

# Introduction to Deep Learning

Strasbourg  
15.04.2023

**Robert Maria**

# AI - the new electricity?

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Automotive

Finance

Security

Robotics

Industry 4.0

Smart homes

Personalized education

Healthcare

And many, many others...

# **What is AI ?**

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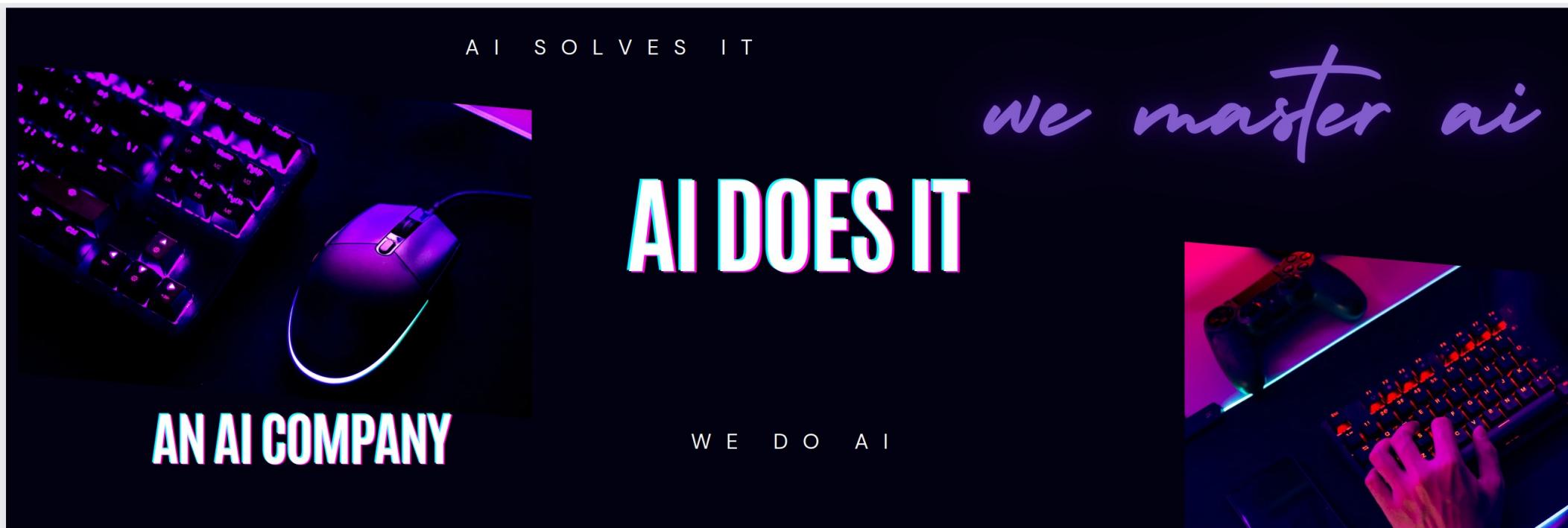
# **What is AI ?**

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Something nice to have on your website / in your slides

# What is AI ?

Something nice to have on your website / in your slides



# **What is AI ?**

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Something that you work with:

# What is AI ?

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Something that you work with:

```
1 from AI import blackbox  
2  
3 # ..... import and process data ....  
4  
5 predictions = blackbox.predict(data)  
6
```

# What is AI ?

MA

hello GPT-4. What is AI? What is according to you, Artificial Intelligence?



Hello! Artificial Intelligence (AI) is a branch of computer science that aims to create machines or systems capable of performing tasks that typically require human-like intelligence. This involves problem-solving, learning, planning, natural language processing, perception, and other cognitive abilities.

According to my understanding as an AI language model, Artificial Intelligence refers to the development of algorithms and computational models that enable machines to exhibit behaviors associated with human intelligence. These behaviors include learning from experience, adapting to new situations, understanding complex patterns, and making informed decisions based on available data.

AI can be categorized into two main types: narrow (or weak) AI and general (or strong) AI. Narrow AI is designed for specific tasks, such as speech recognition or playing a particular game, whereas general AI aims to create a system that can perform any intellectual task that a human being can do.

As a language model, I am an example of narrow AI. I have been trained on a vast dataset of text to understand and generate human-like responses based on the input I receive.

MA

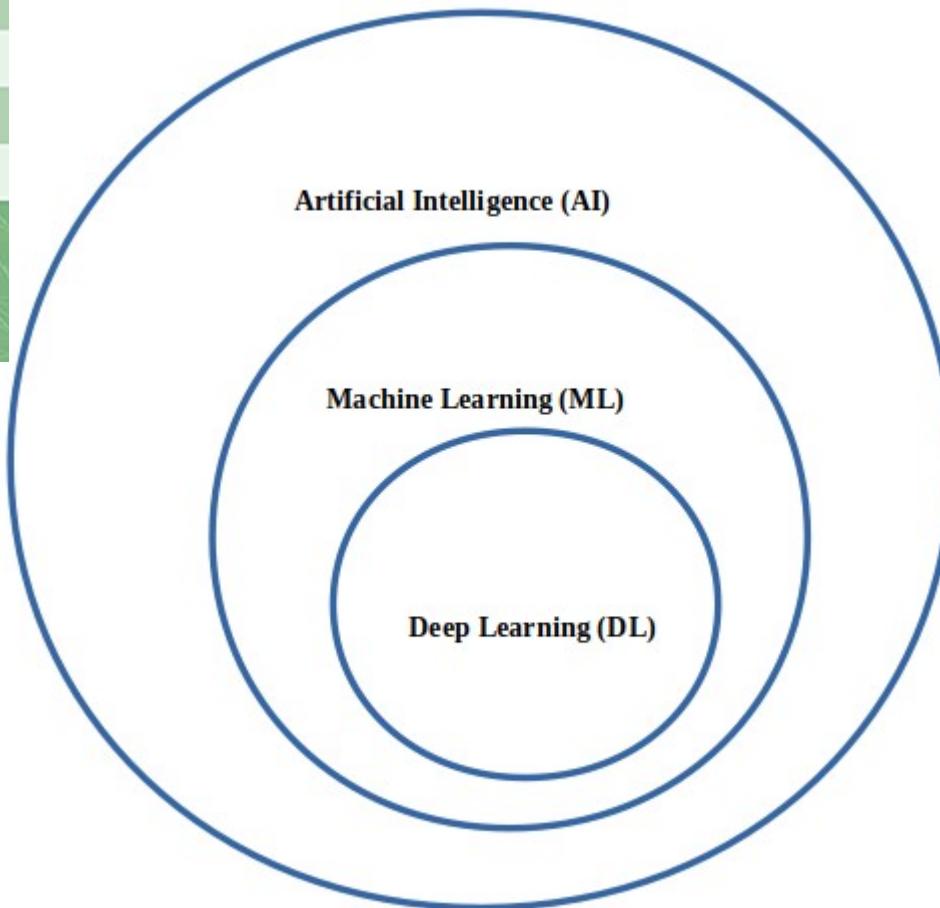
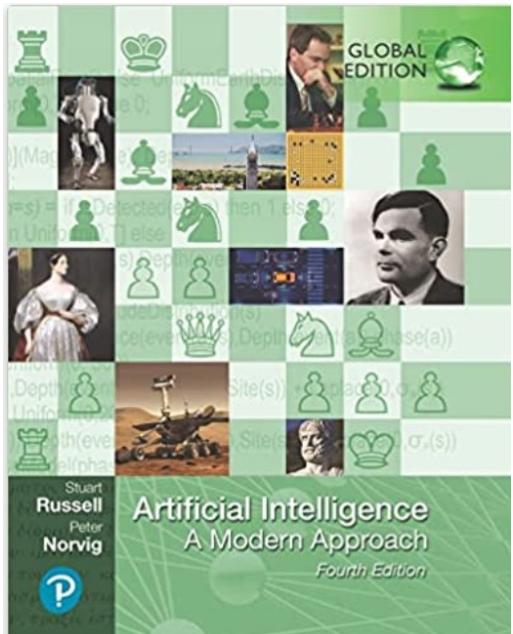
can I use your answer in a presentation?



Yes, you are welcome to use my answer in your presentation. Please keep in mind that I am an AI language model, and my knowledge is based on the information available up to September 2021. If you use my resp

ful □ Stop generating

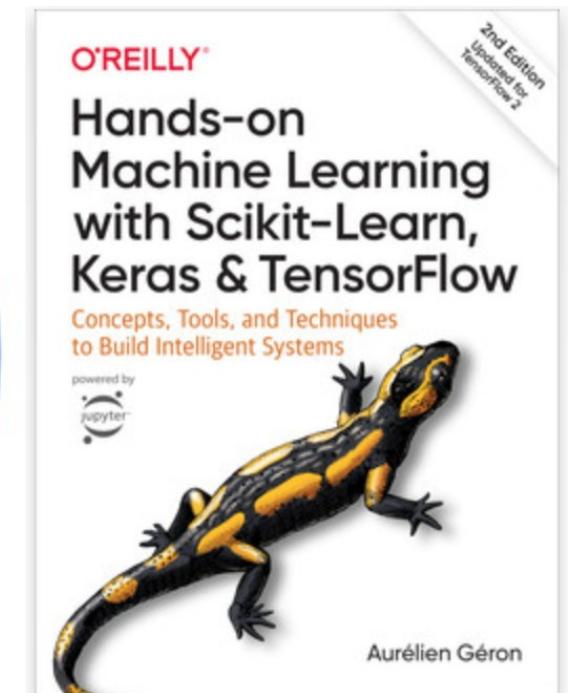
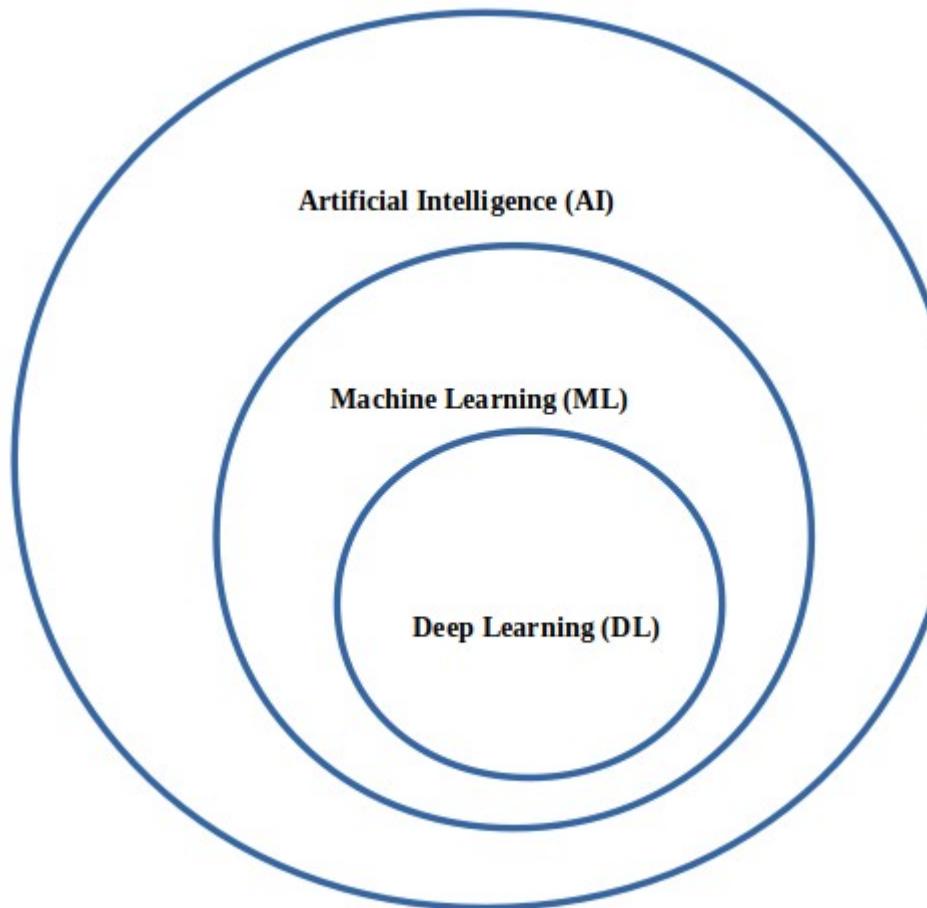
# What is AI ?



# What is machine learning ?

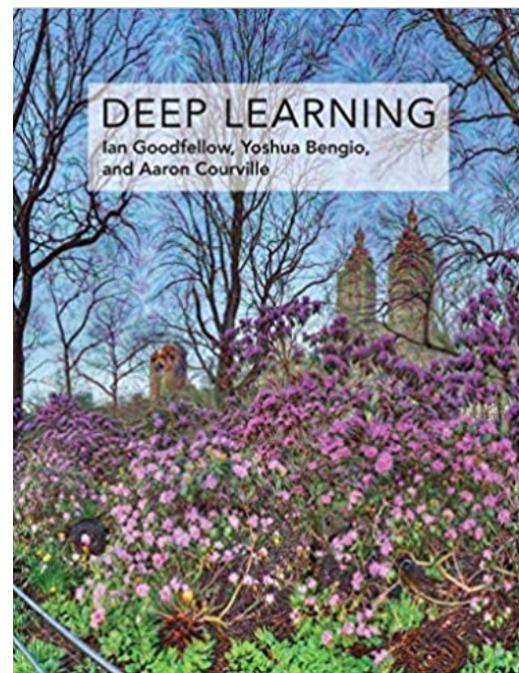
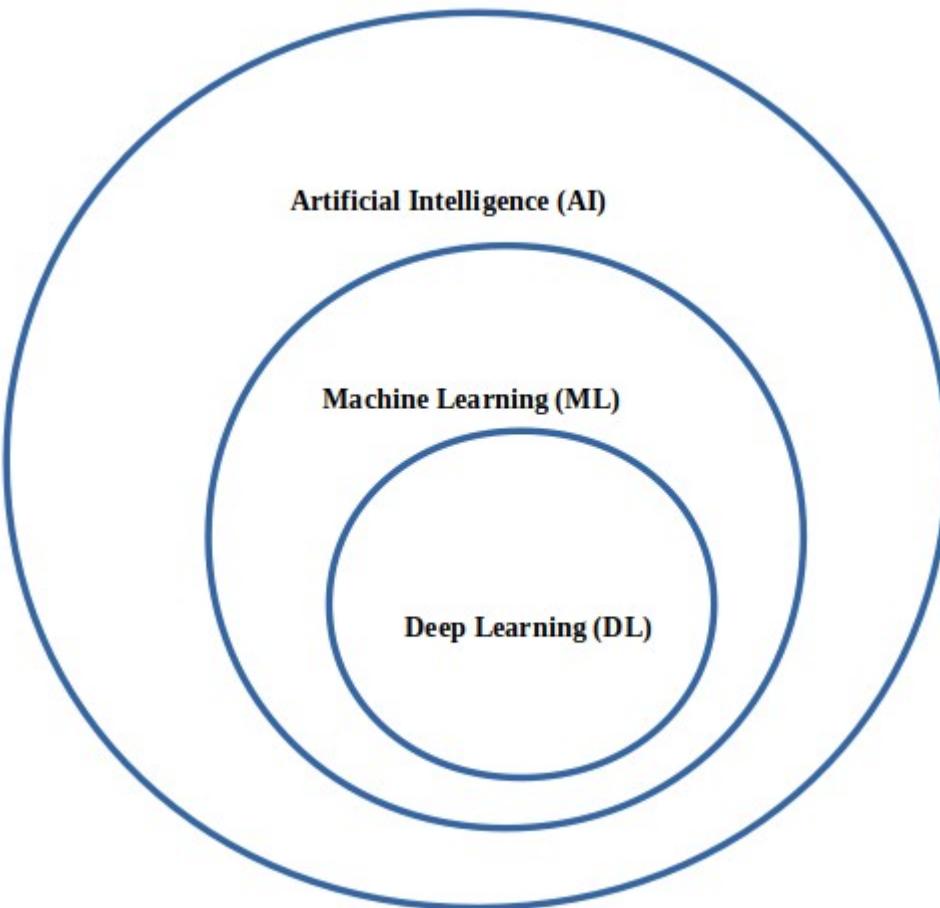
Like regular programming, a way to get computers to solve a **specific** task.

Unlike regular programming, machine learning **learns** from data.



# What is Deep Learning ?

Deep learning is a branch of machine learning, where the learning algorithms are deep neural networks



# Starting use-case: recognizing handwritten digits

How would you solve this problem?



What we see

# Starting use-case: recognizing handwritten digits

How would you solve this problem?



0	2	15	0	0	11	10	0	0	0	0	9	9	0	0	0
0	0	0	4	60	157	236	255	255	177	95	61	32	0	0	29
0	10	16	115	238	255	244	245	243	250	249	255	227	103	10	0
0	14	170	255	255	244	254	255	253	245	249	253	251	124	1	
2	98	255	228	255	256	251	254	211	141	116	117	215	251	238	49
13	217	243	255	155	33	226	52	2	0	10	13	232	255	255	36
16	229	252	254	49	12	0	0	7	7	0	70	237	252	235	62
6	141	245	255	212	25	11	9	3	0	115	236	243	255	137	0
0	87	252	250	248	215	60	0	1	21	252	255	248	144	6	0
0	13	111	255	255	245	255	182	181	248	252	242	208	30	0	19
1	0	5	117	251	255	241	255	247	255	241	162	17	0	7	0
0	0	0	4	58	251	255	246	254	253	255	120	11	0	1	0
0	0	4	97	255	255	255	248	252	255	244	255	182	10	0	4
0	22	206	252	246	251	241	100	24	111	255	245	255	194	9	0
0	111	255	242	255	158	24	0	0	6	39	255	232	230	56	0
0	218	251	250	137	7	11	0	0	2	62	255	250	125	3	
0	173	255	255	101	9	20	0	13	3	13	182	251	245	61	0
0	107	251	241	255	230	98	55	19	111	217	248	253	255	52	4
0	18	146	260	255	247	255	255	249	255	240	255	129	0	5	
0	0	23	113	215	255	250	248	255	248	248	118	14	12	0	
0	0	6	1	0	52	153	233	255	252	147	37	0	0	4	1
0	0	5	5	0	0	0	0	0	14	1	0	6	6	0	0

0	2	15	0	0	11	10	0	0	0	0	9	9	0	0	0
0	0	0	4	60	157	236	255	255	177	95	61	32	0	0	29
0	10	16	115	238	255	244	245	243	250	249	255	227	103	10	0
0	14	170	255	255	244	254	255	253	245	249	253	251	124	1	
2	98	255	228	255	255	251	254	211	141	116	117	215	251	238	49
13	217	243	255	155	33	226	52	2	0	10	13	232	255	255	36
16	229	252	254	49	12	0	0	7	7	0	70	237	252	235	62
6	141	245	255	212	25	11	9	3	0	115	236	243	255	137	0
0	87	252	250	248	215	60	0	1	21	252	255	248	144	6	0
0	13	111	255	255	245	255	182	181	248	252	242	208	30	0	19
1	0	5	117	251	255	241	255	247	255	241	162	17	0	7	0
0	0	0	4	58	251	255	246	254	253	255	120	11	0	1	0
0	0	4	97	255	255	255	248	252	255	244	255	182	10	0	4
0	22	206	252	246	251	241	100	24	111	255	245	255	194	9	0
0	111	255	242	255	158	24	0	0	6	39	255	232	230	56	0
0	218	251	250	137	7	11	0	0	2	62	255	250	125	3	
0	173	255	255	101	9	20	0	13	3	13	182	251	245	61	0
0	107	251	241	255	230	98	55	19	111	217	248	253	255	52	4
0	18	146	260	255	247	255	255	249	255	240	255	129	0	5	
0	0	23	113	215	255	250	248	255	248	248	118	14	12	0	
0	0	6	1	0	52	153	233	255	252	147	37	0	0	4	1
0	0	5	5	0	0	0	0	0	14	1	0	6	6	0	0

What the computer sees

# Starting use-case: recognizing handwritten digits

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We can design rules based on our intuition, set up thresholds. Re-adapt with new data. But real data can look like:

# Starting use-case: recognizing handwritten digits

We can design rules based on our intuition, set up thresholds. Re-adapt with new data. But real data can look like:



[source](#)

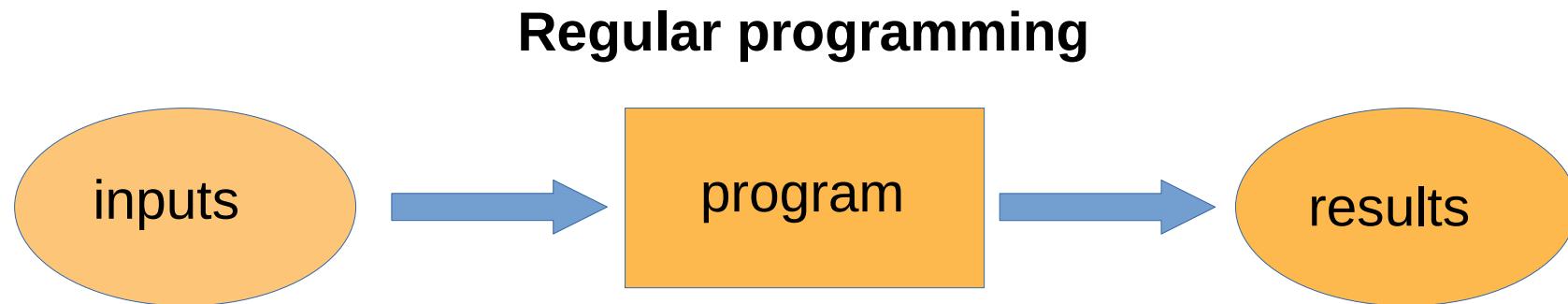
# Recognizing handwritten digits

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Or learn directly from data?

# Arthur Samuel's model for AI

Arthur Samuel's model, 1962



**Machines that learn from experience**

He introduces the idea of weight assignment

Every weight configuration has some performance

The need of a way to change these weights

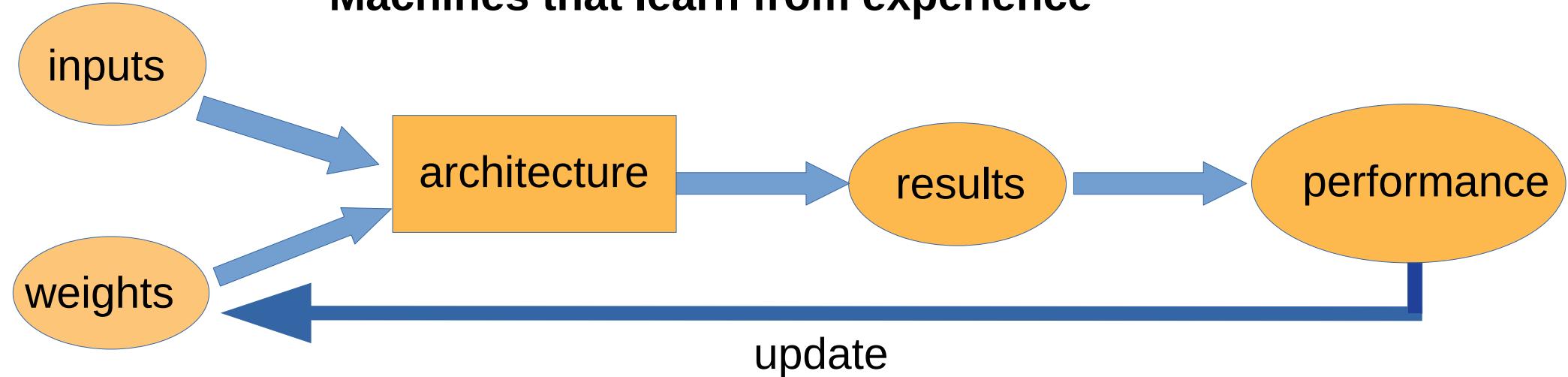
# Arthur Samuel's model for AI

Arthur Samuel's model, 1962

## Regular programming

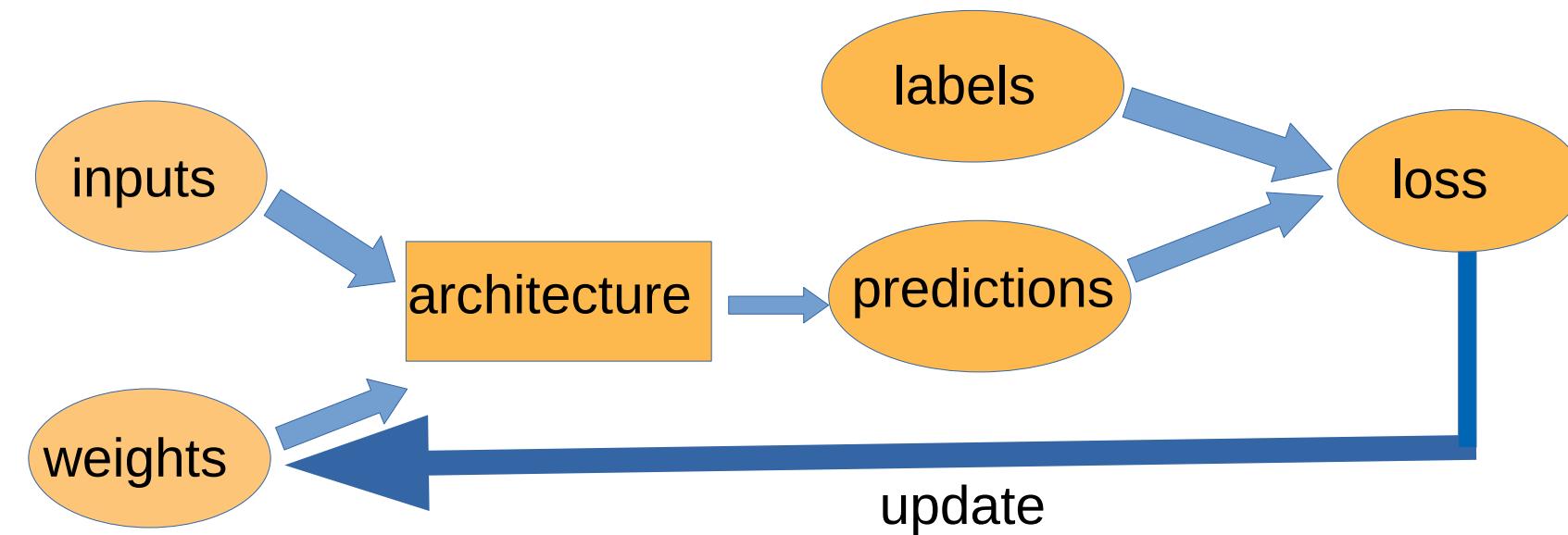


## Machines that learn from experience



# A Deep Learning Training Loop\*

for supervised learning



# A Deep Learning Training Loop



metrics to assess performance

Different methods and problems require different metrics!

# The data

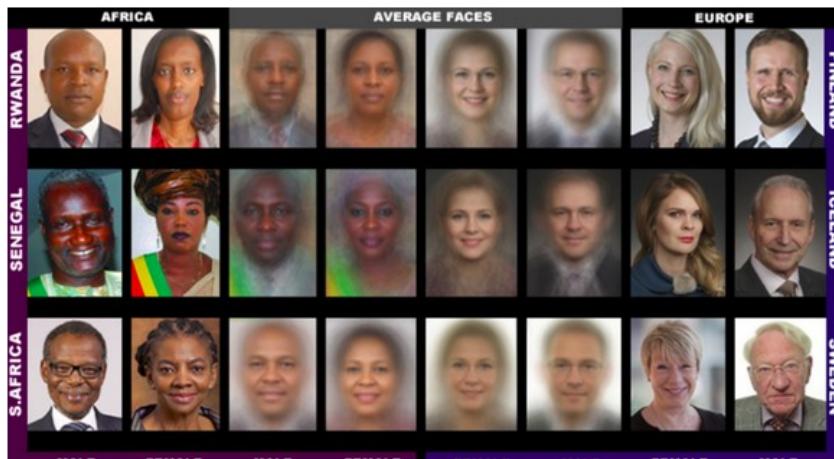
Where to find the data?

kaggle

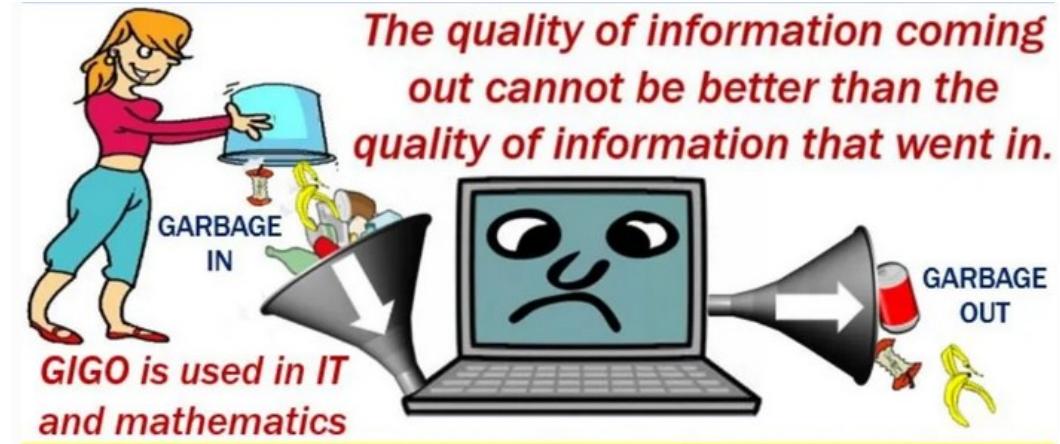
Github

EU Open Data

Careful for the **biases** in the data.

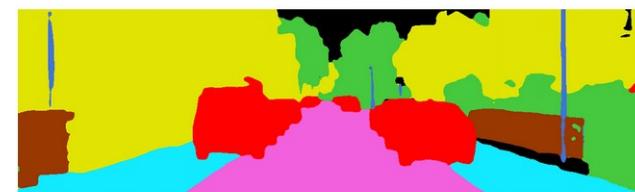


source



What is good data?

source



Road      Sidewalk      Building      Fence  
Pole      Vegetation      Vehicle      Unlabel

Do we need labels?

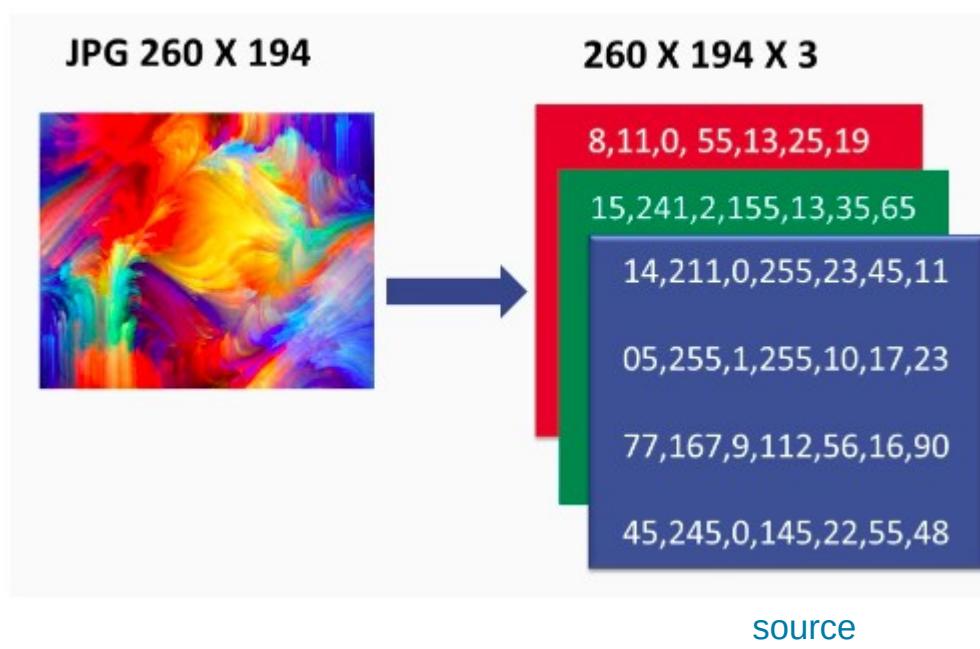
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21

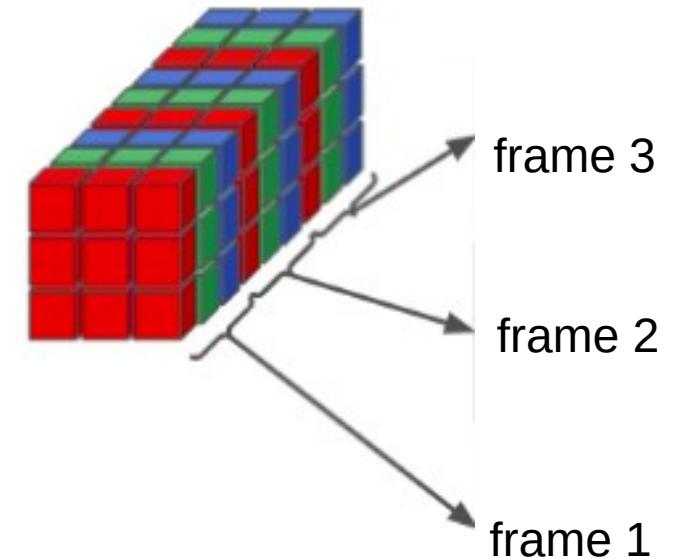
# The data

Input data for deep learning: **tensors**

Image



Video



# The data

Input data for deep learning: **tensors**

Audio



Audio wave

Spectrogram

source

# The data

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Is the data representative?

- be sure all the classes are present in the data

The arrow of time

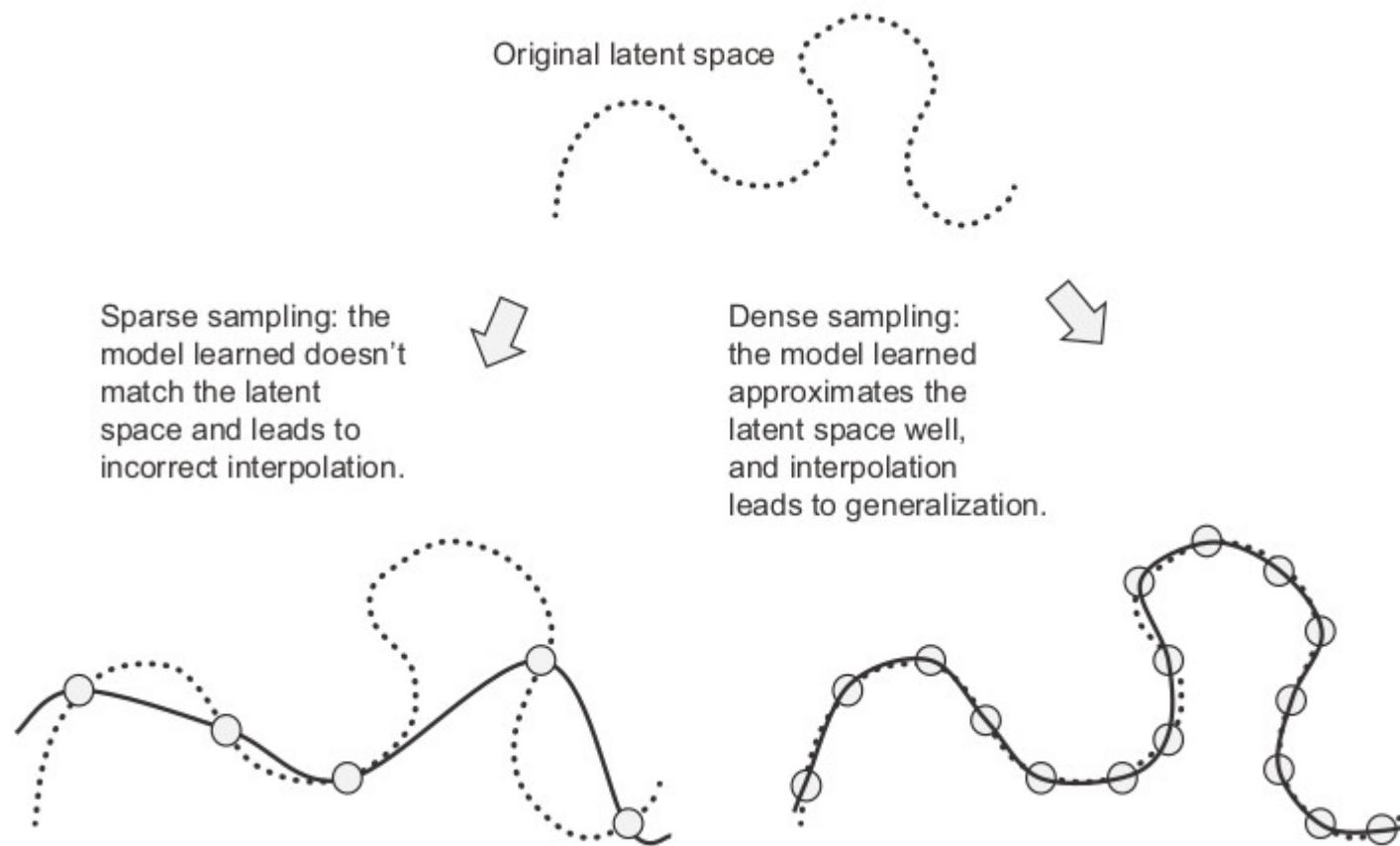
- do not shuffle data with temporal dependencies

Redundancy in the data

- eliminate redundancies in the data

# The data

To ensure god performance, we need the data to cover well (dense) the entire manifold.



[source](#)

# The model

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The model can be a neural network with multiple layers. Why this could be a good option?

Universal function approximation.

No free lunch theorem – one problem, one solution.

How do we pick among the infinite number of possible networks?

- the topology of a model defines a **hypothesis space**

The model transforms the data into meaningful outputs. Central problem in machine learning: how to find **meaningful representations**?

# Meaningful representations

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Solve this fast: MCMLX + XVIII = ???

# Meaningful representations

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Easier: 1960 + 18

# Meaningful representations

---

Solve this fast: MCMLX + XVIII = ???

Easier: 1960 + 18

A good representation helps a lot the problem (task) to be solved

Famous AI conference: ICLR

(International Conference on Learning Representations)

# The choice of a loss function

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Used to measure the performance of a model.

The choice depends on the problem to be solved:

Classification, detection, segmentation, etc.

Examples:

BinaryCrossEntropy

CategoricalCrossEntropy

MeanSquaredError

KLDivergence

CosineSimilarity

# Metrics of performance

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Examples:

BinaryAccuracy

CategoricalAccuracy

SparseCategoricalCrossEntropy

f1-score

AUC

precision

recall

# Generalization

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What is generalization in machine learning?

algorithm providing good performances outside the training set

**Optimization vs generalization**

# Deep learning in 15 minutes

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What is deep learning?

# Deep learning in 15 minutes

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What is deep learning?

Deep learning is a rebranding of neural networks.

# Deep learning in 15 minutes

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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

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## Brain neurons

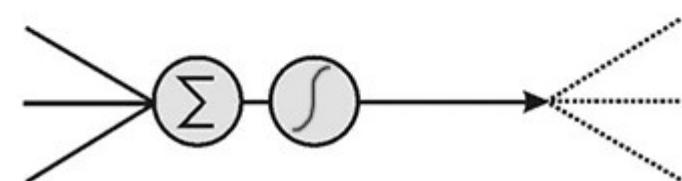
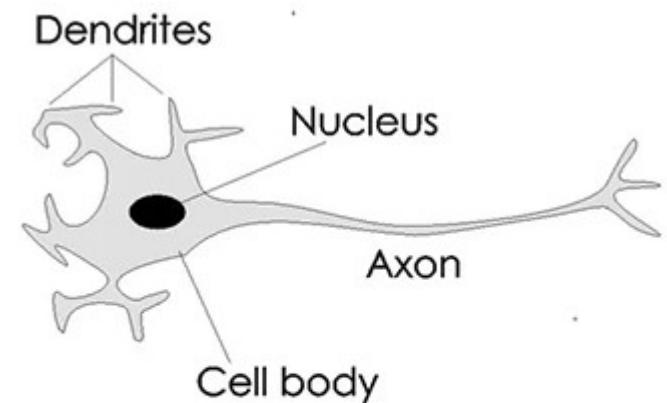


# Deep learning in 15 minutes

Brain neurons



Neural network neurons

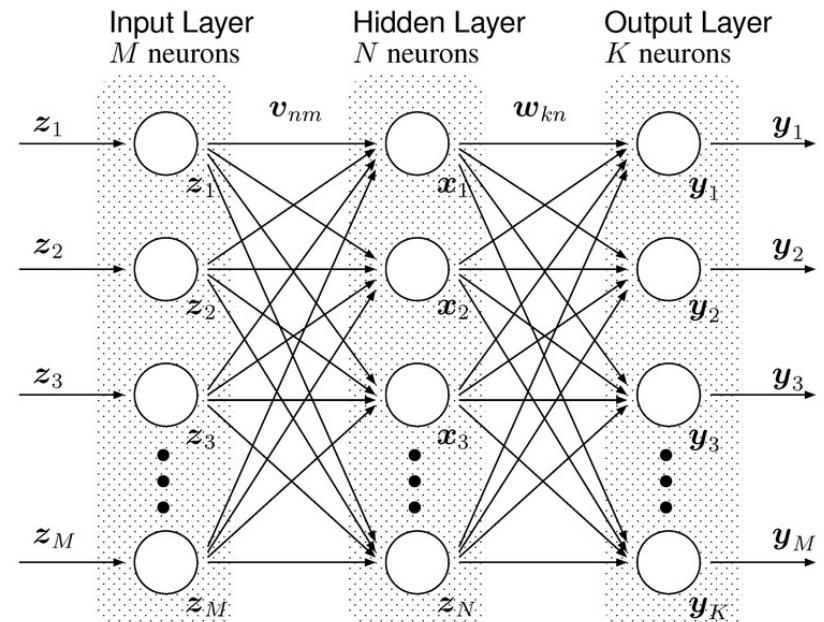


# Deep learning in 15 minutes

## Brain neurons



## Neural network neurons



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

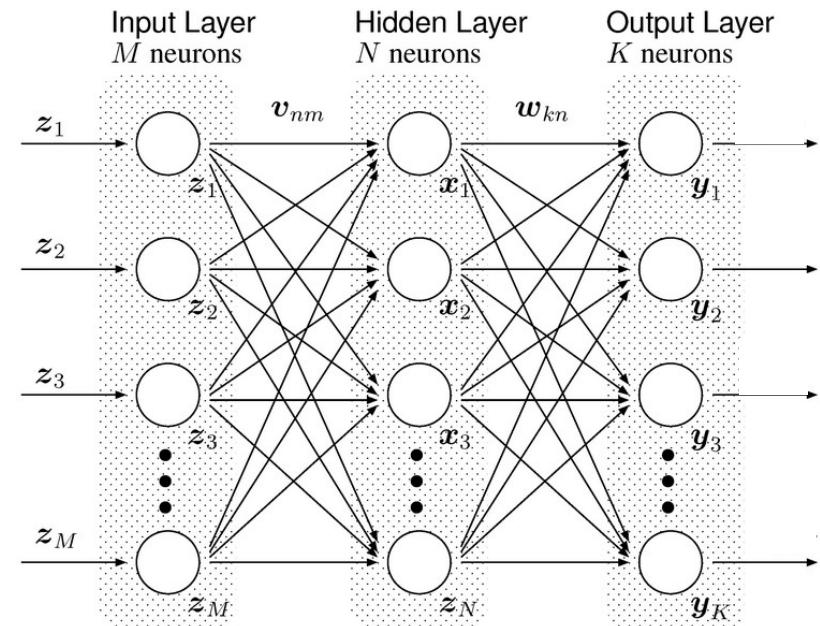
R Collobert

# Deep learning in 15 minutes

## Brain neurons



## Neural network neurons

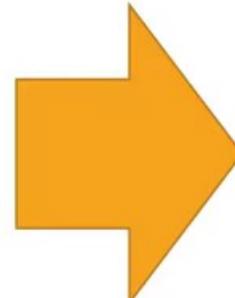


**Deep learning = neural networks with more than 1 hidden layer**

# Deep Learning: Tensor in, Tensor out

## In a nutshell

0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	1	12	0	11	39	137	37	0	152	147	84	0	0	0	0	0
0	0	1	0	0	0	41	160	250	255	235	162	255	238	206	11	13	0	0	0
0	0	0	16	9	9	150	251	45	21	184	159	154	255	233	40	0	0	0	0
10	0	0	0	0	0	145	146	3	10	0	11	124	253	255	107	0	0	0	0
0	0	3	0	4	15	236	216	0	0	38	109	247	240	169	0	11	0	0	0
1	0	2	0	0	0	253	253	23	62	224	241	255	164	0	5	0	0	0	0
6	0	0	4	0	13	252	250	228	255	255	234	112	28	0	2	17	0	0	0
0	2	1	4	0	21	255	253	251	255	172	31	8	0	1	0	0	0	0	0
0	0	4	0	163	225	251	255	229	120	0	0	0	0	0	0	11	0	0	0
0	0	21	162	255	255	254	255	126	6	0	10	14	6	0	0	9	0	0	0
3	79	242	255	141	66	255	245	189	7	8	0	0	5	0	0	0	0	0	0
26	221	237	98	0	67	251	255	144	0	8	0	0	7	0	0	11	0	0	0
125	255	141	0	87	24	255	208	3	0	0	13	0	1	0	1	0	0	0	0
145	248	228	116	235	255	141	34	0	11	0	1	0	0	0	1	3	0	0	0
85	237	253	246	255	210	21	1	0	1	0	0	6	2	4	0	0	0	0	0
6	23	112	157	114	32	0	0	0	0	2	0	8	0	7	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0



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`

# Deep Learning: Fit unknown functions

What does this function do?

$$x(t) = \left( \left( -\frac{199}{9} \sin\left(\frac{11}{7} - 5t\right) - \frac{35}{9} \sin\left(\frac{11}{7} - 4t\right) - \frac{356}{7} \sin\left(\frac{11}{7} - 3t\right) + \frac{523}{6} \sin\left(t + \frac{8}{5}\right) + \frac{7}{2} \sin\left(6t + \frac{8}{5}\right) - \frac{784}{5} \right) \theta(151\pi - t) \theta(t - 143\pi) + \left( \frac{14}{3} \sin\left(\frac{8}{5} - 3t\right) + \frac{158}{3} \sin\left(t + \frac{8}{5}\right) + \frac{155}{4} \sin\left(2t + \frac{8}{5}\right) + \frac{4}{3} \sin\left(\pi - t\right) \theta(t - 143\pi) + \left( \frac{535}{6} \sin\left(t + \frac{8}{5}\right) + 4 \sin\left(2t + \frac{14}{3}\right) + \frac{8}{5} \right) \sin\left(6t + \frac{23}{5}\right) + \frac{469}{9} \right) \theta(143\pi - t) \theta(t - 139\pi) + \left( \frac{8}{5} \right) \sin\left(3t + \frac{14}{3}\right) + \frac{23}{3} \sin\left(4t + \frac{8}{5}\right) + \frac{10}{9} \sin\left(5t + \frac{13}{3}\right) \theta(t - 135\pi) + \left( -\frac{1}{10} \sin\left(\frac{6}{5} - 5t\right) - \frac{26}{5} \sin\left(\frac{8}{5} - \frac{8}{5} - t\right) + \frac{1}{23} \sin\left(3t + \frac{1}{3}\right) - \frac{543}{4} \right) \theta(135\pi - t) \theta(t - 131\pi) + \left( \frac{3}{2} \sin\left(\frac{5}{4} - 120t\right) - \frac{7}{8} \sin\left(\frac{5}{4} - 118t\right) - \frac{4}{5} \sin\left(\frac{5}{6} - 115t\right) - \frac{5}{3} \sin\left(\frac{5}{7} - 97t\right) - \frac{23}{8} \sin\left(\frac{7}{4} - 94t\right) - \frac{39}{2} \sin\left(\frac{7}{6} - 90t\right) \right) \theta(t - 120\pi) \right)$$

# Deep Learning: Fit unknown functions

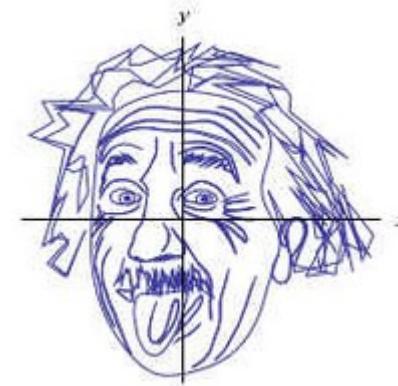
## Parametric equation of Einstein's face.

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

# Deep Learning: Fit unknown functions

**Parametric equation of Einstein's face.**

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



**Draw Einstein's face.**

# Deep Learning: Fit unknown functions

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**And we can sketch all the faces in the world.**

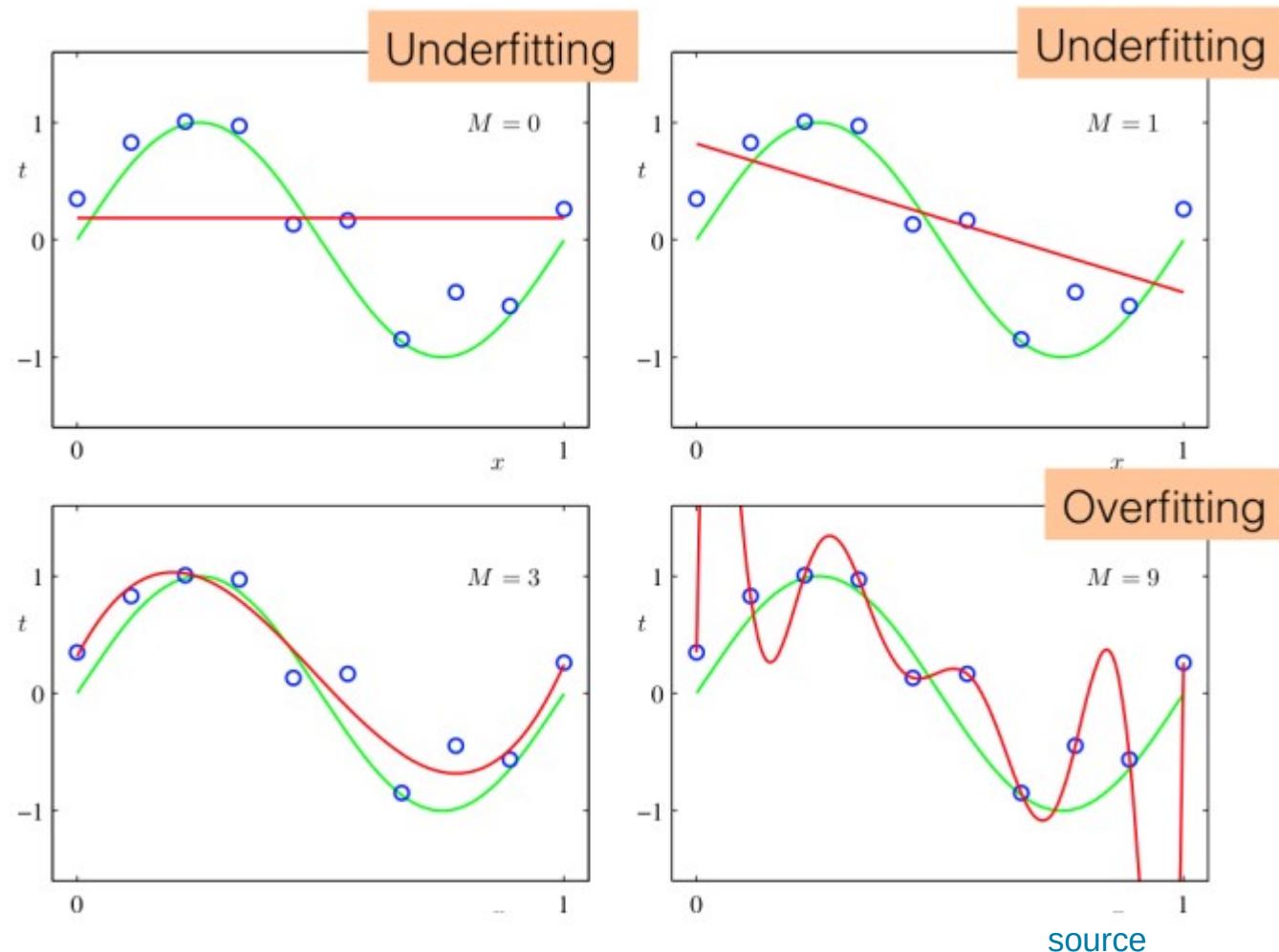
# Deep Learning: Fit unknown functions

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.

# Underfitting vs overfitting

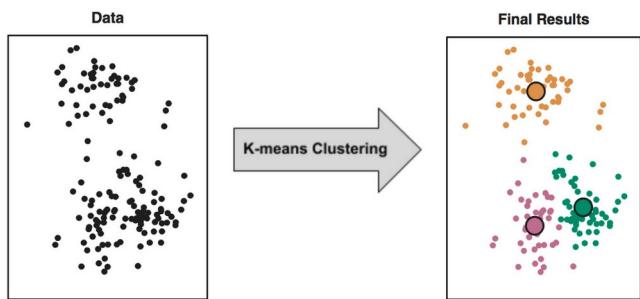


# Types of Learning

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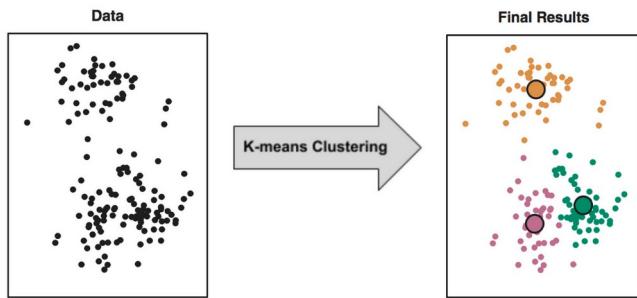
# Types of Learning

## Unsupervised



# Types of Learning

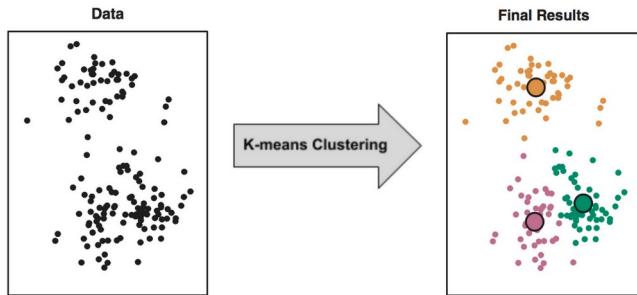
## Unsupervised



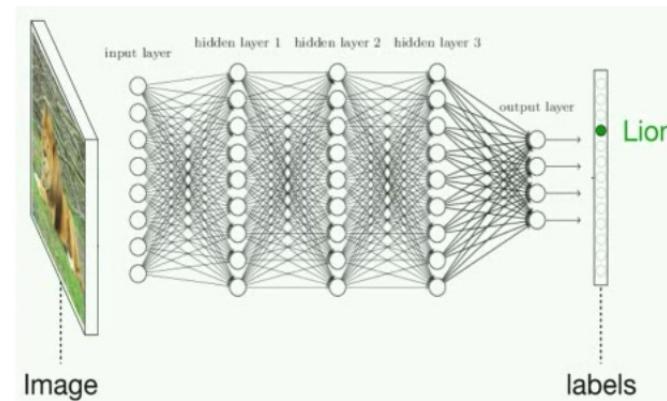
Very hot topic: Generative Adversarial Neural Networks (**GANs**):  
(1) <https://www.youtube.com/watch?v=36IE9tV9vm0>  
(2) <https://www.youtube.com/watch?v=tpr44-G5MbU#t=5m5s>

# Types of Learning

## Unsupervised

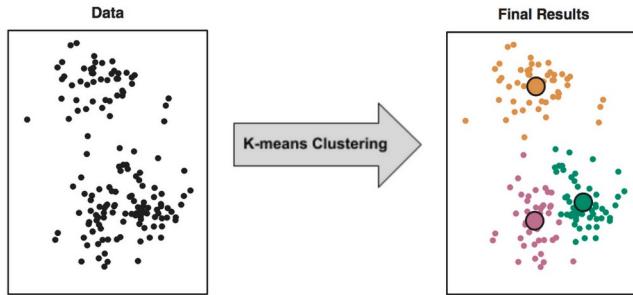


## Supervised

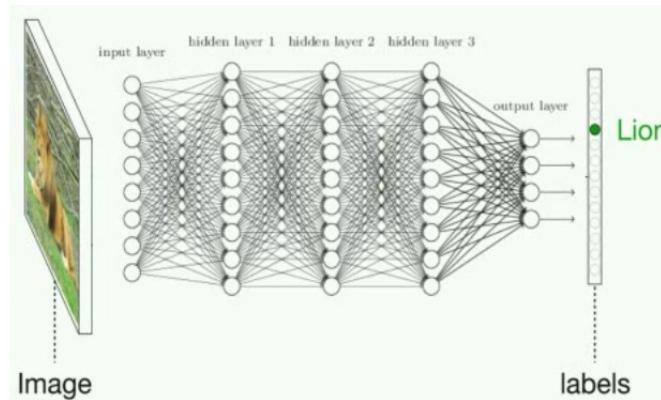


# Types of Learning

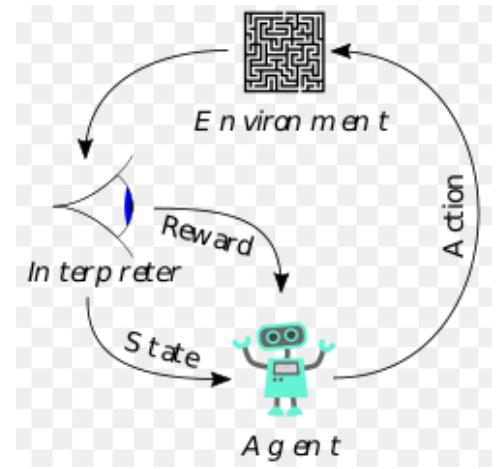
## Unsupervised



## Supervised



## Reinforcement



## Hybrid Learning

## Semi-supervised

## Self-supervised

## Multi-instance

## Learning Techniques

### Multi-task learning

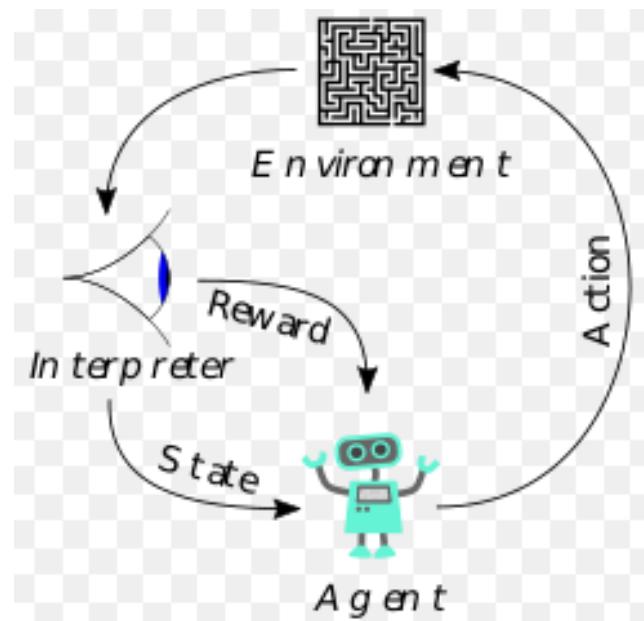
### Continual learning

### Active learning

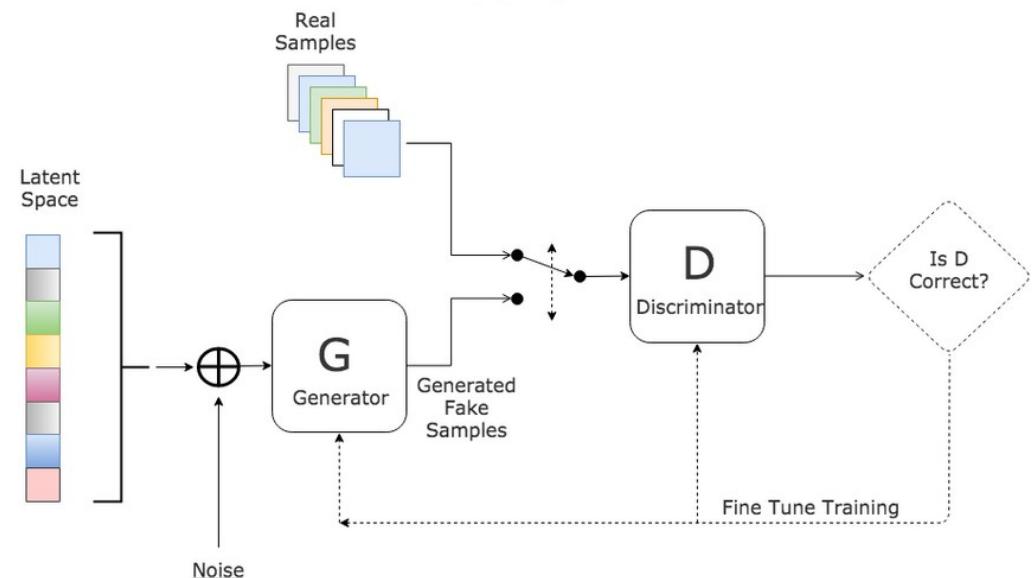
### Online learning

# Hot topics in deep learning

## Reinforcement Learning (RL)



## Generative Adversarial Networks (GANs)



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

(1) <https://www.youtube.com/watch?v=36IE9tV9vm0>  
(2) <https://www.youtube.com/watch?v=tpr44-G5MbU#t=5m5s>

# What's next?

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# 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

**Thank you !**

**Merci !**

**Thank you !**

**Thank you !**

**Merci !**

**Merci !**

**Thank you !**

# Backup slides

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# My former Deep Learning Meetup

2018-10-13	M16	Robert Maria	Joint Face Detection and Alignment using Multi-task Cascaded CNNs	<a href="#">code</a>
2018-10-10	M15	Virgil Petcu	fast.ai Live - Practical Deep Learning For Coders	<a href="#">pdf</a>
2018-09-14	M14	Corina Gurău	Informal discussion about Corina's PhD work at Oxford	
2018-09-08	M13	Alin Dobre	Building a CNN using IBM Watson	<a href="#">docx</a>
2018-06-21	M12	Virgil Petcu	"Zoom in, enhance!" in real-life : super-resolution with deep learning	<a href="#">code</a>
2018-06-02	M11	Robert Maria	Hands on Deep Learning: from the first classifier to neural style transfer (III)	<a href="#">code</a>
2018-03-17	M10	Robert Maria	Hands on Deep Learning: from the first classifier to neural style transfer (II)	<a href="#">code</a>
2018-03-03	M09	Robert Maria	Hands on Deep Learning: from the first classifier to neural style transfer	<a href="#">code</a>
2018-02-01	M08	Victor Adăscăliței	Long short-term memory Networks (LSTMs)	<a href="#">pdf</a> <a href="#">code</a>
2018-01-25	M07	Victor Adăscăliței	Conditional GANs and Project Magenta	<a href="#">pdf1</a> <a href="#">pdf2</a>
2017-12-21	M06	Victor Adăscăliței	Presentation of Generative Adversarial Networks (GANs)	<a href="#">pdf</a>
2017-12-07	M05	Robert Maria	YOLO algorithm for object detection	
2017-10-05	M04	Robert Maria	Faster R-CNN	
2017-07-13	M03	Robert Maria	Fast R-CNN	
2017-05-02	M02	Robert Maria	Convolutional Neural Networks for Image Classification	
2017-03-09	M01	Beer	Let's get to know each other	

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2020-05-29	M29	Laurence Jennings	Natural Language Processing: from word embeddings to transformers	<a href="#">pdf</a>
2020-04-21	M28	Vinkle Srivastav	Visualization and Understanding of DNNs	<a href="#">pdf</a>
2020-03-06	M27	Henning Wachsmuth	Towards an Argument Search Engine for the Web	<a href="#">pdf</a>
2019-12-15	M26	Kristian Miok	Bayesian Neural Networks for Hate Speech Detection	
2019-12-12	M24	Felix Aurel Mic	The analysis of glycemia datasets in diabetes	
2019-12-11	M23	Ana Maria Popescu & Vasile Toma	A compute-efficient SoC for Edge AI	<a href="#">pdf</a>
2019-09-07	M22	Ruxandra Stoean	Deep learning: a practical solution for real-world cases in medicine?	<a href="#">pdf</a>
2019-09-07	M22	Radu Moldovan	Making ML simple, portable and scalable	<a href="#">pdf</a>
2019-09-07	M22	René Donner	Medical Image Retrieval	<a href="#">pdf</a>
2019-05-29	M21	Sorin Țîrc	Introduction to Adversarial Robustness	<a href="#">link</a>
2019-03-20	M20	Alex Petenchea	Extreme Gradient Boosting	<a href="#">code</a>
2019-03-20	M20	Tudor Ștefan	How to create your Recommender System using Embeddings	<a href="#">code</a>
2019-02-23	M19	Razvan Pascanu	Overview of Deep Learning	<a href="#">pdf</a>
2019-02-23	M19	Lucian Busoniu	Overview of Reinforcement Learning	<a href="#">pdf</a>
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2019-01-22	M18	Titus Nicolae	OpenVINO & Neural Compute Stick 2	<a href="#">pdf</a>
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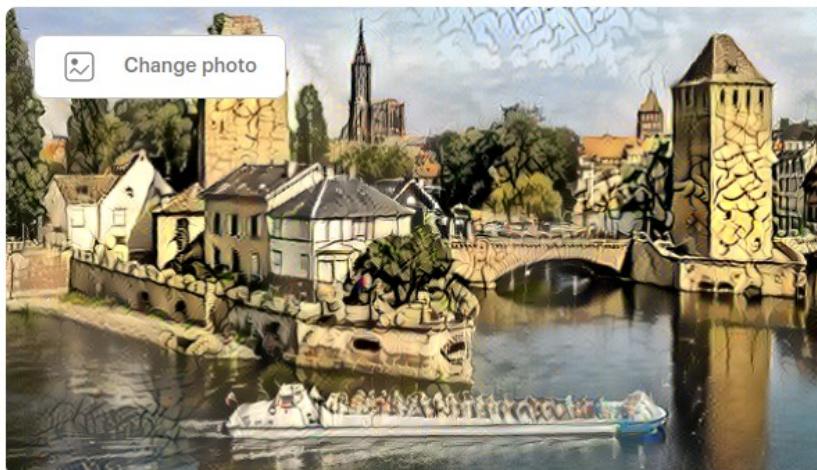
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2021-09-23	M39	Patrick Hynds, Ciprian Jichici	An Introduction to Quantum Computing and Applied Learning	<a href="#">pdf</a>
2021-07-21	M38	Eitan Netzer, Dacian Stroia & Alexandru Iliescu	Accelerating model retraining using coresets & Scoliosis X-ray analysis using DL	<a href="#">pdf</a>
2021-07-07	M37	Iulia Duta & Andrei Nicolicioiu	Introduction to Graph Neural Networks	<a href="#">pdf</a>
2021-04-15	M36	Andrei Hera	Retrieval-Augmented Generation for Knowledge-Intensive NLP Tasks	<a href="#">pdf</a>
2020-12-15	M35	Organizers	NeurIPS meetup #2: Beyond Backpropagation	
2020-12-10	M34	Organizers	NeurIPS meetup #1: Representation/Relational learning	
2020-11-20	M33	Sergio Garrido	Estimating causal effects using NADEs	<a href="#">pdf</a>
2020-11-05	M32	Robert Maria & Titus Nicolae	Autoencoders and Variational Autoencoders	<a href="#">pdf</a>
2020-09-24	M31	Robert Maria	Introduction to Deep Generative Models	<a href="#">pdf</a>
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