

Deep Learning

Lecture 1: Introduction to Deep Learning

Alex Olson

Adapted from material by Charles Ollion & Olivier Grisel

Goal of the class

Overview

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

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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

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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

Why Deep Learning Now?

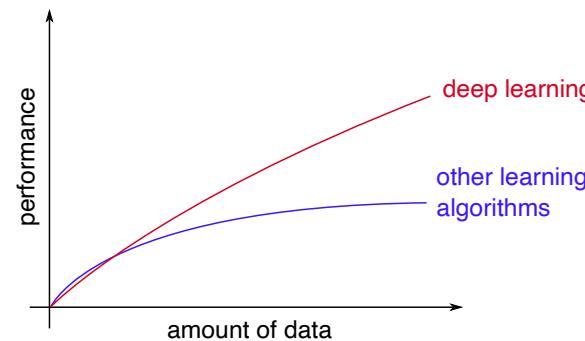
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GPU and TPU

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PYTORCH



CNTK

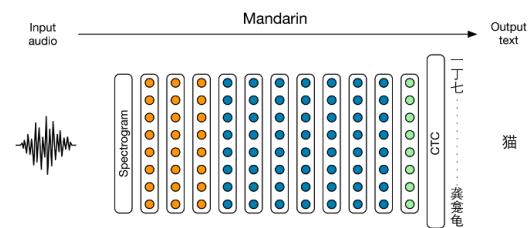
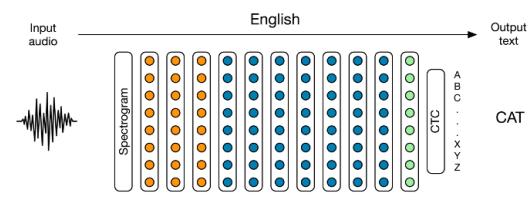
Caffe2

dmlc
mxnet

gensim spaCy

theano

DL Today: Speech-to-Text



- Convolution Layer
- Recurrent Layer
- Fully Connected Layer

[Baidu 2014]

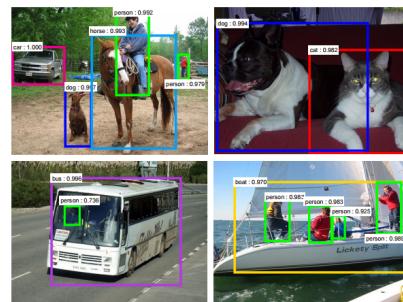
DL Today: Vision



[Krizhevsky 2012]



[Ciresan et al. 2013]



[Faster R-CNN - Ren 2015]

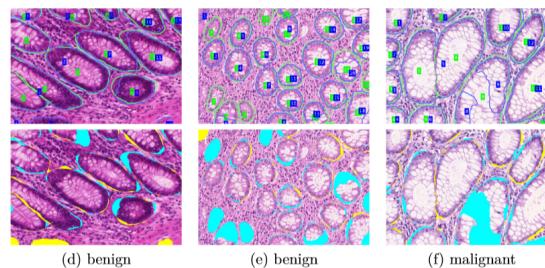


[NVIDIA dev blog]

DL Today: Vision



[Stanford 2017]



[Nvidia Dev Blog 2017]

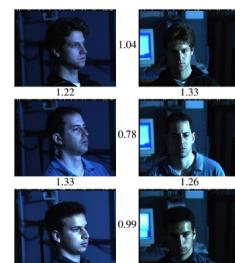
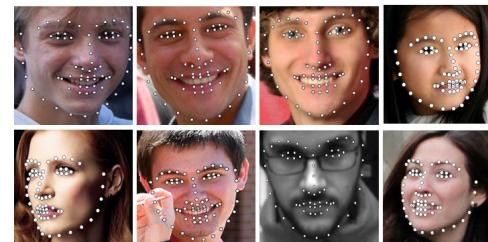


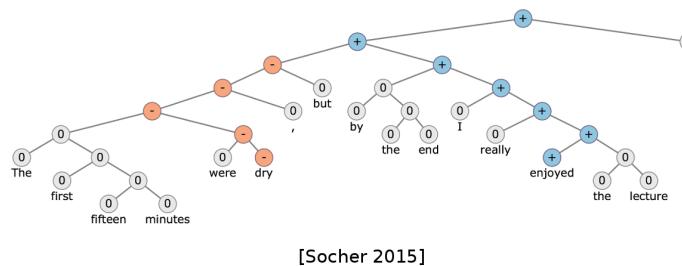
Figure 1. Illumination and Pose invariance.

[FaceNet - Google 2015]



[Facial landmark detection CUHK 2014]

DL Today: NLP



DL Today: NLP



[Google Inbox Smart Reply]



[Amazon Echo / Alexa]

DL Today: NLP



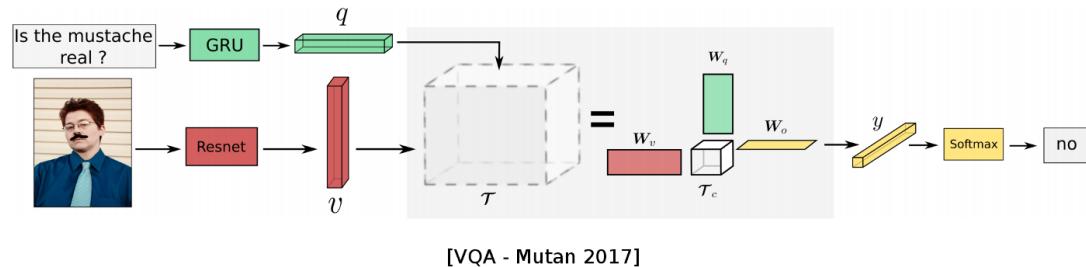
[Google Inbox Smart Reply]



[Amazon Echo / Alexa]

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

DL Today: Vision + NLP



"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]

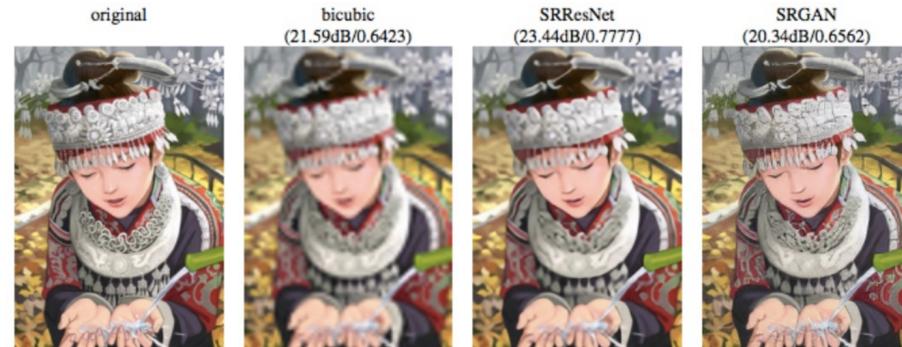
DL Today: Image translation



[DeepDream 2015]



[Gatys 2015]



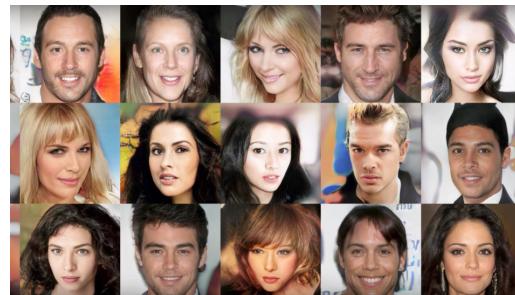
[Ledig 2016]

DL Today: Generative models



Sampled celebrities [Nvidia 2017]

DL Today: Generative models

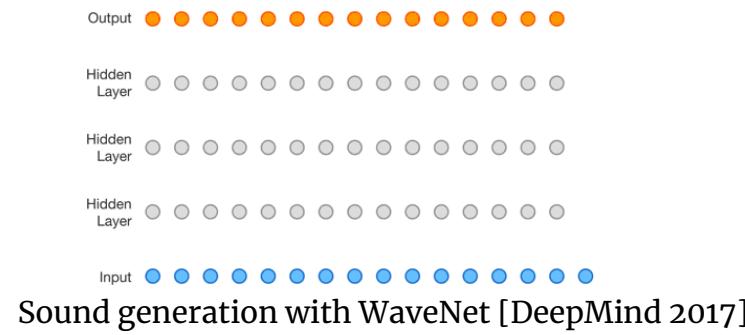


Sampled celebrities [Nvidia 2017]

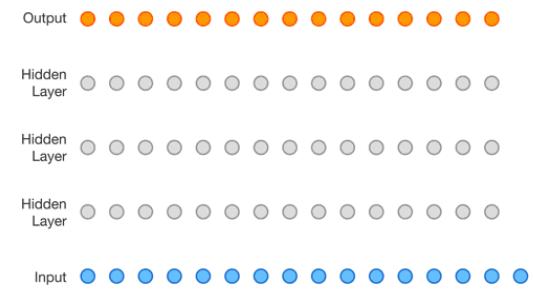
Text description	This bird is blue with white and has a very short beak	This bird has wings that are brown and has a yellow belly	A white bird with a black crown and yellow beak	This bird is white, black, and brown in color, with a brown beak	The bird has small beak, with reddish brown crown and gray 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



DL Today: Generative models



Sound generation with WaveNet [DeepMind 2017]

Guess which one is generated?

0:00 / 0:03

0:00 / 0:03

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

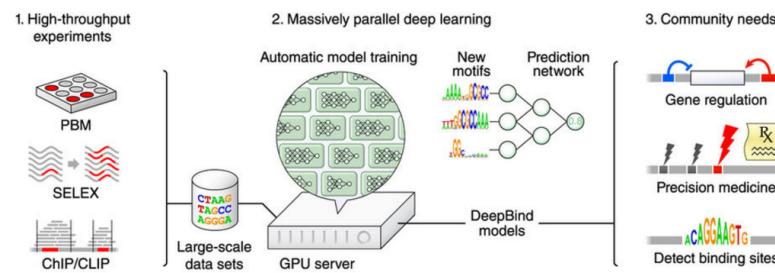
a store front that has the word 'openai' written on it [...]

AI-GENERATED IMAGES



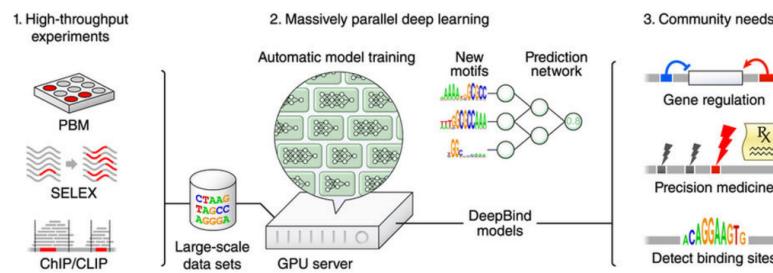
[View more or edit prompt](#) ↴

DL in Science: Genomics

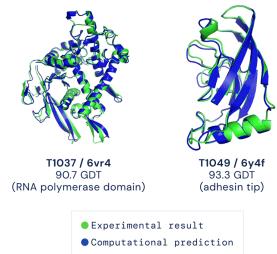


[Deep Genomics 2017]

DL in Science: Genomics

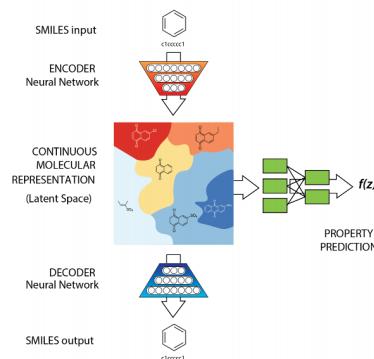


[Deep Genomics 2017]



[AlphaFold by DeepMind](#)

DL in Science: Chemistry, Physics



[Gómez-Bombarelli 2016]



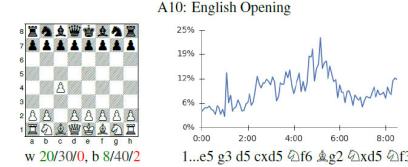
[Tompson 2016]

DL in Science: Chemistry, Physics

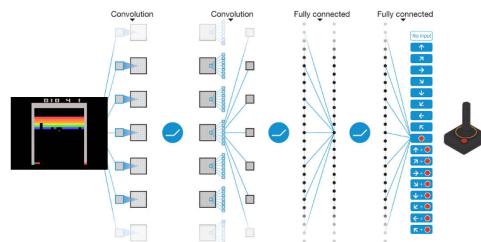


- Finite element simulator accelerated (~100 fold) by a 3D convolutional network

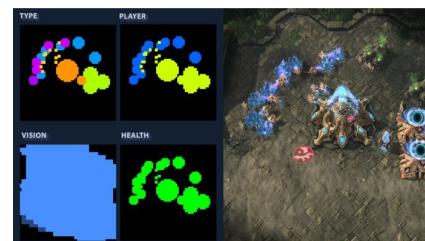
DL for AI in games



[Deepmind AlphaGo / Zero 2017]

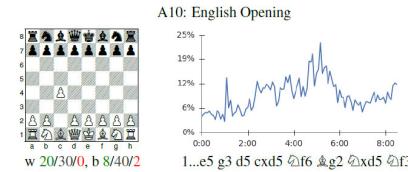


[Atari Games - DeepMind 2016]

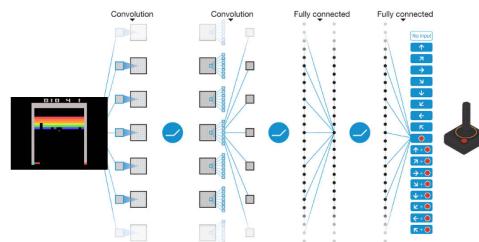


[Starcraft 2 for AI research]

DL for AI in games



[Deepmind AlphaGo / Zero 2017]



[Atari Games - DeepMind 2016]



[Starcraft 2 for AI research]

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

Outline of the class

Backpropagation

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Computer Vision

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Recommender Systems

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Natural Language Processing

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Optimization: theory, methods and tricks

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Backpropagation

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Generative models & unsupervised learning

How this course works

Lectures ~1 hour

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Break ~15 minutes

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Practical session ~1 hour

- Work in breakout groups and discuss!
- Homework: complete the lab

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Two assignments

- Details to be announced next week

Frameworks and Computation Graphs

Libraries & Frameworks



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

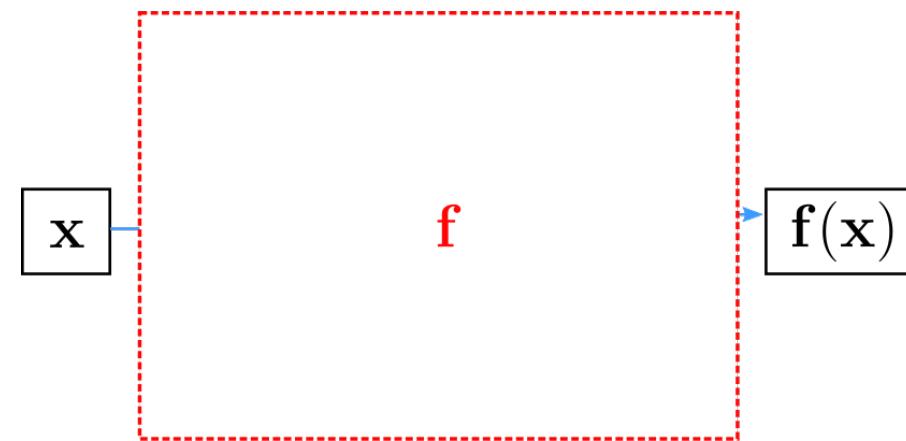
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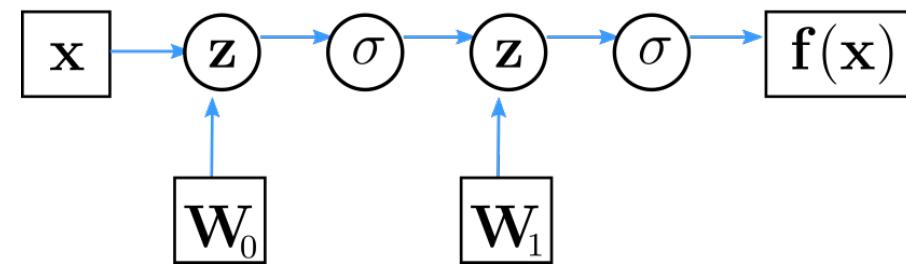
One lab will be dedicated to a short Pytorch introduction.

Computation Graph



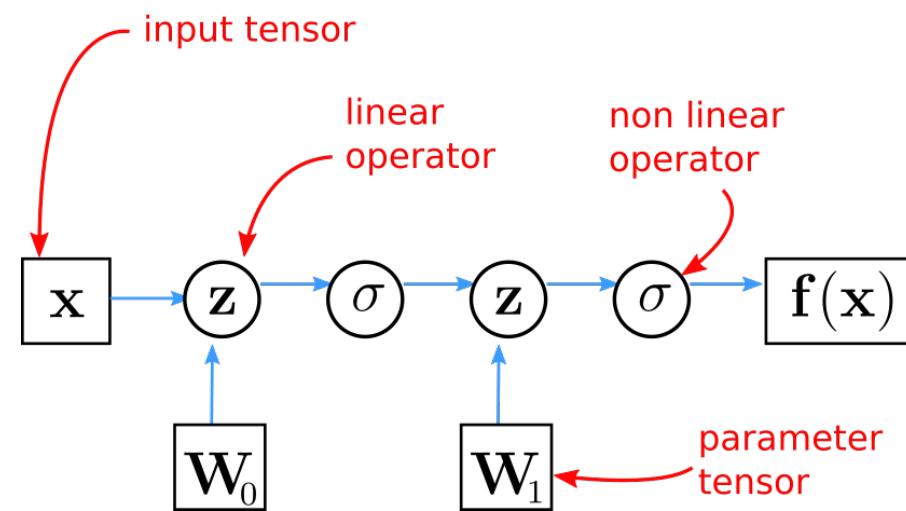
Neural network = parametrized, non-linear function

Computation Graph



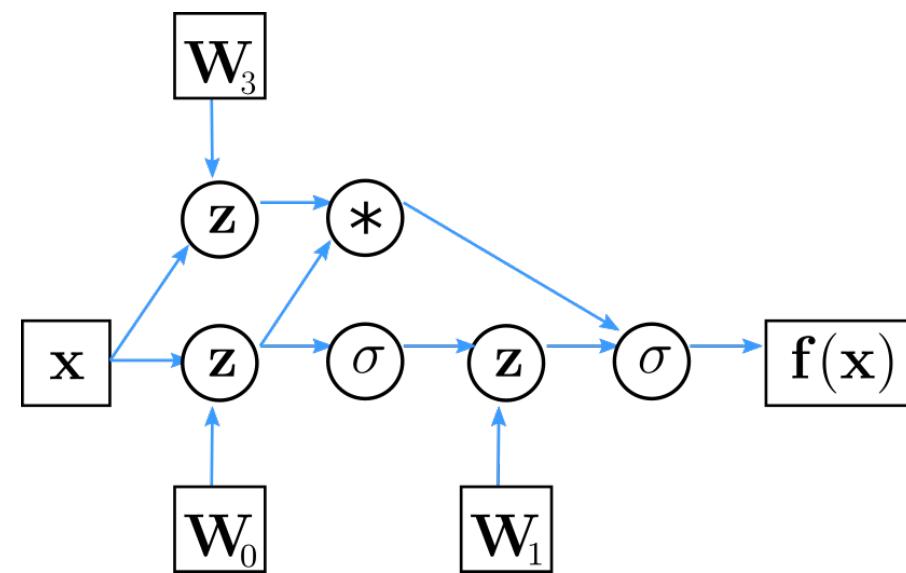
Computation graph: Directed graph of functions, depending on parameters (neuron weights)

Computation Graph



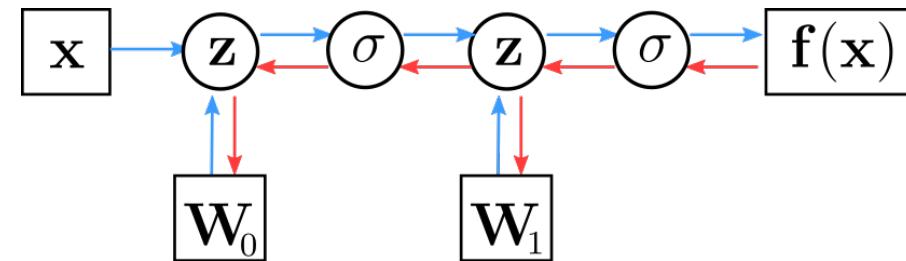
Combination of linear (parametrized) and non-linear functions

Computation Graph



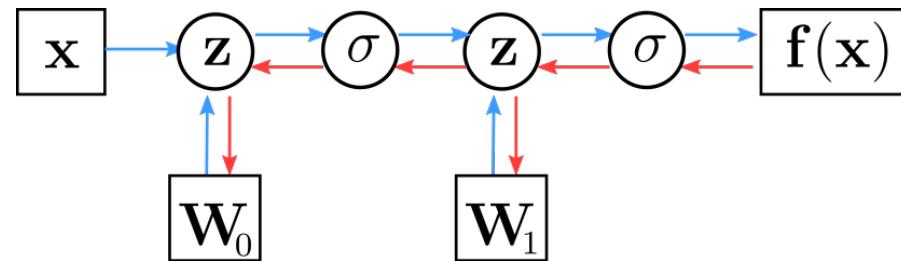
Not only sequential application of functions

Computation Graph



Automatic computation of gradients: all modules are differentiable!

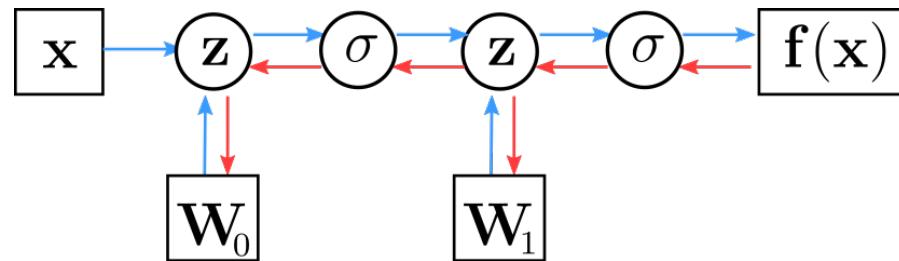
Computation Graph



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Theano (now Aesara), Tensorflow 1, etc. build a static computation graph via static declarations.

Computation Graph

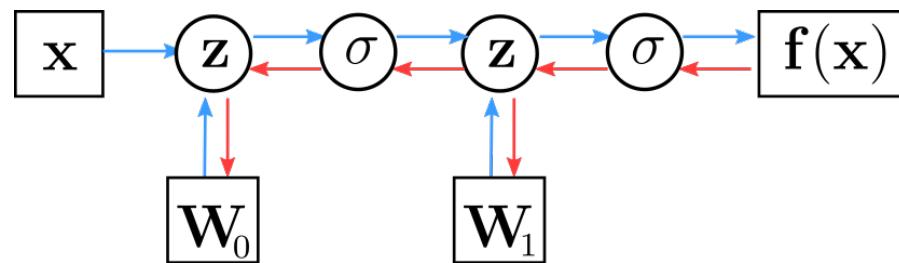


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Tensorflow 2, PyTorch, JAX, etc. rely on dynamic differentiable modules: "define-by-run".

Computation Graph



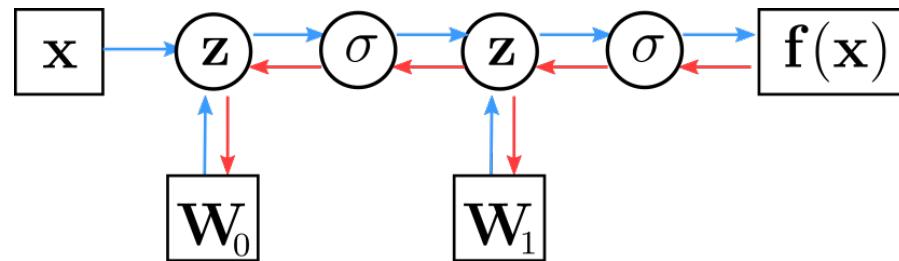
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Tensorflow 2, PyTorch, JAX, etc. rely on dynamic differentiable modules: "define-by-run".

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!