

Deep Learning Using TensorFlow



Dr. Ash Pahwa

Lesson 3: Neural Networks + TensorFlow
Lesson 3.1: What are Neural Networks +
History



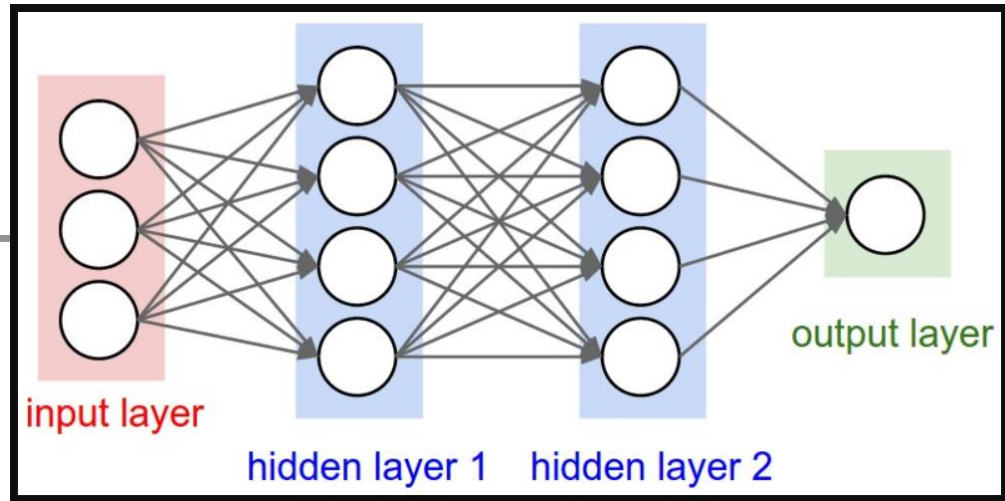
Outline

- How Neural Networks Work?
- History of Neural Networks
- Convolution Neural Networks with Deep Learning

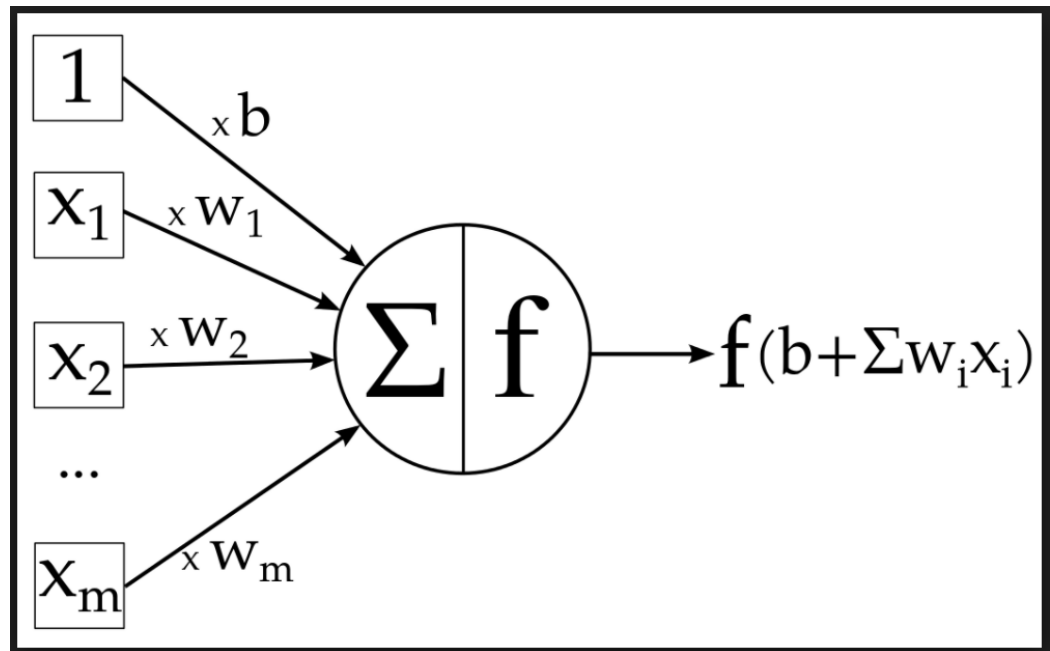


How Neural Networks Work?

Neural Network

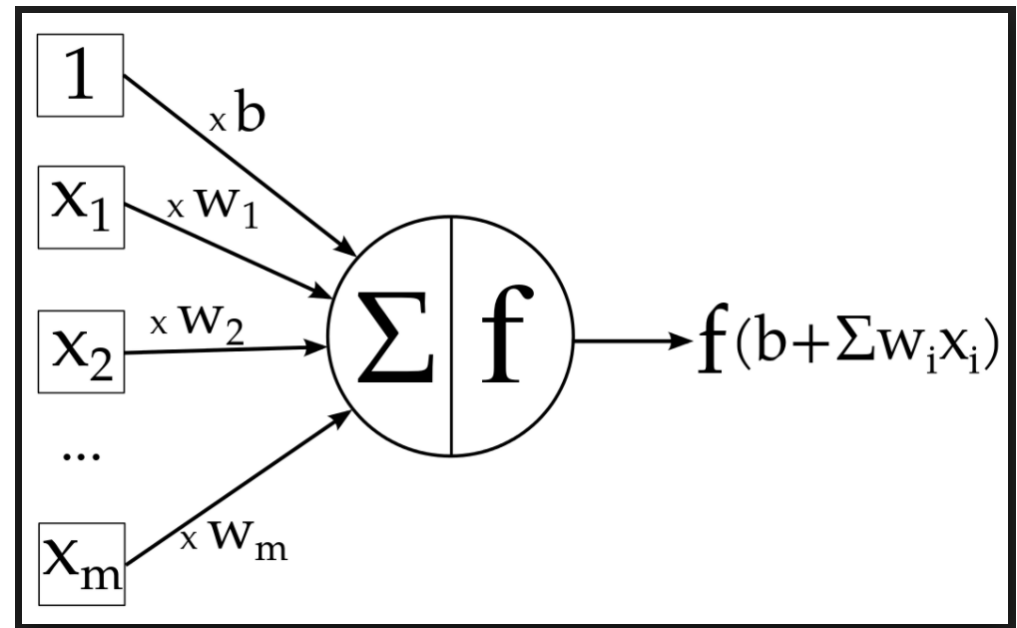


- Input Layer
- Hidden Layer
- Output Layer
- Weights
- Bias
- Activation Function



Single Neuron

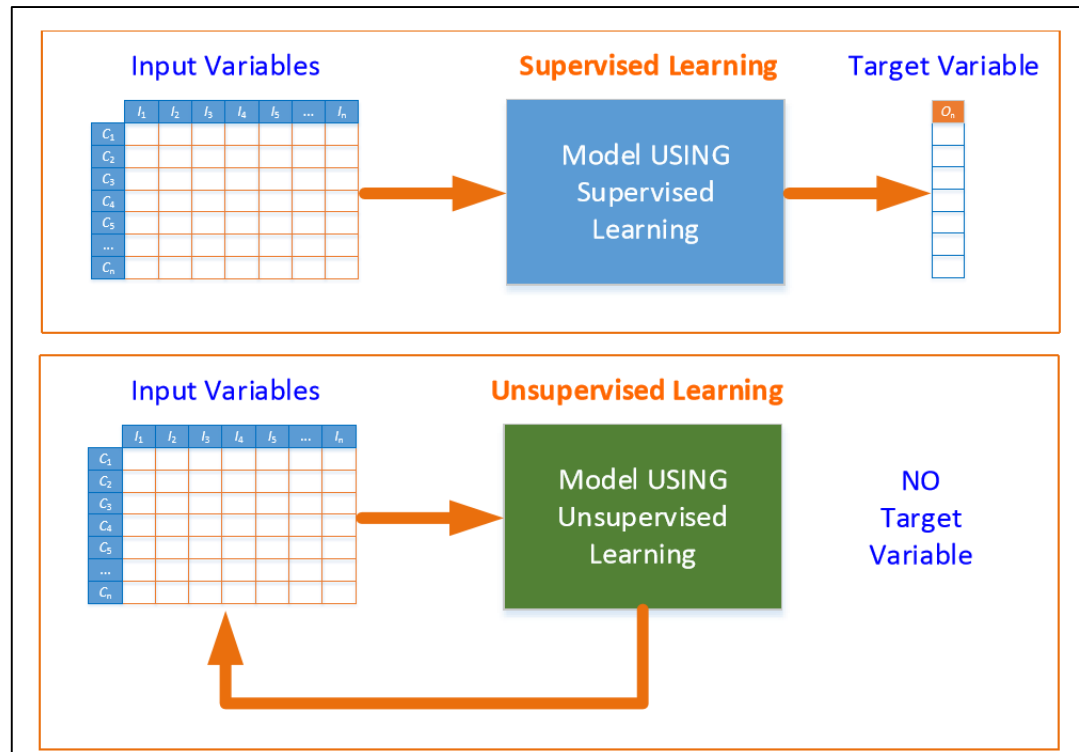
- Input
- Weights
- Bias
- Activation Function
- Output



Activation Function

$$y = f(x_1 w_1 + x_2 w_2 + x_3 w_3 + \cdots + x_m w_m + b)$$

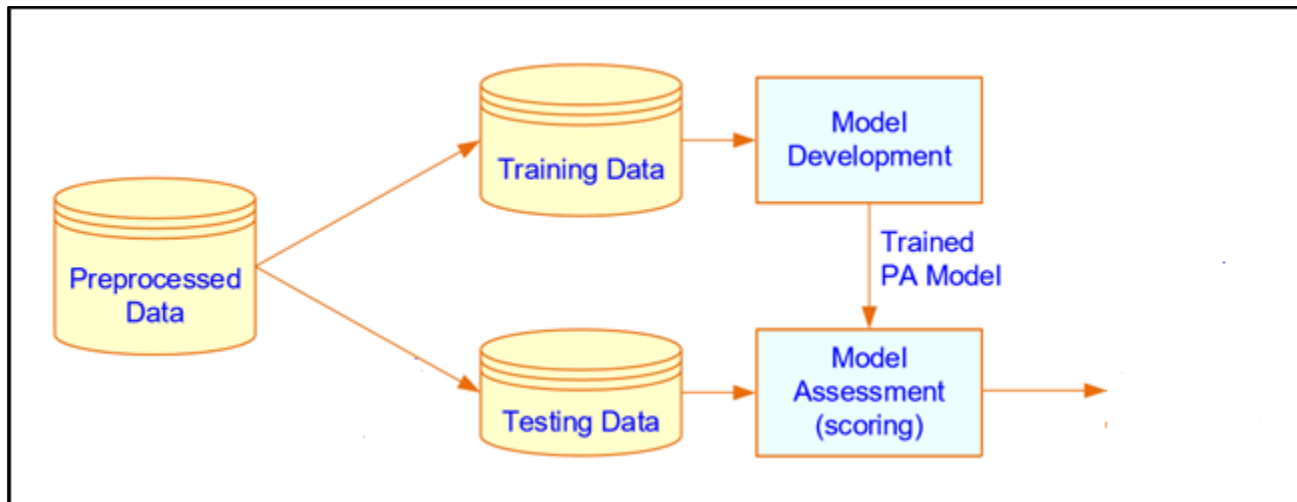
Supervised vs. Unsupervised Learning in ML



Neural Networks are supervised learning method

Split Data into Training and Testing Data

- Single split model assessment methodology
- The model is tested on hold-out sample
 - Only the hold-out sample accuracy is reported

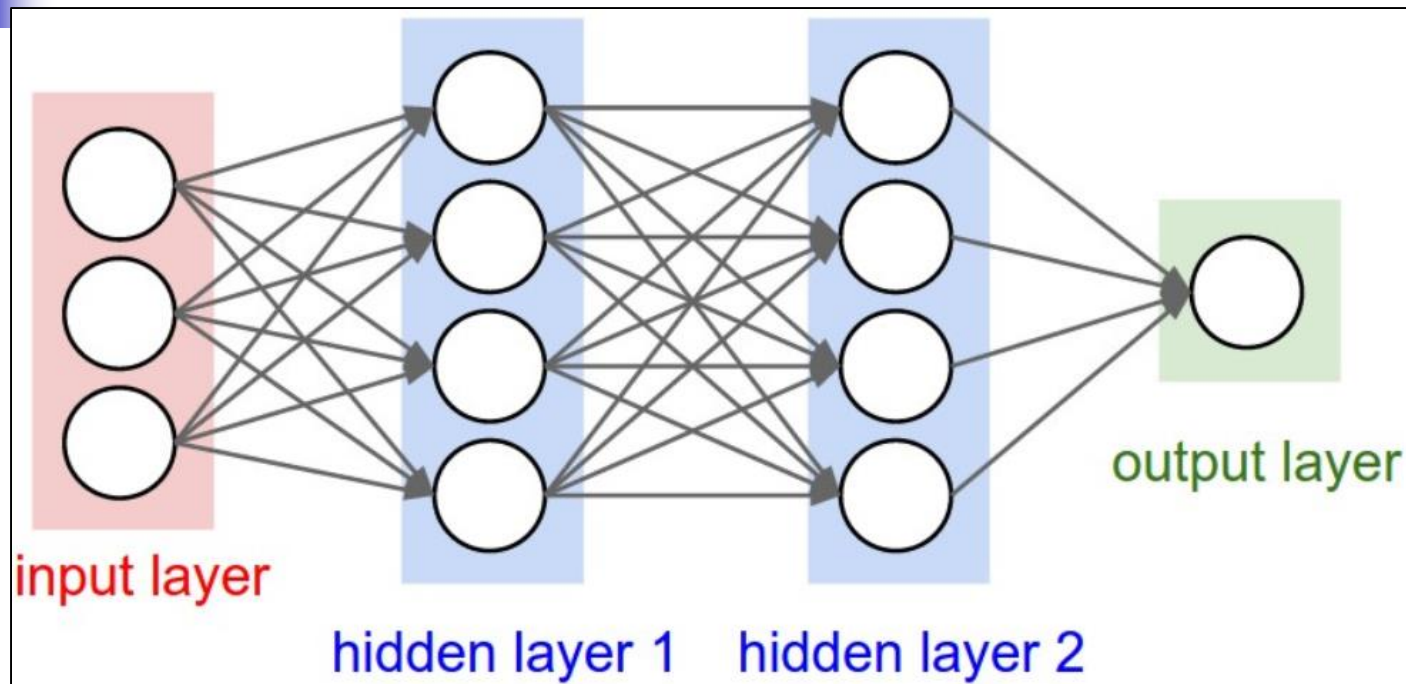




Neural Networks

- Neural Network is a Supervised Learning Method
- We train the model using the Training Data
- Next we test the model by Testing data set

Feed Forward - Fully Connected Neural Network



Question: How to compute the value of the weights and the bias of every node?



Algorithm of Computing Weights

- Assign random values to all the weights
- Compute the output
- Compare the output with the observed output and compute the error
- Adjust the weights using back propagation algorithm till the error is minimized



History of Neural Networks

Neural Networks (1943)

- Warren McCulloch and Walter Pitts (1943) created a computational model for neural networks based on mathematics and algorithms called threshold logic.

| Warren Sturgis McCulloch | |
|--------------------------|--|
| Born | November 16, 1898 Orange, New Jersey |
| Died | September 24, 1969 (aged 70) Cambridge, Massachusetts |
| Citizenship | United States |
| Nationality | United States |
| Fields | Cybernetics Artificial neural network Neuropsychology Biophysics Computer Science |
| Institutions | Massachusetts Institute of Technology (MIT) Yale University University of Illinois at Chicago University of Chicago |
| Alma mater | Yale University Columbia University |
| Notable students | Stafford Beer |
| Notable awards | Wiener Gold Medal (1968) |



Perceptron: Neural Network

Frank Rosenblatt (1957)

- The perceptron algorithm was invented in 1957 at the Cornell Aeronautical Laboratory by Frank Rosenblatt
- The perceptron was intended to be a machine, rather than a program, and while its first implementation was in software for the IBM 704, it was subsequently implemented in custom-built hardware as the "Mark 1 perceptron".





Perceptron

- Single Layer / Eight Neurons
- Today, we have 150 layers and a Billion connections



Rosenblatt Hyped Perceptron

ARCHIVES | 1958

NEW NAVY DEVICE LEARNS BY DOING; Psychologist Shows Embryo of Computer Designed to Read and Grow Wiser

SPECIAL TO THE NEW YORK TIMES JULY 8, 1958

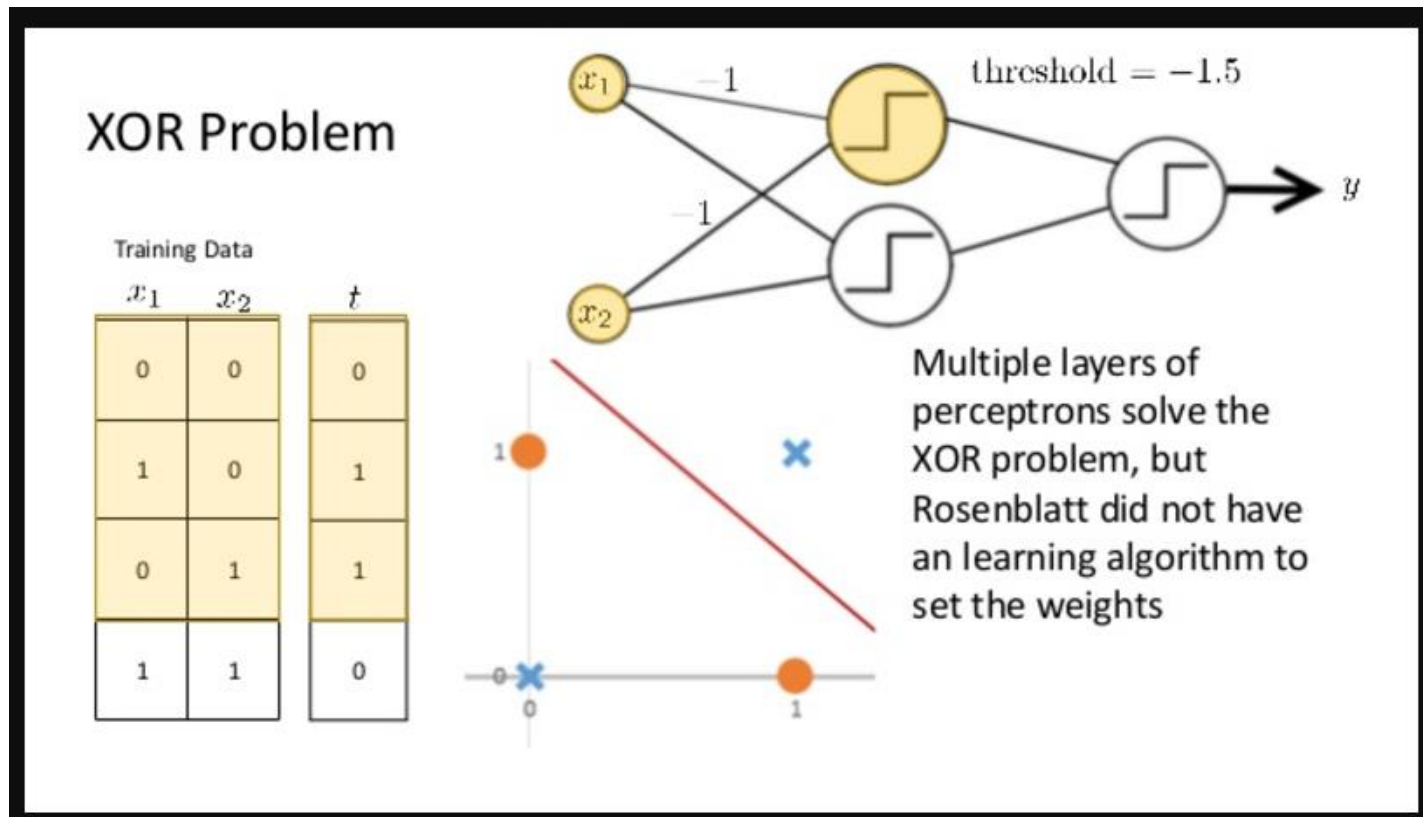
WASHINGTON, July 7 (UPI) -- The Navy revealed the embryo of an electronic computer today that it expects will be able to walk, talk, see, write, reproduce itself and be conscious of its existence.



Perceptron

- Criticized by Marvin Minsky
 - MIT
- Publicly challenged Rosenblatt that Perceptron can learn anything
- XOR pattern cannot be learned by Perceptron
 - However it can be learned by multi-layer neural network
 - At that time technology was not advanced enough to build a multi layer neural network

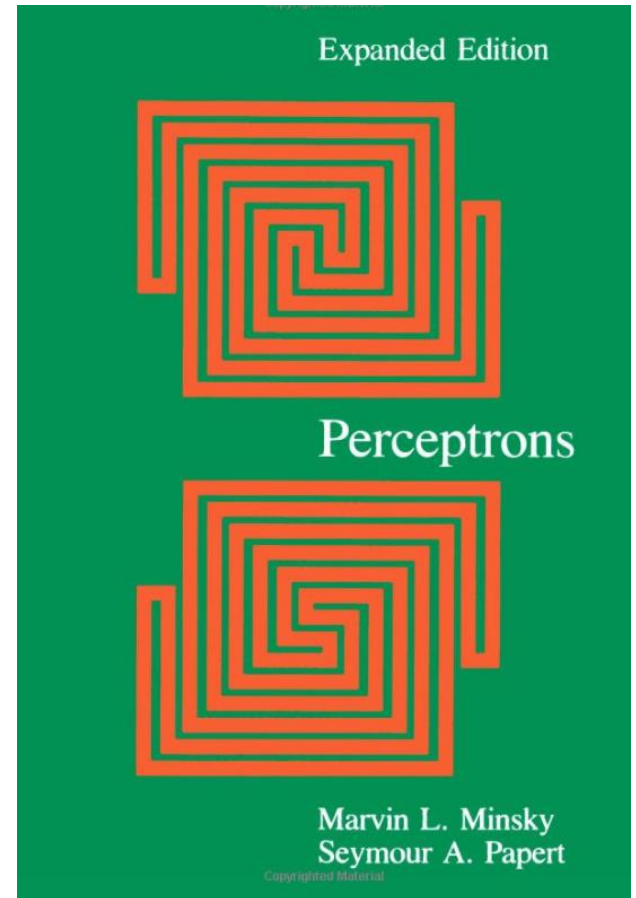
XOR Problem can be solved by Multi-Layer Perceptron



Limitations of Neural Networks

Marvin Minsky (1969)

- Marvin Minsky and Seymour Papert publish their book Perceptrons, describing some of the limitations of perceptrons and neural networks.
- The interpretation the book shows that neural networks are fundamentally limited is seen as a hindrance for research into neural networks.



Marvin Minsky

Artificial Intelligence

- Marvin Lee Minsky (August 9, 1927 – January 24, 2016) was an American cognitive scientist concerned largely with research of artificial intelligence (AI).
- He was the co-founder of the Massachusetts Institute of Technology's AI laboratory, and author of several texts concerning AI and philosophy.

Marvin Minsky



Minsky in 2008

| | |
|---------------------|--|
| Born | Marvin Lee Minsky August 9, 1927 New York City, New York, U.S. |
| Died | January 24, 2016 (aged 88) Boston, Massachusetts, U.S. |
| Nationality | American |
| Fields | Cognitive science Computer science Artificial intelligence Philosophy of mind |
| Institutions | Massachusetts Institute of Technology (MIT) |
| Alma mater | Phillips Academy Harvard University (B.A., 1950) Princeton University (Ph.D., 1954) |
| Thesis | <i>Theory of Neural-Analog Reinforcement Systems and Its Application to the Brain Model Problem</i> [link] (1954) |

Perceptron: Neural Network

Frank Rosenblatt (1971)

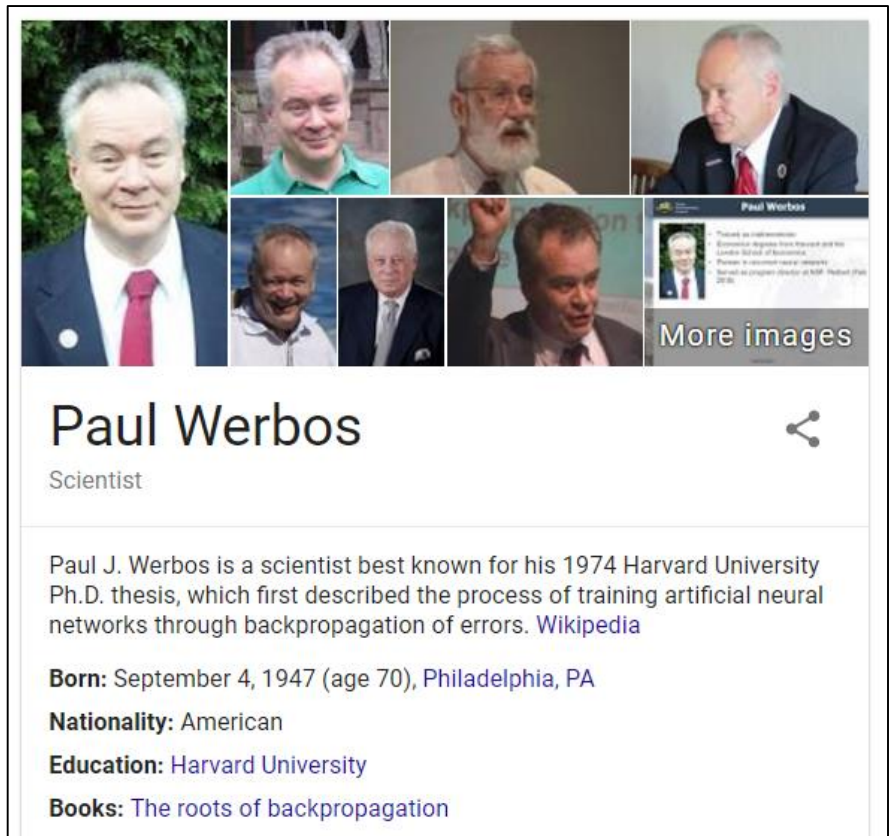
- Frank Rosenblatt died in July 1971 on his 43rd birthday, in a boating accident in Chesapeake Bay.
- That was the end of Neural Networks for the next 20 years



Neural Network Renaissance

Back Propagation Algorithm

- 1974 : New and Improved Perceptron
- Developed only in software
- More than one layer of neurons
- **Back Propagation Algorithm proposed by Paul Werbos of Harvard University**





Software Neural Network

- Paul Werbos solved the XOR problem using multi-layer neural network
- Problem with this approach
 - Overfitting
 - Works very well for the training images
 - But did not work well with the test images



Competition with Support Vector Machine (1990)

- Support Vector Machine (SVM) was proposed by Vladimir N. Vapnik
- The performance of SVM was better than Neural Networks
- The reason SVM was better because it avoided overfitting

Hubel & Wiesel

- 1960 - 1970
- Experimented with the Visual Systems of cats
- Cats retina responded to stripes but not on spots
- Biological visual system respond to edges
- John Hopkins School of Medicine
- Noble prize in Physiology in 1981

David H. Hubel



Torsten Wiesel (left) and Hubel (right), co-recipients of the 1981 Nobel Prize in Physiology or Medicine for their discoveries concerning information processing in the visual system, 1980

Born David Hunter Hubel
February 27, 1926
Windsor, Ontario, Canada

Died September 22, 2013 (aged 87)
Lincoln, Massachusetts, US

Nationality American-Canadian^[1]

Alma mater McGill University

Known for Visual system

Spouse(s) Ruth Izzard (m. 1953)

Awards Louisa Gross Horwitz Prize (1978)
Dickson Prize (1980)
Nobel Prize in Physiology or Medicine (1981)
ForMemRS (1982)^{[2][3]}

Scientific career

Fields Neurophysiologist

Institutions Johns Hopkins School of Medicine
Harvard University

Torsten Wiesel



At a conference in 2011

Born Torsten Nils Wiesel
3 June 1924 (age 93)
Uppsala, Sweden

Nationality Swedish

Alma mater Karolinska Institute

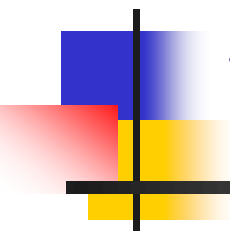
Known for Visual system

Spouse(s) Lizette Mususa Reyes (m. 2008)
Jean Stein (m. 1995; div. 2007)
Ann Yee (m. 1973; div. 1981)
Teeri Stenhammar (m. 1956; div. 1970)

Awards Louisa Gross Horwitz Prize (1978)
Dickson Prize (1980)
Nobel Prize in Physiology or Medicine (1981)^[1]
ForMemRS (1982)^{[2][3]}
National Medal of Science^[4] (2005)

Scientific career

Institutions Johns Hopkins School of Medicine
Rockefeller University
Harvard University



Convolution Neural Networks with Deep Learning

Neocognitron

Developer of Convolution Neural Network K. Fukushima

- Neocognitron: Artificial Neural Network : 1980
- Kunihiro Fukushima received a B.Eng. degree in electronics in 1958 and a PhD degree in electrical engineering in 1966 from Kyoto University, Japan.
- Professor
 - Osaka University
 - University of Electro-Communications
 - Tokyo University of Technology
 - Kansai University

Kunihiro Fukushima





Senior Research Scientist, Fuzzy Logic Systems Institute (Iizuka, Fukuoka, Japan)
E-mail: fukushima@m.ieice.org

Geoffrey Hinton



Yann LeCun



Yann LeCun 

Computer scientist

Yann LeCun is a computer scientist with contributions in machine learning, computer vision, mobile robotics and computational neuroscience. [Wikipedia](#)

Born: July 8, 1960 (age 57), [Paris, France](#)

Alma mater: [Pierre-and-Marie-Curie University](#)

Thesis: Modeles connexionnistes de l'apprentissage (connectionist learning models) (1987)

Known for: [Deep learning](#)

Academic advisor: [Geoffrey Hinton](#)

Institution: [New York University](#)

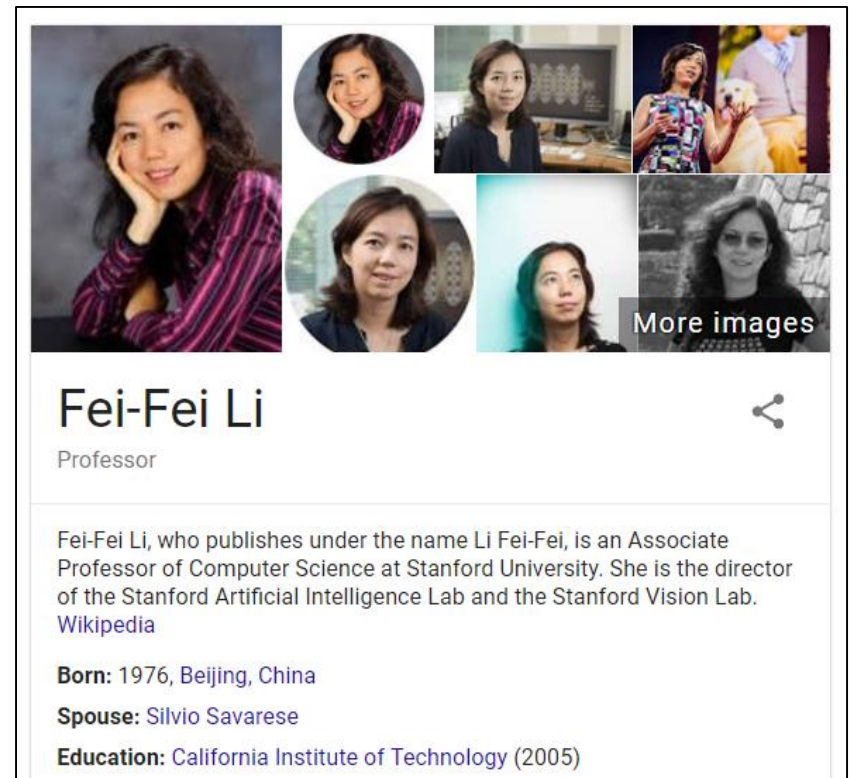
Birth of Deep Learning BigData

- Fei-Fei Li (Stanford) created ImageNet
 - Contains 14 million images of 20,000 categories
- These images were classified by Mechanical Turk workers on Amazon
- For pennies per image, labeled each one



Modern Deep Learning

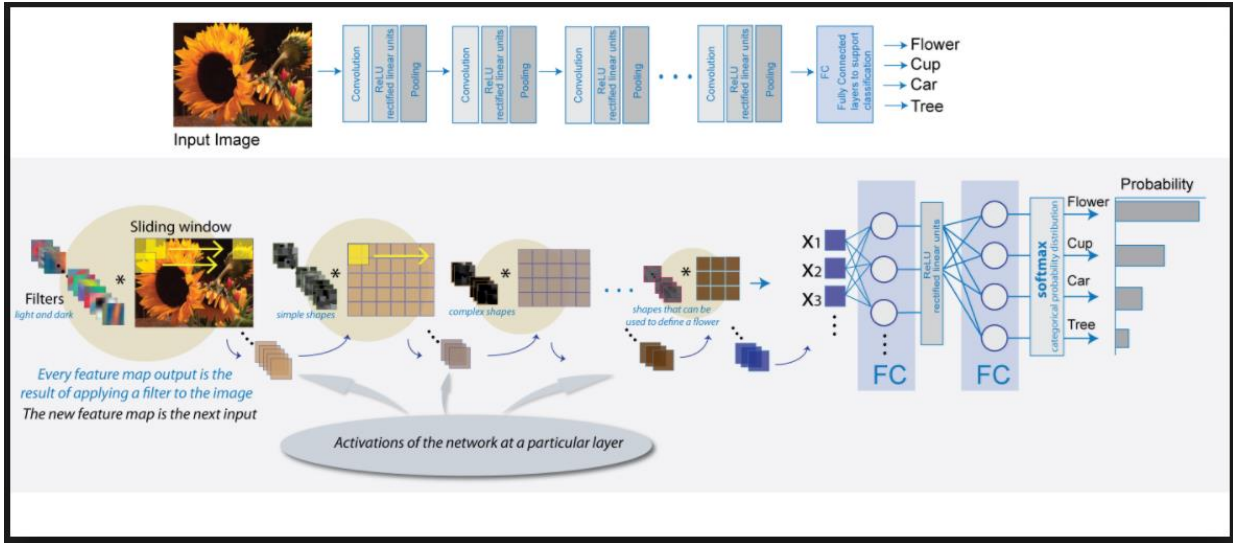
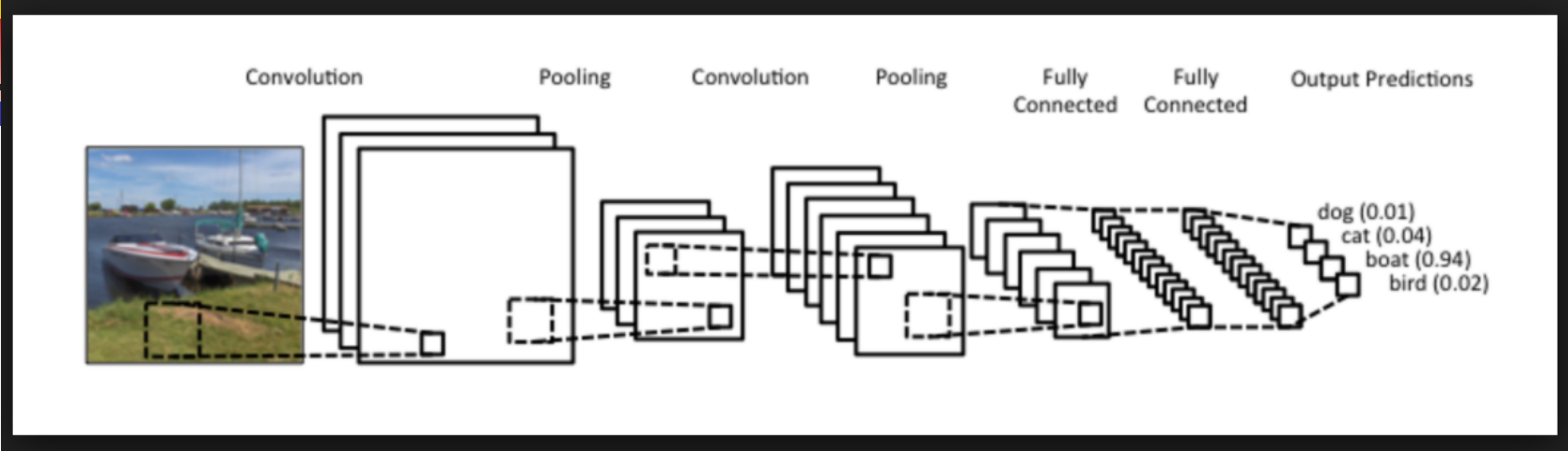
- Large Scale Visual Recognition Competition
- Database of Images: ImageNet
- Organized by
 - Fei-Fei Li
 - Stanford University
- Competition
 - 2011 – 2015
 - 100,000 new images
 - Who can identify them correctly



Supervision University of Toronto

Alex Krizhevsky,
Ilya Sutskever,
Geoffrey Hinton







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