Deep Learning for Developers

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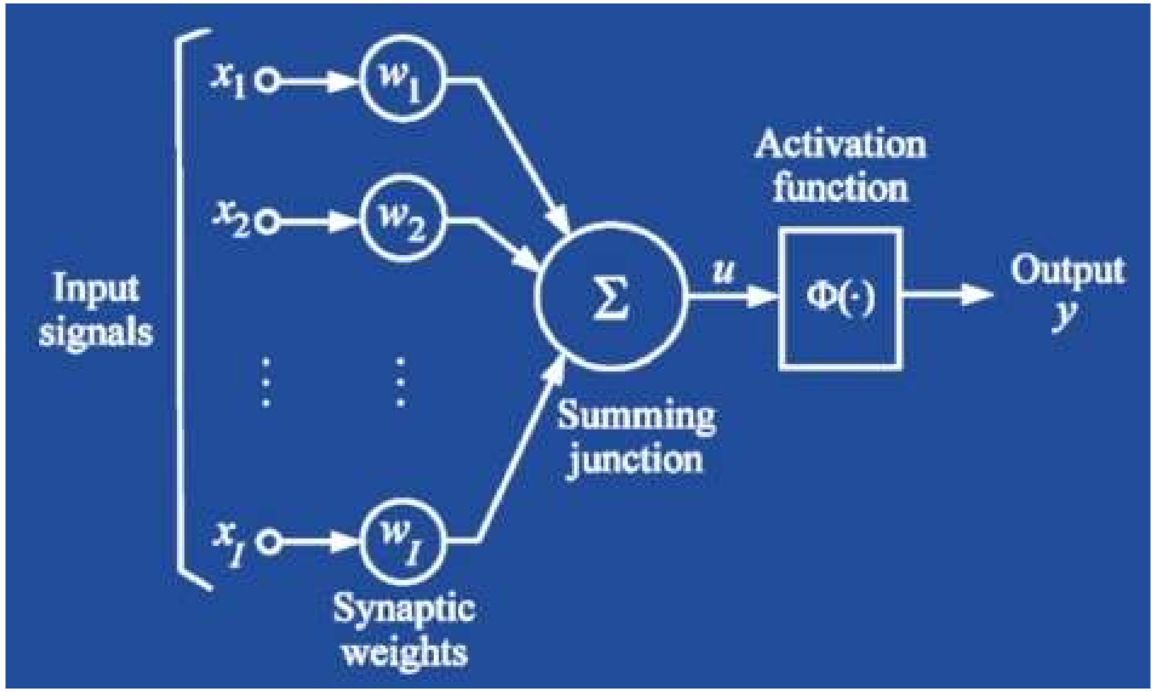
An introduction to Deep Learning

The neuron



$$\sum_{i=1}^{I} x_i * w_i = u$$

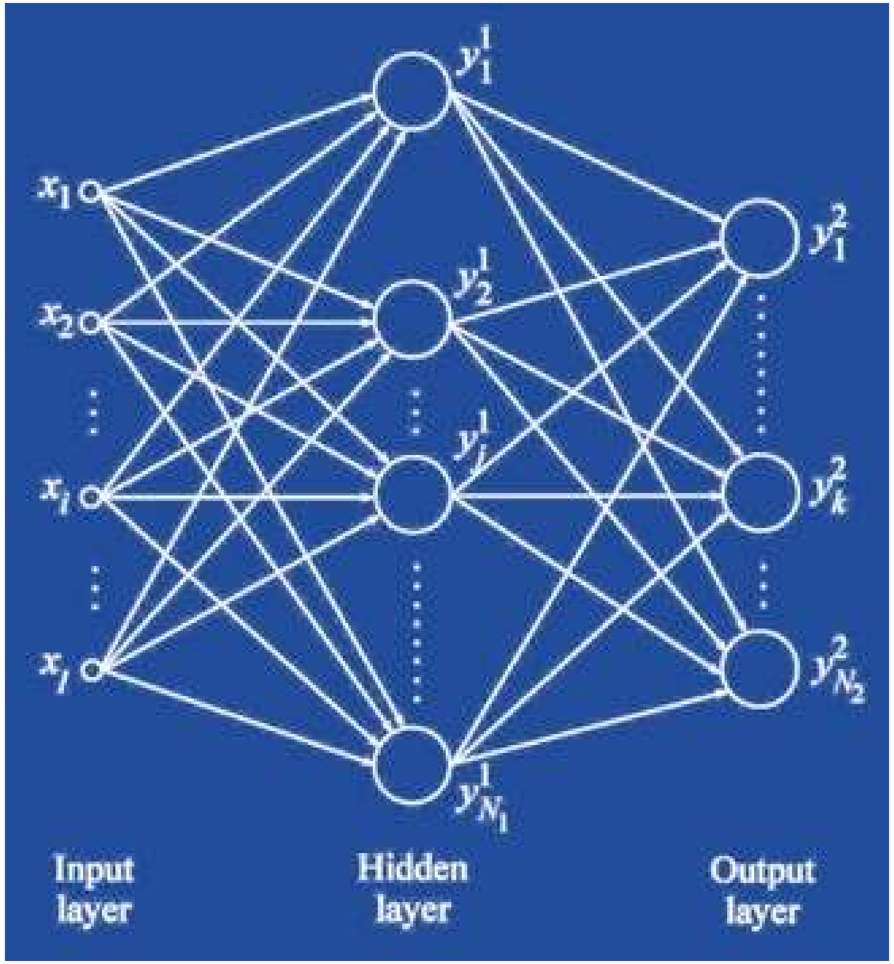
"Multiply and Accumulate"

Activation functions

Name	Plot	Equation
Identity		$f(x) = x$
Binary step		$f(x) = \begin{cases} 0 & \text{for } x < 0 \\ 1 & \text{for } x \geq 0 \end{cases}$
Logistic (a.k.a. Soft step)		$f(x) = \frac{1}{1+e^{-x}}$
TanH		$f(x) = \tanh(x) = \frac{2}{1+e^{-2x}} - 1$
ArcTan		$f(x) = \tan^{-1}(x)$
Softsign [7][8]		$f(x) = \frac{x}{1+\lvert x\rvert}$
Rectified linear unit (ReLU)[9]		$f(x) = \begin{cases} 0 & \text{for } x < 0 \\ x & \text{for } x \geq 0 \end{cases}$

Source: Wikipedia

Neural networks



l features

$$x = \begin{bmatrix} x_{11}, x_{12}, \ldots x_{1l} \\ x_{21}, x_{22}, \ldots x_{2l} \\ \ldots \ldots \ldots \\ x_{m1}, x_{m2}, \ldots x_{ml} \end{bmatrix}$$

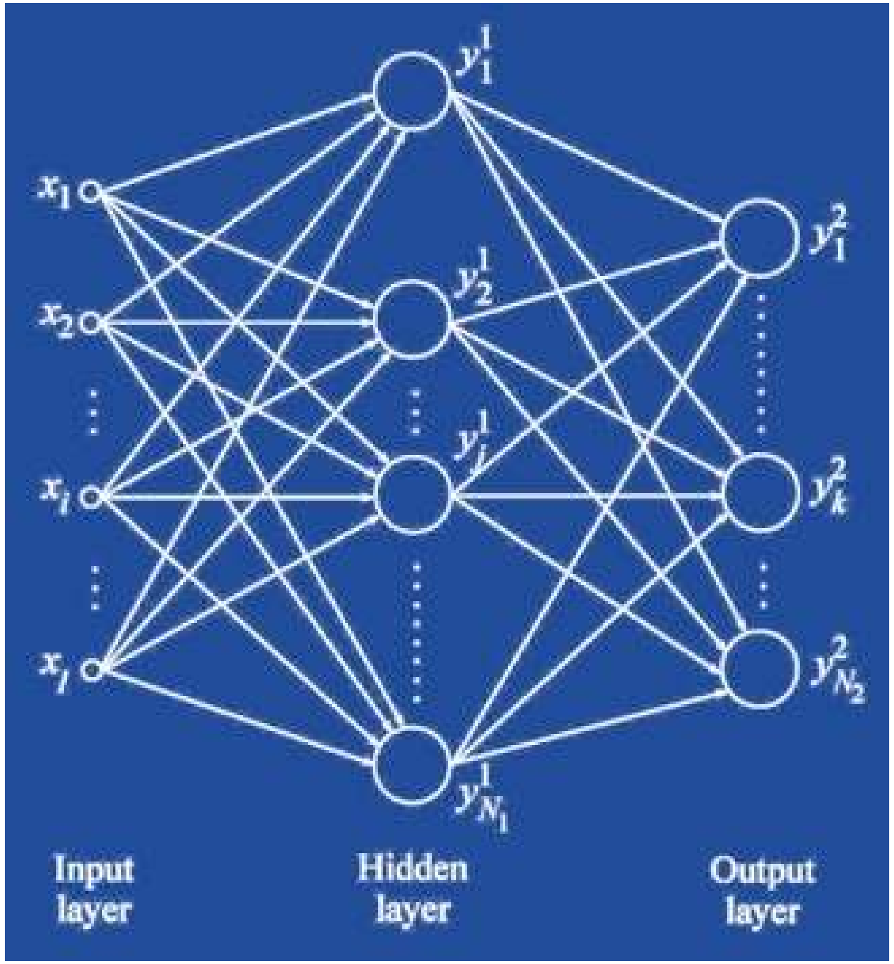
m samples

$$y = \begin{bmatrix} 2 \\ 0 \\ \ldots \\ 4 \end{bmatrix} \quad \begin{bmatrix} 0,0,1,0,0,\ldots,0 \\ 1,0,0,0,0,\ldots,0 \\ \ldots \\ 0,0,0,0,1,\ldots,0 \end{bmatrix}$$

One-hot encoding

m labels,
N_2 categories

Neural networks



l features

x =

$x_{11,}$ x … x_{1l}
$x_{21,}$ x … x_{2l}
… …
$x_{m1,}$ x …

$x_{11}, x_{12}, \ldots, x_{1l}$

m samples

y =

2
0
…
4

0,0,1, …,0
1,0,0, …,0
…
0,0,0, …,0

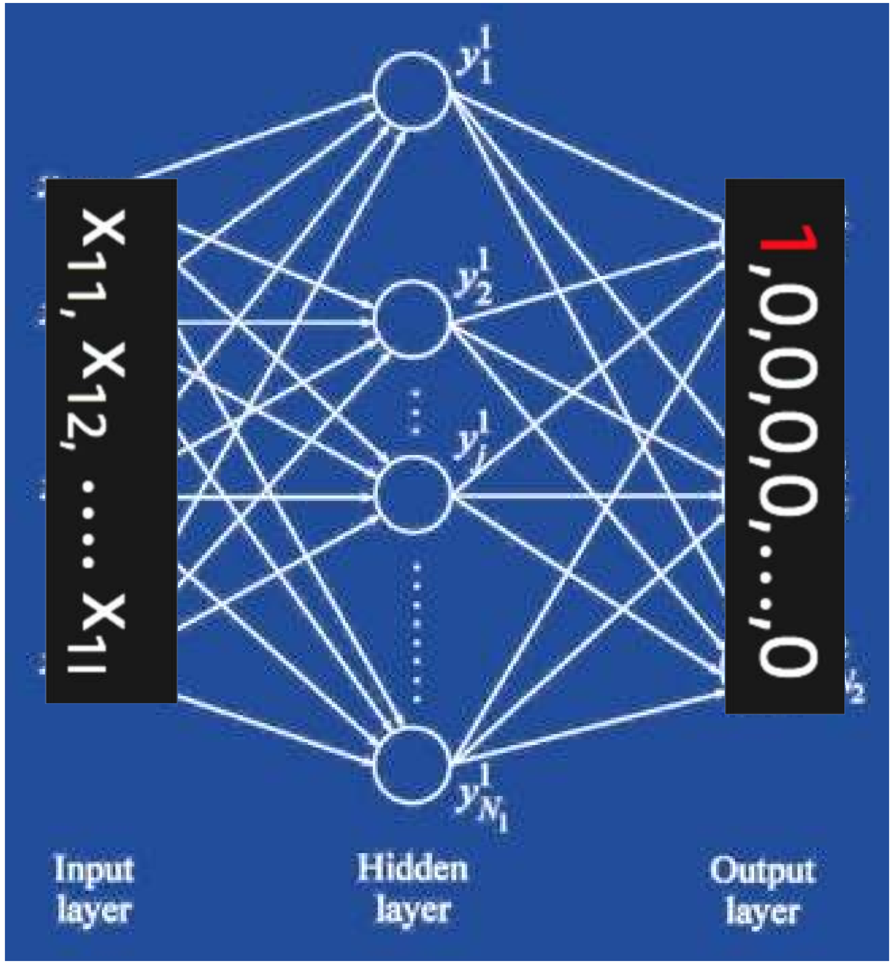
0,0,1,0,0,…,0

One-hot encoding

m labels,
N_2 categories

$$\text{Accuracy} = \frac{\text{Number of correct predictions}}{\text{Total number of predictions}}$$

Neural networks



Initially, the network will not predict correctly

`f(X1) = Y'1` — $f(X_1) = Y'_1$

A loss function measures the difference between the real label Y_1 and the predicted label Y'_1

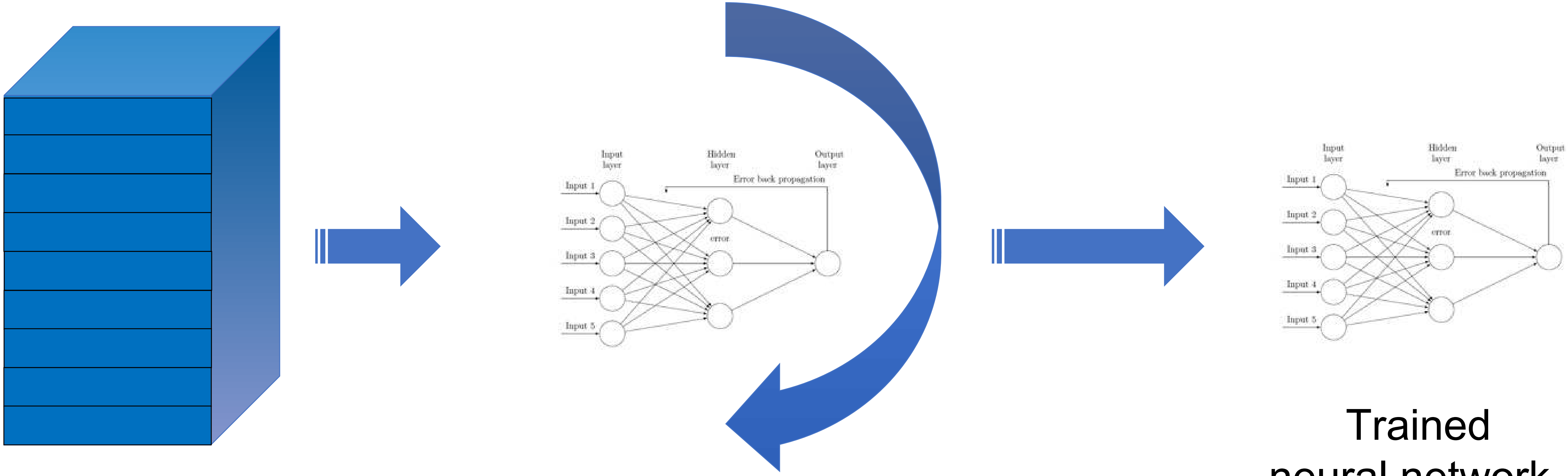
$error = loss(Y_1, Y'_1)$

For a batch of samples:

$$\sum_{i=1}^{batch\ size} loss(Y_i, Y'_i) = \text{batch error}$$

The purpose of the training process is to minimize loss by gradually adjusting weights

Training



Training data set

Backpropagation

Trained neural network

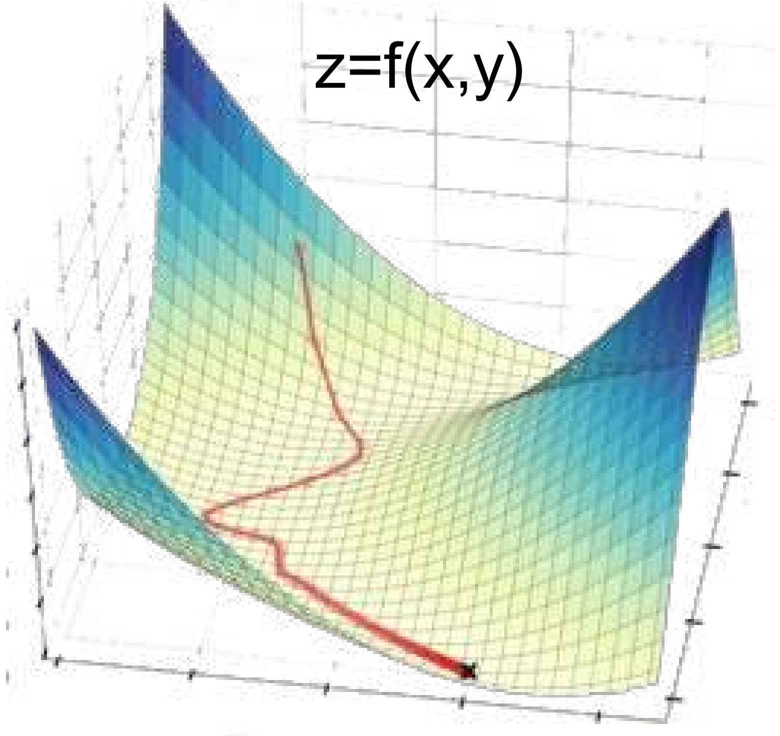
Batch size
Learning rate
Number of epochs

Hyper parameters

Stochastic Gradient Descent (SGD)

Imagine you stand on top of a mountain with skis strapped to your feet. You want to get down to the valley as quickly as possible, but there is fog and you can only see your immediate surroundings. How can you get down the mountain as quickly as possible? You look around and identify the steepest path down, go down that path for a bit, again look around and find the new steepest path, go down that path, and repeat—this is exactly what gradient descent does.

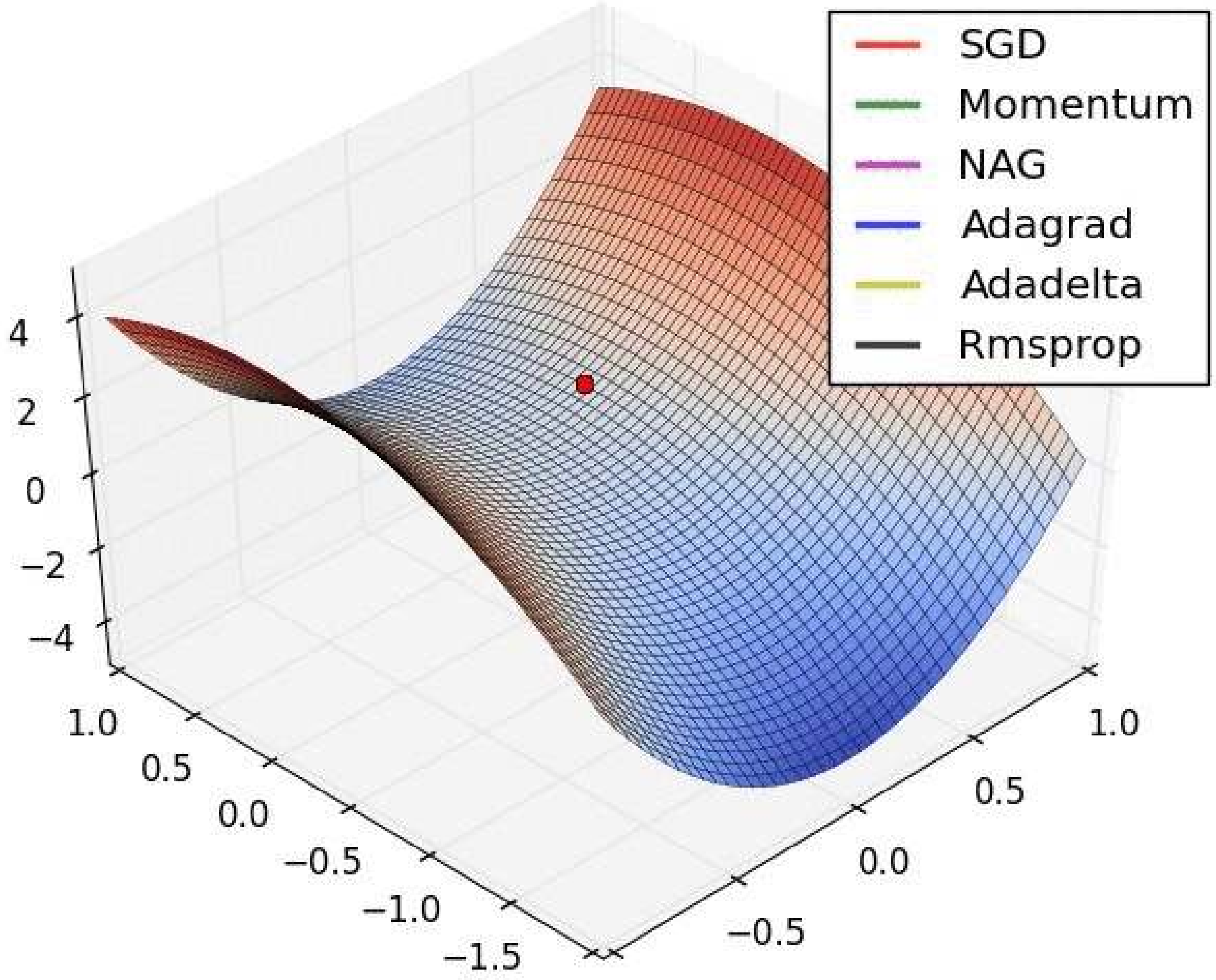
Tim Dettmers
University of Lugano
2015



The « step size » is called the learning rate

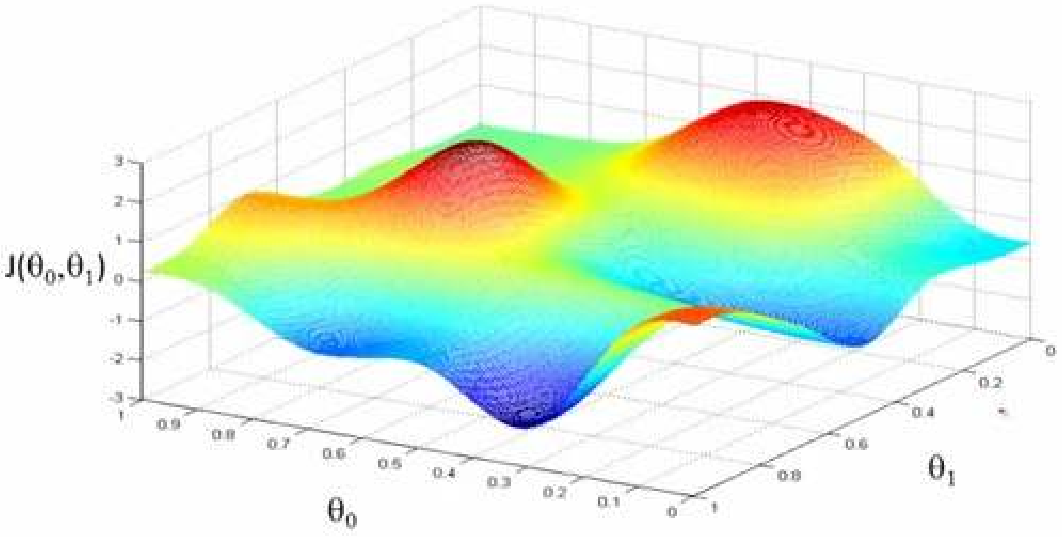
https://devblogs.nvidia.com/parallelforall/deep-learning-nutshell-history-training/

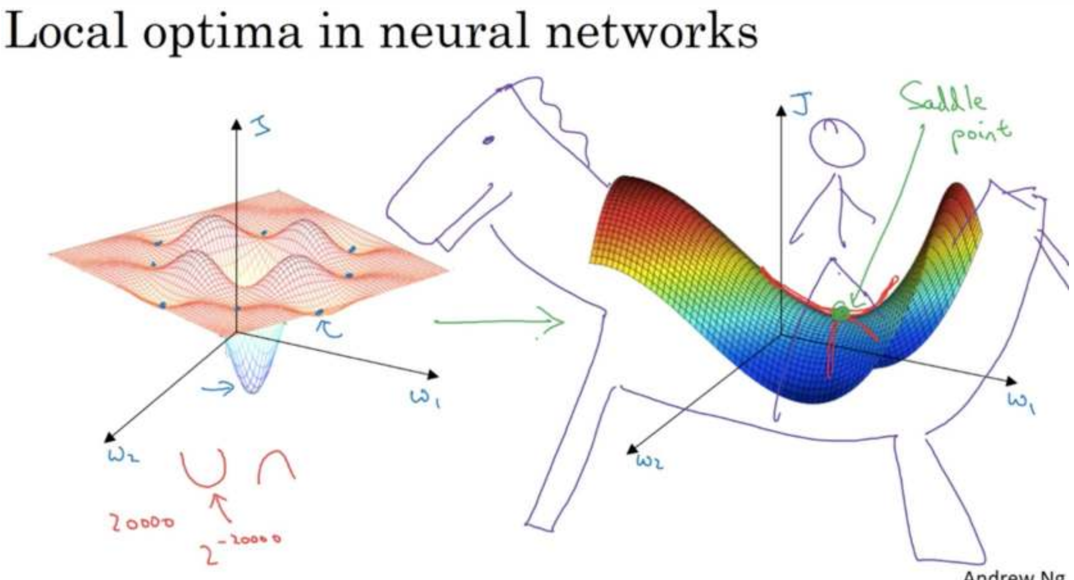
Optimizers



https://medium.cim/@julsimon/tumbling-down-the-sgd-rabbit-hole-part-1-740fa402f0d7

Local minima and saddle points

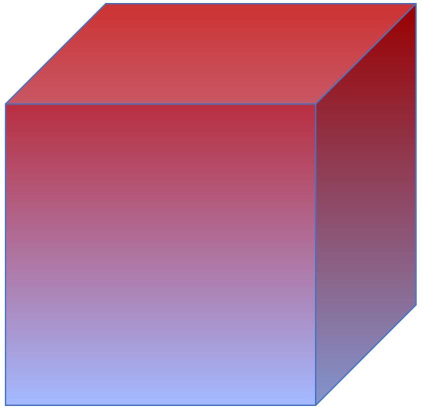




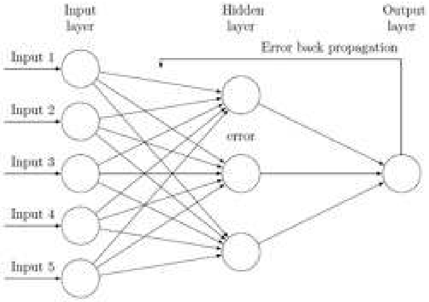
« *Do neural networks enter and escape a series of local minima? Do they move at varying speed as they approach and then pass a variety of saddle points? Answering these questions definitively is difficult, but we present evidence strongly suggesting that the answer to all of these questions is no.* »

« Qualitatively characterizing neural network optimization problems », Goodfellow et al, 2015
https://arxiv.org/abs/1412.6544

Validation



Validation data set

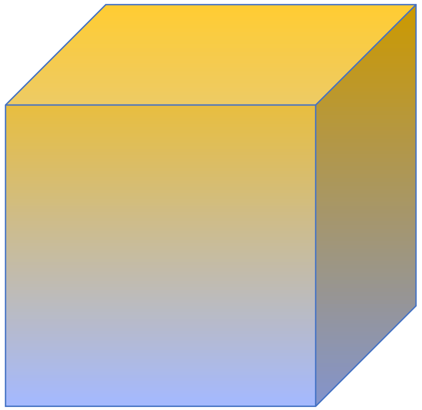


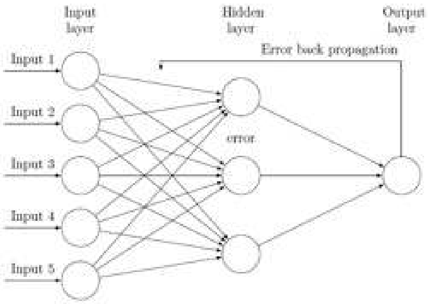
Trained neural network

Prediction at the end of each epoch

Validation accuracy

Test





Test accuracy

Test data set

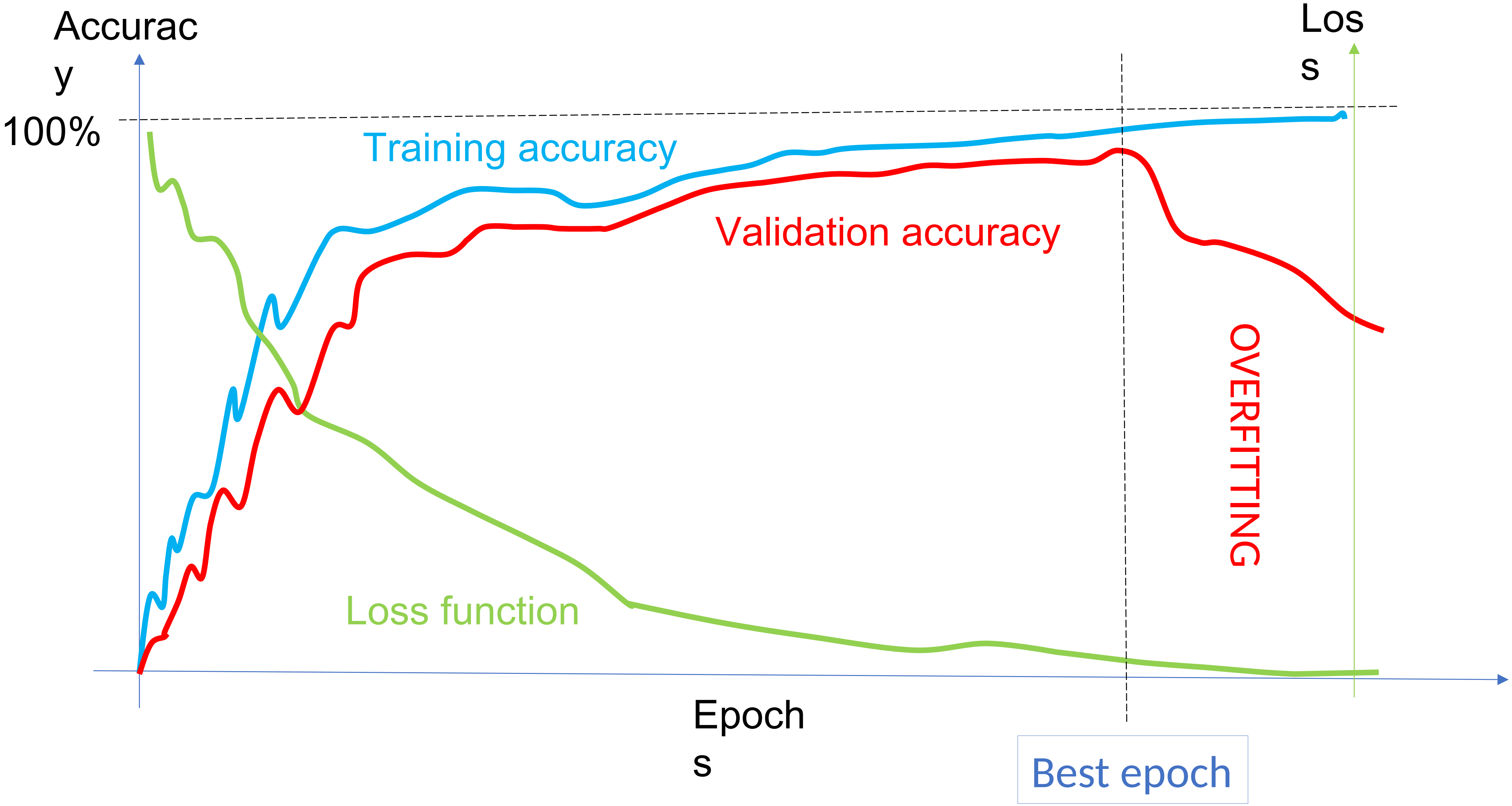
Fully trained neural network

Prediction at the end of experimentation

<u>This data set must have the same distribution as real-life samples, or else test accuracy won't reflect real-life accuracy.</u>

Early stopping

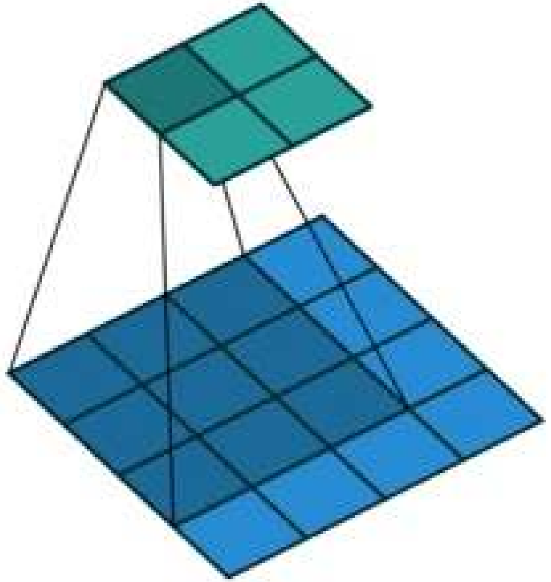
« *Deep Learning ultimately is about finding a minimum that generalizes well, with bonus points for finding one fast and reliably* », Sebastian Ruder

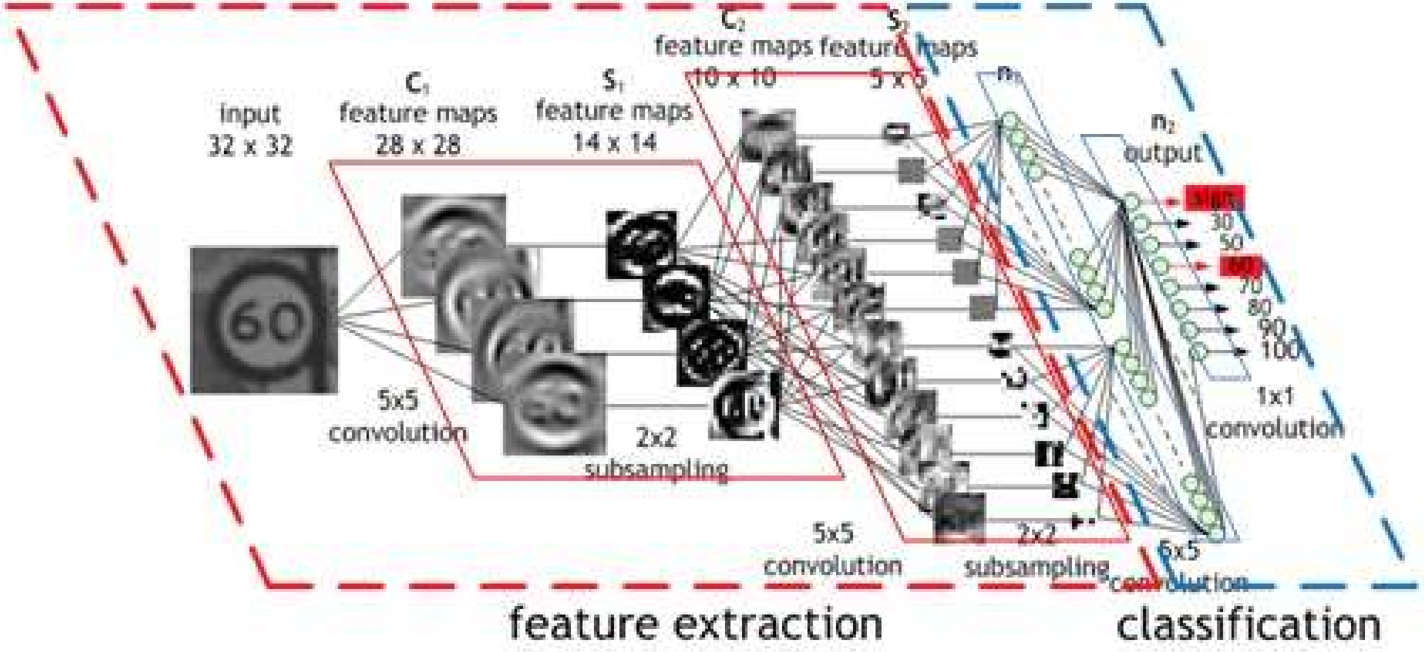


Demo: fully connected network

Convolutional Neural Networks (CNN)

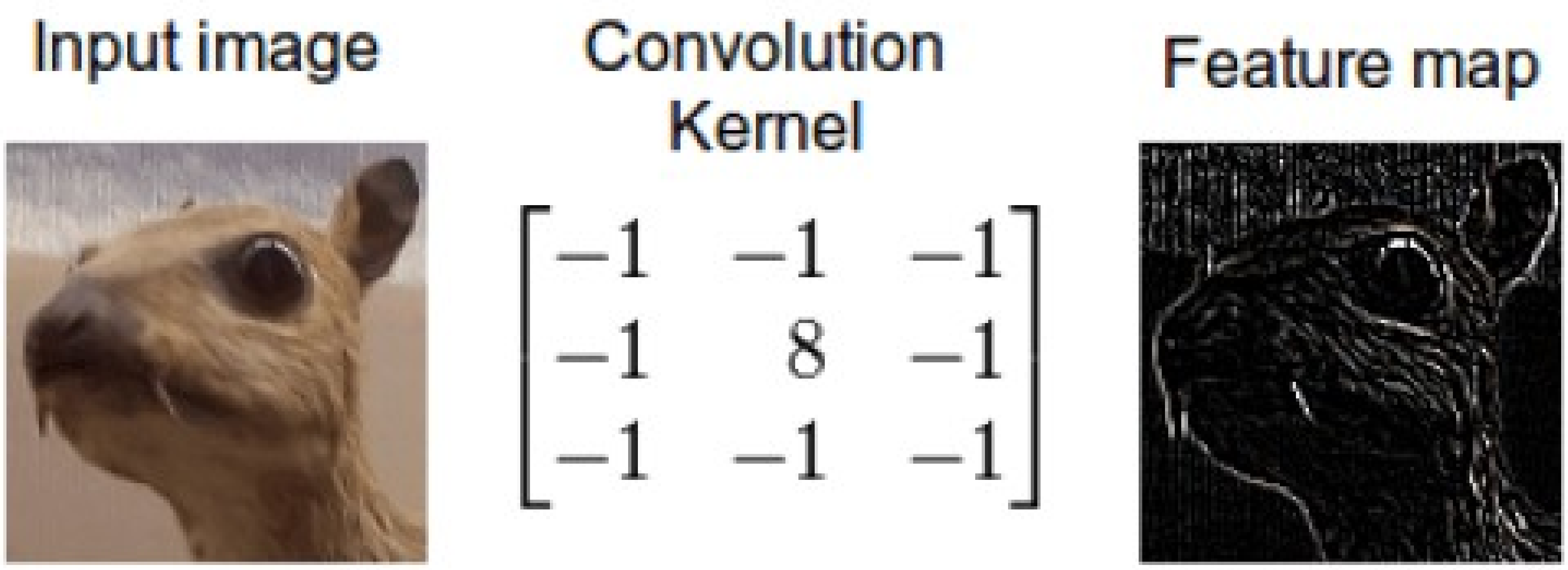
Le Cun, 1998: handwritten digit recognition, 32x32 pixels





https://devblogs.nvidia.com/parallelforall/deep-learning-nutshell-core-concepts/

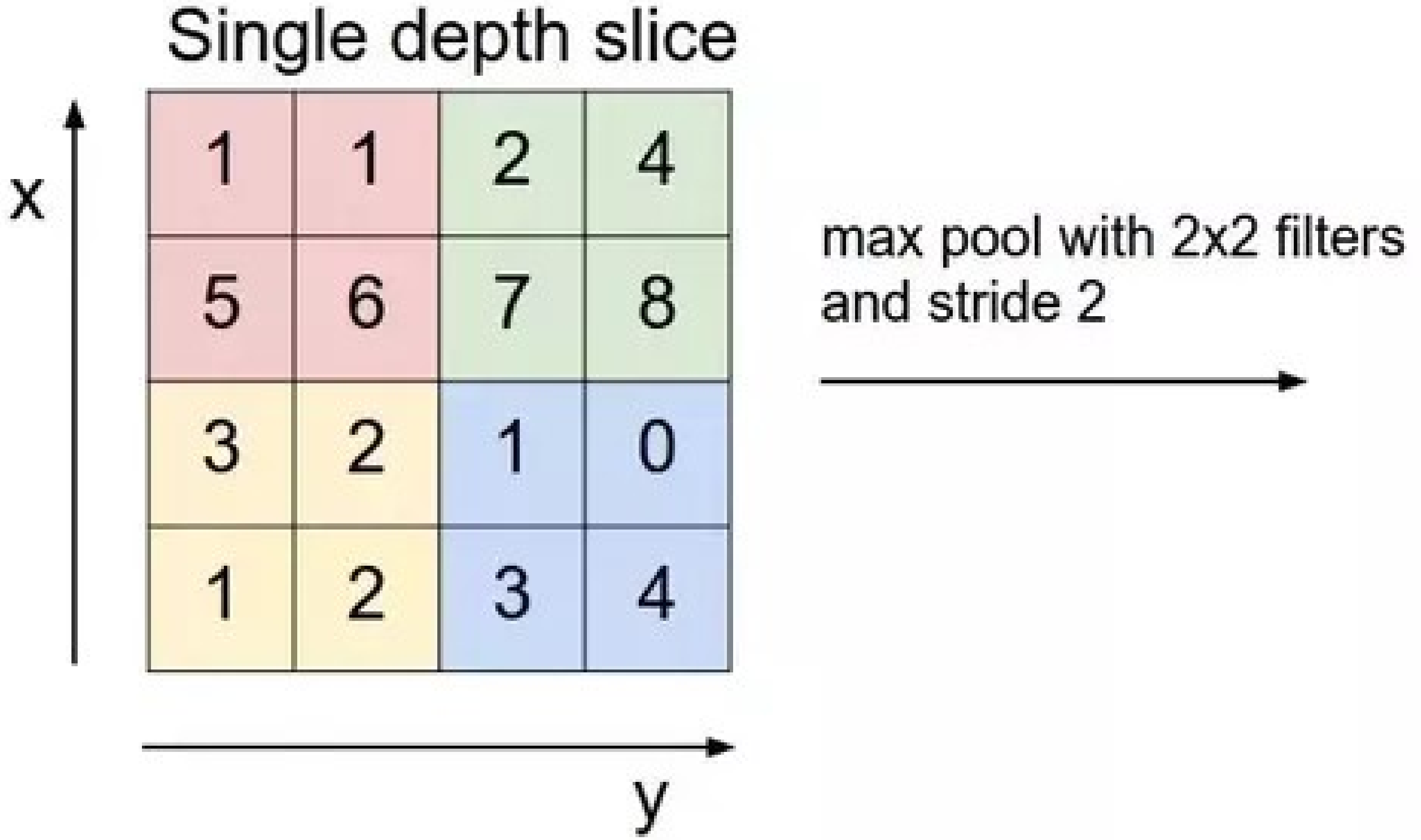
Extracting features with convolution



Source: http://timdettmers.com

Convolution extracts features automatically.
Kernel parameters are learned during the training process.

Downsampling images with pooling



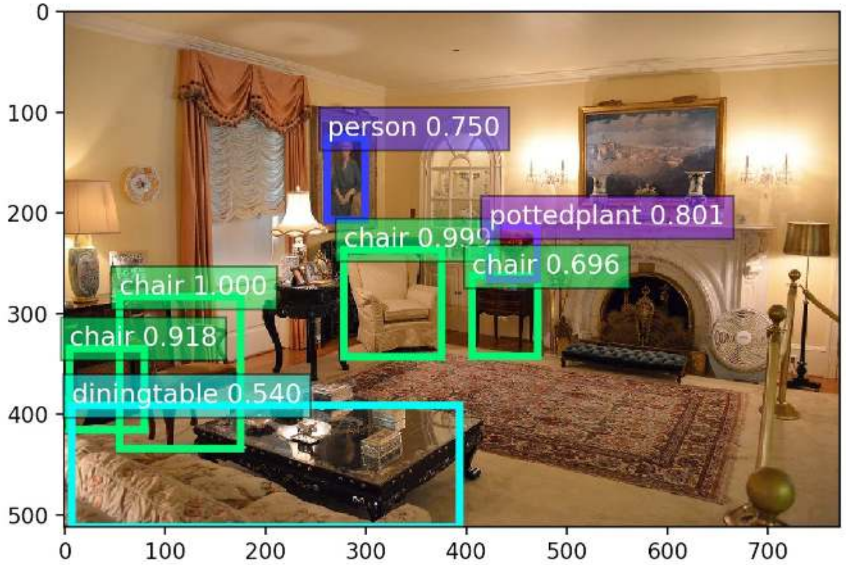
Source: Stanford University

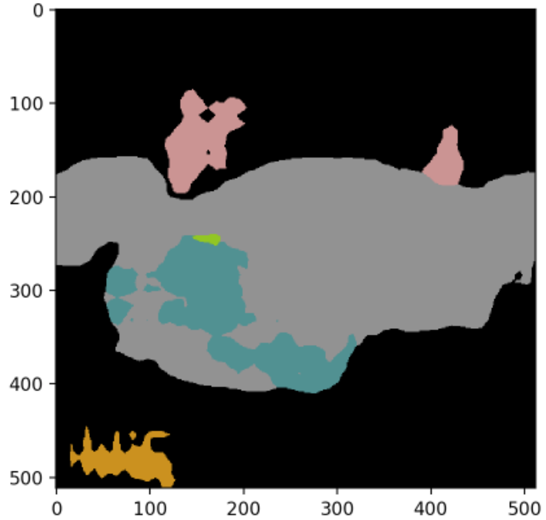
Pooling shrinks images while preserving significant information.

Gluon CV: classification, detection, segmentation

MXNet

[electric_guitar],
with probability 0.671



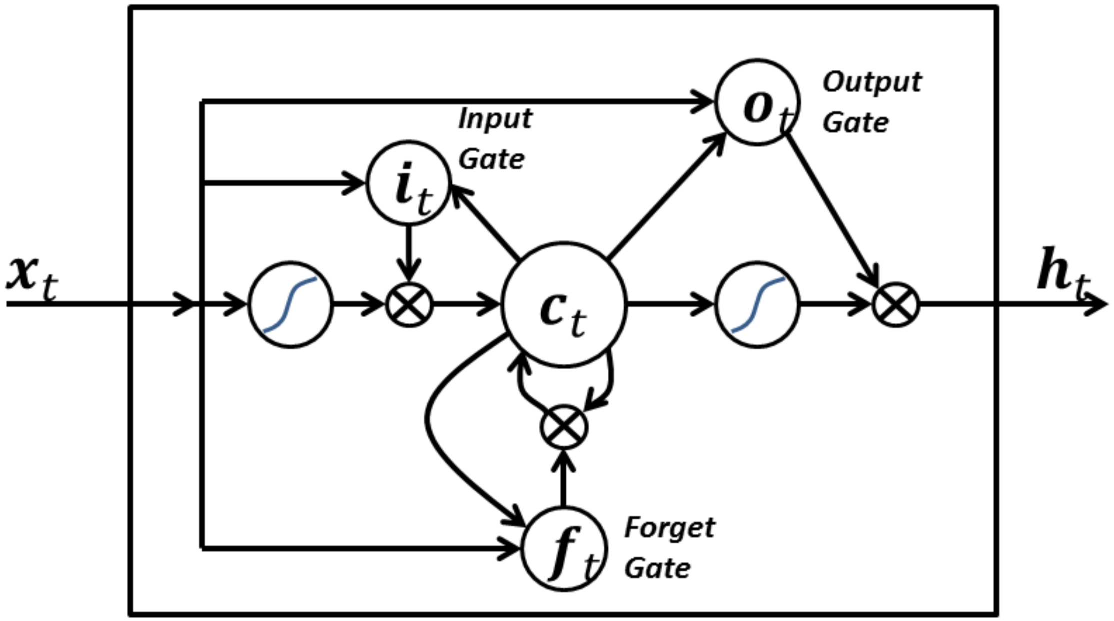


https://github.com/dmlc/gluon-cv

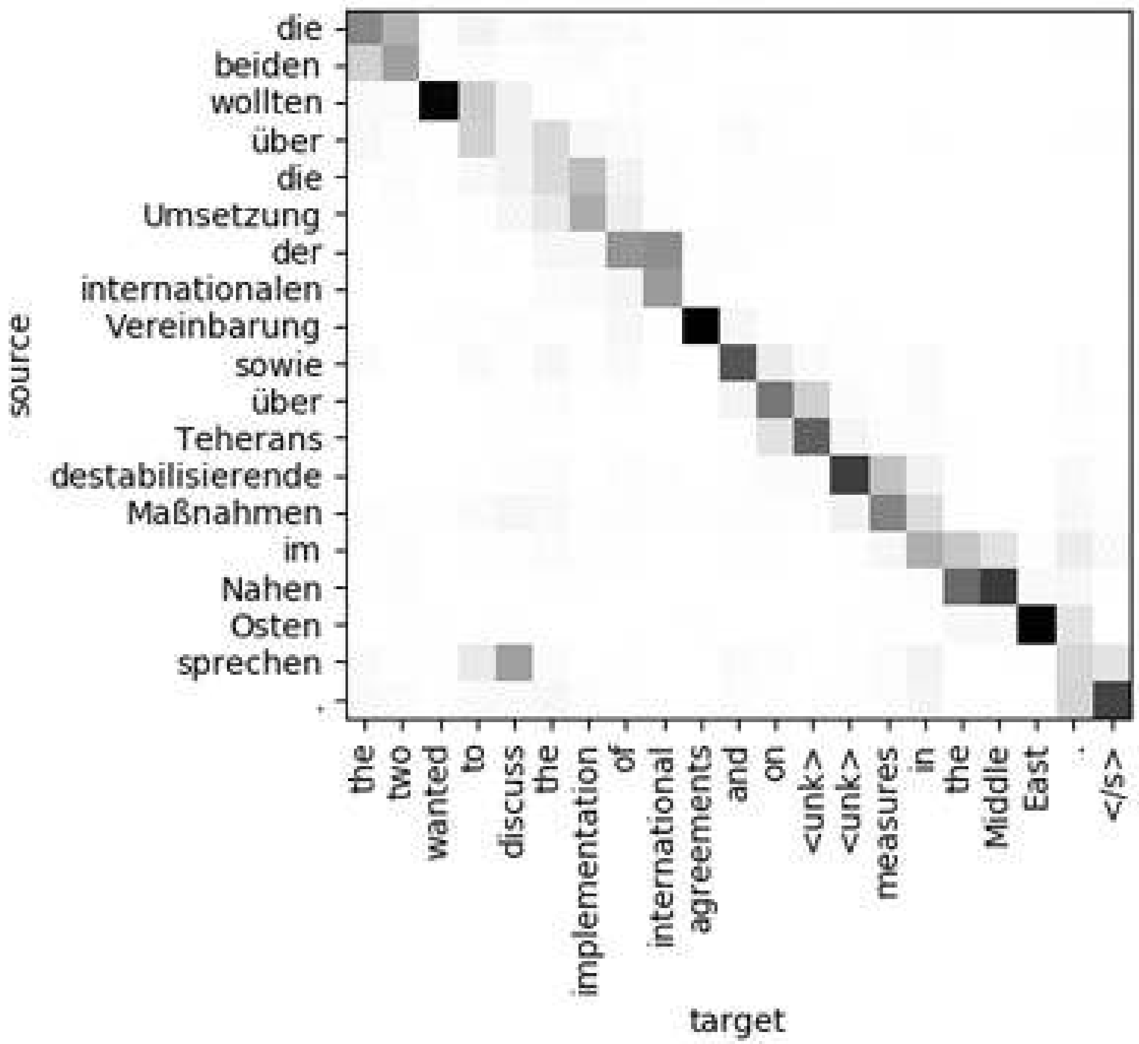
Demo: convolutional network

Long Short Term Memory Networks (LSTM)

- A LSTM neuron computes the output based on the input and a previous state
- LSTM networks have memory
- They're great at predicting sequences, e.g. machine translation



Machine Translation



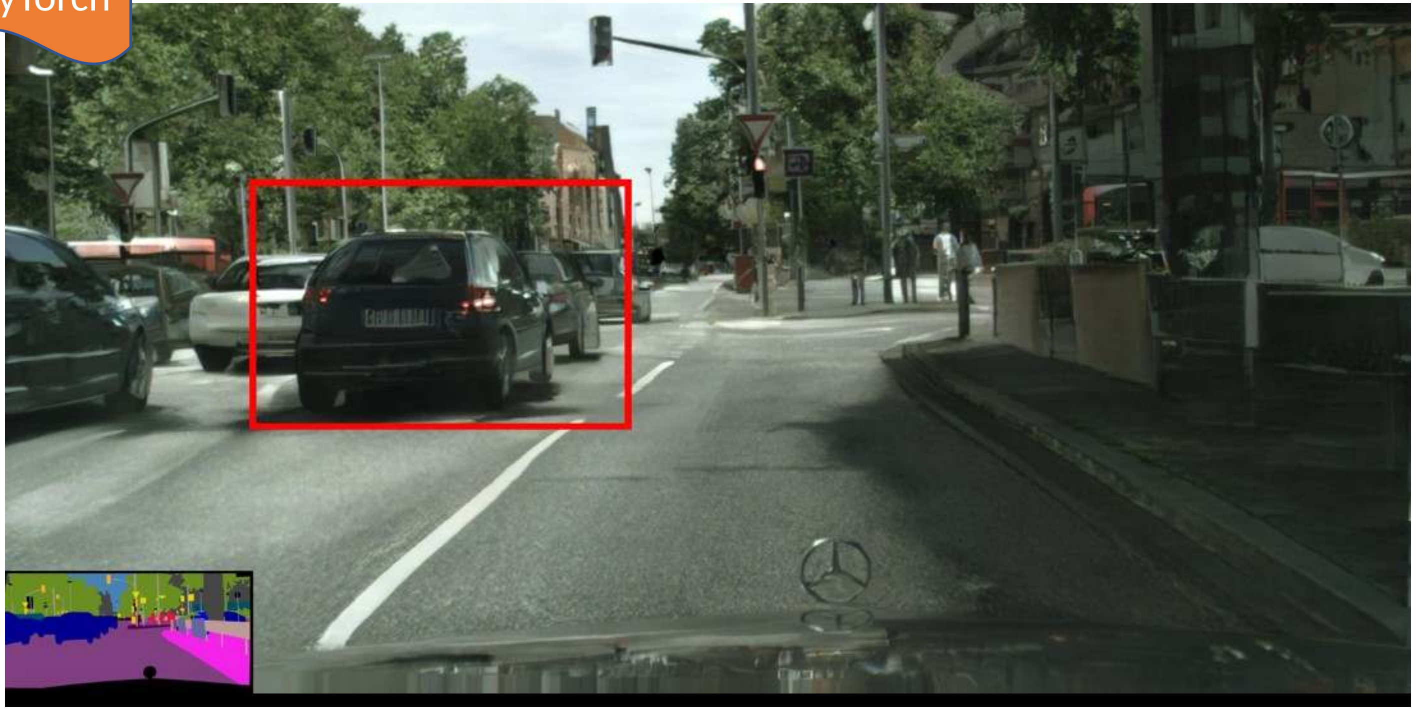
https://github.com/awslabs/sockeye

GAN: Welcome to the (un)real world, Neo

TF

Generating new ”celebrity” faces https://github.com/tkarras/progressive_growing_of_gans

PyTorch



From semantic map to 2048x1024 picture https://tcwang0509.github.io/pix2pixHD/

Scalable training on AWS

Amazon SageMaker

Pre-built notebooks for common problems

Built-in, high-performance algorithms

Build

One-click training

Hyperparameter optimization

Train

One-click deployment

Fully managed hosting with auto-scaling

Deploy

AWS Deep Learning AMI

TensorFlow

K

Microsoft CNTK

mxnet

GLUON

PYTORCH

Chainer

Caffe2

torch

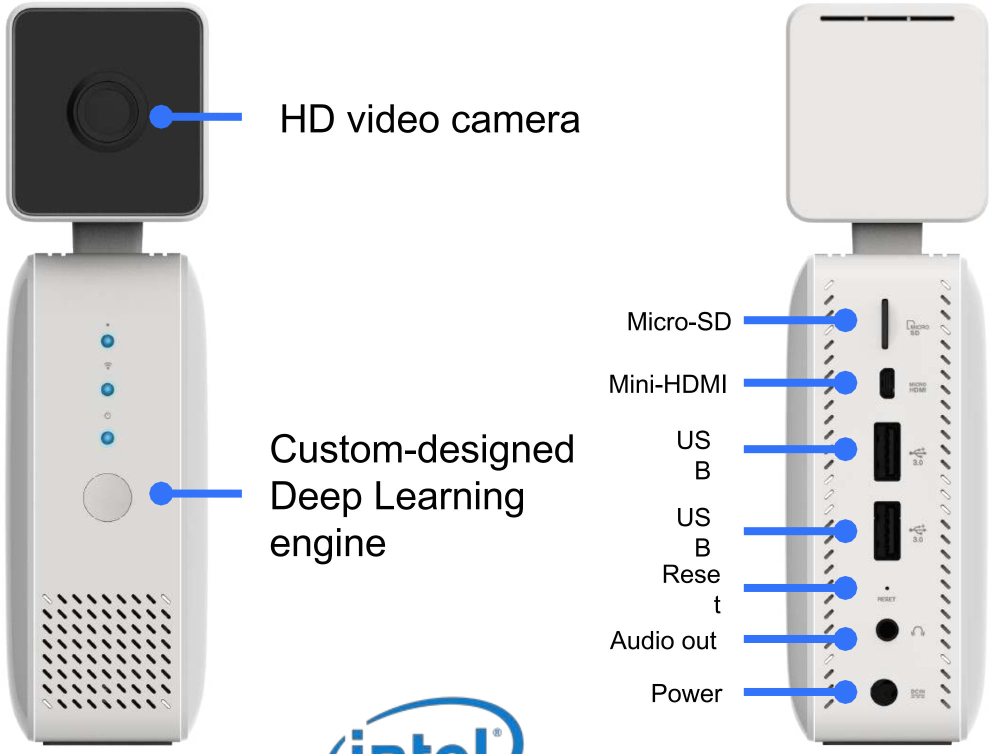
Amazon EC2

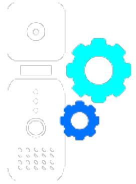
c5

p3

AWS DeepLens

The world's first Deep Learning-enabled video camera for developers

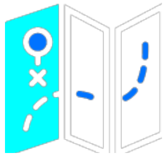




HD video camera with on-board compute optimized for Deep Learning

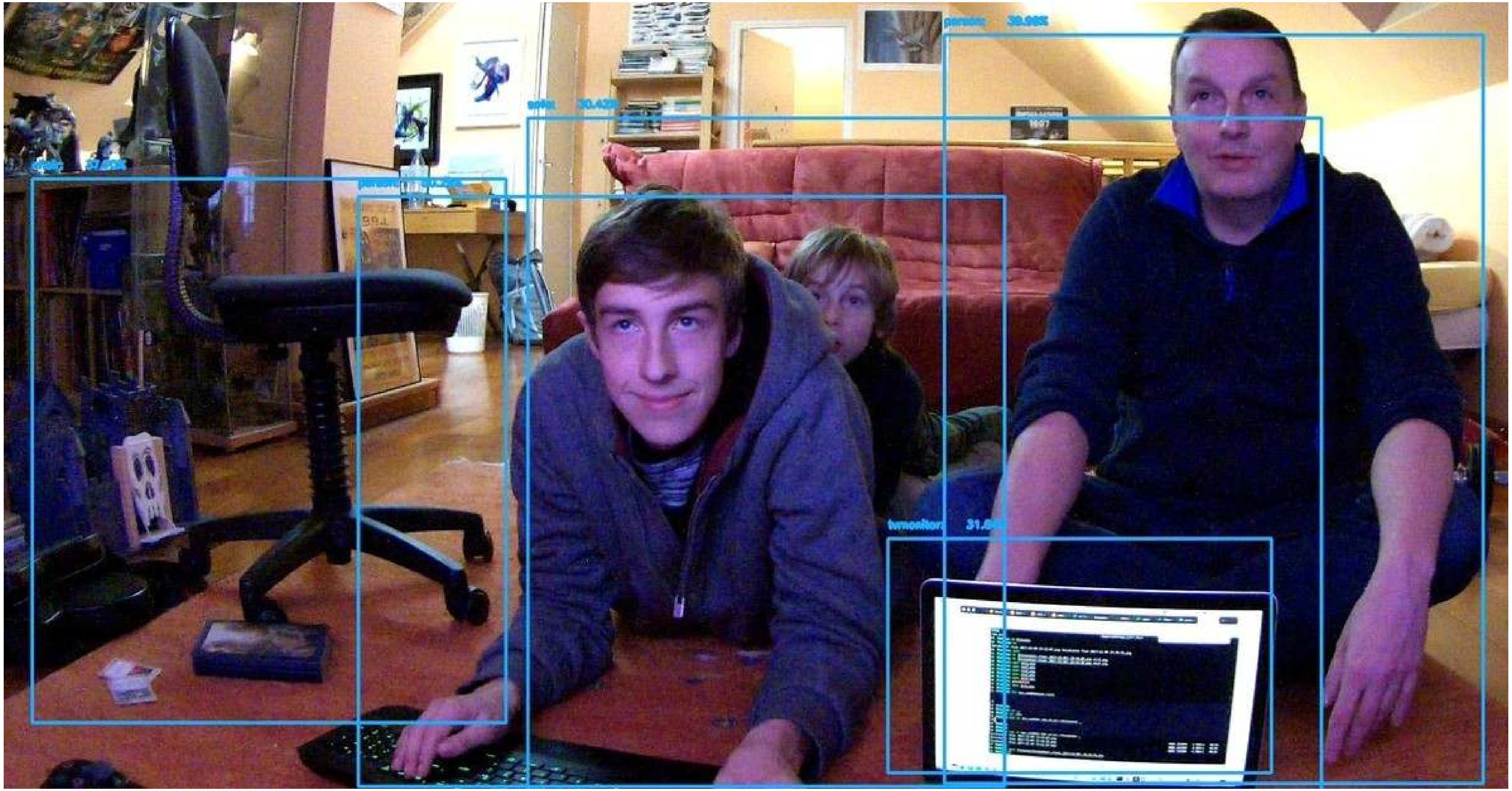
Integrates with Amazon SageMaker and AWS Lambda

From unboxing to prediction in <10 minutes



Tutorials, examples, demos, and pre-built models

Object detection with AWS DeepLens



Getting started

https://aws.amazon.com/machine-learning | https://aws.amazon.com/blogs/ai

https://mxnet.incubator.apache.org | https://github.com/apache/incubator-mxnet

https://gluon.mxnet.io | https://github.com/gluon-api

https://aws.amazon.com/sagemaker

https://github.com/awslabs/amazon-sagemaker-examples

https://github.com/aws/sagemaker-python-sdk | https://github.com/aws/sagemaker-spark

https://medium.com/@julsimon

https://youtube.com/juliensimonfr

https://gitlab.com/juliensimon/dlnotebooks

Thank you!

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