Deep Learning (with TensorFlow 2)

Jon Krohn, Ph.D.

#ODSC Open Data Science Conference
April 15th, 2020

`jonkrohn.com/talks`

`github.com/jonkrohn/tf2`

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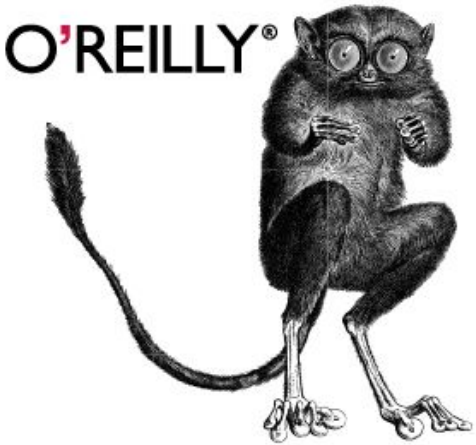
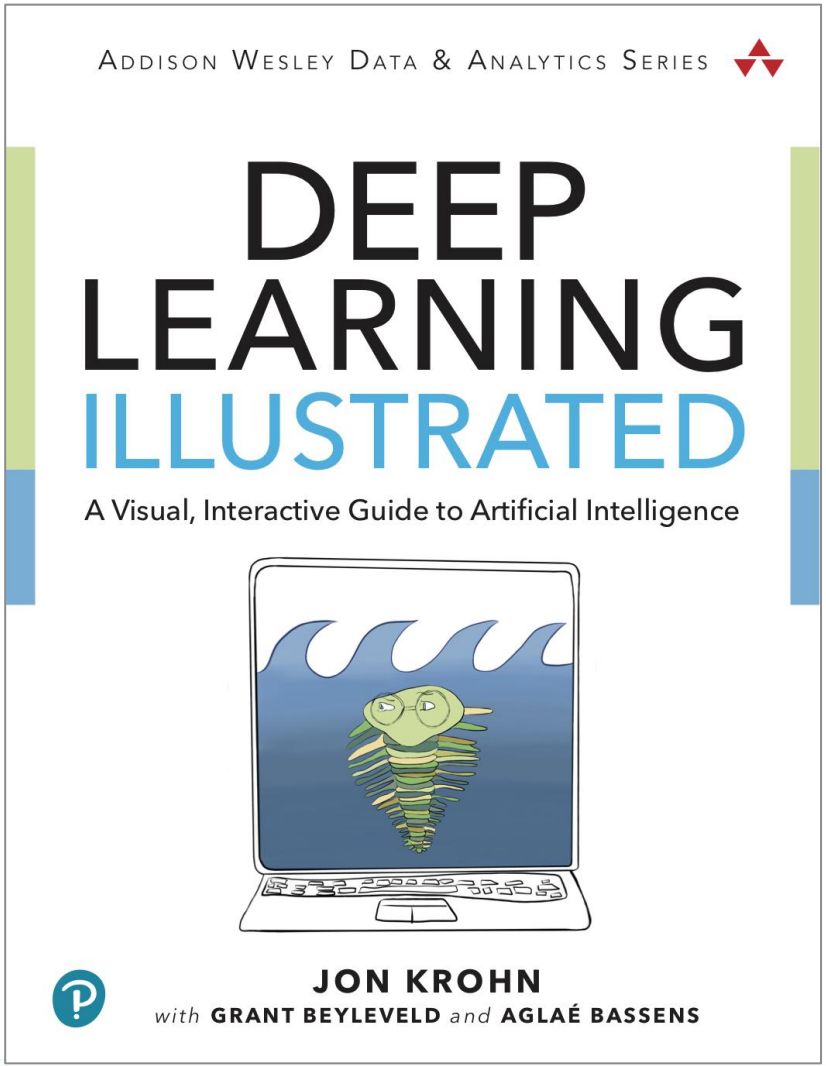


Pearson



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What are you?

- Developer / Engineer
- Scientist / Analyst / Statistician / Mathematician
- Combination of the Above
- Other

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What's your level of experience with the topic?

- Little to no exposure to deep learning
- Some deep learning theory
- Deep learning theory + experience with a deep learning library
- Deep learning theory + experience with TensorFlow/Keras

Deep Learning Fundamentals

1. The Unreasonable Effectiveness of Deep Learning
2. Essential Deep Learning Theory
3. Deep Learning with TensorFlow 2

Deep Learning Fundamentals

Part 1:

The Unreasonable Effectiveness of Deep Learning

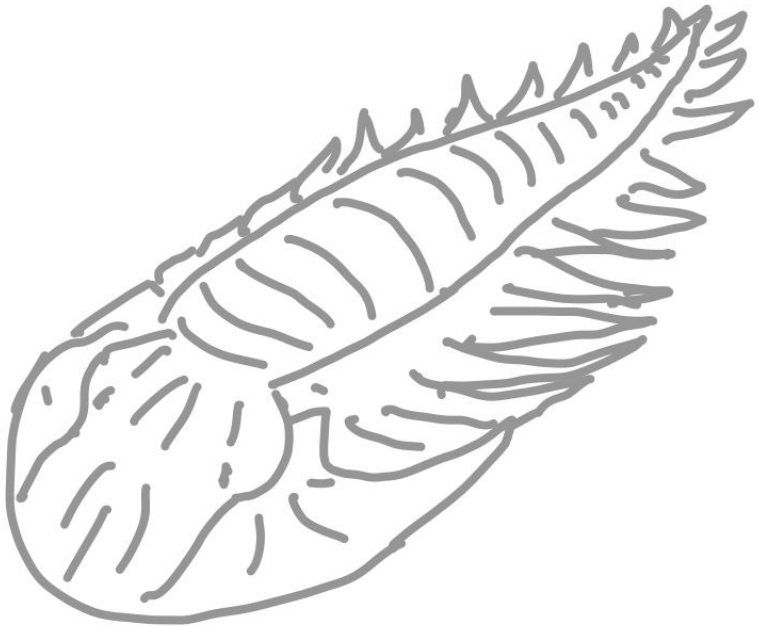
- Intro to Neural Networks and Deep Learning
- Deep Learning Families
- Deep Learning Libraries

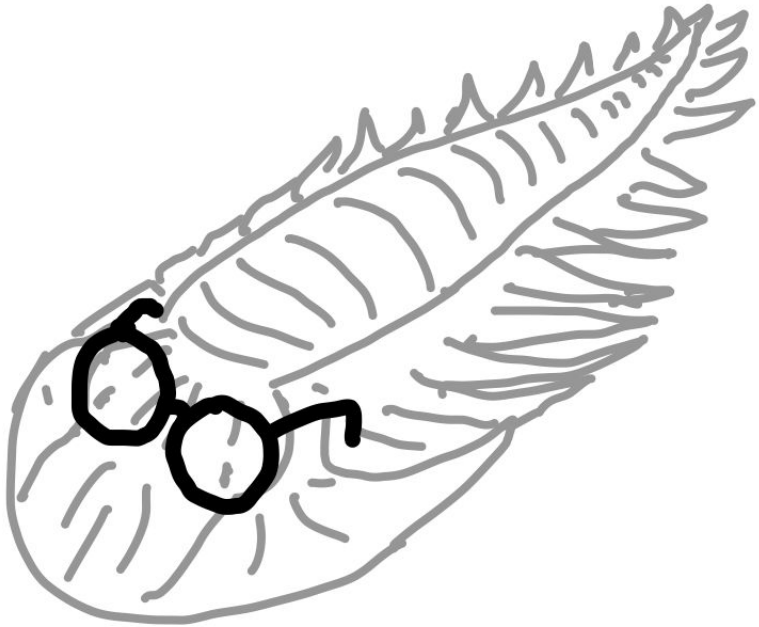
Deep Learning Fundamentals

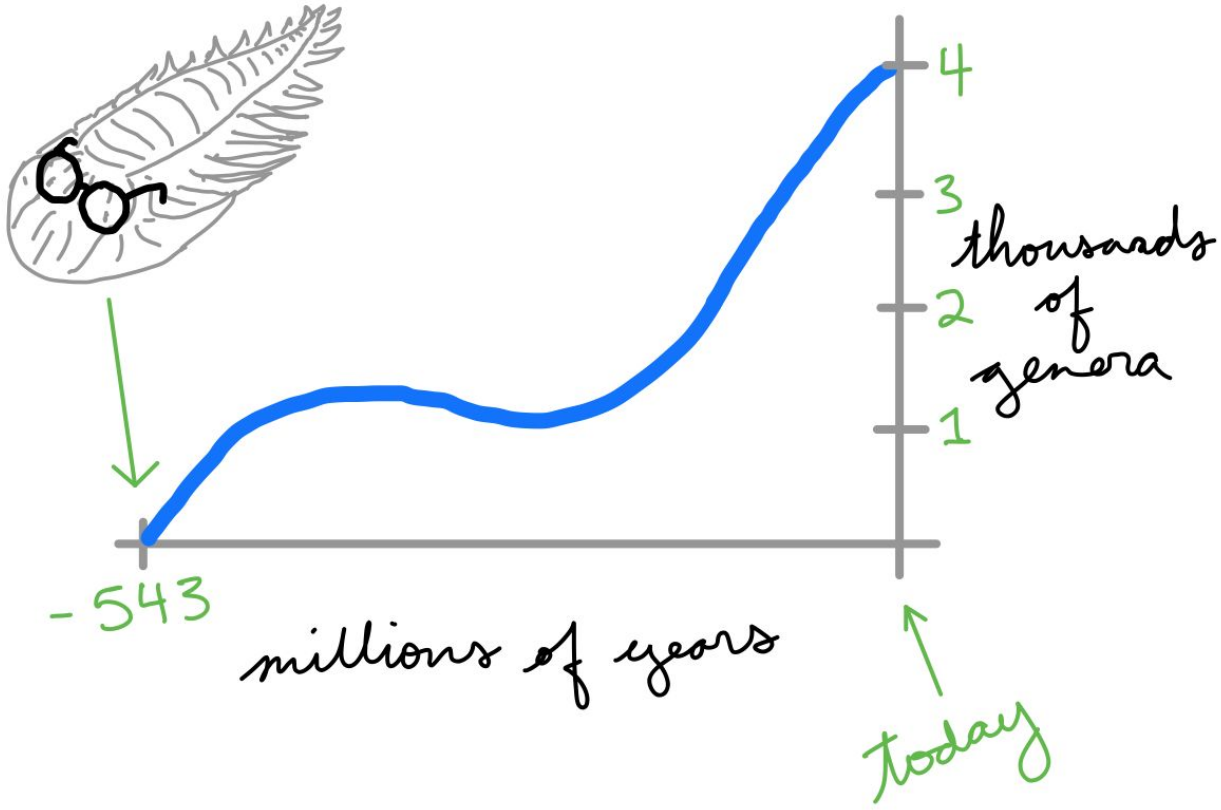
Part 1:

The Unreasonable Effectiveness of Deep Learning

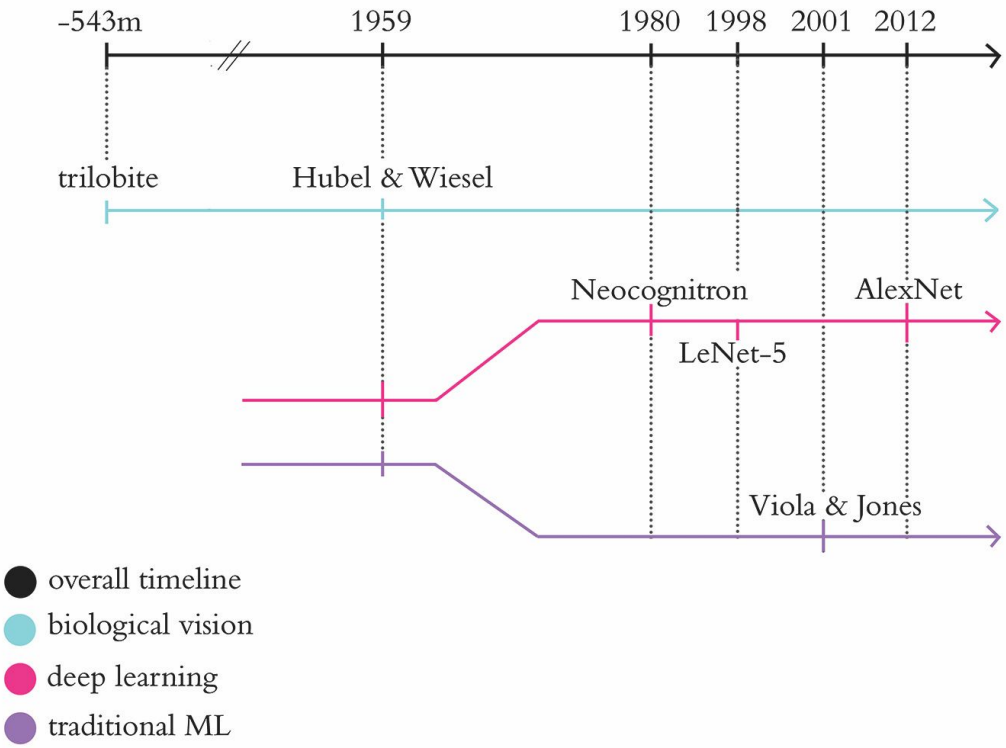
- **Intro to Neural Networks and Deep Learning** *(Chapter 1)*
- Deep Learning Families
- Deep Learning Libraries

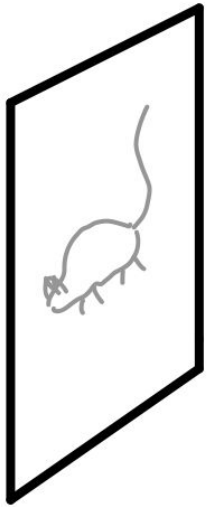


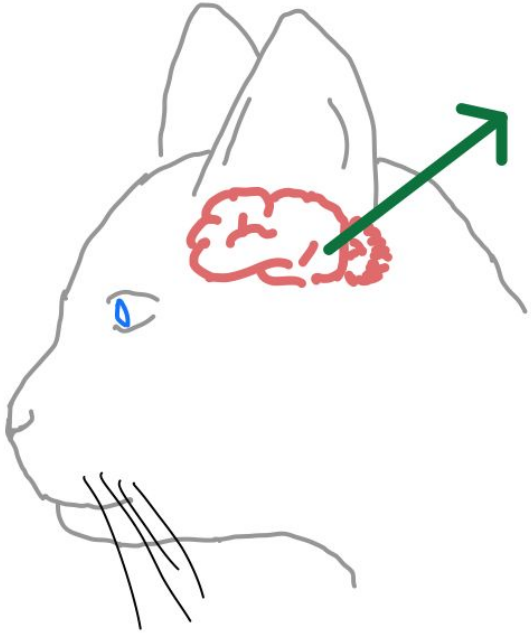


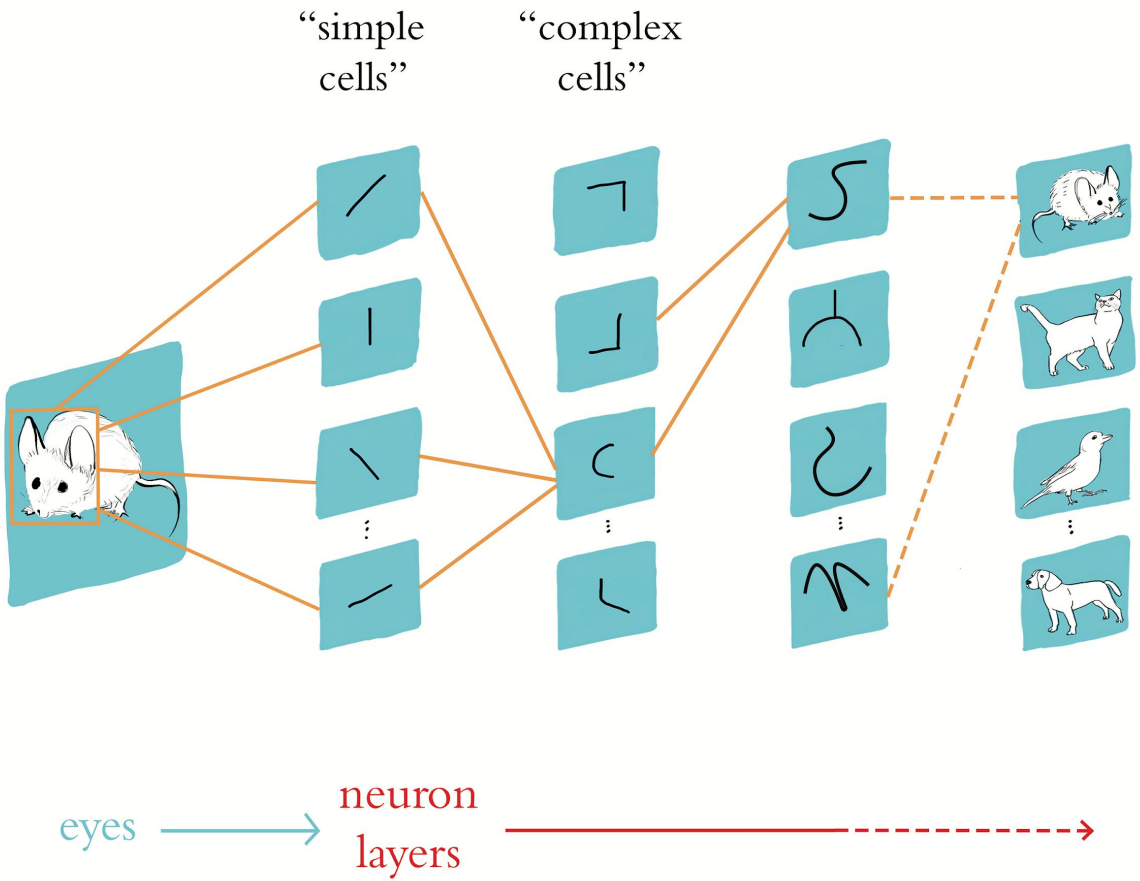


Case Study: The History of Vision









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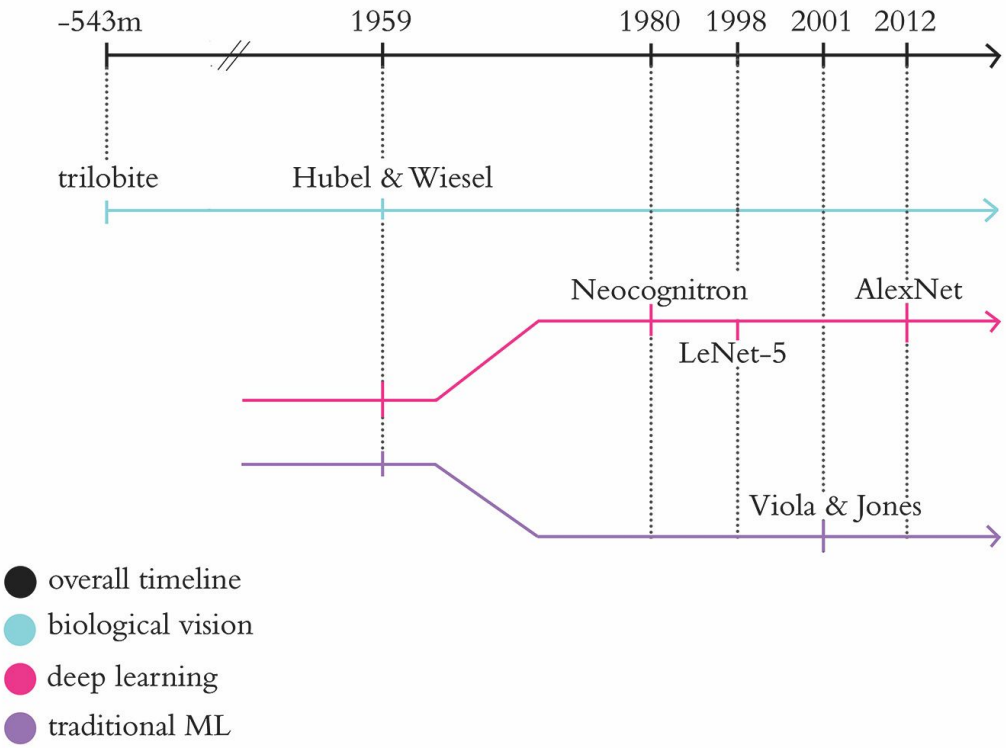


Neocognitron (Fukushima, 1980)

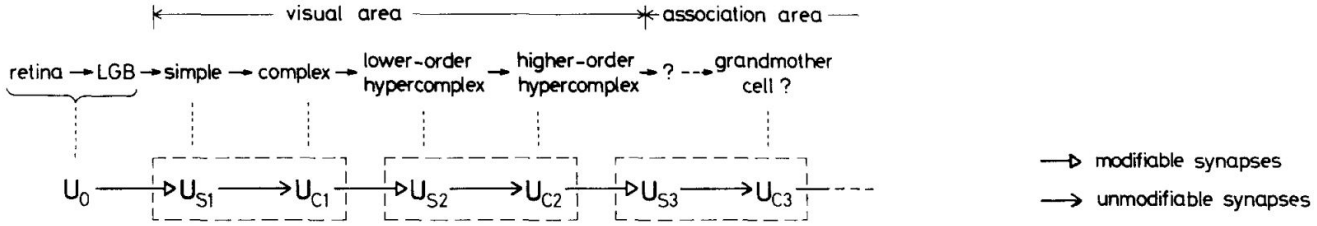


Fig. 1. Correspondence between the hierarchy model by Hubel and Wiesel, and the neural network of the neocognitron

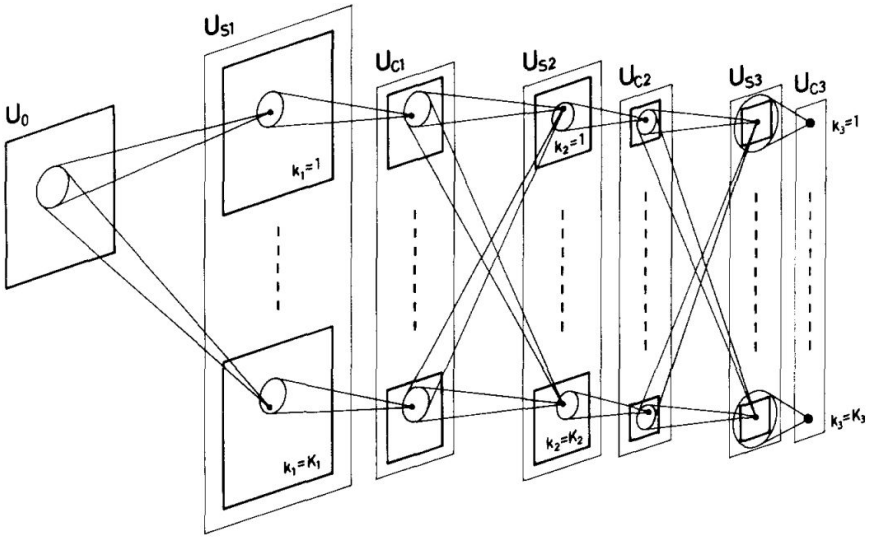
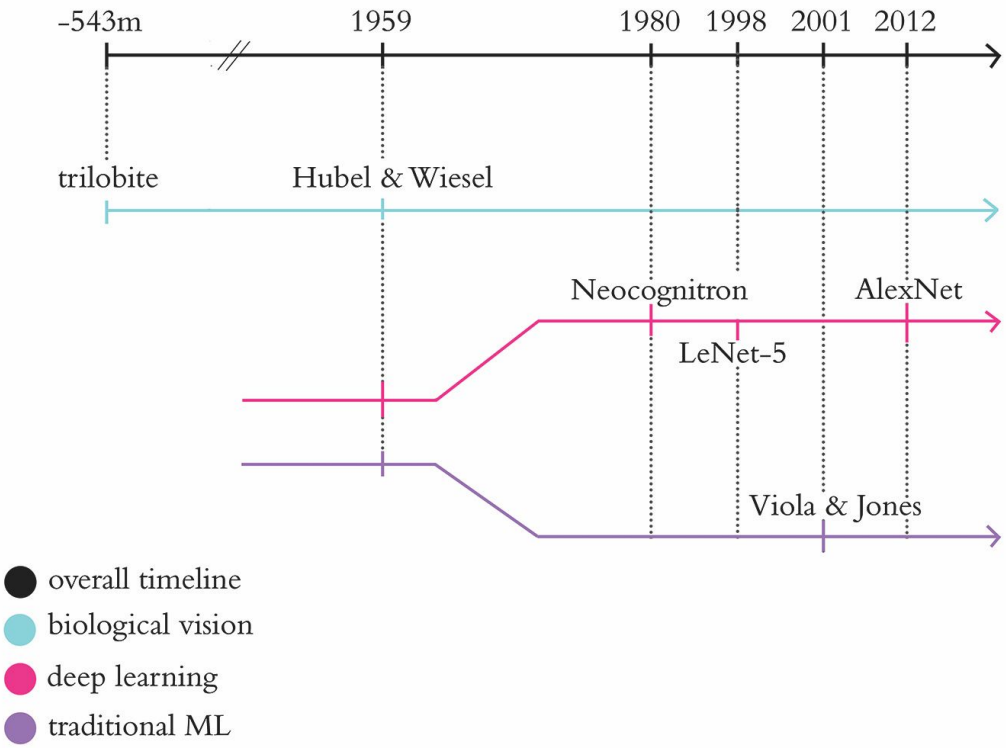


Fig. 2. Schematic diagram illustrating the interconnections between layers in the neocognitron

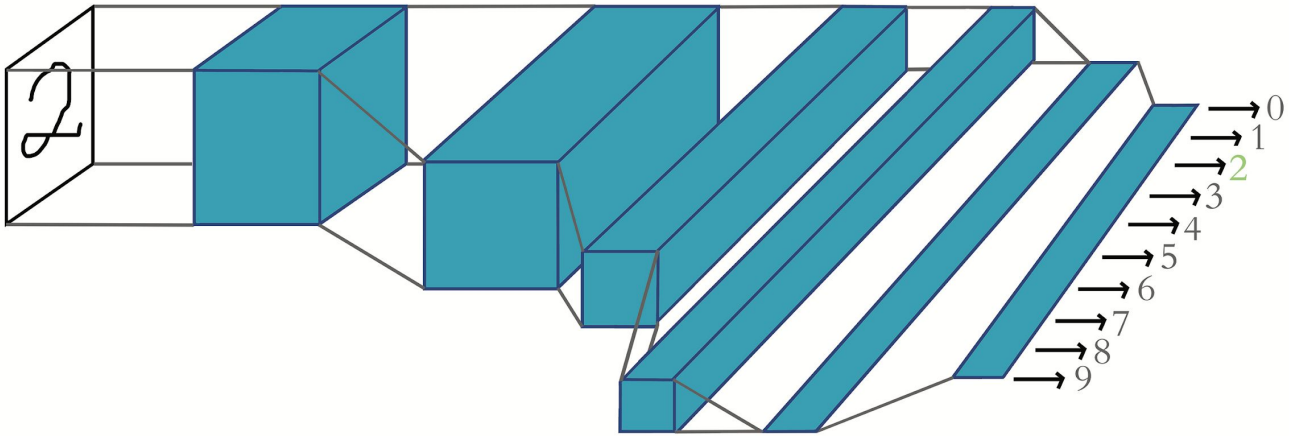
Case Study: The History of Vision



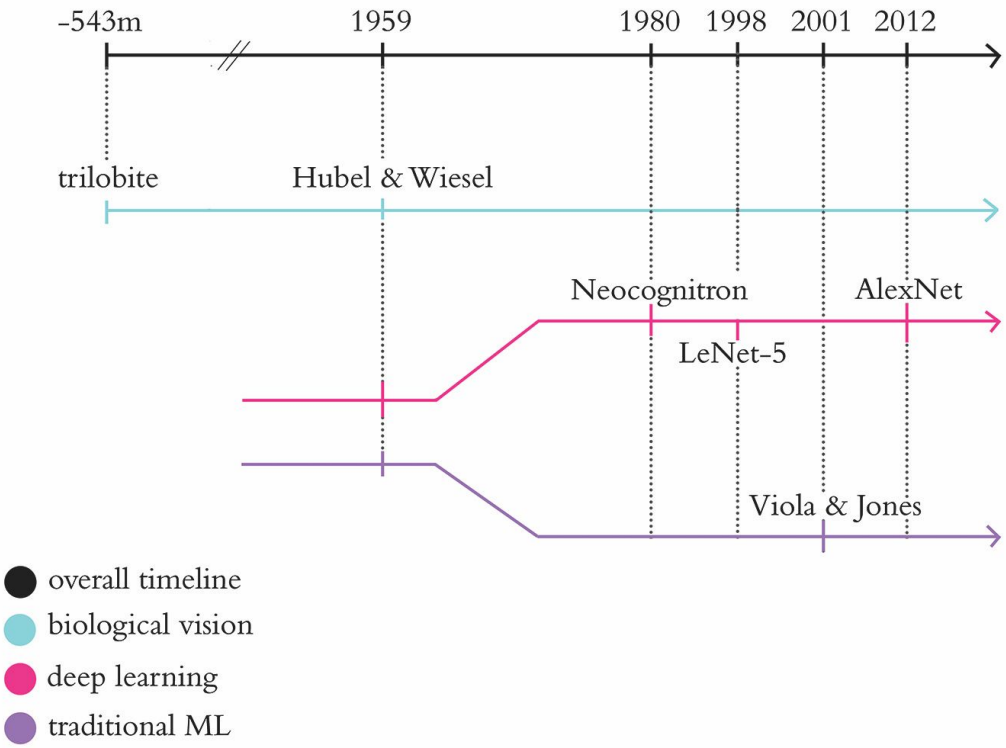
Yann LeCun and Yoshua Bengio

LeNet-5 (LeCun et al., 1998)

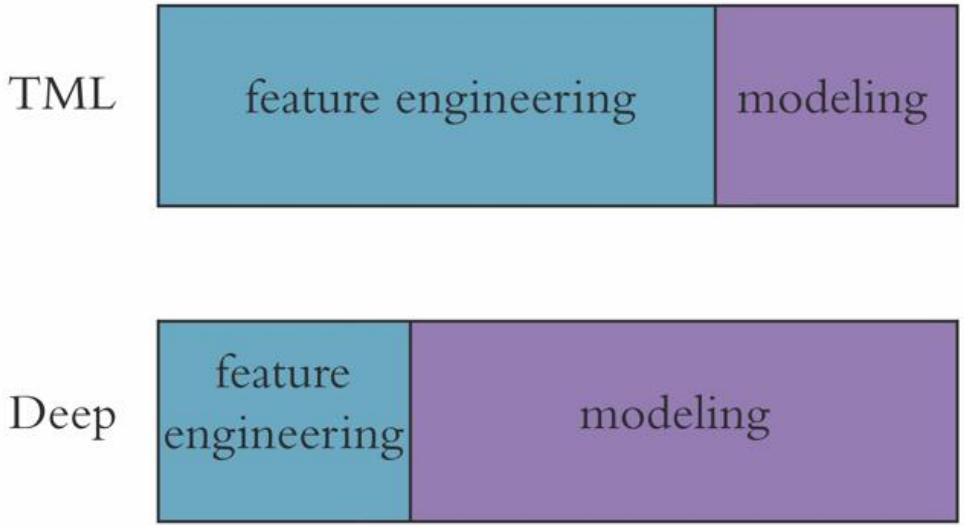
input image → large simple features → → smaller more complex features → probability outputs



Case Study: The History of Vision



Traditional ML vs Deep Learning



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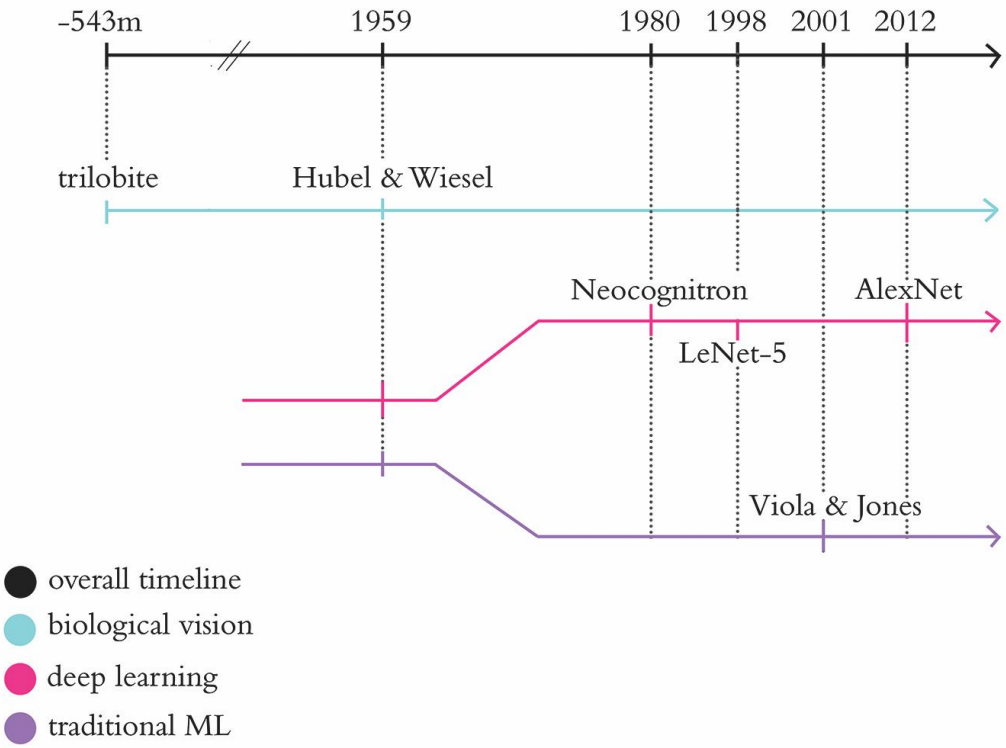
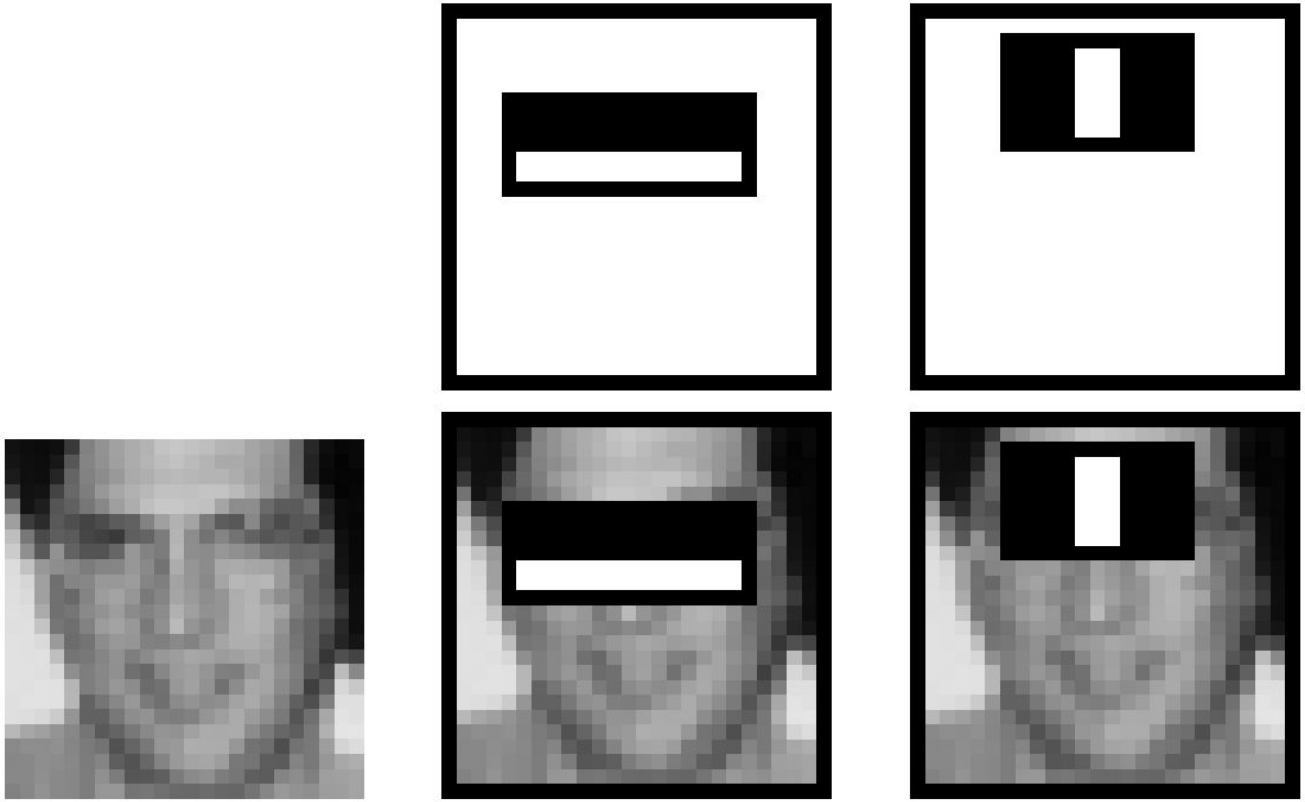


Viola & Jones (2001)



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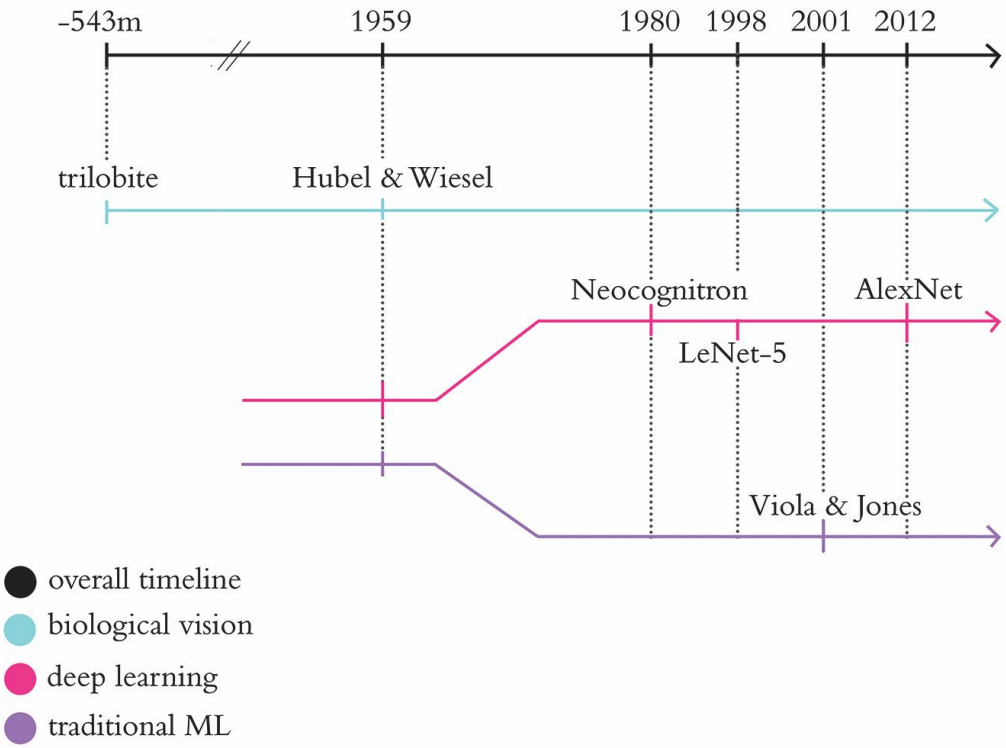
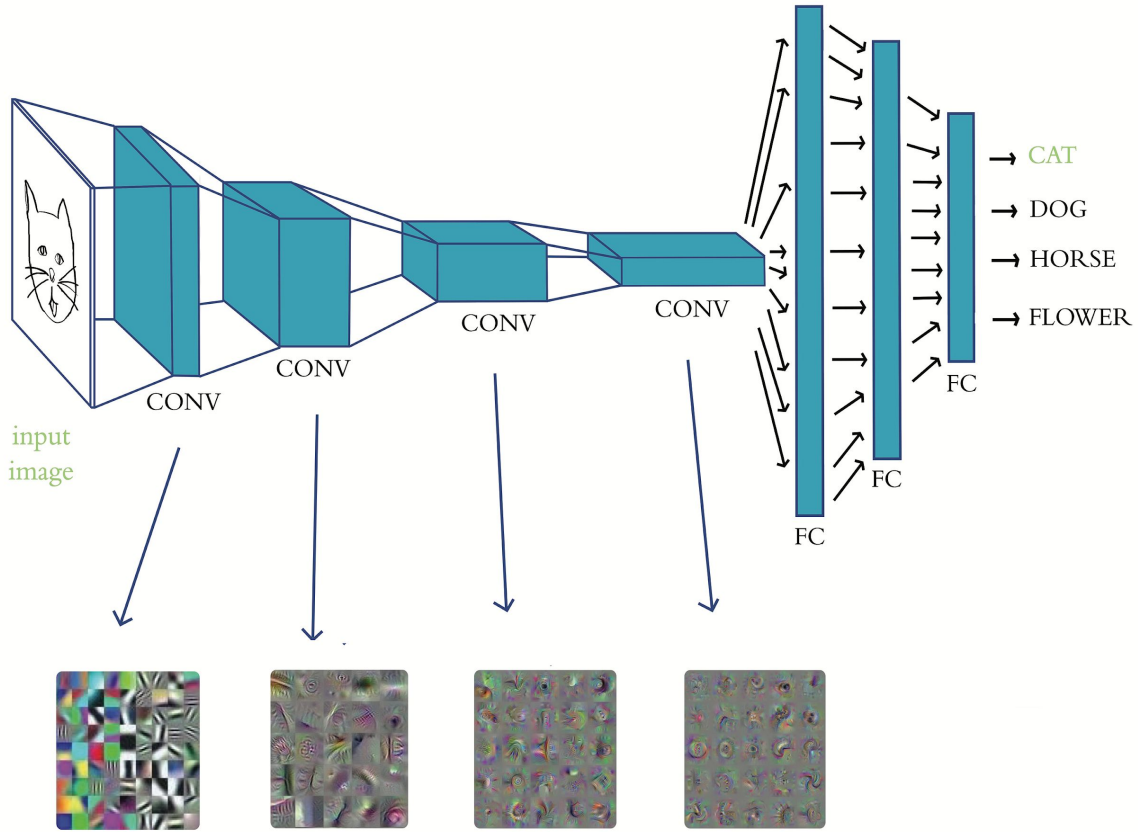


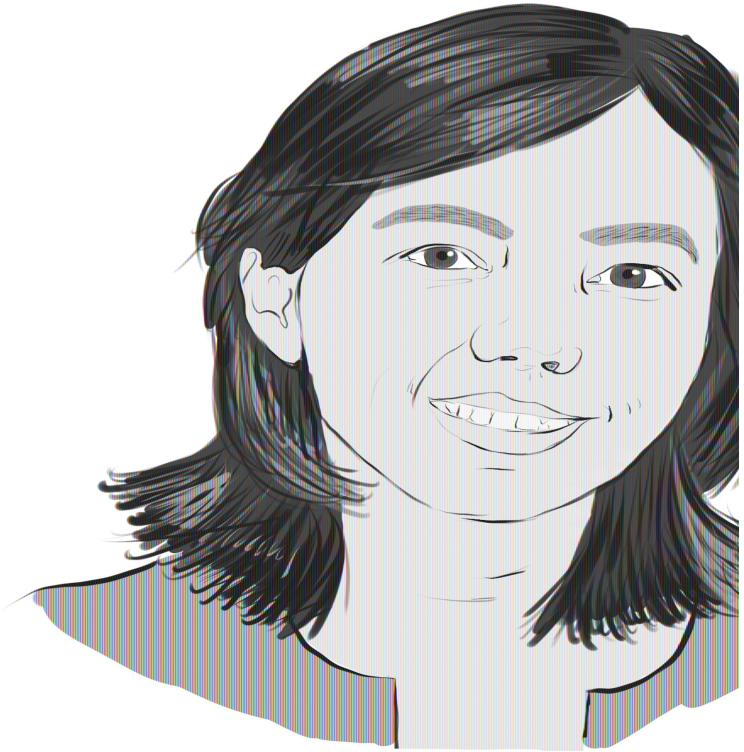
Geoff Hinton

AlexNet (Krizhevsky et al., 2012)



ILSVRC Results

Fei-Fei Li



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If a voice recognition algorithm is fed audio of speech as inputs, given corresponding text as the outputs (labels) to learn, and no features are explicitly programmed, is this a:

- Traditional Machine Learning Algorithm
- Deep Learning Algorithm
- I Don't Know

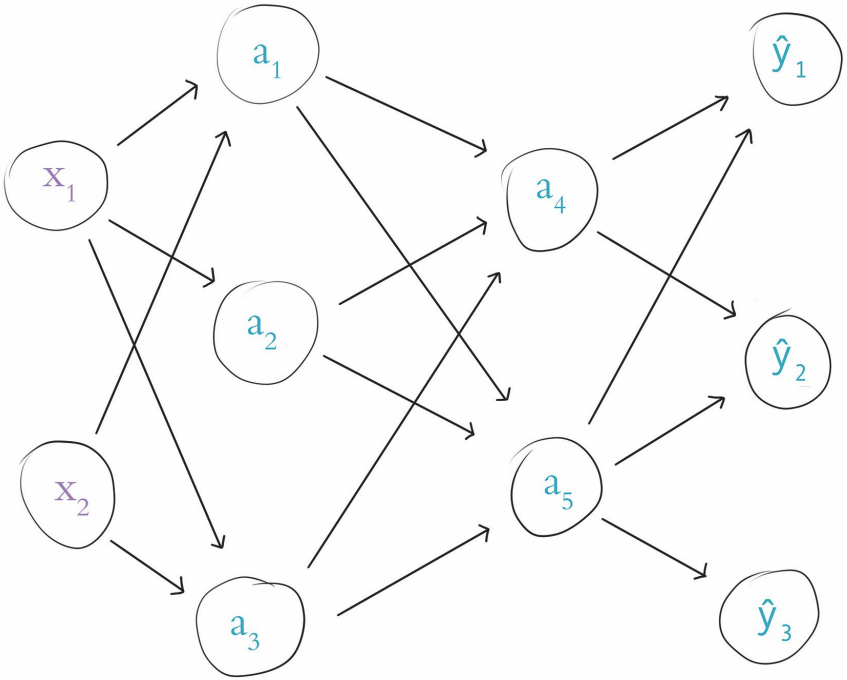
Deep Learning Fundamentals

Part 1:

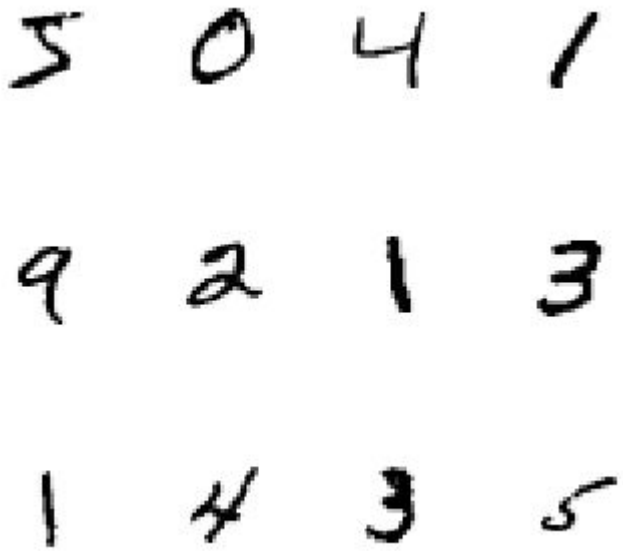
The Unreasonable Effectiveness of Deep Learning

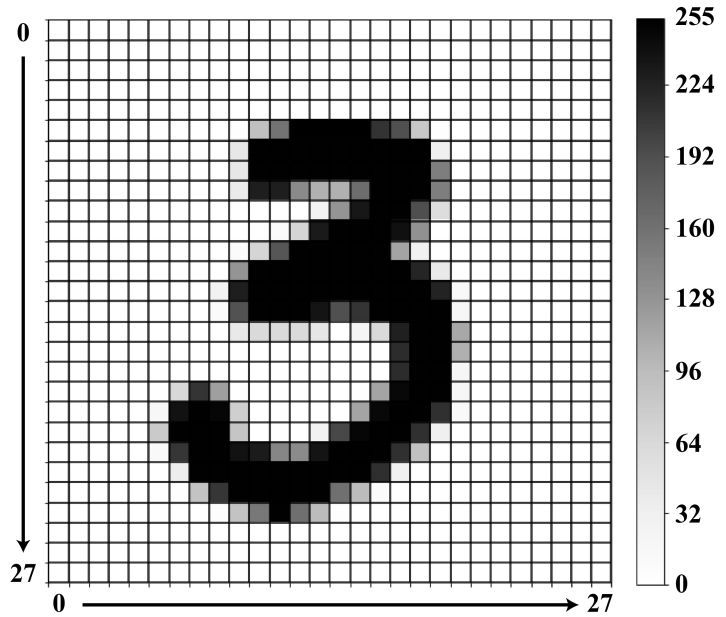
- Intro to Neural Networks and Deep Learning
- **Deep Learning Families** *(Chapters 2-4)*
- Deep Learning Libraries

Dense Networks



The Cart Before the Horse *(Chapter 5)*





interactive Colab demo: *Shallow Net in TF 2.0* (`bit.ly/shallowTF`)

GitHub repo: `github.com/jonkrohn/tf2`

ConvNets: Convolutional Networks

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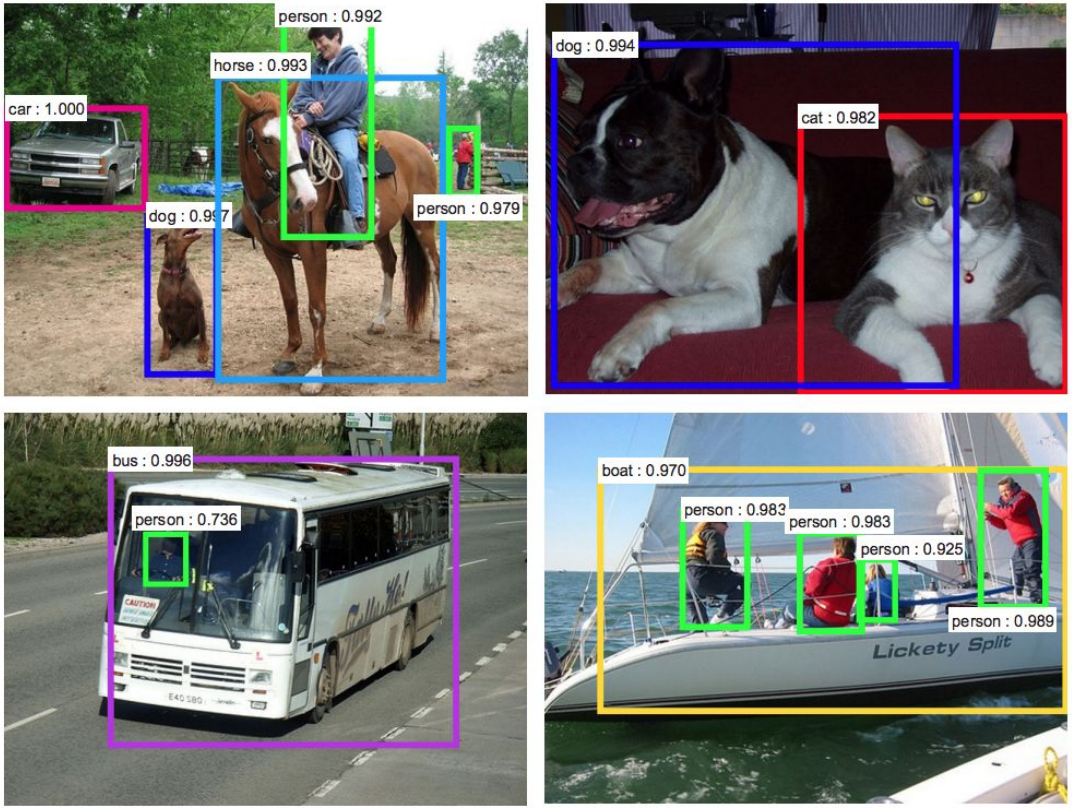


Ren et al. (2015)

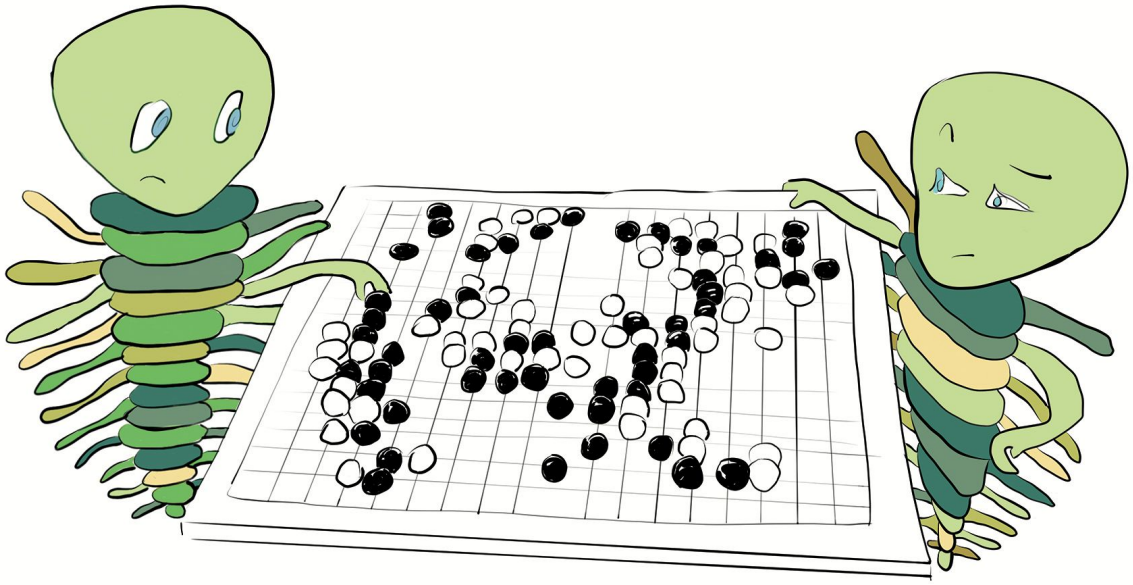
RNNs: Recurrent Neural Networks

GANs: Generative Adversarial Networks

GANs: Generative Adversarial Networks

Karros et al. (2018)

Deep Reinforcement Learning



Demis Hassabis and David Silver

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If you were designing an algorithm to learn to play Tetris by maximizing its score, which of these Deep Learning approaches would be most appropriate?

- Convolutional Neural Network
- Recurrent Neural Network
- Deep Reinforcement Learning
- Generative Adversarial Network

POLL

If you were designing an algorithm to recognise tumours in medical images, which of these Deep Learning approaches would be most appropriate?

- Convolutional Neural Network
- Recurrent Neural Network
- Deep Reinforcement Learning
- Generative Adversarial Network

POLL

If you were designing an algorithm to predict stock price movements based on time series data, which of these Deep Learning approaches would be most appropriate?

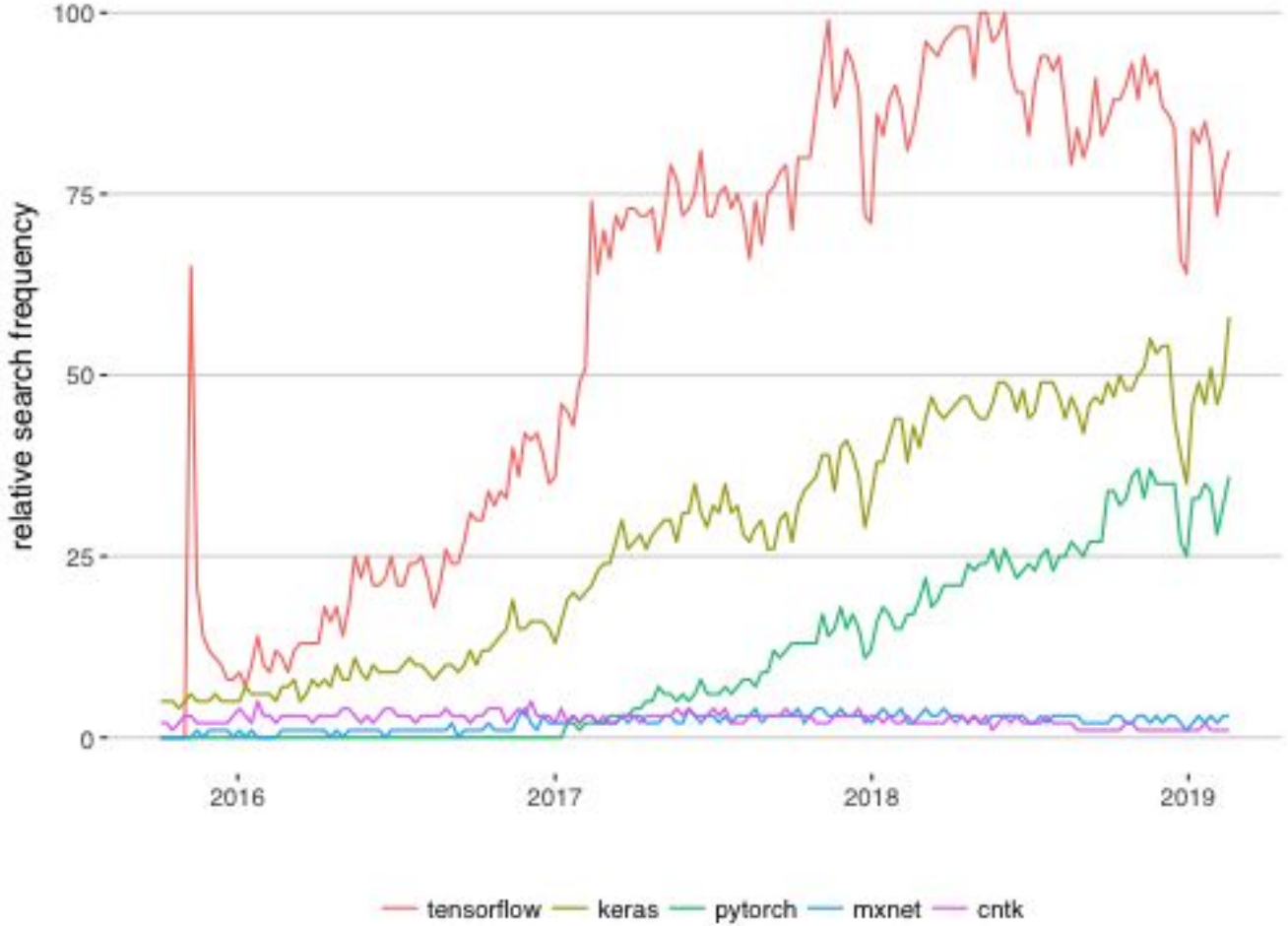
- Convolutional Neural Network
- Recurrent Neural Network
- Deep Reinforcement Learning
- Generative Adversarial Network

Deep Learning Fundamentals

Part 1:

The Unreasonable Effectiveness of Deep Learning

- Intro to Neural Networks and Deep Learning
- Deep Learning Families
- **Deep Learning Libraries** *(Chapter 14)*


relative search frequency
100
75
50
25
0
2016
2017
2018
2019
tensorflow
keras
pytorch
mxnet
cntk

Leading Deep Learning Libraries

	Caffe	Torch	MXNet	TensorFlow
Language	Python, Matlab	Lua, C	Python, R, C++ Julia, Matlab JavaScript, Go Scala, Perl	**Python, C**, C++ Java, Go, JS, Swift (*Haskell, Julia, R, Scala, Rust, C#)*
Programming Style	Symbolic	Imperative	Imperative	Imperative *(since 2.0)*
Parallel GPUs: Data	Yes	Yes	Yes	Yes
Parallel GPUs: Model		Yes	Yes	Yes
Pre-Trained Models	Model Zoo	Model Zoo	Model Zoo	github.com/tensorflow/models
High-Level APIs		PyTorch	in-built	Keras
Particular Strength	CNNs	interactivity		production deployment

PyTorch	TensorFlow
“NumPy”, optimized for GPUs	ported to Python from C++
dynamic auto-differentiation (autodiff)	static computational graph *(historically)*
debugging is easier	
fast.ai API	Keras API
	more widely adopted
TorchScript Just-In-Time compilation	TensorFlow Serving, .js, Lite, tf.data, tf.io
	better for production deployments

Deep Learning Fundamentals

Part 2:

Essential Deep Learning Theory

- **Learning with Artificial Neurons** *(Chapters 6-7)*
- **TensorFlow Playground**

“Whiteboarding”!

Your Arsenal

Neurons

- sigmoid
- tanh
- ReLU

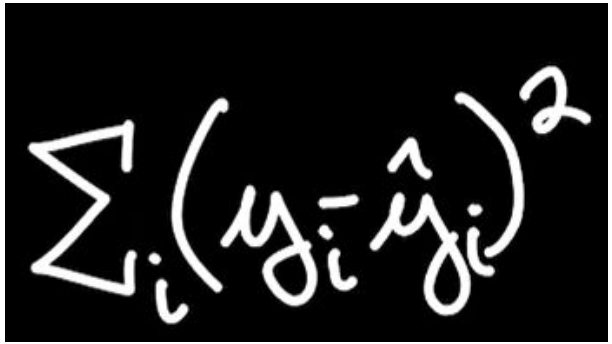
Your Arsenal

Neurons

- sigmoid
- tanh
- ReLU

Cost Functions

- quadratic cost



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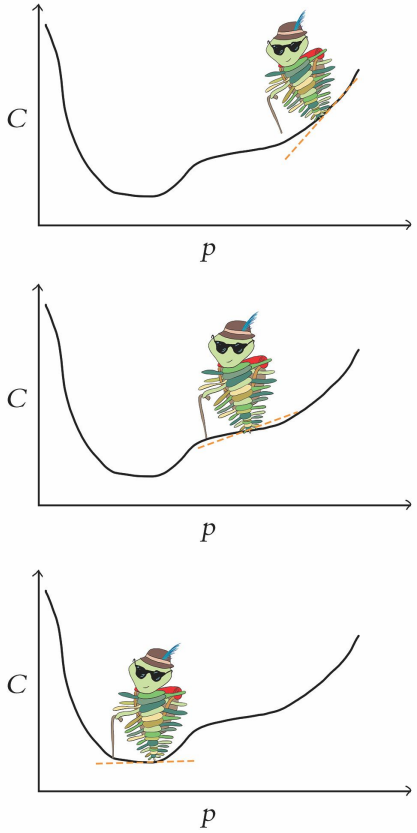
Gradient Descent



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Gradient Descent

Backpropagation

Layers

- dense
- softmax

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Initialization

- Glorot

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- quadratic cost
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***Stochastic* Gradient Descent**

- mini-batch size
- learning rate
- second-order, e.g., Nadam

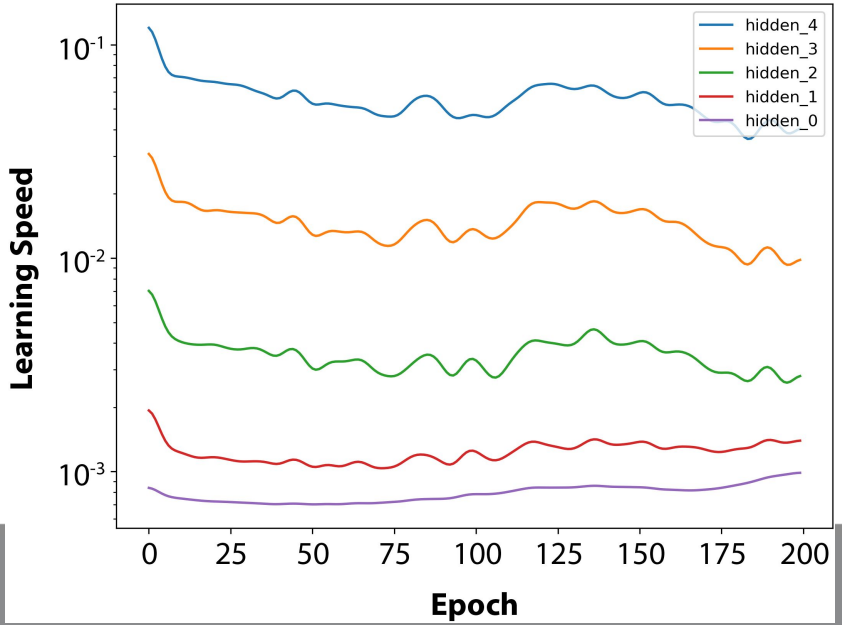
Backpropagation

Initialization

- Glorot

Layers

- dense
- softmax



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Backpropagation

Initialization

- Glorot

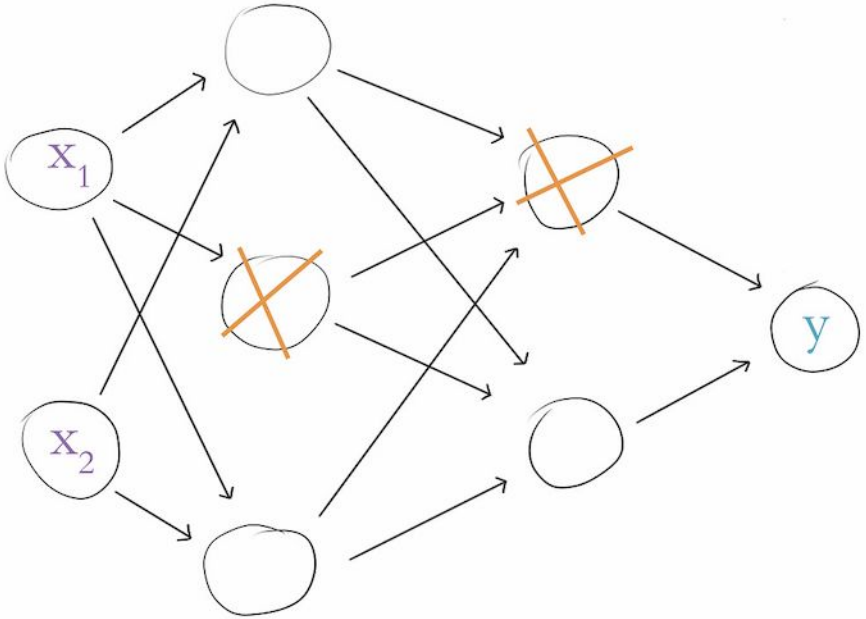
Layers

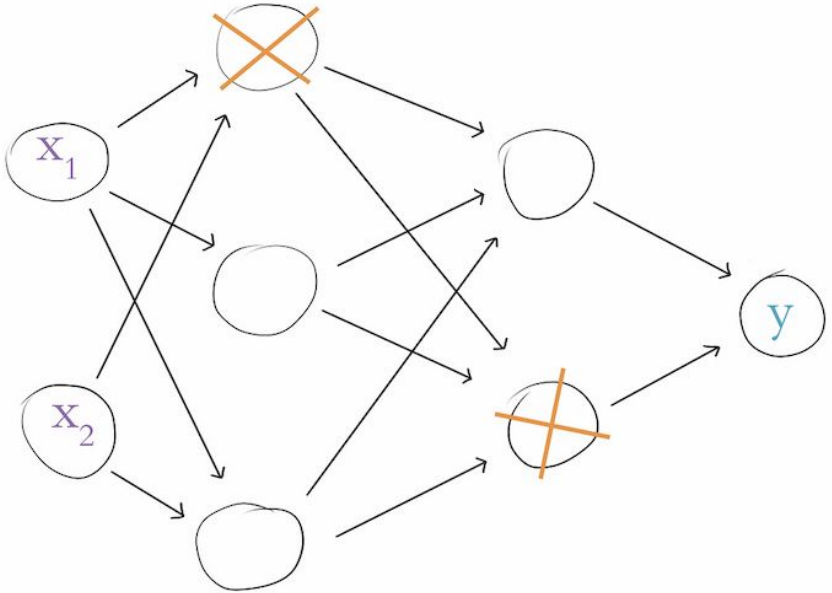
- dense
- softmax

Avoiding Overfitting

- Dropout

Dropout





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***Stochastic* Gradient Descent**

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Backpropagation

Initialization

- Glorot

Layers

- dense
- softmax

Avoiding Overfitting

- Dropout
- Data Augmentation

TensorFlow Playground

interactive demo: `bit.ly/TFplayground`

Deep Learning Fundamentals

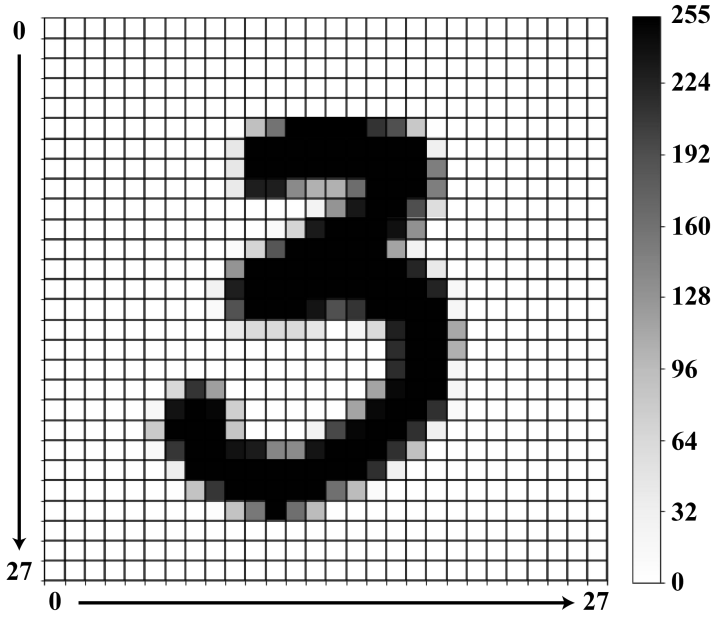
Part 3:

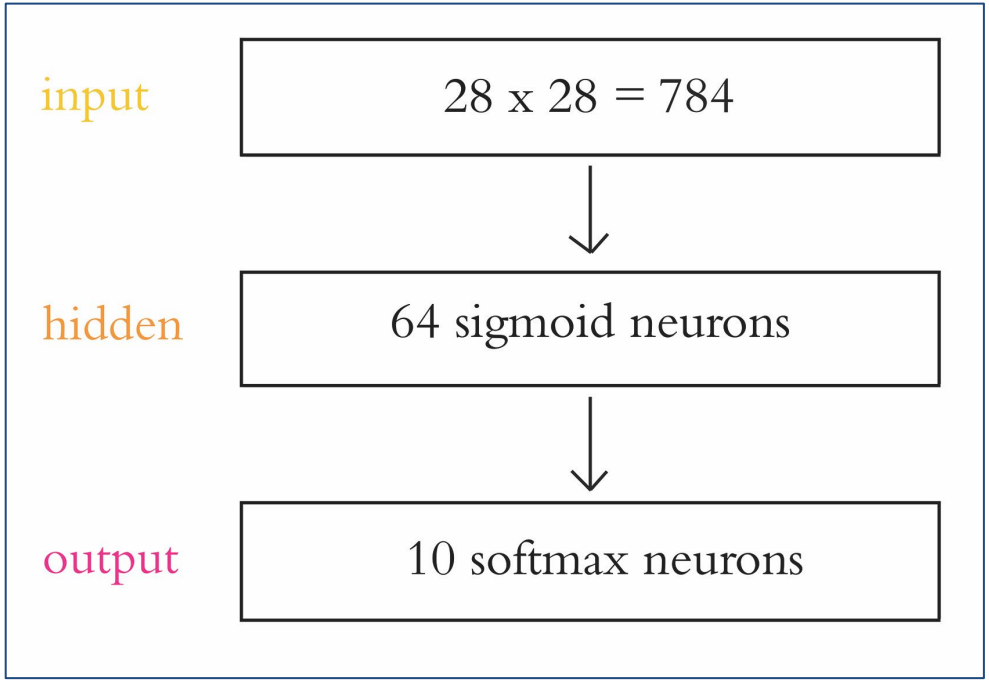
Deep Learning with TensorFlow

- **Revisiting our Shallow Neural Network**
- **Deep Nets in TensorFlow** *(Chapters 8-9)*
- **What to Study Next, Depending on Your Interests**

Revisiting our Shallow Net

interactive Colab demo: *Shallow Net in TensorFlow*





Deep Nets in TensorFlow

interactive Colab demo: *Deep Net in TF 2.0* (`bit.ly/deepNetTF`)

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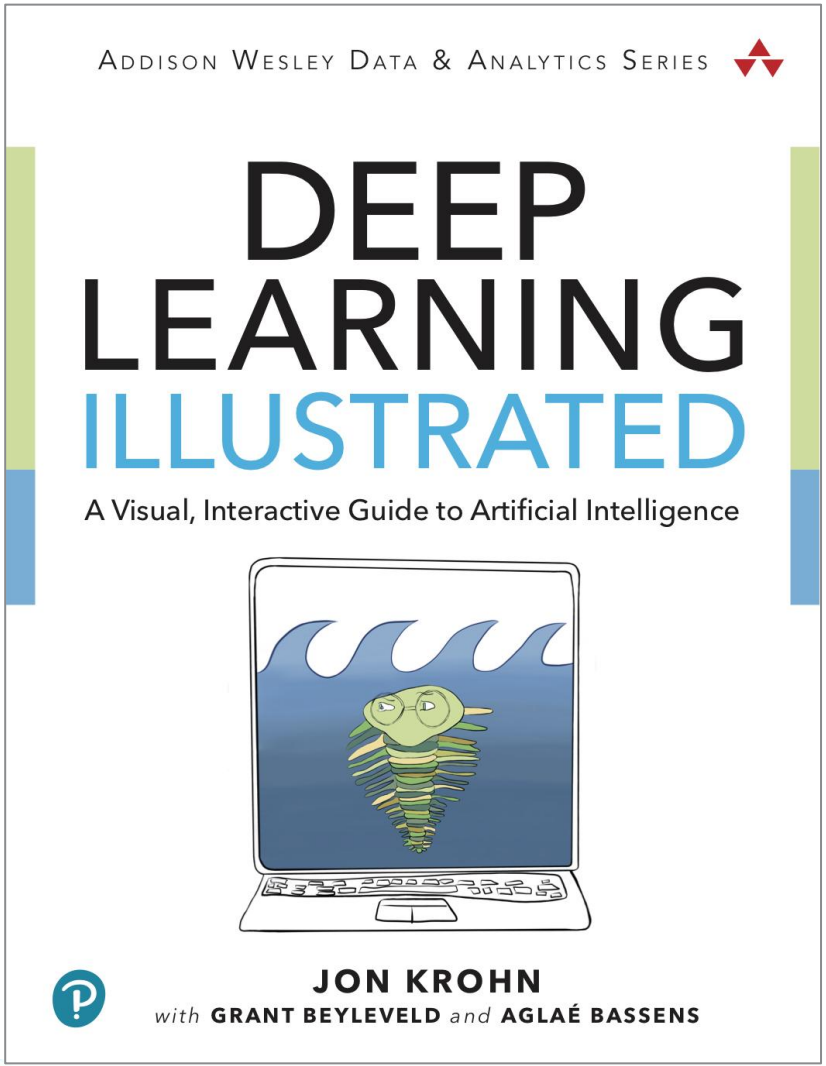
What follow-up Deep Learning topics interest you most?

- CNNs and Machine Vision
- Sequences: RNNs, LSTMs, NLP, Financial Time Series
- Generative Adversarial Networks
- Deep Reinforcement Learning
- Something Else



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(with message mentioning today's Live Training)