *Autoencoders:* Are there anomalies in the process data?
- *Self-organizing maps:* Into which clusters can we segment our customers?

A first look at a neural network

The biological inspiration



Source: Wikipedia

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But keep in mind, this is only an inspiration

"A single **neuron in the brain** is an **incredibly complex machine** that even today we don't understand. A single **neuron in a neural network** is an **incredibly simple mathematical function** that captures a minuscule fraction of the complexity of a biological neuron.

"So, to say neural networks mimic the brain, that is **true at the level of loose inspiration**, but really artificial neural networks are nothing like what the biological brain does."

– Andrew Ng (Wired.com)

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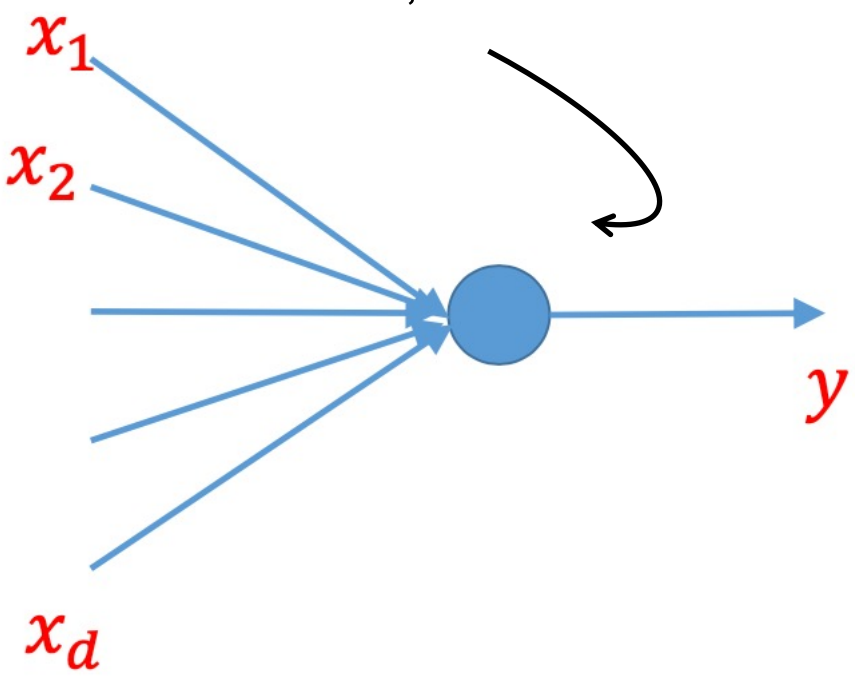
An abstract model of a neuron

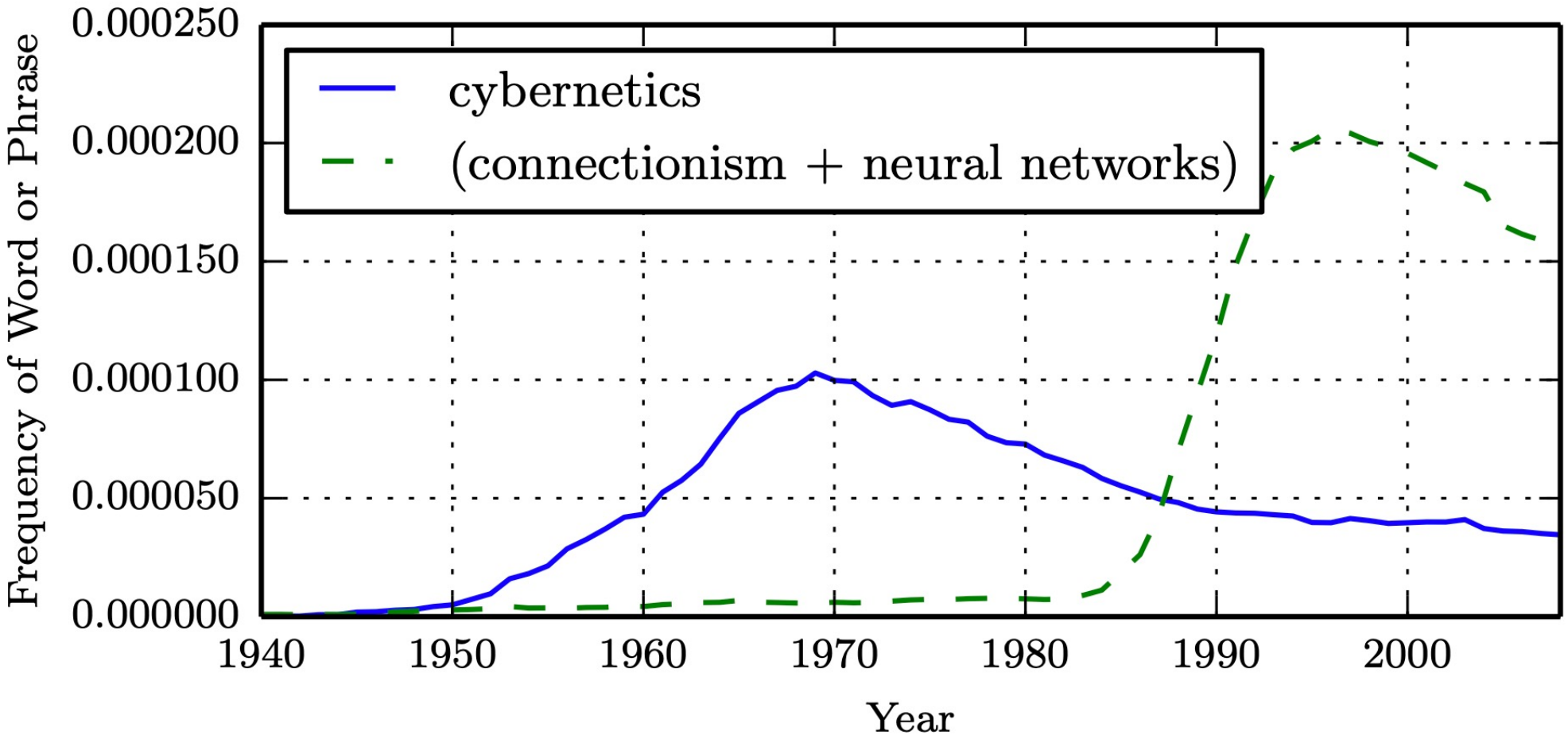
When the combined input signals reach a certain threshold, the neuron emits an output signal



So where are the input signals coming from?

Lessons from history

Previous waves of “deep learning”



Source: Goodfellow et al.

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Why the next wave?

Ongoing research into Algorithms

Page Rank for Google Search, Deep Learning Algorithms (ANNs, CNNs), Reinforcement Learning, ADMM

Increasing access to Data

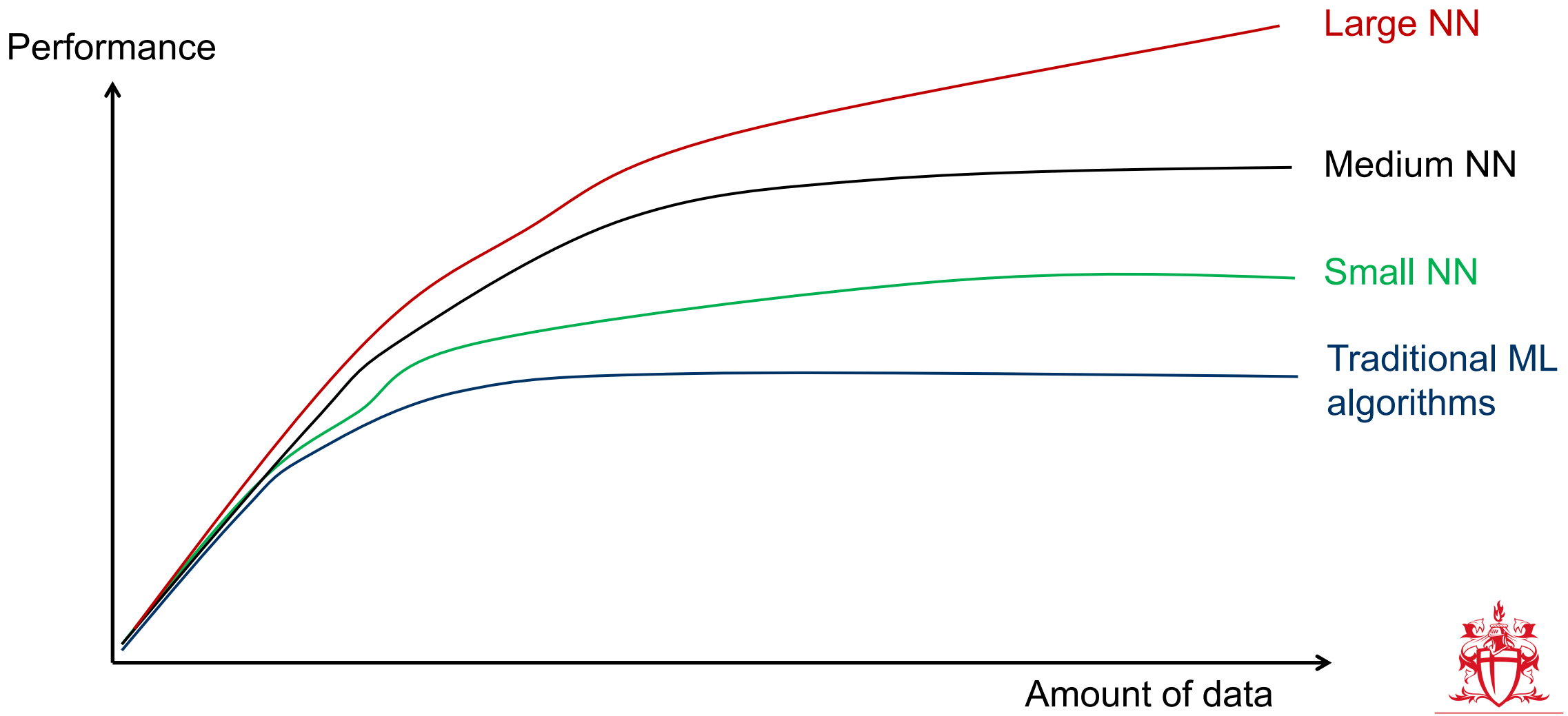
1991: Internet
1997: Google
2000s: Home PC
2004: Facebook
2005: YouTube
2007: Iphone
Etc.

Better computing capabilities

More processors per sq. inch (Moore's law), cloud-based services (storage and computation)

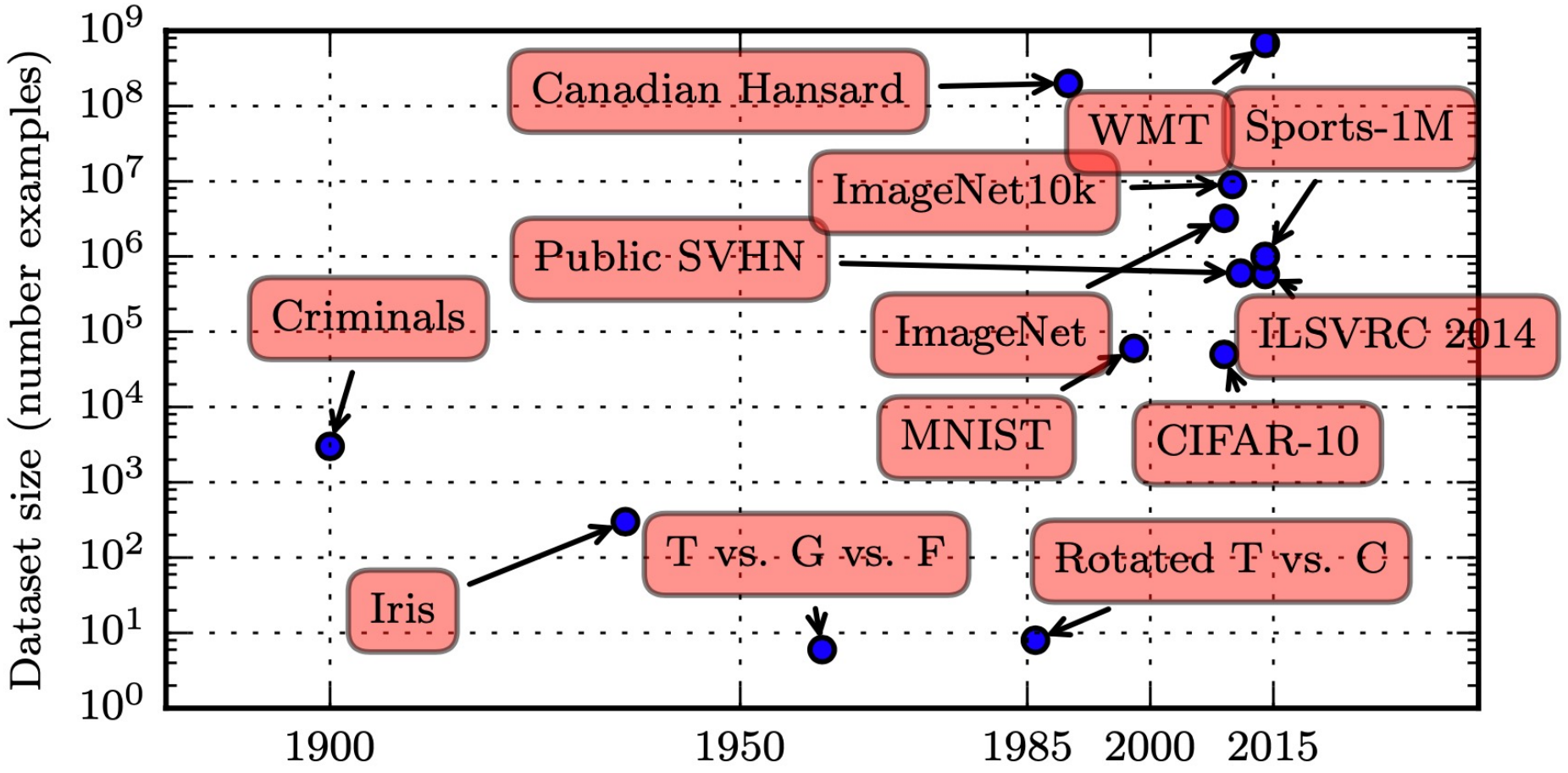
"Perfect storm" for Analytics – and deep learning in particular

Scale of data drives deep learning progress



Source: DeepLearning.AI

Availability of data



Source: Goodfellow et al.

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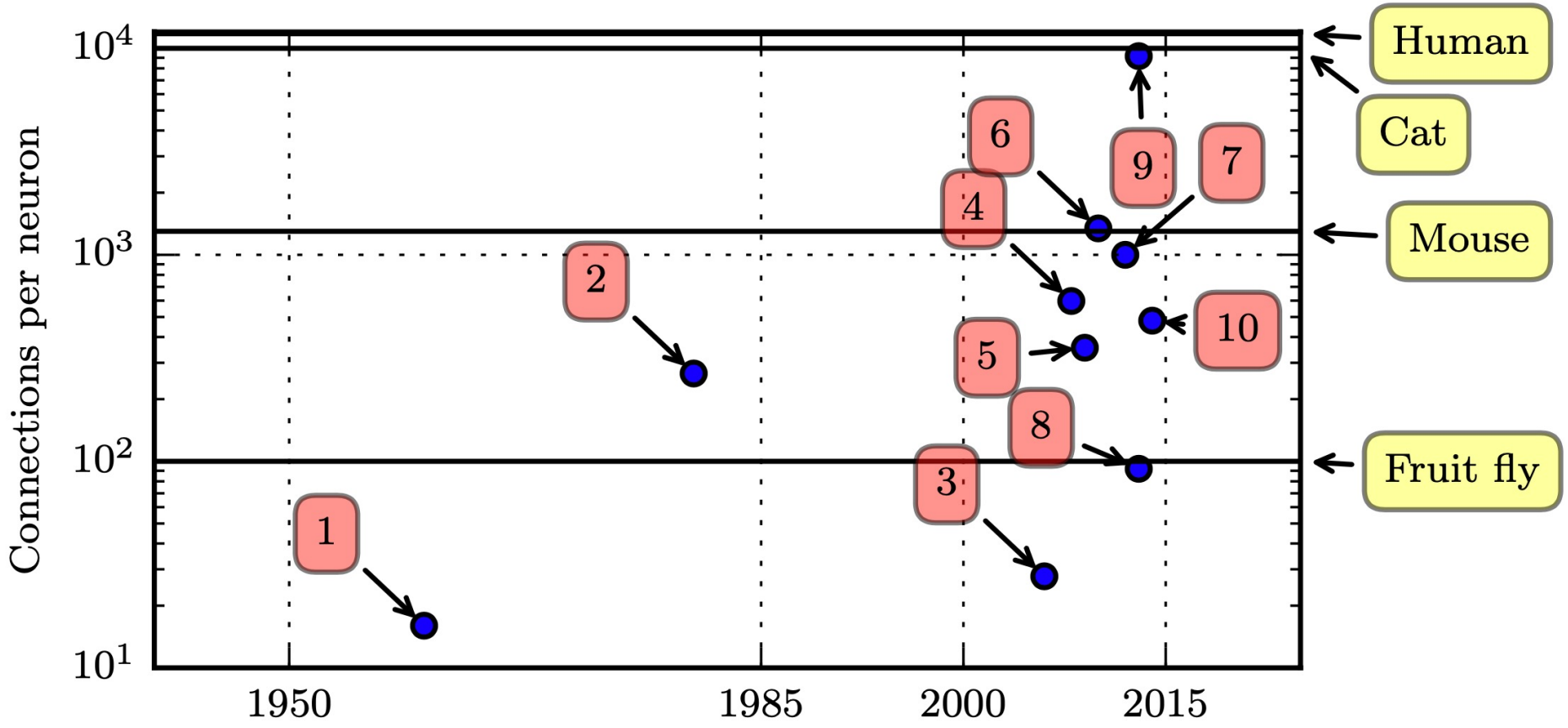
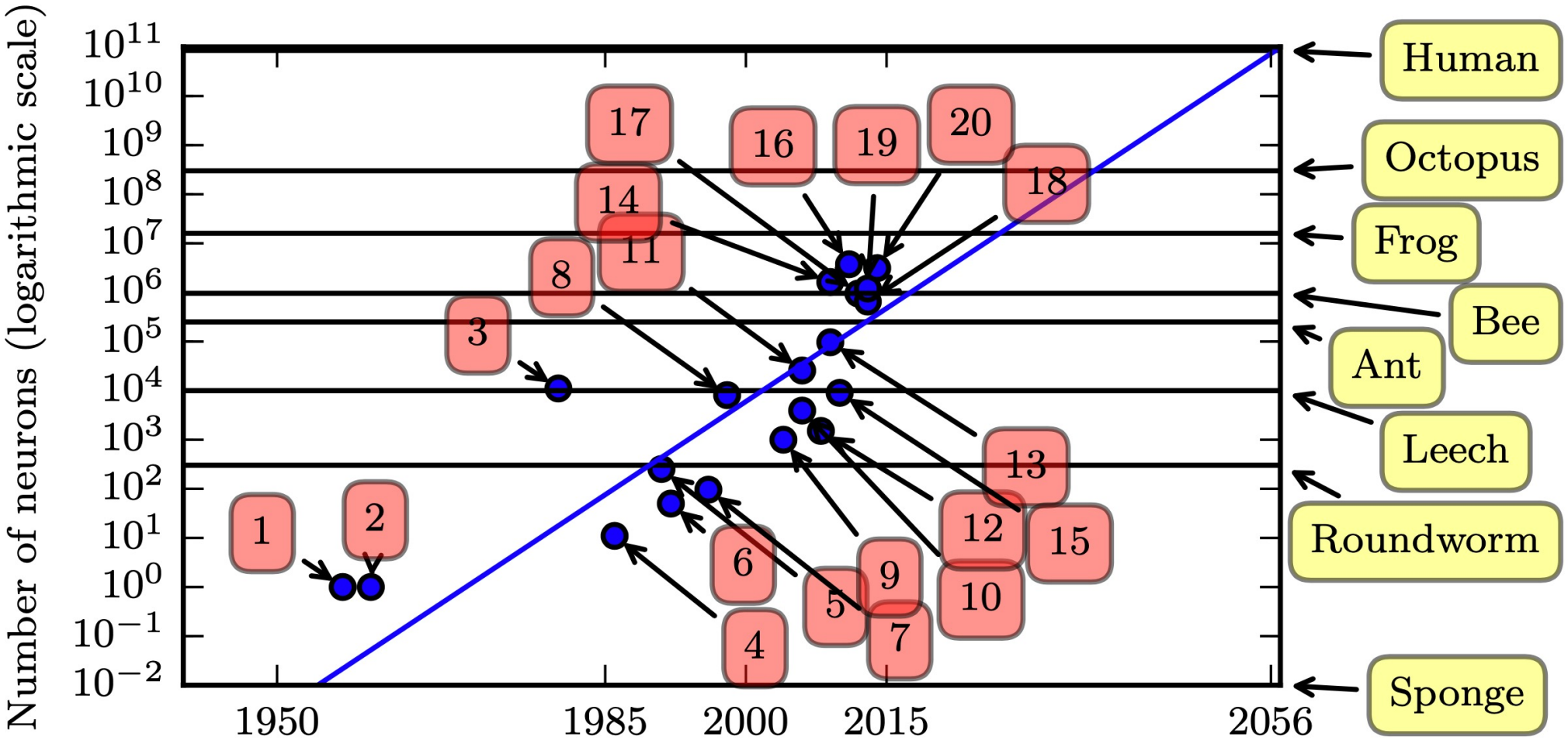
Model complexity: a function of computational power (1/2)



Source: Goodfellow et al.

Model complexity: a function of computational power (2/2)



Source: Goodfellow et al.

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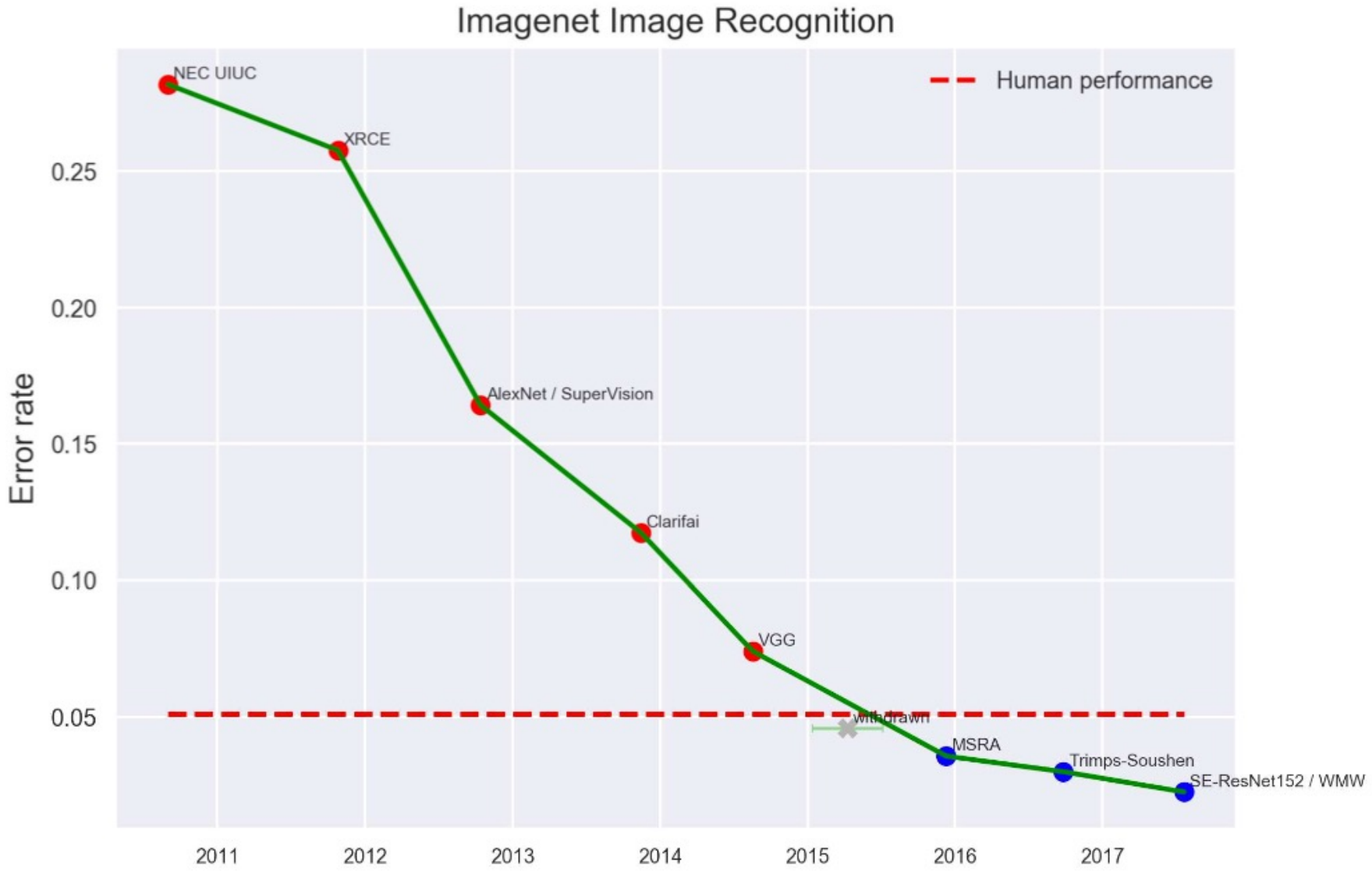
Impressive results of deep learning algorithms in recent years



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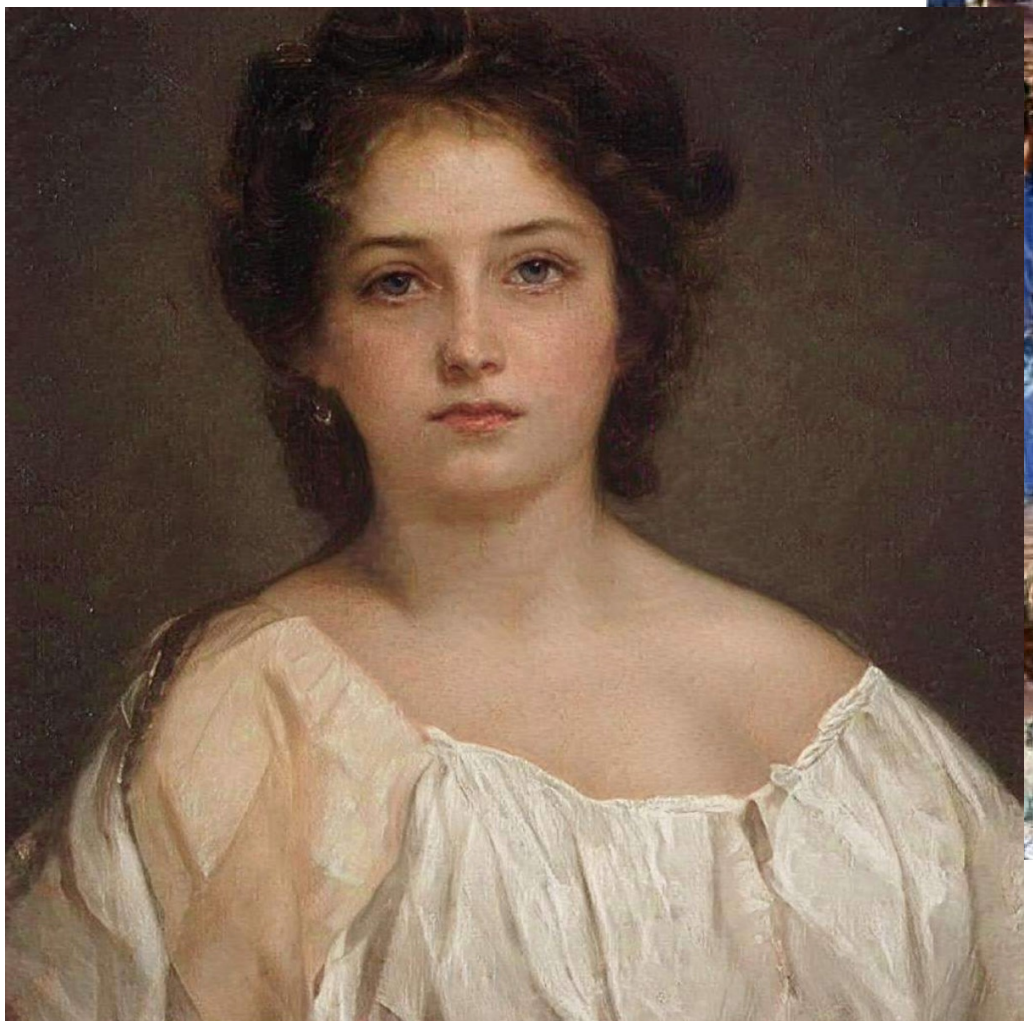
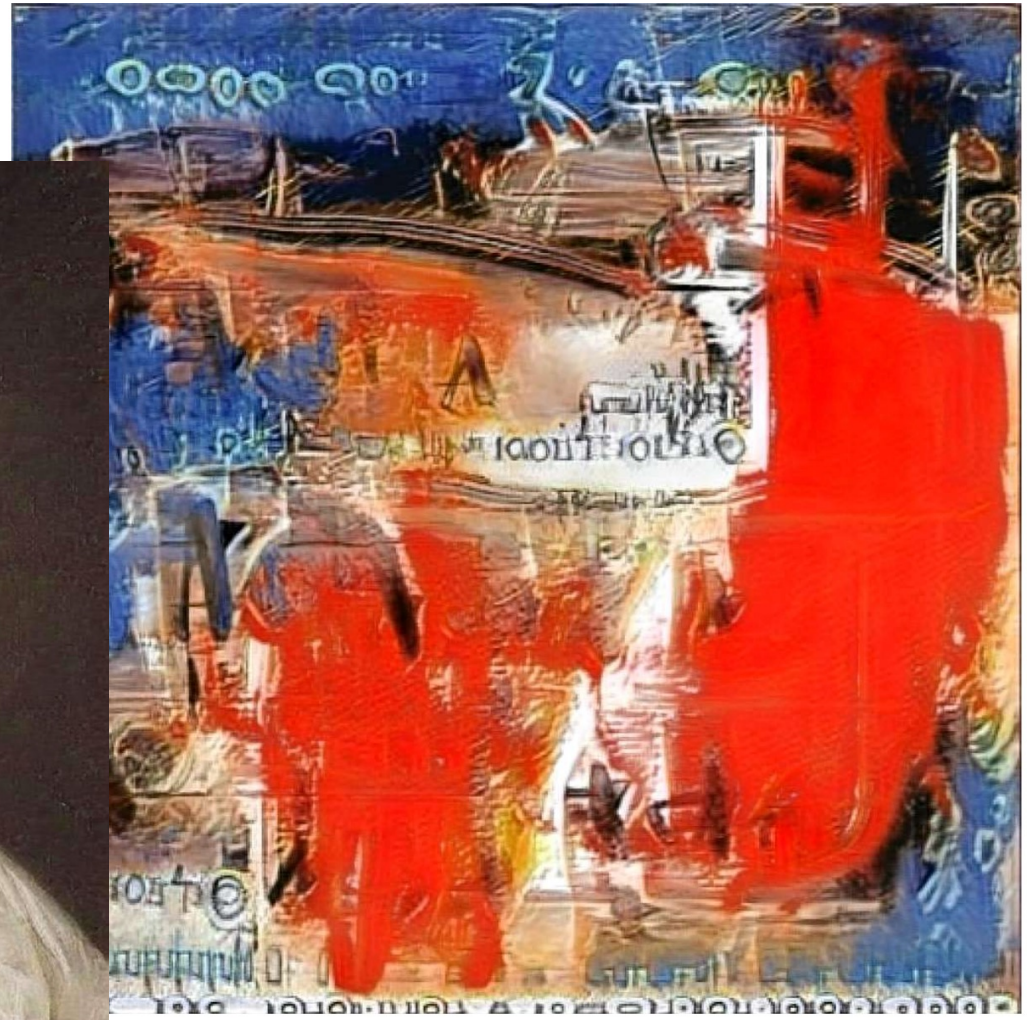
Deep learning allows also for content creation





Source: artaigallery.com

Naturally, with the increasing power of deep learning, possible issues arise

https://www.youtube.com/watch?v=cQ54GDm1eL0

Learning objectives and modalities

Learning objectives of the module

Goals: Provide you with the knowledge to

- feel comfortable with the key concepts relevant to deep learning
- be aware of the most important deep learning architectures
- know how to use TensorFlow to easily create neural networks in Python
- apply deep learning tools to solve relevant business problems

How will we do this?

- Some theory to understand the most fundamental concepts underlying neural networks
- Hands-on approach to programming neural networks
- Guided use of state-of-the-art frameworks and architectures

General modalities

Lectures:

- Video and reading material to study **before** class (broken up into digestible bits), mostly to introduce new concepts and tools. I will release videos before the live class on Moodle and update you by email
- Two hours of face-to-face lecture every week during the term. This will be **very interactive**, and you will get plenty of chance to practice your coding and learn-by-doing. This also means that we need to follow a few norms:
  - Please arrive on time – or even a couple of mins ahead of schedule
  - Please only use your computers for the task at hand: no social media, no browsing
  - Come prepared to class: lecture learnt, homework done

Tutorials:

- Three tutorials throughout the term, two hours each
- Focused on repeating difficult parts of the previous lecture(s) and going into more depth

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Small to do for the first class

Read the case “Preferred Networks: A Deep Learning Startup Powers the Internet of Things”

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See you in class!

Sources

- DeepLearning.AI, n.d., deeplearning.ai
- Goodfellow, Bengio, Courville, 2016, The Deep Learning Book: http://www.deeplearningbook.org
- Liang, 2016, Introduction to Deep Learning: https://www.cs.princeton.edu/courses/archive/spring16/cos495/
- Wikipedia, n.d., Neuron: https://en.wikipedia.org/wiki/Neuron