LMU LUDWIG-MAXIMILIANS-UNIVERSITÄT MÜNCHEN

Introduction to Deep Learning

Chapter 1: Brief History

Bernd Bischl

Department of Statistics – LMU Munich

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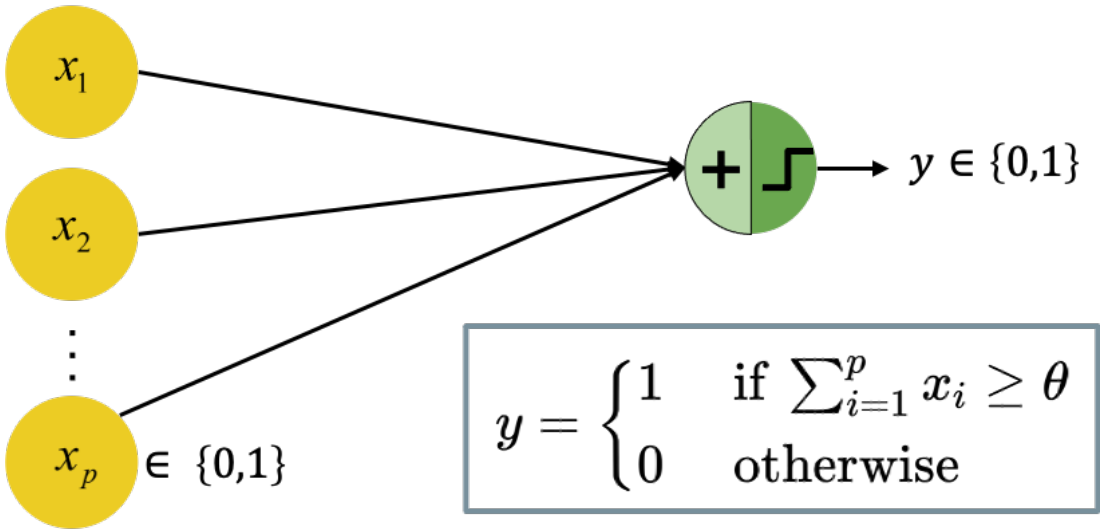
A BRIEF HISTORY OF NEURAL NETWORKS

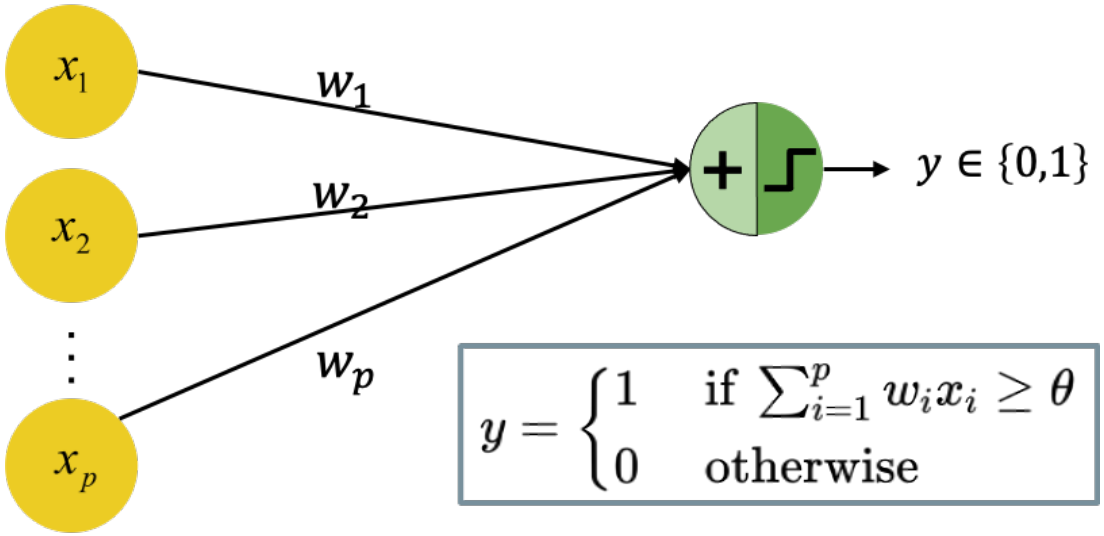
- **1943:** The first artificial neuron, the "Threshold Logic Unit (TLU)", was proposed by Warren McCulloch & Walter Pitts.



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

A BRIEF HISTORY OF NEURAL NETWORKS

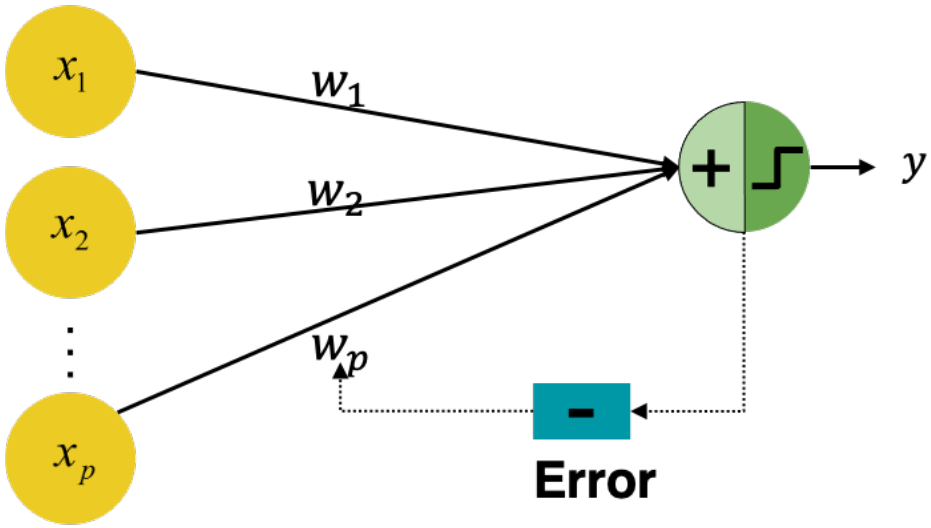
- **1957:** The perceptron was invented by Frank Rosenblatt.



  - 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

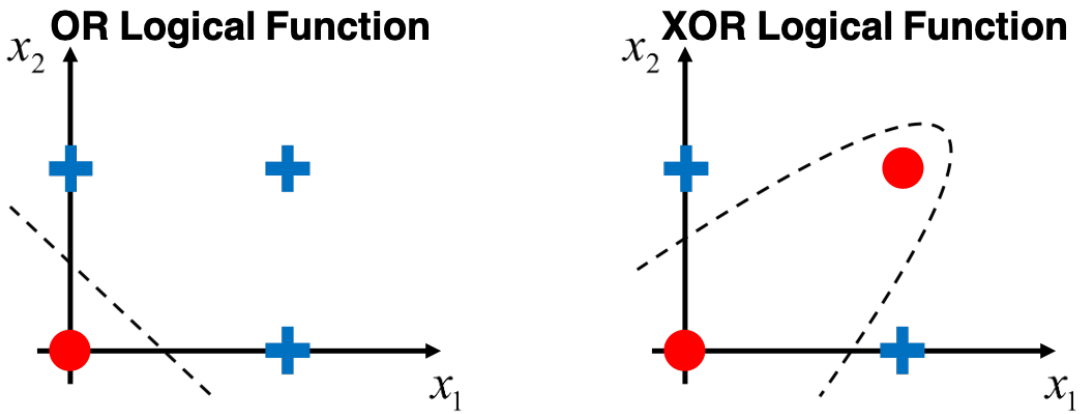
- **1960:** Adaptive Linear Neuron (ADALINE) was invented by Bernard Widrow & Ted Hoff; weights are now adjustable according to the weighted sum of the inputs.



- **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 $\Rightarrow$ 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.

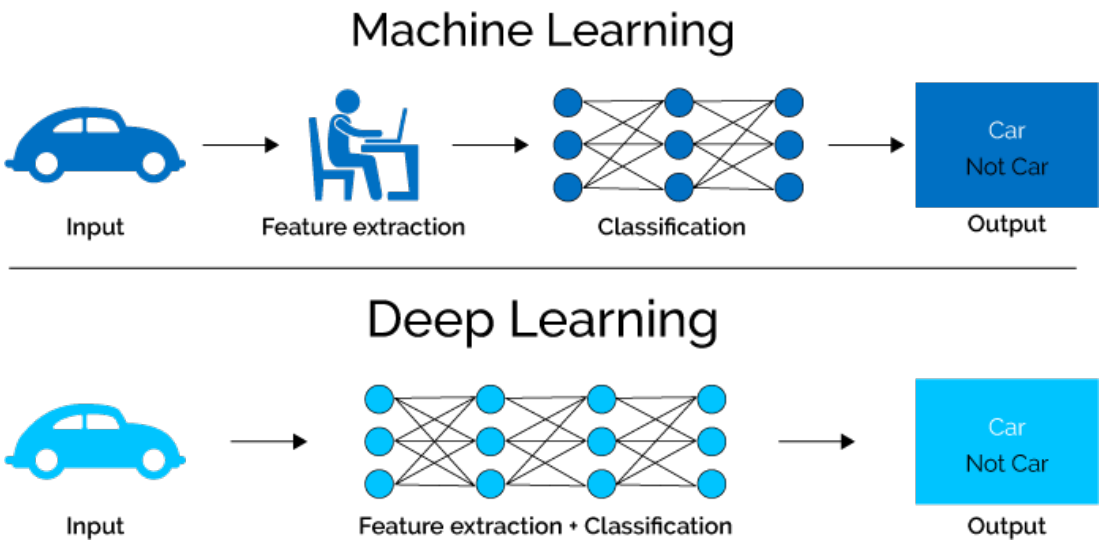
A BRIEF HISTORY OF NEURAL NETWORKS

- **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?

1. Significantly bigger datasets.
2. Better algorithms resolving the vanishing gradient problem.
3. Better regularization.
4. Unsupervised representation learning.
5. More layers lead to a significant increase of parameters.
6. Deep neural networks are trained on GPUs, rather than CPUs. So processing power can handle huge amounts of parameters.
7. Investment by industries and universities.
8. DL tools make learning and applying DL easier.

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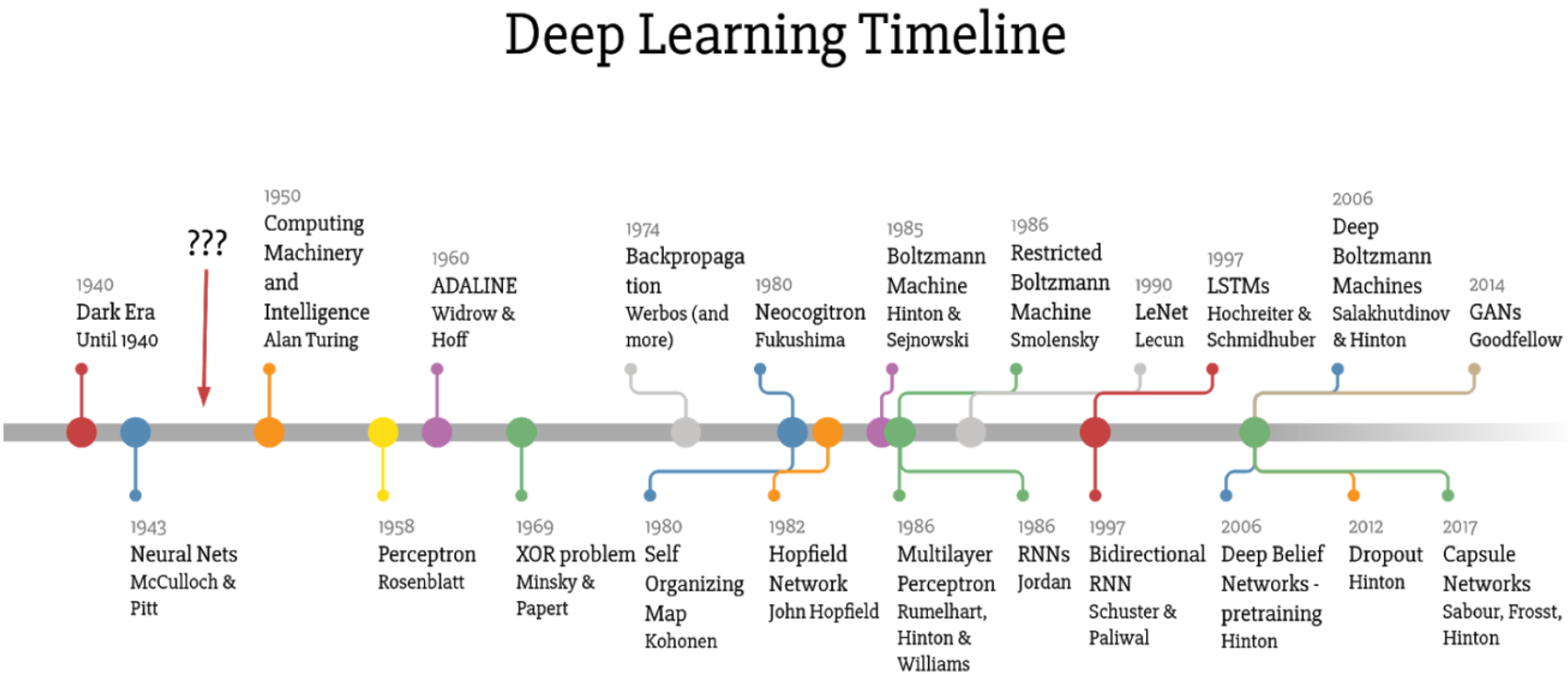

Credit: Favio Vazquez

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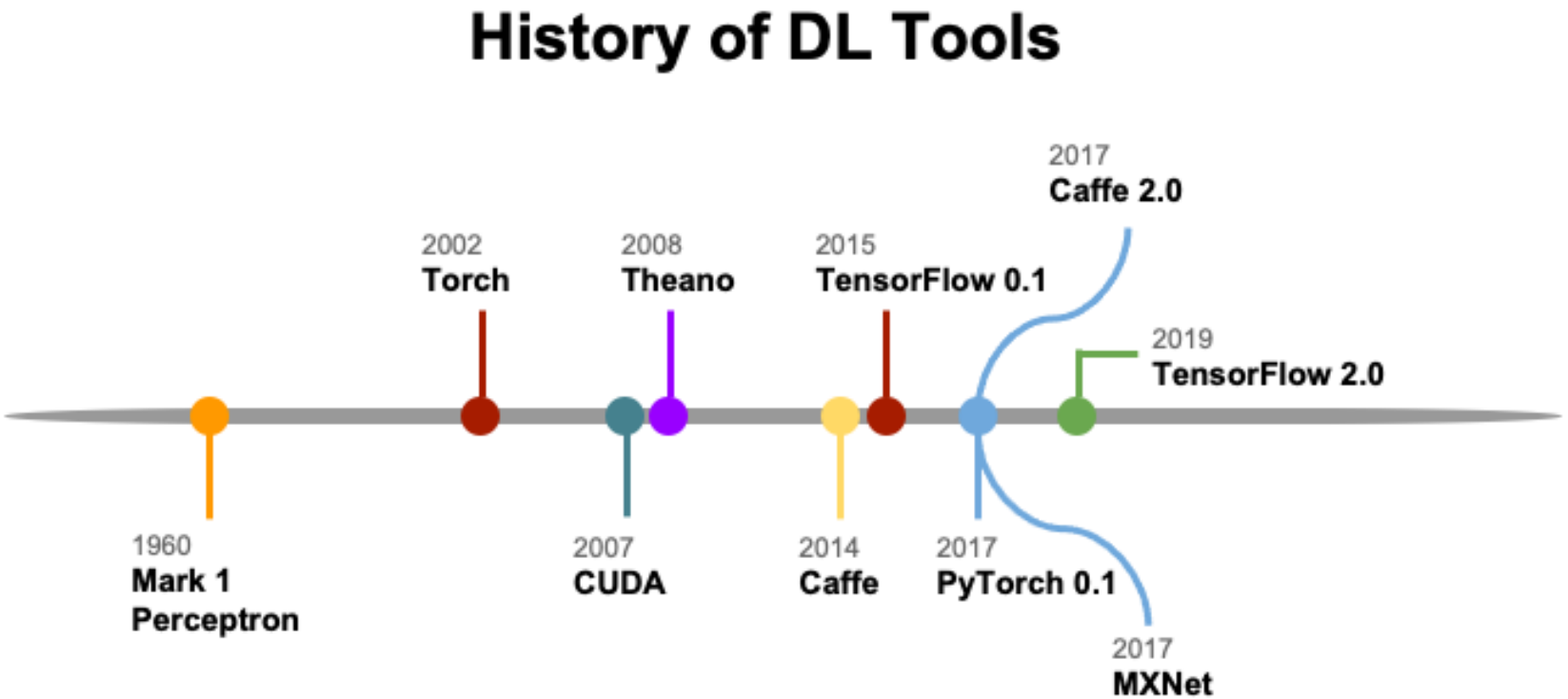

A BRIEF HISTORY OF NEURAL NETWORKS

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.

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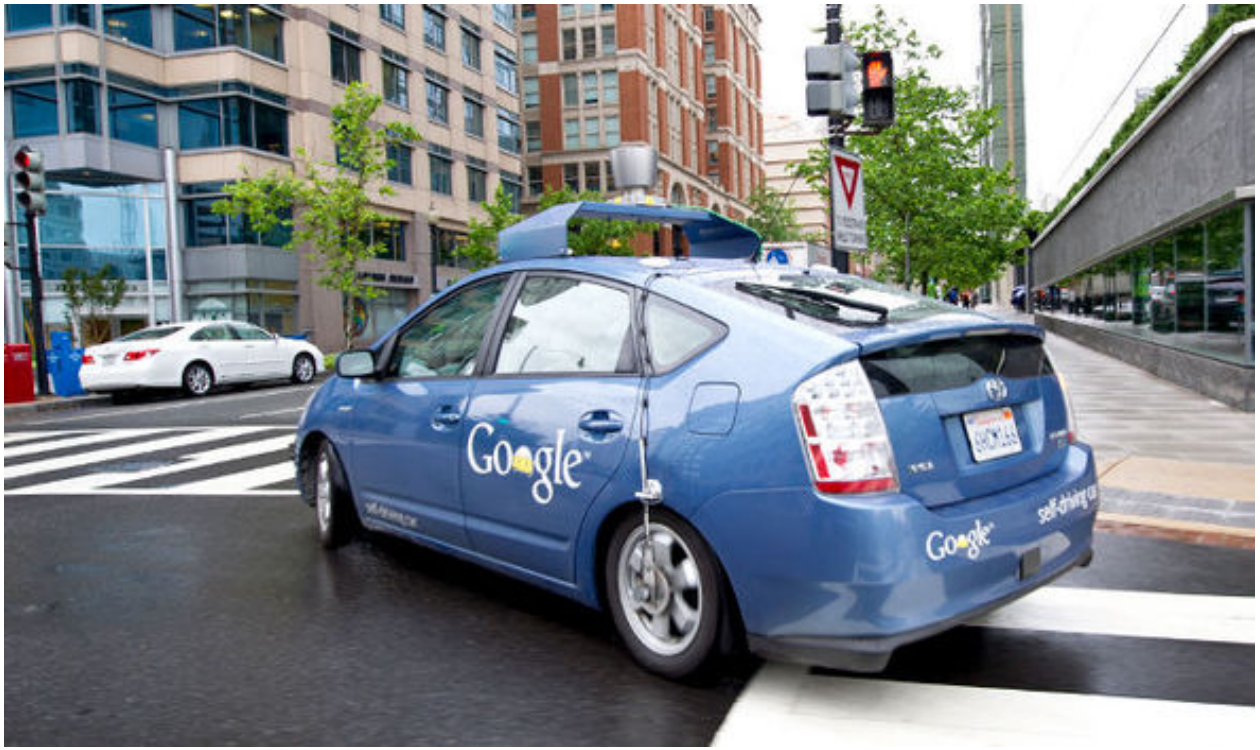

Figure: Google self driving car (Waymo)

- 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).