A Short Introduction to Deep Learning

Strasbourg
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Main Points

1. Applications of deep learning

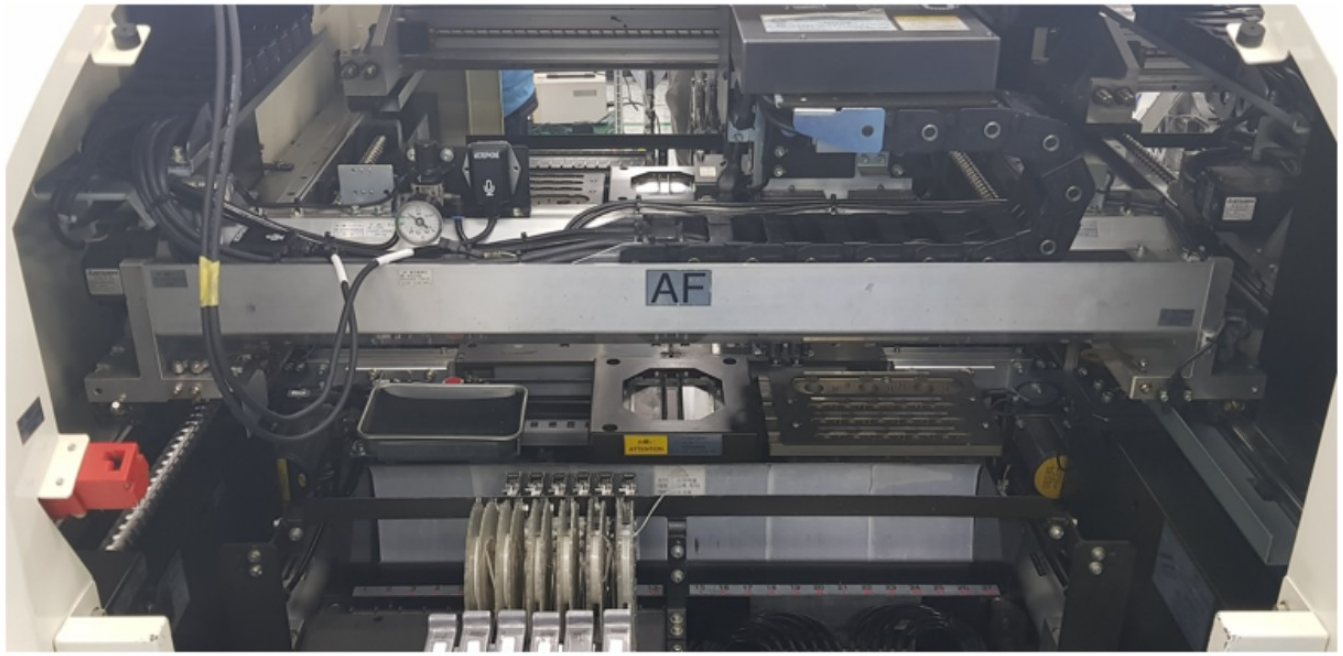
2. Deep learning in 15 minutes (intuition behind)

3. Convolutional Neural Networks (CNNs)

4. The Deep Learning Meetup Strasbourg

Applications of deep learning

Autoencoder based audio anomaly detection for SMD assembly



audio

Figure 7. SMD semiconductor assembly equipment.

https://www.mdpi.com/1424-8220/18/5/1308/pdf

Fight against illegal deforestation

source

A recycled phone is transformed into a solar-powered acoustic monitoring device that listens to sounds of illegal logging in the forrest

Healthcare

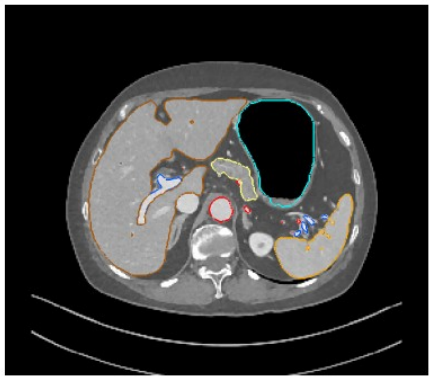
Drug discovery, personalized medicine, population-based healthcare

graphs, images, medical records

link

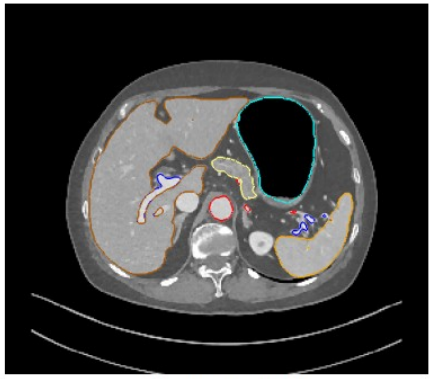
Applications of deep learning

CT Scans semantic segmentation with 3D U-net



(a) Ground truth (axial)

(b) Ground truth (3D)



(c) Segmentation (axial)

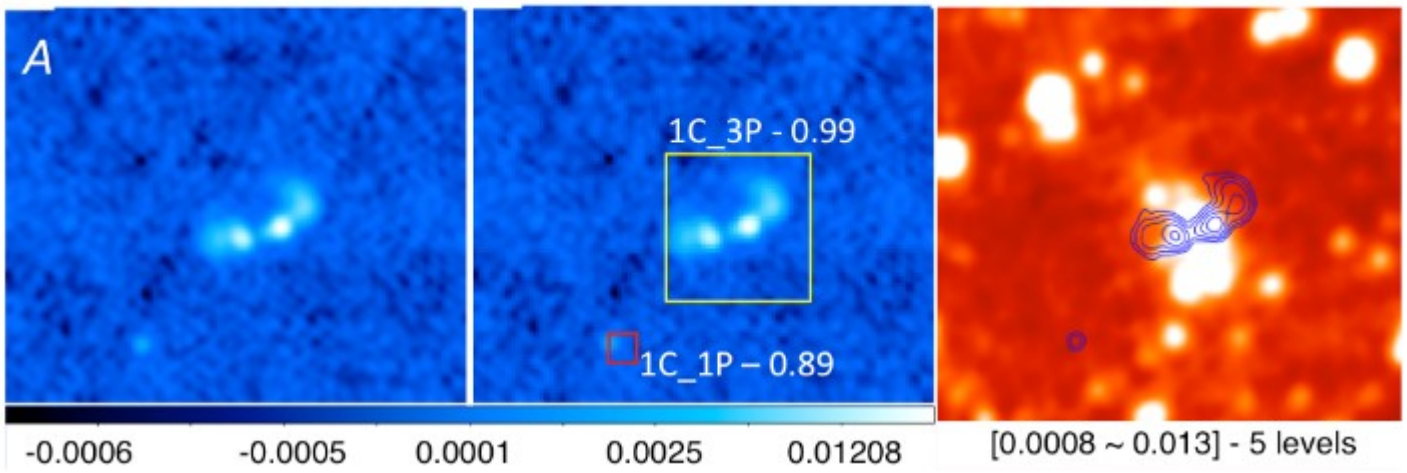
(d) Segmentation (3D)

3D images

https://arxiv.org/pdf/1803.08691.pdf

Find new galaxies

Researchers from the University of Western Australia have developed a deep learning system that can identify galaxies in deep space



2D images

https://arxiv.org/pdf/1805.12008.pdf

Applications of deep learning

Deep Learning and Physics

Data analysis at CERN in the 60^{s} and 70^{s}

Deep Learning and Physics

Data analysis at CERN in the 60ˢ and 70ˢ

Deep learning and HEP

Event selection

Event reconstruction

Event classification

Deep Learning and Physics

Data analysis at CERN in the 60ˢ and 70ˢ

Deep learning and HEP

Event selection

Event reconstruction

Event classification

Higgs challenge

Higgs Boson Machine Learning Challenge

Use the ATLAS experiment to identify the Higgs boson

$13,000 · 1,785 teams · 4 years ago

Overview Data Kernels Discussion Leaderboard Rules

"tau tau decay of a Higgs boson" versus "background."

https://www.kaggle.com/c/higgs-boson#description

The new electricity?

Automotive Finance

Security Robotics

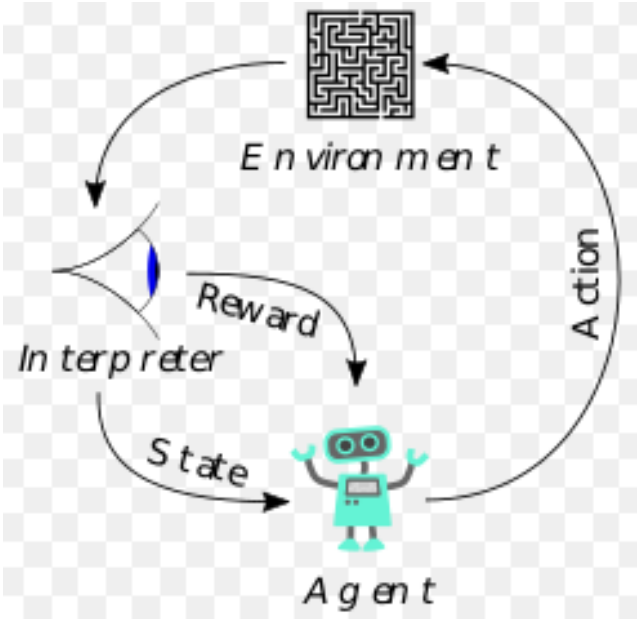
Industry 4.0 Smart homes

Personalized education

And many, many others...

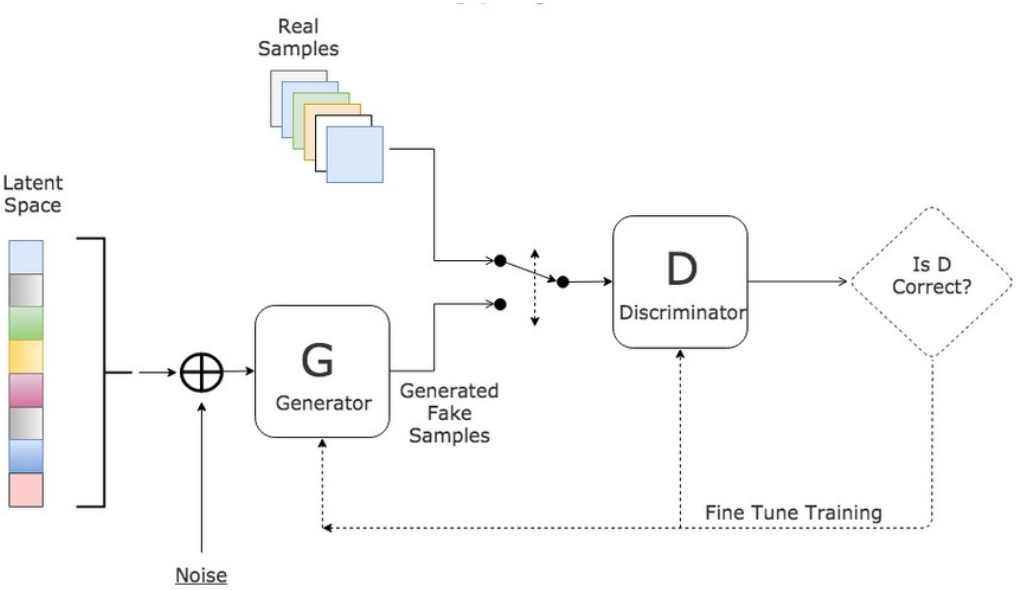
Hot topics now

Reinforcement Learning (RL)



(1) https://www.youtube.com/watch?v=8IjAT-tEG-E

Generative Adversarial Networks (GANs)



(1) https://www.youtube.com/watch?v=36lE9tV9vm0
(2) https://www.youtube.com/watch?v=tpr44-G5MbU#t=5m5s

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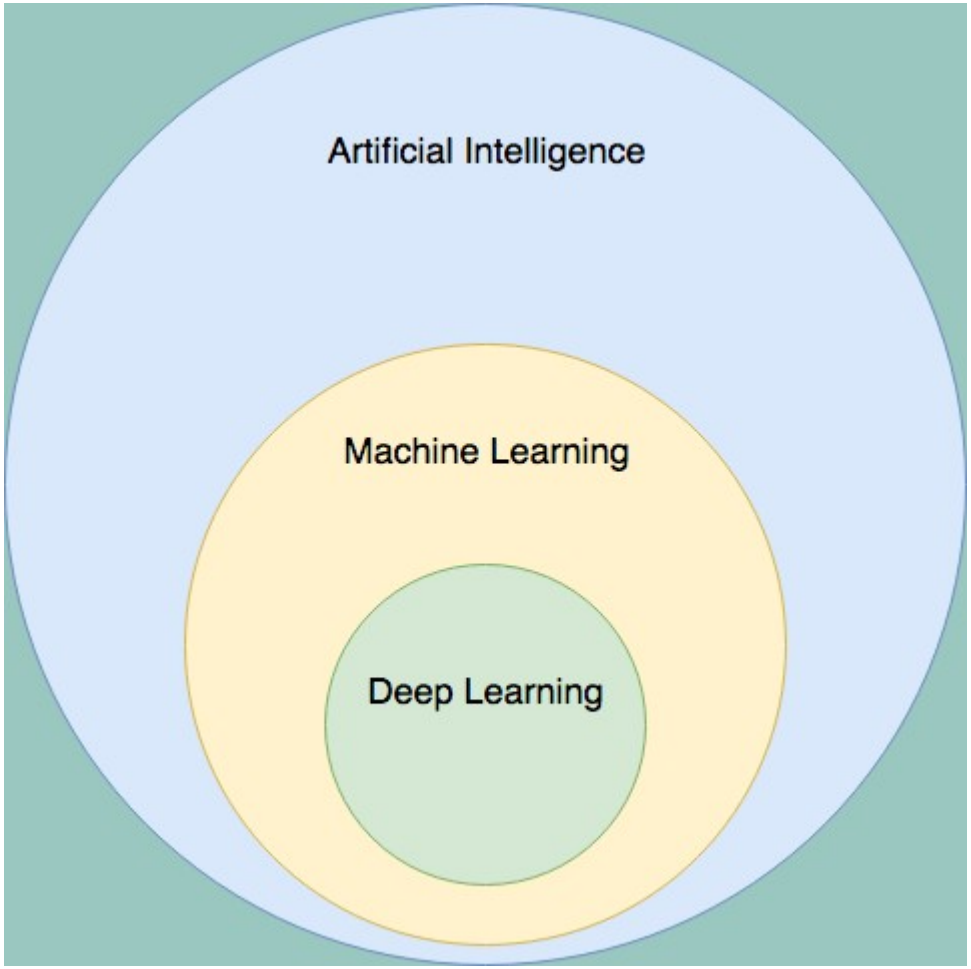
Deep learning vs AI



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Deep learning in 15 minutes

What is deep learning?

Deep learning in 15 minutes

What is deep learning?

Deep learning is a rebranding of neural networks.

Deep learning in 15 minutes

What is deep learning?

Deep learning is a rebranding of neural networks.

Neural networks:

Systems that make use of an architecture (weakly) inspired by the brain.

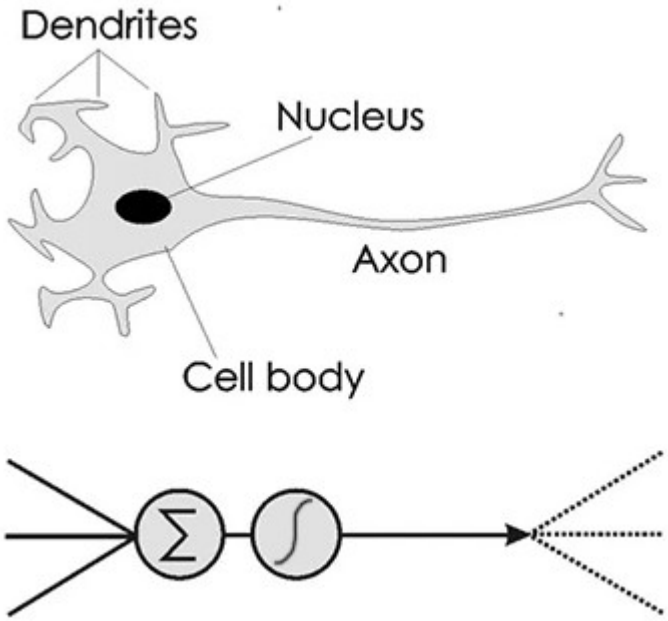
Deep learning in 15 minutes

Brain neurons

Deep learning in 15 minutes

Brain neurons

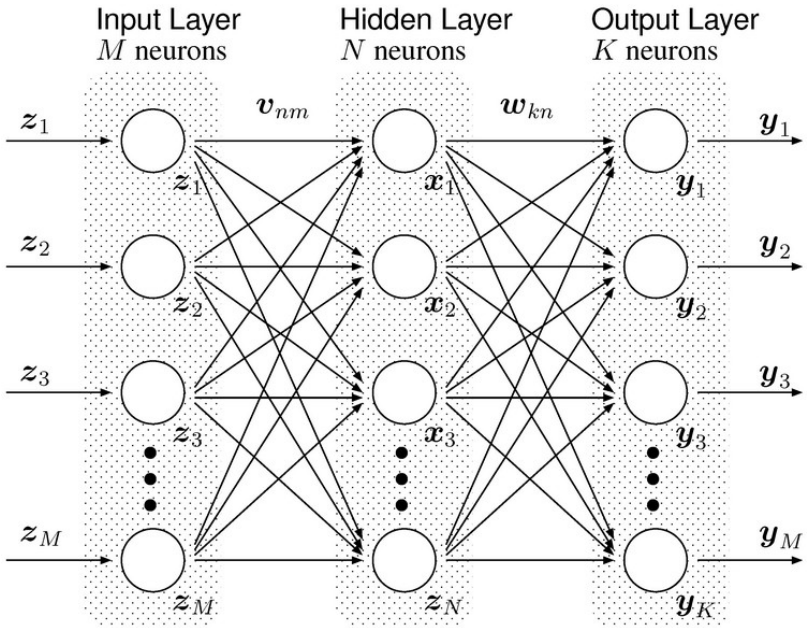
Neural network neurons



Deep learning in 15 minutes

Brain neurons

Neural network neurons



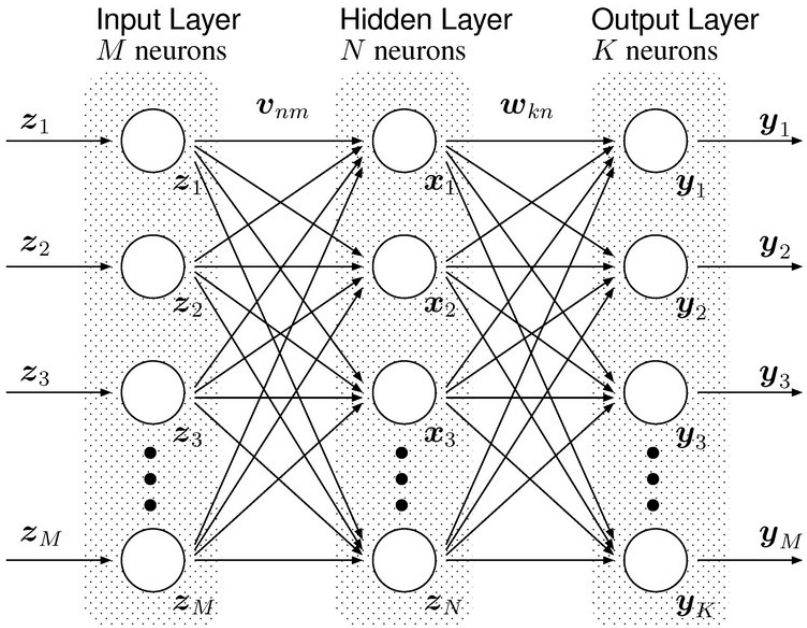
Deep learning = stack matrix-vector multiplications interleaved with non-linearities

R Collobert

Deep learning in 15 minutes

Brain neurons

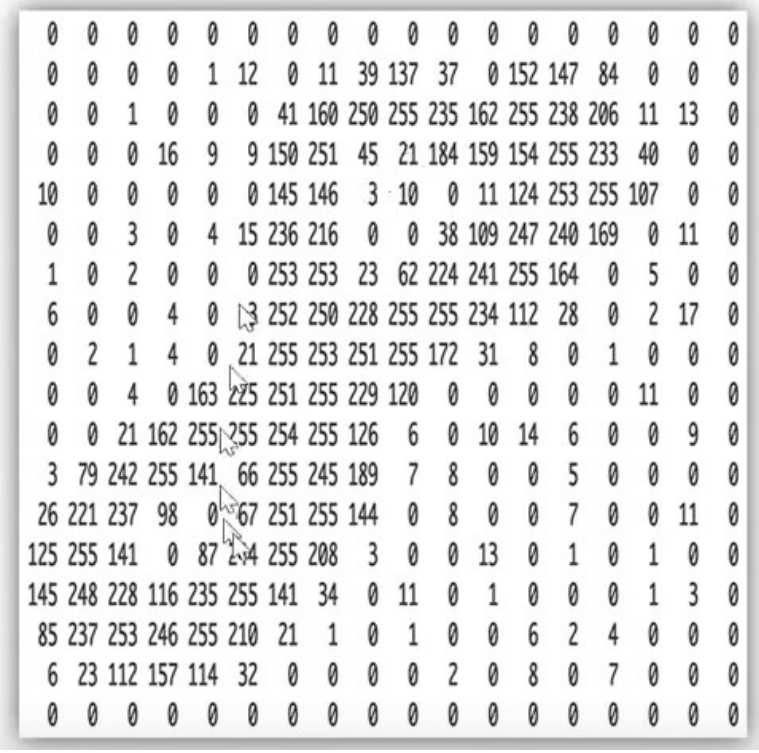
Neural network neurons



Deep learning = neural networks with more than 1 hidden layer

Deep Learning: Tensor in, Tensor out

In a nutshell



Number	Prob
0	0.01
1	0.03
2	0.03
3	0.04
4	0.07
5	0.08
6	0.10
7	0.02
8	0.59
9	0.01

np.argmax

TensorFlow

Deep Learning: Fit unknown functions

What does this function do?

$$x(t) = \left(\left(-\frac{199}{9}\sin\left(\frac{11}{7}-5\,t\right)-\frac{35}{9}\sin\left(\frac{11}{7}-4\,t\right)-\frac{356}{7}\,\text{si}\right.\right.$$
$$\frac{523}{6}\sin\left(t+\frac{8}{5}\right)+\frac{7}{2}\sin\left(6\,t+\frac{8}{5}\right)-\left.\frac{784}{5}\right)\theta(151\,\pi-t)\,\theta(t-$$
$$\frac{14}{3}\sin\left(\frac{8}{5}-3\,t\right)+\frac{158}{3}\sin\left(t+\frac{8}{5}\right)+\frac{155}{4}\sin\left(2\,t+\frac{8}{5}\right)+\frac{4}{3}$$
$$\pi-t)\,\theta(t-143\,\pi)+\left(\frac{535}{6}\sin\left(t+\frac{8}{5}\right)+4\sin\left(2\,t+\frac{14}{3}\right)+\right.$$
$$\frac{8}{5}\Big)+\frac{1}{7}\sin\left(6\,t+\frac{23}{5}\right)+\frac{469}{9}\Big)\,\theta(143\,\pi-t)\,\theta(t-139\,\pi)+\Big($$
$$\frac{8}{5}\Big)+\frac{43}{14}\sin\left(3\,t+\frac{14}{3}\right)+\frac{23}{3}\sin\left(4\,t+\frac{8}{5}\right)+\frac{10}{9}\sin\left(5\,t+\right.$$
$$139\,\pi-t)\,\theta(t-135\,\pi)+\left(-\frac{1}{10}\sin\left(\frac{6}{5}-5\,t\right)-\frac{26}{5}\sin\left(\frac{8}{5}-\right.\right.$$
$$\frac{8}{5}-t\Big)+\frac{1}{23}\sin\left(3\,t+\frac{1}{3}\right)-\frac{543}{4}\Big)\,\theta(135\,\pi-t)\,\theta(t-131\,\pi)$$
$$\frac{3}{2}-120\,t\Big)-\frac{7}{8}\sin\left(\frac{5}{4}-118\,t\right)-\frac{4}{5}\sin\left(\frac{5}{6}-115\,t\right)-\frac{5}{3}\,\text{sir}$$
$$t\Big)-\frac{8}{5}\sin\left(\frac{5}{5}-97\,t\right)-\frac{23}{5}\sin\left(\frac{7}{5}-94\,t\right)-\frac{39}{5}\sin\left(\frac{7}{5}-90\right.$$

Deep Learning: Fit unknown functions

Parametric equation of Einstein's face.

$$x(t) = \left(\left(-\frac{199}{9}\sin\left(\frac{11}{7}-5t\right)-\frac{35}{9}\sin\left(\frac{11}{7}-4t\right)-\frac{356}{7}\sin\right.\right.$$
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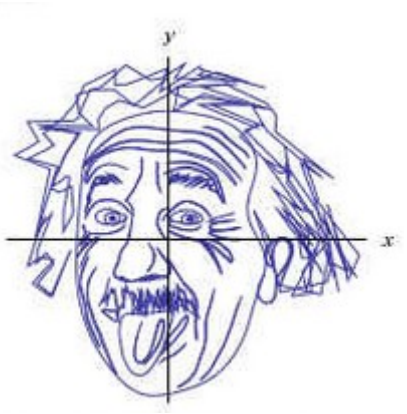


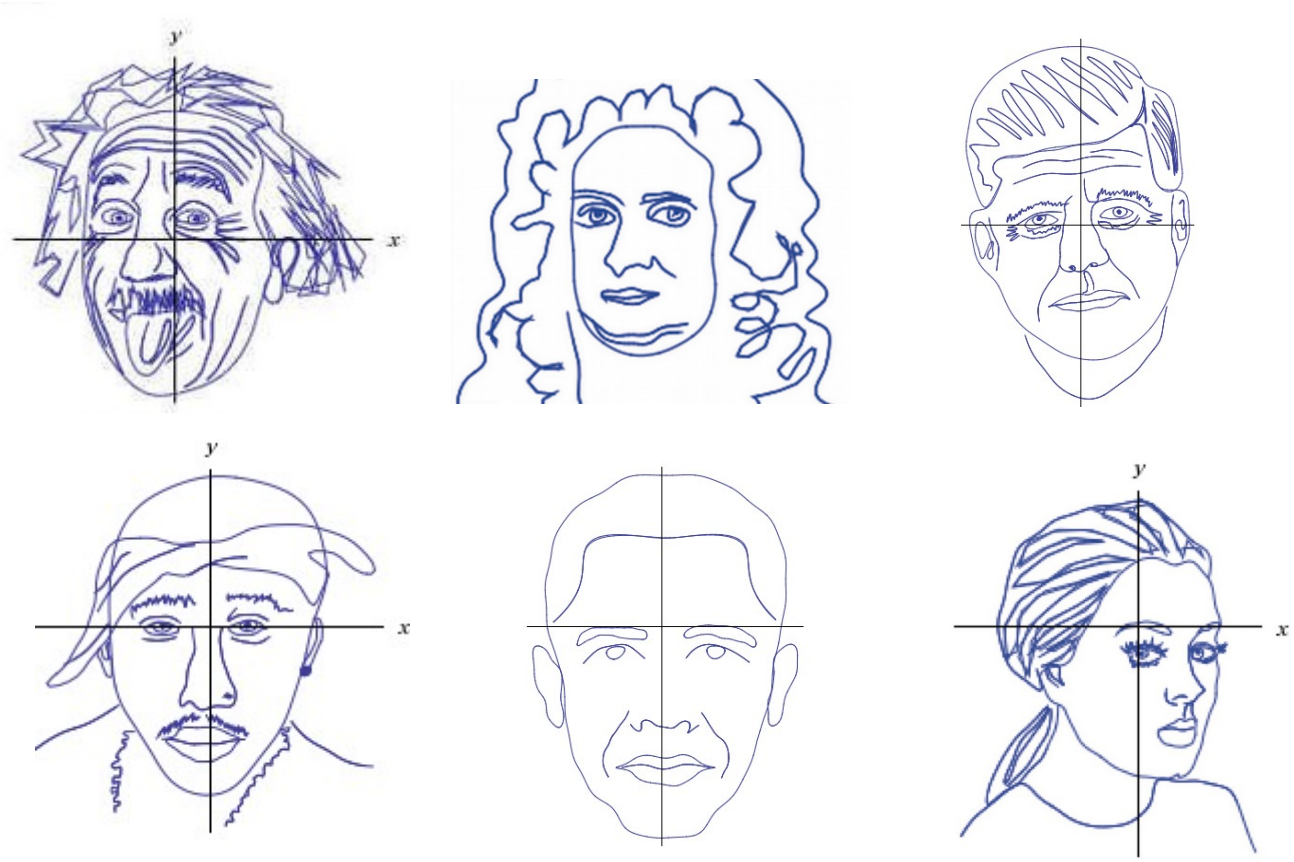
Draw Einstein's face.

Deep Learning: Fit unknown functions

And we can sketch all the faces in the world.

Deep Learning: Fit unknown functions

And we can sketch all the faces in the world.



We *just* have to approximate the unknown function producing all the faces in the world.

Deep Learning: Fit unknown functions

How to detect all the faces in the world.

Deep Learning: Fit unknown functions

How to detect all the faces in the world.

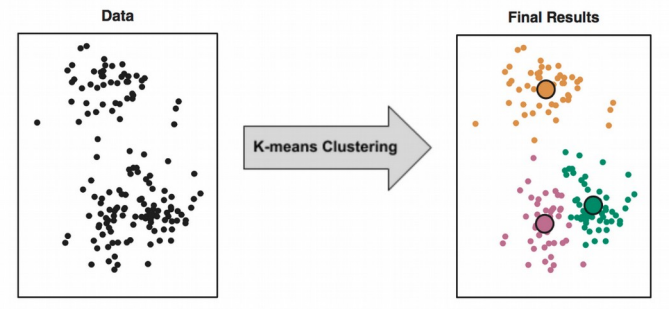
Feed many faces to a neural network.

And train the neural network to find the parameters.

Types of Learning

Types of Learning

Unsupervised



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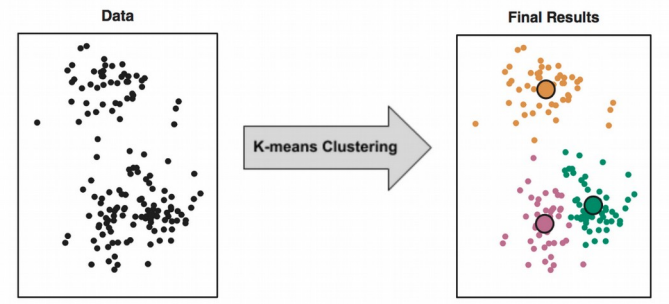

Very hot topic: Generative Adversarial Neural Networks (**GANs**):
(1) https://www.youtube.com/watch?v=36lE9tV9vm0
(2) https://www.youtube.com/watch?v=tpr44-G5MbU#t=5m5s

Types of Learning

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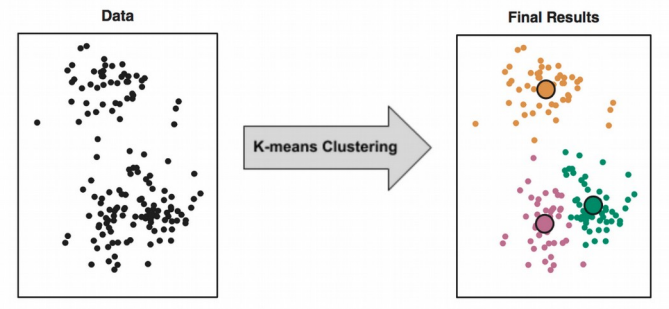
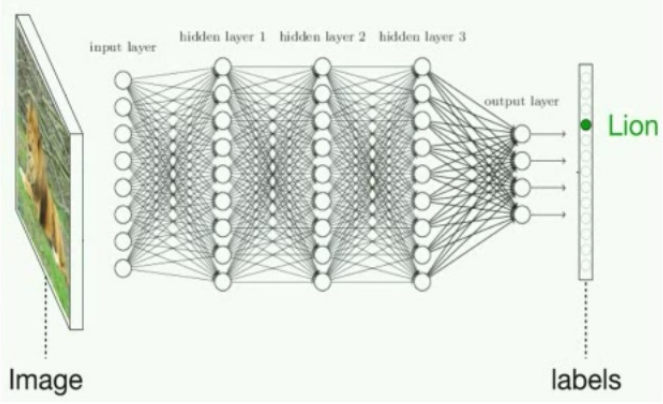


Supervised



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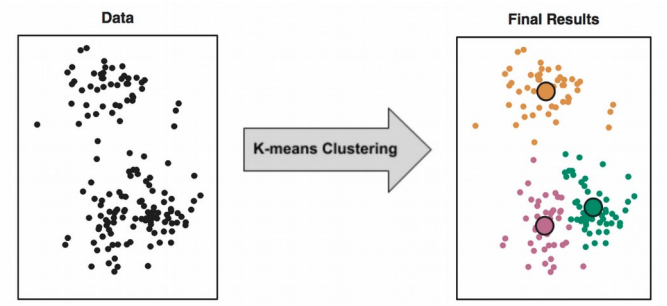
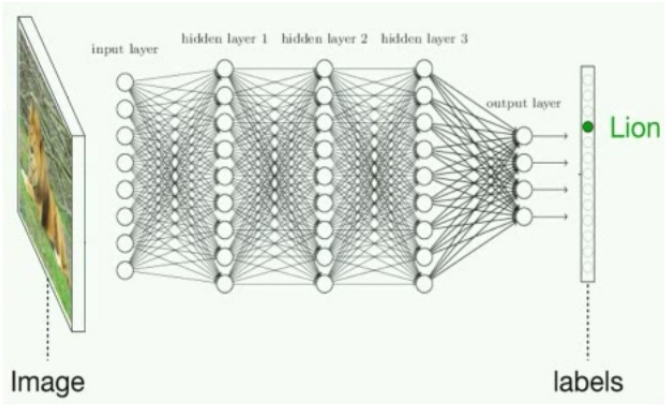
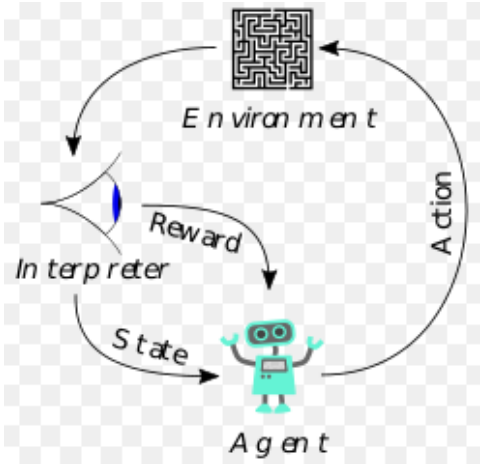


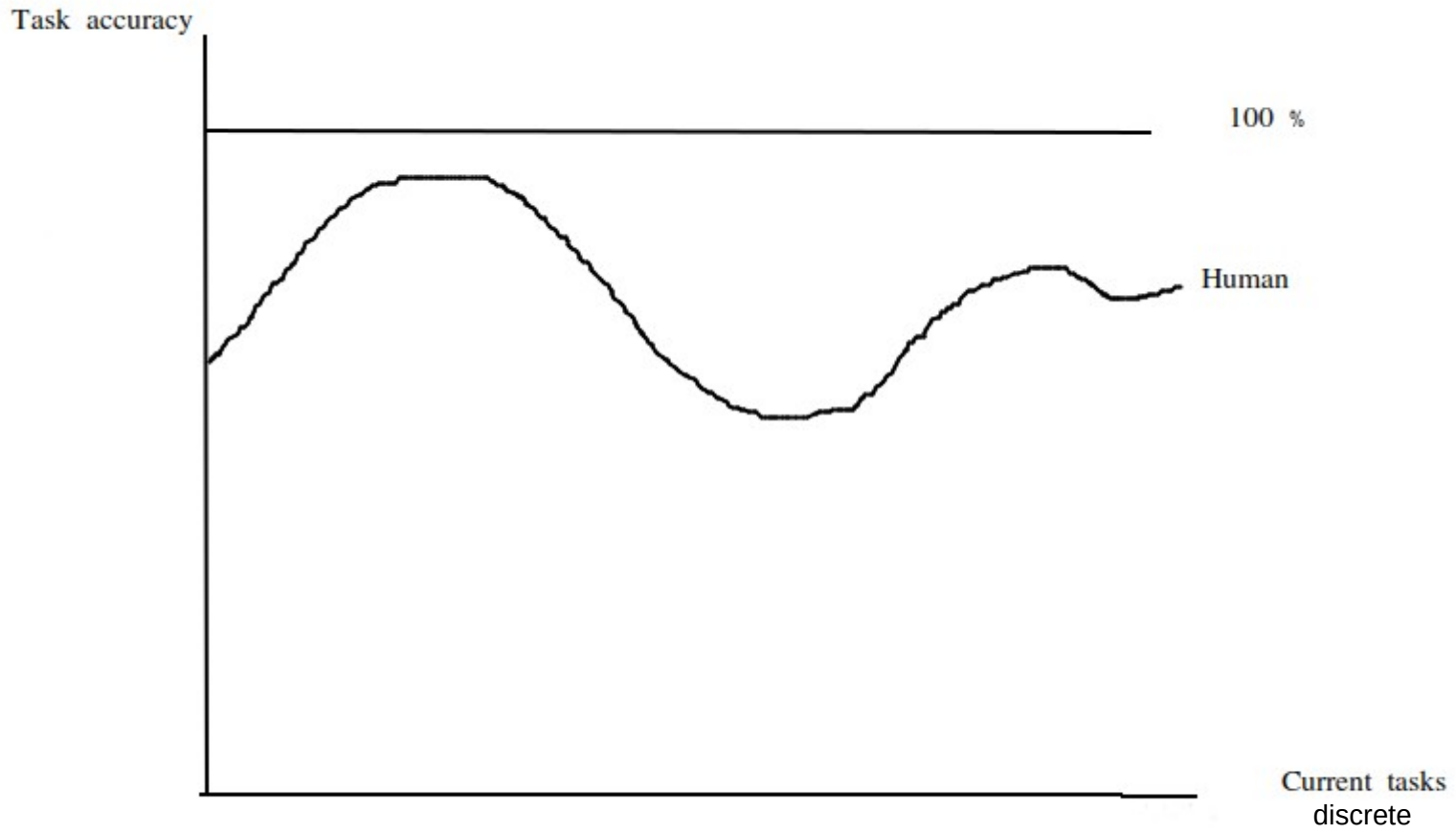
Supervised



Reinforcement



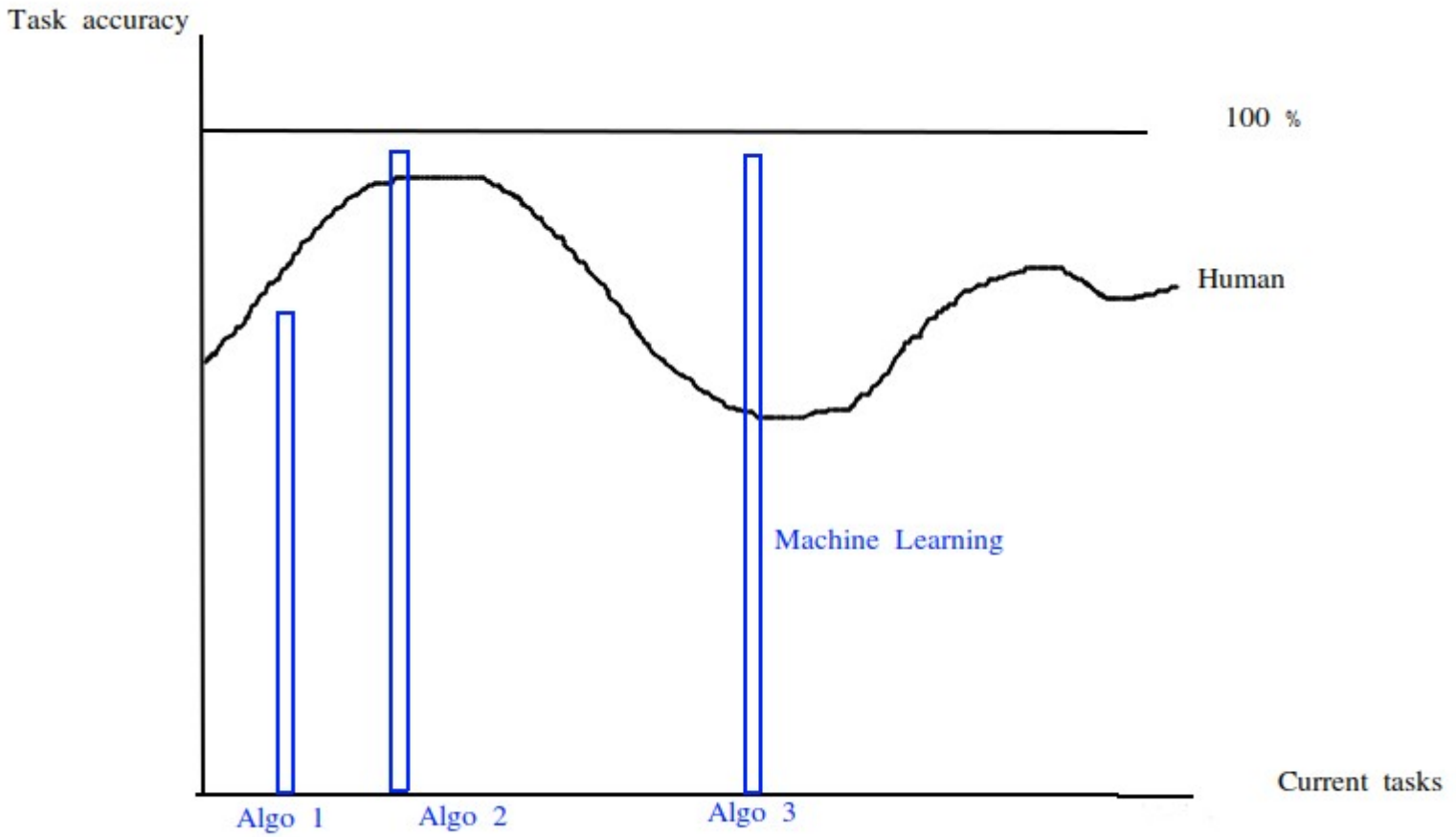
No free lunch theorem



Just for illustration purpose, sometimes we don’t have a clear scale for measuring skills

Inspired by Florian Miconi

No free lunch theorem



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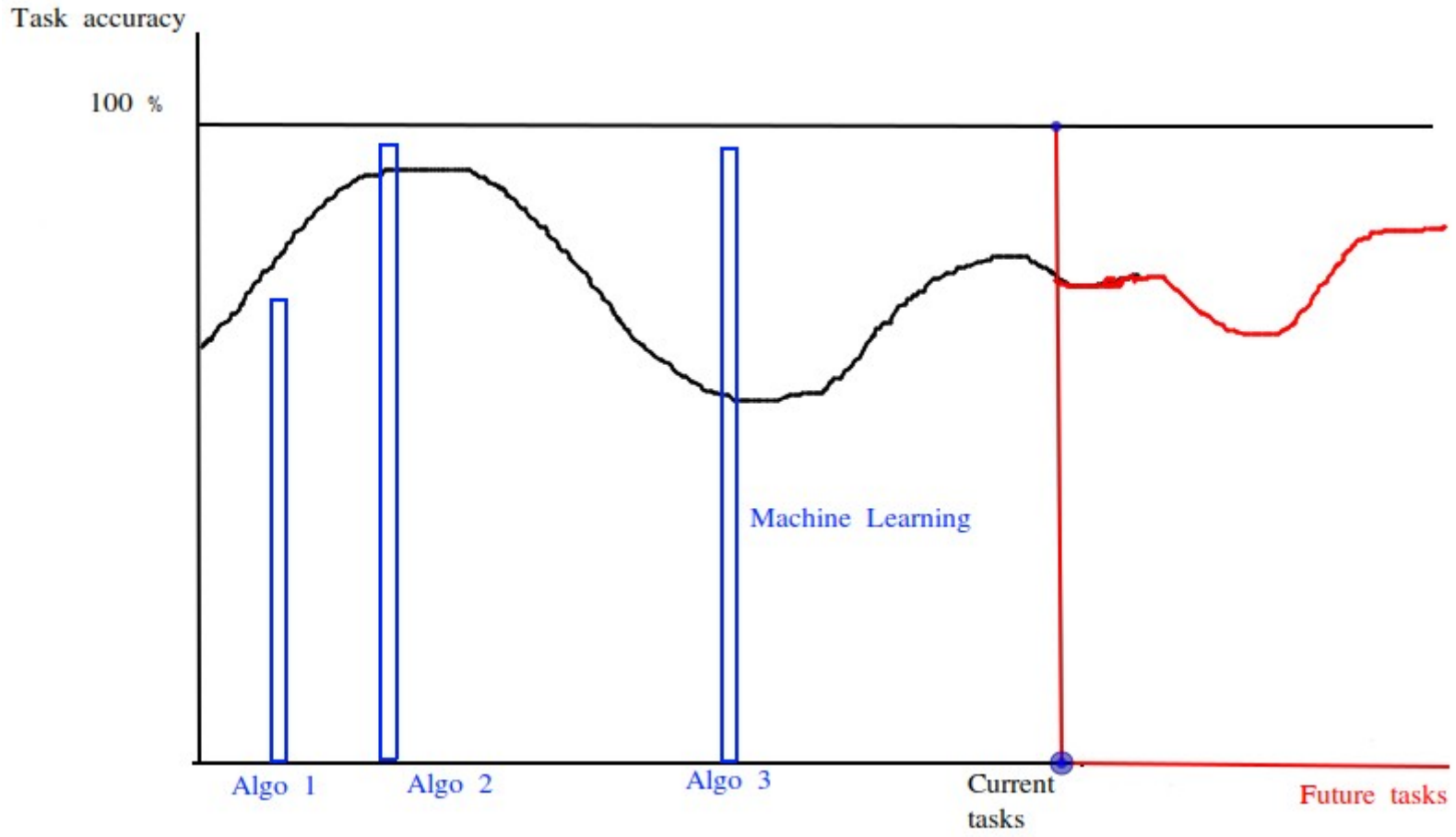


Inspired by Florian Miconi

Overall

Deep learning has made us really good at turning large datasets of perceptual inputs (images, sounds, videos) and simple human-annotated targets (e.g. the list of objects present in a picture) into models that can automatically map the inputs to the targets.
Francois Chollet

What’s next?

What's next?

Multi-task Learning

Unsupervised Learning

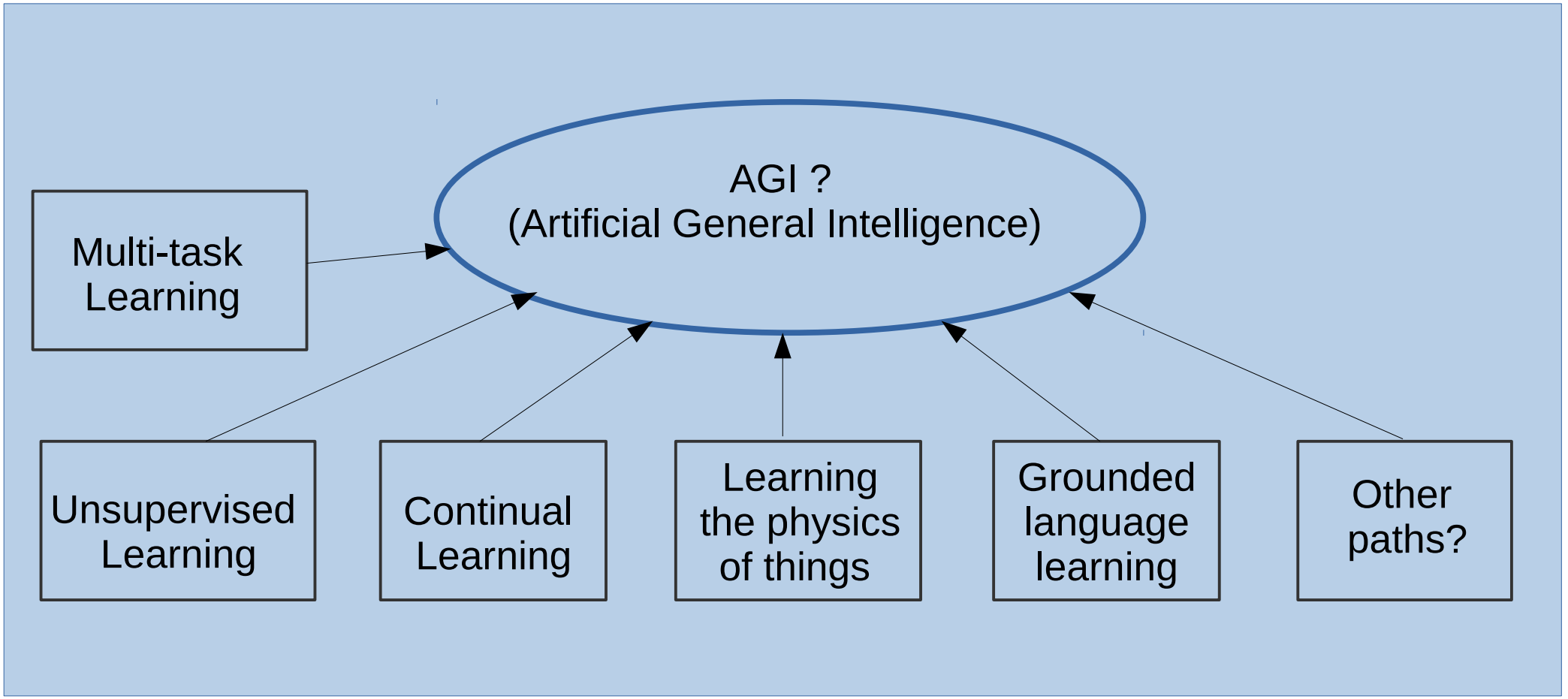
Continual Learning

Learning the physics of things

Grounded language learning

Other paths?

What's next?


AGI ?
(Artificial General Intelligence)
Multi-task Learning
Unsupervised Learning
Continual Learning
Learning the physics of things
Grounded language learning
Other paths?

What's next?

AGI ?
(Artificial General Intelligence)

Causality, future prediction – imagination, a model of the world, consciousness,

Level (Symbol)	Typical Activity	Typical Questions	Examples
1. Association $P(y\|x)$	Seeing	What is? How would seeing X change my belief in$Y$?	What does a symptom tell me about a disease? What does a survey tell us about the election results?
2. Intervention $P(y\|do(x), z)$	Doing Intervening	What if? What if I do X?	What if I take aspirin, will my headache be cured? What if we ban cigarettes?
3. Counterfactuals $P(y_x\|x', y')$	Imagining, Retrospection	Why? Was it X that caused Y? What if I had acted differently?	Was it the aspirin that stopped my headache? Would Kennedy be alive had Oswald not shot him? What if I had not been smoking the past 2 years?

source

Main Points

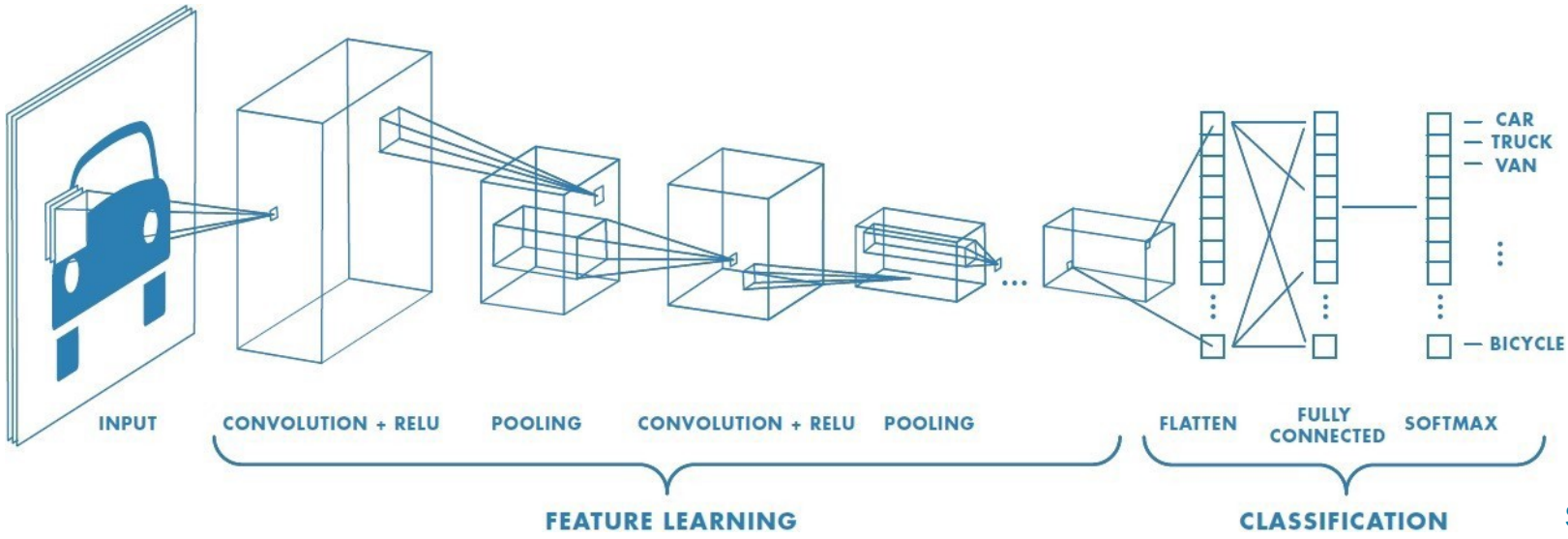
1. Applications of deep learning

2. Deep learning in 15 minutes (intuition behind)

3. Convolutional Neural Networks (CNNs)

4. The Deep Learning Meetup Strasbourg

CNNs – building blocks



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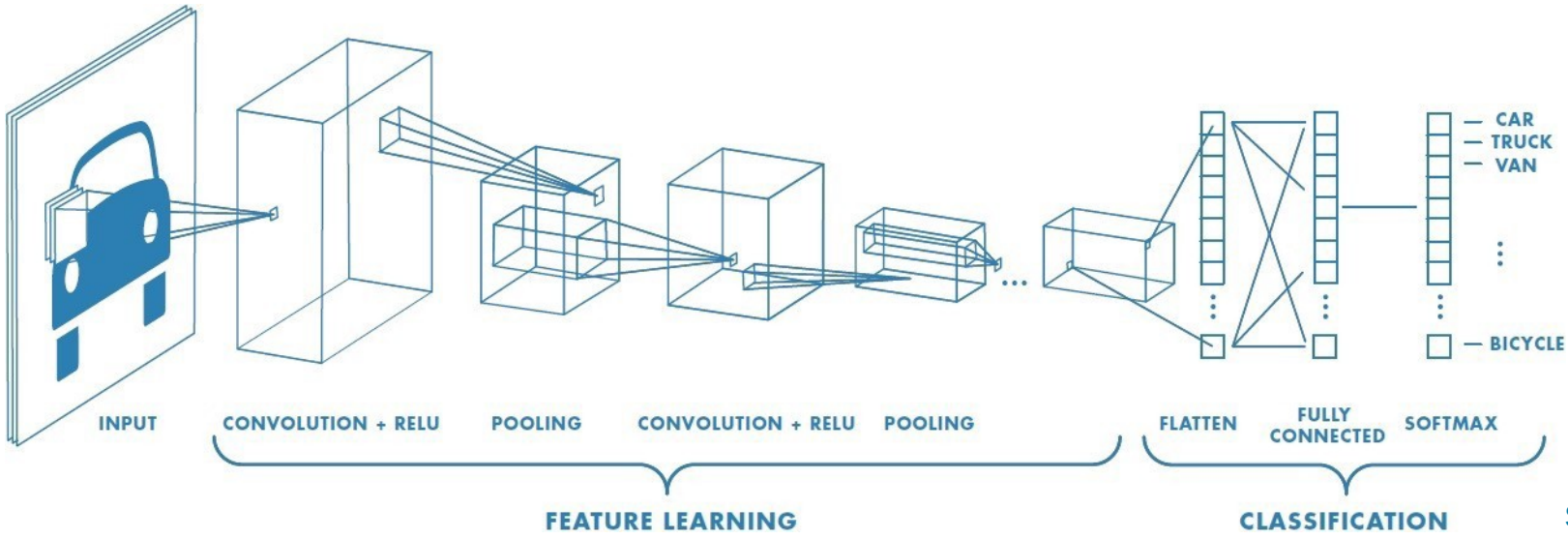
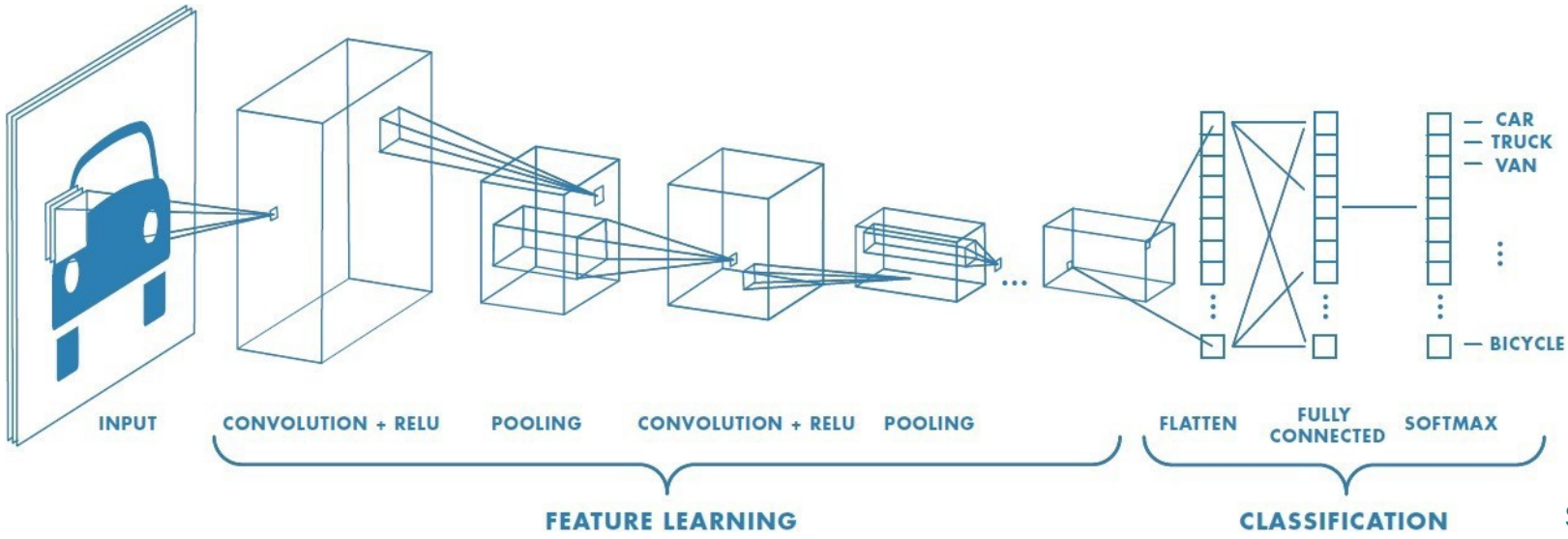
CNNs – building blocks



source

```python
def my_model(x):

    x = Conv2D(filters=4, kernel_size=(3,3),
               strides=(1,1),padding= 'same', activation='relu')(x)

    x = MaxPool2D(pool_size=(2,2), strides=(2,2), padding='valid')(x)

    x = Conv2D(filters=8, kernel_size=(3,3),
               strides=(1,1),padding= 'same', activation='relu')(x)

    x = MaxPool2D(pool_size=(2,2), strides=(2,2), padding='valid')(x)


    x = Flatten()(x)
    x = Dense(nb_classes, activation='softmax')(x)

    return x
```

CNNs – building blocks



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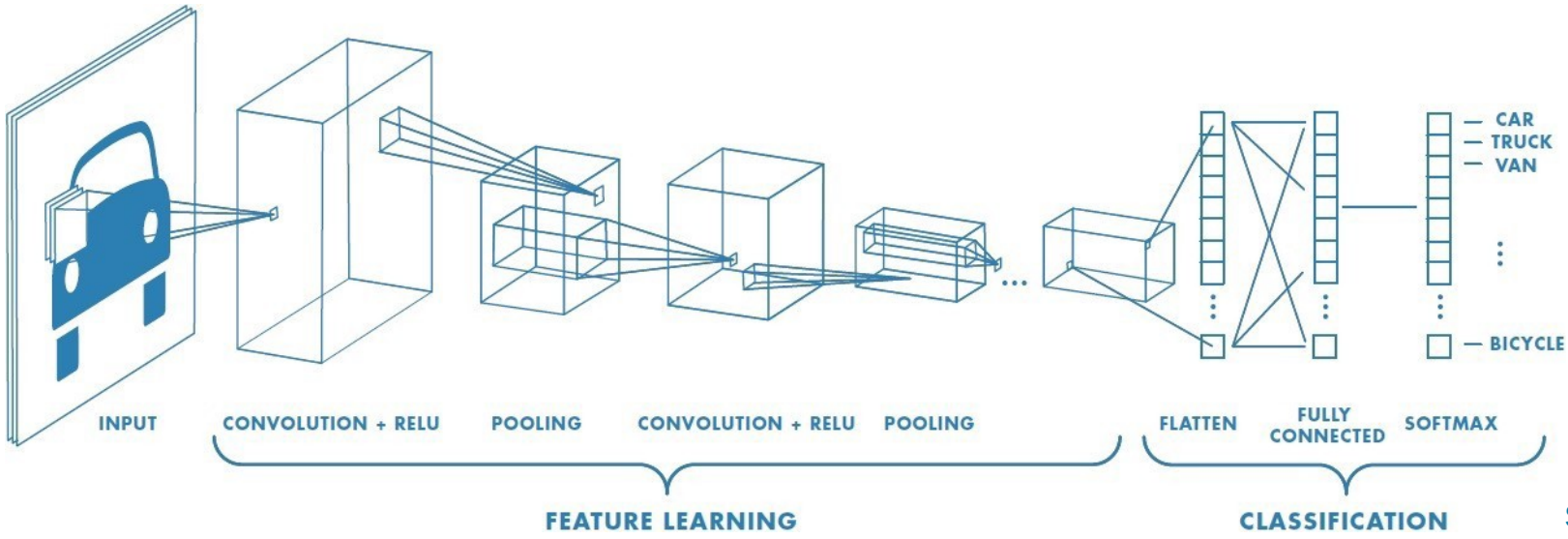
Forward propagation

CNNs – building blocks



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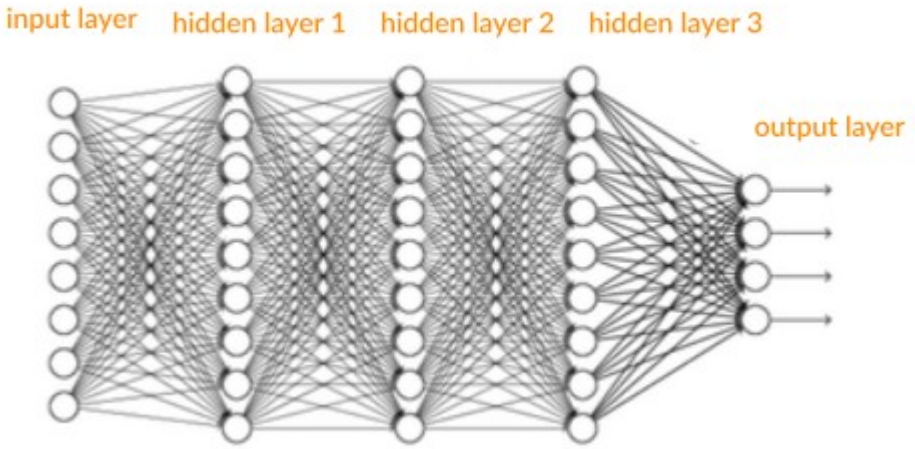
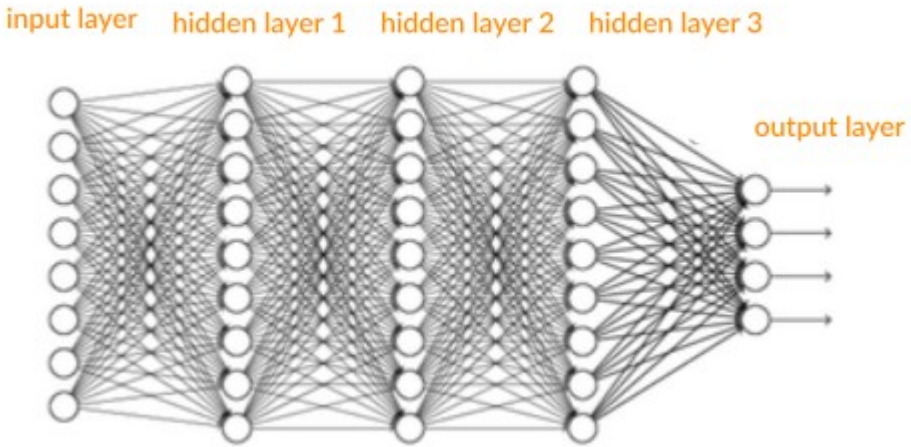
Backward propagation (backprop)

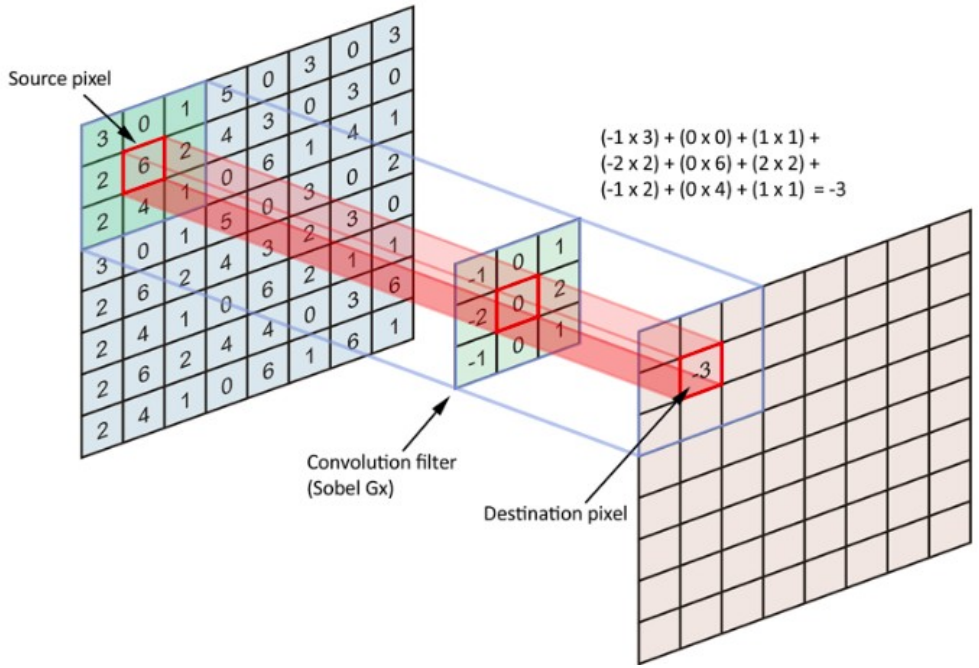
Fully connected layers (networks) and convolutional layers (networks)



Pros and cons regarding
fully connected layers

Fully connected layers (networks) and convolutional layers (networks)

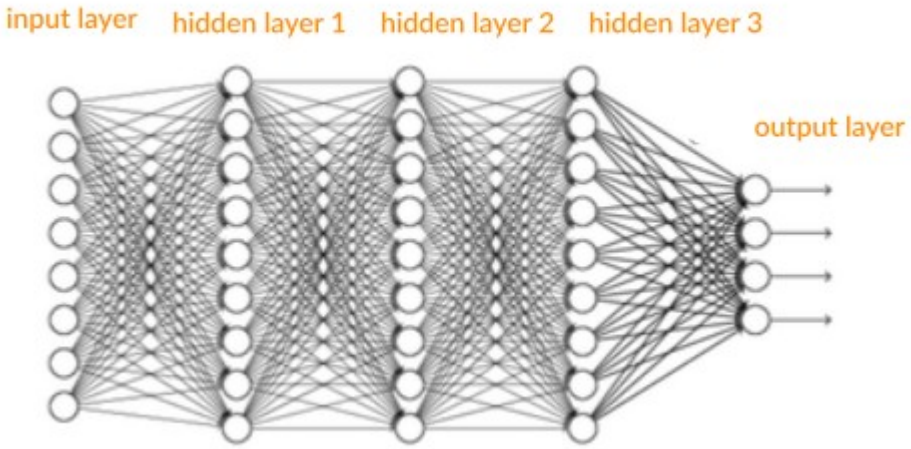


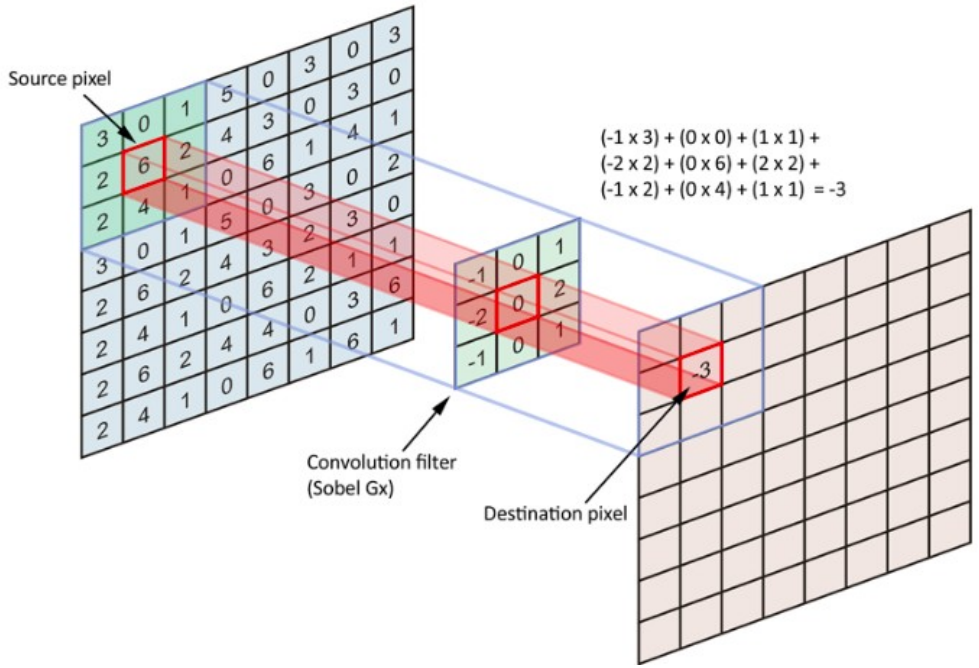


Pros and cons regarding fully connected layers

Pros and cons regarding convolutional layers

Fully connected layers and convolutional layers



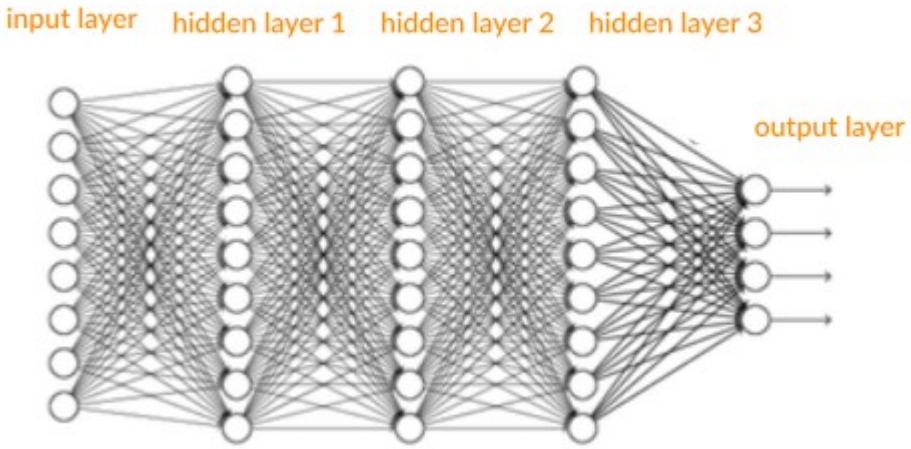


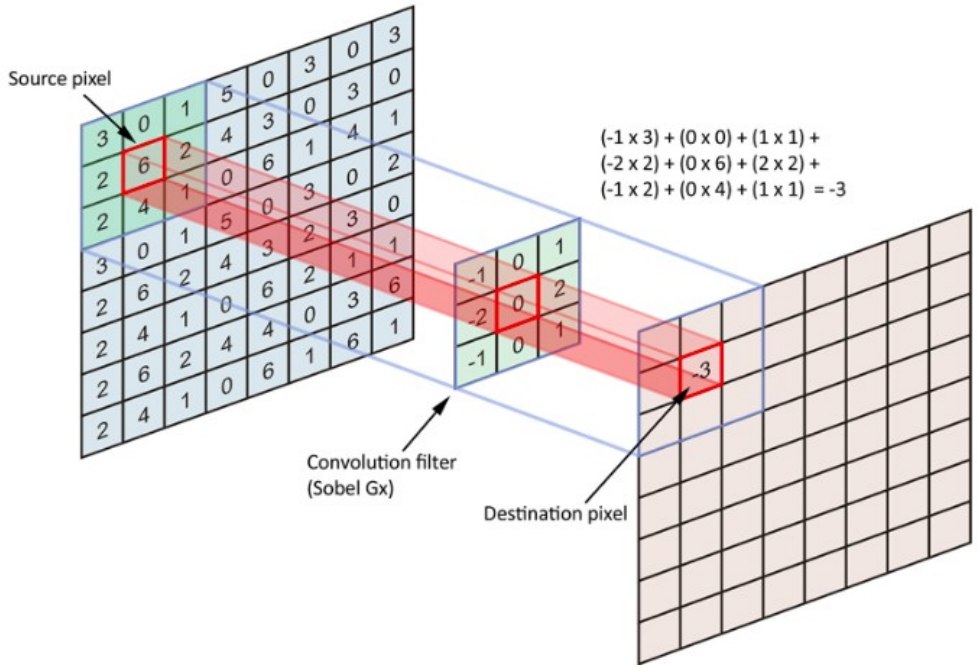
Pros and cons regarding
fully connected layers

Pros and cons regarding
convolutional layers

For an interesting discussion on CNNs' drawbacks, watch G Hinton's talk: link

Fully connected layers and convolutional layers





Pros and cons regarding
fully connected layers

Pros and cons regarding
convolutional layers

Nonetheless CNNs are a very powerful tool today in the deep learning arsenal.

Convolutional filters

Why do we need convolutional filters?

Convolutional filters

Why do we need convolutional filters?

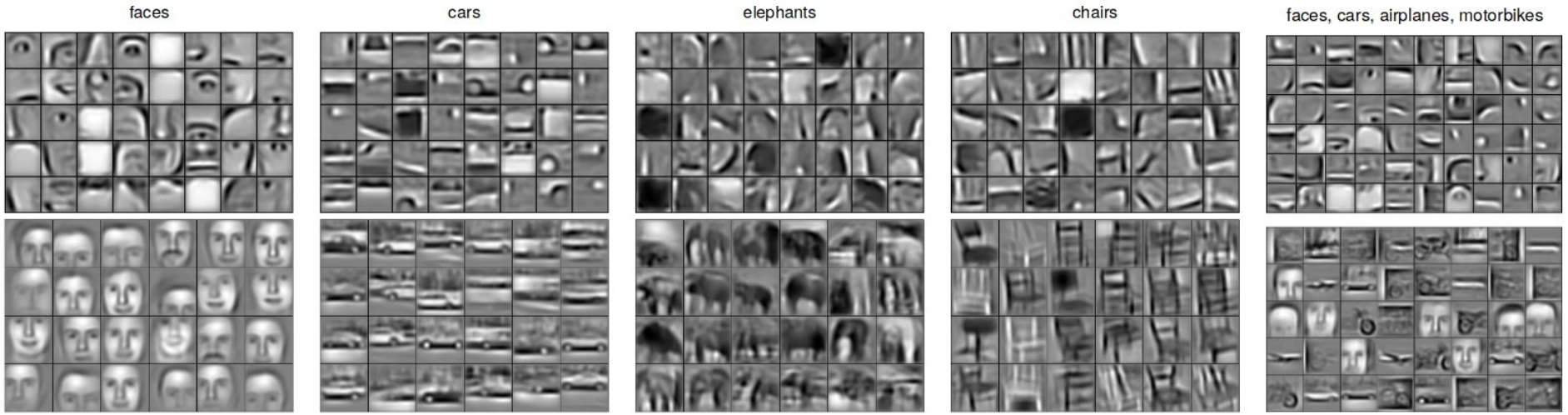
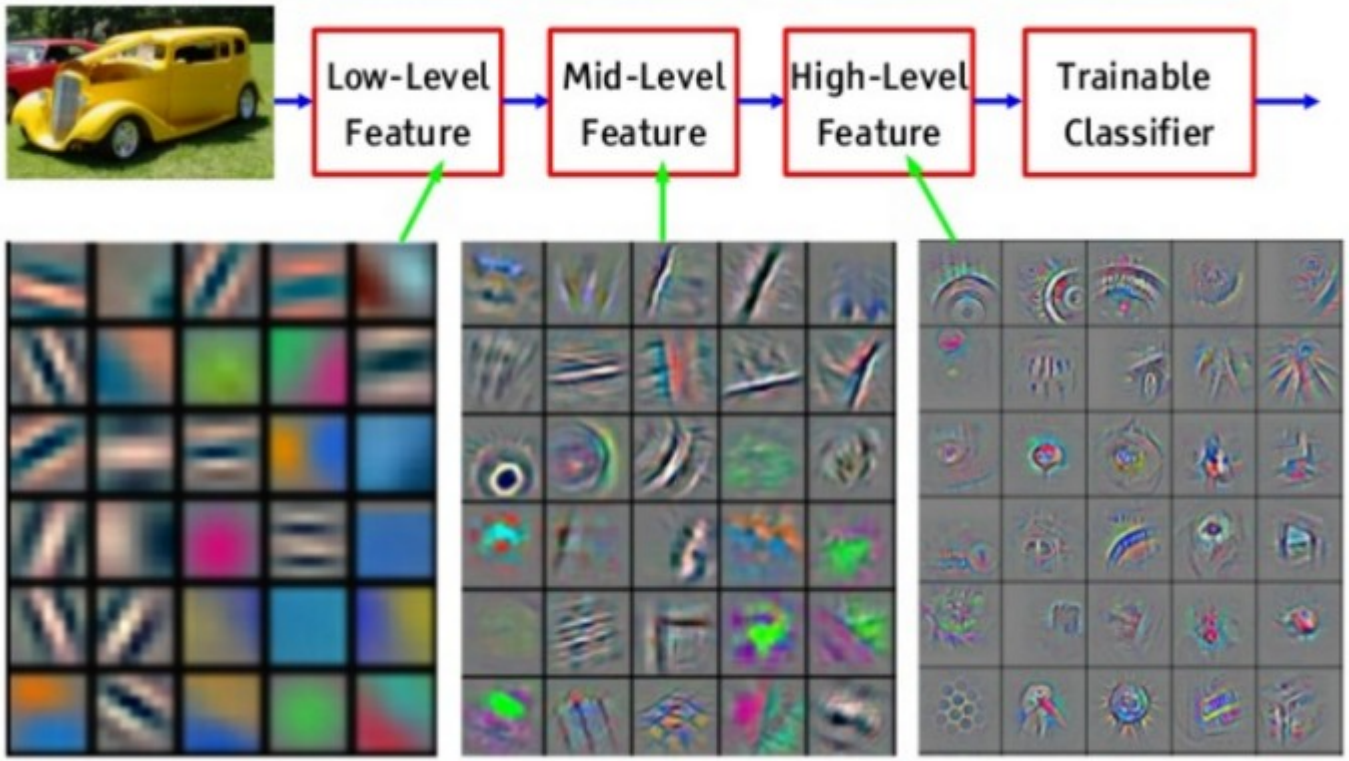


Figure 3. Columns 1-4: the second layer bases (top) and the third layer bases (bottom) learned from specific object categories. Column 5: the second layer bases (top) and the third layer bases (bottom) learned from a mixture of four object categories (faces, cars, airplanes, motorbikes).

source

Convolutional filters

Why do we need convolutional filters?

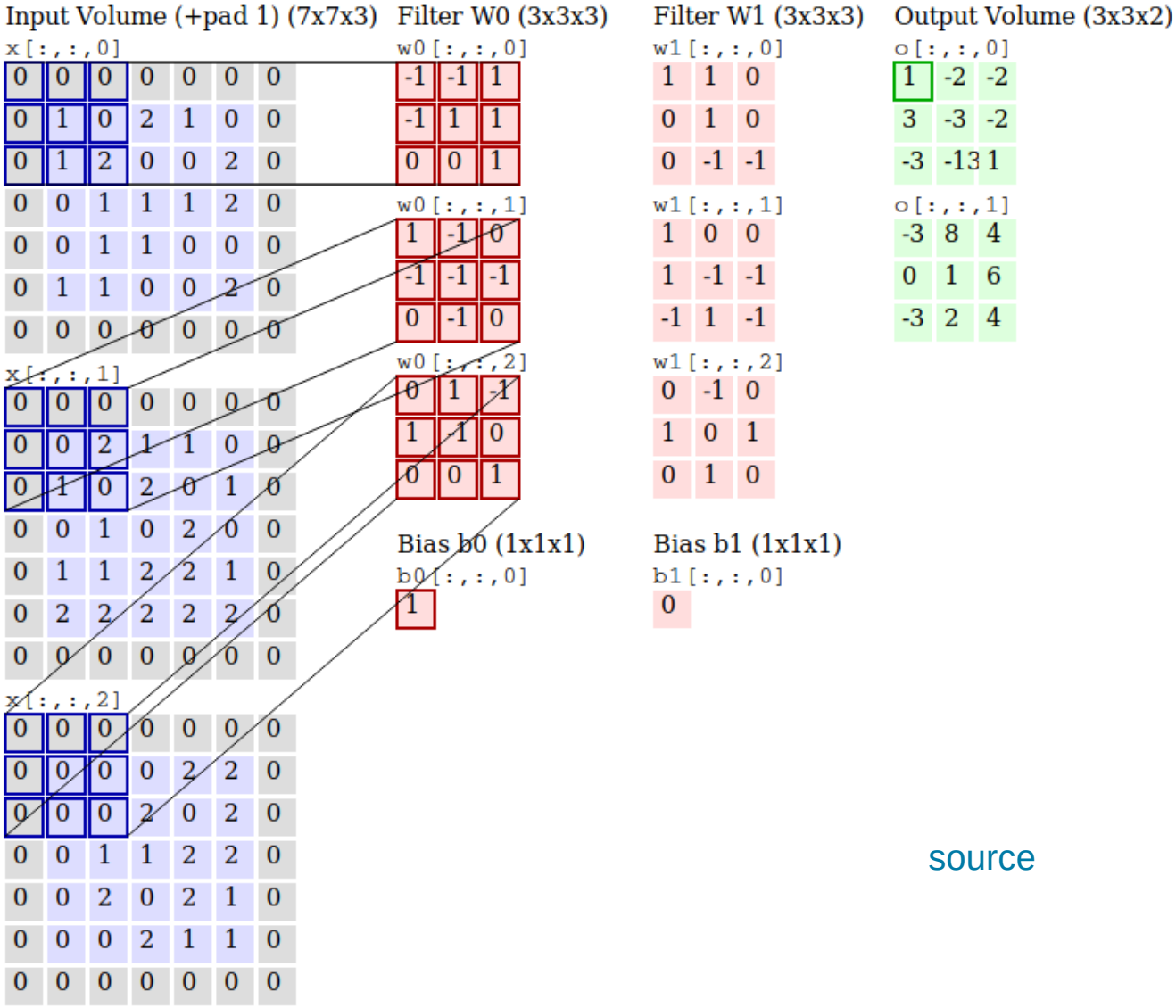


Adapted from source

Convolutional filters

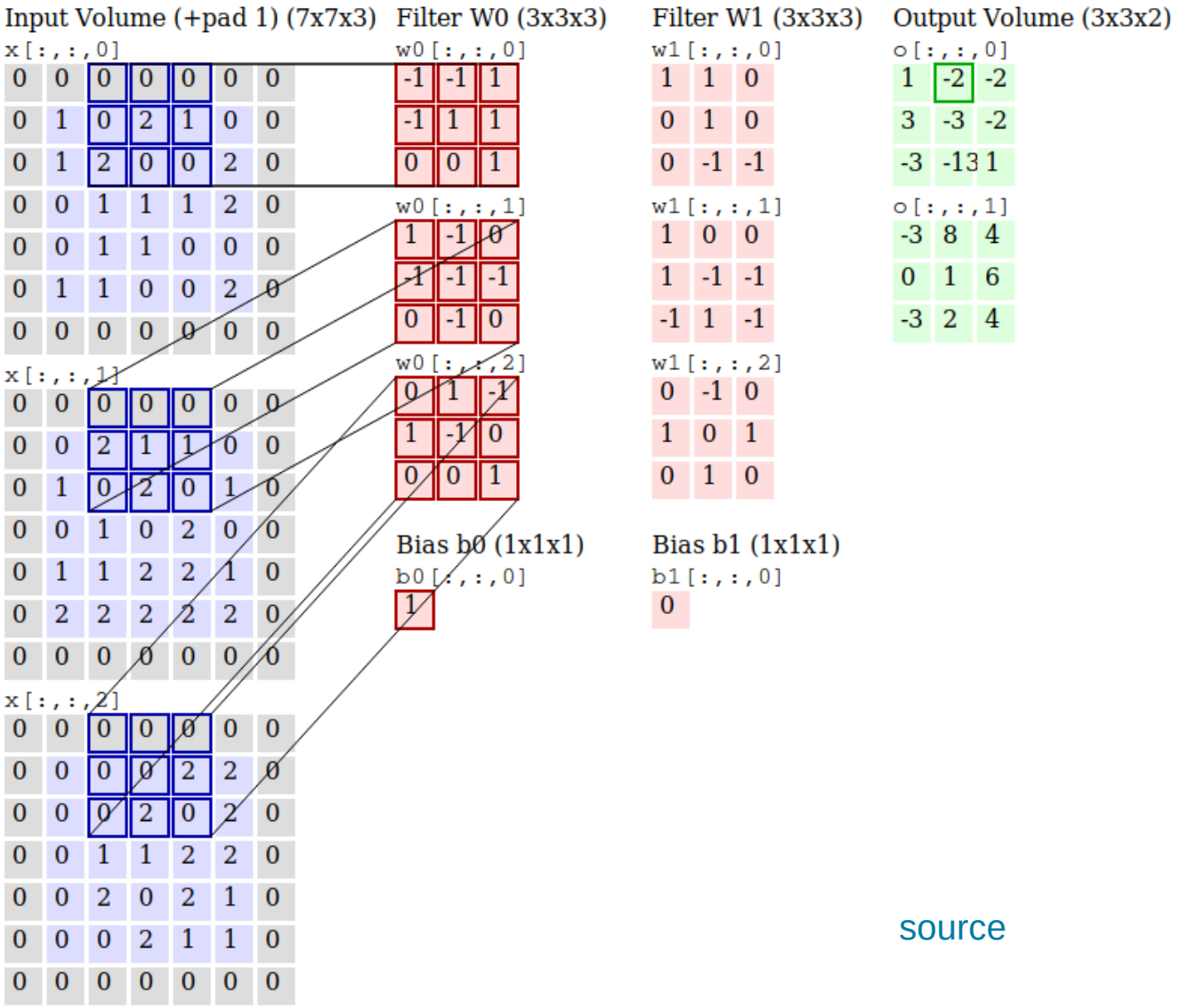
How do they work?

Convolution filters, stride and padding



source

Convolution filters, stride and padding



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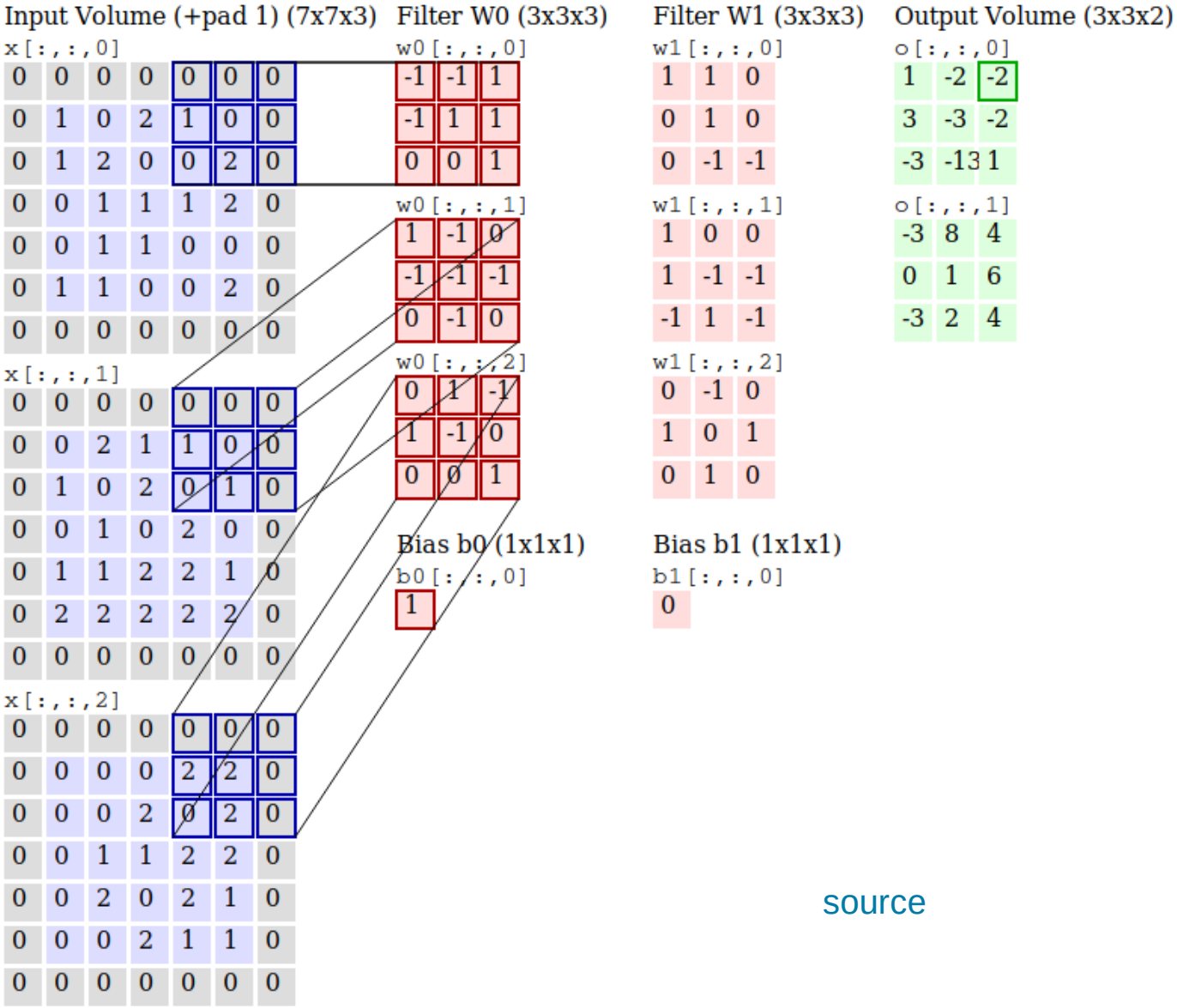

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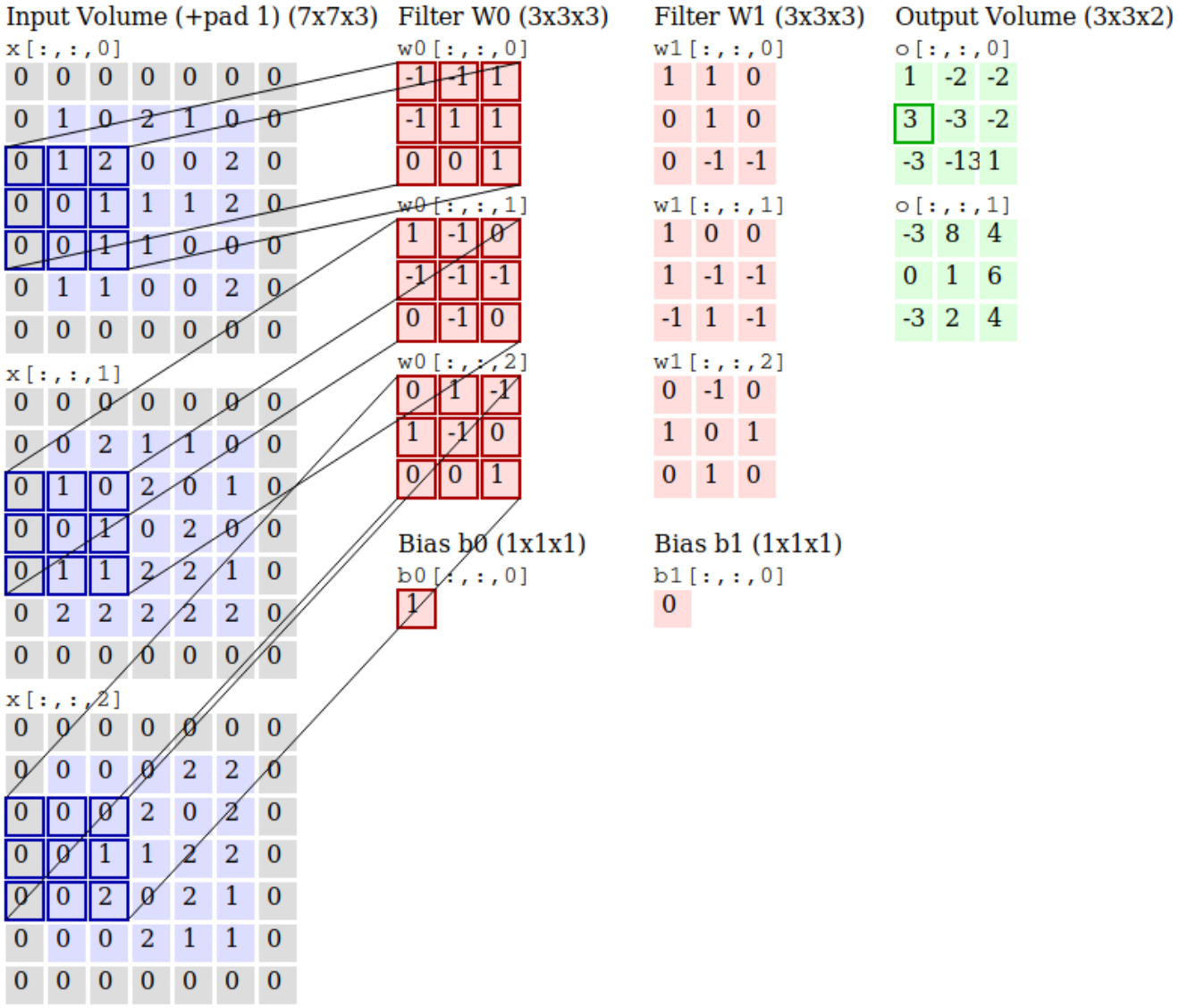

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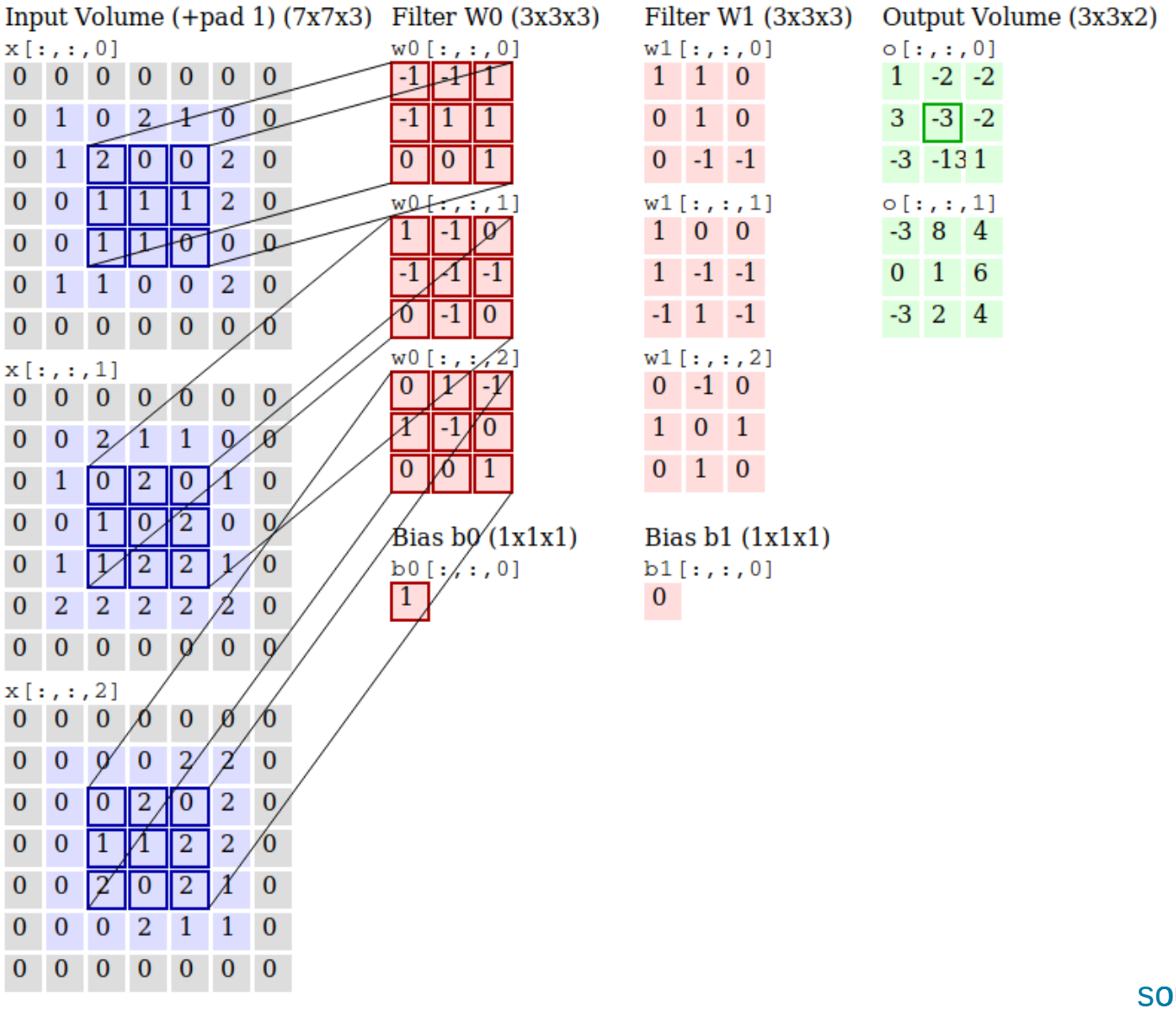

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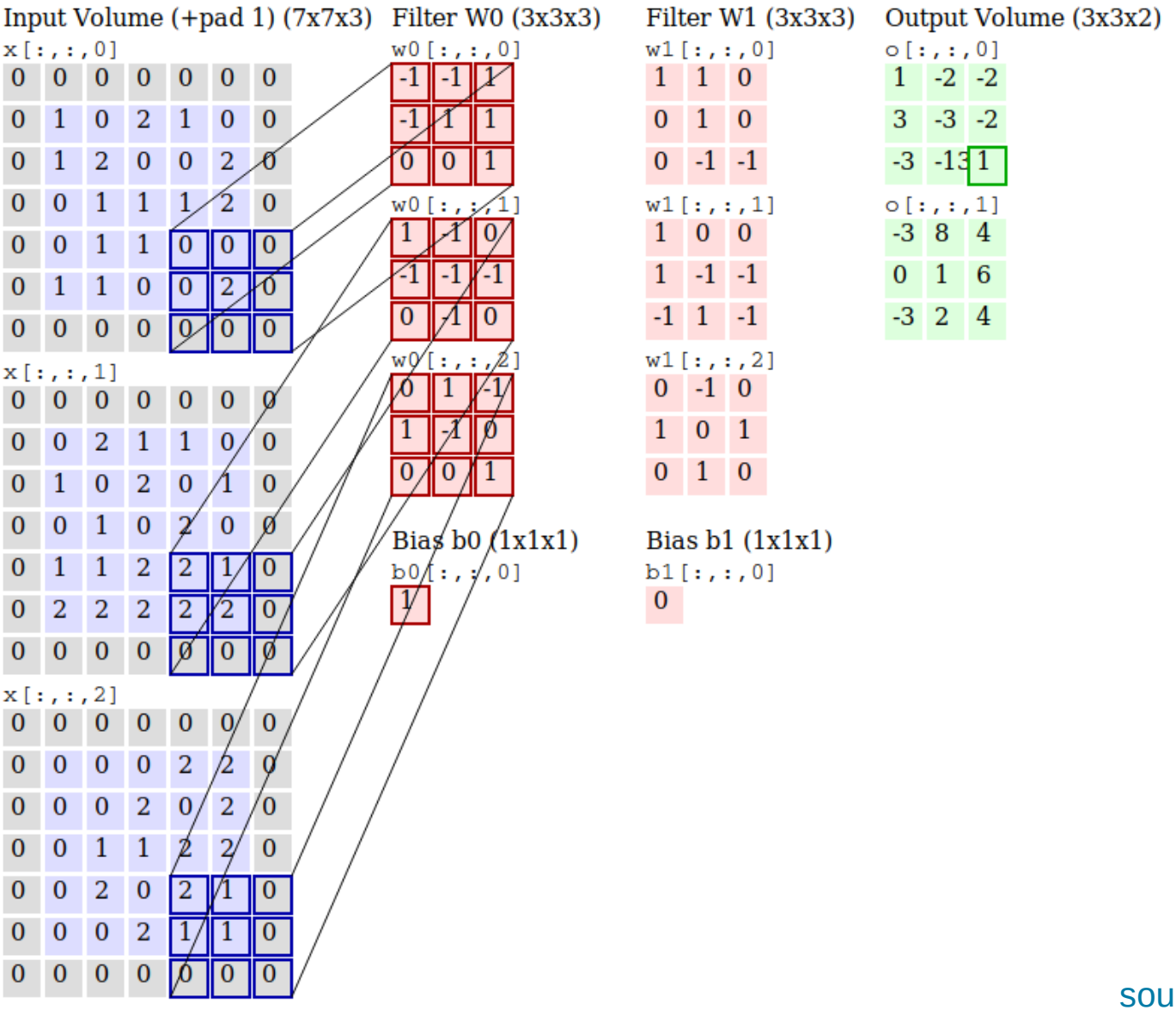
Convolution filters, stride and padding

...

Convolution filters, stride and padding



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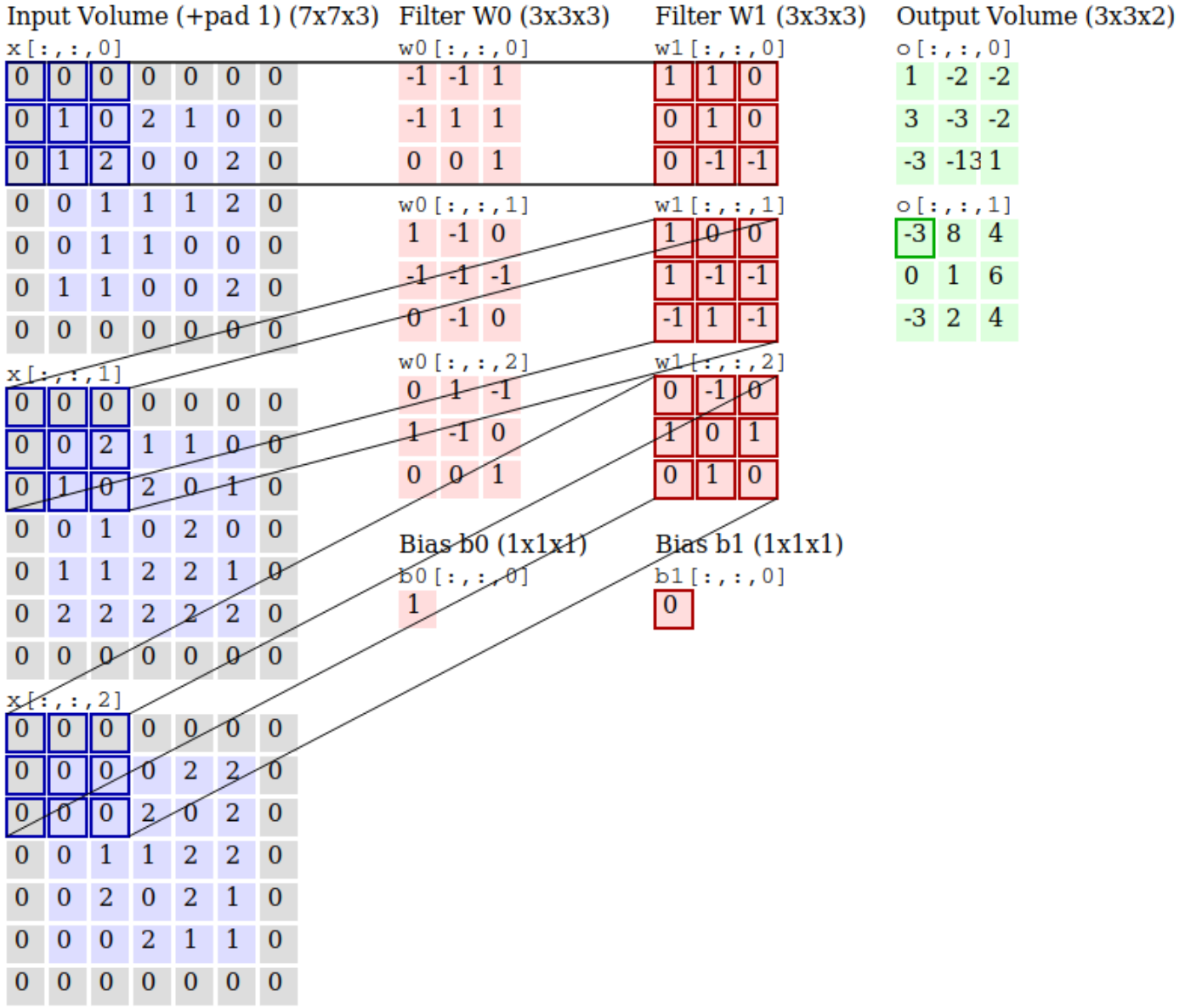

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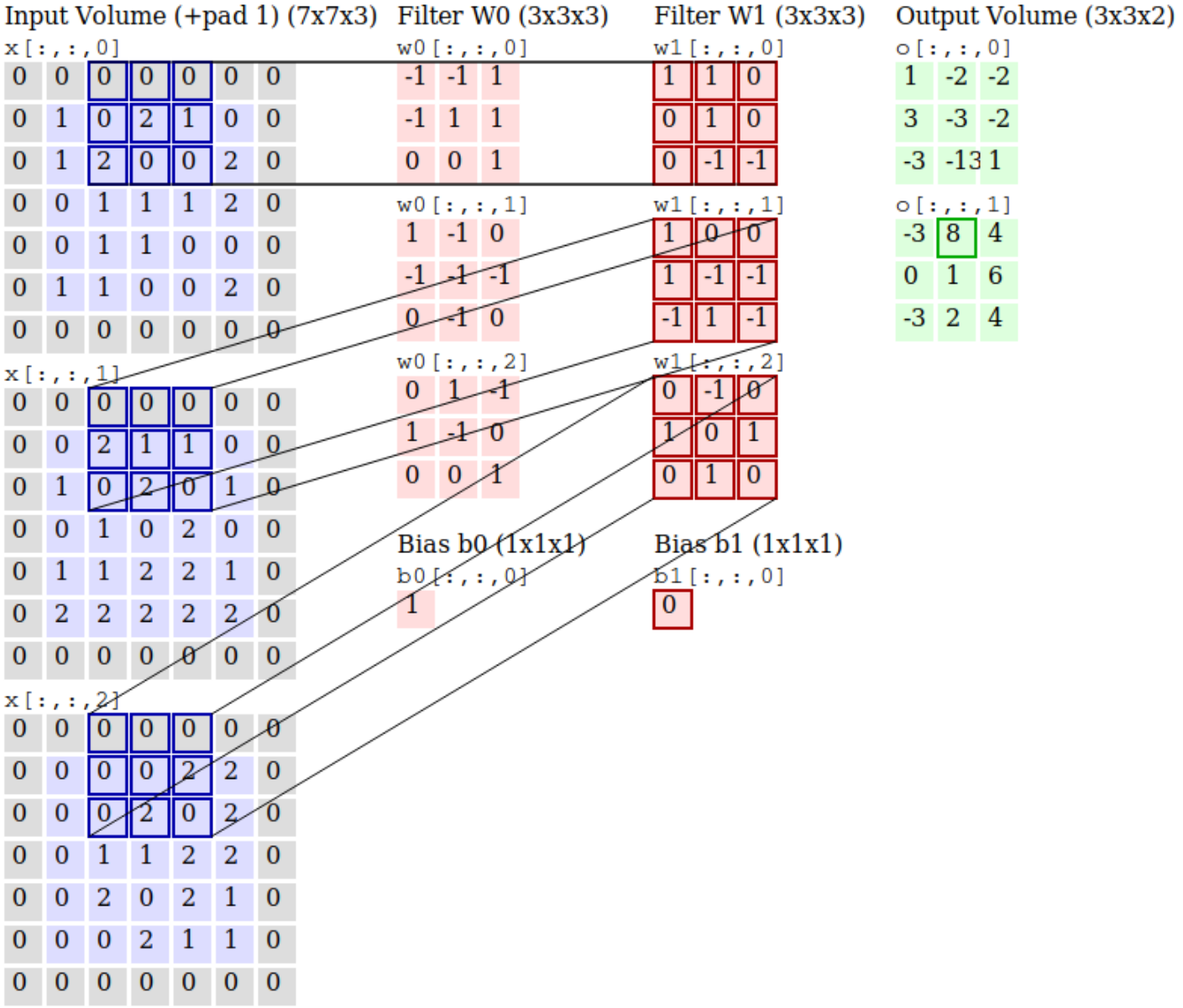

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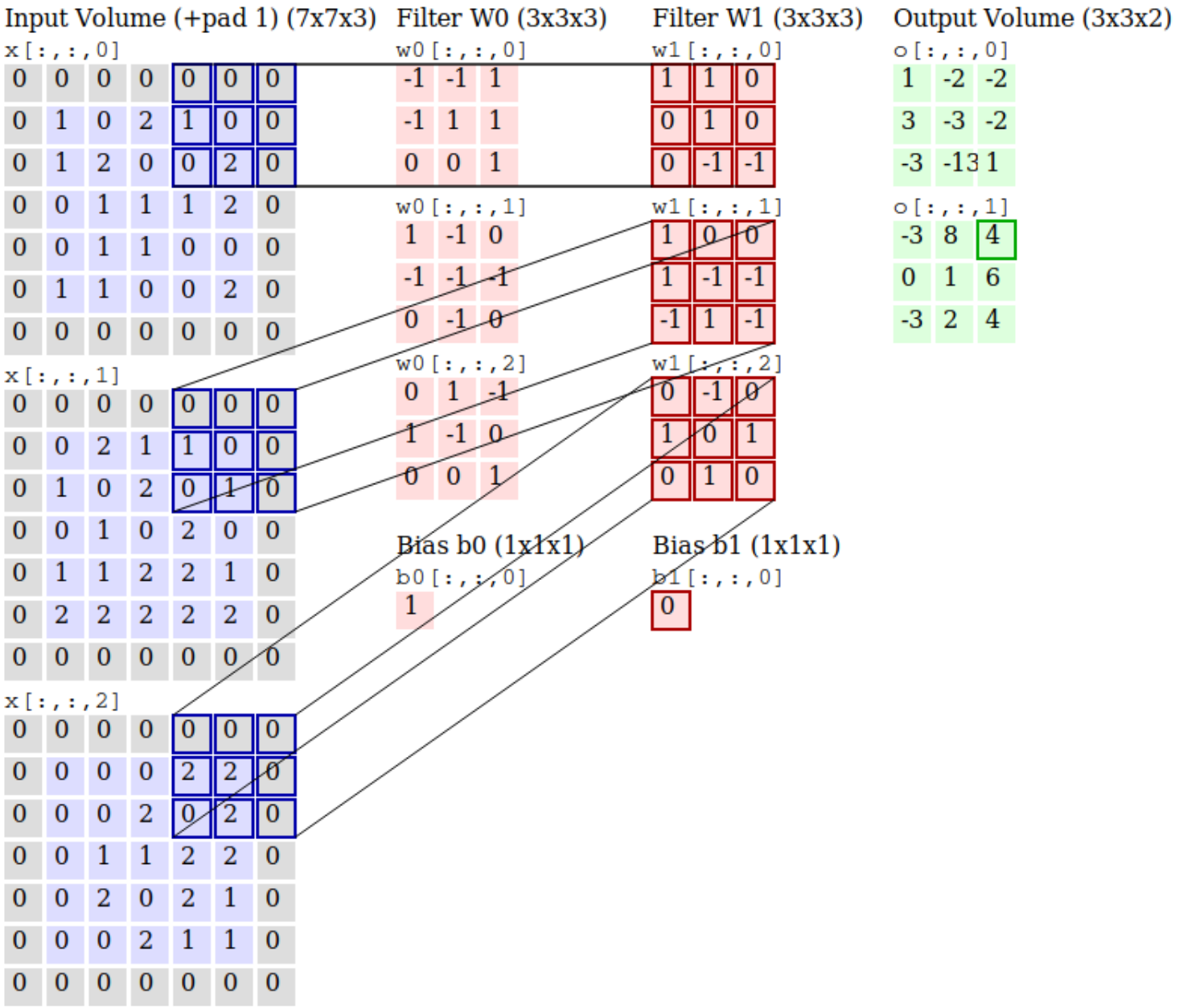

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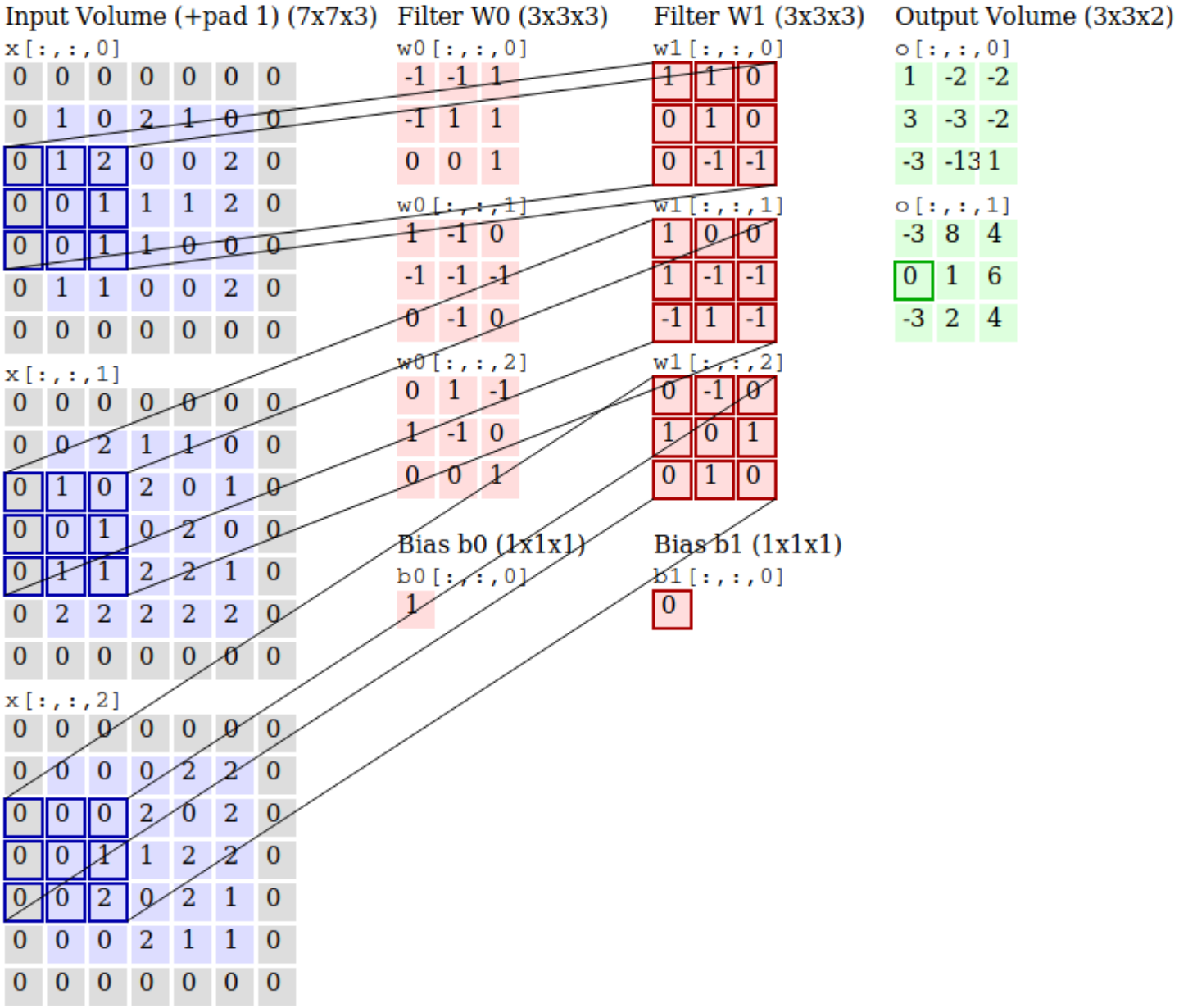
Convolution filters, stride and padding



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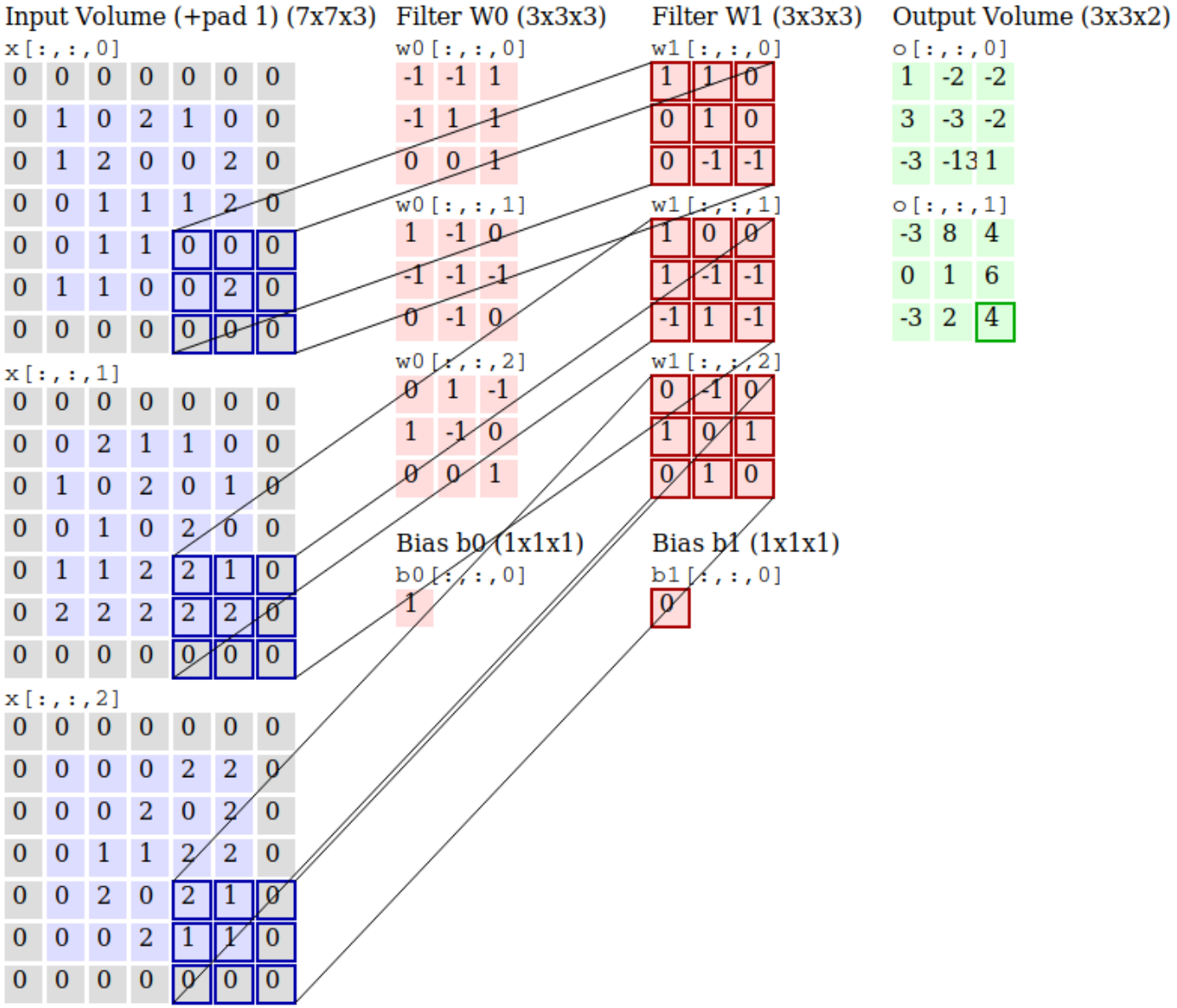
Convolution filters, stride and padding

...

Convolution filters, stride and padding



source

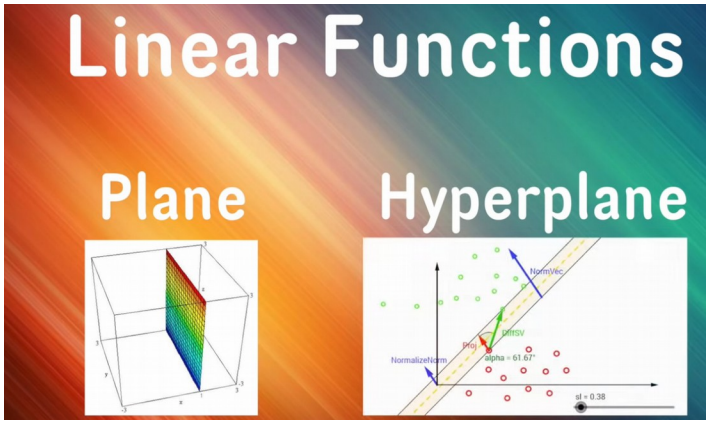
Activation functions

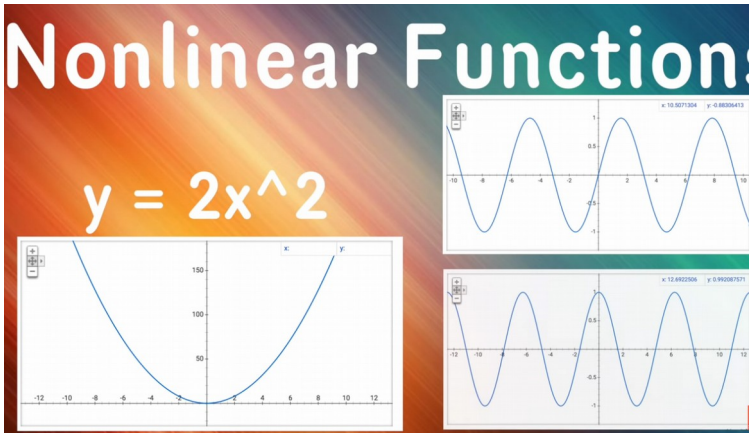
Why do we need activation functions?

Activation functions

Why do we need activation functions?

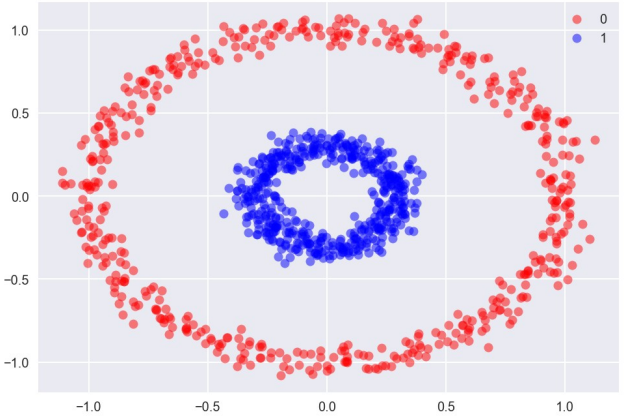
To improve the expressive power of the network (neural networks are universal function appproximators).





source

How do we separate the blue and red points with a hyperplane?



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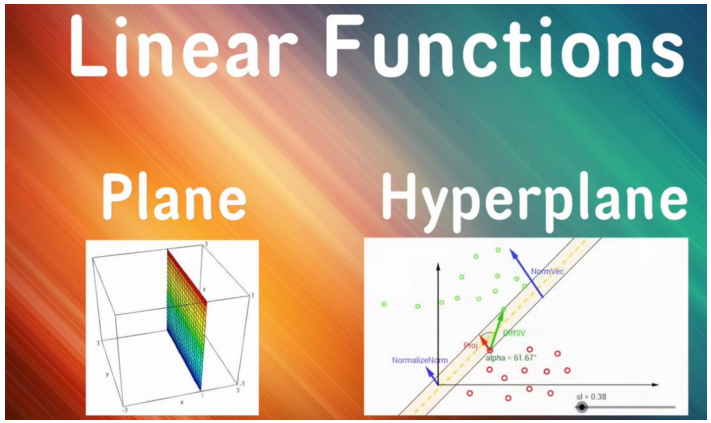

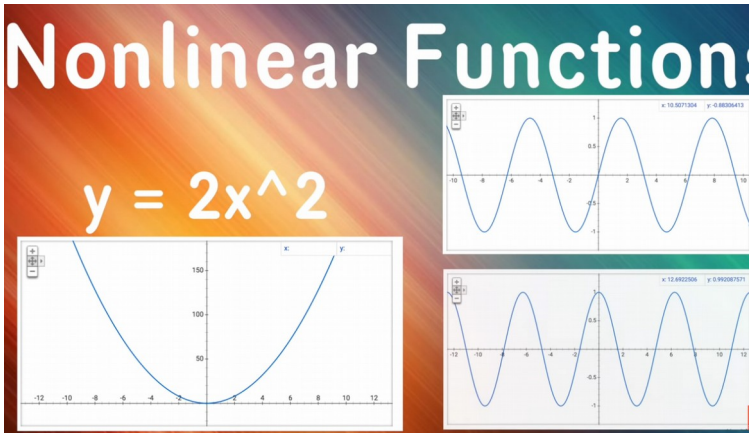

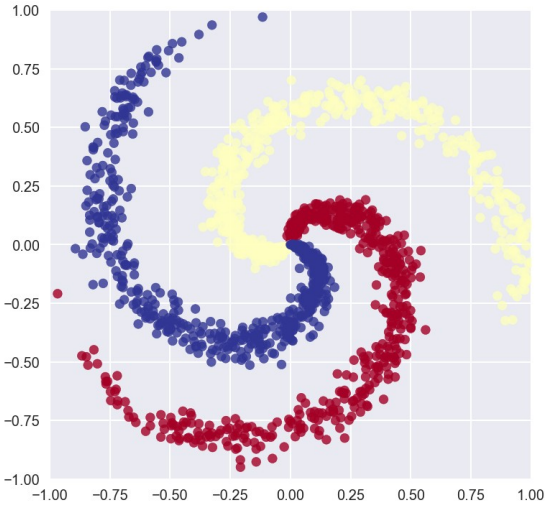

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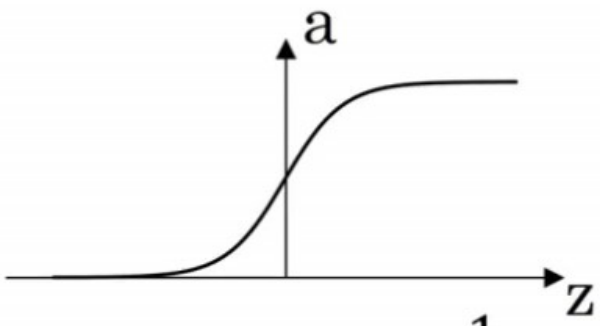
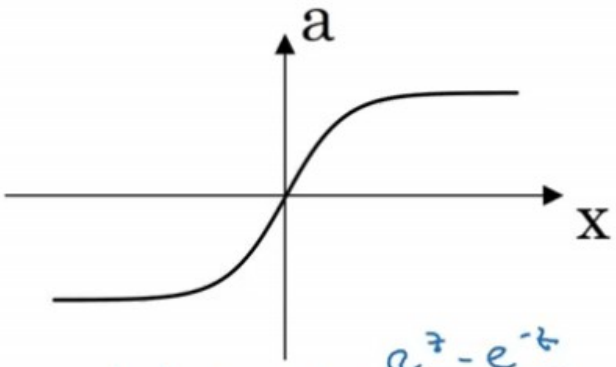
How do we separate the blue and red points with a hyperplane?

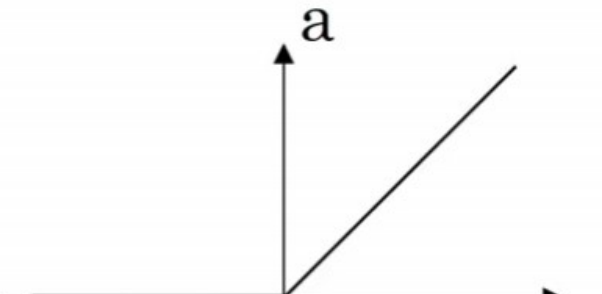
Activation functions



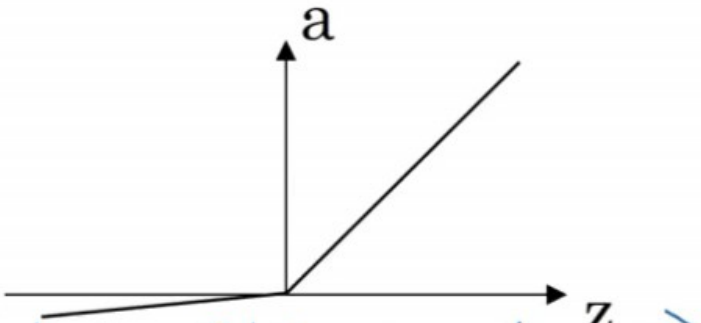
sigmoid: $a = \frac{1}{1+e^{-z}}$



tanh: $a = \frac{e^{z}-e^{-z}}{e^{z}+e^{-z}}$



ReLU $a = \max(0, z)$



Leaky ReLU $a = \max(0.01z, z)$

Andrew Ng

source

Pooling Layers

Why do we need pooling layers?

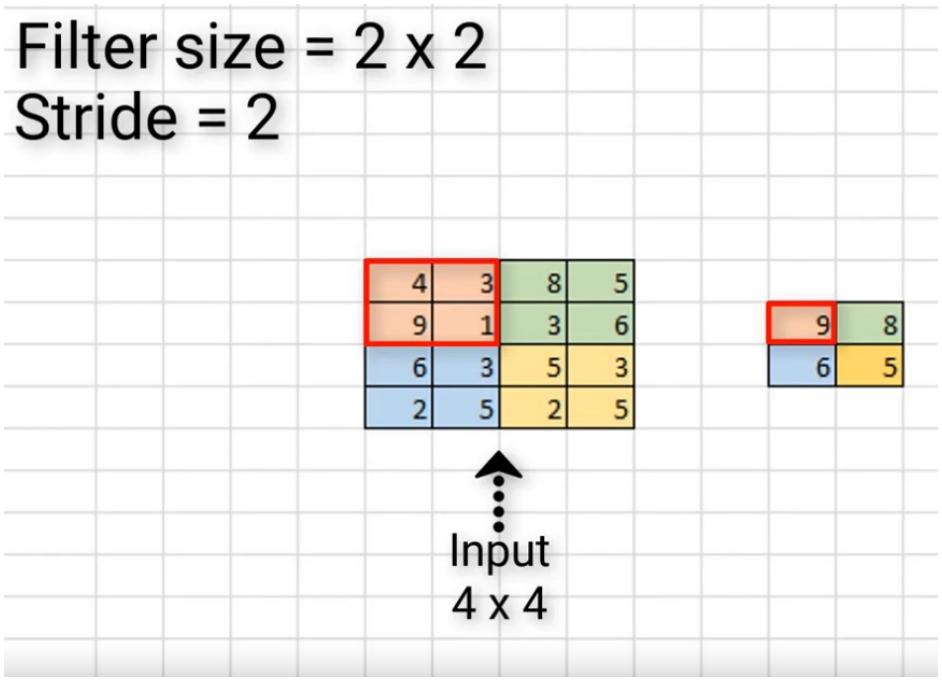
Pooling Layers

Why do we need pooling layers?

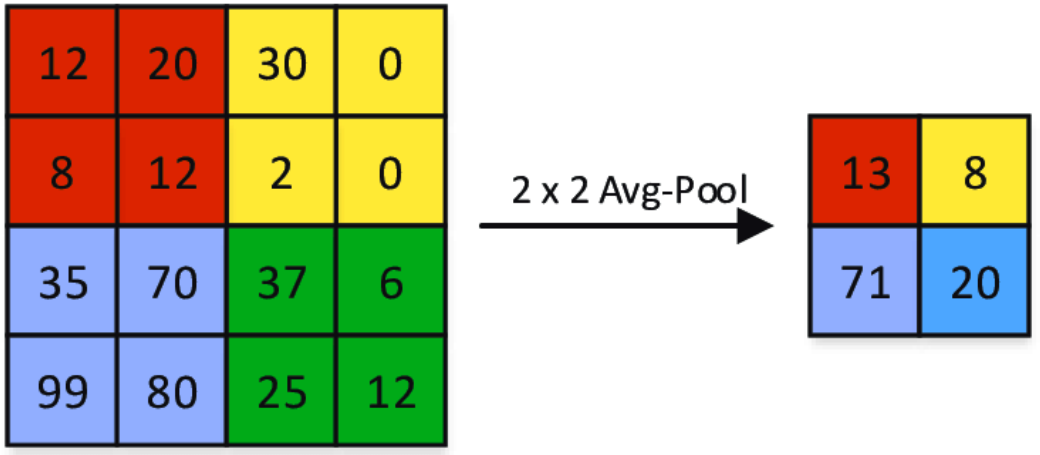
- reduce the number of parameters (control overfitting)

Pooling Layers

How does it work?

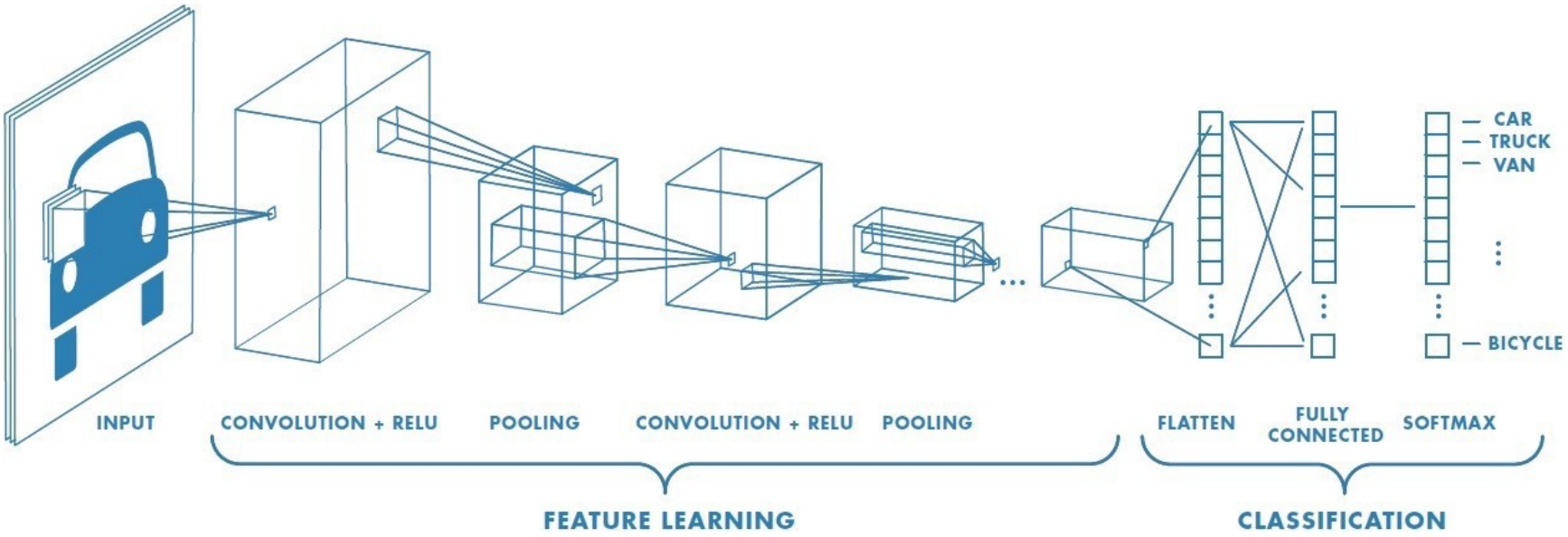


Max pooling, source

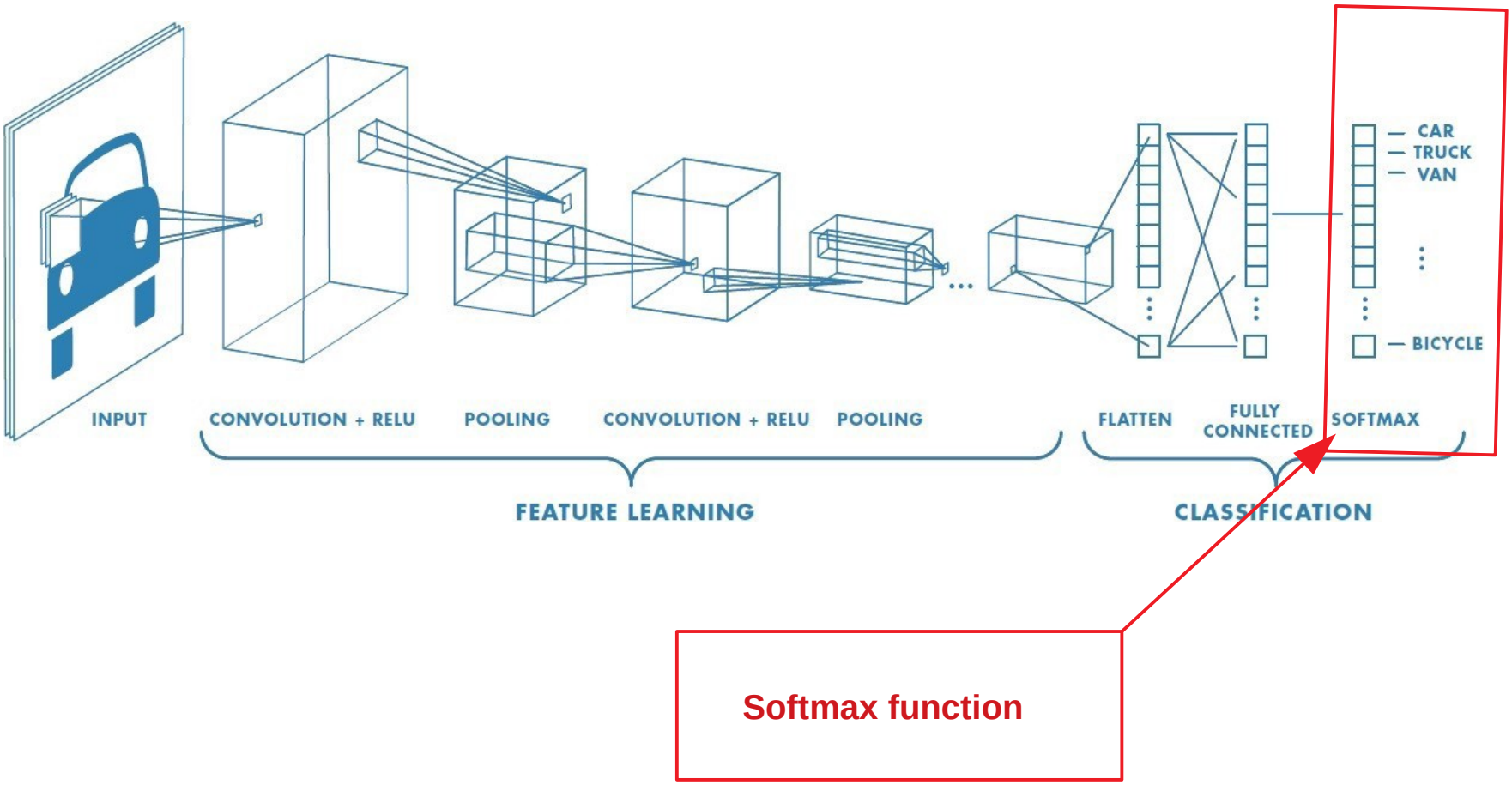


Average pooling, link

All together



All together

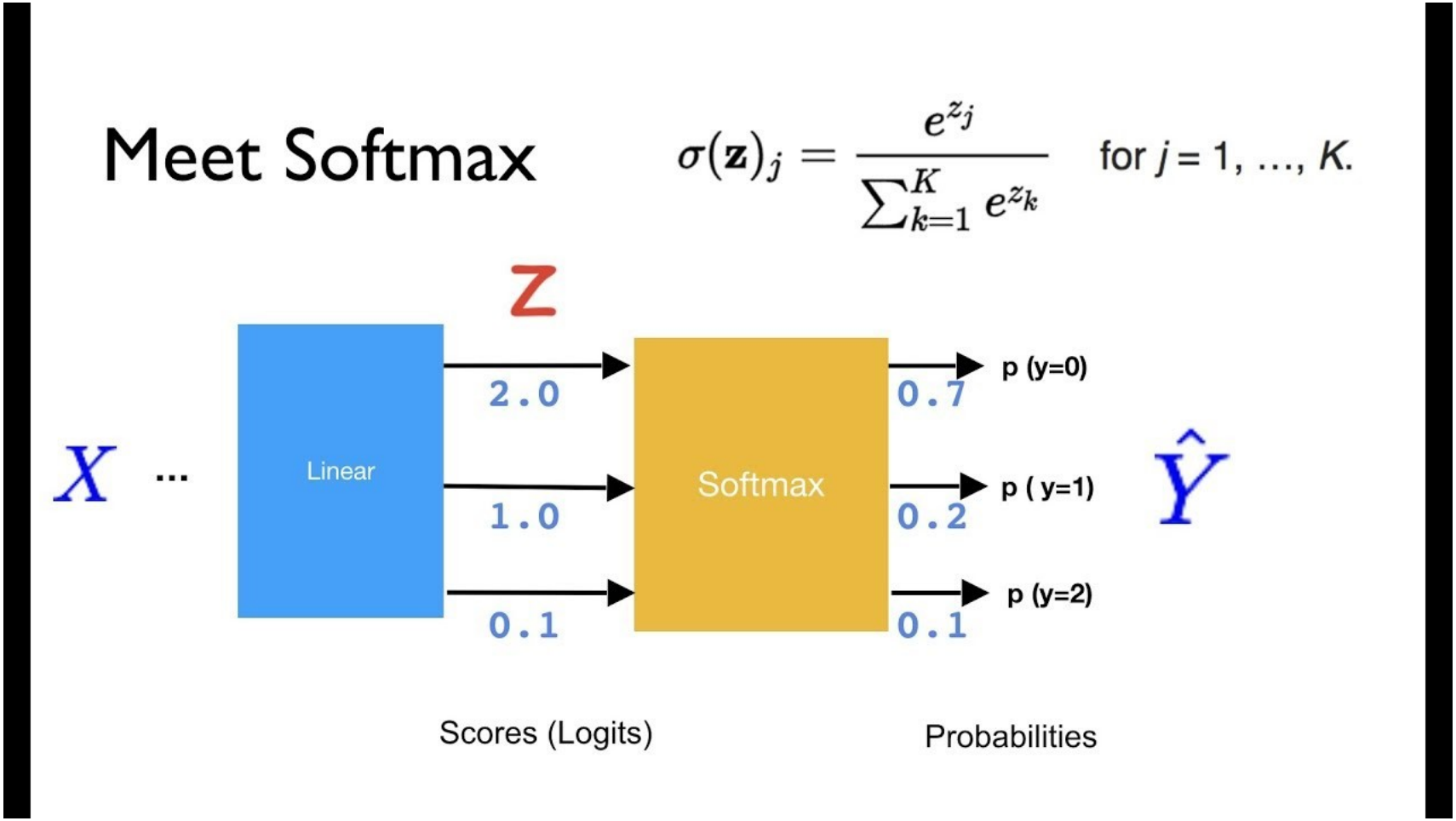


Softmax Function

Why do we need softmax function?

Softmax Function

Why do we need softmax function?



source

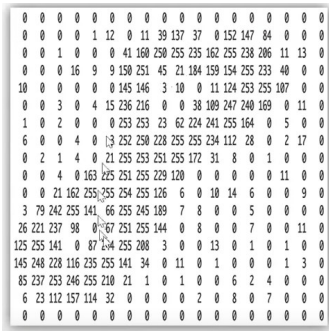
Loss Functions

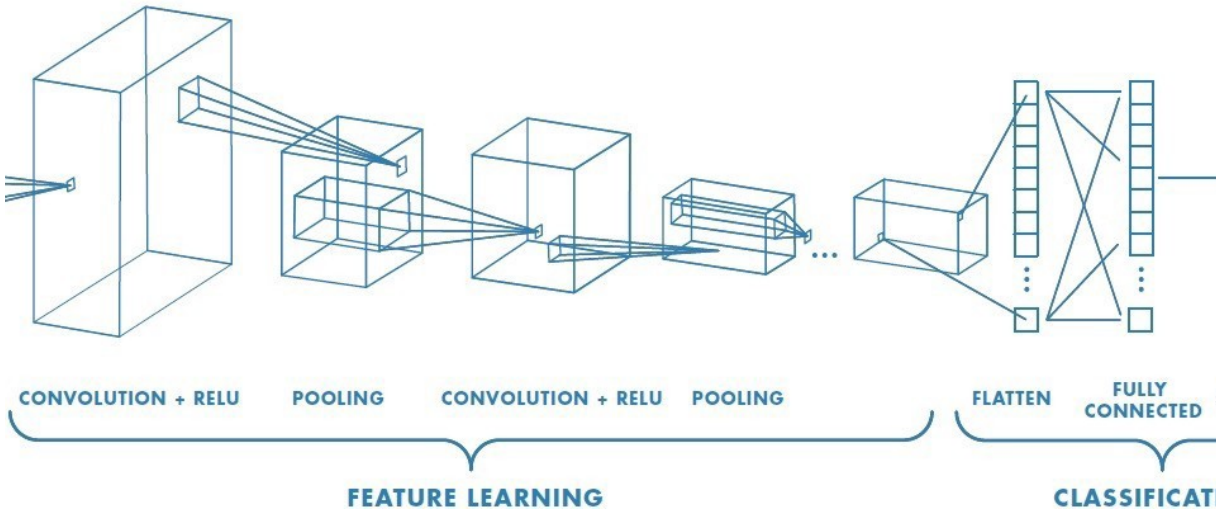
Why do we need loss functions?

Loss Functions

Why do we need loss functions?

- a way to measure how good the network performs (supervised learning)





Number	Prob
0	0.01
1	0.03
2	0.03
3	0.04
4	0.07
5	0.08
6	0.10
7	0.02
8	0.59
9	0.01

Loss Functions

Ex: regression

Residual

$$r = y - \hat{y}$$

Squarred Error

$$\mathrm{MSE} = \frac{1}{n}\sum_{i=1}^{n}(Y_i - \hat{Y}_i)^2.$$

L1 (Laplace) loss

$$\ell(r) = |r|$$

source

Loss Functions

Residual

$r = y - \hat{y}$ **Not robust**

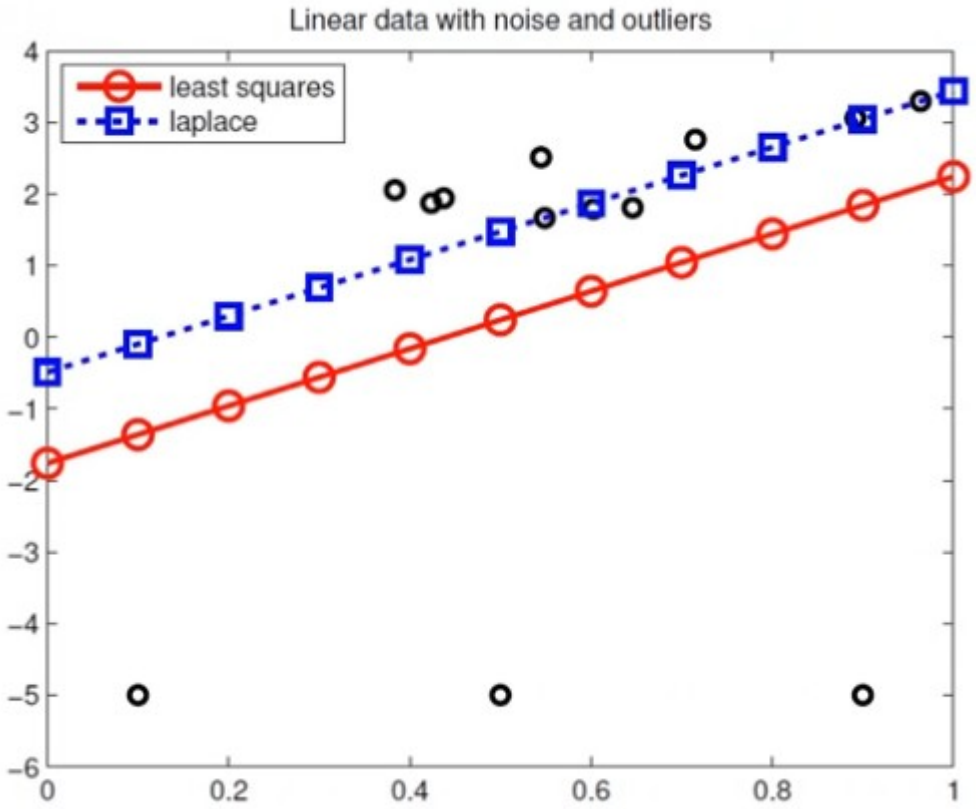
Mean Squarred Error

$$\mathrm{MSE} = \frac{1}{n}\sum_{i=1}^{n}(Y_i - \hat{Y}_i)^2.$$

L1 (Laplace) loss

$\ell(r) = |r|$ **Not differentiable**

y	$\hat{y}$	$\lvert r\rvert = \lvert y-\hat{y}\rvert$	$r^2 = (y-\hat{y})^2$
1	0	1	1
5	0	5	25
10	0	10	100
50	0	50	2500



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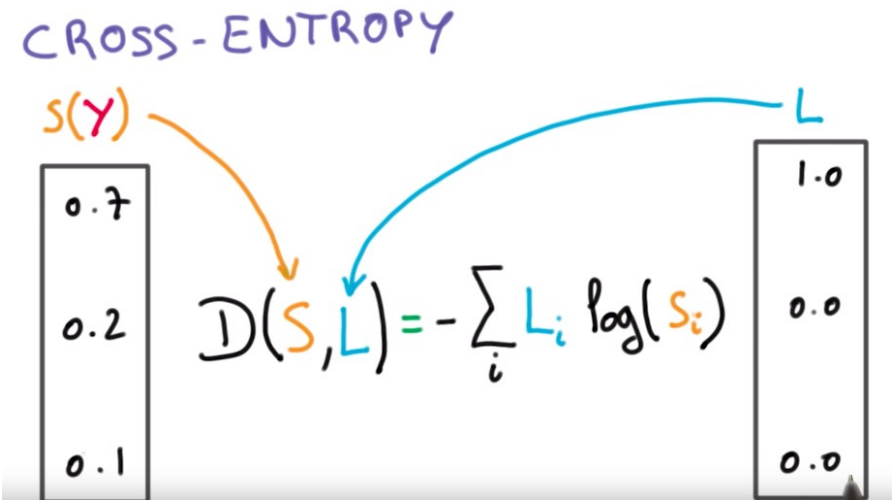
Loss Functions

Cross Entropy Loss

$$J = -\frac{1}{N}\left(\sum_{i=1}^{N} \mathbf{y_i} \cdot \log(\hat{\mathbf{y}}_\mathbf{i})\right)$$



Loss Functions

YOLO v2 Loss Function

$$
\begin{aligned}
&\lambda_{\text{coord}} \sum_{i=0}^{S^2} \sum_{j=0}^{B} \mathbb{1}_{ij}^{\text{obj}} \left[(x_i - \hat{x}_i)^2 + (y_i - \hat{y}_i)^2 \right] \\
&+ \lambda_{\text{coord}} \sum_{i=0}^{S^2} \sum_{j=0}^{B} \mathbb{1}_{ij}^{\text{obj}} \left[\left(\sqrt{w_i} - \sqrt{\hat{w}_i} \right)^2 + \left(\sqrt{h_i} - \sqrt{\hat{h}_i} \right)^2 \right] \\
&+ \sum_{i=0}^{S^2} \sum_{j=0}^{B} \mathbb{1}_{ij}^{\text{obj}} \left(C_i - \hat{C}_i \right)^2 \\
&+ \lambda_{\text{noobj}} \sum_{i=0}^{S^2} \sum_{j=0}^{B} \mathbb{1}_{ij}^{\text{noobj}} \left(C_i - \hat{C}_i \right)^2 \\
&+ \sum_{i=0}^{S^2} \mathbb{1}_{i}^{\text{obj}} \sum_{c \in \text{classes}} \left(p_i(c) - \hat{p}_i(c) \right)^2
\end{aligned}
$$

Loss Functions

There are many many cost functions, depending of the problem we want to solve.

We can even write our own cost function.

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Main Points

1. Applications of deep learning

2. Deep learning in 15 minutes (intuition behind)

3. Convolutional Neural Networks (CNNs)

4. The Deep Learning Meetup Strasbourg

What we want to do with this meetup:

What we want to do with this meetup:

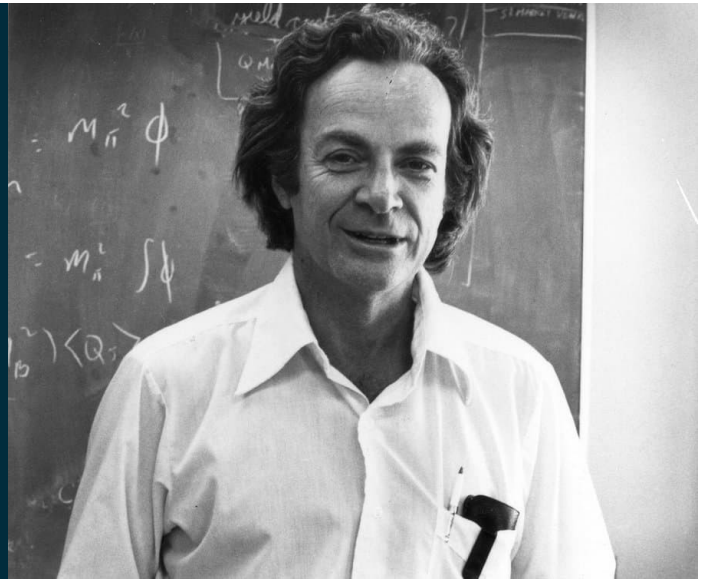
Learn by teaching. We need volunteers!

What we want to do with this meetup:

Learn by teaching. We need volunteers!

If you want to master something, teach it. A great way to learn is to teach.

—Richard Feynman



What we want to do with this meetup:

Become a community and a pool of competences in Strasbourg

Find your own project based on deep learning

How to become an expert in deep learning?

Resources

Courses:

- ***machine learning:***
1)Andrew Ng's machine learning course link
- ***deep learning:***
2)Andrew Ng's deep learning course link
3)fast.ai link
- ***computer vision with DL:***
4)cs231n Stanford link
- ***natural language processing with DL***:
5)cs224n Stanford link
- ***deep reinforcement learning***
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7)cs285: link

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Choose 1

Frameworks:

- Tensorflow (TF)
- Pytorch
- Mxnet
- Keras backend TF (or Mxnet)
- Sonnet (TF)
- Swift (TF)
- Onnx (all together?)
- fast.ai (Pytorch)

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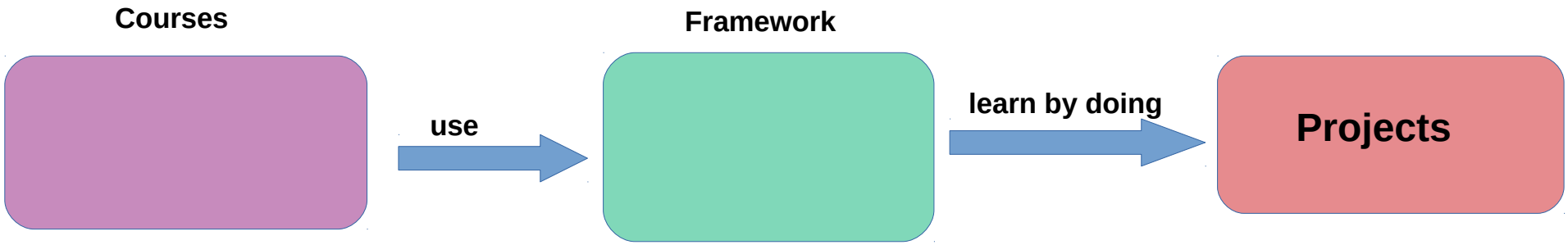
Projects

Competitions
(Kaggle)

How to become an expert in deep learning?



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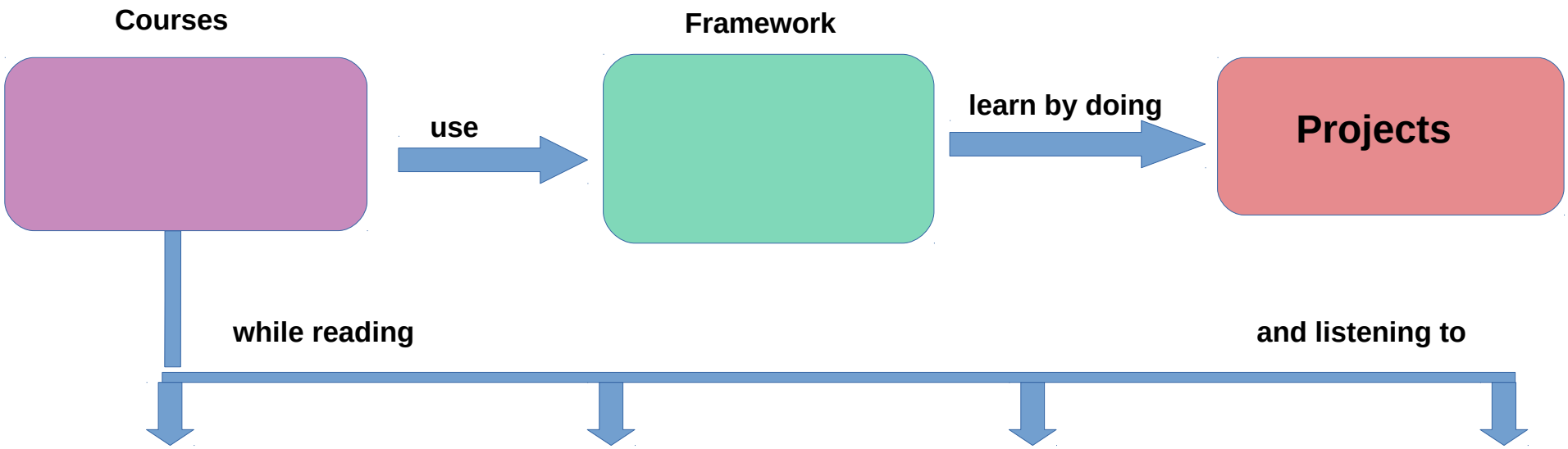

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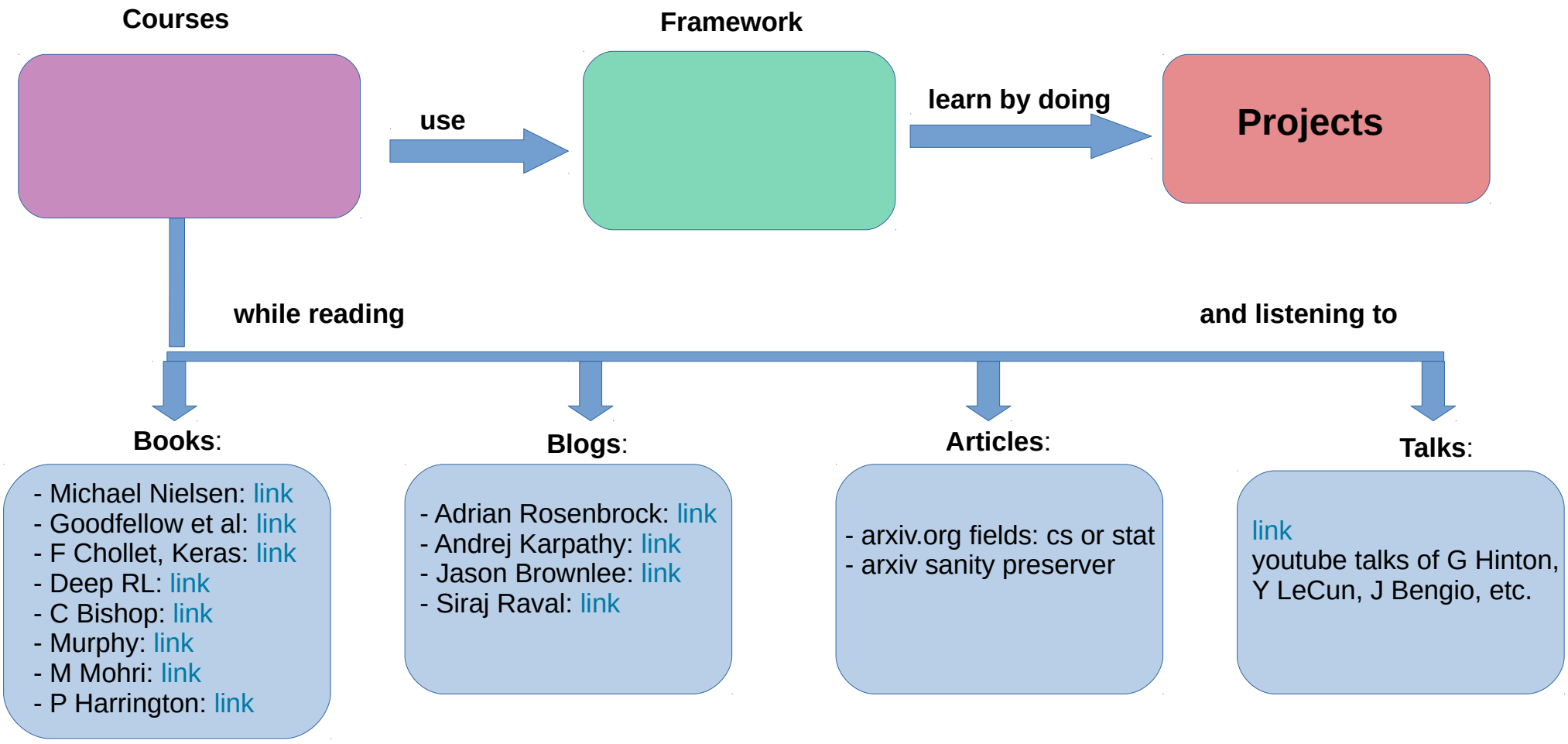

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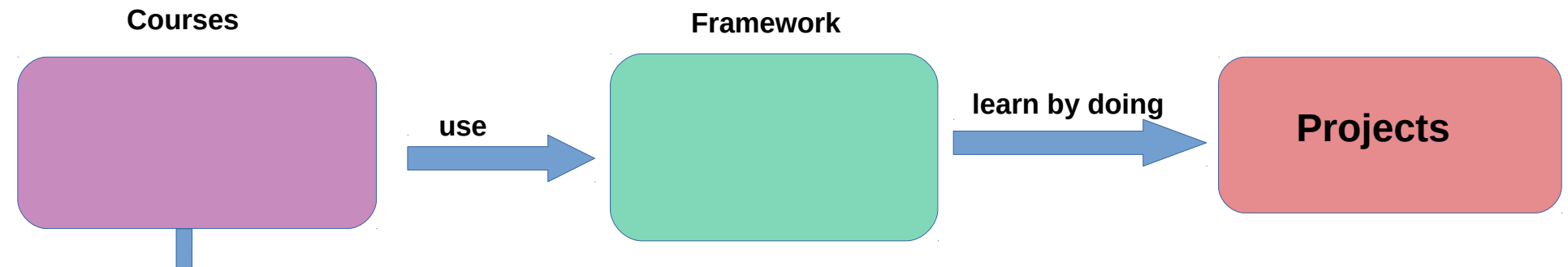

while reading

and listening to

Books:

- Michael Nielsen: link
- Goodfellow et al: link
- F Chollet, Keras: link
- Deep RL: link
- C Bishop: link
- Murphy: link
- M Mohri: link
- P Harrington: link

Blogs:

- Adrian Rosenbrock: link
- Andrej Karpathy: link
- Jason Brownlee: link
- Siraj Raval: link

Articles:

- arxiv.org fields: cs or stat
- arxiv sanity preserver

Talks:

link
youtube talks of G Hinton, Y LeCun, J Bengio, etc.

Conferences!!!

- NeurIPS (usually Canada)
- ICLR (usually USA)
- ECCV (Europe, next year in Glasgow)
- CVPR (USA next year)
- ICML (next year in Vienna)
- BMVC (UK)

How to Learn Deep Learning

The **secret** is:

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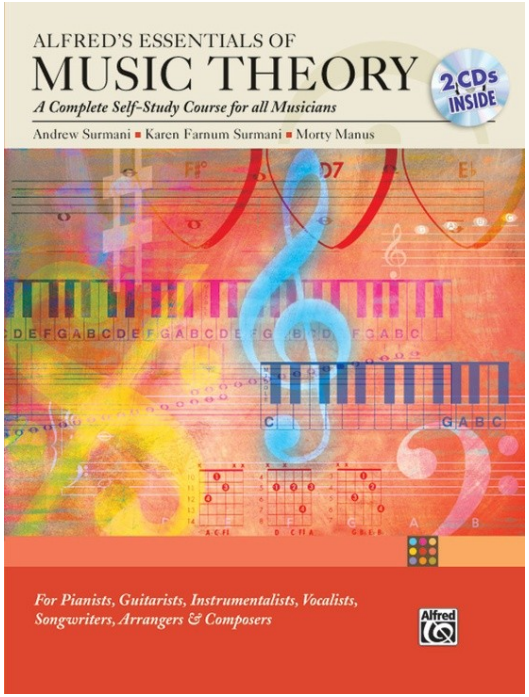
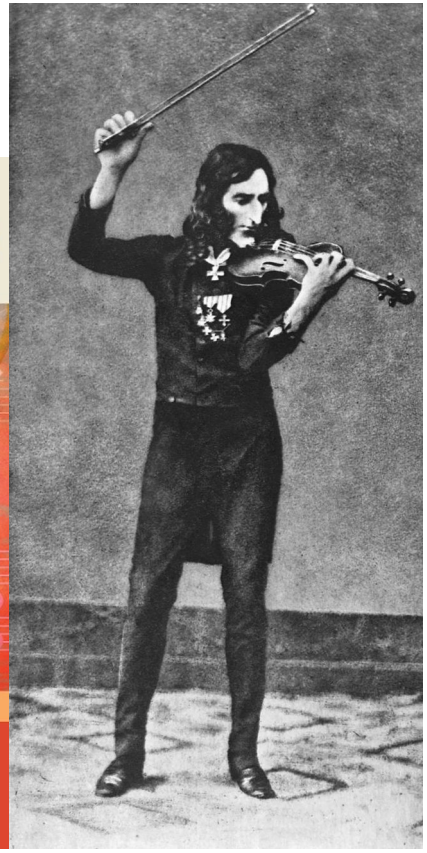


Theory

How to Learn Deep Learning

The **secret** is:

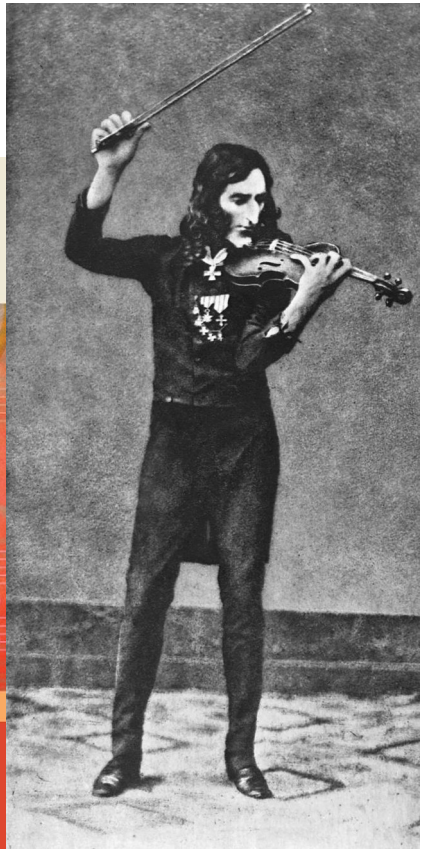
Theory



Practice

How to Learn Deep Learning

The **secret** is:



Theory **Practice**

Learning deep learning is like learning a musical instrument !!!