

# Introduction to Deep Learning

## Chapter 1: Brief History

**Bernd Bischl**

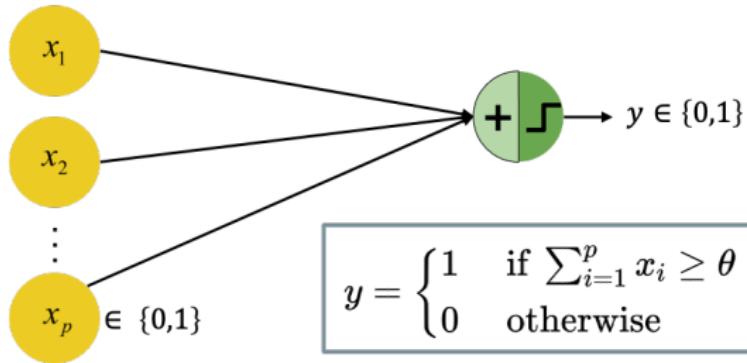
Department of Statistics – LMU Munich

WS 2021/2022



# A BRIEF HISTORY OF NEURAL NETWORKS

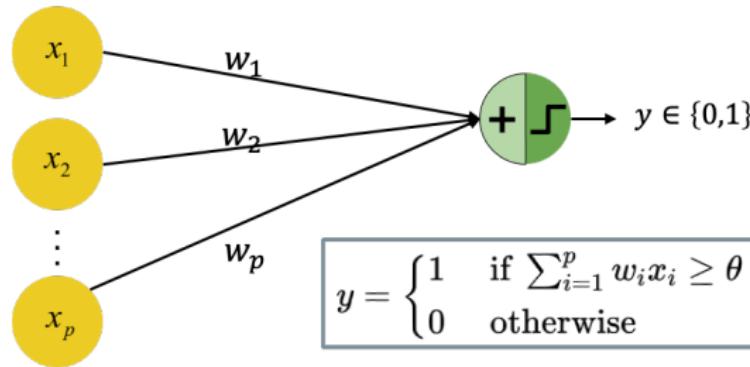
- 1943: The first artificial neuron, the "Threshold Logic Unit (TLU)", was proposed by Warren McCulloch & Walter Pitts.



- The model is limited to binary inputs.
- The MP-neuron fires a +1 if the input exceeds a certain threshold  $\theta$ .
- The weights are not adjustable, so learning could only be achieved by changing the threshold  $\theta$ .

# A BRIEF HISTORY OF NEURAL NETWORKS

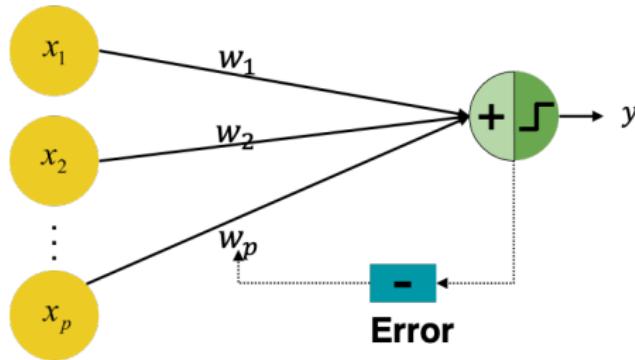
- 1957: The perceptron was invented by Frank Rosenblatt.



- The inputs are not restricted to be binary.
- In perceptron, the weights are adjustable and can be learned by learning algorithms.
- Similar to the MP-neuron, the threshold is adjustable, and decision boundaries are linear.

# A BRIEF HISTORY OF NEURAL NETWORKS

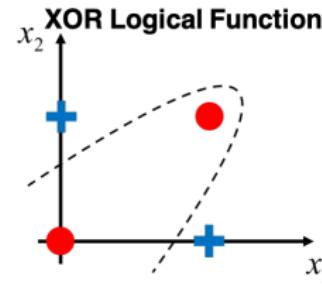
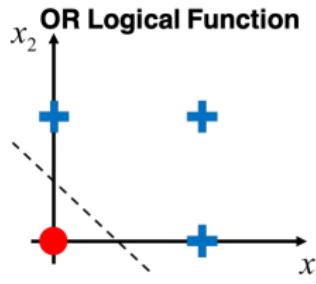
- **1960:** Adaptive Linear Neuron (ADALINE) was invented by Bernard Widrow & Ted Hoff; weights are now adjustable according to the weighted sum of the inputs.



- **1965:** Group method of data handling (also known as polynomial neural networks) by Alexey Ivakhnenko. The first learning algorithm for supervised deep feedforward multilayer perceptrons.

# A BRIEF HISTORY OF NEURAL NETWORKS

- 1969: The first “AI Winter” kicked in.
  - Marvin Minsky & Seymour Papert proved that a perceptron cannot solve the XOR-Problem (linear separability).
  - Less funding ⇒ Standstill in AI/DL research



- 1985: Multi-layered perceptron with backpropagation by David Rumelhart, Geoffrey Hinton and Ronald Williams.
  - Efficiently compute derivatives of composite functions.
  - Backpropagation was developed already in 1970 by Linnainmaa.

# A BRIEF HISTORY OF NEURAL NETWORKS

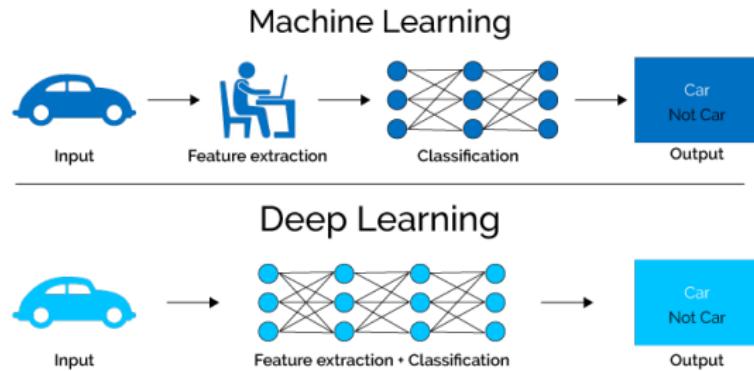
- **1985:** The second “AI Winter” kicked in.
  - Overly optimistic expectations concerning potential of AI/DL.
  - The phrase “AI” even reached a pseudoscience status.
  - Kernel machines and graphical models both achieved good results on many important tasks.
  - Some fundamental mathematical difficulties in modeling long sequences were identified.



Credit: <https://emerj.com/ai-executive-guides/will-there-be-another-artificial-intelligence-winter-probably-not/>

# A BRIEF HISTORY OF NEURAL NETWORKS

- **2006:** Age of deep neural networks began.
  - Geoffrey Hinton showed that a deep belief network could be efficiently trained using *greedy layer-wise pretraining*.
  - This wave of research popularized the use of the term deep learning to emphasize that researchers were now able to train deeper neural networks than had been possible before.
  - At this time, deep neural networks outperformed competing AI systems based on other ML technologies as well as hand-designed functionality.



Credit: <https://towardsdatascience.com/cnn-application-on-structured-data-automated-feature-extraction-8f2cd28d9a7e>

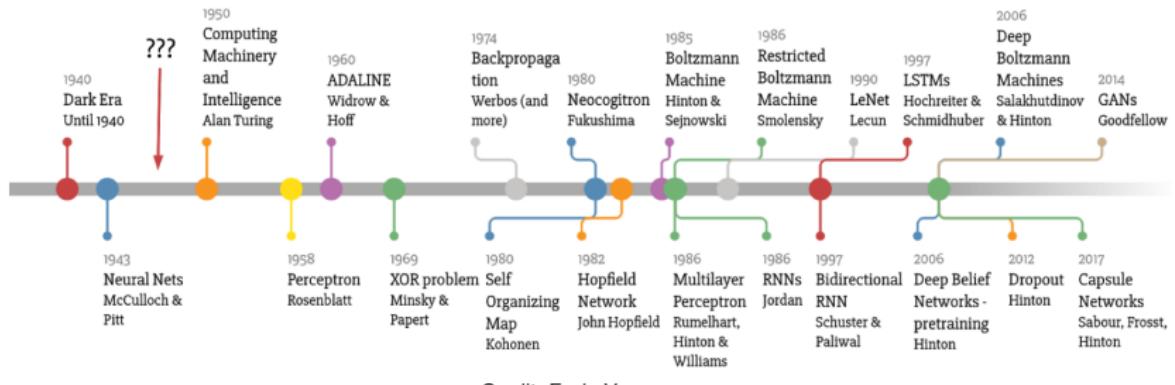
# A BRIEF HISTORY OF NEURAL NETWORKS

## Why now and not earlier?

- ➊ Significantly bigger datasets.
- ➋ Better algorithms resolving the vanishing gradient problem.
- ➌ Better regularization.
- ➍ Unsupervised representation learning.
- ➎ More layers lead to a significant increase of parameters.
- ➏ Deep neural networks are trained on GPUs, rather than CPUs. So processing power can handle huge amounts of parameters.
- ➐ Investment by industries and universities.
- ➑ DL tools make learning and applying DL easier.

# A BRIEF HISTORY OF NEURAL NETWORKS

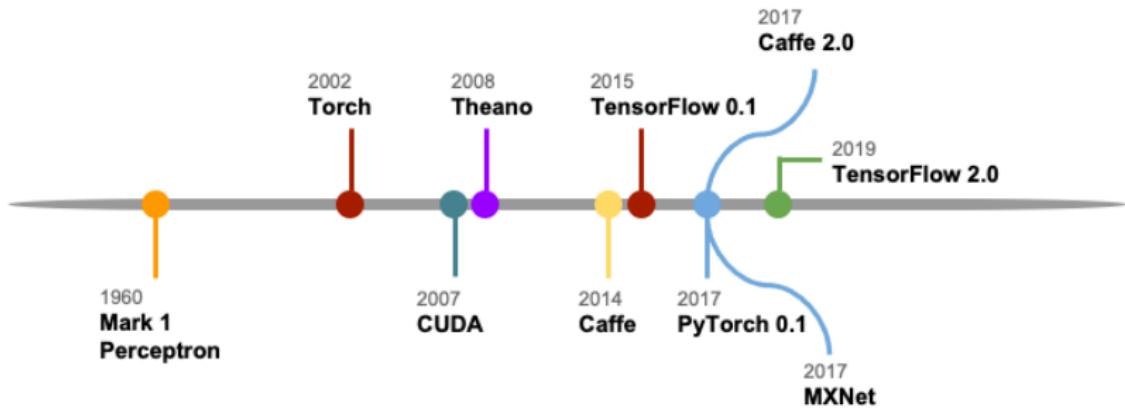
## Deep Learning Timeline



Credit: Favio Vazquez

# A BRIEF HISTORY OF NEURAL NETWORKS

## History of DL Tools



# A BRIEF HISTORY OF NEURAL NETWORKS



**Figure:** Boston Dynamics ([click here](#))

- Boston Dynamics is a world leader in mobile robots founded in 1992 as a spin-off from the Massachusetts Institute of Technology.
- The company is best known for the development of a series of dynamic highly-mobile robots, including BigDog, Spot, Atlas, and Handle.

# A BRIEF HISTORY OF NEURAL NETWORKS



**Figure:** IBM Supercomputer

- Watson is a question-answering system capable of answering questions posed in natural language, developed in IBM's DeepQA project.
- In 2011, Watson competed on *Jeopardy!* against champions Brad Rutter and Ken Jennings, winning the first place prize of \$1 million.

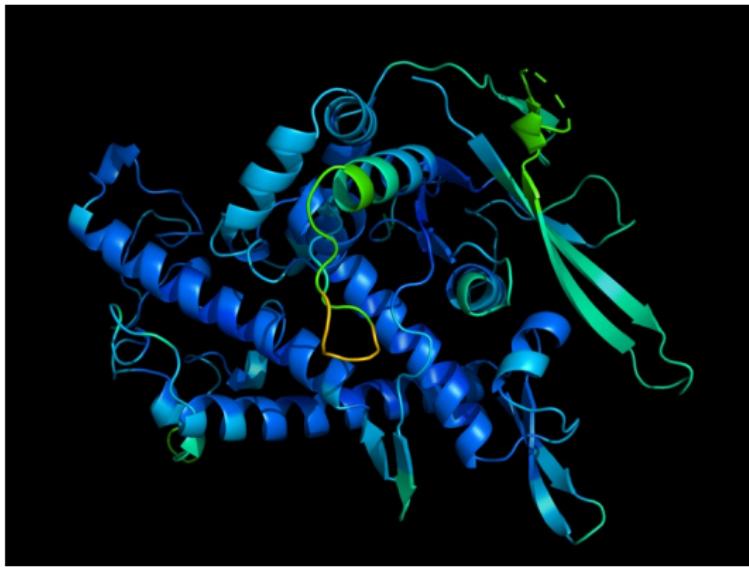
# A BRIEF HISTORY OF NEURAL NETWORKS



**Figure:** Google self driving car (Waymo)

- Google's development of self-driving technology began on January 17, 2009, at the company's secretive X lab.
- By January 2020, 20 million miles of self-driving on public roads had been completed by Waymo.

# A BRIEF HISTORY OF NEURAL NETWORKS



Credit: DeepMind

- **AlphaFold** is a deep learning system developed by Google DeepMind, to solve determine a protein's 3D shape from its amino-acid sequence.
- In 2018 and 2020, AlphaFold placed first in the overall rankings of the Critical Assessment of Techniques for Protein Structure Prediction (CASP).