Deep Learning

Lecture 0: Introduction

Prof. Gilles Louppe
g.louppe@uliege.be

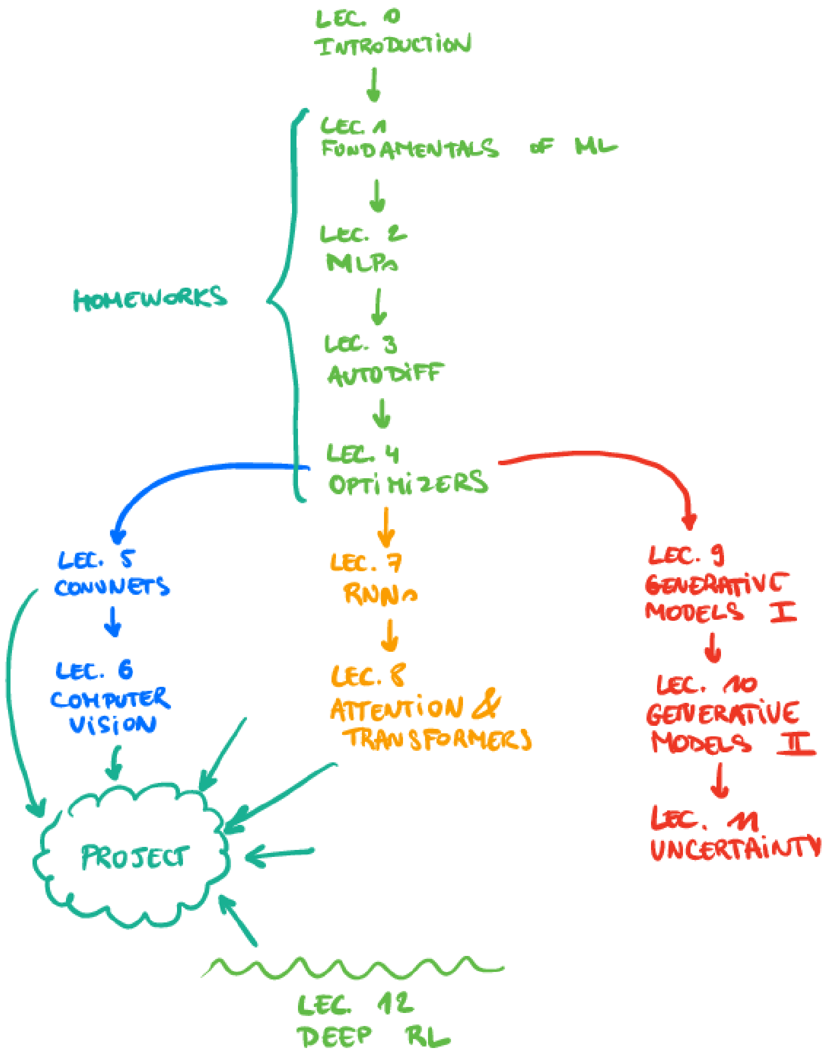
LIÈGE université

Today

- Course outline
- Introduction to deep learning
- Fundamentals of machine learning

Outline

- Lecture 0: Introduction
- Lecture 1: Fundamentals of machine learning
- Lecture 2: Multi-layer perceptron
- Lecture 3: Automatic differentiation
- Lecture 4: Training neural networks
- Lecture 5: Convolutional neural networks
- Lecture 6: Computer vision
- Lecture 7: Recurrent neural networks
- Lecture 8: Attention and transformer networks
- Lecture 9: Generative models (Part 1)
- Lecture 10: Generative models (Part 2)
- Lecture 11: Uncertainty
- Lecture 12: Deep reinforcement learning


LEC. 0
INTRODUCTION
LEC. 1
FUNDAMENTALS OF ML
LEC. 2
MLPs
LEC. 3
AUTODIFF
LEC. 4
OPTIMIZERS
HOMEWORKS
LEC. 5
CONVNETS
LEC. 6
COMPUTER VISION
LEC. 7
RNNs
LEC. 8
ATTENTION &
TRANSFORMERS
LEC. 9
GENERATIVE
MODELS I
LEC. 10
GENERATIVE
MODELS II
LEC. 11
UNCERTAINTY
PROJECT
LEC. 12
DEEP RL

My mission

By the end of this course, you will have acquired a solid and detailed understanding of the field of deep learning.

You will have learned how to use and architecture deep neural networks for a wide range of advanced probabilistic inference tasks, including supervised learning on high-dimensional and structured data, unsupervised representation learning, or conditional data generation.

These techniques apply to a wide variety of artificial intelligence problems, with plenty of applications in engineering and science.

Why learning?

What do you see?

Sheepdog or mop?

—
Credits: Karen Zack, 2016.

Chihuahua or muffin?

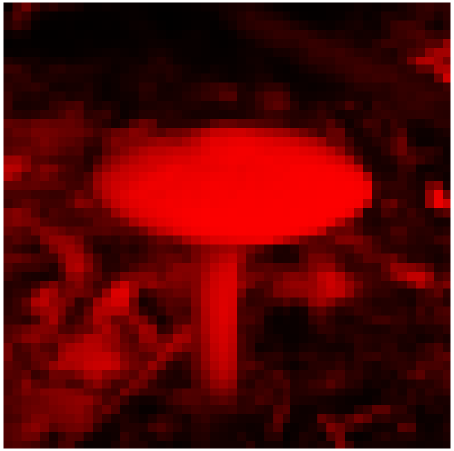
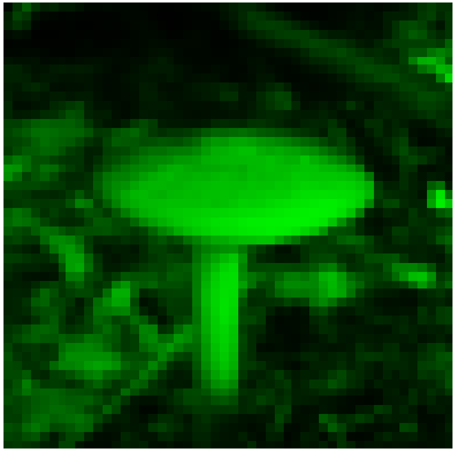
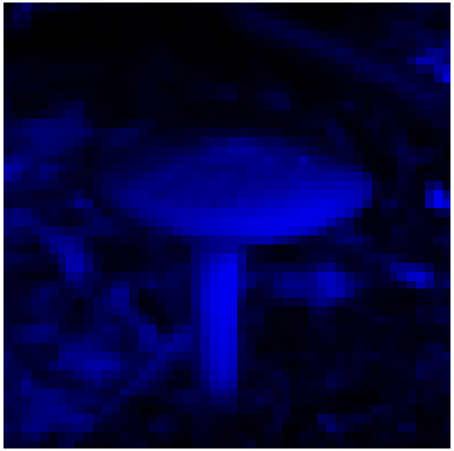
—

Credits: Karen Zack. 2016.

The (human) brain is so good at interpreting visual information that the gap between raw data and its semantic interpretation is difficult to assess intuitively:

This is a mushroom.

This is a mushroom.

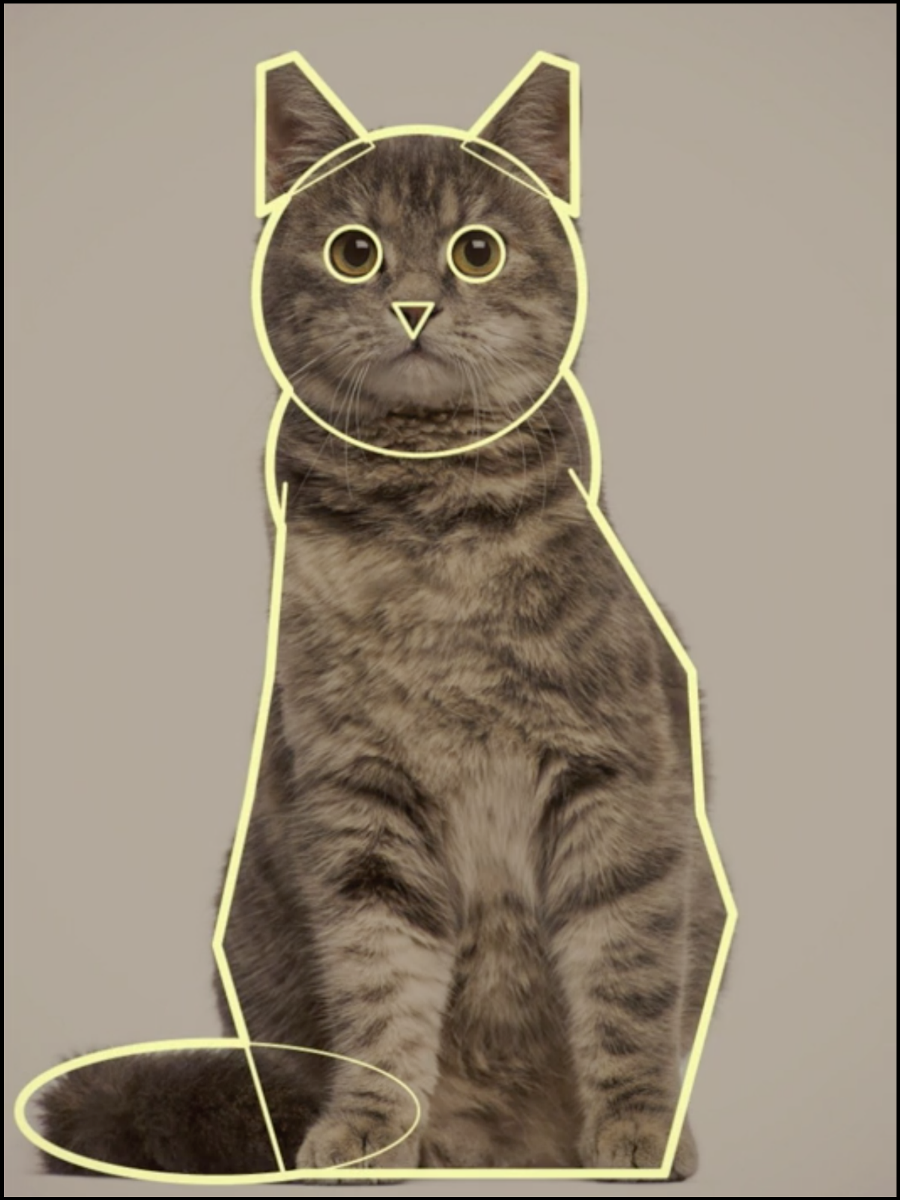

+

+


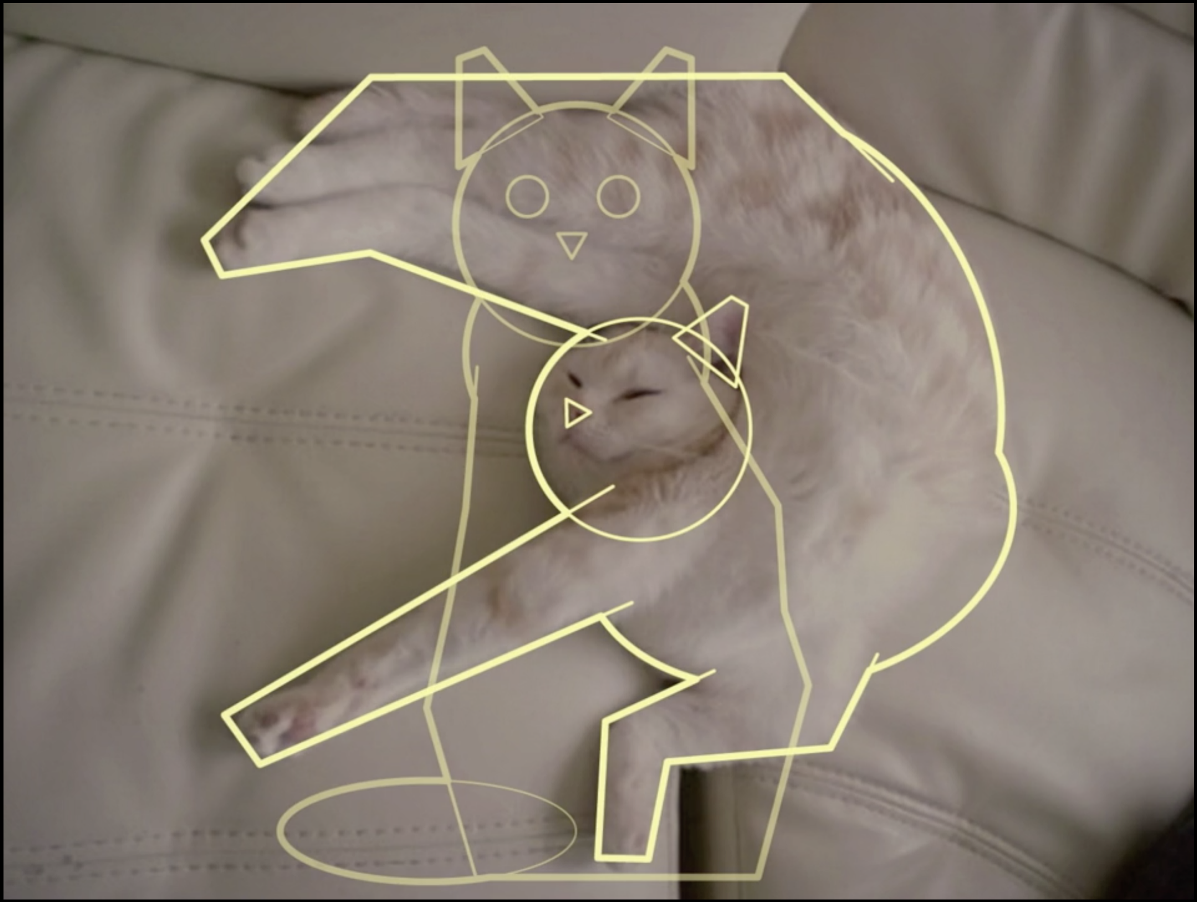
This is a mushroom.

```
array([[[0.03921569, 0.03529412, 0.02352941, 1.        ],
        [0.2509804 , 0.1882353 , 0.20392157, 1.        ],
        [0.4117647 , 0.34117648, 0.37254903, 1.        ],
        ...,
        [0.20392157, 0.23529412, 0.17254902, 1.        ],
        [0.16470589, 0.18039216, 0.12156863, 1.        ],
        [0.18039216, 0.18039216, 0.14117648, 1.        ]],

       [[0.1254902 , 0.11372549, 0.09411765, 1.        ],
        [0.2901961 , 0.2509804 , 0.24705882, 1.        ],
        [0.21176471, 0.2       , 0.20392157, 1.        ],
        ...,
        [0.1764706 , 0.24705882, 0.12156863, 1.        ],
        [0.10980392, 0.15686275, 0.07843138, 1.        ],
        [0.16470589, 0.20784314, 0.11764706, 1.        ]],

       [[0.14117648, 0.12941177, 0.10980392, 1.        ],
        [0.21176471, 0.1882353 , 0.16862746, 1.        ],
        [0.14117648, 0.13725491, 0.12941177, 1.        ],
        ...,
        [0.10980392, 0.15686275, 0.08627451, 1.        ],
        [0.0627451 , 0.08235294, 0.05098039, 1.        ],
        [0.14117648, 0.2       , 0.09803922, 1.        ]],

       ...,
```

This is a mushroom.

Writing a computer program that sees?





Extracting semantic information requires models of high complexity, which cannot be designed by hand.

However, one can write a program that learns the task of extracting semantic information.

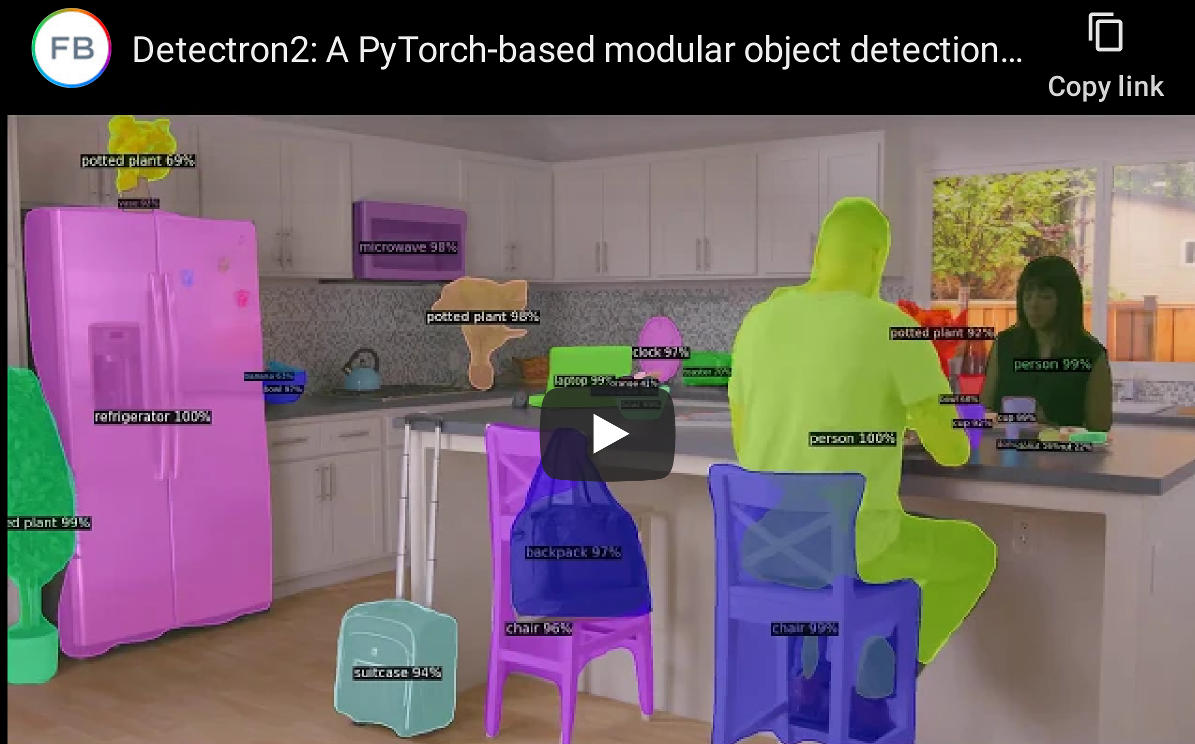
The common approach used in practice consists of:

- defining a parametric model with high capacity,
- optimizing its parameters, by "making it work" on the training data.

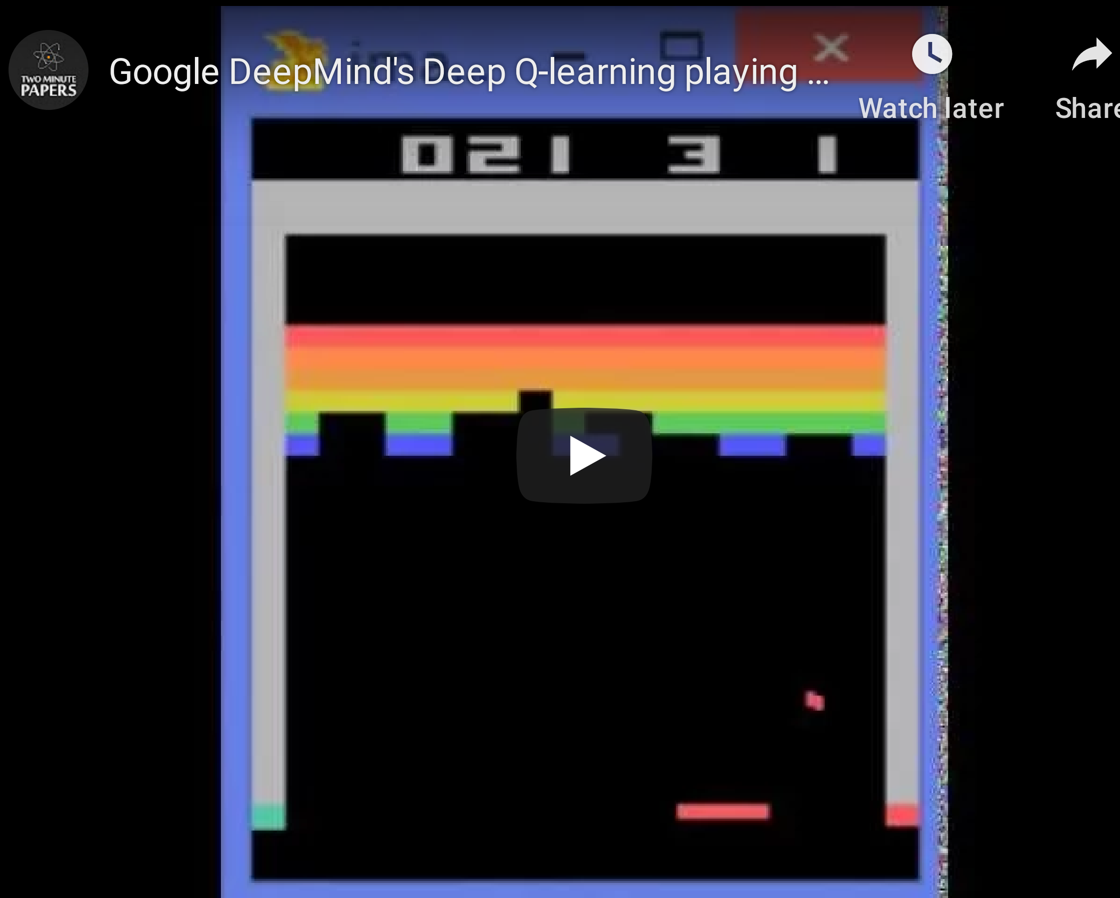
A change of paradigm

We used to program computers. We will now train them.

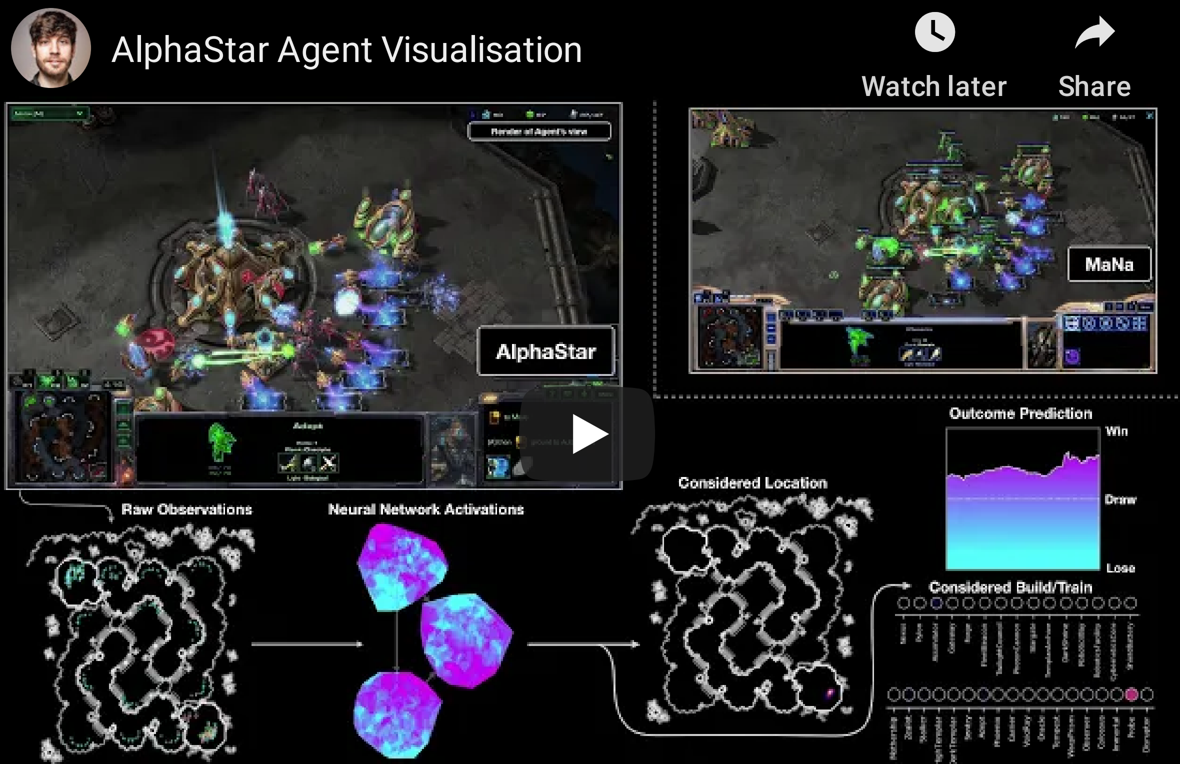
Applications and successes



Object detection, pose estimation, segmentation (2019)



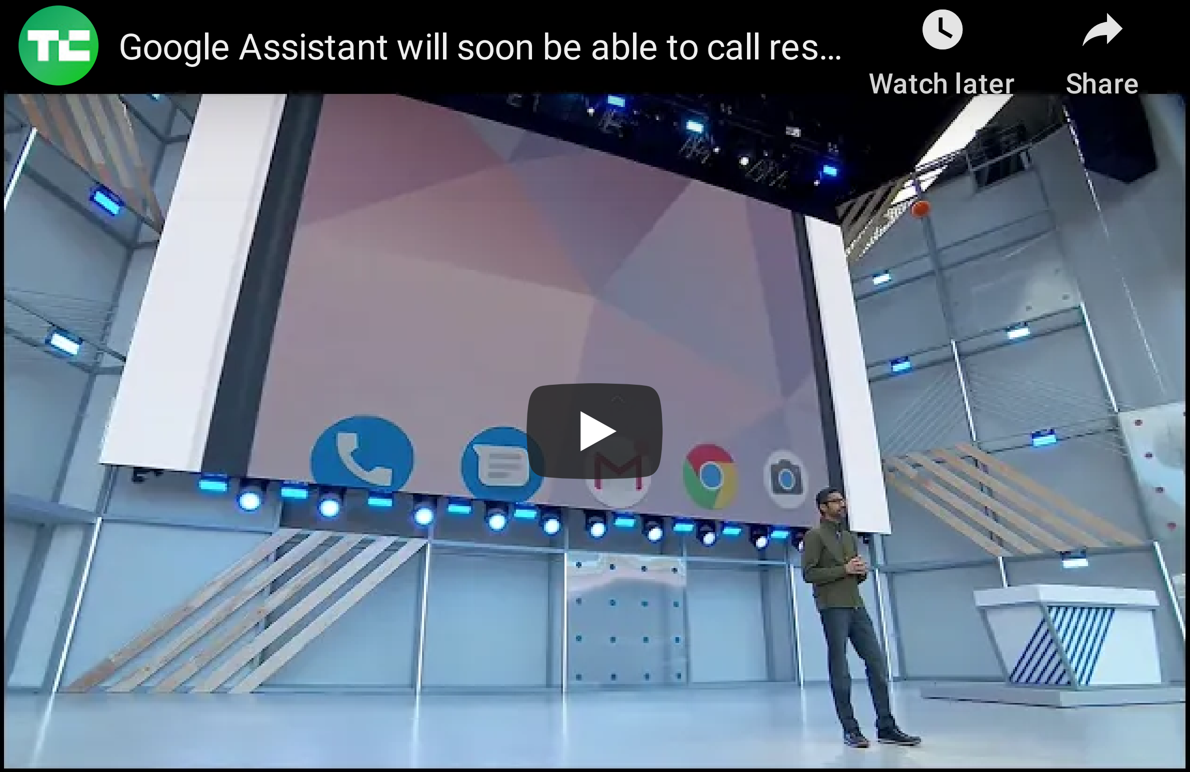
Reinforcement learning (Mnih et al, 2014)



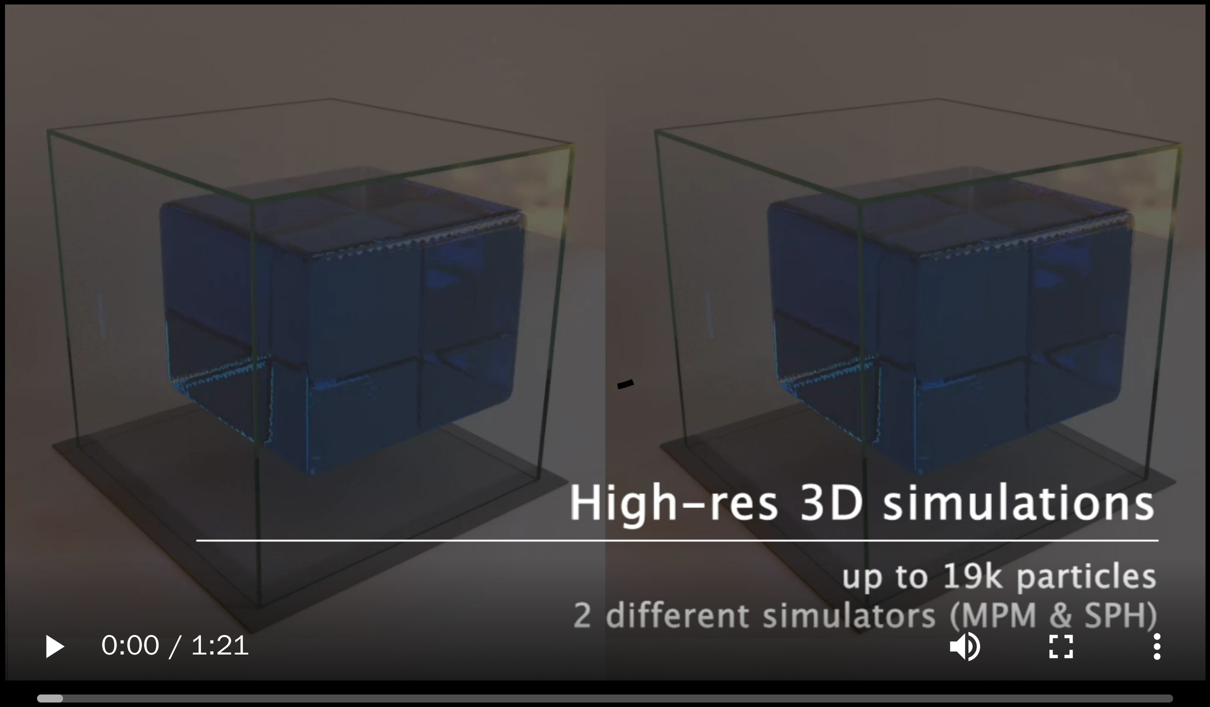
Strategy games (Deepmind, 2016-2018)

Autonomous cars (NVIDIA, 2016)

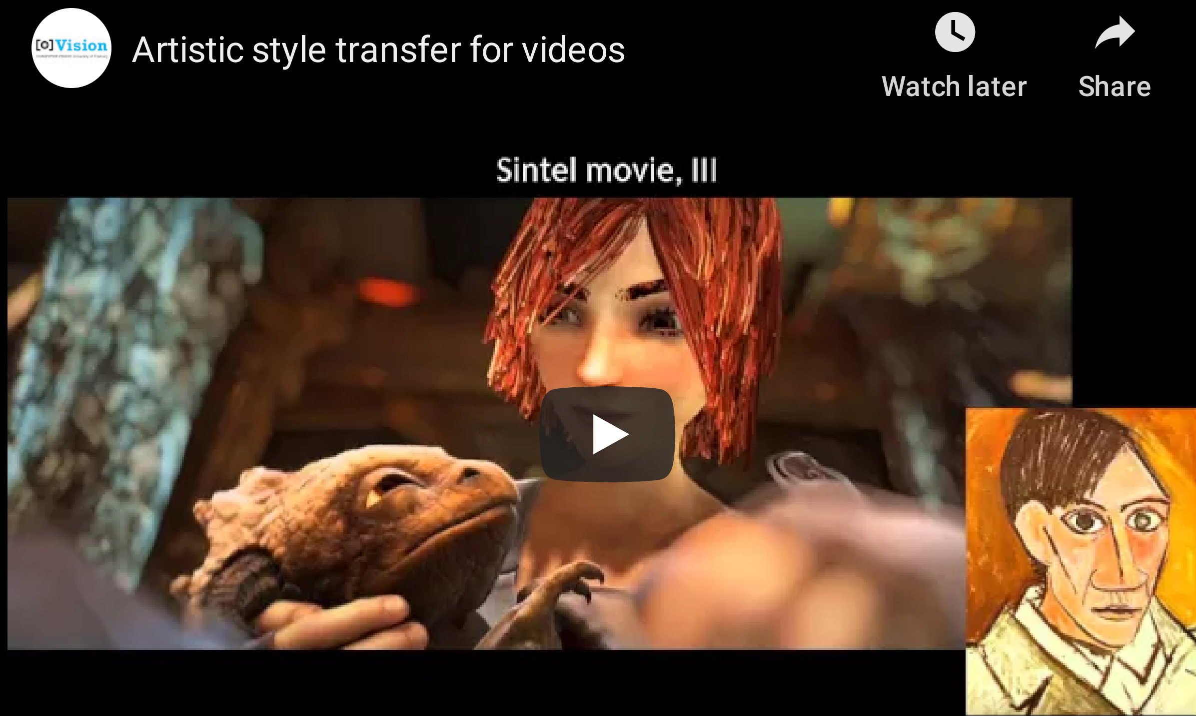
Autopilot (Tesla, 2019)



Speech synthesis and question answering (Google, 2018)



Physics simulation (Sanchez-Gonzalez et al, 2020)



Artistic style transfer (Ruder et al, 2016)

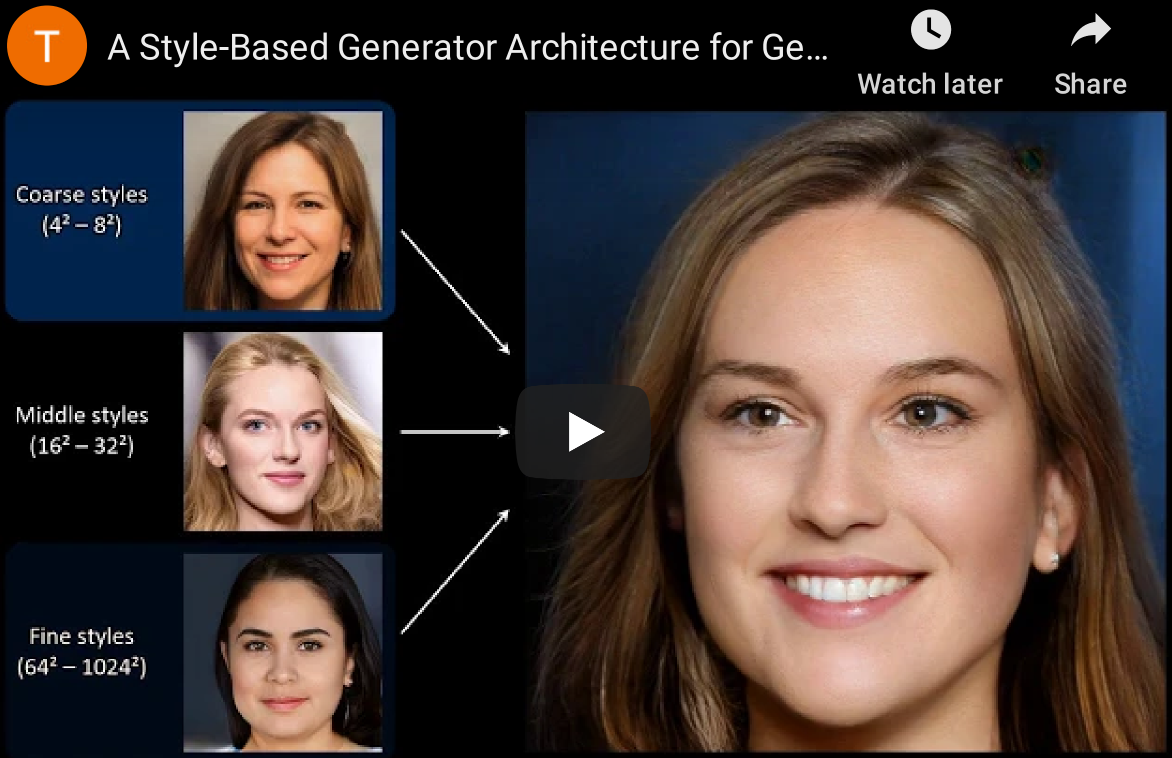


Image generation (Karras et al, 2018)

Music composition (NVIDIA, 2017)

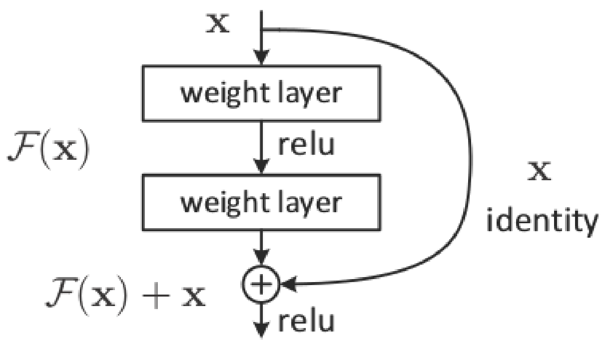
Dali Lives (2019)

*"ACM named **Yoshua Bengio**, **Geoffrey Hinton**, and **Yann LeCun** recipients of the **2018 ACM A.M. Turing Award** for conceptual and engineering breakthroughs that have made deep neural networks a critical component of computing."*


Konbini techno
Il y a eu
des hauts et des bas.
0:00 / 4:41

Why does it work now?

Algorithms (old and new)



More data

Software

Caffe2 Microsoft CNTK TensorFlow theano

Chainer PYTORCH dmlc mxnet K

Faster compute engines

Building on the shoulders of giants

Five decades of research in machine learning provided

- a taxonomy of ML concepts (classification, generative models, clustering, kernels, linear embeddings, etc.),
- a sound statistical formalization (Bayesian estimation, PAC),
- a clear picture of fundamental issues (bias/variance dilemma, VC dimension, generalization bounds, etc.),
- a good understanding of optimization issues,
- efficient large-scale algorithms.

—
Credits: Francois Fleuret, EE559 Deep Learning, EPFL.

Deep learning

From a practical perspective, deep learning

- lessens the need for a deep mathematical grasp,
- makes the design of large learning architectures a system/software development task,
- allows to leverage modern hardware (clusters of GPUs),
- does not plateau when using more data,
- makes large trained networks a commodity.

The end.

References

- LeCun, Y., Bengio, Y., & Hinton, G. (2015). Deep learning. nature, 521(7553), 436-444.