

# Deep Learning

HSE University

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2024

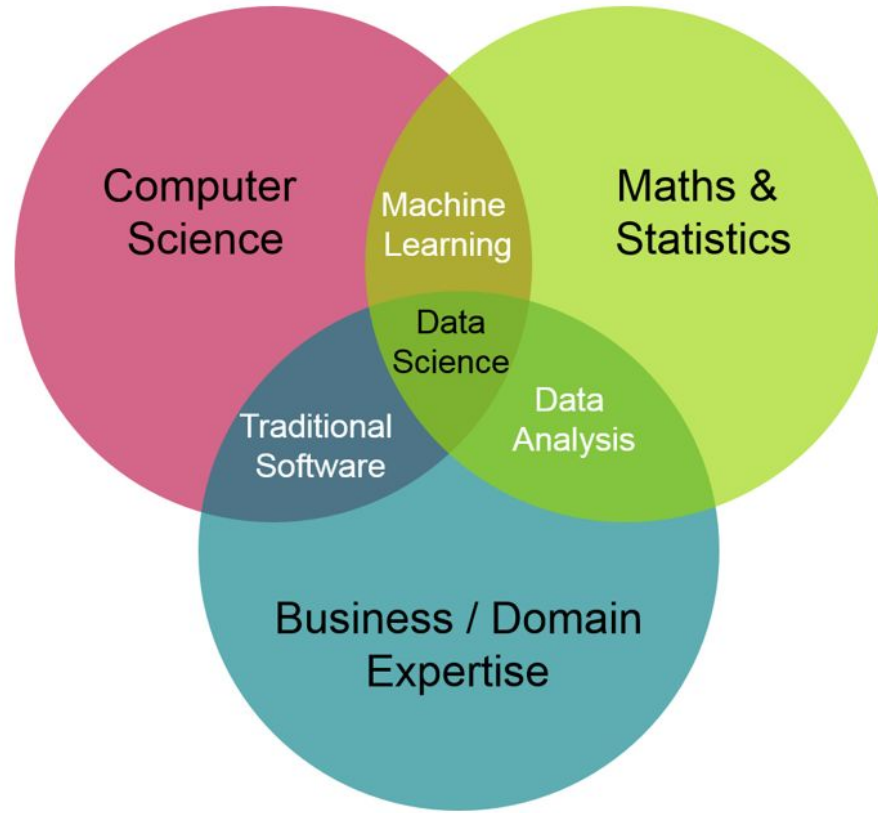


LAMBDA • HSE

# Intro

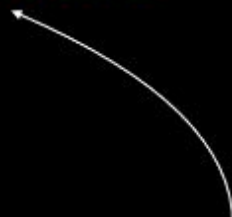


# What is Deep Learning?



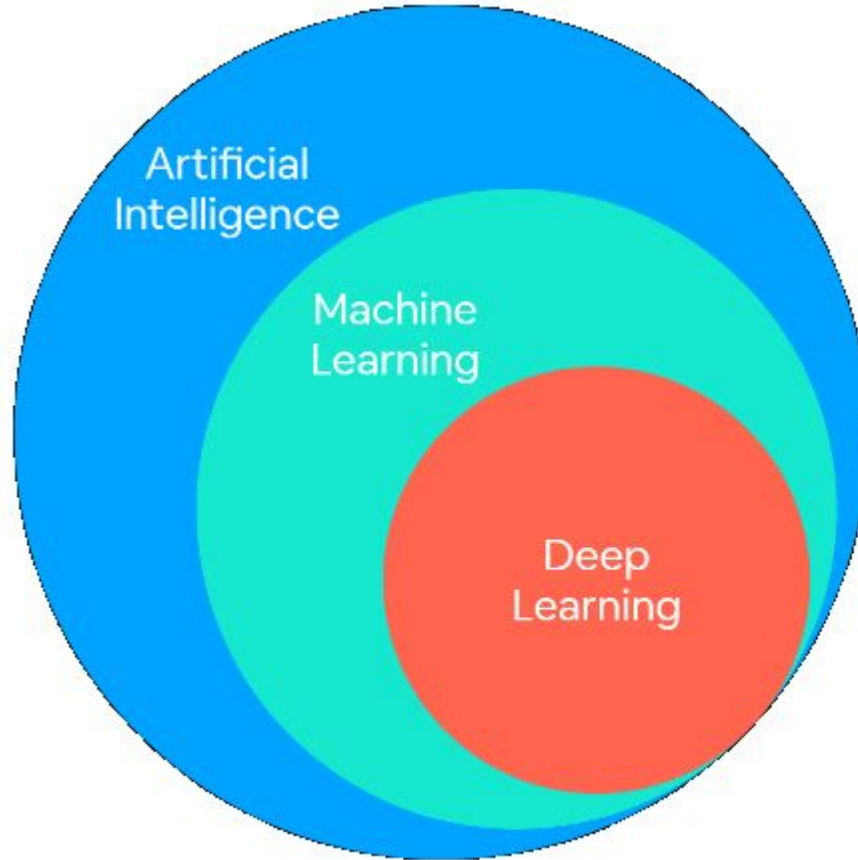
# What is Deep Learning?

Machine learning is turning things (data) into numbers and **finding patterns** in those numbers.

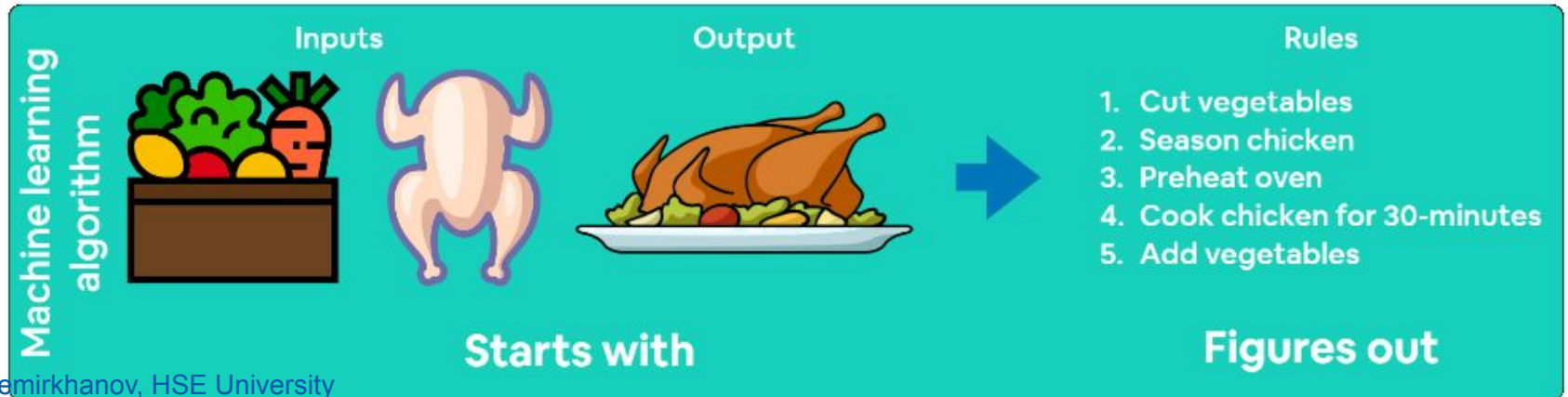


The computer does this part.  
How?  
Code & math.  
We're going to be writing the code.

# What is Deep Learning?



# What is Deep Learning?



# ML vs DL

## ML

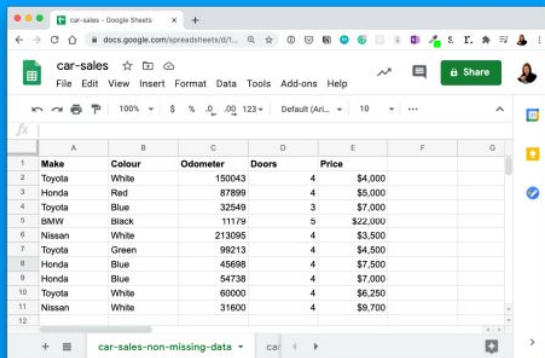
- ▶ Simple
- ▶ Explainable
- ▶ Less data required
- ▶ Feature engineering is required

## DL

- ▶ Complex
- ▶ Unexplainable
- ▶ A lot of data is required
- ▶ No feature engineering
- ▶ Higher quality on complex tasks, but more computation cost

# ML vs DL

## Machine Learning



	Make	Colour	Odometer	Doors	Price
1	Toyota	White	150043	4	\$4,000
2	Honda	Red	87899	4	\$5,000
3	Toyota	Blue	32549	3	\$7,000
4	BMW	Black	11179	5	\$22,000
5	Nissan	White	213095	4	\$3,500
6	Toyota	Green	99213	4	\$4,500
7	Honda	Blue	45698	4	\$7,500
8	Honda	Blue	54738	4	\$7,000
9	Toyota	White	60000	4	\$6,250
10	Nissan	White	31600	4	\$9,700

Algorithm: gradient  
boosted machine

dmlc  
XGBoost

Structured data

## Deep Learning



**Daniel Bourke** @mrdbourke · Nov 1  
"How do I learn #machinelearning?"

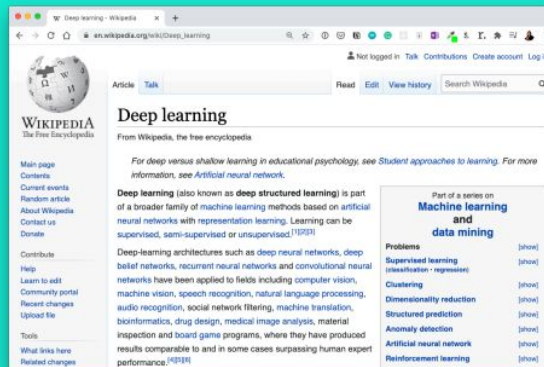
What you want to hear:

1. Learn Python
2. Learn Math/Stats/Probability
3. Learn software engineering
4. Build

What you need to do:

1. Google it
2. Go down the rabbit hole
3. Resurface in 6-9 months and reassess

See you on the other side.



WIKIPEDIA  
The free encyclopedia

### Deep learning

From Wikipedia, the free encyclopedia

For deep versus shallow learning in educational psychology, see *Student approaches to learning*. For more information, see *Artificial neural network*.

**Deep learning** (also known as **deep structured learning**) is part of a broader family of machine learning methods based on artificial neural networks with representation learning. Learning can be supervised, semi-supervised or unsupervised.<sup>[1][2]</sup>

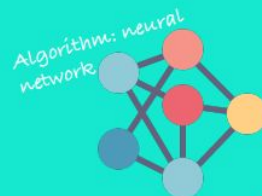
Deep-learning architectures such as deep neural networks, deep belief networks, recurrent neural networks and convolutional neural networks have been applied to fields including computer vision, machine vision, speech recognition, natural language processing, audio recognition, social network filtering, machine translation, bioinformatics, drug design, medical image analysis, material inspection and board game programs, where they have produced results comparable to and in some cases surpassing human expert performance.<sup>[1][2]</sup>

Part of a series on  
**Machine learning and data mining**

**Problems**

- Supervised learning (classification - regression) [show]
- Clustering [show]
- Dimensionality reduction [show]
- Structured prediction [show]
- Anomaly detection [show]
- Artificial neural network [show]
- Reinforcement learning [show]

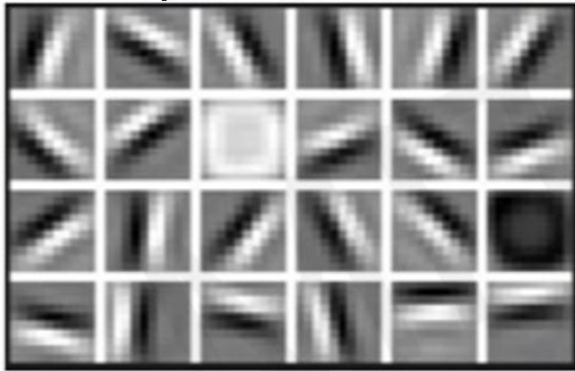
Unstructured data





# Feature engineering

**Low Level Features**



Lines & Edges

**Mid Level Features**



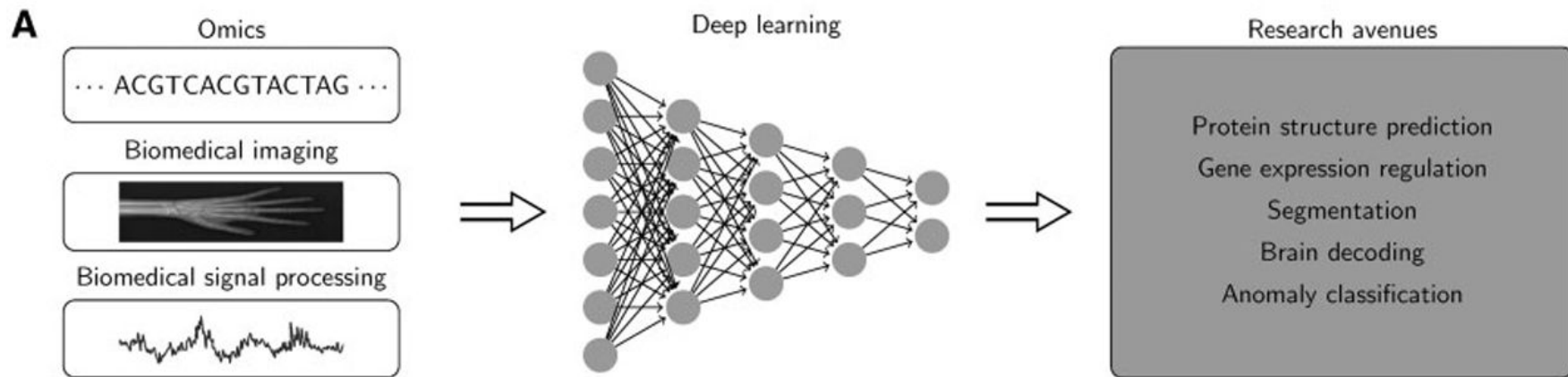
Eyes & Nose & Ears

**High Level Features**

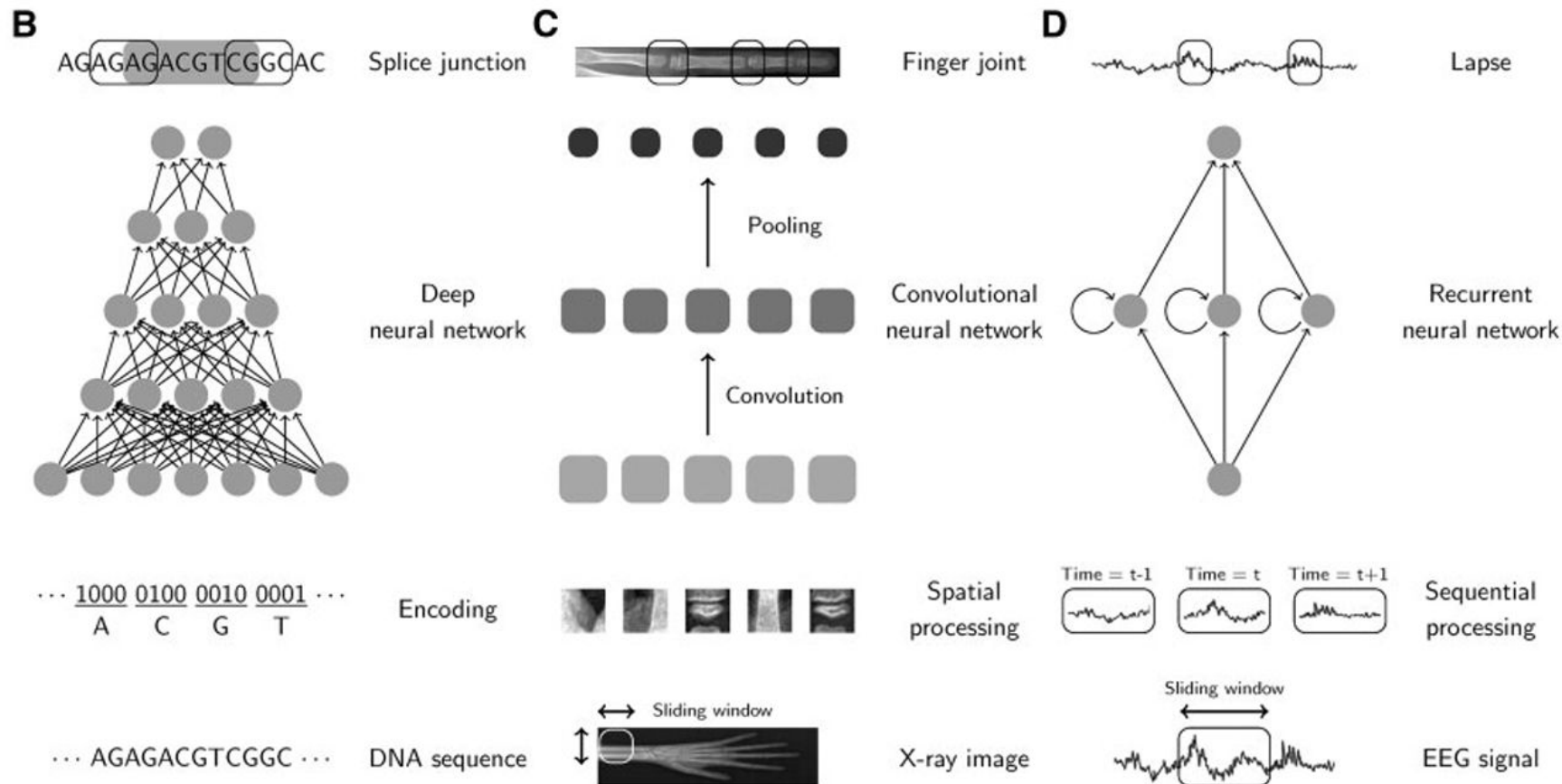


Facial Structure

# Applications



# Applications



# Applications



2014



2015



2016



2017



2018



2020



2021

Source: Goodfellow et al., 2014; Radford et al., 2016; Liu & Tuzel, 2016; Karras et al., 2018; Karras et al., 2019; Goodfellow, 2019; Karras et al., 2020; AI Index, 2021; Vahdat et al., 2021

# Applications



+



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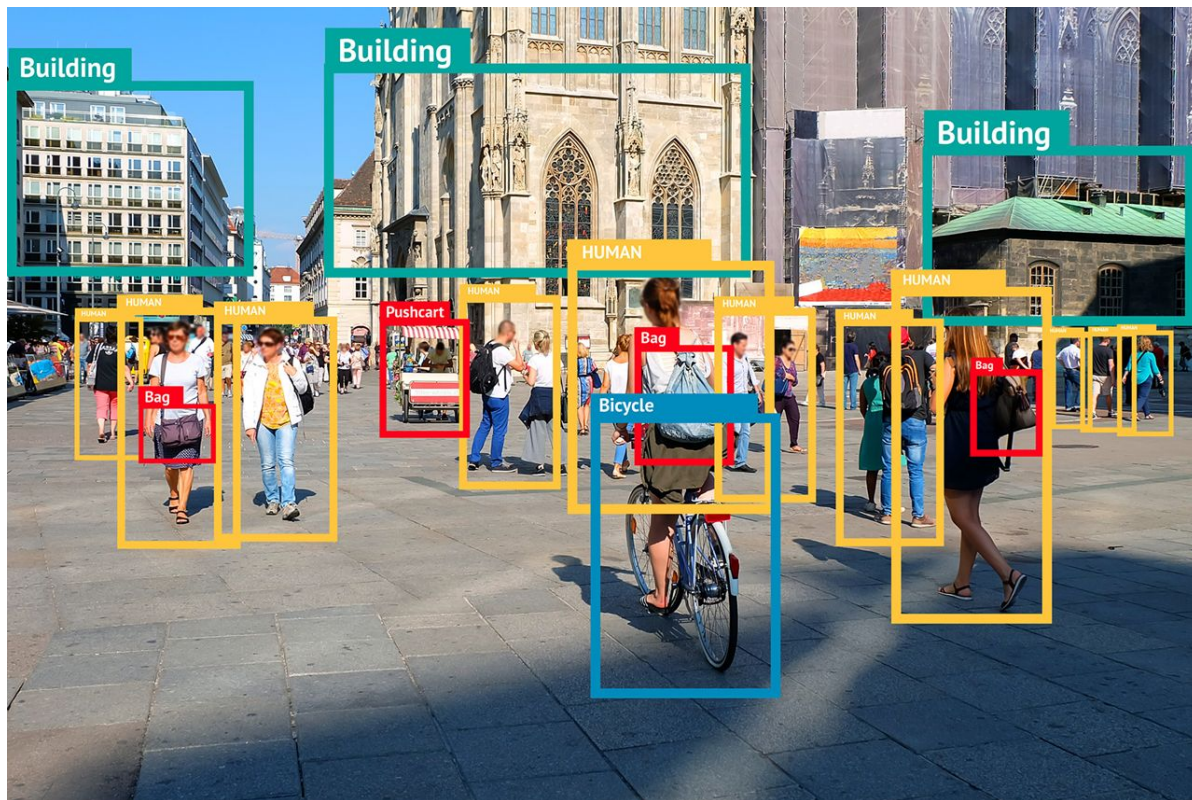


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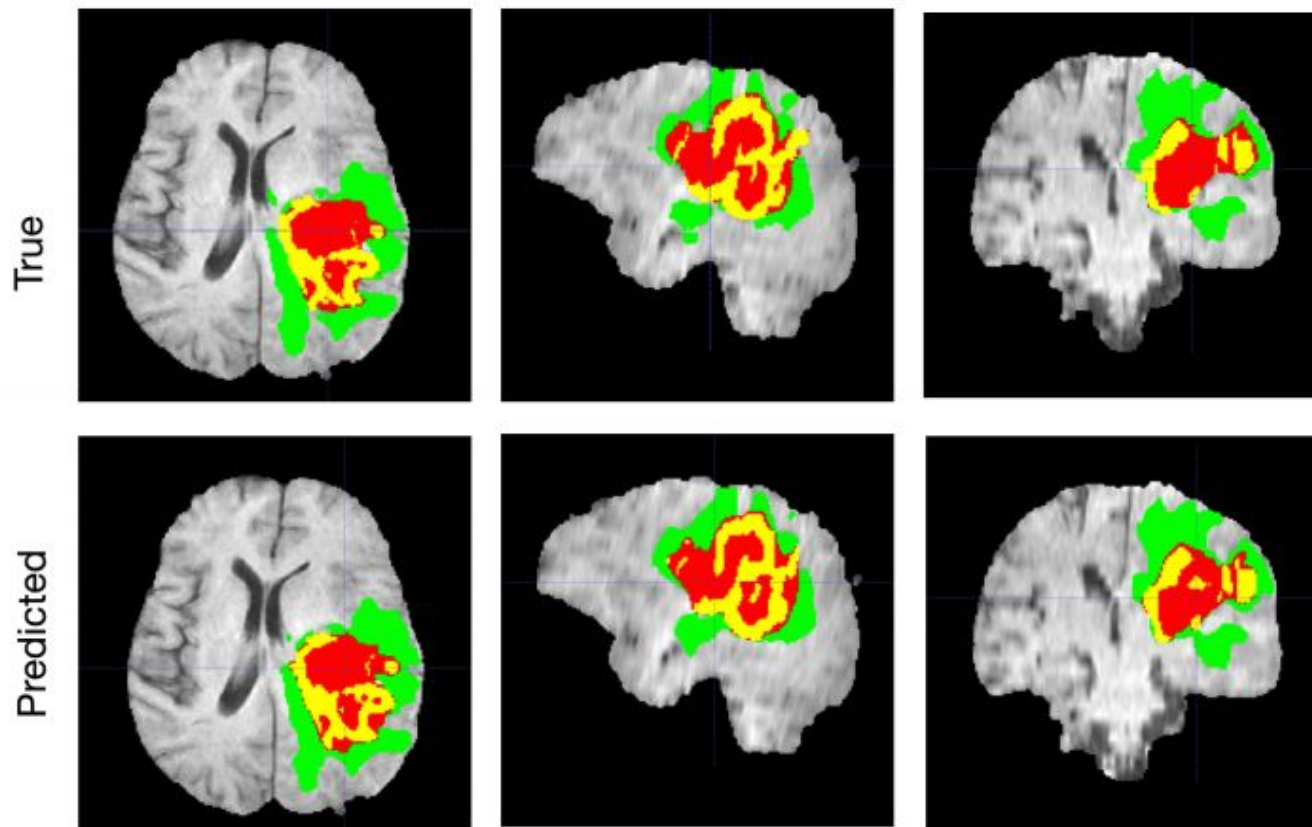




# Applications



# Applications



<https://developer.nvidia.com/blog/automatically-segmenting-brain-tumors-with-ai/>

# Applications

## Text Summarization using NLP

### Natural Language Processing

Natural language processing (NLP) is a subfield of linguistics, computer science, and artificial intelligence concerned with the interactions between computers and human language, in particular how to program computers to process and analyze large amounts of natural language data. The result is a computer capable of "understanding" the contents of documents, including the contextual nuances of the language within them. The technology can then accurately extract information and insights contained in the documents as well as categorize and organize the documents themselves.

Summary

`summarize(text, 0.6)`

### Natural Language Processing

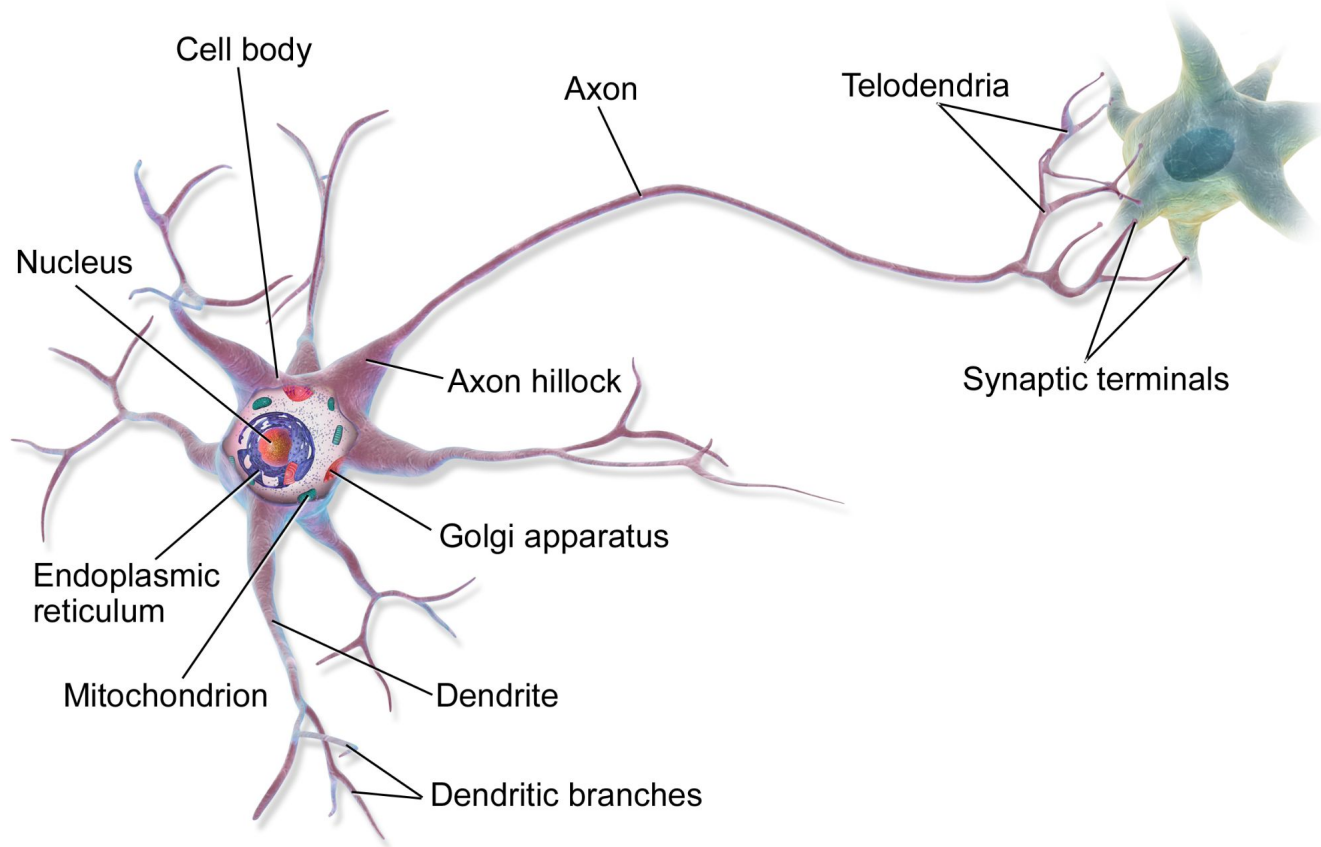
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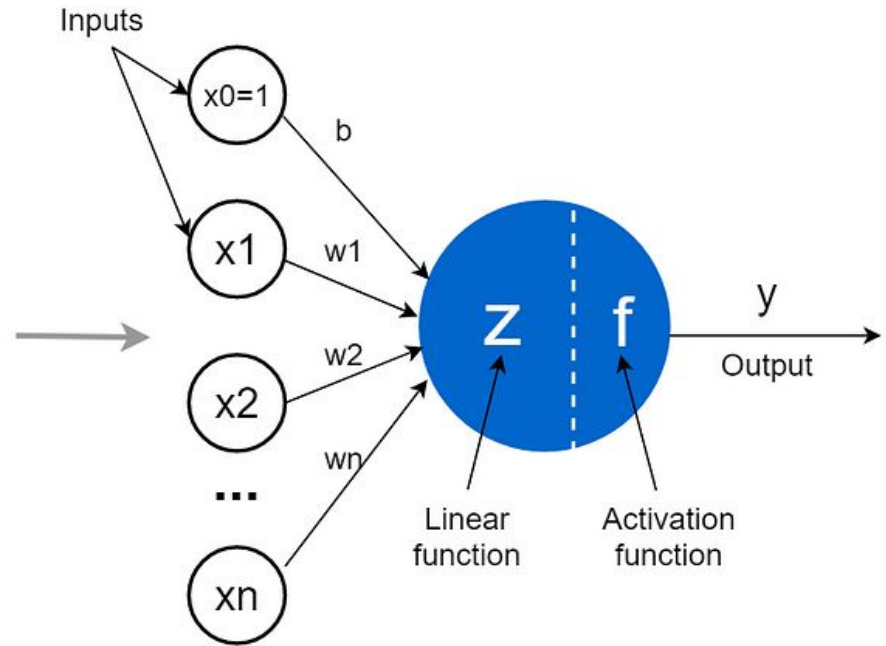
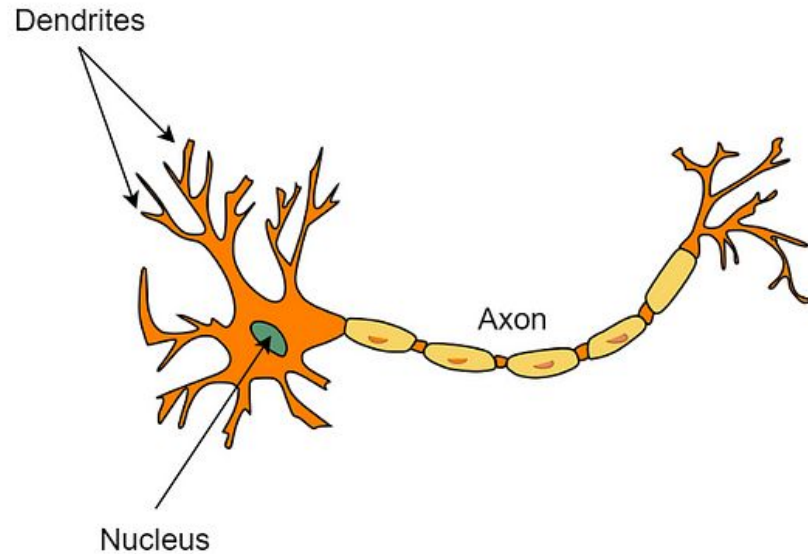
# Perceptron



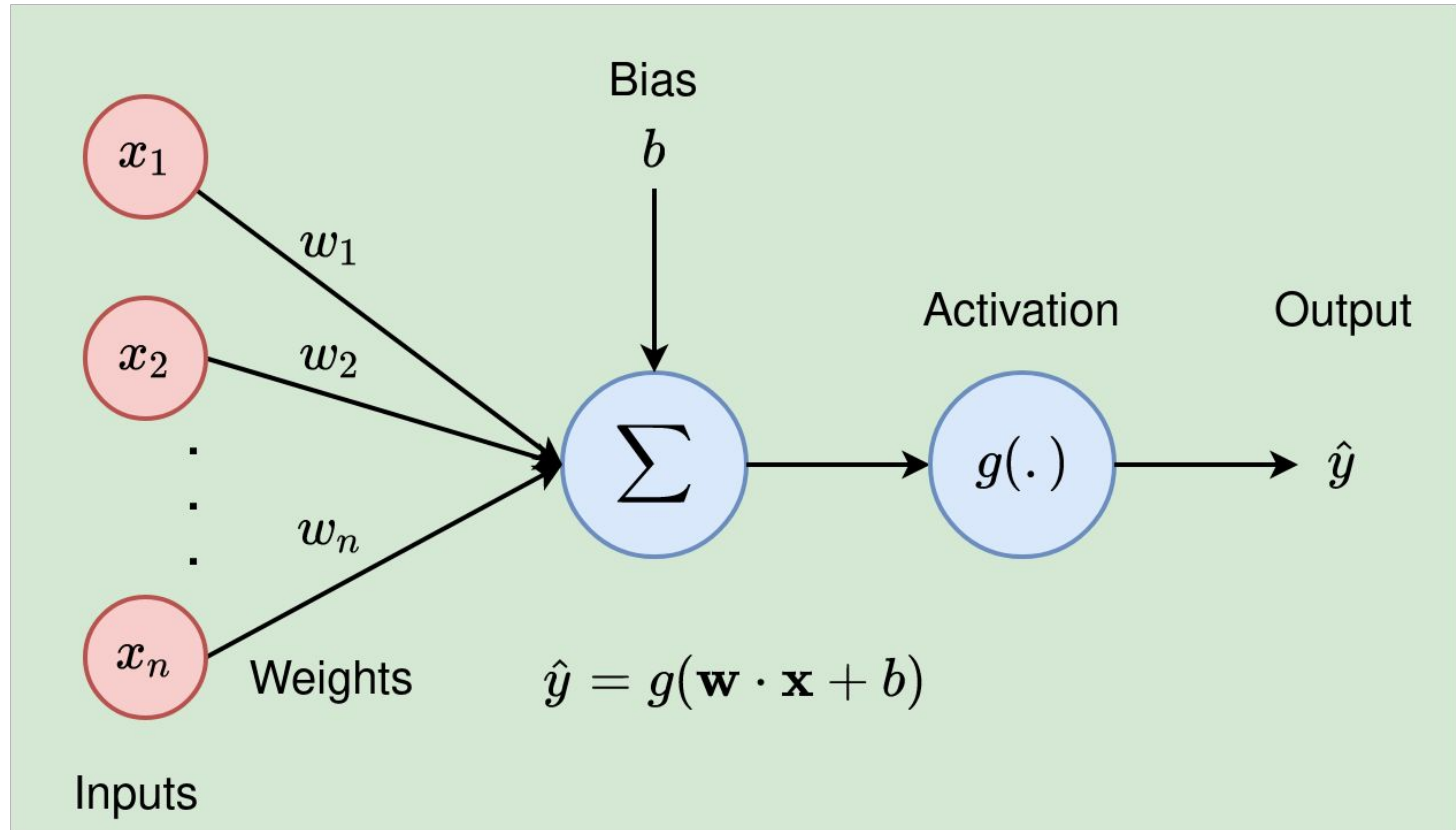
# Neuron



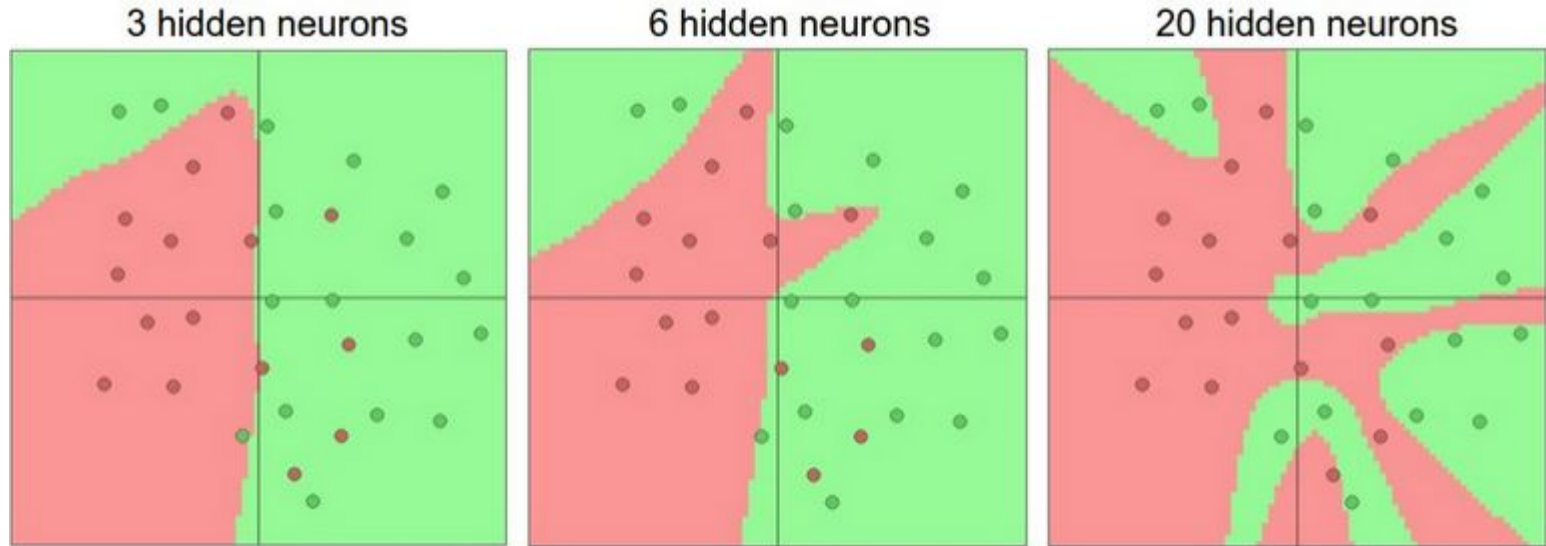
# Perceptron



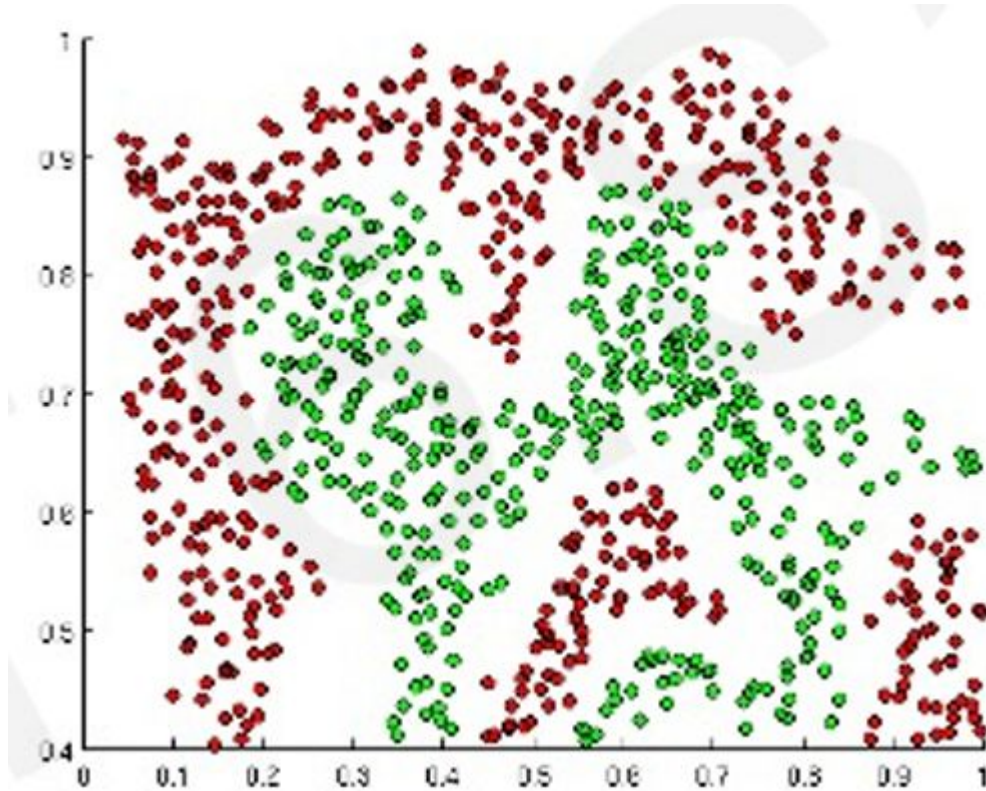
# Perceptron



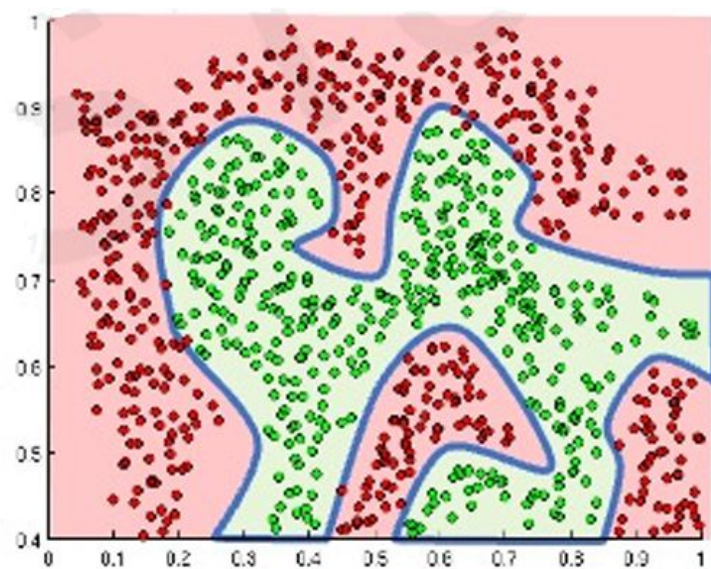
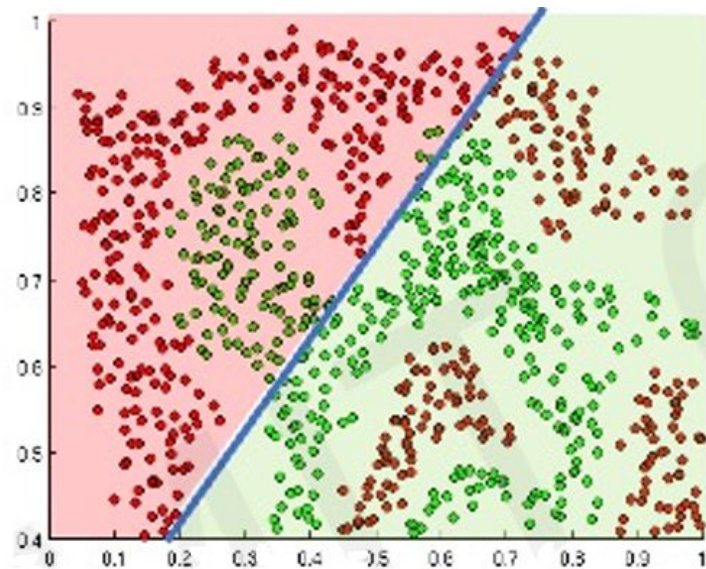
# Multilayer Perceptron



# Deep Networks



# Deep Networks

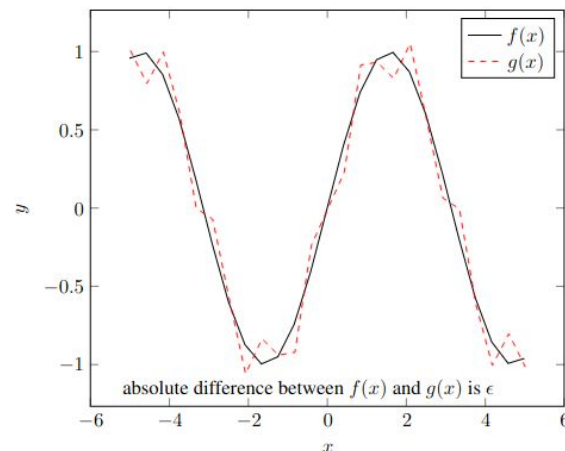
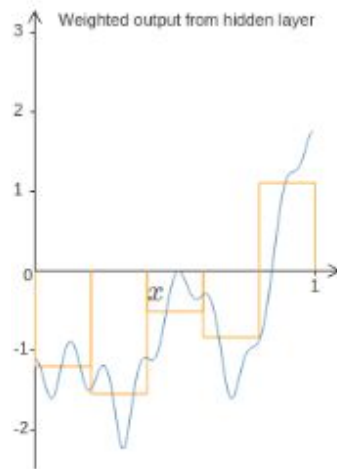
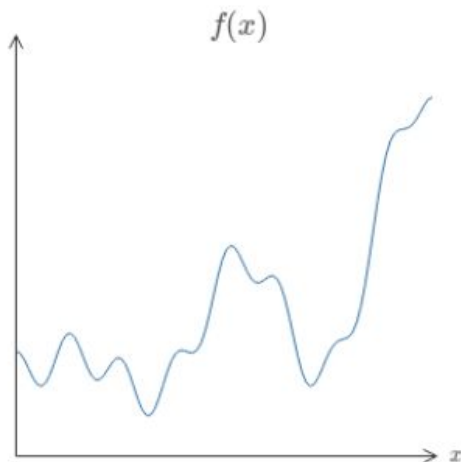




# Universal approximation theorem

**Theorem 3.** (*Universal Approximation Theorem for Width-Bounded ReLU Networks*). For any Lebesgue-integrable function  $f : \mathbb{R}^n \rightarrow \mathbb{R}$  and any  $\epsilon > 0$ , there exists a fully-connected ReLU network  $A$  with width  $d_m \leq n + 4$ , such that the function  $F_A$  represented by this network satisfies

$$\int_{\mathbb{R}^n} |f(x) - F_A(x)| dx < \epsilon$$





# How to train NN



# Training

- ▶ Define a problem (e.g. classification, ranking, etc.)
- ▶ Find a dataset
- ▶ Prepare data (cleaning, labeling, augmentation, etc.)
- ▶ Set an objective function
- ▶ Choose an evaluation metric
- ▶ Set or choose a baseline model
- ▶ Record every experiment

