

Deep Learning

Lecture 0: Introduction

Prof. Gilles Louppe
g.louppe@uliege.be

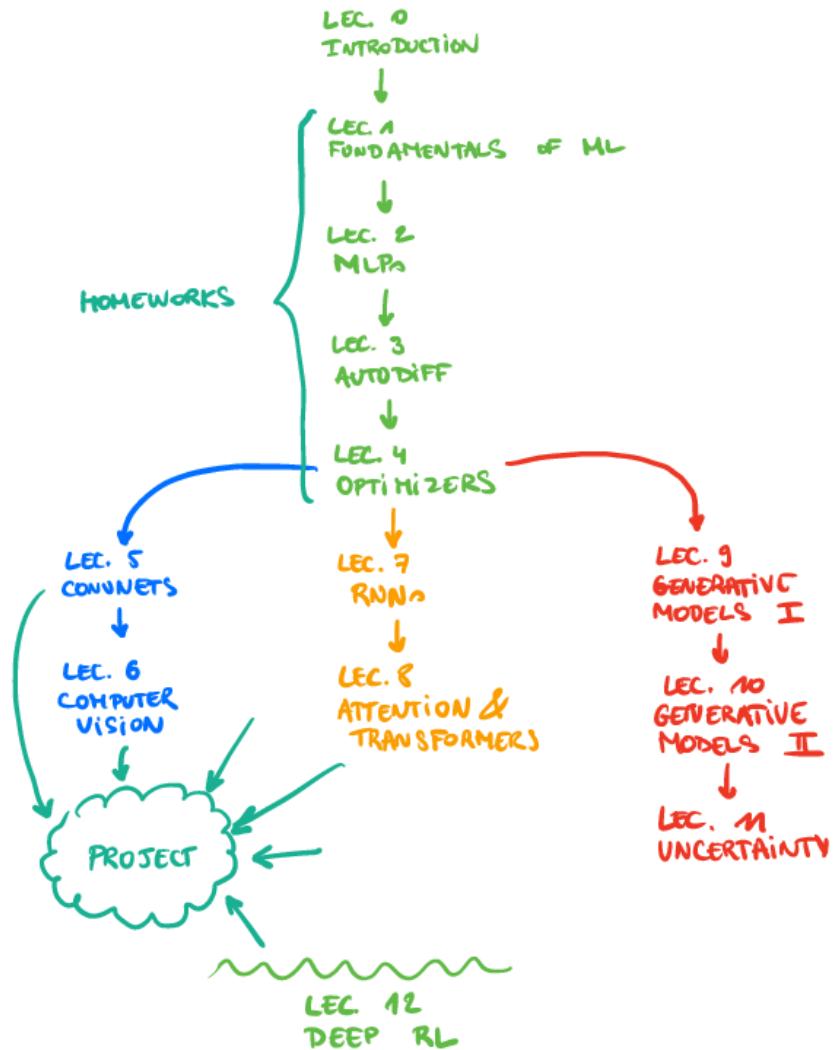


Today

- 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



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 design deep neural networks for a wide range of advanced probabilistic inference tasks and how to train them.

These models seen in the course 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?



Chihuahua or muffin?

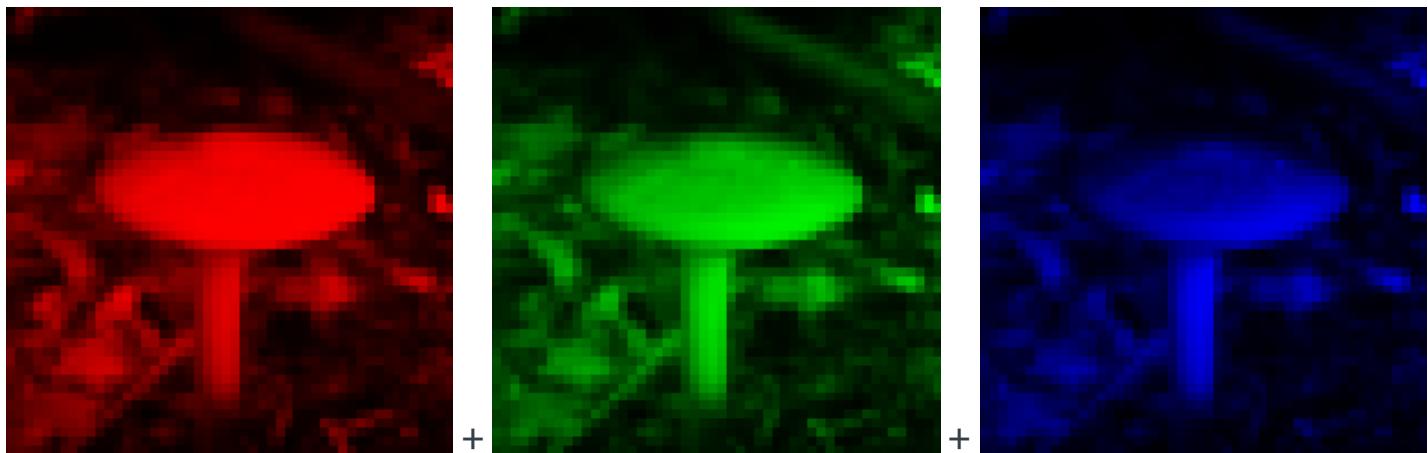
The (human) brain is so good at interpreting visual information that the **gap** between raw data and its semantic interpretation is difficult to assess intuitively:



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.          ]],

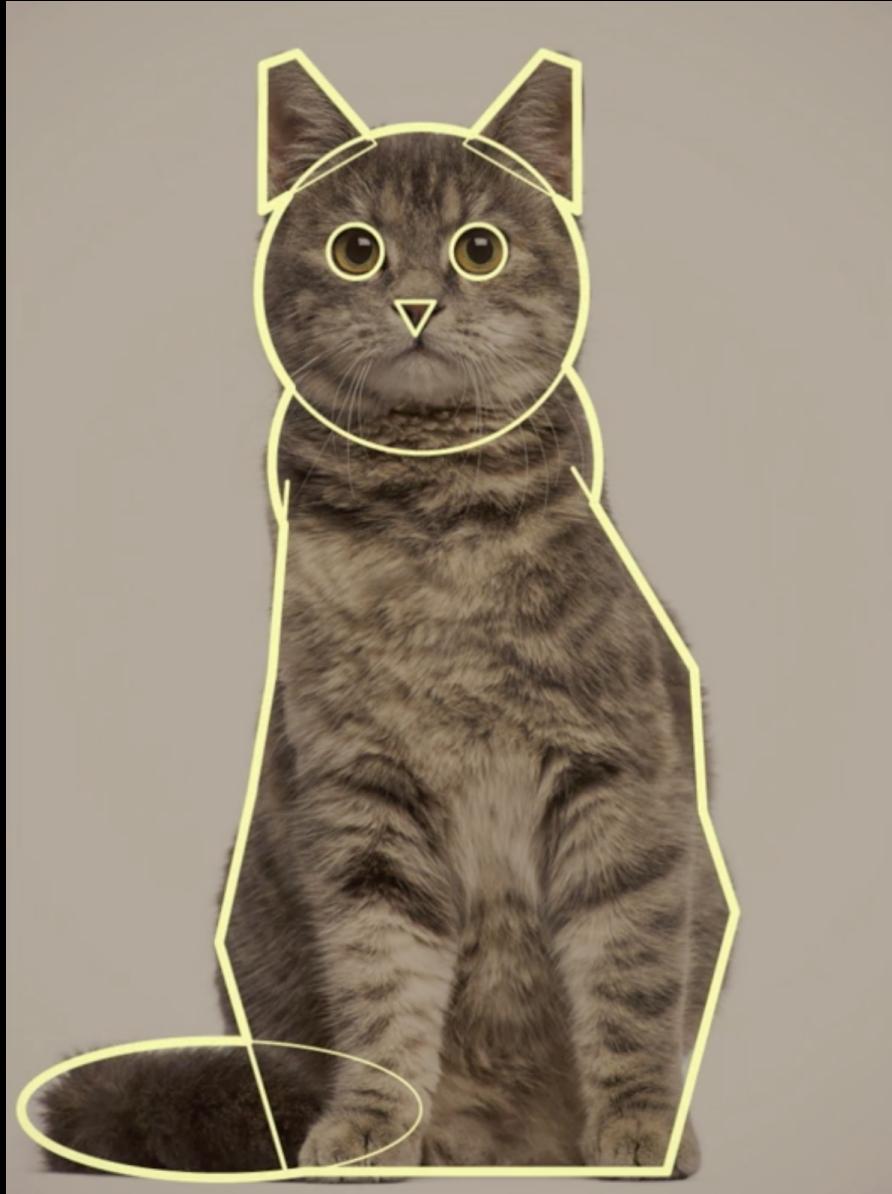
      [[0.14117648, 0.12941177, 0.10980392, 1.          ],
       [0.21176471, 0.1882353 , 0.16862746, 1.          ],
       [0.14117648, 0.13725491, 0.12941177, 1.          ],
       ...,
       [0.10980392, 0.15686275, 0.08627451, 1.          ],
       [0.0627451 , 0.08235294, 0.05098039, 1.          ],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

      ...]
```

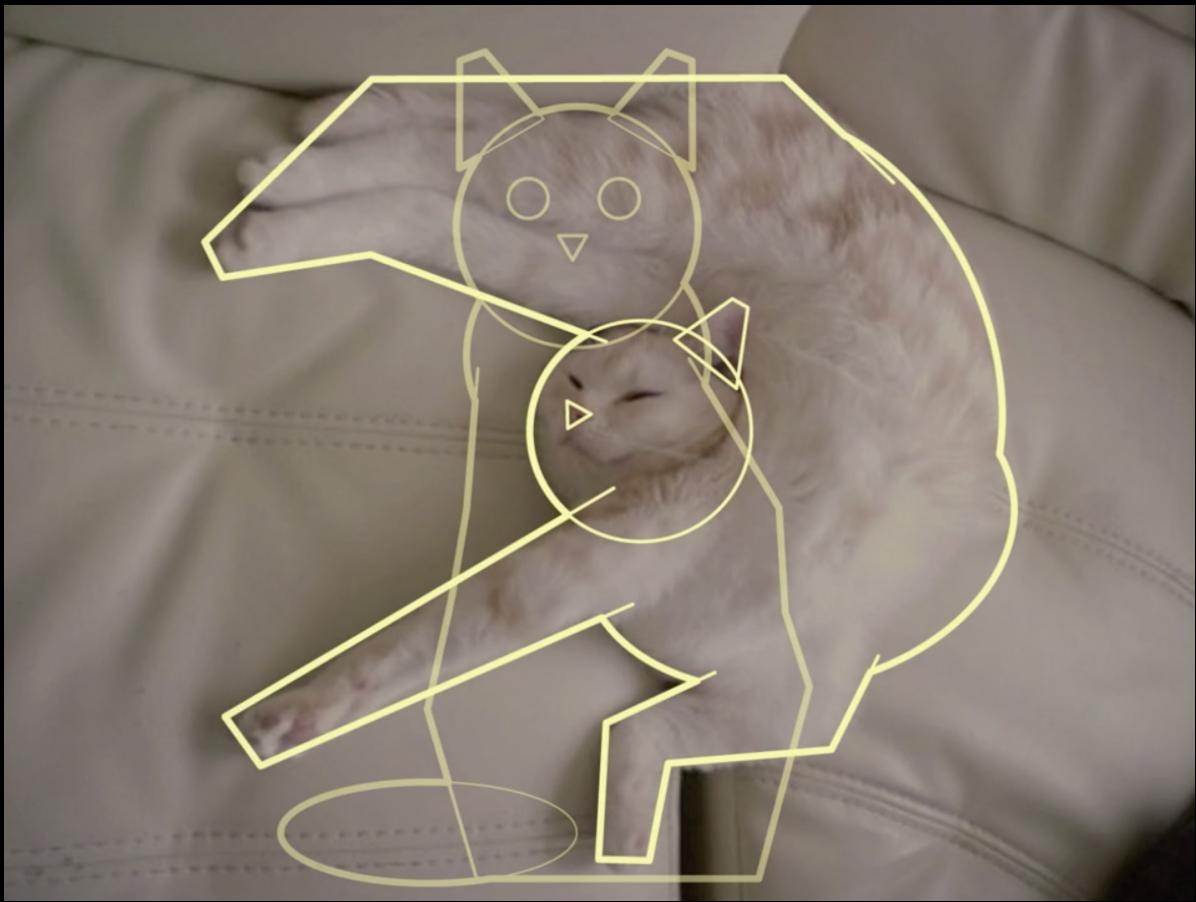
This is a mushroom.

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.



Applications and successes



Detectron2: A PyTorch-based modular object detecti...



Link kopië...



Object detection, pose estimation, segmentation (2019)



Google DeepMind's Deep Q-learning playing...



Later bekijk...
Delen



Reinforcement learning (Mnih et al, 2014)



AlphaStar Agent Visualisation



Later bekijk...



Delen



Strategy games (Deepmind, 2016-2018)



NVIDIA Autonomous Car



Later bekijk...



Delen



Autonomous cars (NVIDIA, 2016)



Full Self-Driving



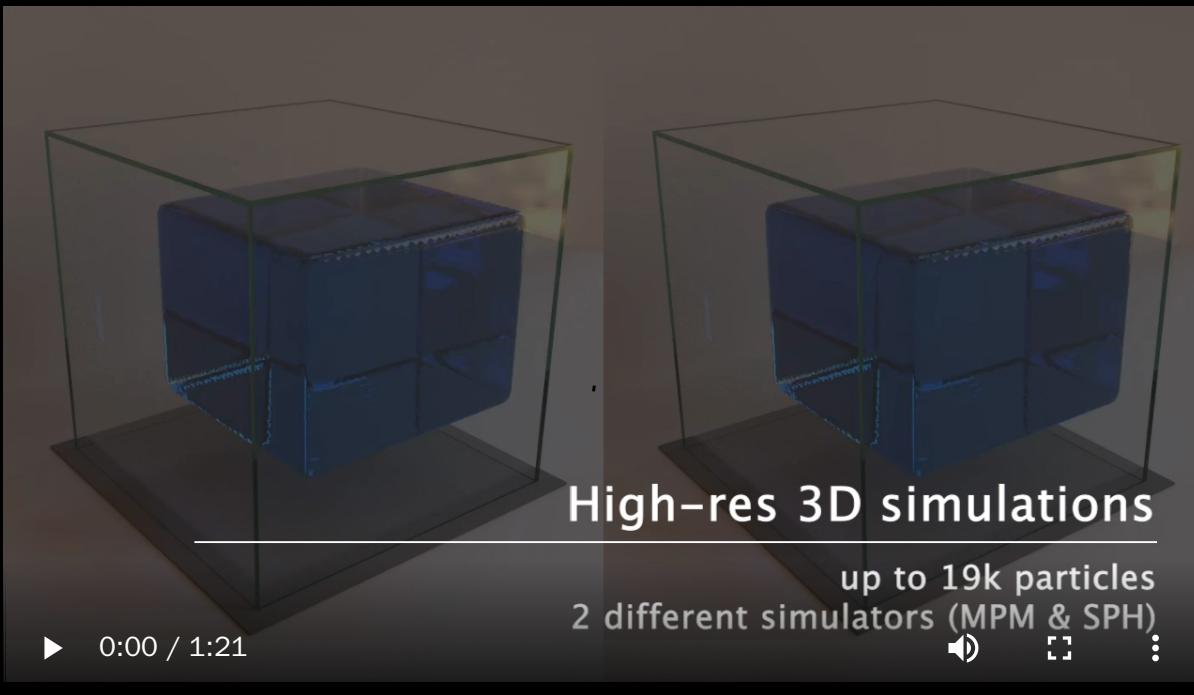
Later bekijk...



Delen



Autopilot (Tesla, 2019)



Physics simulation (Sanchez-Gonzalez et al, 2020)



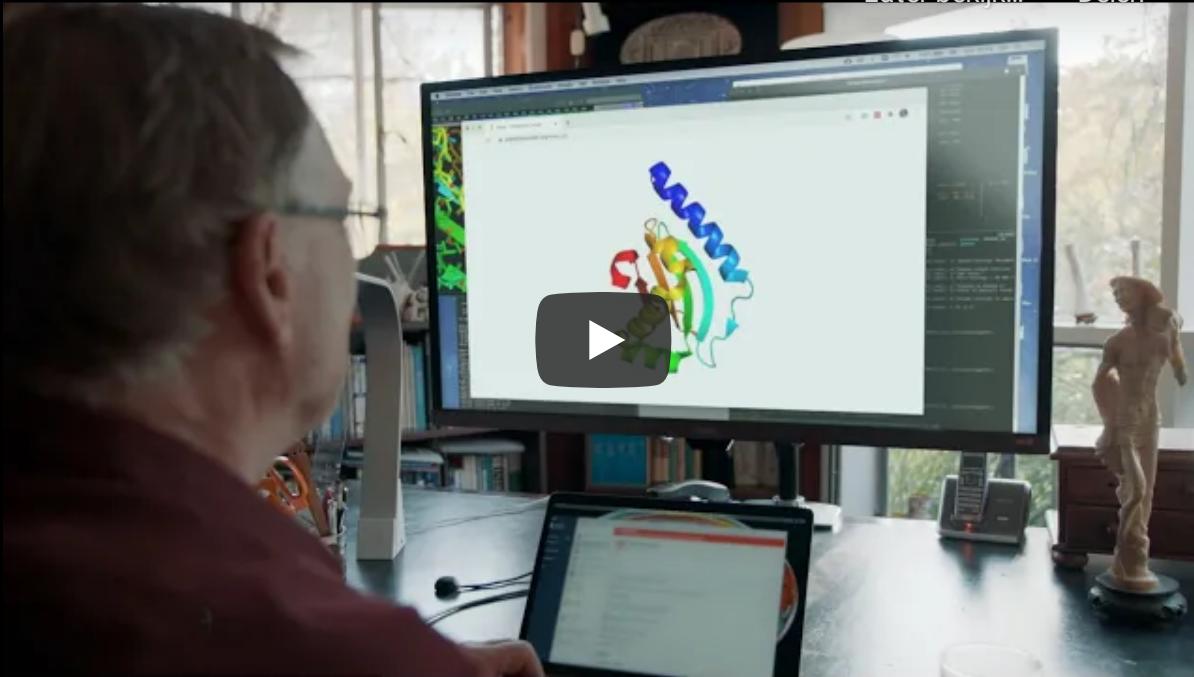
AlphaFold: The making of a scientific breakt...



Later bekijk...



Delen



AI for Science (Deepmind, AlphaFold, 2020)



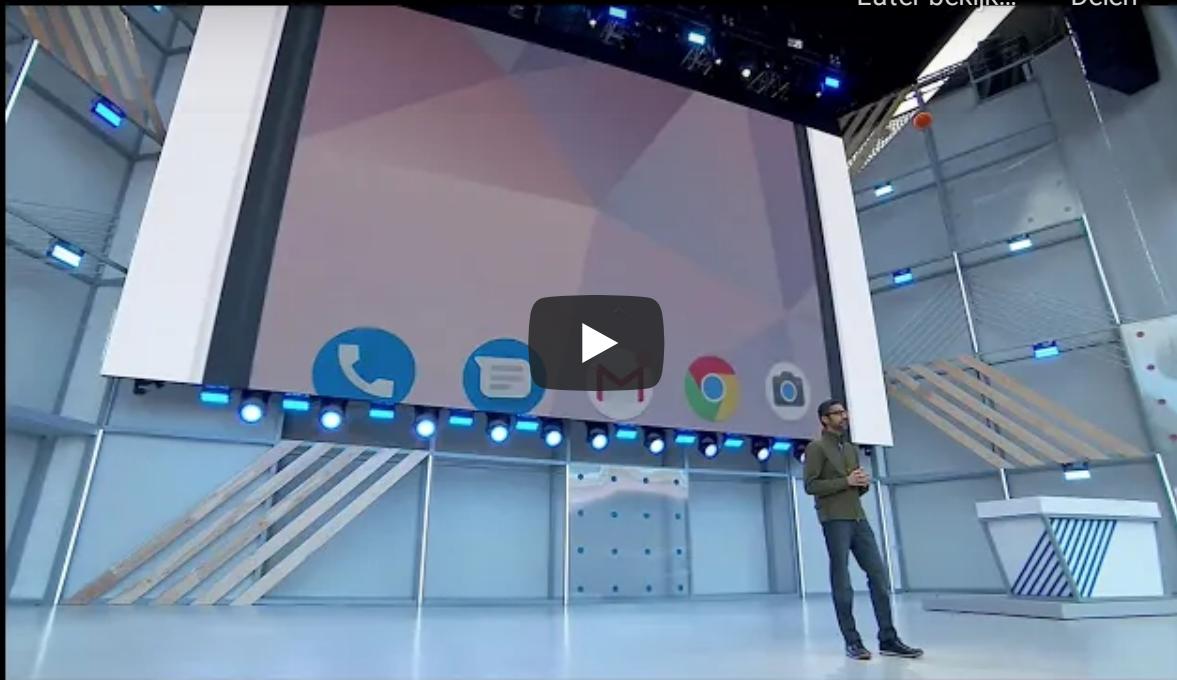
Google Assistant will soon be able to call re...



Later bekijk...



Delen



Speech synthesis and question answering (Google, 2018)



Artistic style transfer for videos



Later bekijk...



Delen

Sintel movie, III



Artistic style transfer (Ruder et al, 2016)

T

A Style-Based Generator Architecture for G...



Later bekijk...



Delen

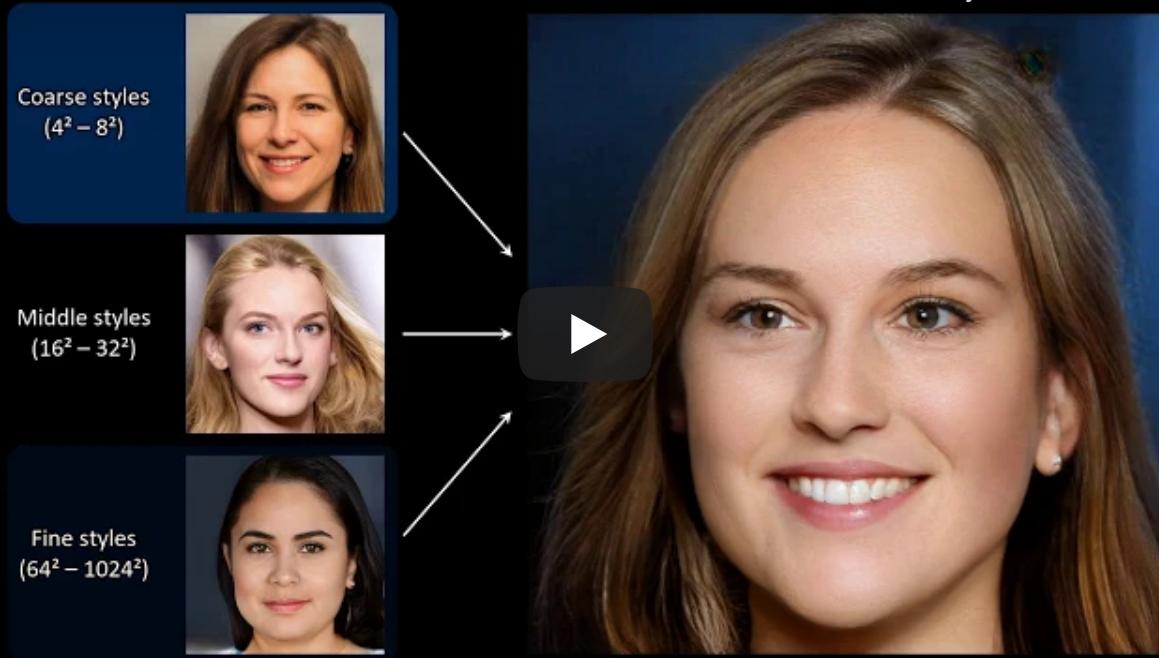


Image generation (Karras et al, 2018)



GTC Japan 2017 Part 9: AI Creates Original ...



Later bekijk...



Delen



Music composition (NVIDIA, 2017)



Behind the Scenes: Dali Lives



Later bekijk...



Delen



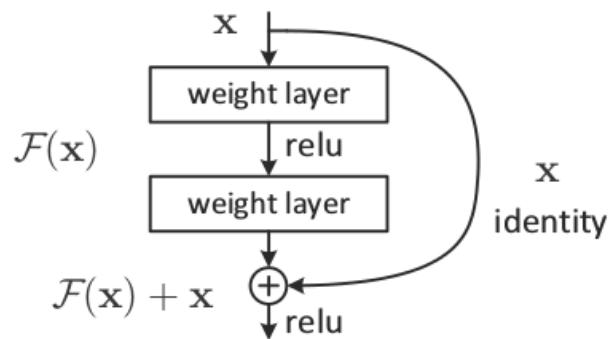
Dali Lives (2019)



*"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."*

Why does it work now?

Algorithms (old and new)



More data



Software



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.

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.



For the last forty years we have programmed computers; for the next forty years we will train them.

Chris Bishop, 2020.

The end.

References

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