Deep Learning

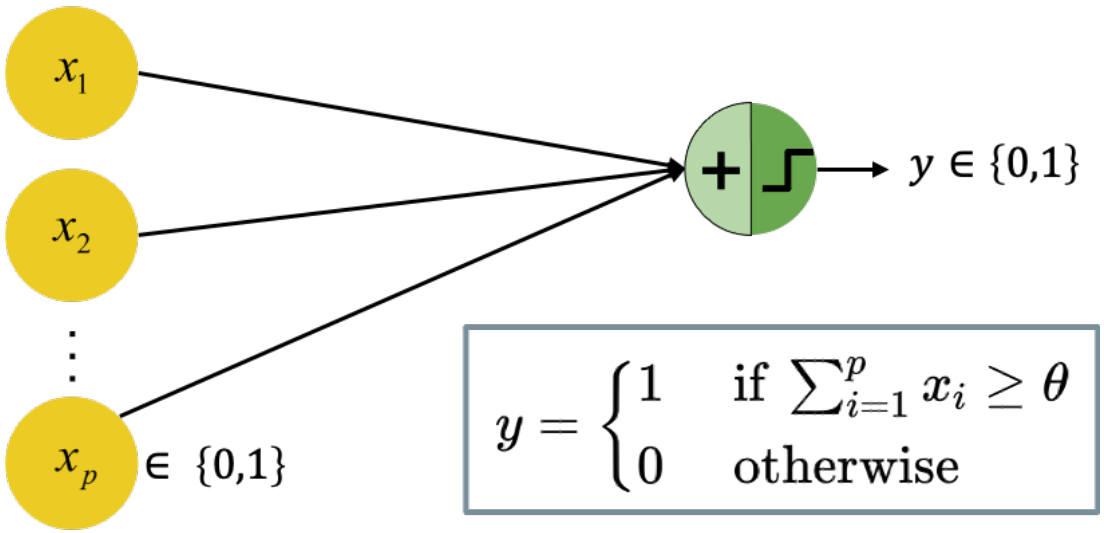
Brief History

Learning goals

- Predecessors of modern(deep) neural networks
- History of DL as a field

A BRIEF HISTORY OF NEURAL NETWORKS

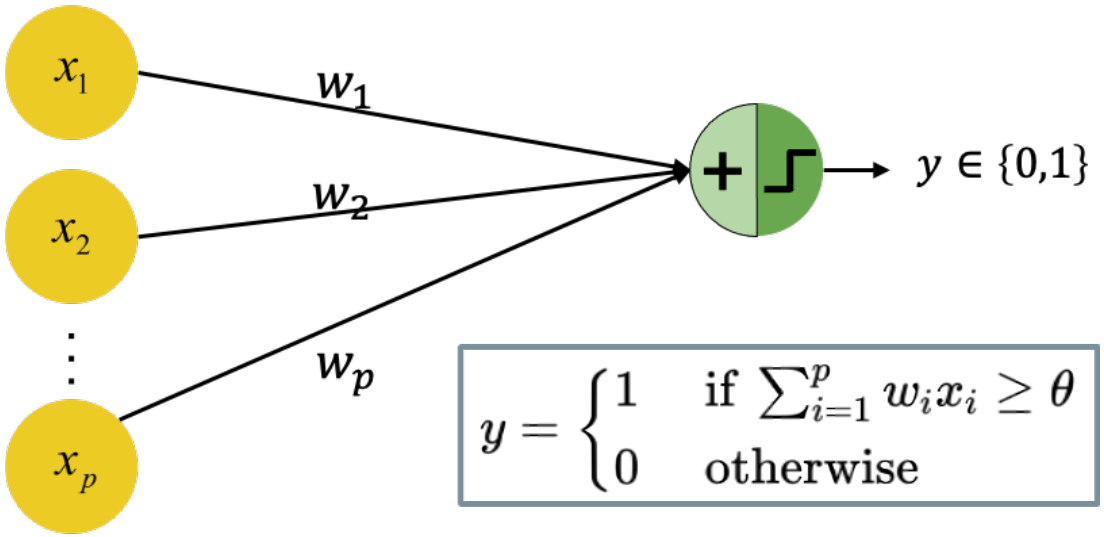
- **1943:** The first artificial neuron, the "Threshold Logic Unit (TLU)", was proposed by Warren McCulloch & Walter Pitts.



  - 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

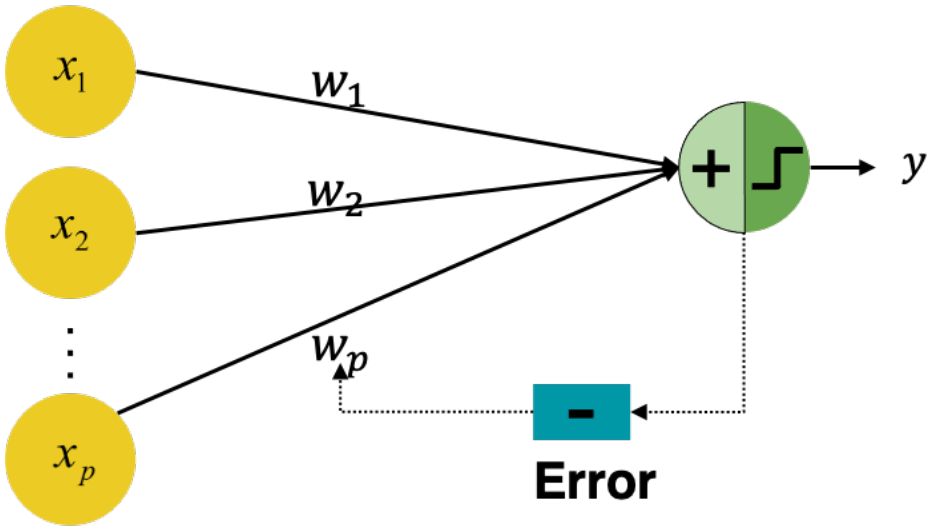
- **1957:** The perceptron was invented by Frank Rosenblatt.



  - 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

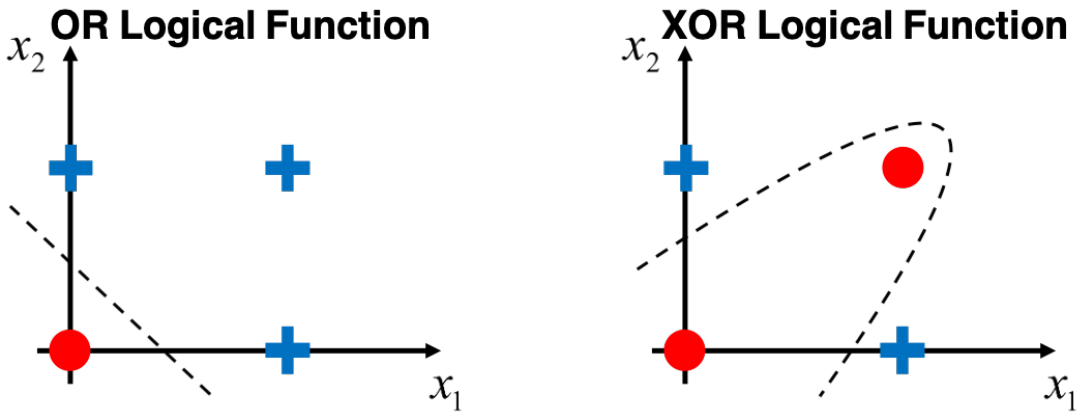
- **1960:** Adaptive Linear Neuron (ADALINE) was invented by Bernard Widrow & Ted Hoff; weights are now adjustable according to the weighted sum of the inputs.



- **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:** Multilayer 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.

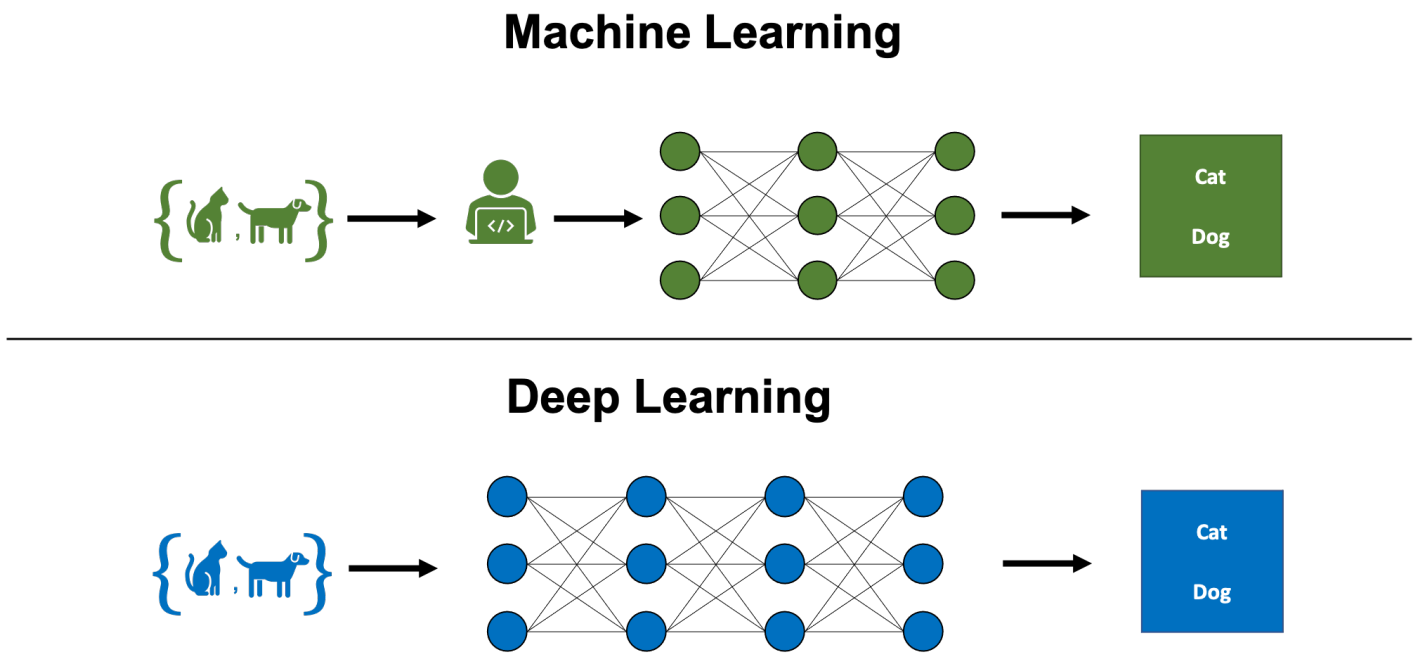
A BRIEF HISTORY OF NEURAL NETWORKS

- **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.



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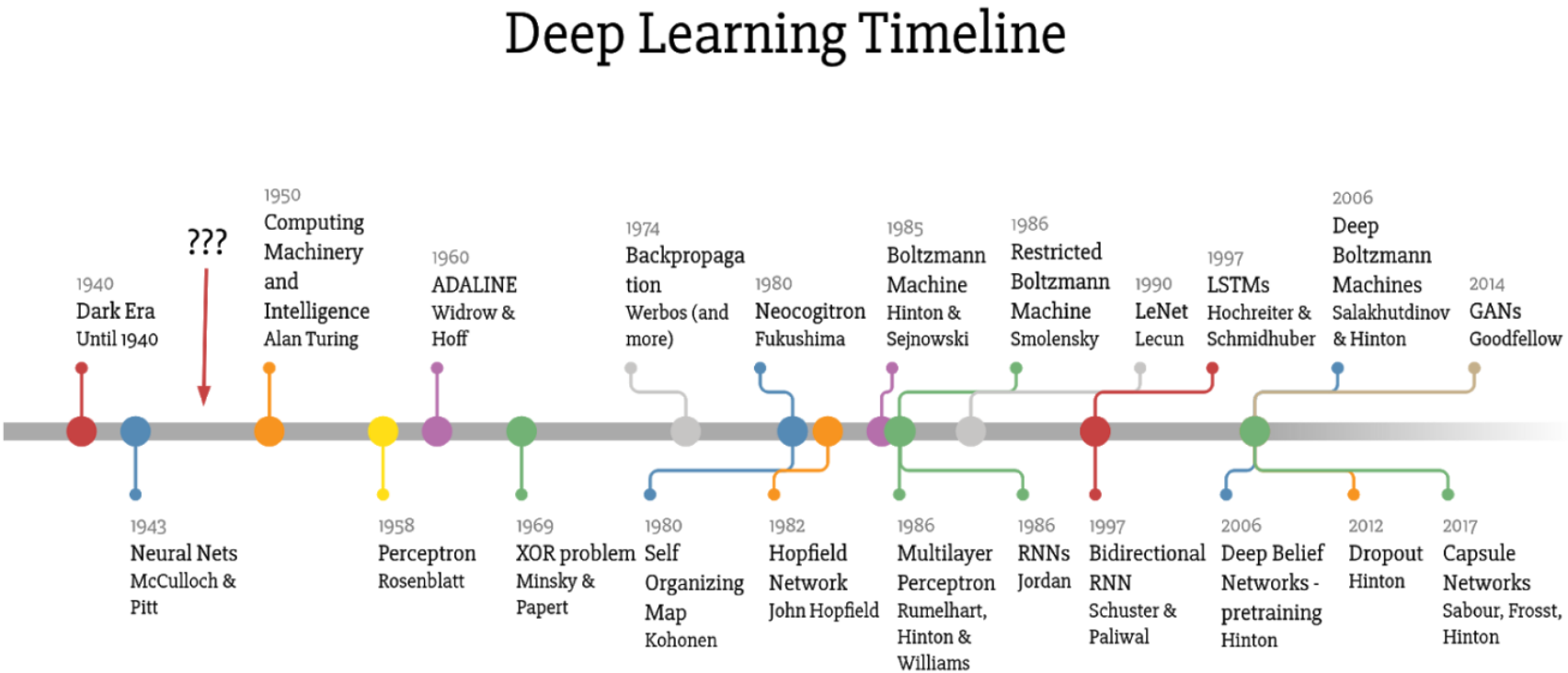

Credit: https://towardsdatascience.com/a-weird-introduction-to-deep-learning-7828803693b0

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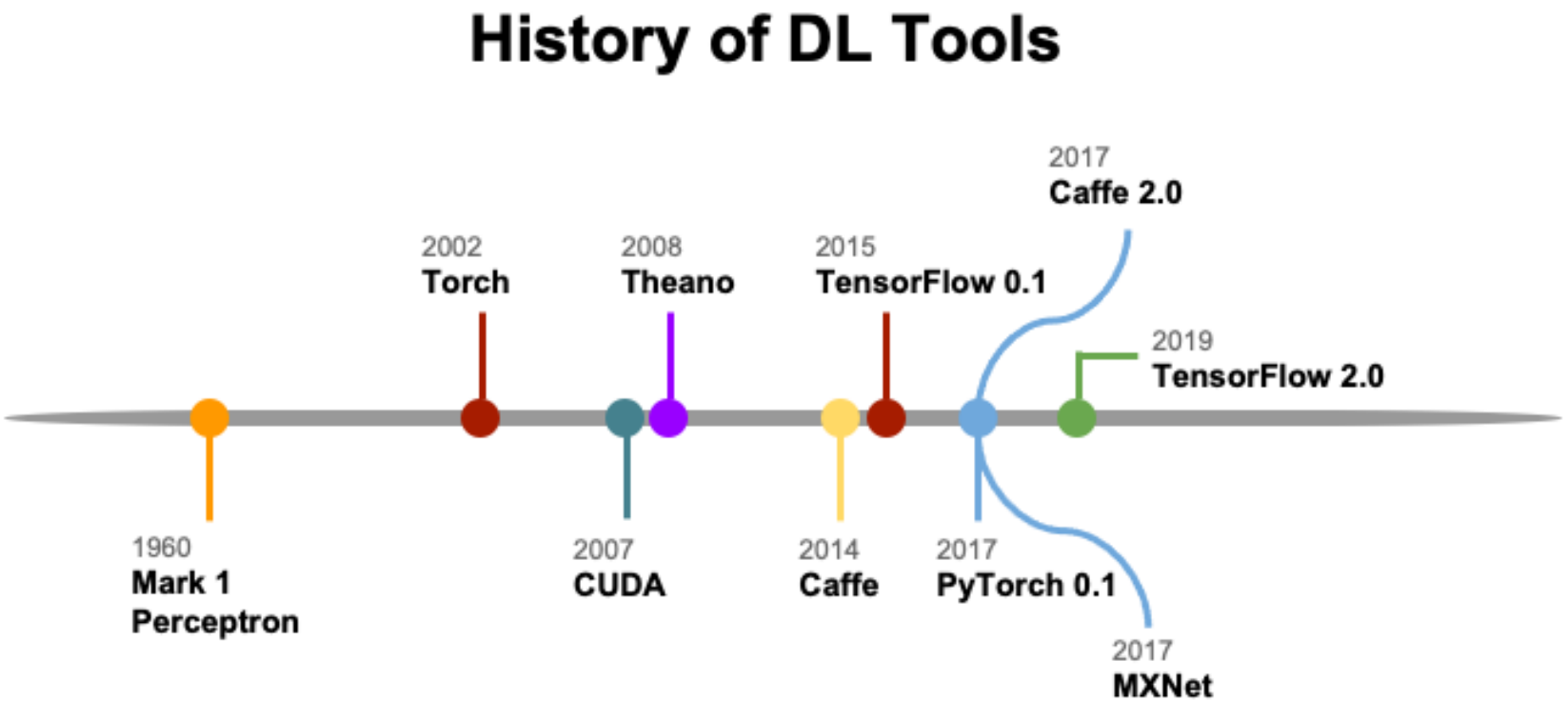

A BRIEF HISTORY OF NEURAL NETWORKS

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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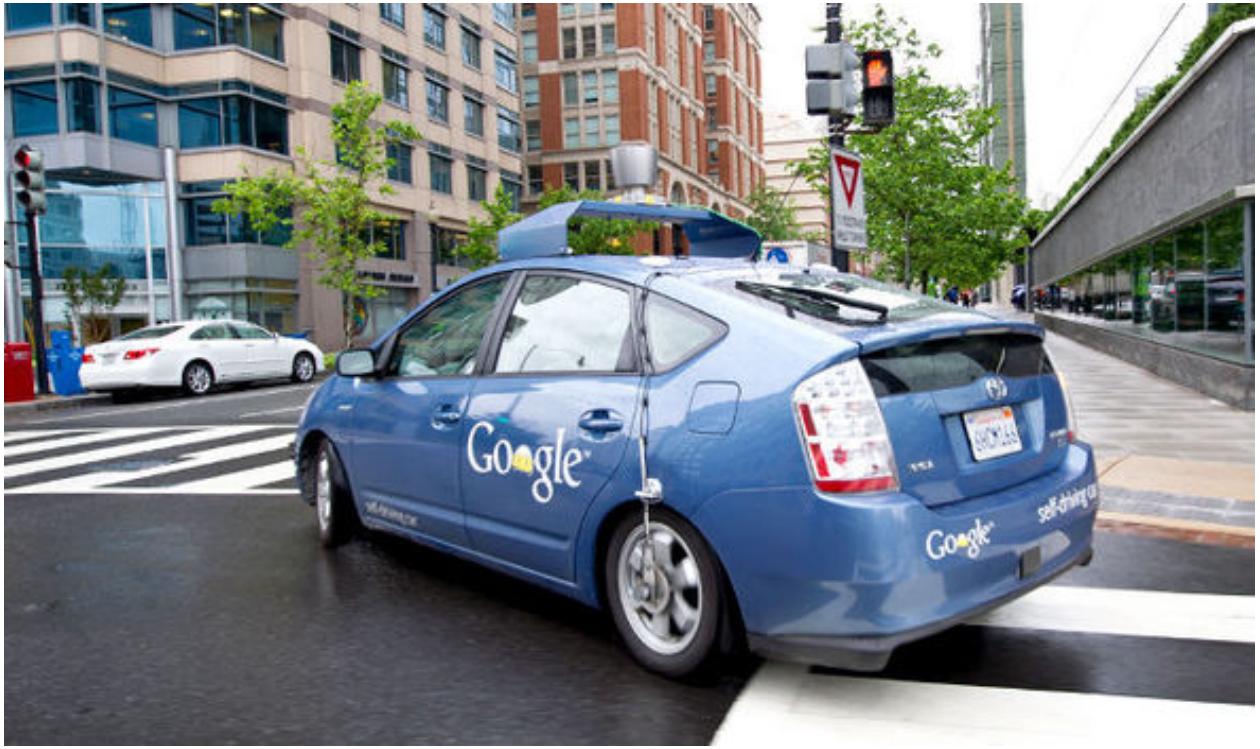

Figure: Google self driving car (Waymo)

- 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).

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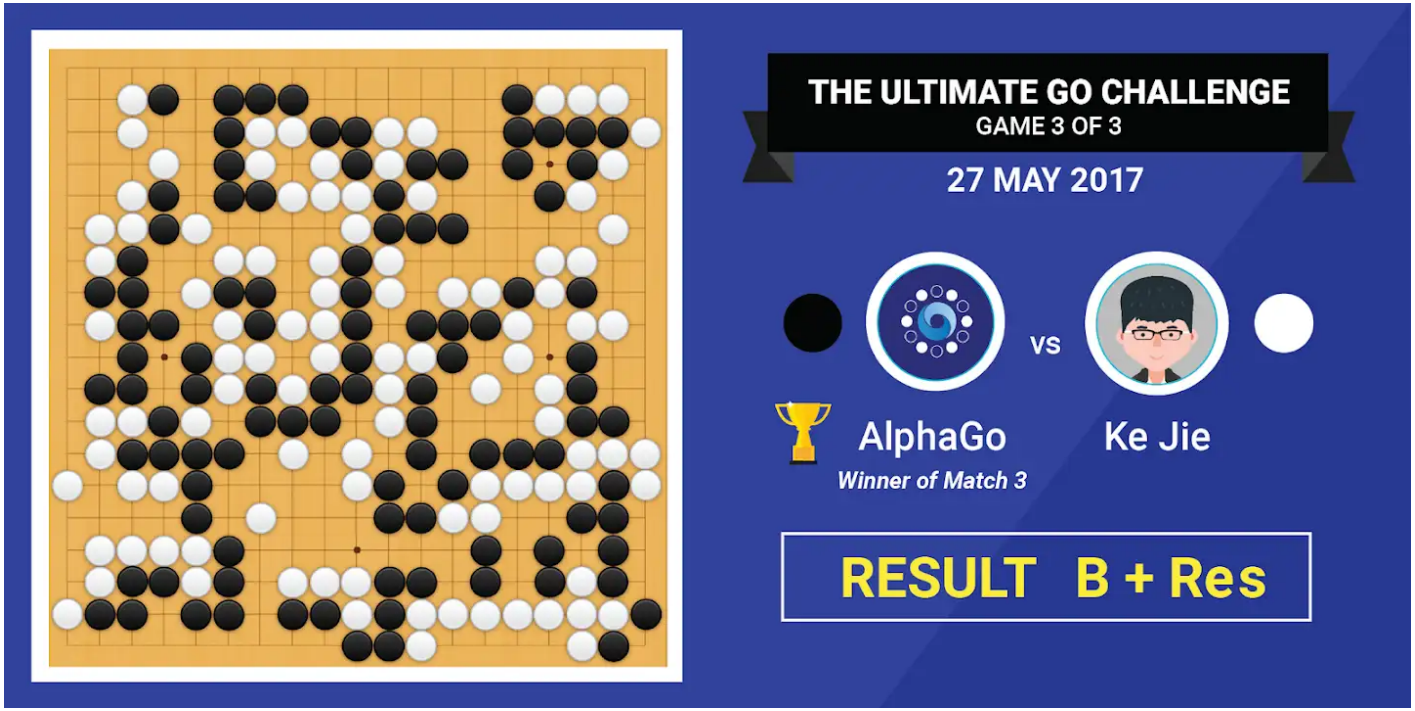

Credit: DeepMind

- **AlphaGo**, originally developed by DeepMind, is a deep learning system that plays the board game Go. In 2017, the Master version of AlphaGo beat Ke Jie, the number one ranked player in the world at the time.
- While there are several extensions to AlphaGo (e.g., Master AlphaGo, AlphaGo Zero, AlphaZero, and MuZero), the main idea is the same: search for optimal moves based on knowledge acquired by machine learning.

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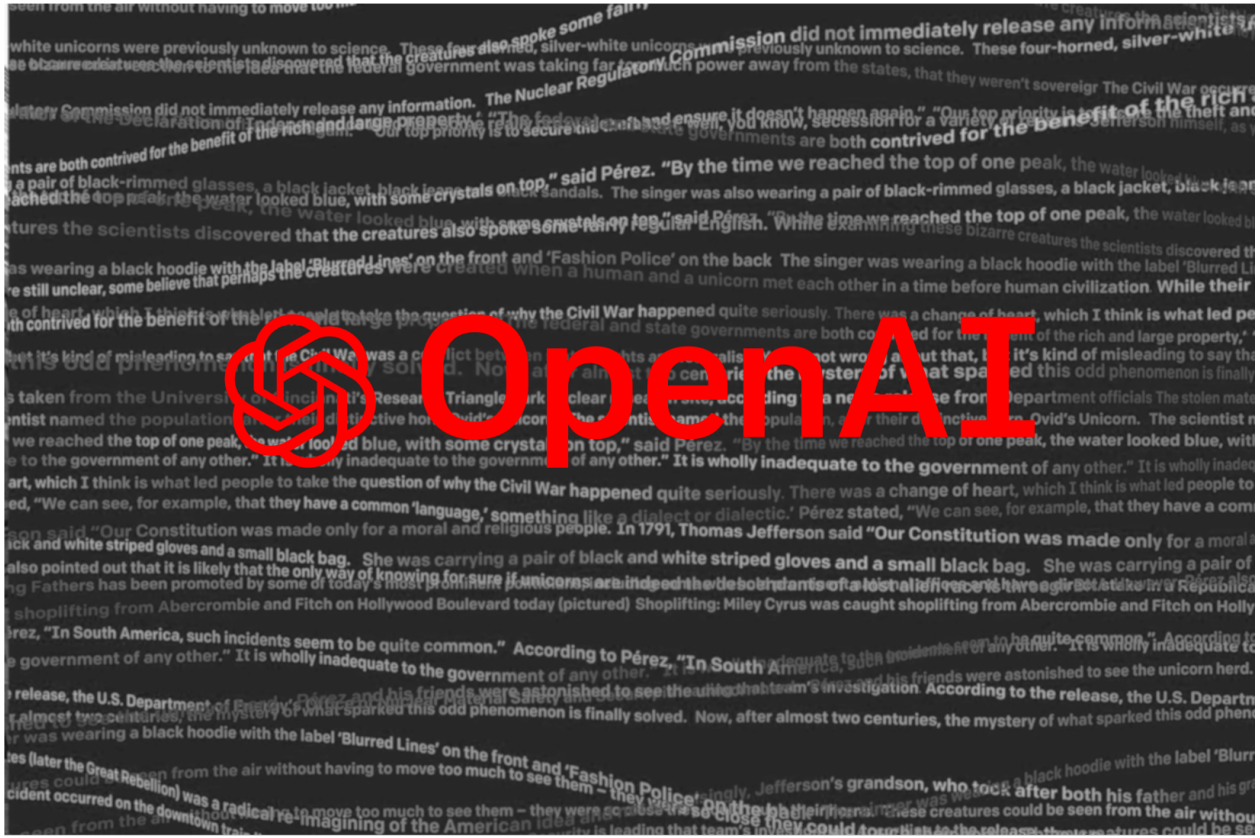

- **Generative Pre-trained Transformer 3 (GPT-3)** is the third generatation of the GPT model, introduced by OpenAI in May 2020, to produce human-like text.
- There are 175 billion parameters to be learned by the algorithm, but the quality of the generated text is so high that it is hardly possible to distinguish it from a human-written text.