

Deep Learning: Introduction to Deep Learning

```
$ echo "Data Sciences Institute"
```

Warning: This lecture is more theoretical compared to the other lectures.

Goal of the class

Overview

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

Using DL

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

What is Deep Learning

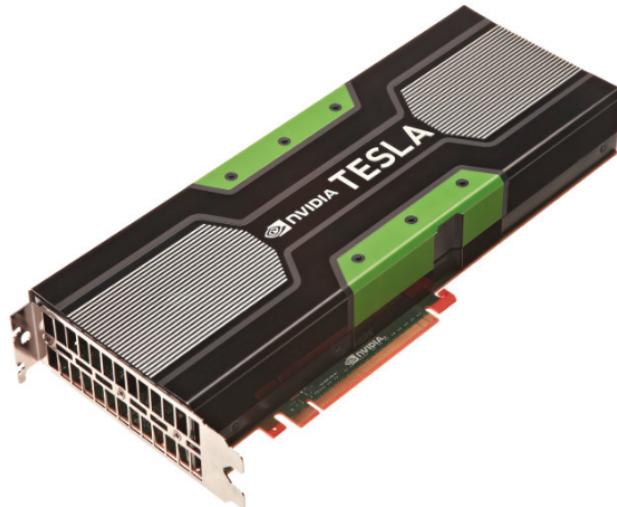
- Good old Neural Networks, with more layers/modules
- Non-linear, hierarchical, abstract representations of data
- Flexible models with any input/output type and size
- Differentiable Functional Programming

Why Deep Learning Now?

- Better algorithms & understanding

Why Deep Learning Now?

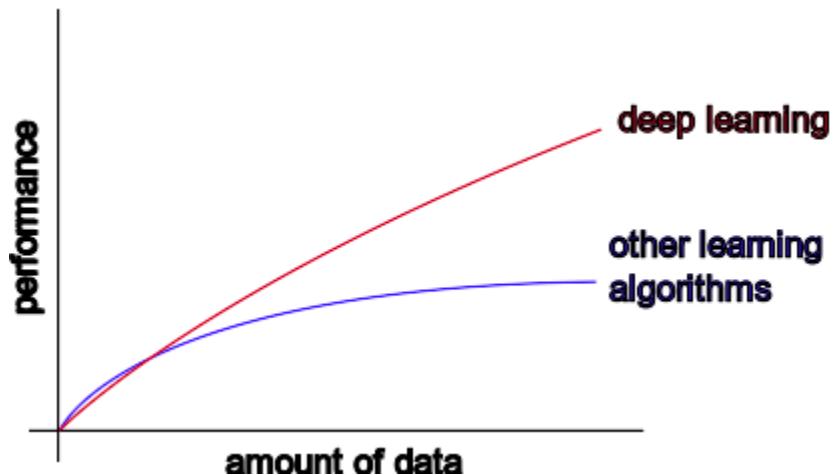
- Computing power (GPUs, TPUs, ...)



GPU and TPU

Why Deep Learning Now?

- Data with labels



Adapted from Andrew Ng

Why Deep Learning Now?

- Open source tools and models



PYTORCH



Microsoft
CNTK

Caffe2

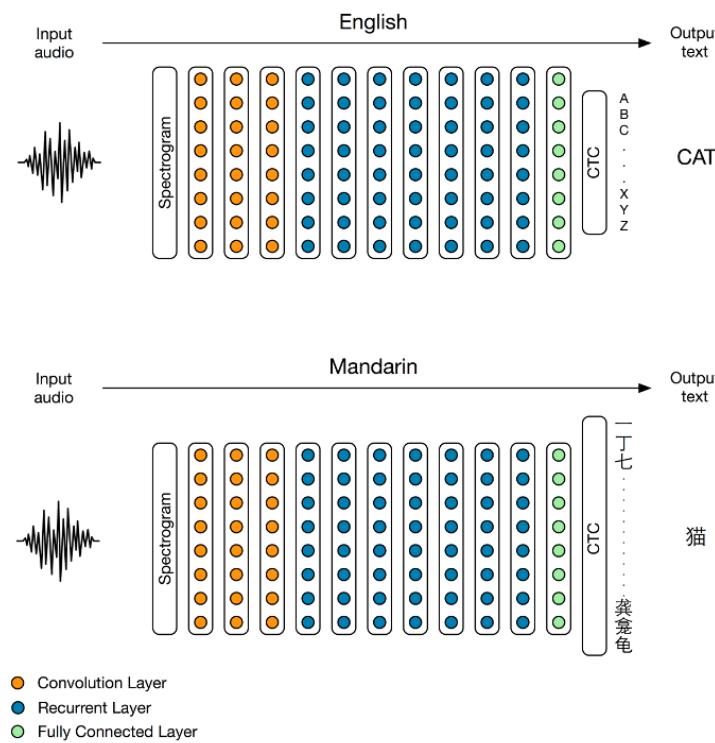
dmlc
mxnet

gensim

spaCy

theano

DL Today: Speech-to-Text



[Baidu 2014]

DL Today: Vision

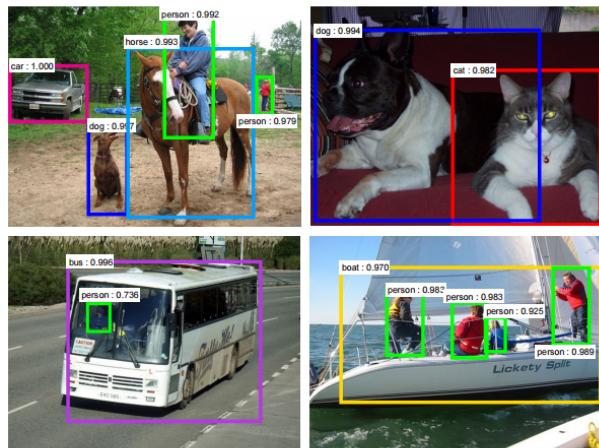
DL Today: Vision



[Krizhevsky 2012]



[Ciresan et al. 2013]



[Faster R-CNN - Ren 2015]

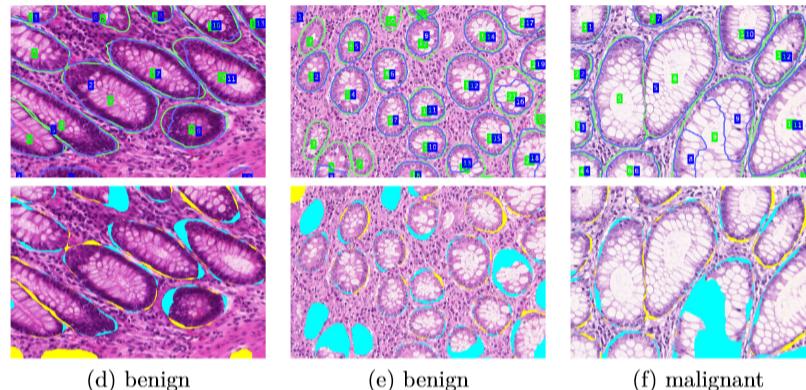


[NVIDIA dev blog]

DL Today: Vision



[Stanford 2017]



[Nvidia Dev Blog 2017]

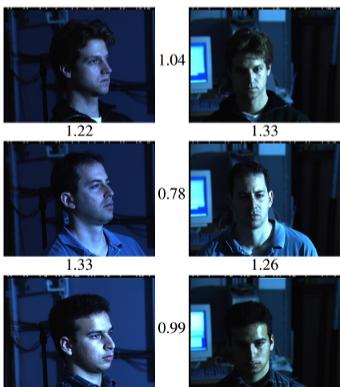
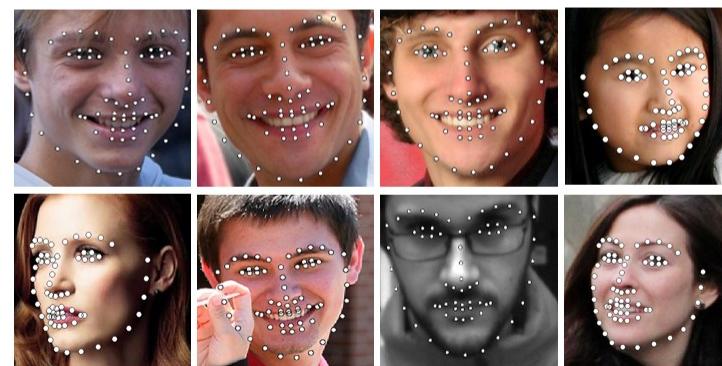


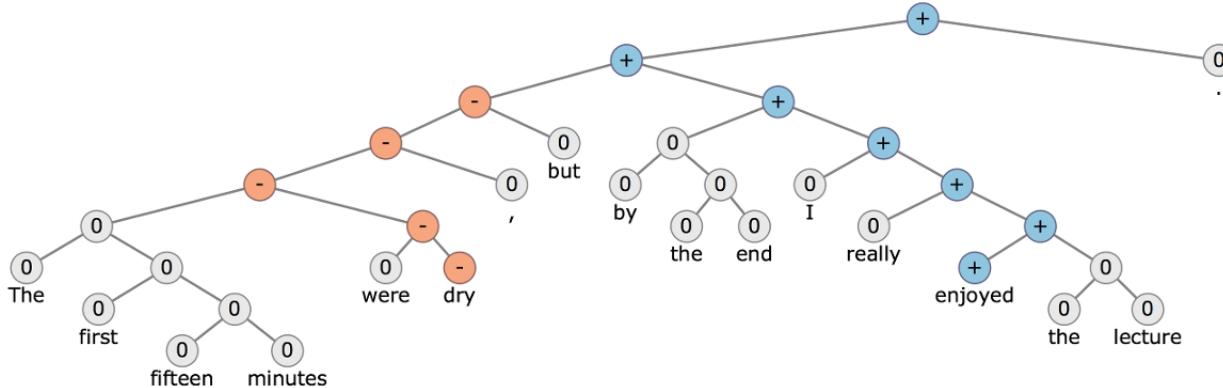
Figure 1. Illumination and Pose invariance.

[FaceNet - Google 2015]

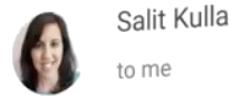


[Facial landmark detection CUHK 2014]

DL Today: NLP



DL Today: NLP



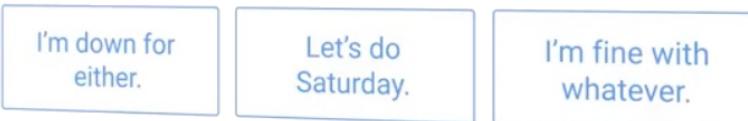
Salit Kulla

to me

11:29 AM •••

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

-S



Reply



Forward

[Google Inbox Smart Reply]

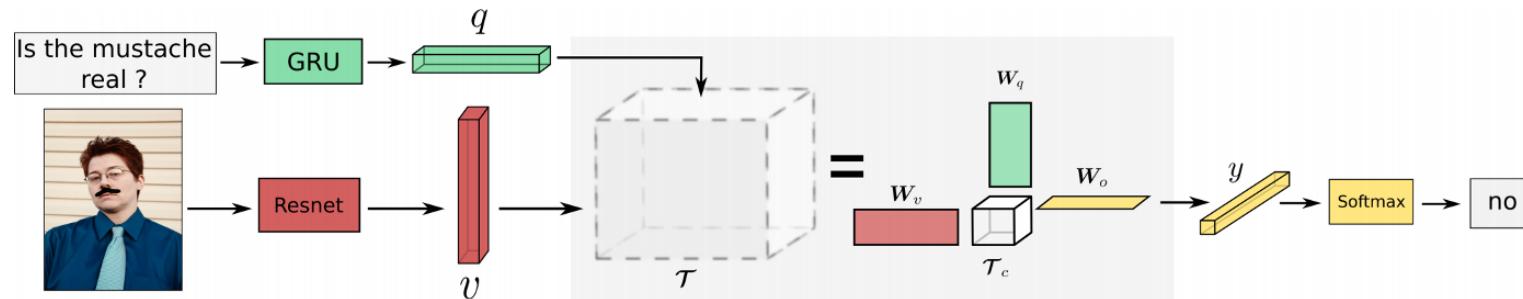


[Amazon Echo / Alexa]

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

13

DL Today: Vision + NLP



[VQA - Mutan 2017]



[Karpathy 2015]

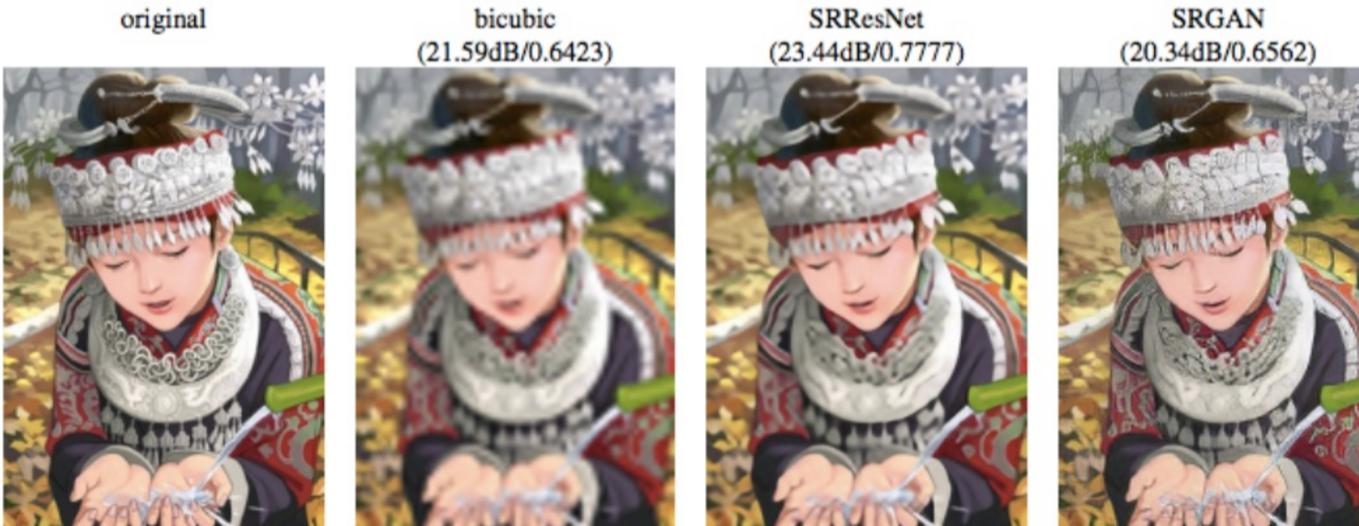
DL Today: Image translation



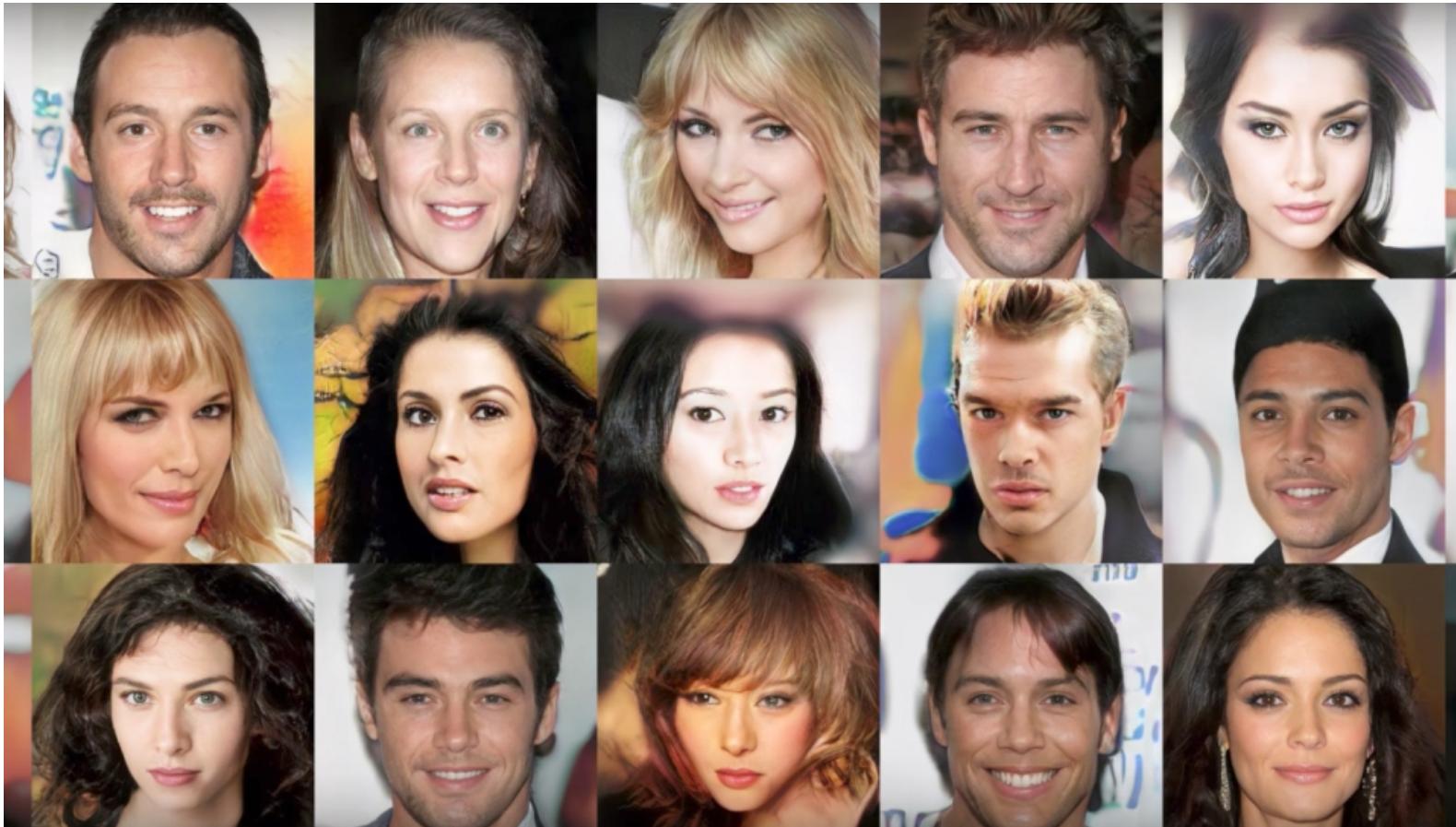
[DeepDream 2015]



[Gatys 2015]

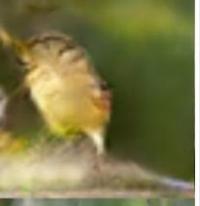


DL Today: Generative models



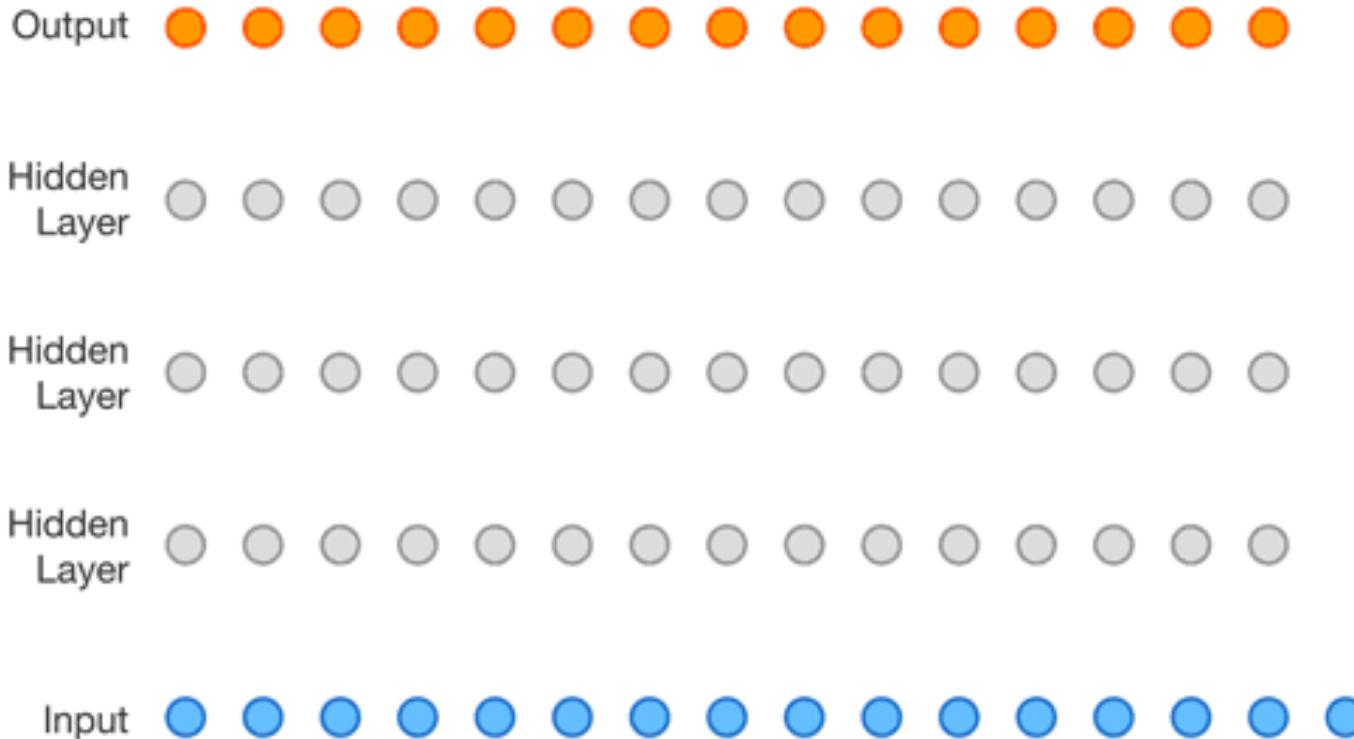
sampled celebrities [Nvidia 2017]

DL Today: Generative models

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



Sound generation with WaveNet [DeepMind 2017]

DL Today: Generative models

Guess which one is generated?

[columbia_gen](#)

[columbia_gt](#)

Tacotron 2 Natural TTS Synthesis by Conditioning WaveNet on Mel Spectrogram Predictions, 2017

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 ↓](#)

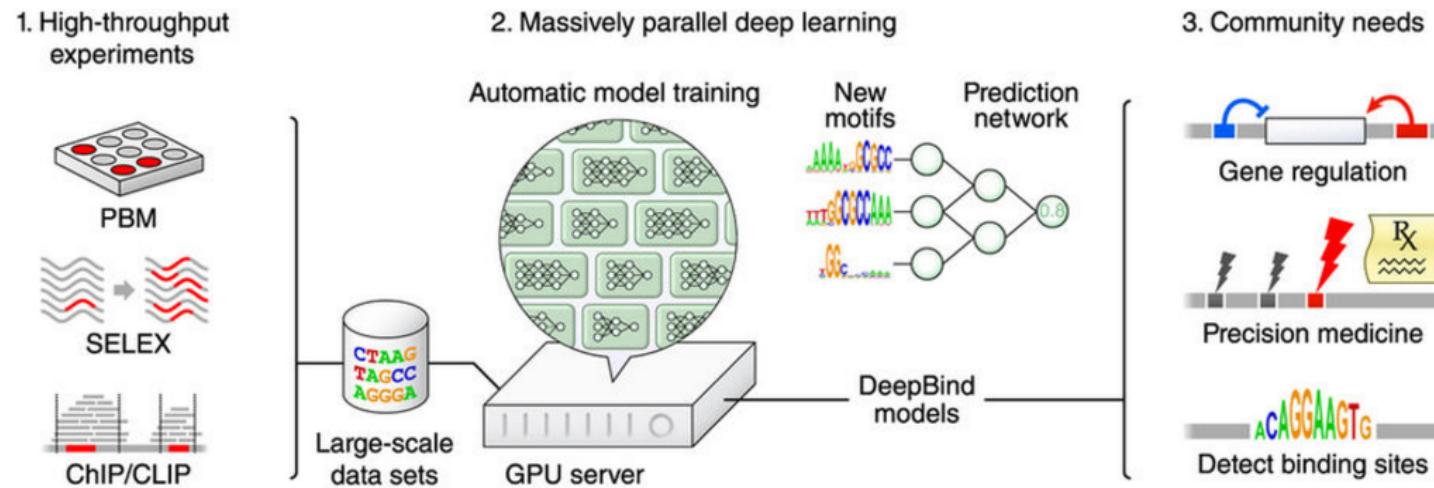
TEXT PROMPT

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

AI-GENERATED IMAGES



DL in Science: Genomics

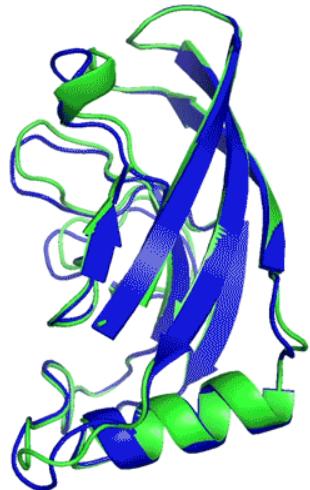


[Deep Genomics 2017]

DL in Science: Genomics



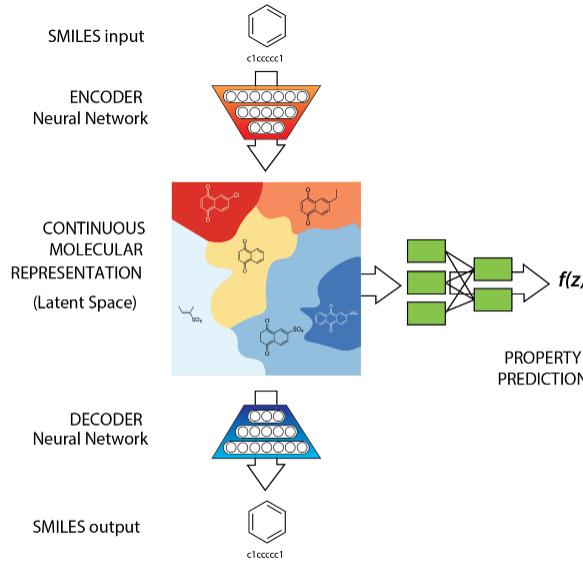
T1037 / 6vr4
90.7 GDT
(RNA polymerase domain)



T1049 / 6y4f
93.3 GDT
(adhesin tip)

- Experimental result
- Computational prediction

DL in Science: Chemistry, Physics



[Gómez-Bombarelli 2016]



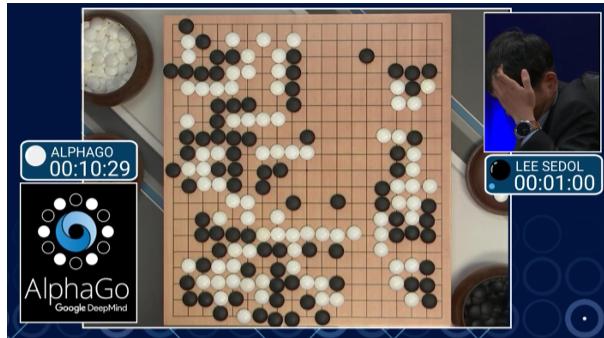
[Tompson 2016]

DL in Science: Chemistry, Physics

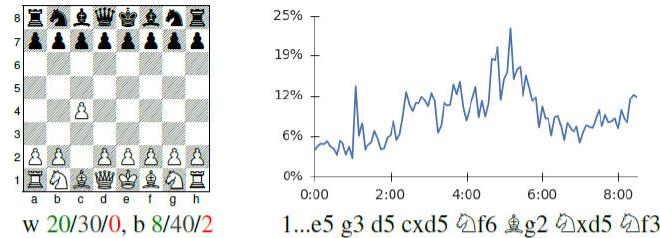


Finite element simulator accelerated (~100 fold) by a 3D convolutional network

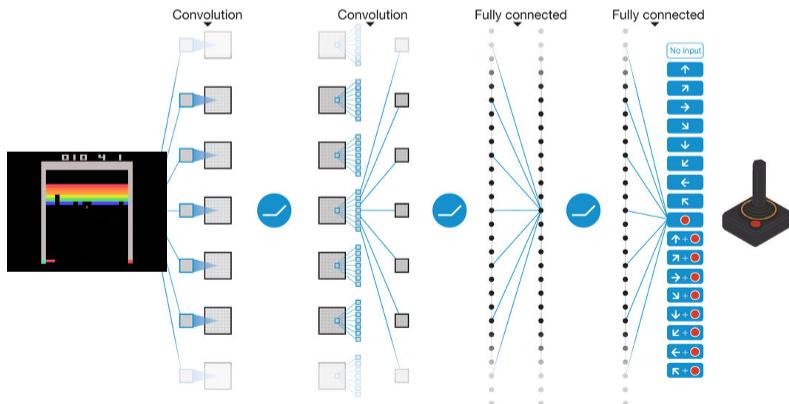
DL for AI in games



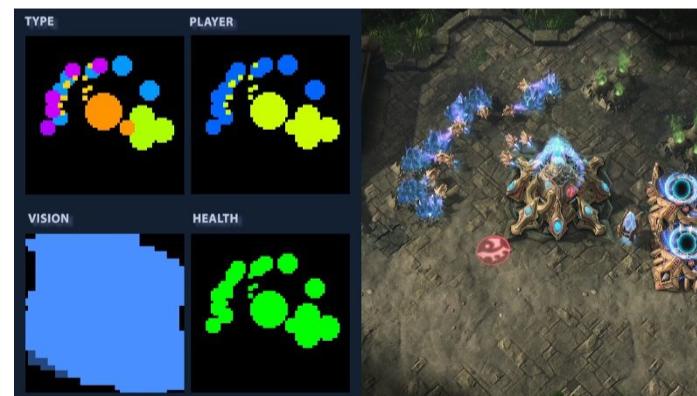
A10: English Opening



[Deepmind AlphaGo / Zero 2017]



[Atari Games - DeepMind 2016]



[Starcraft 2 for AI research]

Outline of the class

- Backpropagation
- Computer Vision
- Recommender Systems
- Natural Language Processing
- Optimization: theory, methods and tricks
- Generative models & unsupervised learning

How this course works works

- Lectures ~1 hour
- Break ~15 minutes
- Practical session ~1 hour
 - Work in breakout groups and discuss!
 - Homework: complete the lab
- Two assignments
 - One due at the end of week 1, one at the end of week 2

Frameworks and Computation Graphs

Libraries & Frameworks



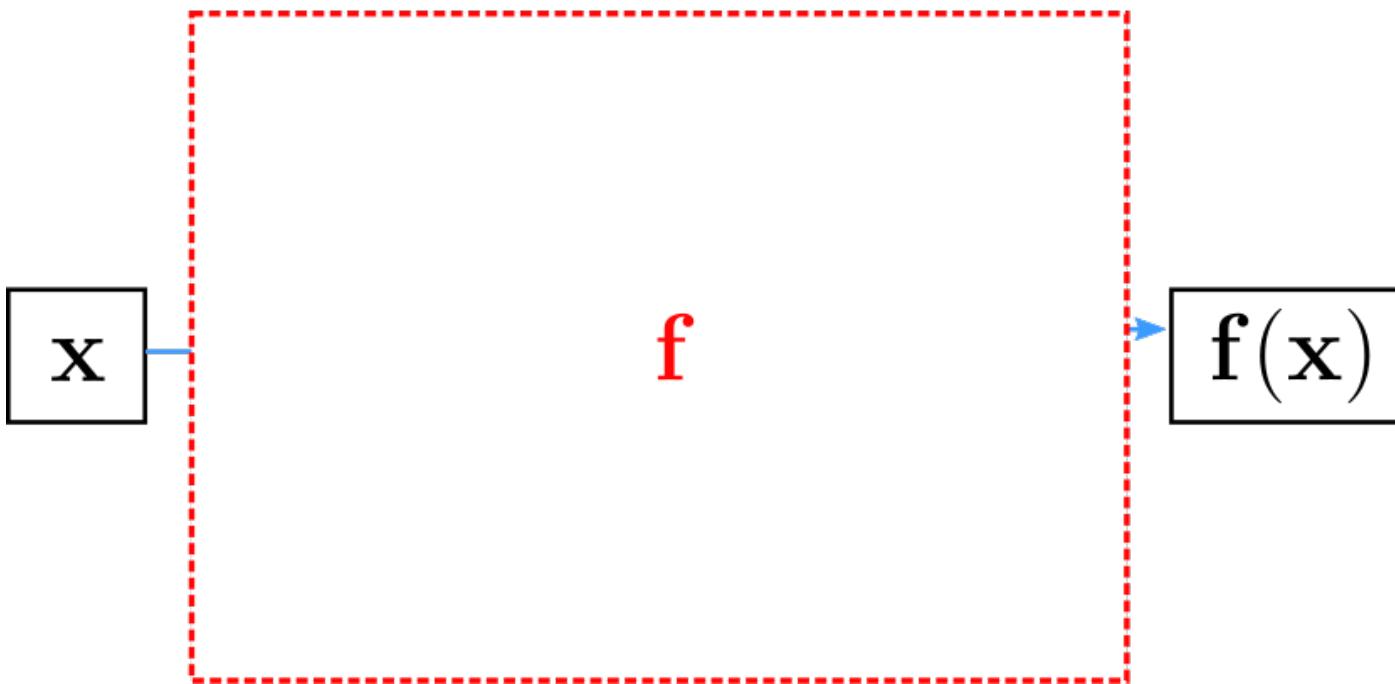
gensim **spaCy**

theano

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

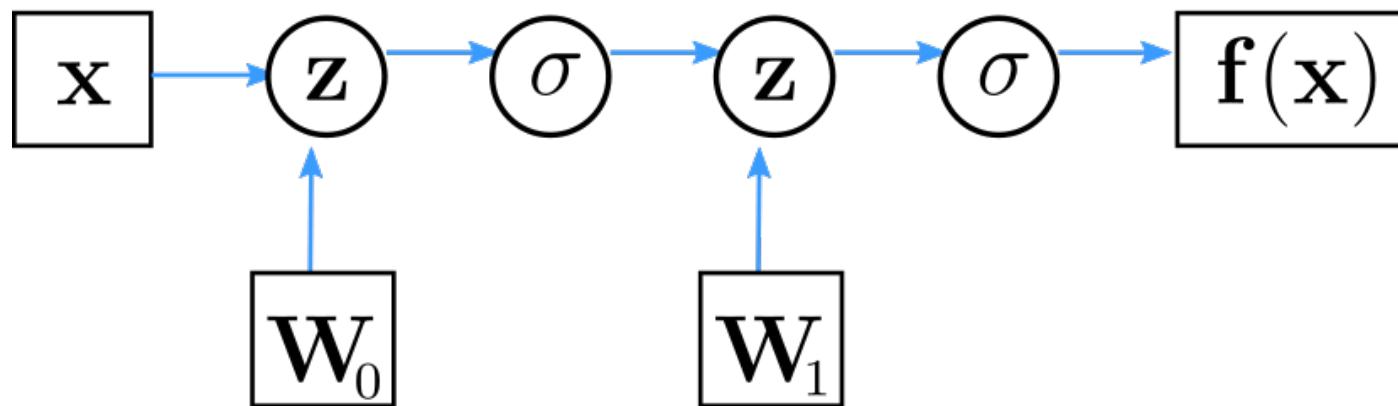
One lab will be dedicated to a short **Pytorch** introduction.

Computation Graph



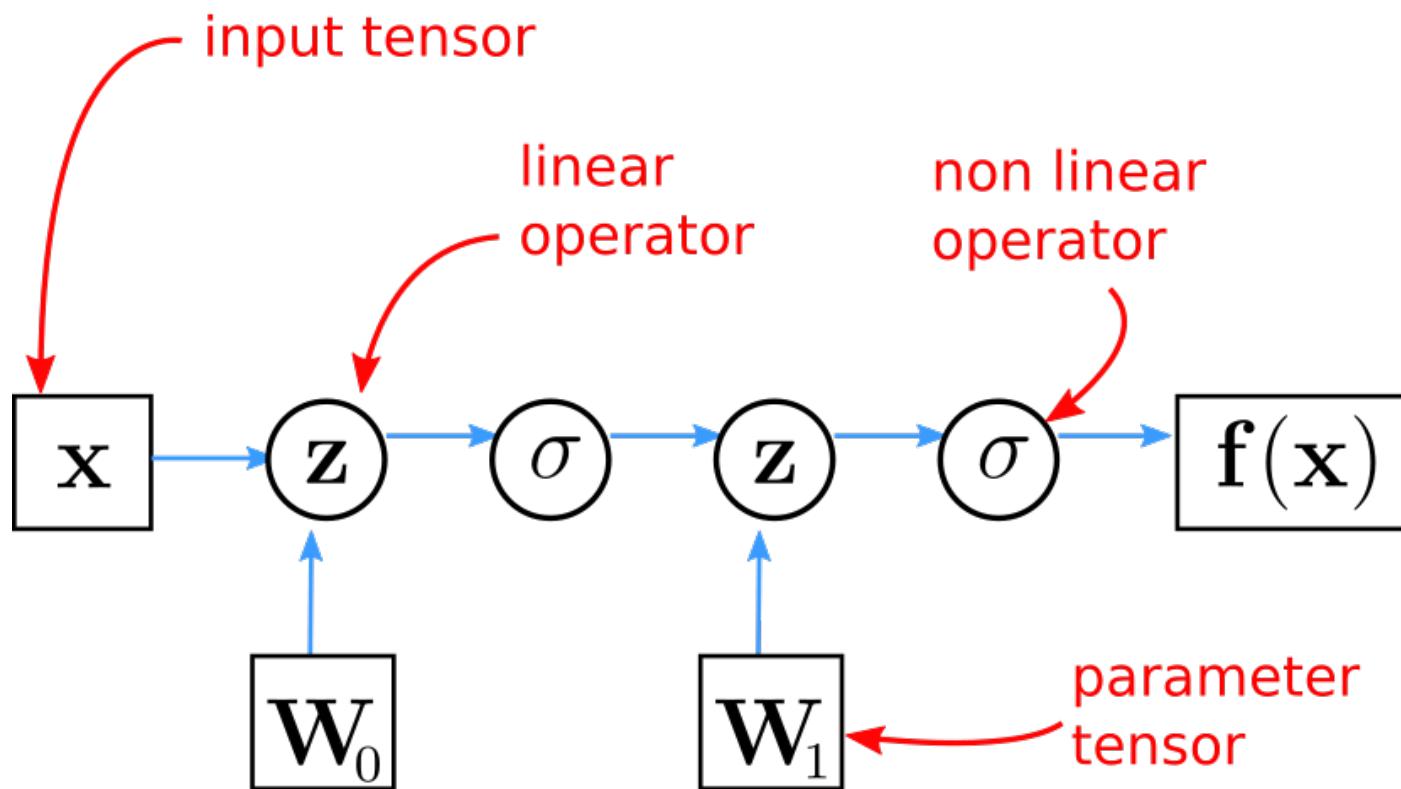
Neural network = parametrized, non-linear function

Computation Graph



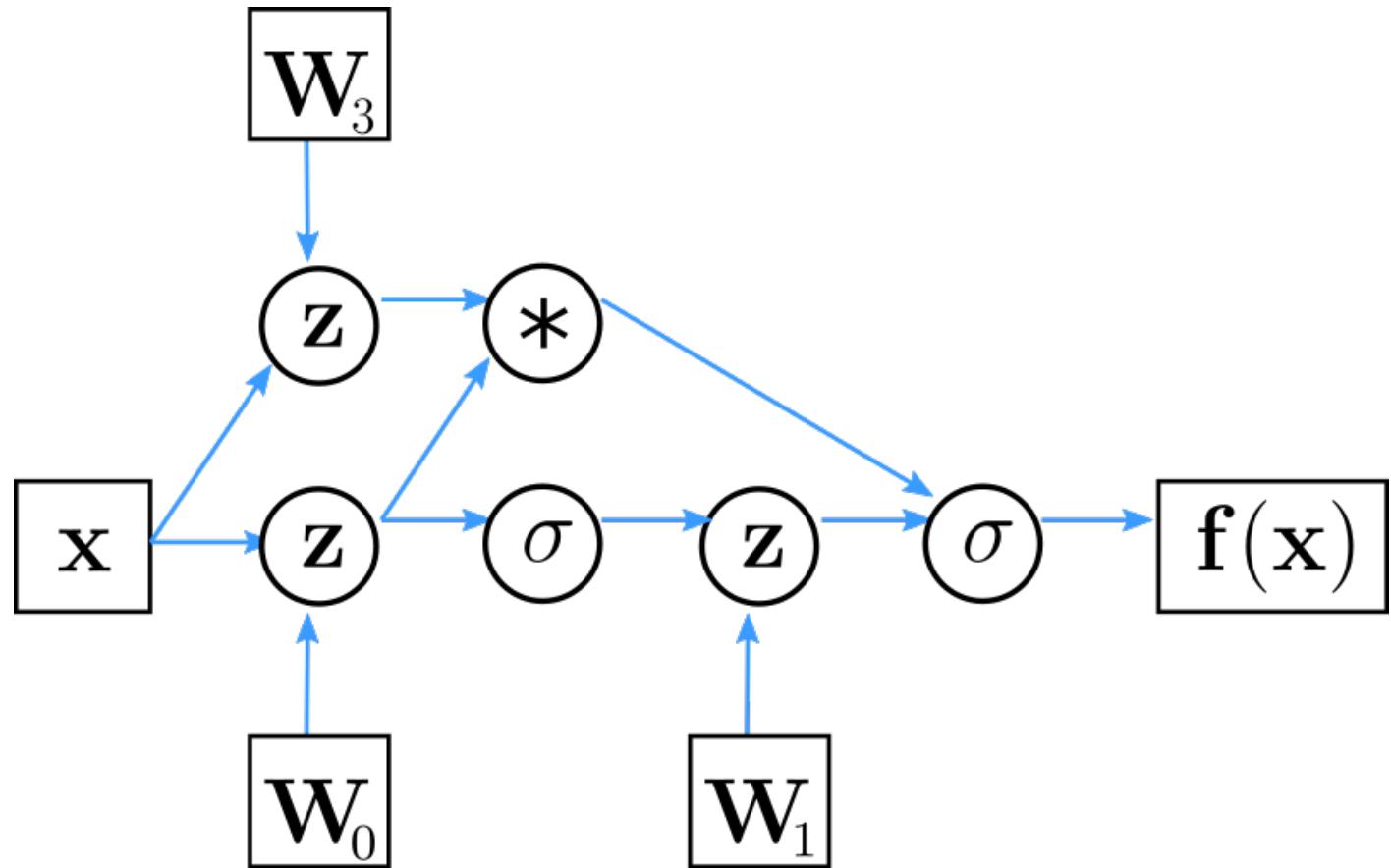
Computation graph: Directed graph of functions, depending on parameters (neuron weights)

Computation Graph



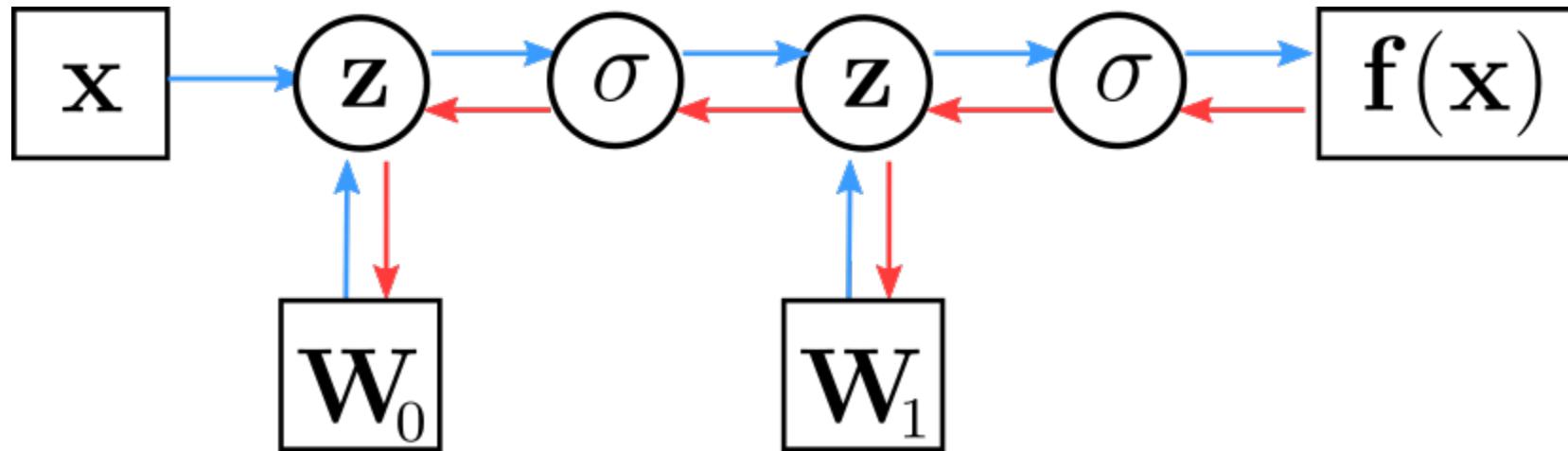
Combination of linear (parametrized) and non-linear functions

Computation Graph



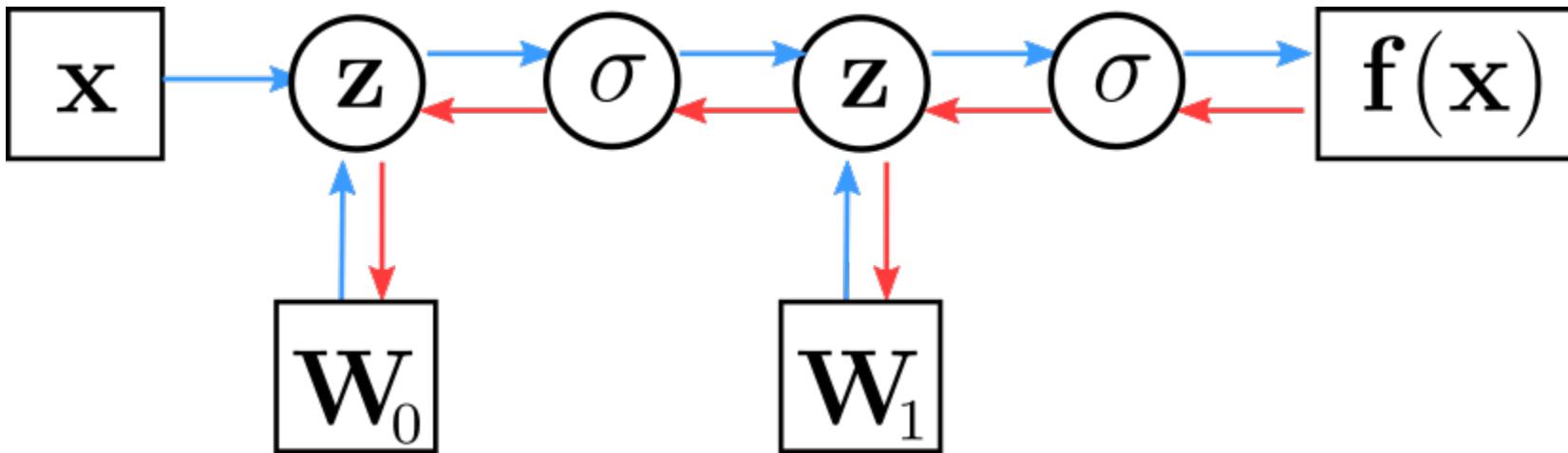
Not only sequential application of functions

Computation Graph



- Automatic computation of gradients: all modules are **differentiable!**
- Theano (now Aesara), **Tensorflow 1**, etc. build a static computation graph via static declarations.
- **Tensorflow 2**, **PyTorch**, **JAX**, etc. rely on dynamic differentiable modules: "define-by-run".
- 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"))
```

Next: Lab 1!