LMU LUDWIG-MAXIMILIANS-UNIVERSITÄT MÜNCHEN

Introduction to Machine Learning

Chapter 1: Deep Learning- History of Neural Networks

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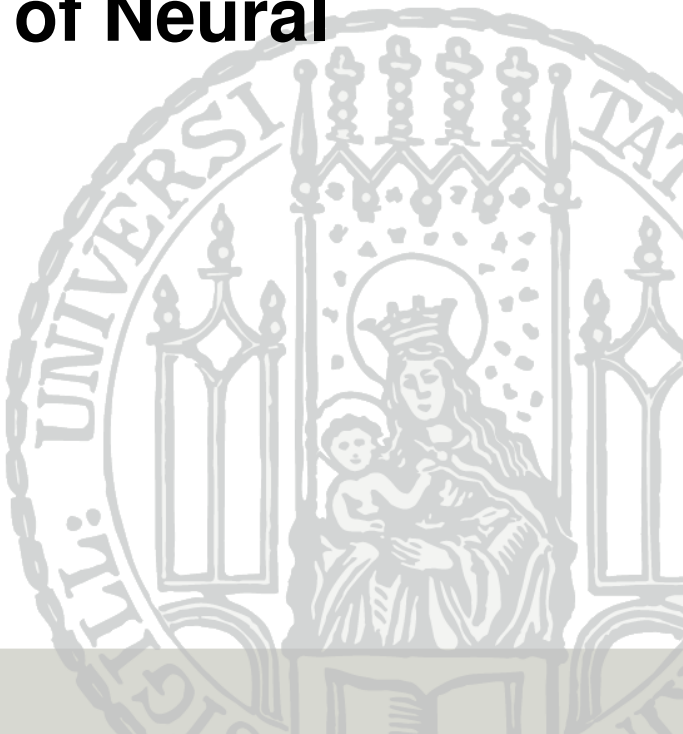
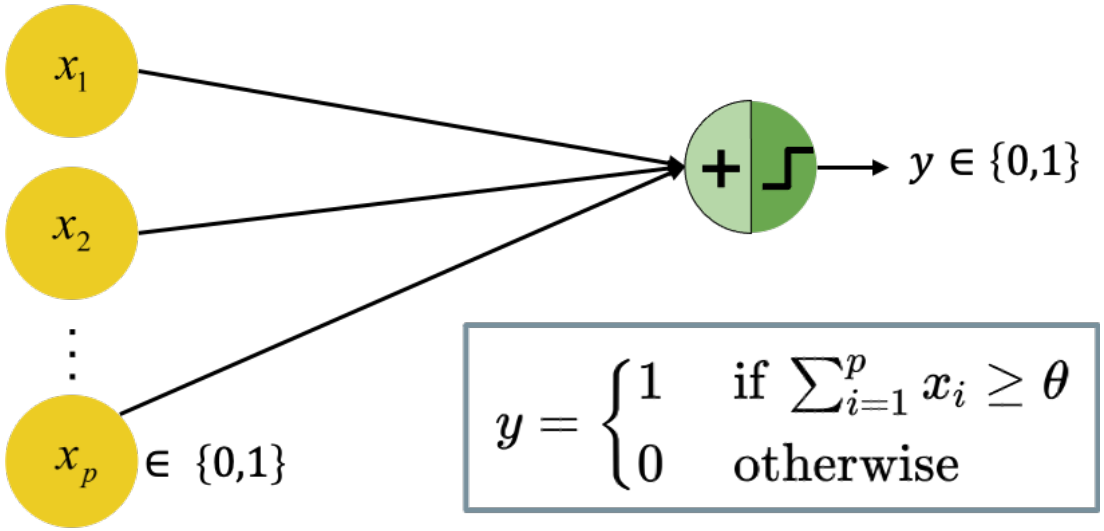


A BRIEF HISTORY OF NEURAL NETWORKS

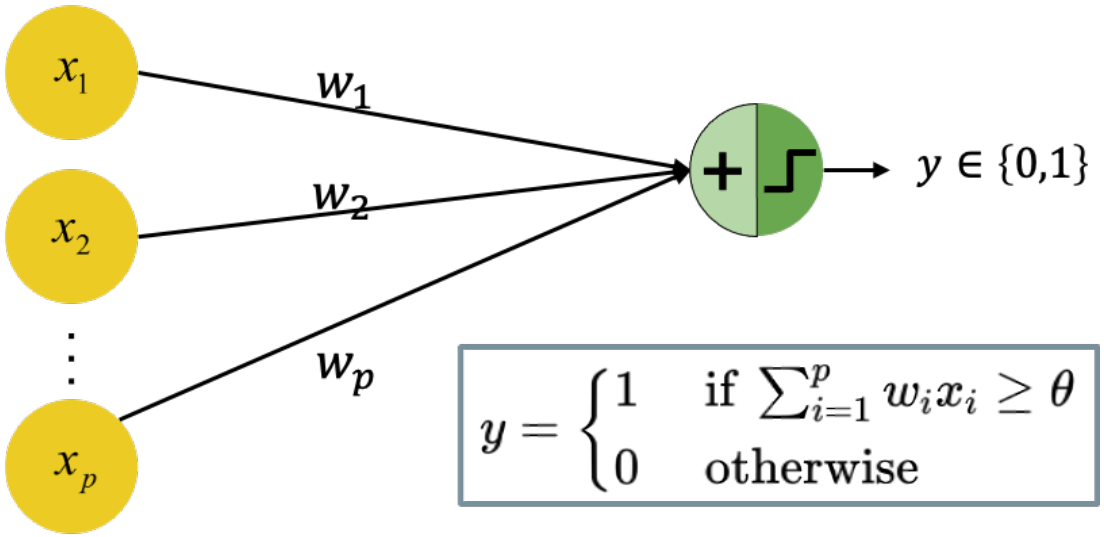
- **1943:** The first artificial neuron, the "Threshold Logic Unit (TLU)", was proposed by Warren McCulloch & Walter Pitts.



  - In this model the neuron fires a $+1$ if the input exceeds a certain threshold θ.
  - However, this model did not have adjustable weights, so learning could only be achieved by changing the threshold θ.

A BRIEF HISTORY OF NEURAL NETWORKS

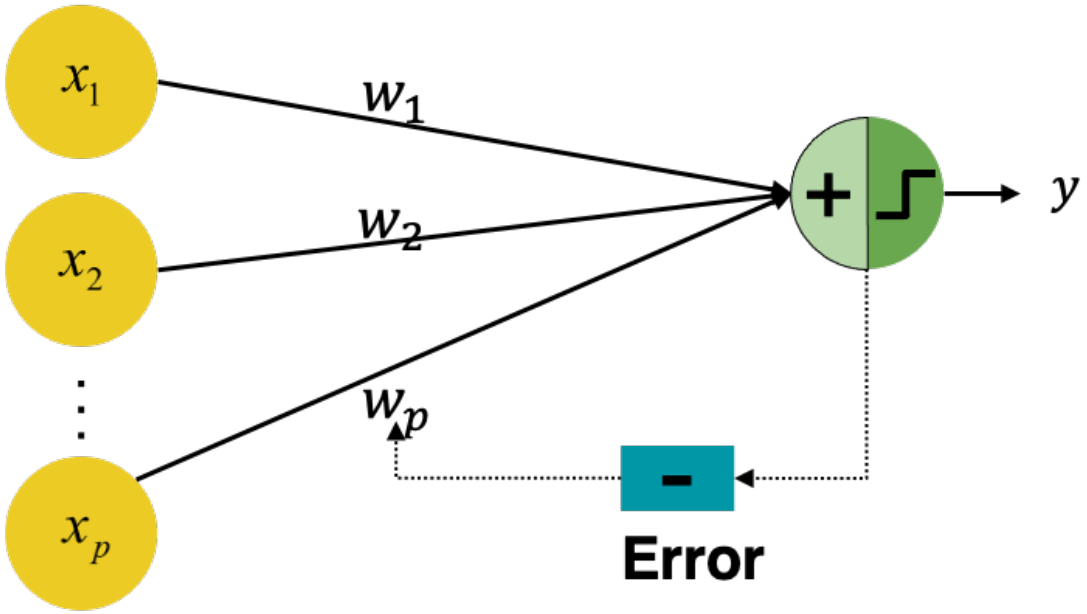
- **1957:** The perceptron was invented by Frank Rosenblatt.



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

A BRIEF HISTORY OF NEURAL NETWORKS

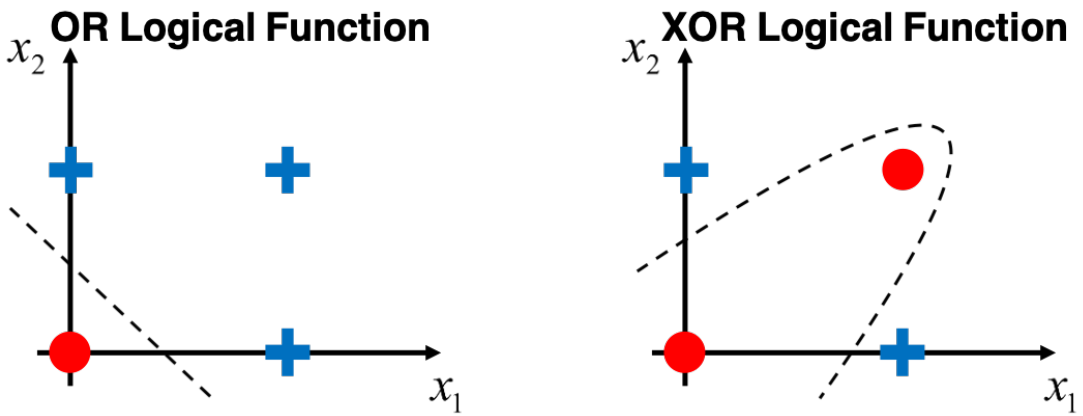
- **1960:** ADALINE by Bernard Widrow & Ted Hoff; weights are now adjustable according to the weighted sum of the inputs.



- **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



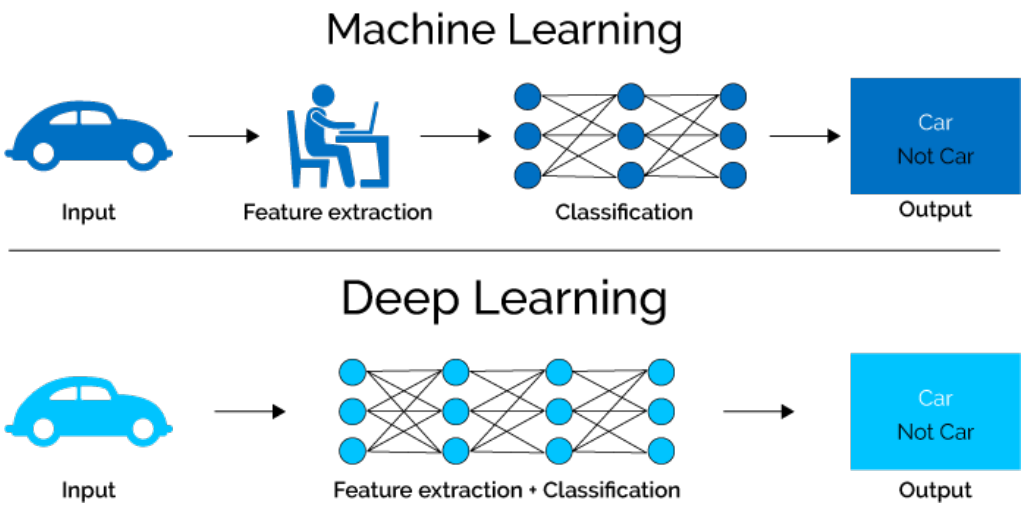
- **1985:** Multi-layered perceptron with backpropagation by David Rumelhart, Geoffrey Hinton and Ronald Williams.
  - Efficiently compute derivatives of composite functions.
  - Backpropagation was developed already in 1970 by Linnainmaa.

A BRIEF HISTORY OF NEURAL NETWORKS

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

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.



A BRIEF HISTORY OF NEURAL NETWORKS

Why now and not earlier?

- Significantly bigger datasets.
- Better algorithms and the vanishing gradient problem (optimization chapter).
- Better regularization (regularization chapter).
- Unsupervised representation learning (autoencoder chapter).
- More layers inevitably lead to a significant increase of parameters.
- Back then, processing power was simply not capable to handle such huge amounts of parameters. $\Rightarrow$ Nowadays, deep neural networks are trained on GPUs (graphic processing units), not on CPUs (central processing units).
- Investment by industries and universities.
- Deep learning tools make learning and applying deep learning easier.

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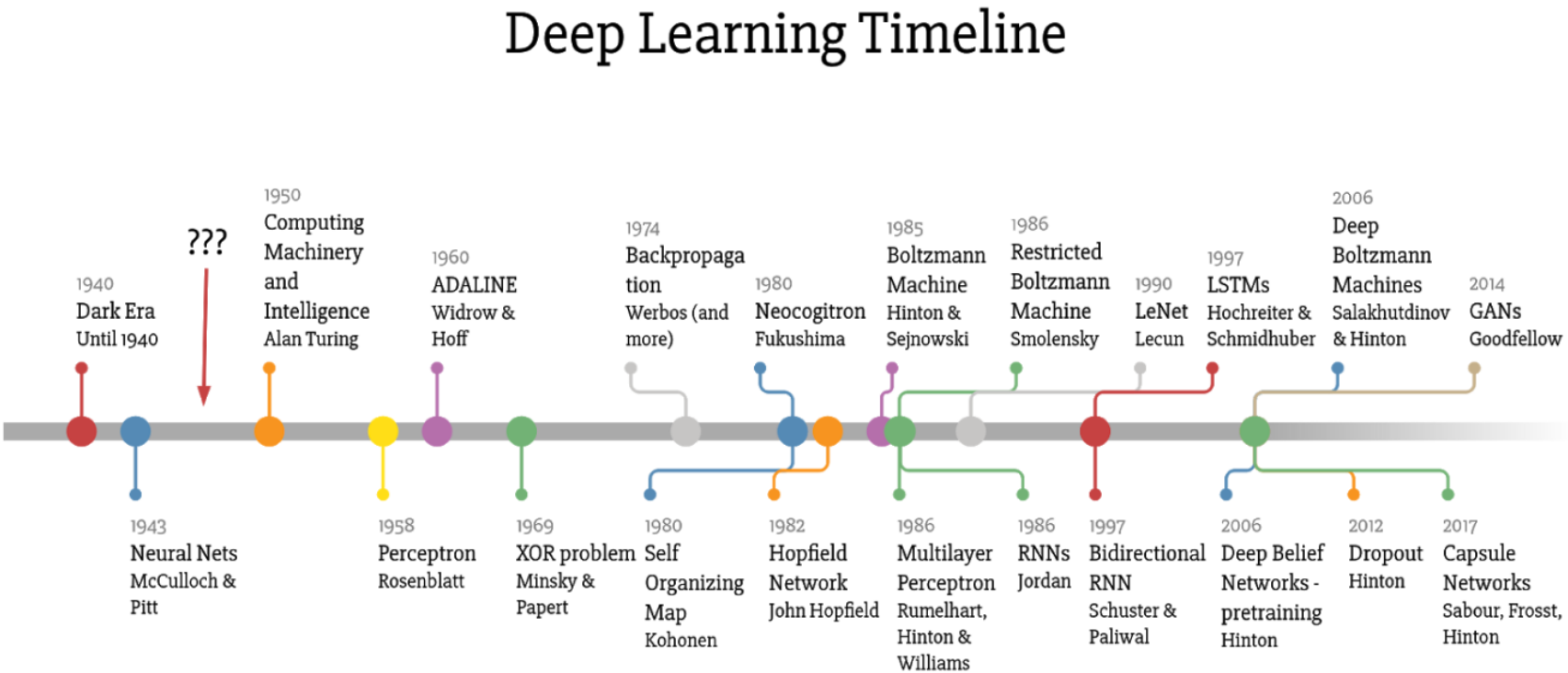

Figure: Credit: Favio Vazquez

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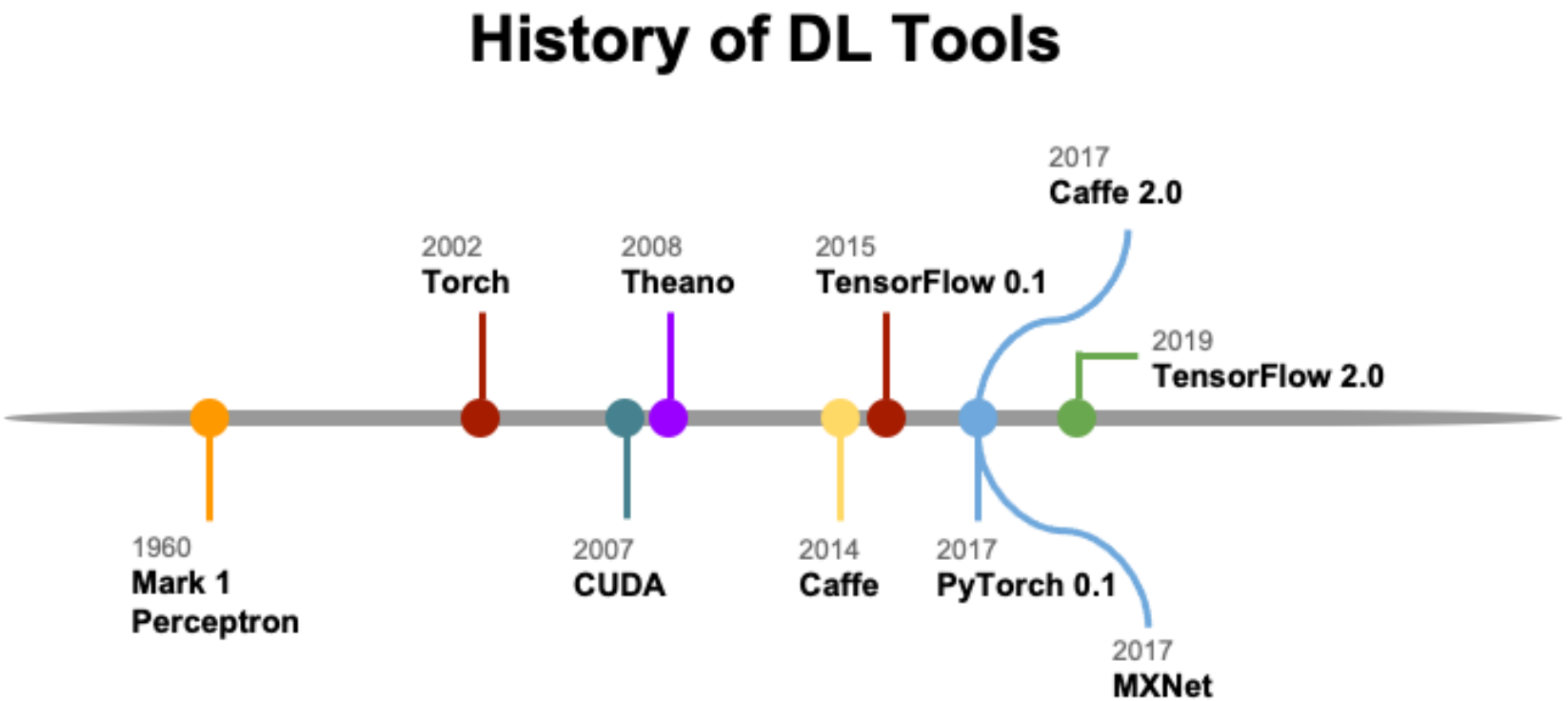

A BRIEF HISTORY OF NEURAL NETWORKS

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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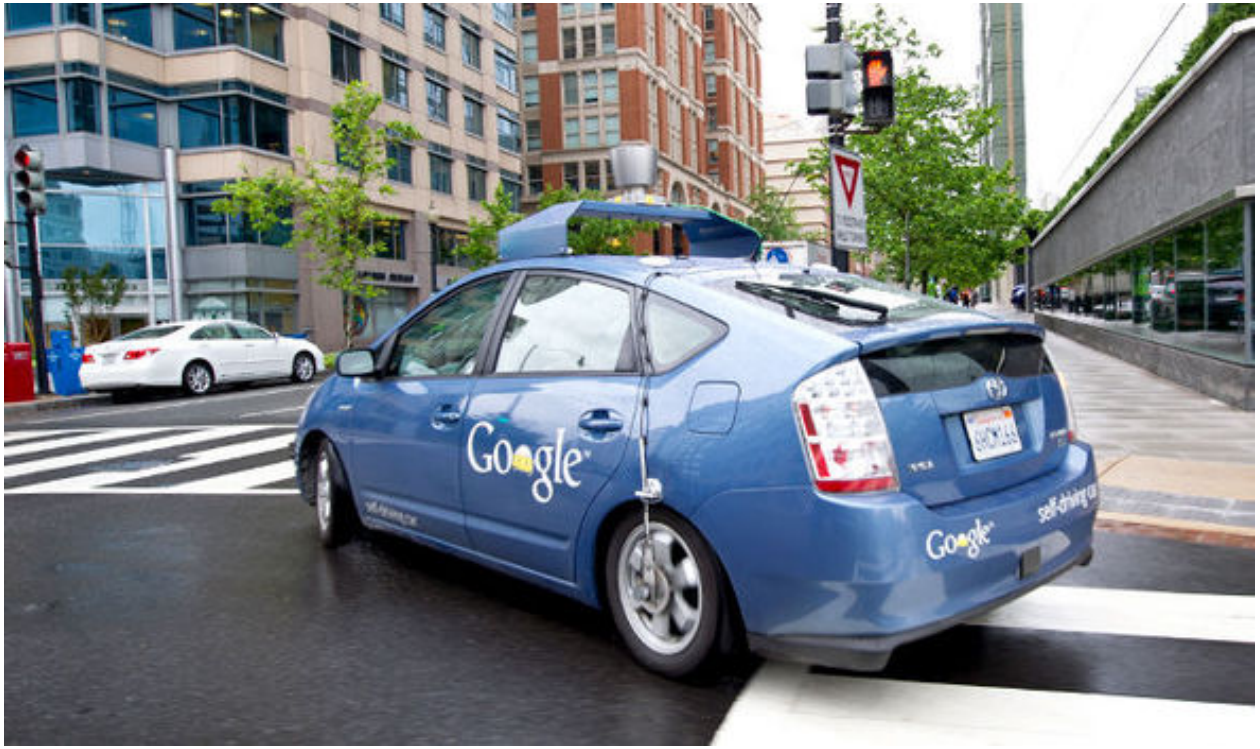

Figure: Google self driving car (Waymo)

- 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.