

# Deep Learning

Lecture 0: Introduction

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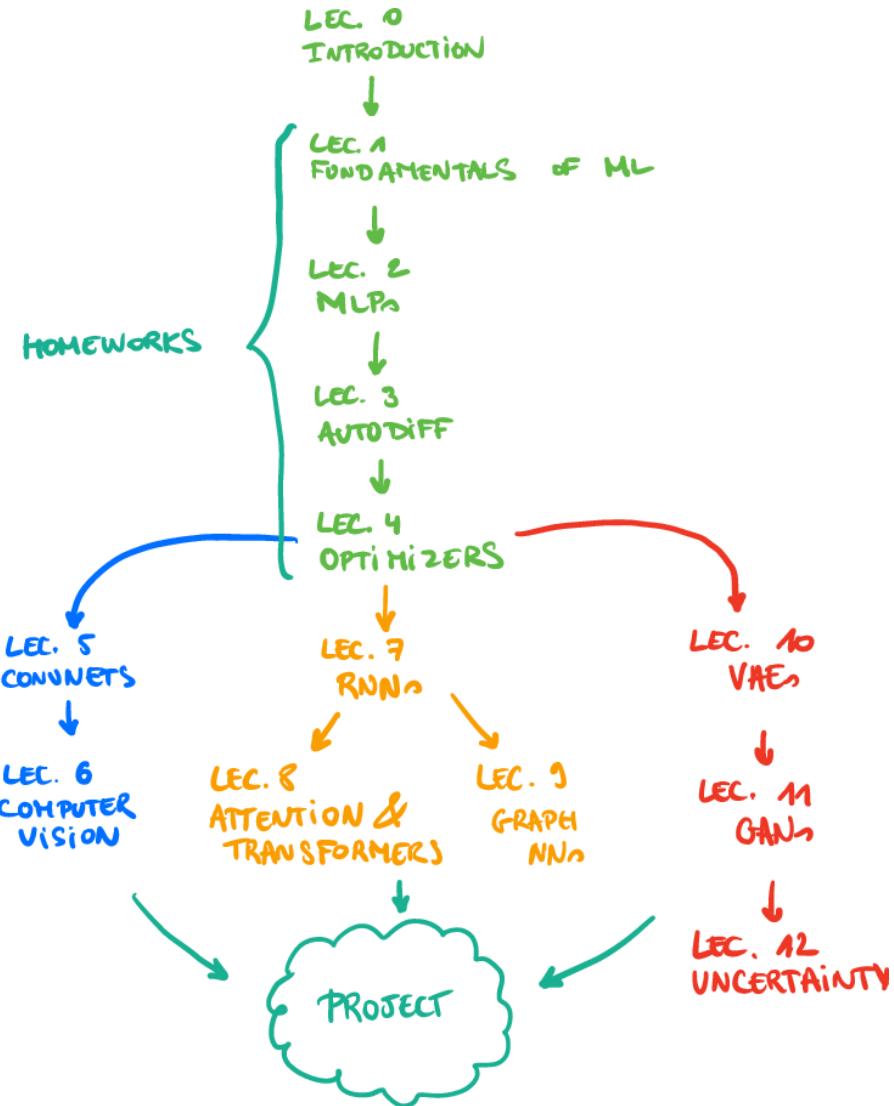


# Today

- 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: Graph neural networks
- Lecture 10: Auto-encoders and variational auto-encoders
- Lecture 11: Generative adversarial networks
- Lecture 12: Uncertainty



## **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?

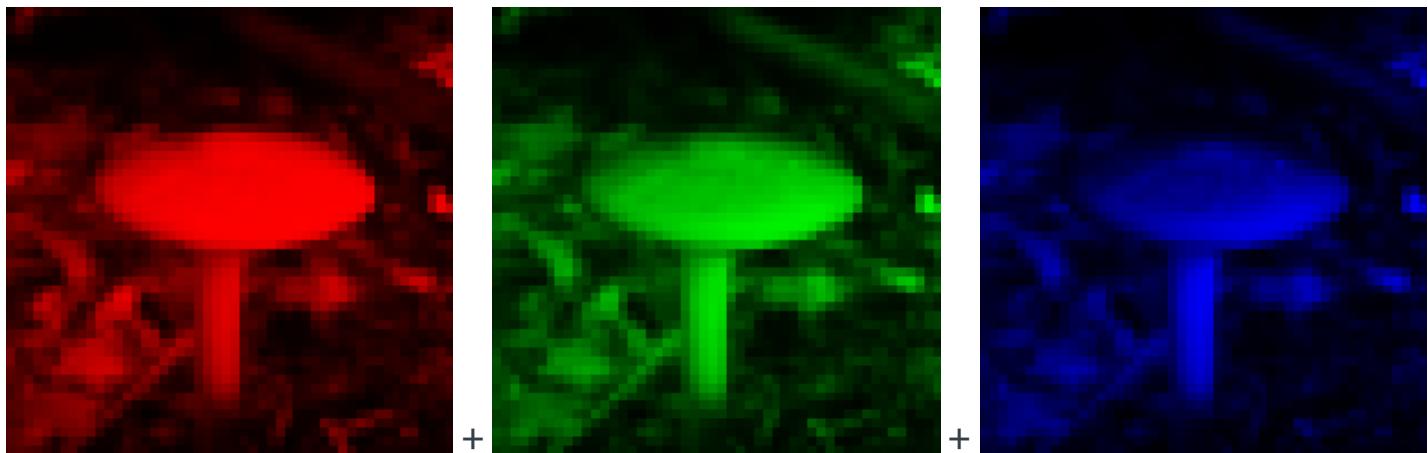
The (human) brain is so good at interpreting visual information that the **gap** between raw data and its semantic interpretation is difficult to assess intuitively:



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.          ]],

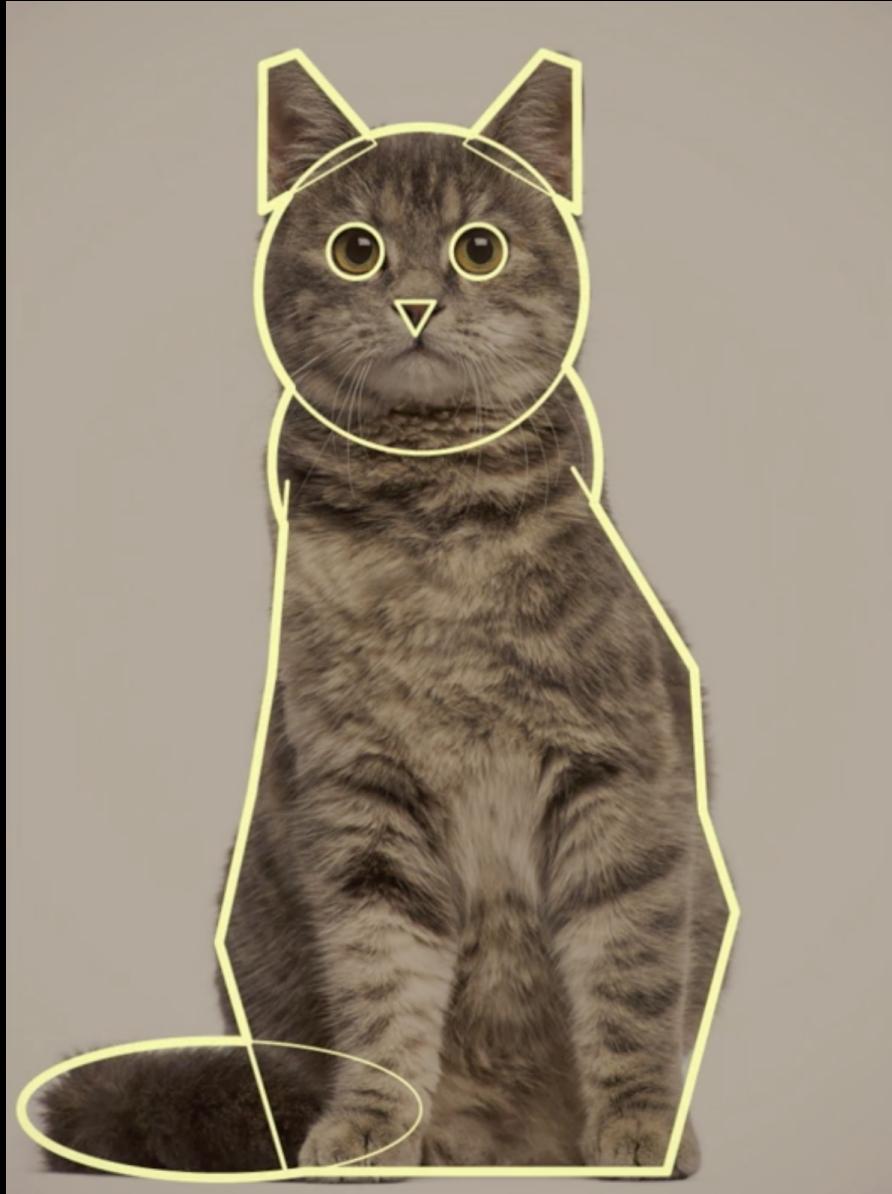
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       [0.10980392, 0.15686275, 0.08627451, 1.          ],
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      ...,
```

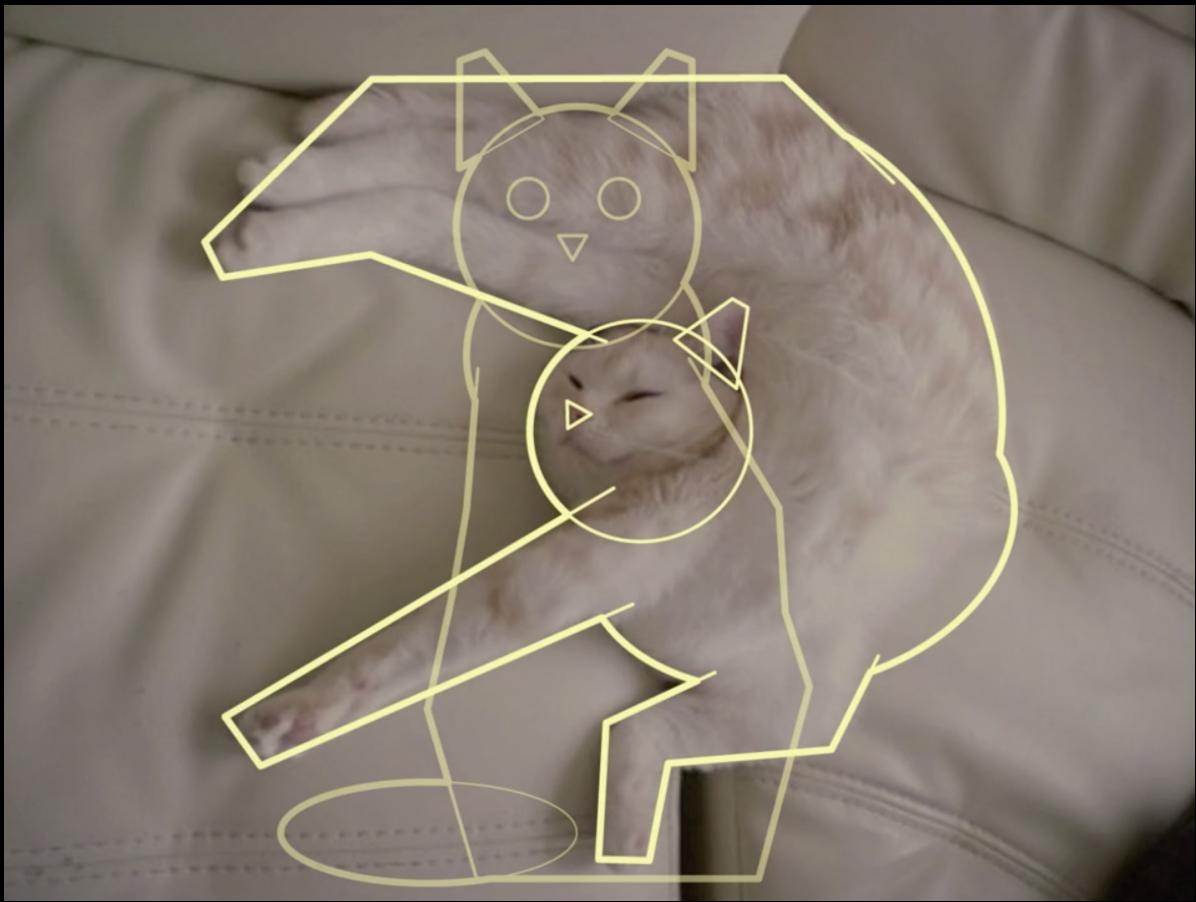
This is a mushroom.

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 kopiér...



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...



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Autonomous cars (NVIDIA, 2016)



Full Self-Driving



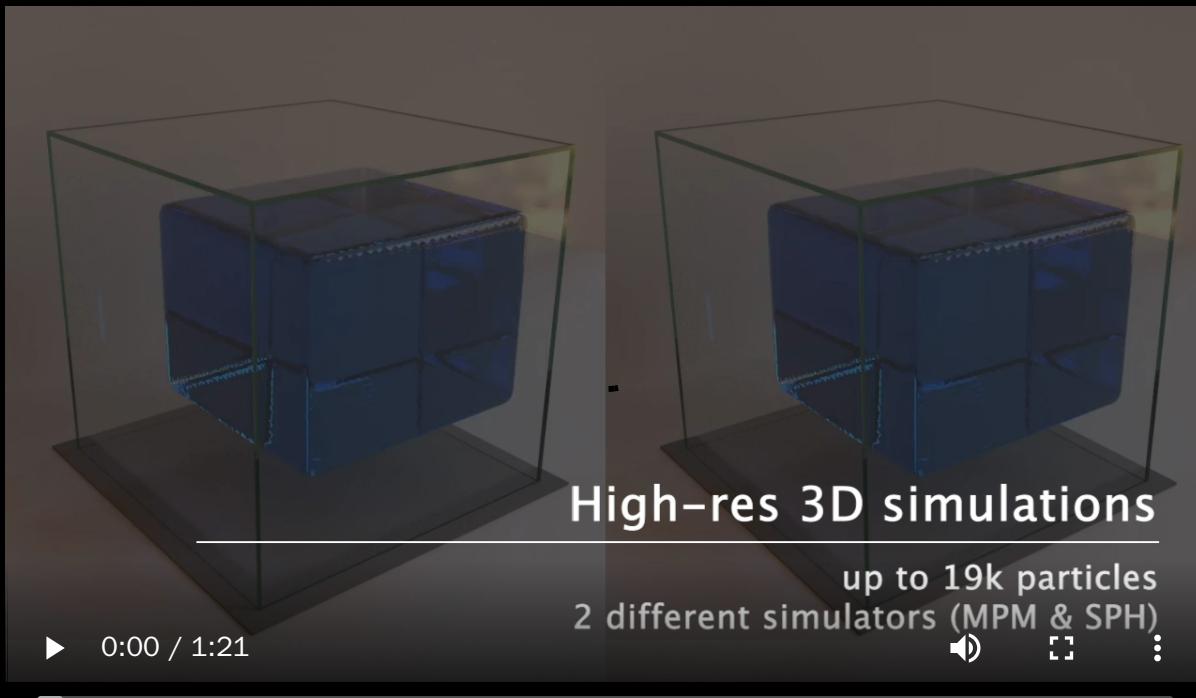
Later bekijk...



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Autopilot (Tesla, 2019)



Physics simulation (Sanchez-Gonzalez et al, 2020)



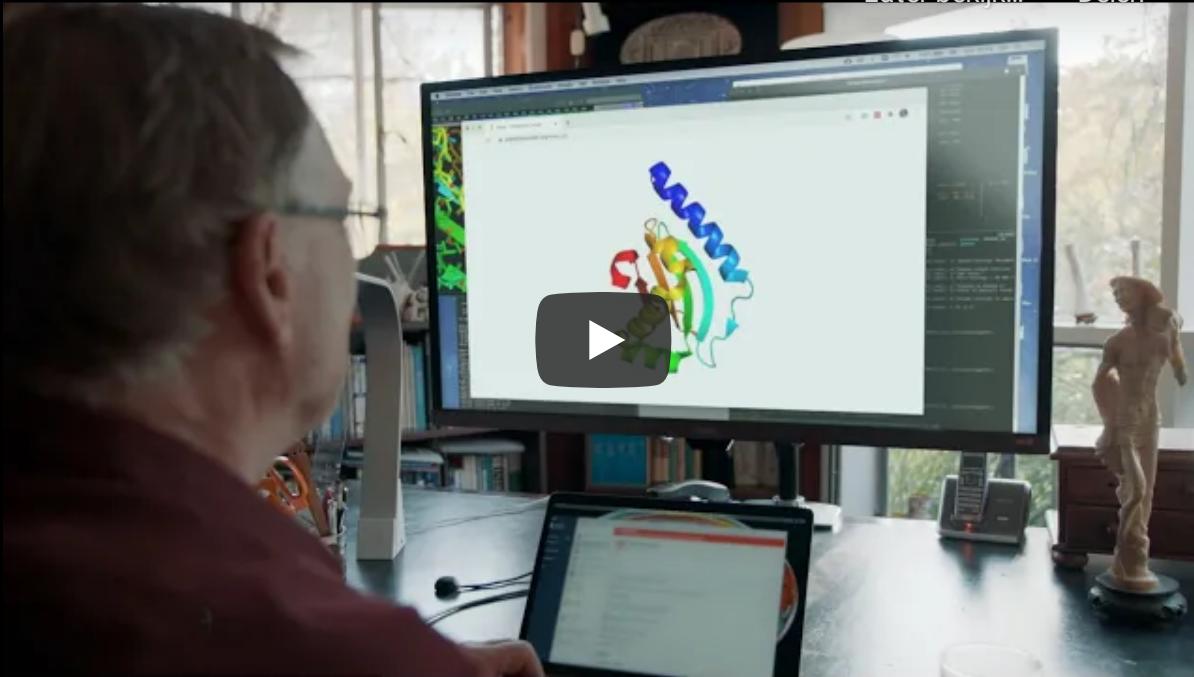
AlphaFold: The making of a scientific breakt...



Later bekijk...



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AI for Science (Deepmind, AlphaFold, 2020)



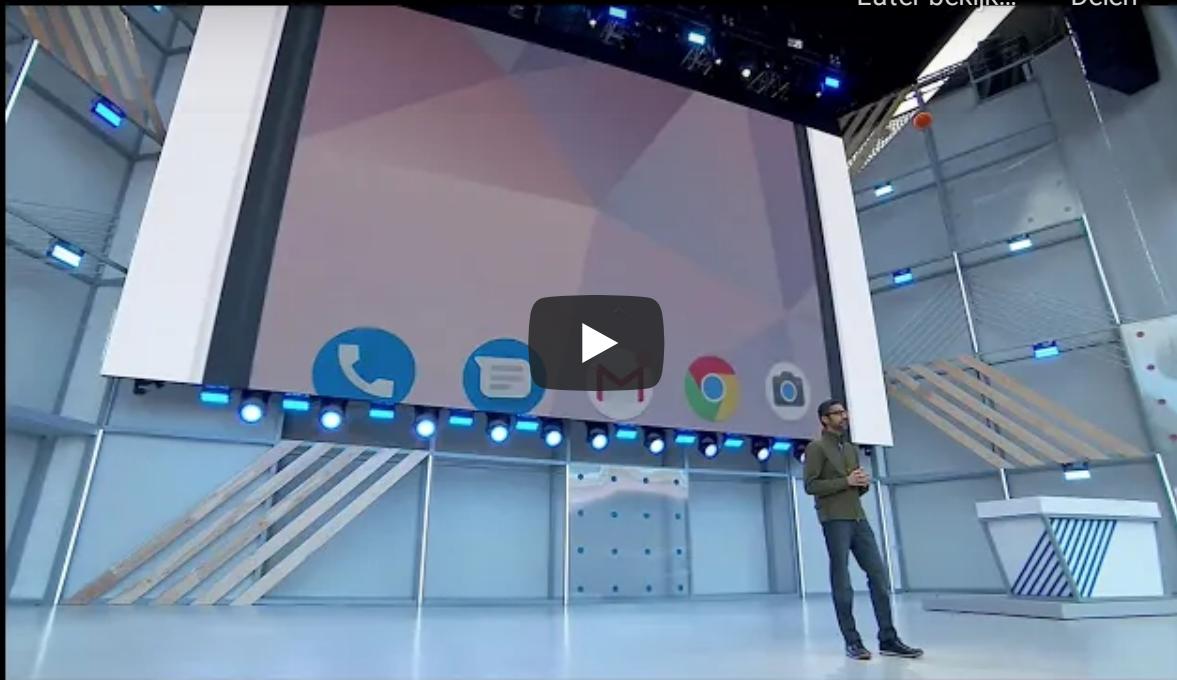
Google Assistant will soon be able to call re...



Later bekijk...



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Speech synthesis and question answering (Google, 2018)



## Synthesizing High-Resolution Images with ...



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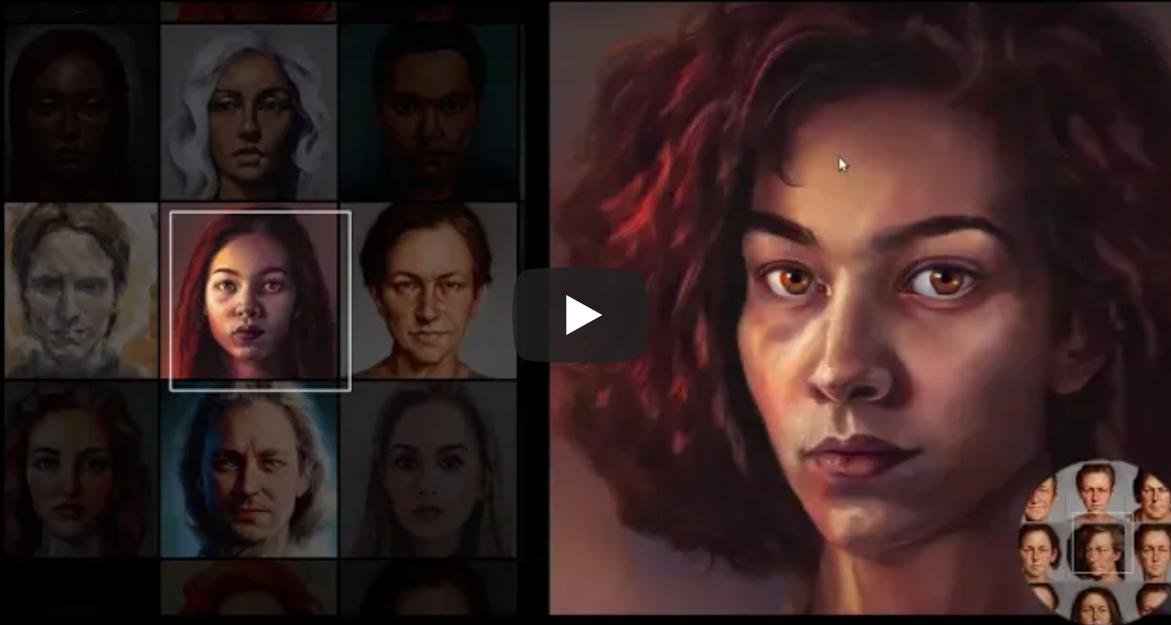


Image generation (Karras et al, 2018)



## Creating a Space Game with OpenAI Codex



Later bekijk... Delen



Make it be the size of the rocketship times 0.75



```
text.style.left =  
rocketship.offsetLeft + 'px';  
text.style.top =  
rocketship.offsetTop + 'px';  
  
document.body.appendChild(text);  
xSpeed = 20;  
setTimeout(function() {  
    xSpeed = 5;  
  
    document.body.removeChild(text);  
}, 250);  
};  
  
/* Now add an image of an  
asteroid:  
https://d.newsweek.com/en/full/1721338/asteroid.jpg?w=1600&h=1600&q=88&f=9d82d35c9de96a82b3fcdf7705eb325b */  
var asteroid =  
document.createElement('img');  
asteroid.src =  
https://d.newsweek.com/en/full/1721338/asteroid.jpg?w=1600&h=1600&q=88&f=9d82d35c9de96a82b3fcdf7705eb325b;  
document.body.appendChild(asteroid);
```



Write computer code (OpenAI, 2021)



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



Later bekijk...



Delen



Music composition (NVIDIA, 2017)



Behind the Scenes: Dalí Lives



Later bekijk...



Delen



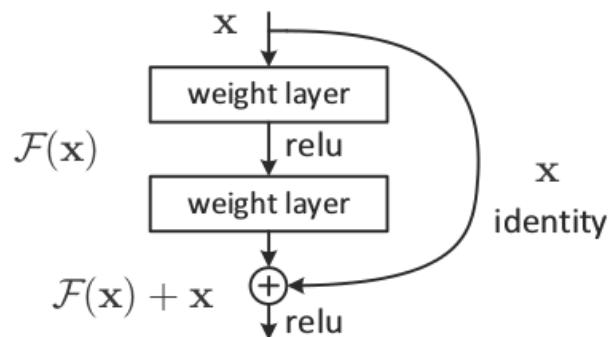
Dali Lives (2019)



*"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.