Lecture 1

Introduction to AI and Deep Learning

Minh-Tan Pham, Matthieu Le Lain

BUT2 INFO, 2023-2024

IUT de Vannes, Université Bretagne Sud

minh-tan.pham@univ-ubs.fr

Planning

- Why learning ?
- Applications and Successes
- Basics of AI, Machine learning, Deep learning
- Outlook and takeaway messages
- Assignments (teamwork)
- Pytorch

Why learning ?

Why learning ?

What do you see ?

How can we recognize them ?!

Image credits: sidechef

Why learning ?

What do you see ?

Chihuahua or muffin ?

Image credits: freecodecamp

Why learning ?

What do you see ?

Apple or Barn owl ? Croissant or Shar Pei ?

Image credits: ranker

Why learning ?

The automatic extraction of **semantic information** from raw signal is at the core of many applications, such as

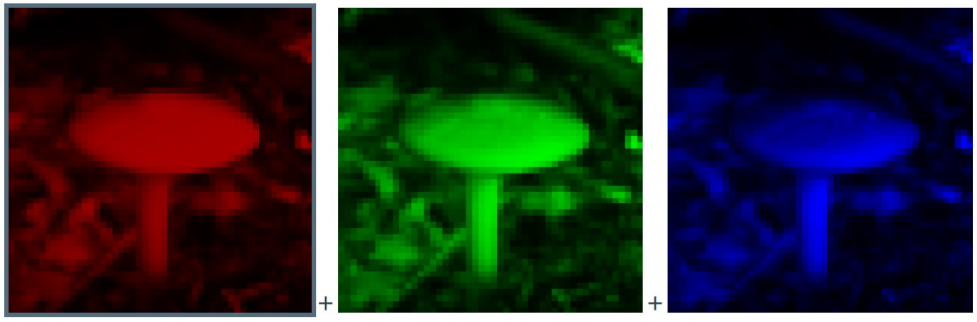
- image recognition
- speech processing
- natural language processing
- robotic control
- geometric reconstruction
- ... and many others.

How can we write a computer program (algorithm) that implements that ?

Why learning ?

The (human) brain is so good at interpreting visual information that the **"big gap"** between raw data and its semantic interpretation is difficult to assess intuitively:

This is a mushroom.



These are also mushrooms.

This is a mushroom.

Why learning ?

```
array([[[0.03921569, 0.03529412, 0.02352941, 1.        ],
        [0.2509804 , 0.1882353 , 0.20392157, 1.        ],
        [0.4117647 , 0.34117648, 0.37254903, 1.        ],
        ...,
        [0.20392157, 0.23529412, 0.17254902, 1.        ],
        [0.16470589, 0.18039216, 0.12156863, 1.        ],
        [0.18039216, 0.18039216, 0.14117648, 1.        ]],

       [[0.1254902 , 0.11372549, 0.09411765, 1.        ],
        [0.2901961 , 0.2509804 , 0.24705882, 1.        ],
        [0.21176471, 0.2       , 0.20392157, 1.        ],
        ...,
        [0.1764706 , 0.24705882, 0.12156863, 1.        ],
        [0.10980392, 0.15686275, 0.07843138, 1.        ],
        [0.16470589, 0.20784314, 0.11764706, 1.        ]],

       [[0.14117648, 0.12941177, 0.10980392, 1.        ],
        [0.21176471, 0.1882353 , 0.16862746, 1.        ],
        [0.14117648, 0.13725491, 0.12941177, 1.        ],
        ...,
        [0.10980392, 0.15686275, 0.08627451, 1.        ],
        [0.0627451 , 0.08235294, 0.05098039, 1.        ],
        [0.14117648, 0.2       , 0.09803922, 1.        ]],

       ...,
```

This is also a mushroom.

Why learning ?

How can we write a computer program (algorithm) that implements that ?

Extracting **semantic information** requires models of high complexity, which cannot be designed by hand. However, one can write a **computer program** that learns the task of extracting semantic information.

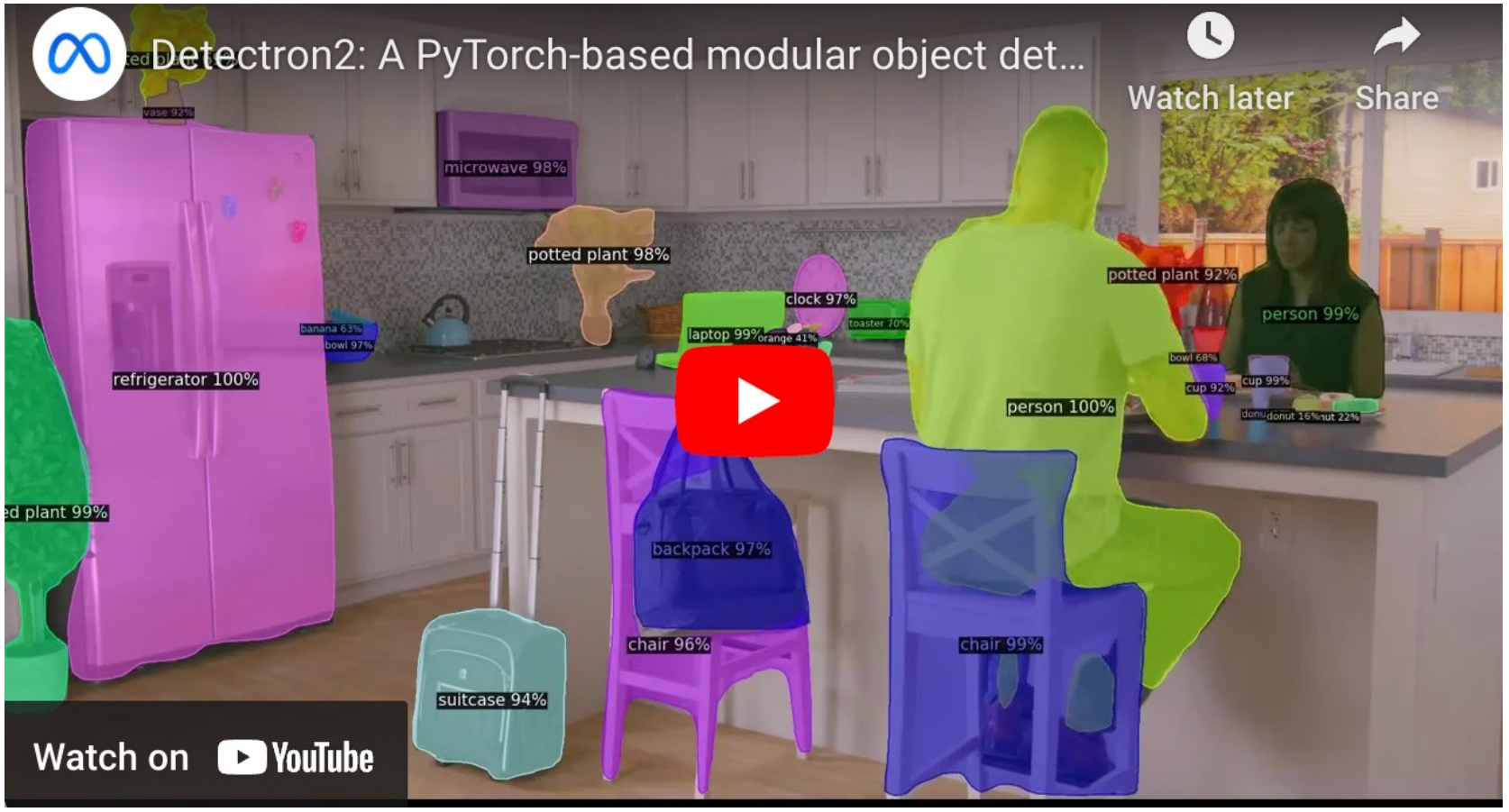
Techniques used in practice consist of:

- defining a **parametric model** with high capacity,
- optimizing its parameters, by "making it work" on the **training data**.

The core idea of **AI (ML/DL)** is to write programs (algorithms) that depend on p arameters whose values are let unspecified and optimized to work on **examples (training data).**

Applications and Successes

Detection, segmentation, pose estimation



Link: https://www.youtube.com/watch?v=5kpsZoKjPgQ

Autopilot

Link: https://www.youtube.com/watch?v=tlThdr3O5Qo

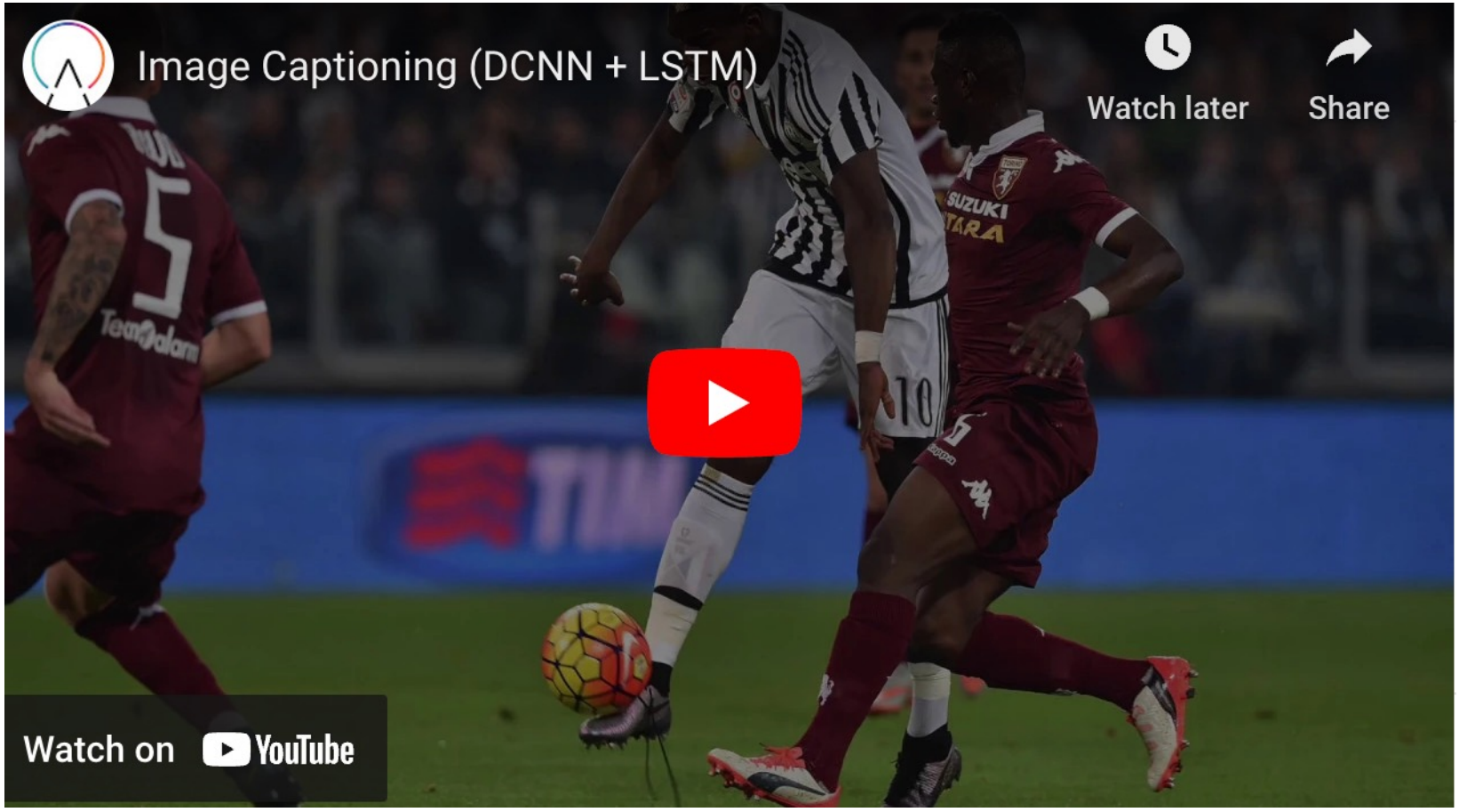
AI ChatBot

Link: https://www.youtube.com/watch?v=svl_GIBRkSA

AI for music

Link: https://www.youtube.com/watch?v=egJ0PTKQp4U

Image captioning (image to text)



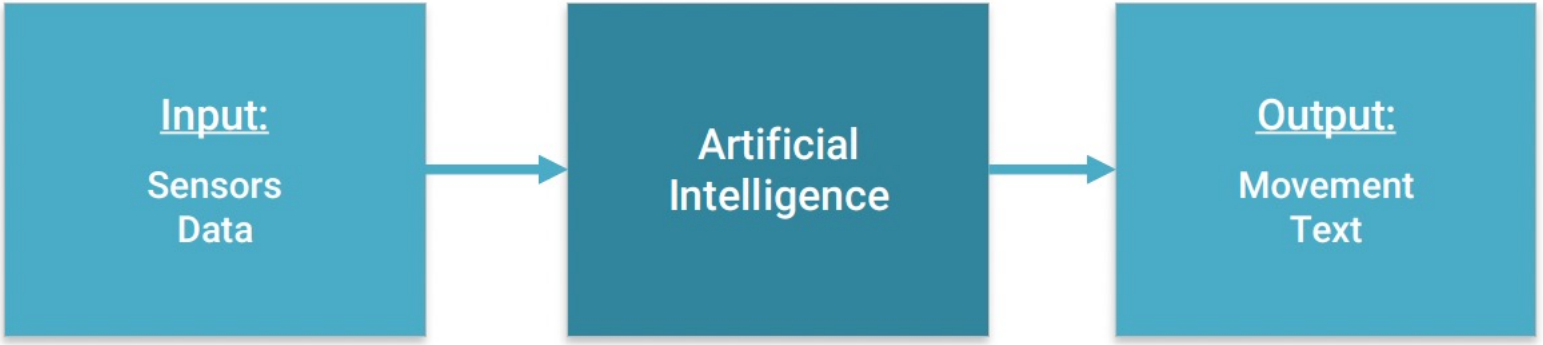
Link: https://www.youtube.com/watch?v=BIYrmAPbTPE

Video generation (text to video)

Link: https://www.youtube.com/watch?v=YxmAQiiHOkA

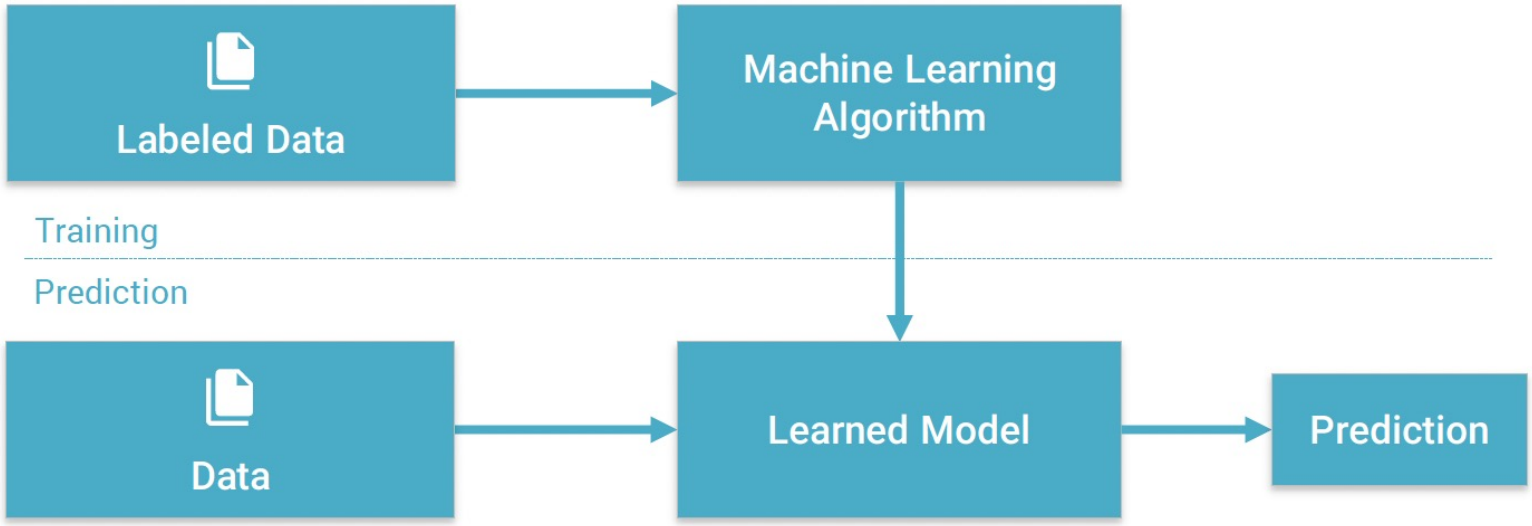
How does AI work ?

What is Artificial Intelligence ?



Machine learning

Machine Learning is a type of Artificial Intelligence that provides computers with the ability to learn without being explicitly programmed.



Provides various techniques that can learn from and make predictions on data

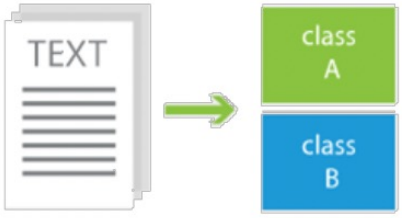
Machine learning

Supervised Learning: Learning with a labeled training set
Example: email spam detector with training set of already labeled emails

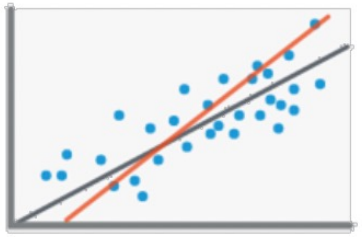
Unsupervised Learning: Discovering patterns in unlabeled data
Example: cluster similar documents based on the text content

Reinforcement Learning: learning based on feedback or reward
Example: learn to play chess by winning or losing

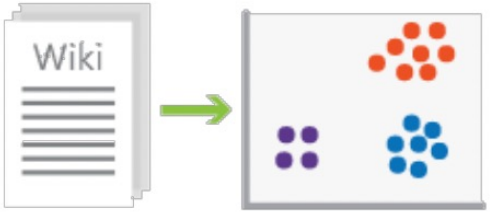
Machine learning



Classification
(supervised – predictive)



Regression
(supervised – predictive)



Clustering
(unsupervised – descriptive)

Anomaly Detection
(unsupervised– descriptive)

Deep learning

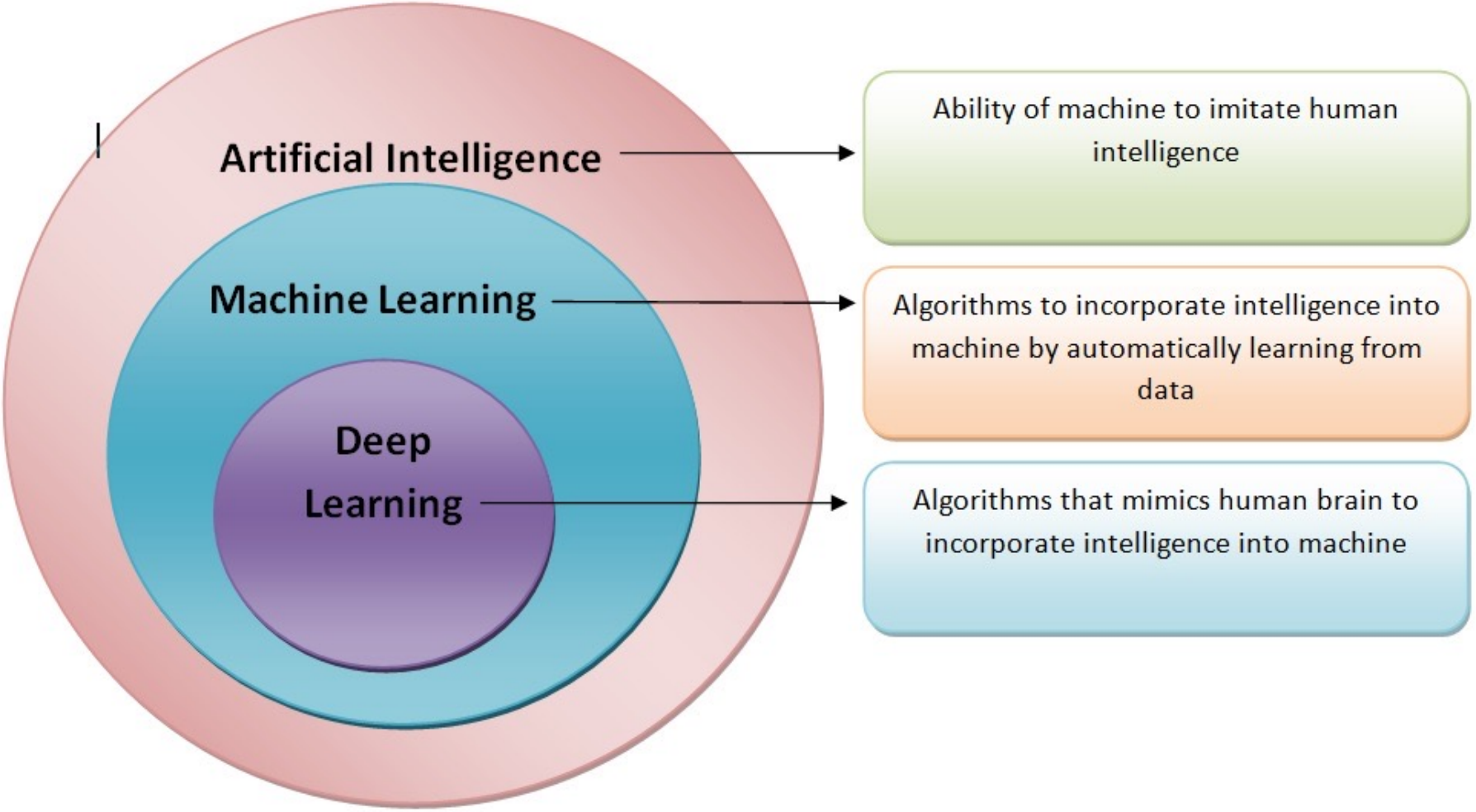
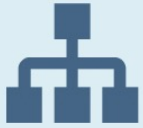


Image credits: analyticsvidhya

Deep learning

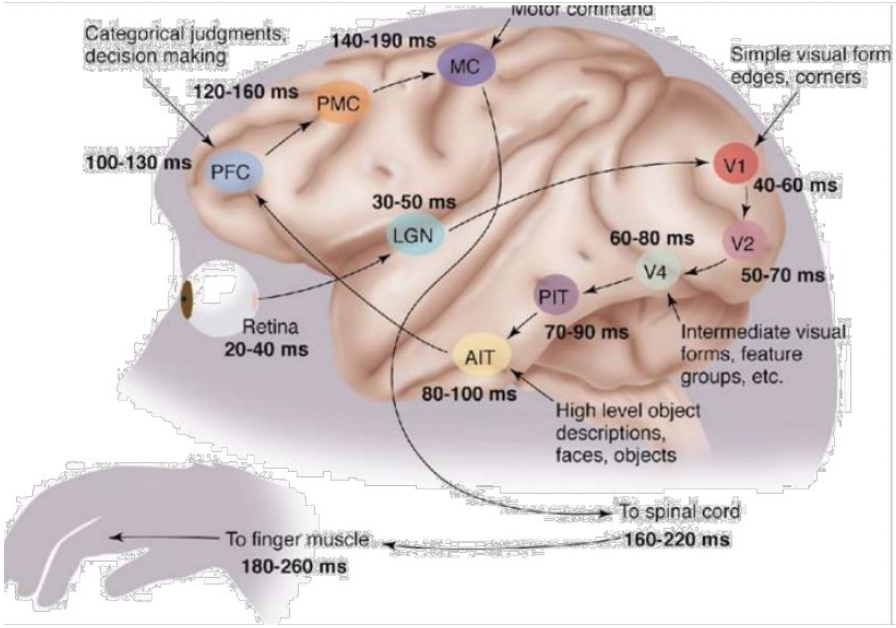
Part of the machine learning field of learning representations of data. Exceptional effective at learning patterns.



Utilizes learning algorithms that derive meaning out of data by using a hierarchy of multiple layers that mimic the neural networks of our brain.

If you provide the system tons of information, it begins to understand it and respond in useful ways.

Inspired by the Brain



The first hierarchy of neurons that receives information in the visual cortex are sensitive to specific edges while brain regions further down the visual pipeline are sensitive to more complex structures such as faces.

Our brain has lots of neurons connected together and the strength of the connections between neurons represents long term knowledge.

1

One learning algorithm hypothesis: all significant mental algorithms are learned except for the learning and reward machinery itself.

A brief history (A long time ago…)

1958 Perceptron

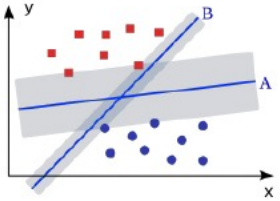
1969
Perceptron criticized

1974 Backpropagation

awkward silence (AI Winter)

Convolution Neural Networks for Handwritten Recognition
1998

1995
SVM reigns



2006
Restricted Boltzmann Machine

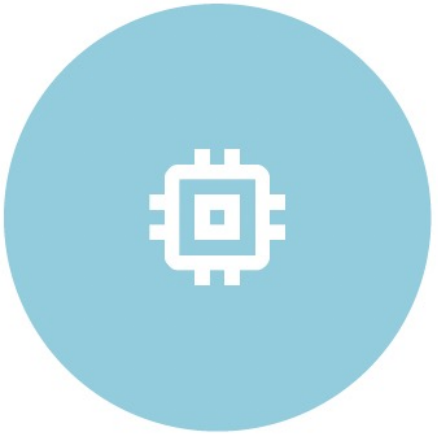
Google Brain Project on 16k Cores
2012

2012
AlexNet wins ImageNet
IMAGENET

Link: https://www.youtube.com/watch?v=cNxadbrN_aI

Deep learning – What changed ?

Big Data
(Digitalization)



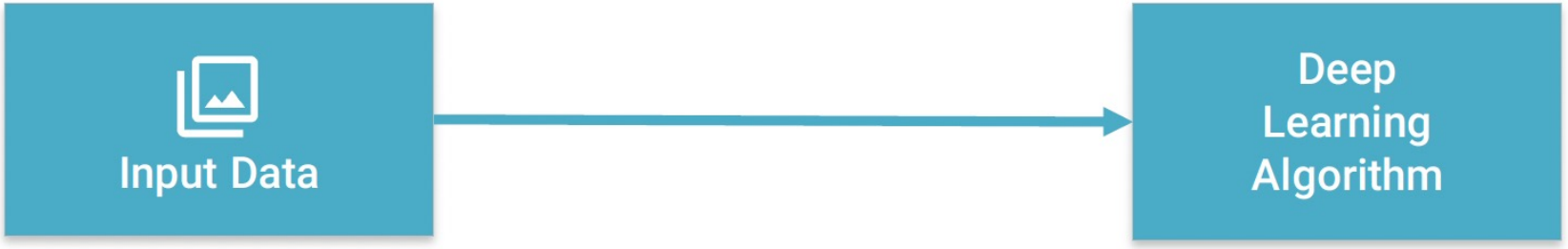
Computation
(Moore's Law, GPUs)

Algorithmic
Progress

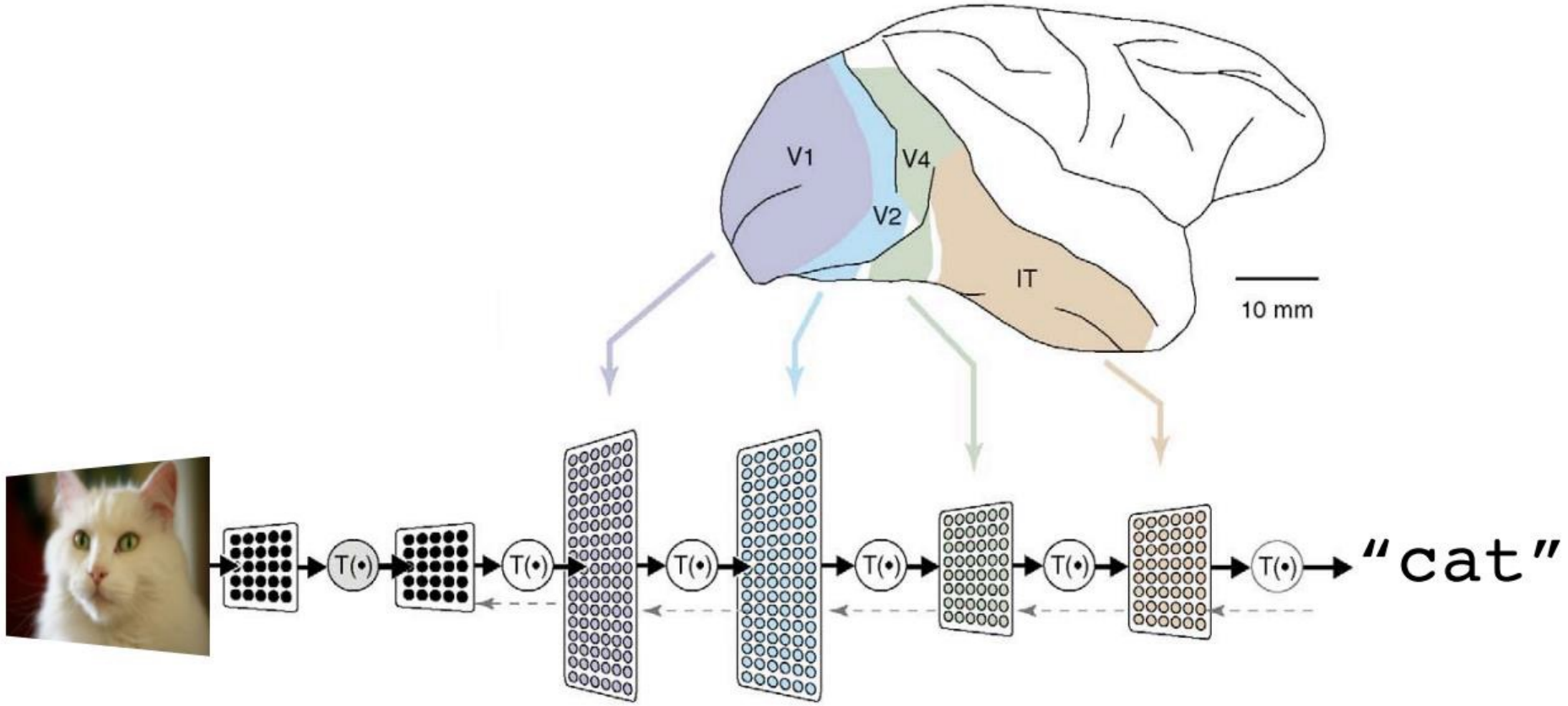
Deep learning - Basics

Traditional approaches

Deep learning

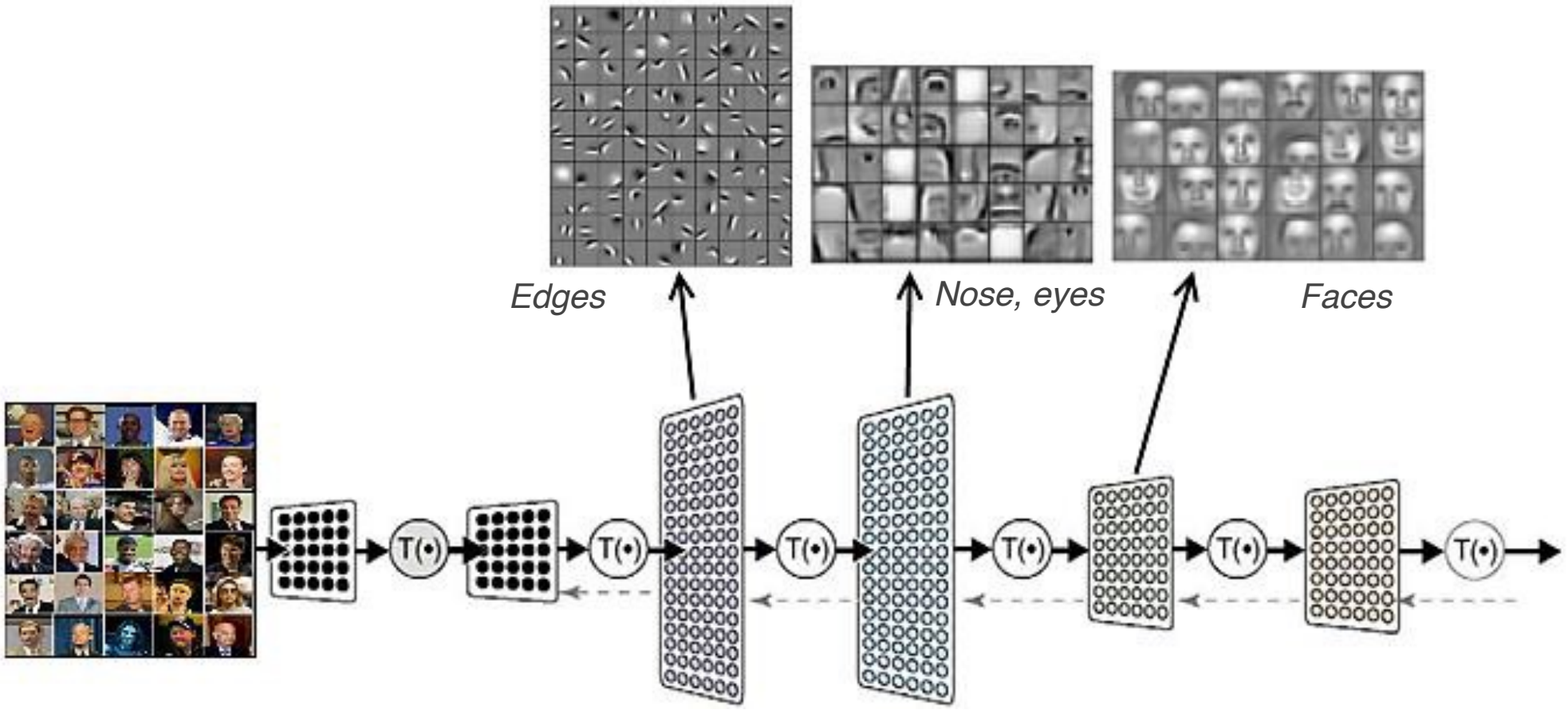


Deep learning - Basics

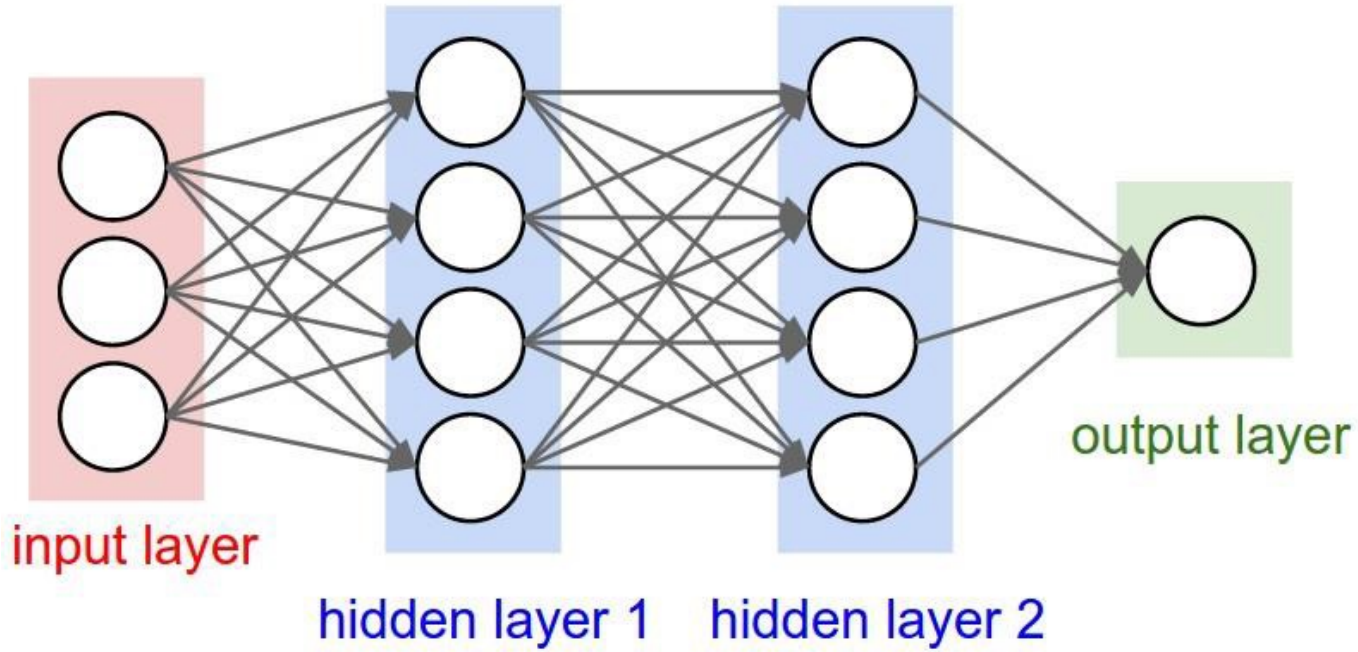


*A **deep neural network** consists of a hierarchy of layers, whereby each layer transforms the input data into more abstract representations (e.g. edge -> nose -> face). The output layer combines those features to make predictions.*

Deep learning - Basics



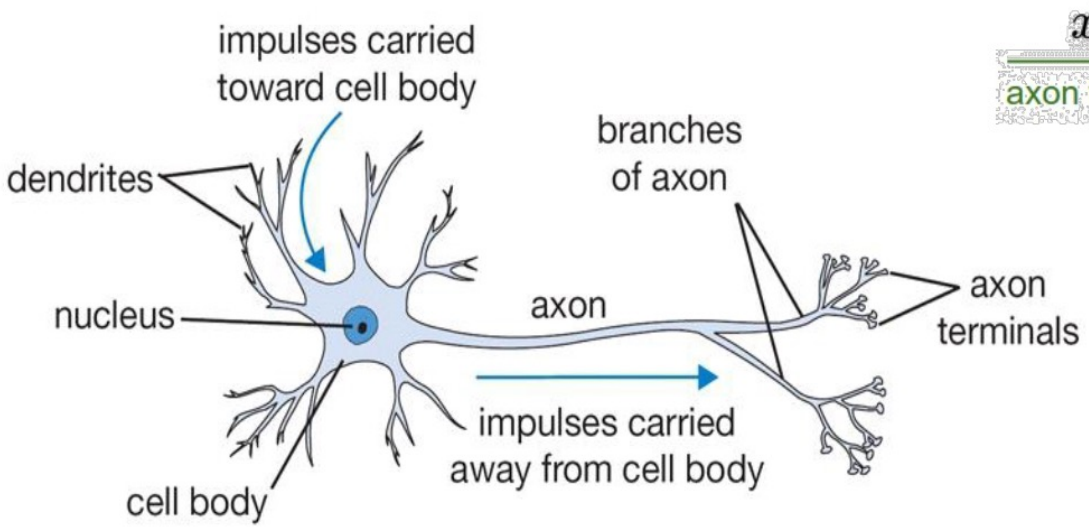
Deep learning - Basics

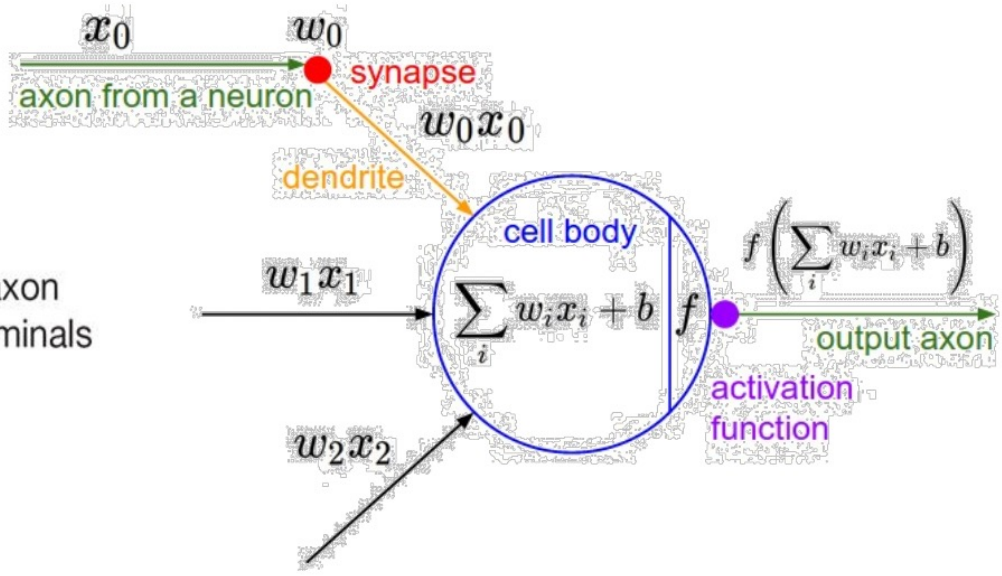


Artificial neural network *consists of one input, one output and multiple fully-connected hidden layers in between.*

Each layer is represented as a series of neurons and progressively extracts higher and higher-level features of the input until the final layer which makes a decision about what the input shows. The more layers the network has, the higher level features it will learn.

Deep learning - Basics

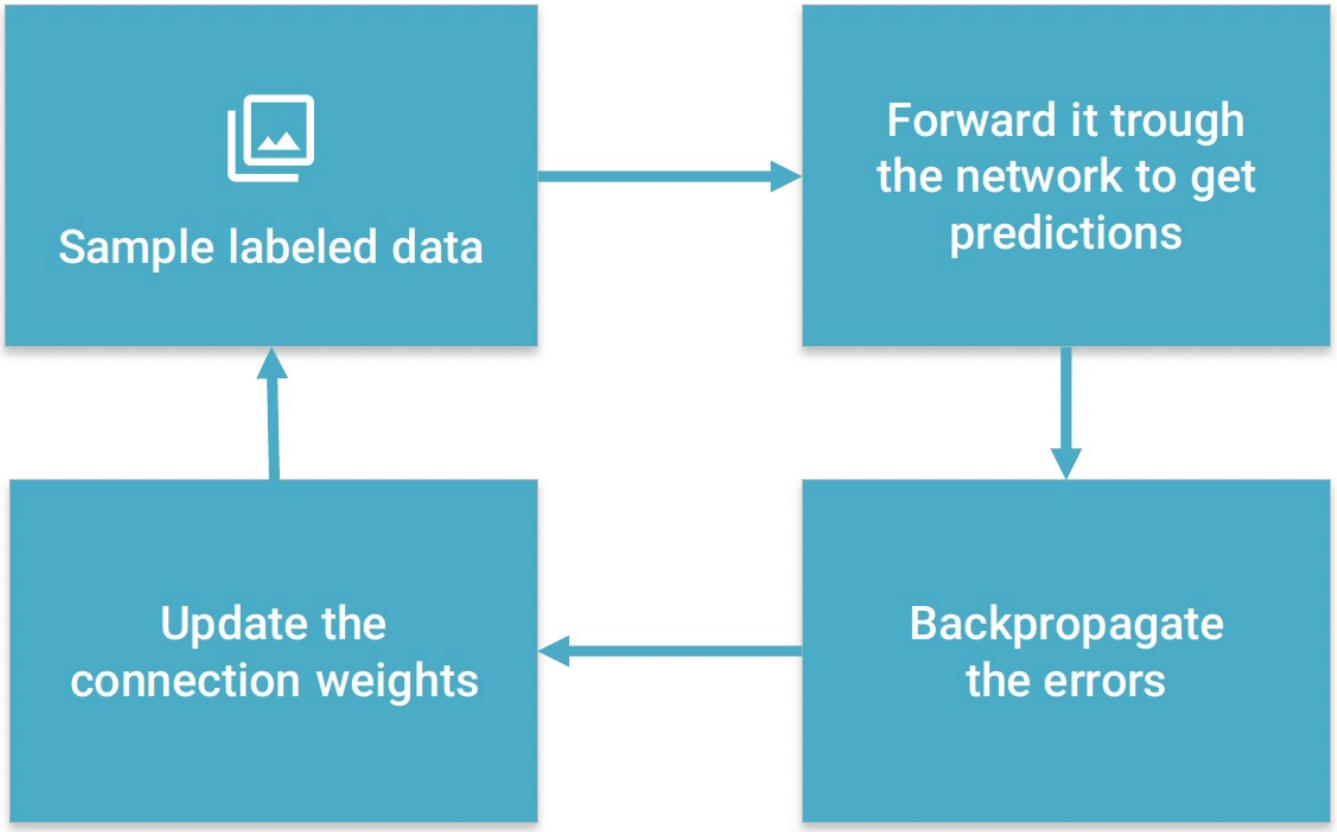




An artificial neuron *contains a nonlinear activation function and has several incoming and outgoing weighted connections.*

Neurons are ***trained to filter and detect*** *specific features or patterns (e.g. edge, nose, eye, etc.) by receiving weighted input, transforming it with the activation function und passing it to the outgoing connections.*

Deep learning - Basics



Training processing → *learn by generating an error signal that measures the difference between the predictions of the network and the desired values and then using this error signal to change the weights (or parameters) so that predictions get more accurate.*

Deep learning – Usage requirements

Large data set with good quality *(input-output mappings)*

Measurable and describable goals *(define the cost)*

Enough computing power *(AWS GPU Instance)*

Excels in tasks where the basic unit *(pixel, word)* has very little meaning in itself, but the combination of such units has a useful meaning

Computing power ?

AWS EC2 GPU Spot Instance: *g2.2xlarge - $0.0782 per Hour*

The **DIGITS DevBox** combines the world's best hardware (4 GPUs), software, and systems engineering for deep learning in a powerful solution that can fit under your desk. *Cost: $15k*

Deep learning – Outlook

Significant advances in deep reinforcement and unsupervised learning

Bigger and more complex architectures based on various interchangeable modules/techniques

Deeper models that can learn from much fewer training cases

Harder problems such as video understanding and natural language processing will be successfully tackled by deep learning algorithms

ML/DL - Takeaways

Machines that learn to represent the world from experience.

Deep Learning is no magic! Just statistics in a black box, but exceptional effective at learning patterns.

We haven't figured out creativity and human-empathy.

Transitioning from research to consumer products. Will make the tools you use every day work better, faster and smarter.

Assignment

Teamwork

- **Group of 3 or 4 --> forming 6 or 8 groups**
- **Choose one of the following topics --> 2 groups/topic !**
  1. AI for Heathcare
  2. AI for E-commerce
  3. AI for Autopilot
  4. AI for Environment
  5. AI for Gaming
  6. AI for Chatbot
  7. AI for Robotics
  8. AI for Education
  9. Others (Defense, Transportation, Space Exploration, Banking, etc.)
- **Prepare a presentation with (approximately):**
  - 1 slide to present your group + your topic
  - 1 slide to present the solutions before the AI generation
  - Some (2-4) slides to present the solutions and advances of AI on the topic
  - Demos (graphics, figures, youtube link, video, etc.)
  - 1 slide to present the pros/cons
  - 1 slide to present on-going/future challenges
  - 1 slide to conclude, member contribution, etc.
- **Present your work (10 minutes/group) next week + Q/A**
- **Your work will be evaluated !**

Pytorch

Python libraries for ML/DL

Image credits: selectedfirms

Pytorch - Basics

- Open your Google Colab and create a new notebook

"R4A13_lab0_Practical_Pytorch.ipynb"

- Learn the basics from Pytorch tutorials :

  https://pytorch.org/tutorials/beginner/basics/intro.html

- Re-implement the codes (DO NOT COPY/PASTE) and try to understand the following functionalities.

  1. *Tensors (numpy vs torch.tensor)*
  2. *Datasets and DataLoaders*
  3. *Transforms*
  4. *Build models*
  5. *Autograd*
  6. *Save, Load and Use models*

PyTorch

References and Sources

- Thank **Nicolas Courty** (Prof at UBS) for sharing his slides
- **Neural networks and deep learning** (free online book)

  http://neuralnetworksanddeeplearning.com/index.html
- **Machine learning course** – Oxford

  https://www.cs.ox.ac.uk/people/nando.defreitas/machinelearning/
- **Neural network course** - Hugo Larochelle

  https://info.usherbrooke.ca/hlarochelle/neural_networks/content.html
- **Deep learning course** – François Fleuret

  https://fleuret.org/dlc/