Introduction to Deep Learning

Charles Ollion - Olivier Grisel

MASTER
DATASCIENCE
UNIVERSITÉ PARIS-SACLAY

Goal of the class

Overview

- When and where to use DL
- "How" it works
- Frontiers of DL

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Arcanes of DL

- Implement using `Numpy`, and `Tensorflow` (`Keras`)
- Engineering knowledge for building and training DL

What is Deep Learning

Good old Neural Networks, with more layers/modules

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Differentiable Functional Programming

Why Deep Learning Now?

- Better algorithms & understanding
- Computing power (GPUs, TPUs, ...)
- Data with labels
- Open source tools and models

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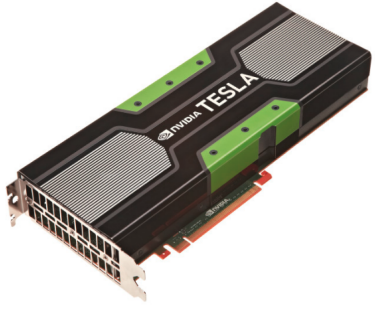

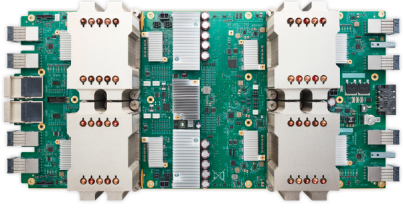

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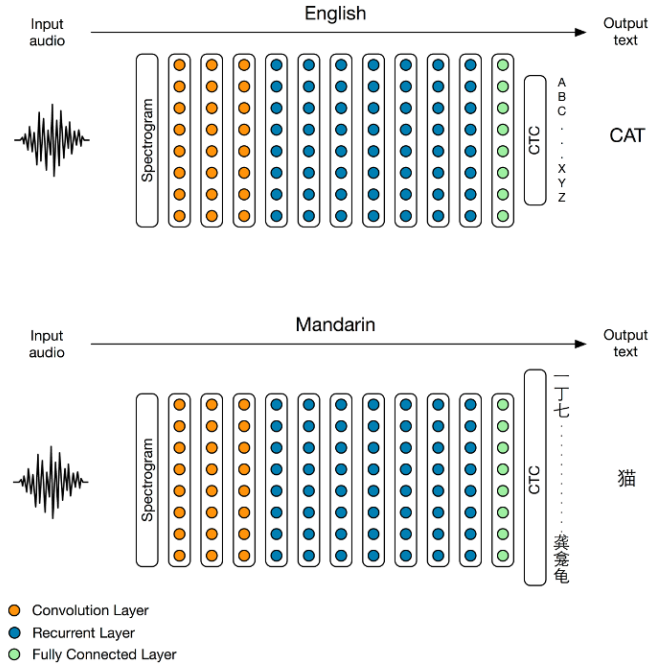
DL Today: Speech-to-Text

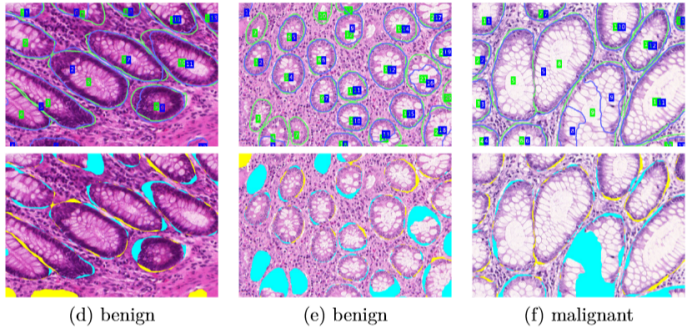


[Baidu 2014]

DL Today: Vision

DL Today: Vision

[Stanford 2017]



[Nvidia Dev Blog 2017]

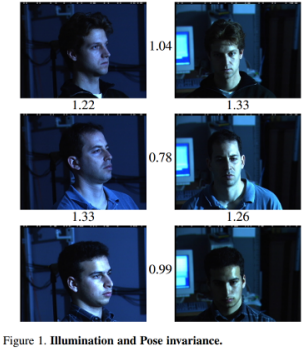
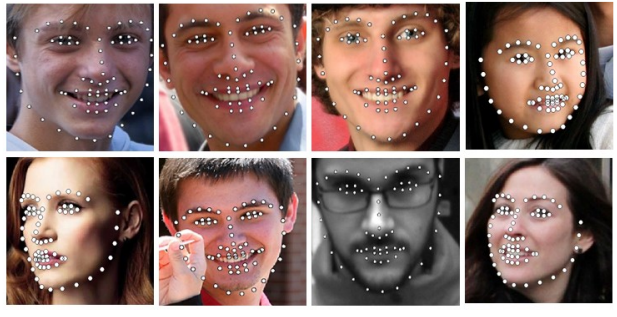


Figure 1. **Illumination and Pose invariance.**

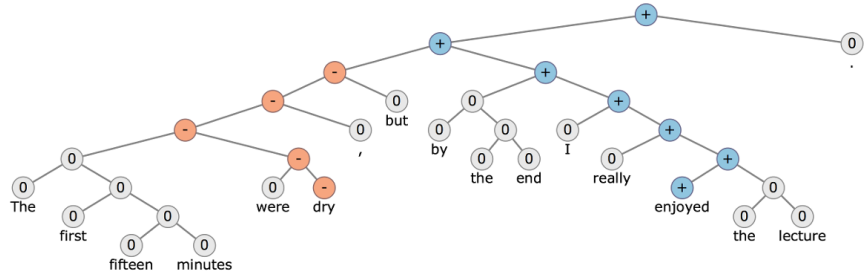
[FaceNet - Google 2015]



[Facial landmark detection CUHK 2014]

DL Today: NLP

[Google Translate System - 2016]



[Socher 2015]

DL Today: NLP

[Google Inbox Smart Reply]

[Amazon Echo / Alexa]

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Most of chatbots claiming "AI" do not use Deep Learning (yet?)

DL Today: Vision + NLP

DL Today: Image translation

DL Today: Generative models

Sampled celebrities [Nvidia 2017]

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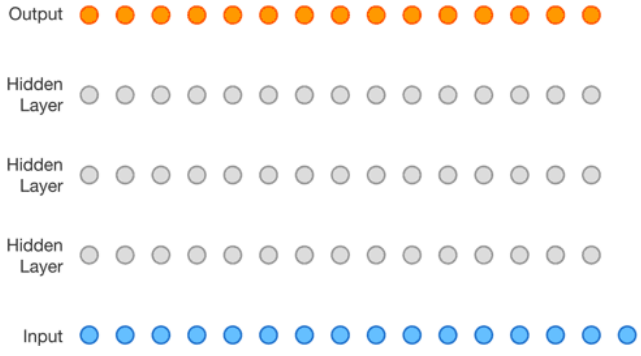
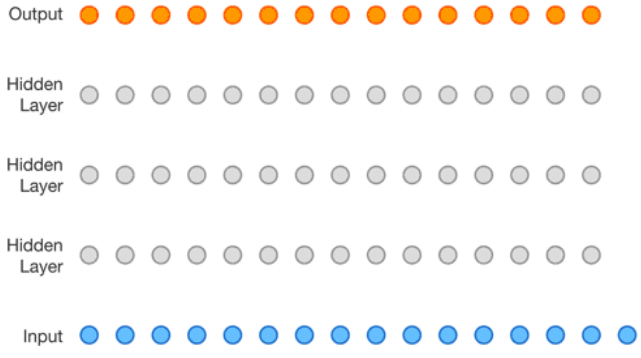


Sound generation with WaveNet [DeepMind 2017]

DL Today: Generative models

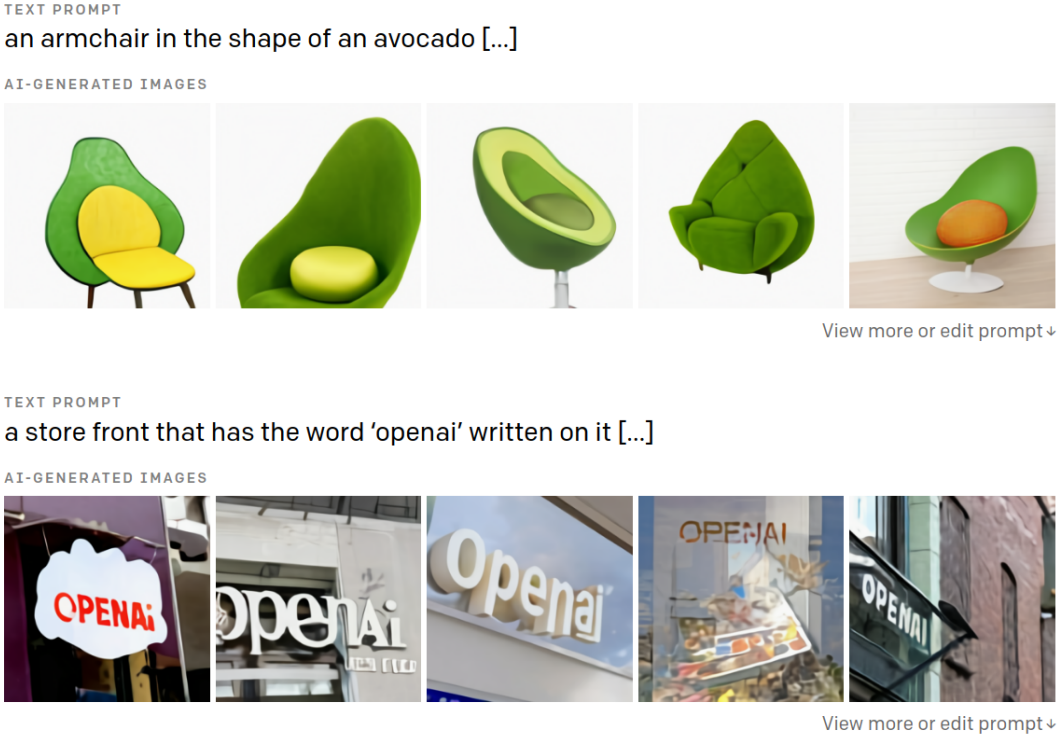


Sound generation with WaveNet [DeepMind 2017]

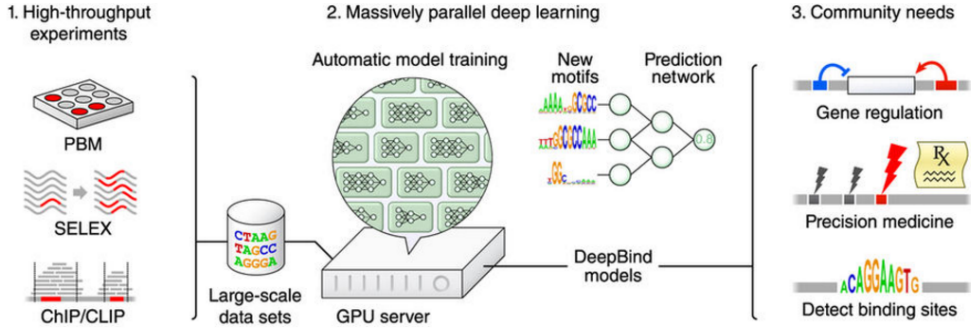
Guess which one is generated?

Language / Image models

Open-AI GPT-3, or DALL-E: https://openai.com/blog/dall-e/



DL in Science: Genomics



[Deep Genomics 2017]

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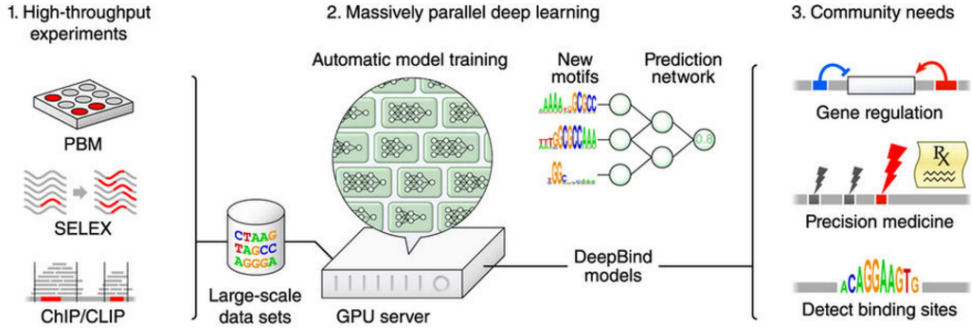

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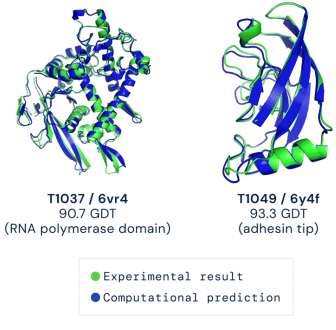
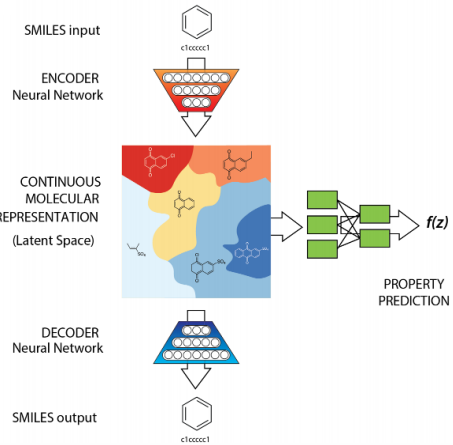


AlphaFold by DeepMind

DL in Science: Chemistry, Physics



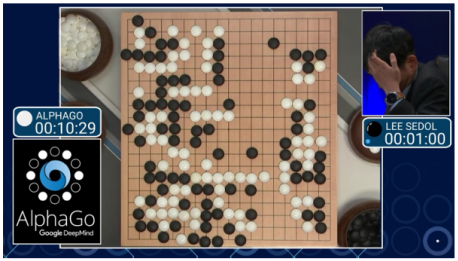
[Gómez-Bombarelli 2016]

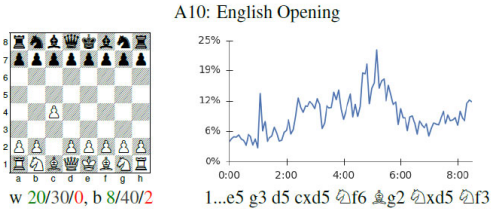
[Tompson 2016]

DL in Science: Chemistry, Physics

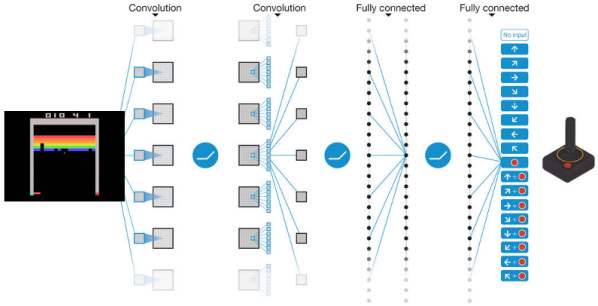
- Finite element simulator accelerated (~100 fold) by a 3D convolutional network

DL for AI in games





[Deepmind AlphaGo / Zero 2017]



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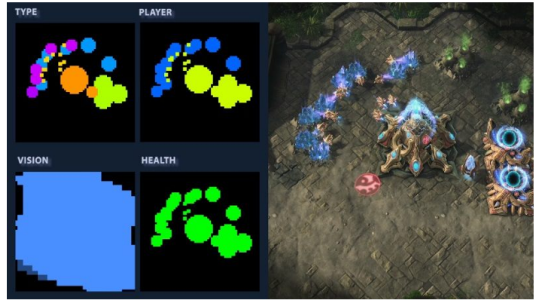

[Starcraft 2 for AI research]

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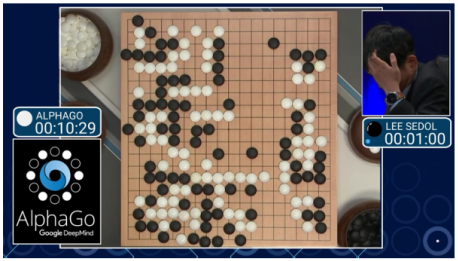

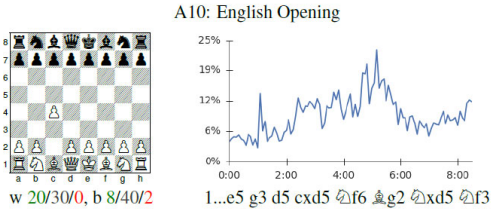

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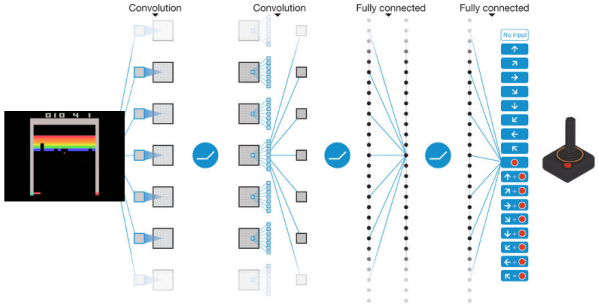

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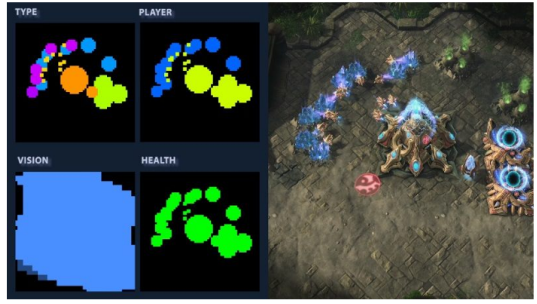

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Outline of the class

Backpropagation

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Computer Vision (2)

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Recommender Systems

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Natural Language Processing (2)

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Optimization: theory, methods and tricks (2)

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Generative models & unsupervised learning

How this unit works

Lectures 1h-1h30

- Can include a Quiz on Moodle (from time to time)
- Small part of the final grade

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Final Project

- Project of your choice in teams of 2-4 people.
- Create a private channel on slack to decide on a topic with instructors as early as possible.

Recommended reading

- deeplearningbook.org: Math and main concepts
- Francois Chollet's book: Keras programming
- Aurélien Géron's book: Generic Machine Learning with Scikit-learn and Deep Learning with TF/Keras

Frameworks and Computation Graphs

Libraries & Frameworks

This lecture is using **Keras**: high level frontend for **TensorFlow** (and MXnet, Theano, CNTK)

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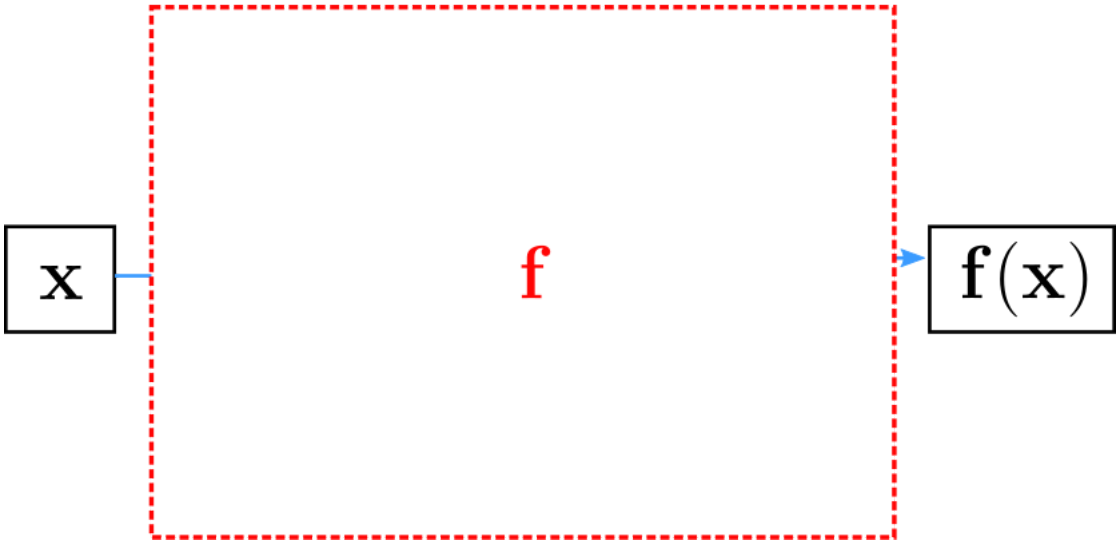
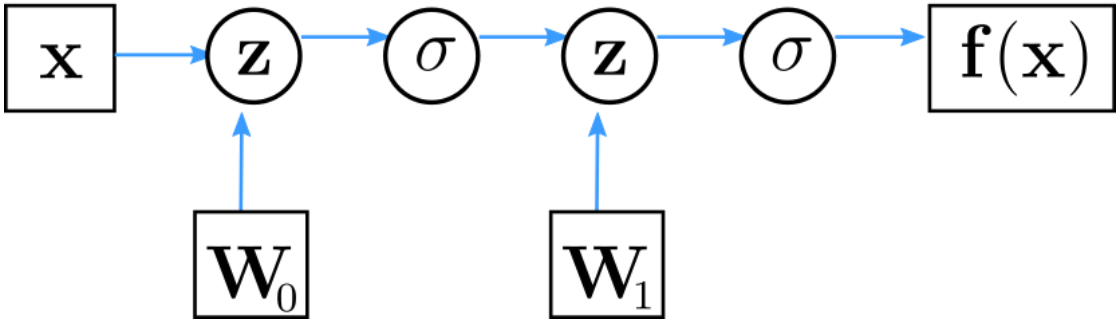
One lab will be dedicated to a short **Pytorch** introduction.

Computation Graph



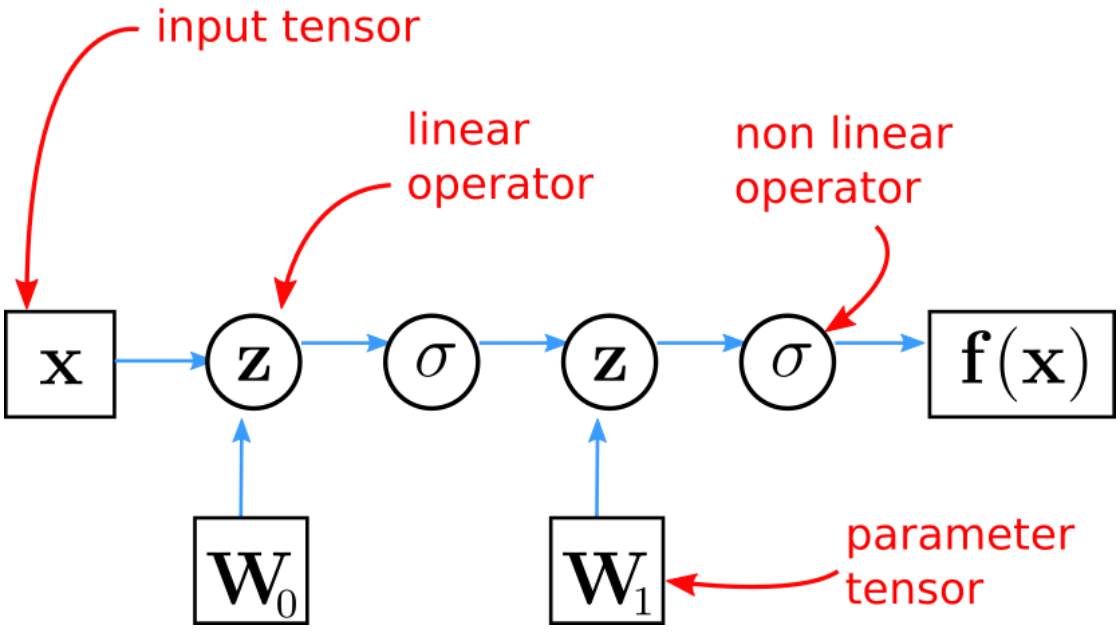
Neural network = parametrized, non-linear function

Computation Graph



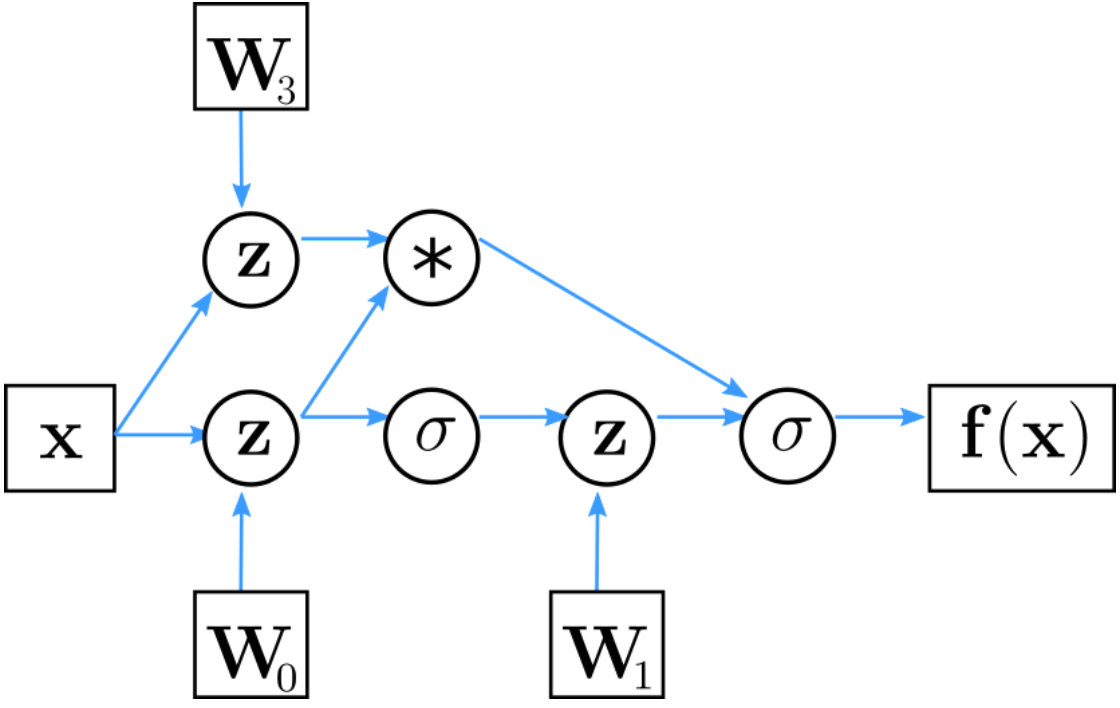
Computation graph: Directed graph of functions, depending on parameters (neuron weights)

Computation Graph



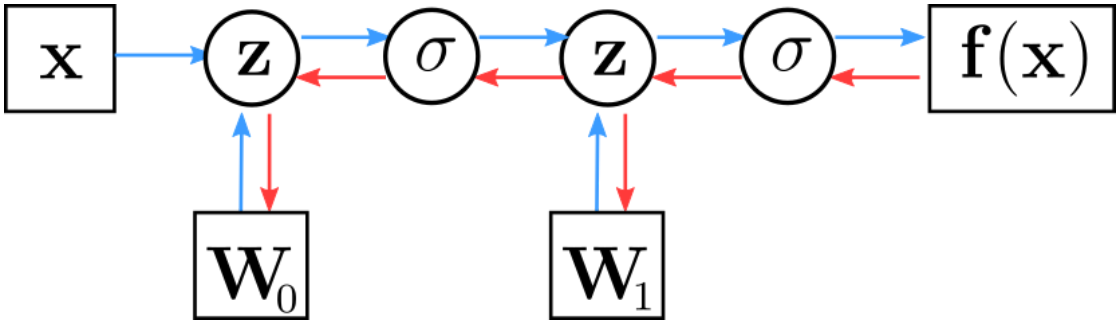
Combination of linear (parametrized) and non-linear functions

Computation Graph



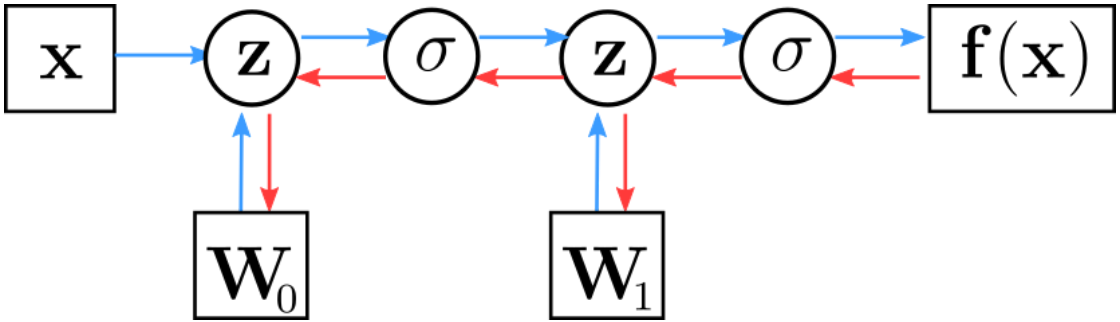
Not only sequential application of functions

Computation Graph



Automatic computation of gradients: all modules are **differentiable**!

Computation Graph



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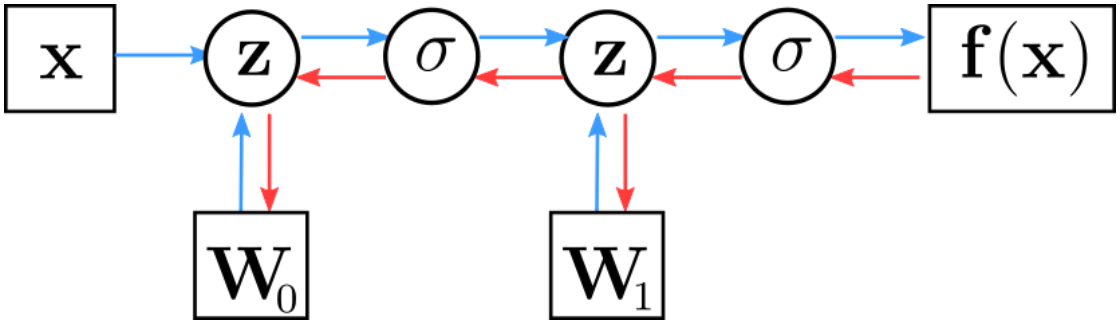

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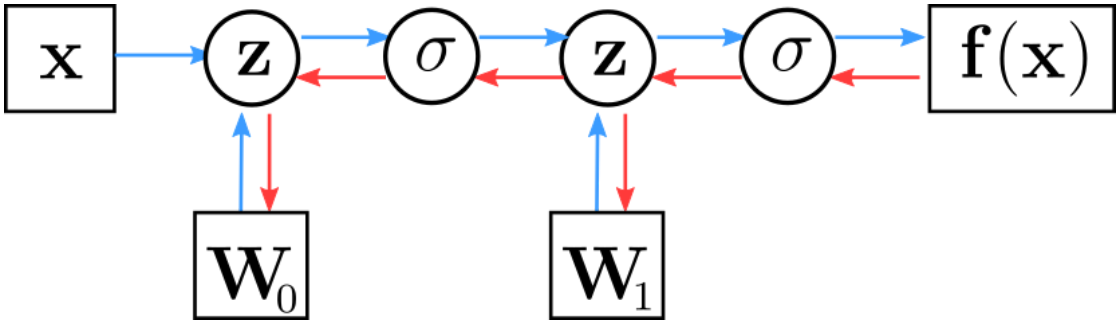

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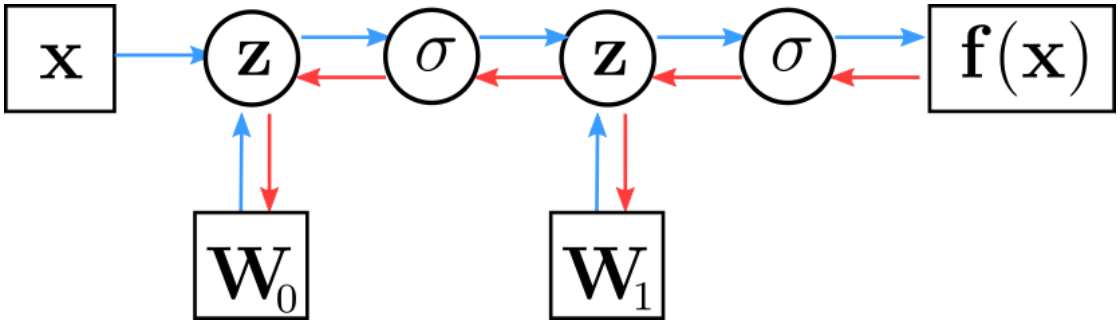

Simple keras implementation

```
model = Sequential()
model.add(Dense(H, input_dim=N))
model.add(Activation("tanh"))
model.add(Dense(K))
model.add(Activation("softmax"))
```

Lab 1: here in 15min!