

# Introduction to Deep Learning

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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

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Good old Neural Networks, with more  
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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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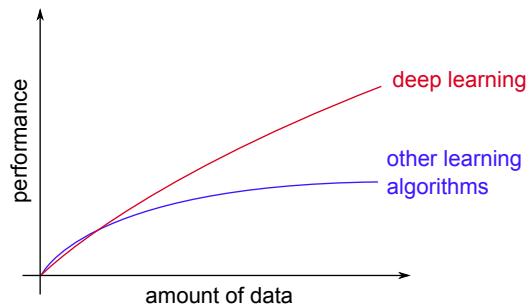
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*GPU and TPU*

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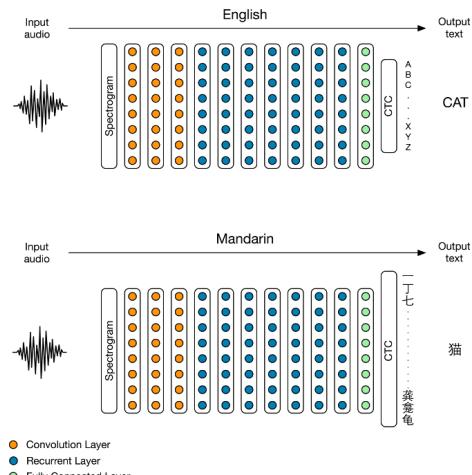


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# DL Today: Speech-to-Text



[Baidu 2014]

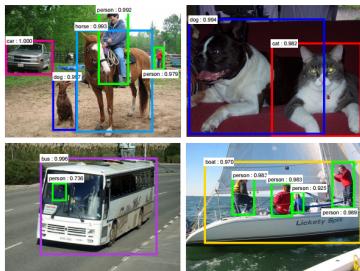
# DL Today: Vision



[Krizhevsky 2012]



[Ciresan et al. 2013]



[Faster R-CNN - Ren 2015]

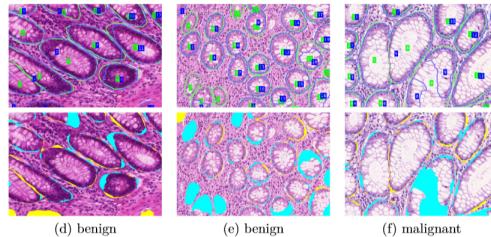


[NVIDIA dev blog]

# DL Today: Vision



[Stanford 2017]



[Nvidia Dev Blog 2017]

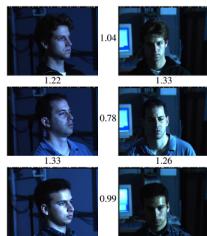
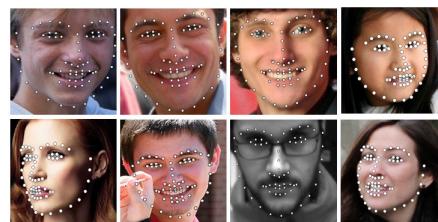


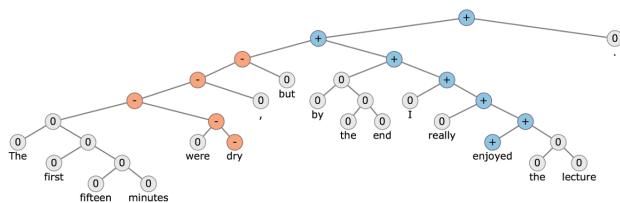
Figure 1. Illumination and Pose invariance.

[FaceNet - Google 2015]



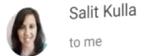
[Facial landmark detection CUHK 2014]

# DL Today: NLP



[Socher 2015]

# DL Today: NLP



Salit Kulla

to me

11:29 AM \*\*\*

Hey, Wynton Marsalis is playing this weekend. Do you have a preference between Saturday and Sunday?

-S

I'm down for either.

Let's do Saturday.

I'm fine with whatever.



Reply



Forward



[Google Inbox Smart Reply]

[Amazon Echo / Alexa]

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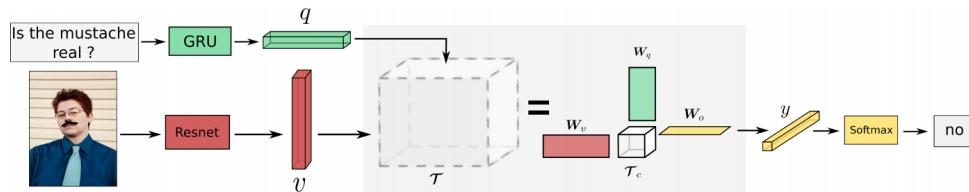


[Google Inbox Smart Reply]

[Amazon Echo / Alexa]

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

# DL Today: Vision + NLP



[VQA - Mutan 2017]



"man in black shirt is playing guitar."



"construction worker in orange safety vest is working on road."



"two young girls are playing with lego toy."



"boy is doing backflip on wakeboard."

[Karpathy 2015]

# DL Today: Image translation



[DeepDream 2015]



[Gatys 2015]



[Ledig 2016]

# DL Today: Generative models



Sampled celebrities [Nvidia 2017]

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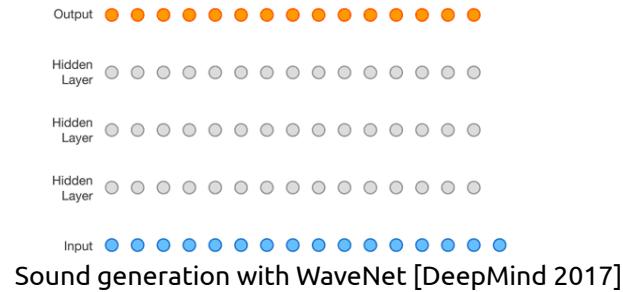


Sampled celebrities [Nvidia 2017]

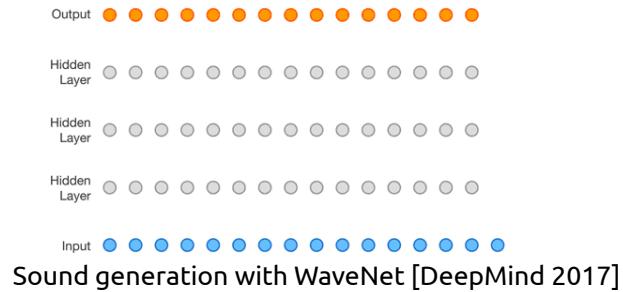
Text description	This bird is blue with white and has a very short beak	This bird has wings that are brown and has a yellow belly	A white bird with a black crown and yellow beak	This bird is white, black, and brown in color, with a brown beak	The bird has small beak, with reddish brown crown and gray belly	This is a small, black bird with a white breast and white on the wingbars.	This bird is white black and yellow in color, with a short black beak
Stage-I images							
Stage-II images							

StackGAN v2 [Zhang 2017]

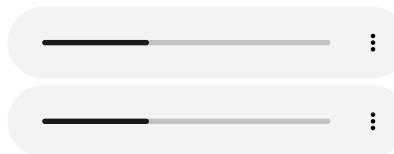
# DL Today: Generative models



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Guess which one is generated?



# Language / Image models

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

TEXT PROMPT  
an armchair in the shape of an avocado [...]

AI-GENERATED IMAGES



[View more or edit prompt ↴](#)

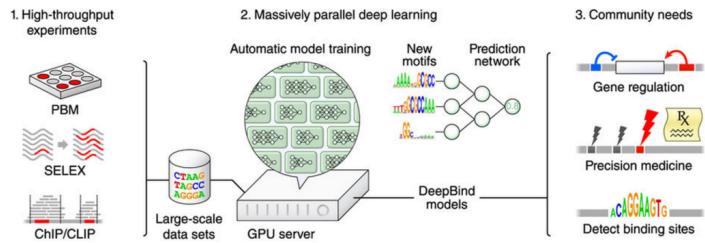
TEXT PROMPT  
a store front that has the word 'openai' written on it [...]

AI-GENERATED IMAGES



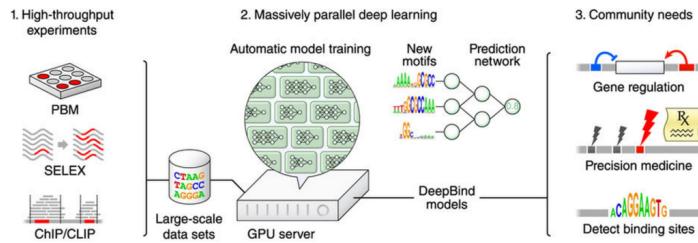
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# DL in Science: Genomics

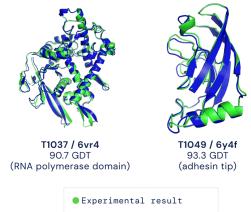


[Deep Genomics 2017]

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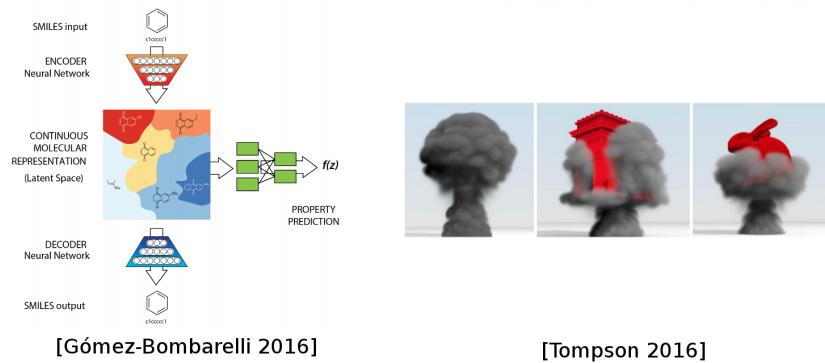


[Deep Genomics 2017]



[AlphaFold by DeepMind](#)

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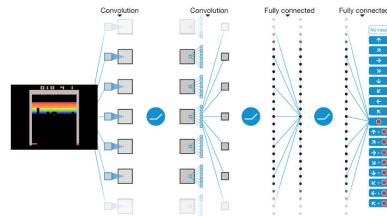
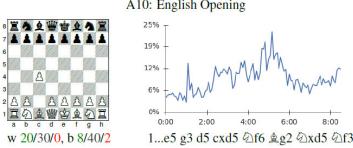


- Finite element simulator accelerated (~100 fold) by a 3D convolutional network

# DL for AI in games



[Deepmind AlphaGo / Zero 2017]



[Atari Games - DeepMind 2016]

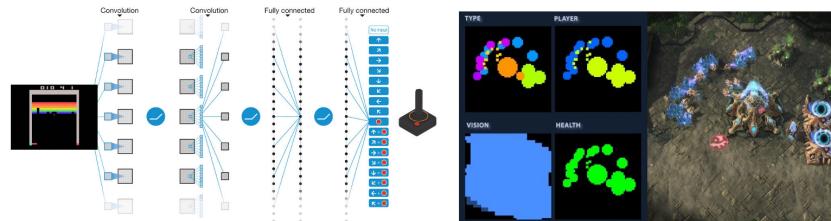


[Starcraft 2 for AI research]

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AlphaGo/Zero: Monte Carlo Tree Search, Deep Reinforcement Learning, self-play

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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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Optimization: theory, methods and tricks (2)

Generative models & unsupervised learning

# How this unit works

Lectures 1h-1h30

- Can include a Quiz on Moodle (from time to time)
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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](https://deeplearningbook.org): Math and main concepts
- [Francois Chollet's book](https://www.manning.com/books/deep-learning-with-keras): Keras programming
- [Aurélien Géron's book](https://www.manning.com/books/hands-on-machine-learning-with-scikit-learn-and-tensorflow): 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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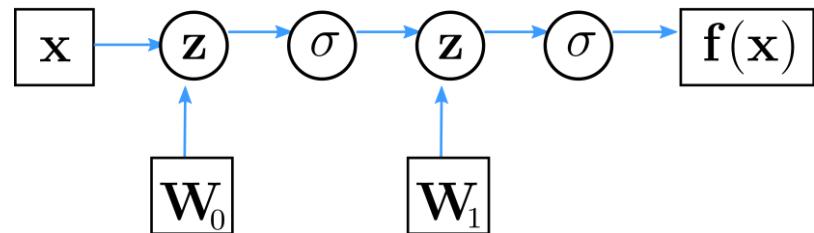
One lab will be dedicated to a short **Pytorch** introduction.

# Computation Graph



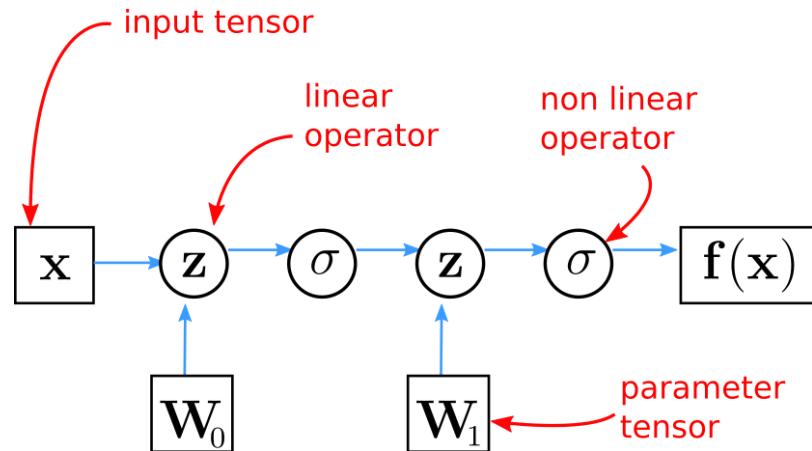
Neural network = parametrized, non-linear function

# Computation Graph



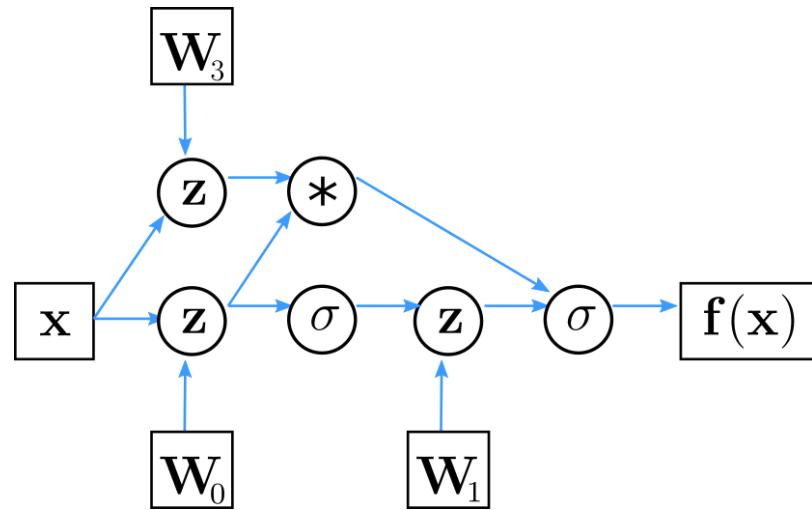
Computation graph: Directed graph of functions, depending on parameters (neuron weights)

# Computation Graph



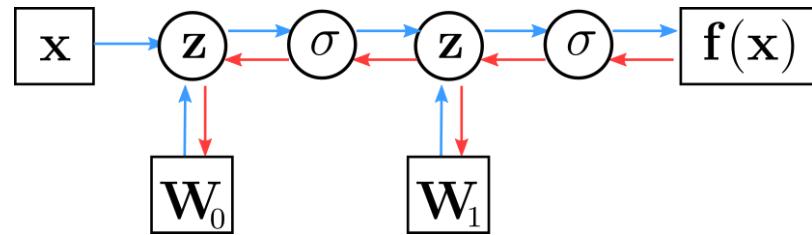
Combination of linear (parametrized) and non-linear functions

# Computation Graph



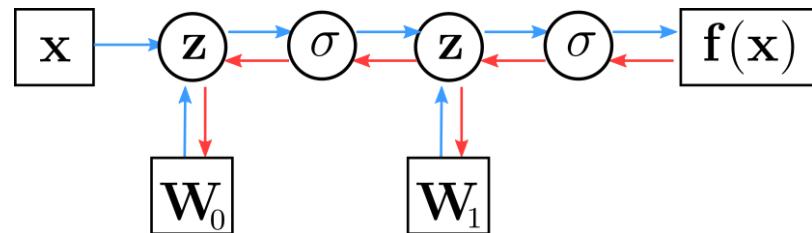
Not only sequential application of functions

# Computation Graph



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

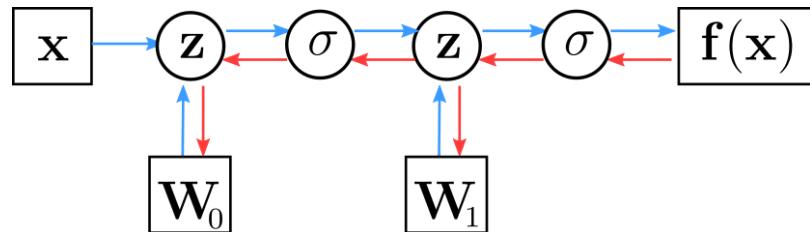
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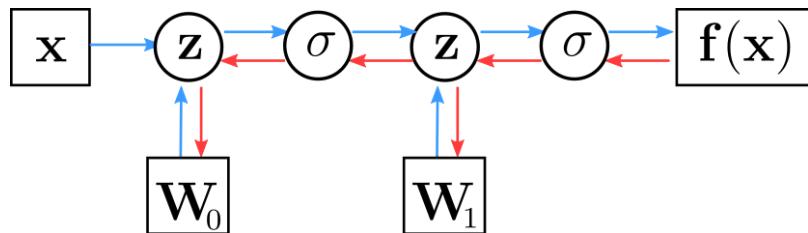


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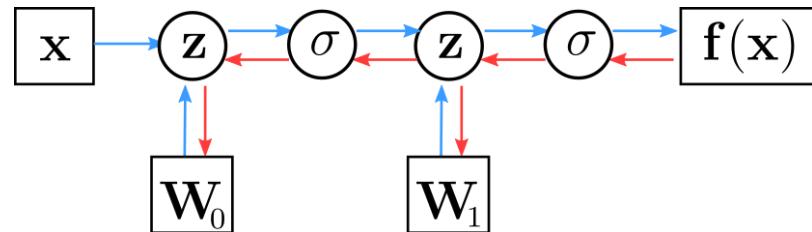
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Vector computation on **CPU** and accelerators (**GPU** and **TPU**).

# Computation Graph



Simple keras implementation

```
model = Sequential()
model.add(Dense(H, input_dim=N)) # defines W0
model.add(Activation("tanh"))
model.add(Dense(K))           # defines W1
model.add(Activation("softmax"))
```

Lab 1: here in 15min!

