NUS-ISS
Problem Solving Using Pattern Recognition

Deep learning: Before and After

Dr. Tan Jen Hong
Lecturer & Consultant
Institute of System Science
National University of Singapore
tanjenhong@nus.edu.sg

TAN Jen Hong

Lecturer & Consultant, Analytics & Intelligent Systems Practice

isstjh@nus.edu.sg

Profile

Jen Hong develops algorithms. He specializes in deep learning, image processing and medical image diagnosis. He designs illustrations, web page and posters. He plays piano.

He invented a mathematical model to analyze dry eye. He used deep learning to correct medical images. He trained deep learning models to identify pathologies in retinal images. And he made deep learning to draw anatomical features.

He was the co-Principal Investigator of 6 research grants and 3 clinical trials. He and his team member co-developed algorithms to diagnose breast cancer, ovarian cancer, heart attack, fatty liver, diabetic retinopathy, epilepsy and glaucoma. He has published more than 90 journal articles, 12 of which are deep learning related.

Worldwide his publications are cited more than 2000 times.

Educational Qualifications

- Ph.D. (Biomedical Engineering), Nanyang Technological University
- Bachelor of Engineering (Mechanical & Production Engineering), Minor in Chinese, Nanyang Technological University

Selected Publications

jen hong, tan

FOLLOW

GET MY OWN PROFILE

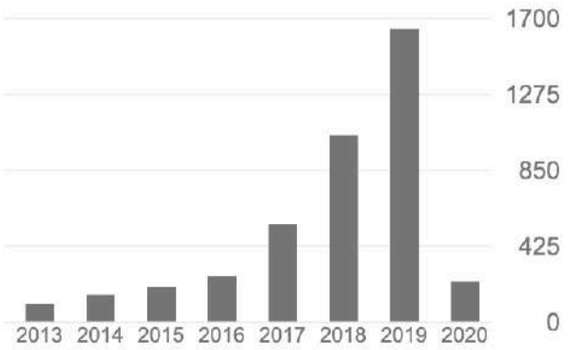
Lecturer & Consultant, NUS Institute of System Science
Verified email at nus.edu.sg

image processing automated segmentation deep learning infrared thermography fundus image

TITLE	CITED BY	YEAR
Deep convolutional neural network for the automated detection and diagnosis of seizure using EEG signals UR Acharya, SL Oh, Y Hagiwara, JH Tan, H Adeli Computers in biology and medicine 100, 270-278	339	2018
Thermography based breast cancer detection using texture features and support vector machine UR Acharya, EYK Ng, JH Tan, SV Sree Journal of medical systems 36 (3), 1503-1510	225	2012
Application of deep convolutional neural network for automated detection of myocardial infarction using ECG signals UR Acharya, H Fujita, SL Oh, Y Hagiwara, JH Tan, M Adam Information Sciences 415, 190-198	213	2017
A deep convolutional neural network model to classify heartbeats UR Acharya, SL Oh, Y Hagiwara, JH Tan, M Adam, A Gertych, R San Tan Computers in biology and medicine 89, 389-396	203	2017
Automated detection of arrhythmias using different intervals of tachycardia ECG segments with convolutional neural network UR Acharya, H Fujita, OS Lih, Y Hagiwara, JH Tan, M Adam Information sciences 405, 81-90	200	2017
Deep learning for healthcare applications based on physiological signals: A review O Faust, Y Hagiwara, TJ Hong, OS Lih, UR Acharya Computer methods and programs in biomedicine 161, 1-13	195	2018
Infrared thermography on ocular surface temperature: a review JH Tan, EYK Ng, UR Acharya, C Chee Infrared physics & technology 52 (4), 97-108	193	2009
Application of empirical mode decomposition (EMD) for automated detection of epilepsy using EEG signals RJ Martis, UR Acharya, JH Tan, A Petznick, R Yanti, CK Chua, EYK Ng, ... International journal of neural systems 22 (06), 1250027	145	2012
An integrated index for the identification of diabetic retinopathy stages using texture parameters UR Acharya, EYK Ng, JH Tan, SV Sree, KH Ng Journal of medical systems 36 (3), 2011-2020	124	2012

Cited by VIEW ALL

	All	Since 2015
Citations	4309	3936
h-index	36	34
i10-index	67	66



Co-authors


Rajendra (Raj) Acharya
Ngee Ann, Singapore University ...


Yuki Hagiwara
Ngee Ann Polytechnic


Kuang Chua Chua
Ngee Ann Polytechnic, Singapore


Shu Lih Oh
Department of Electronics and C...


EYK Ng
Nanyang Technological University


Joel Koh En Wei
R&D Project Engineer, Ngee Ann...

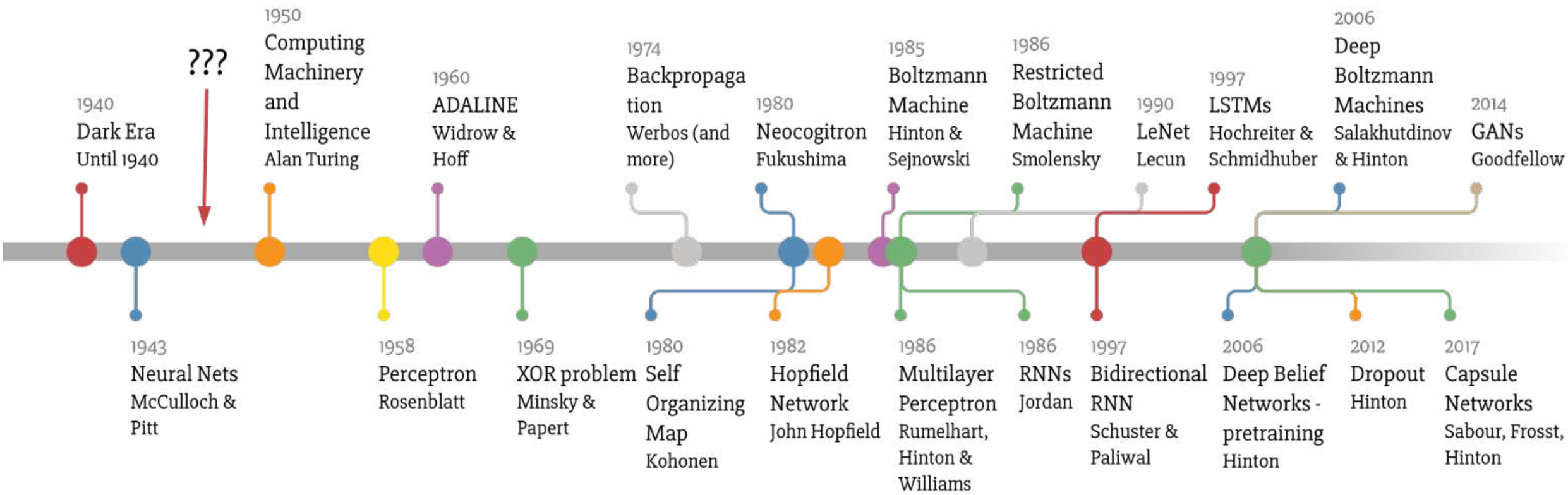

Louis Tong
Professor, Duke-National Univer...


Vidya K. Sudarshan, MSc, PhD
Adjunct Faculty, SIM University, ...

Deep learning: The Before

Time line

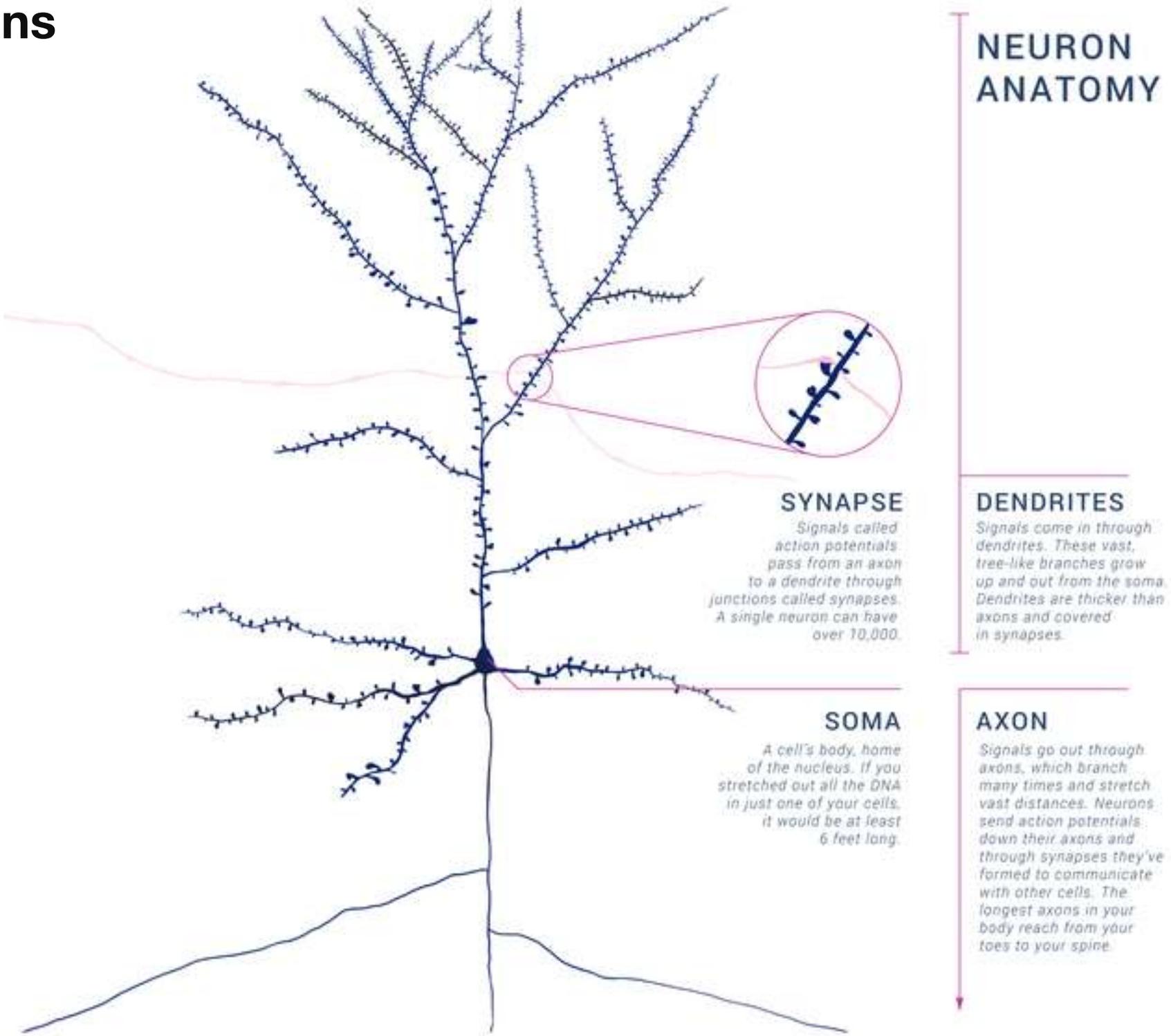
Of deep learning



Source: https://medium.com/@faviovazquez

Biological neurons

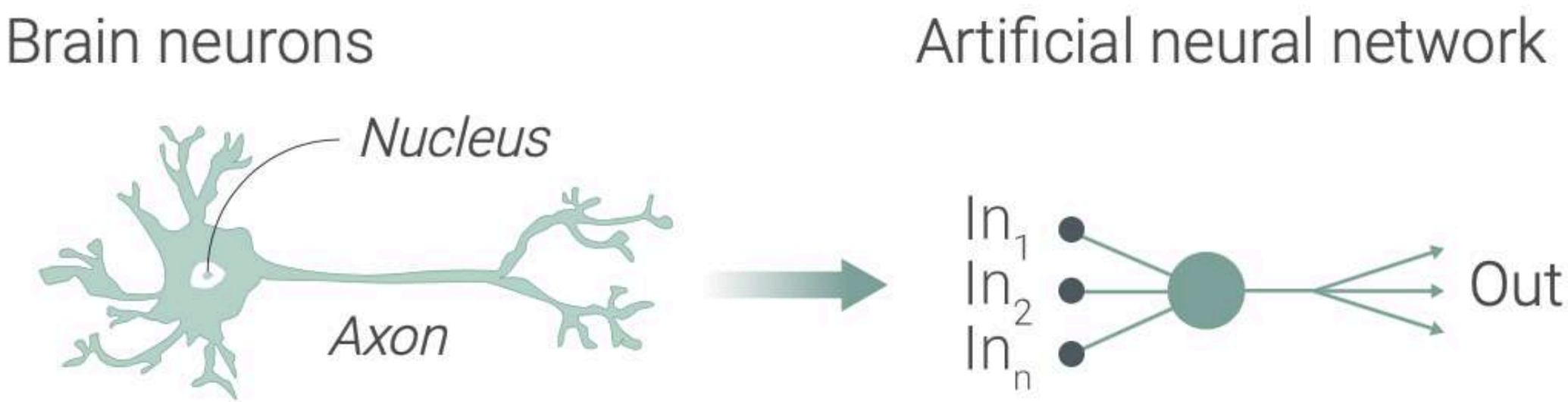
Simplified illustration



Source: https://en.wikipedia.org/wiki/File:Anatomy_of_a_Neuron_with_Synapse.png

The evolution

From neurons to neural network

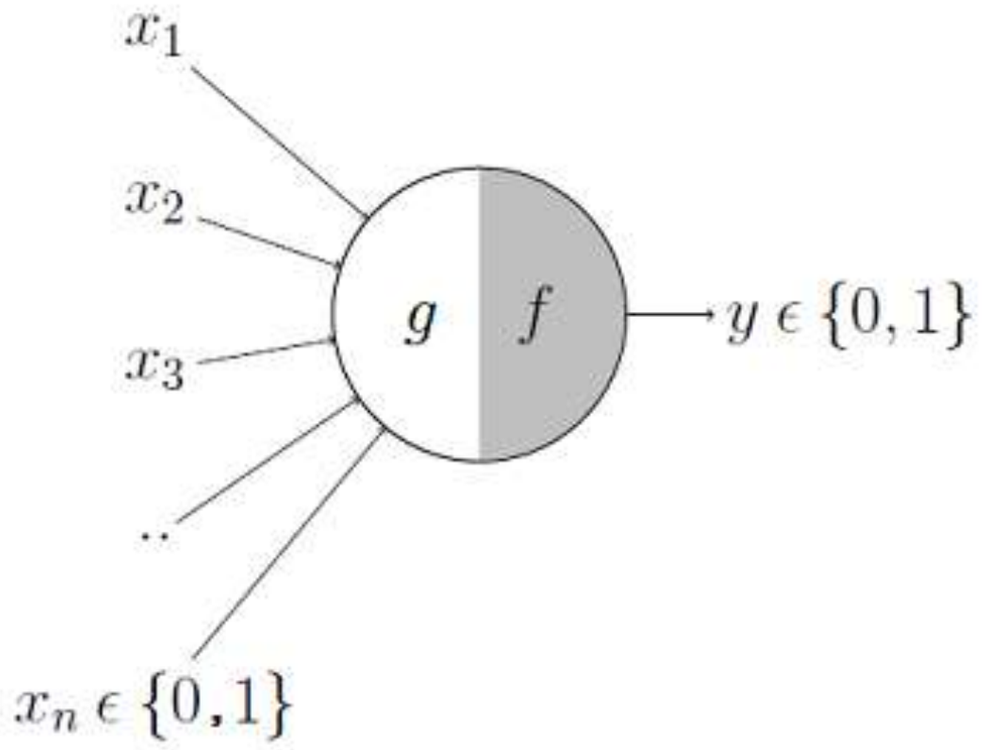


Source: https://multimedia.scmp.com/news/china/article/2166148/china-2025-artificial-intelligence/index.html?src=follow-chapter

The first artificial neuron

McCulloch-Pitts Neuron

- By Warren McCulloch (neuroscientist) and Walter Pitts (logician) in 1943



$$g(x_1, x_2, x_3, ..., x_n) = g(\mathbf{x}) = \sum_{i=1}^{n} x_i$$

$$y = f(g(\mathbf{x})) = 1 \quad if \quad g(\mathbf{x}) \geq \theta$$
$$= 0 \quad if \quad g(\mathbf{x}) < \theta$$

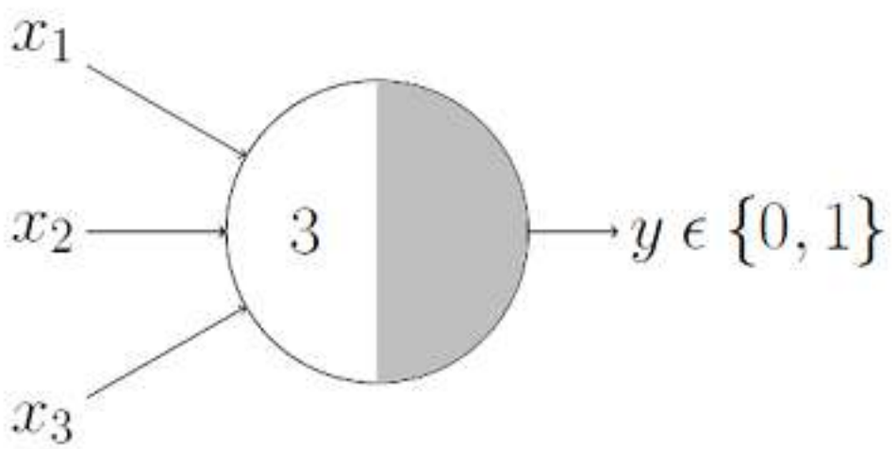
Source: https://en.wikipedia.org/wiki/File:Anatomy_of_a_Neuron_with_Synapse.png

The first artificial neuron

McCulloch-Pitts Neuron

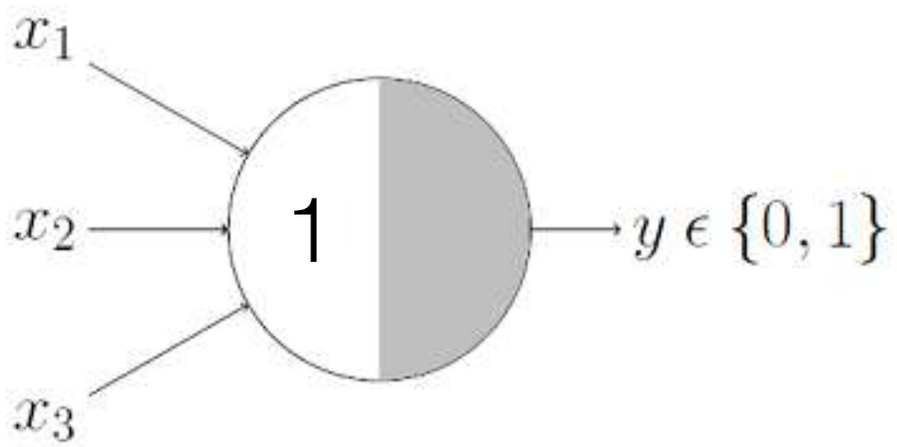
- Can be used to represent a few Boolean functions

AND function



$y = 1$ if $x_1 + x_2 + x_3 \geq 3$

OR function



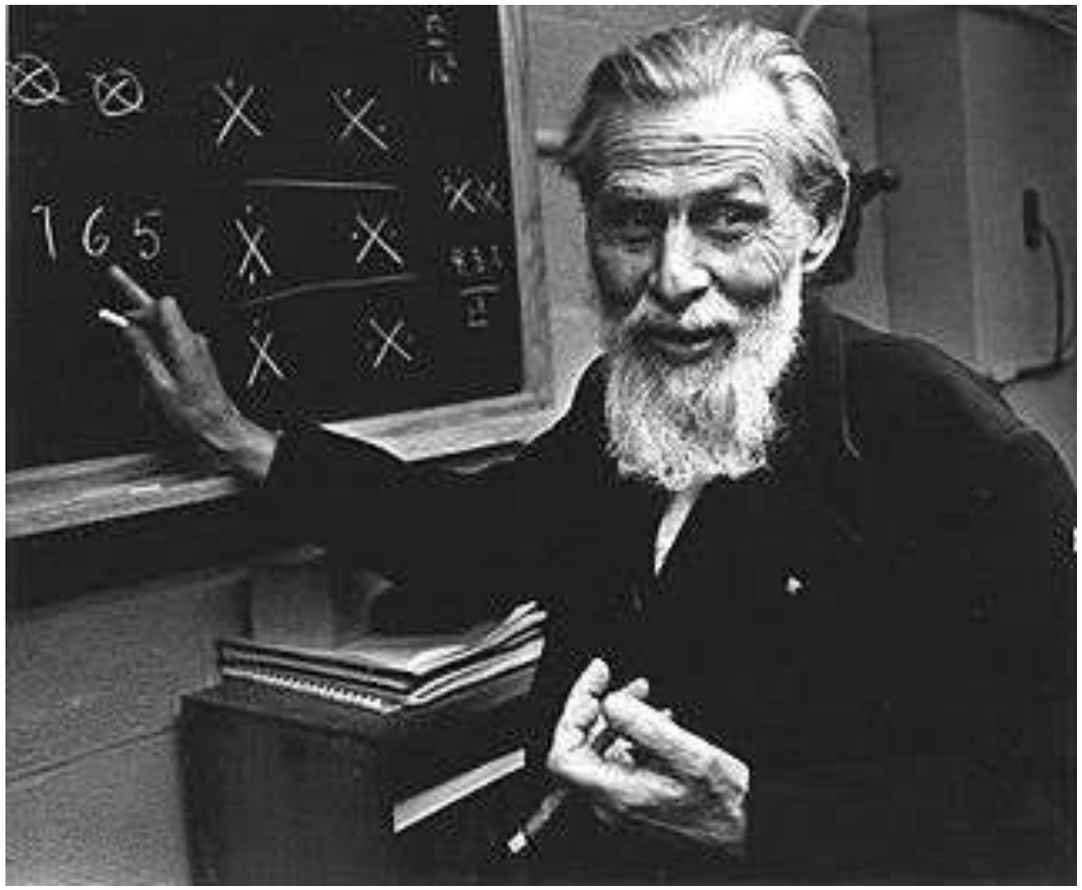
$y = 1$ if $x_1 + x_2 + x_3 \geq 1$

Source:https://towardsdatascience.com/mcculloch-pitts-model-5fdf65ac5dd1

The first artificial neuron

McCulloch-Pitts Neuron

- Inputs accepts only boolean values
- No learning algorithm

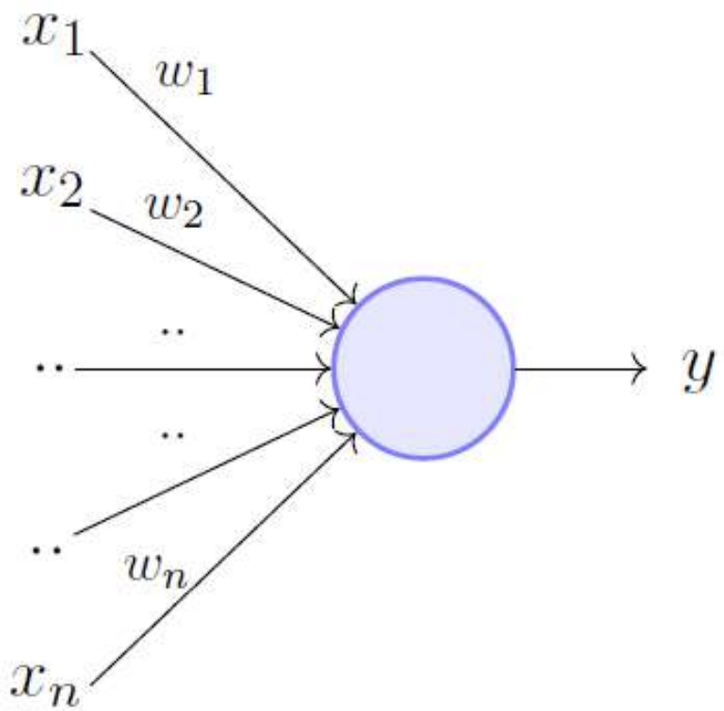


Left: Warren S. McCulloch. Right: Walter H. Pitts Jr.

The improved artificial neuron

Perceptron

- By Frank Rosenblatt, refined by Minsky and Papert
- Support real inputs, not just boolean values



$$y = 1 \quad if \sum_{i=1}^{n} w_i * x_i \geq \theta$$

$$= 0 \quad if \sum_{i=1}^{n} w_i * x_i < \theta$$

Rewriting the above,

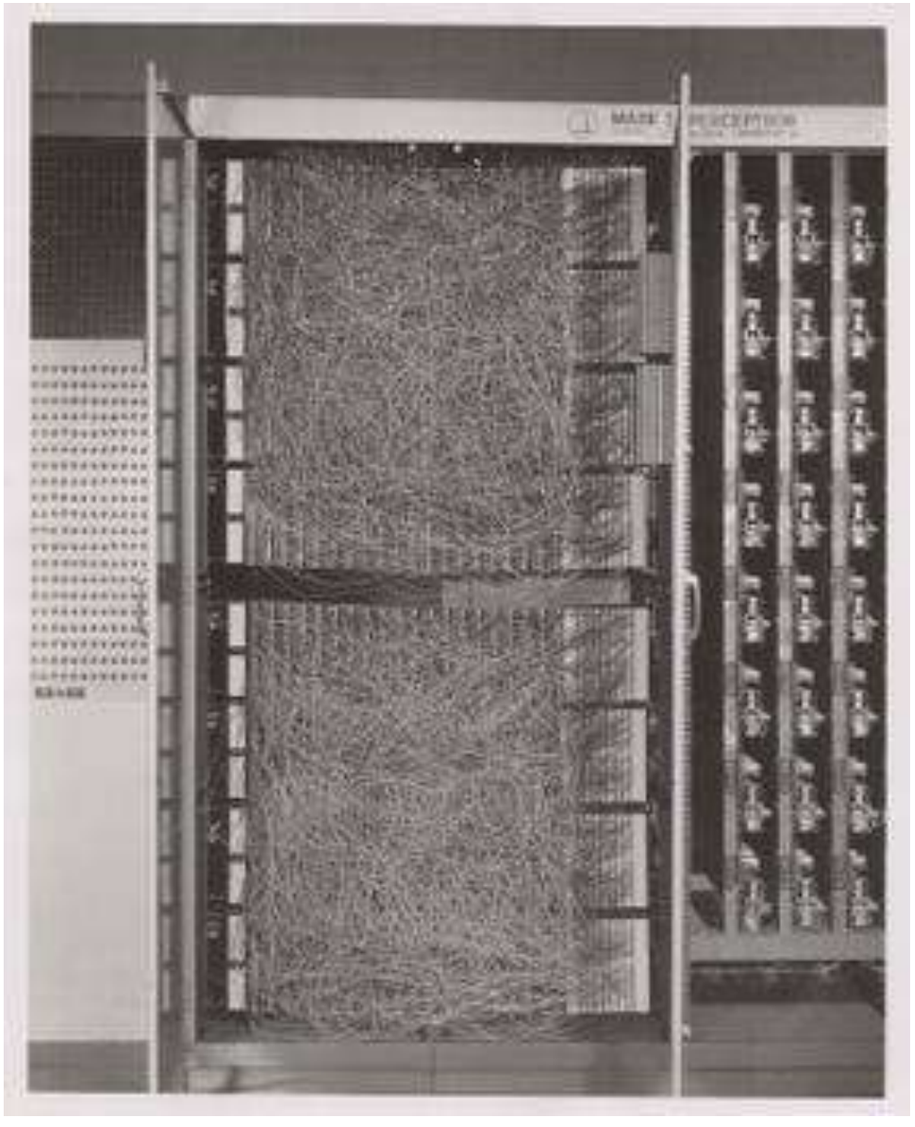
$$y = 1 \quad if \sum_{i=1}^{n} w_i * x_i - \theta \geq 0$$

$$= 0 \quad if \sum_{i=1}^{n} w_i * x_i - \theta < 0$$

Source: https://towardsdatascience.com/perceptron-the-artificial-neuron-4d8c70d5cc8d

The improved artificial neuron

Perceptron



Source: 'Mark I Perceptron at the Cornell Aeronautical Laboratory', hardware implementation of the first Perceptron (Source: Wikipedia / Cornell Library)

- Rosenblatt's achievement: artificial neurons could actually learn from data
- He came up a supervised learning algorithm!
- He implemented Perceptron in custom hardware, which can learn to classify simple shapes correctly with 20x20 pixel-like inputs

The first AI winter

XOR affair

Source: https://amethix.com/2018/06/ai-winter-is-coming/

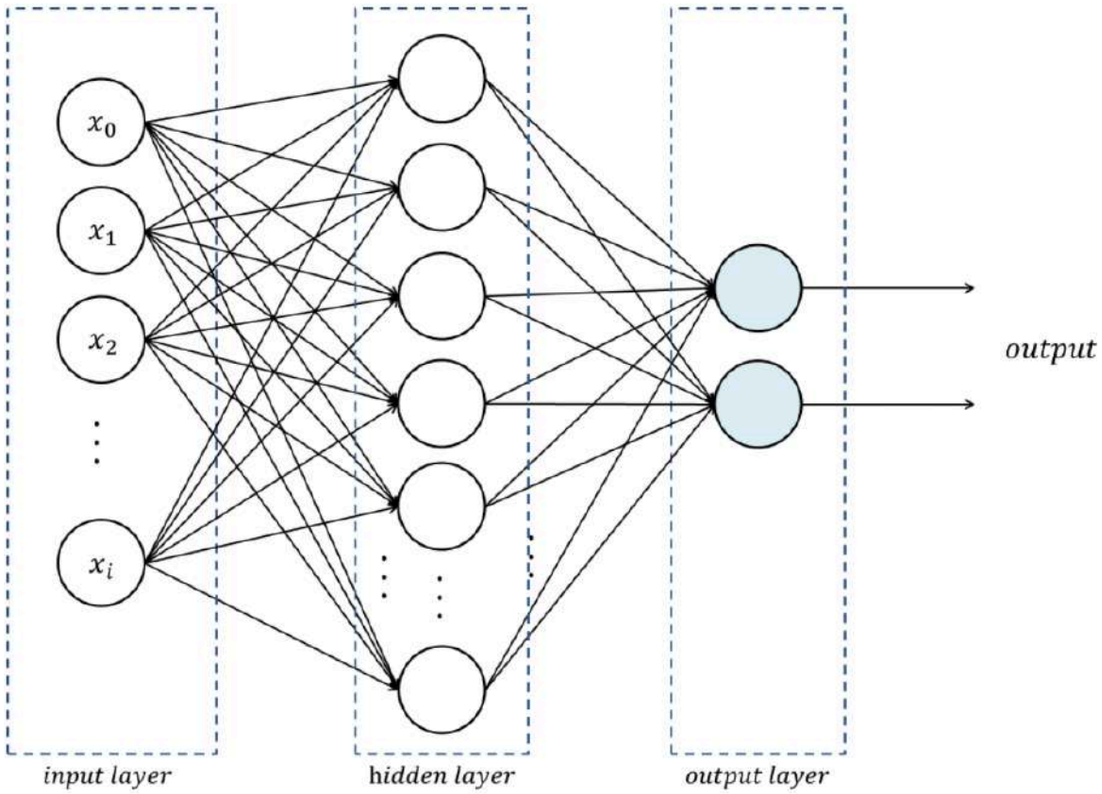
- Marvin Minsky, founder of MIT AI lab, and Seymour Papert, director of the lab in 1969 published a book named 'Perceptrons'
- They showed that a single perceptron cannot do XOR
- Multiple layers of Perceptron can do XOR, but the proposed learning algorithm does not work for that!
- Here comes the winter ...

Where is the learning algorithm?

The thaw of AI winter

- Multilayer layers of perceptron should work, but need learning algorithm

- Between 60s and 80s, several researchers separately derived the solution, but few people knew



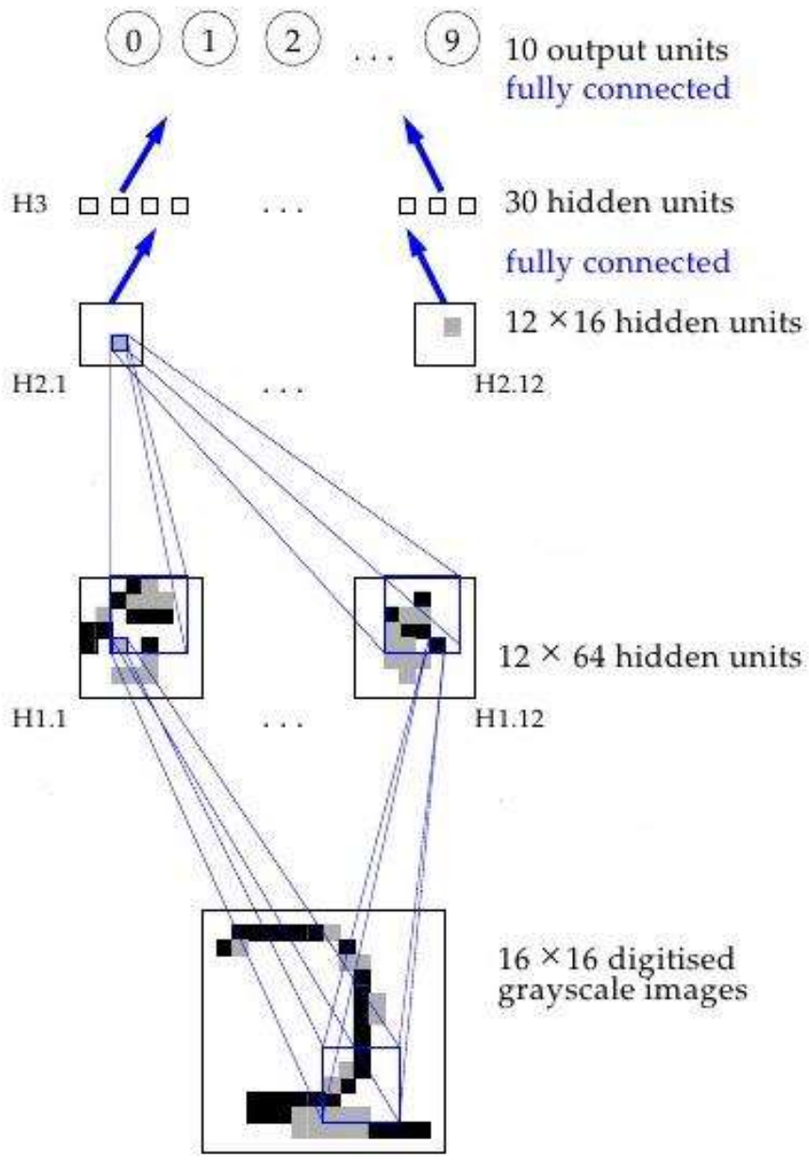
Source: https://www.cc.gatech.edu/~san37/post/dlhc-fnn/

- In 1986, Rumelhart, Hinton Williams published a method in Nature

- They called the learning procedure "backpropagation"

Year 1989

Annus mirabillis, sort of



Source: http://www.andreykurenkov.com/writing/ai/a-brief-history-of-neural-nets-and-deep-learning-part-2/

- Multilayer feedforward networks are proved to be universal approximators
- LeNet was proposed and put into actual significant use: recognizing numbers
- It is a neural net + convolutional layers (weight sharing)

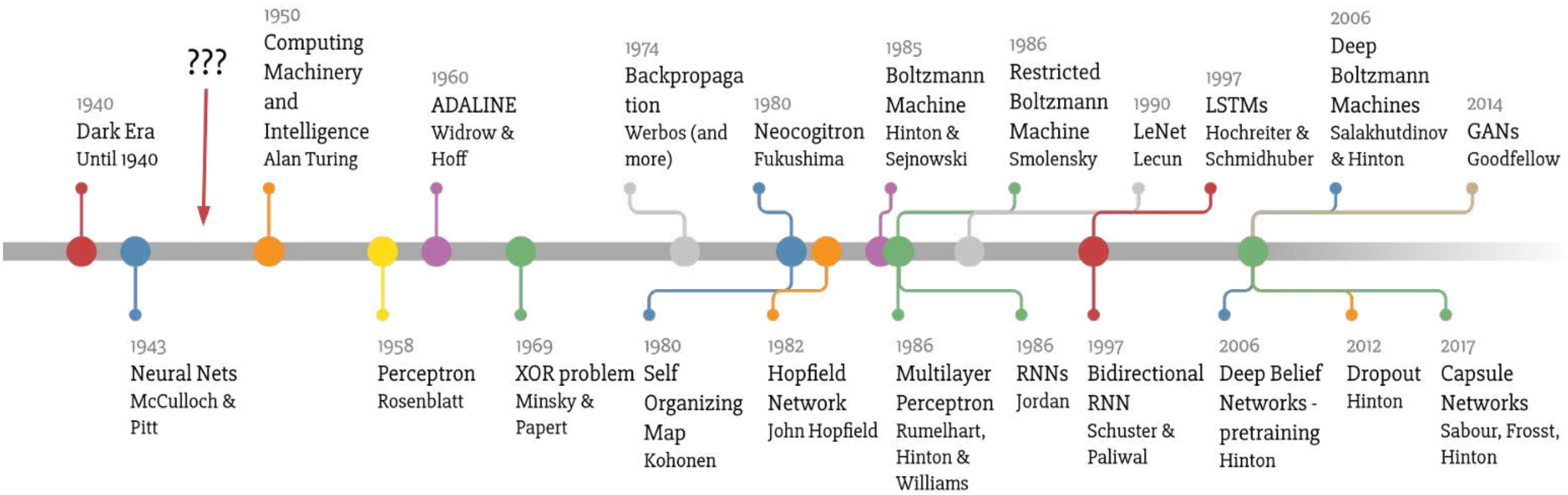
Another winter dawns
by backpropagation

Source: https://amethix.com/2018/06/ai-winter-is-coming/

- By late 80s, already knew that deep neural net was hard to train
- Deep neural nets trained with backpropagation did not work very well, not as well as nets with fewer layers
- Support vector machine came into fashion
- Random forests, with lovely mathematical theory behind proved to be effective

Time line

Of deep learning



Source: https://medium.com/@faviovazquez

ImageNet

by Stanford Vision Lab

Source: https://gluon-cv.mxnet.io/build/examples_datasets/imagenet.html

Competition
on ImageNet

- ILSVRC: ImageNet Large Scale Visual Recognition Challenge

- Started from 2010; teams evaluate their algorithms on given data set, compete to achieve highest accuracy on visual recognition tasks.

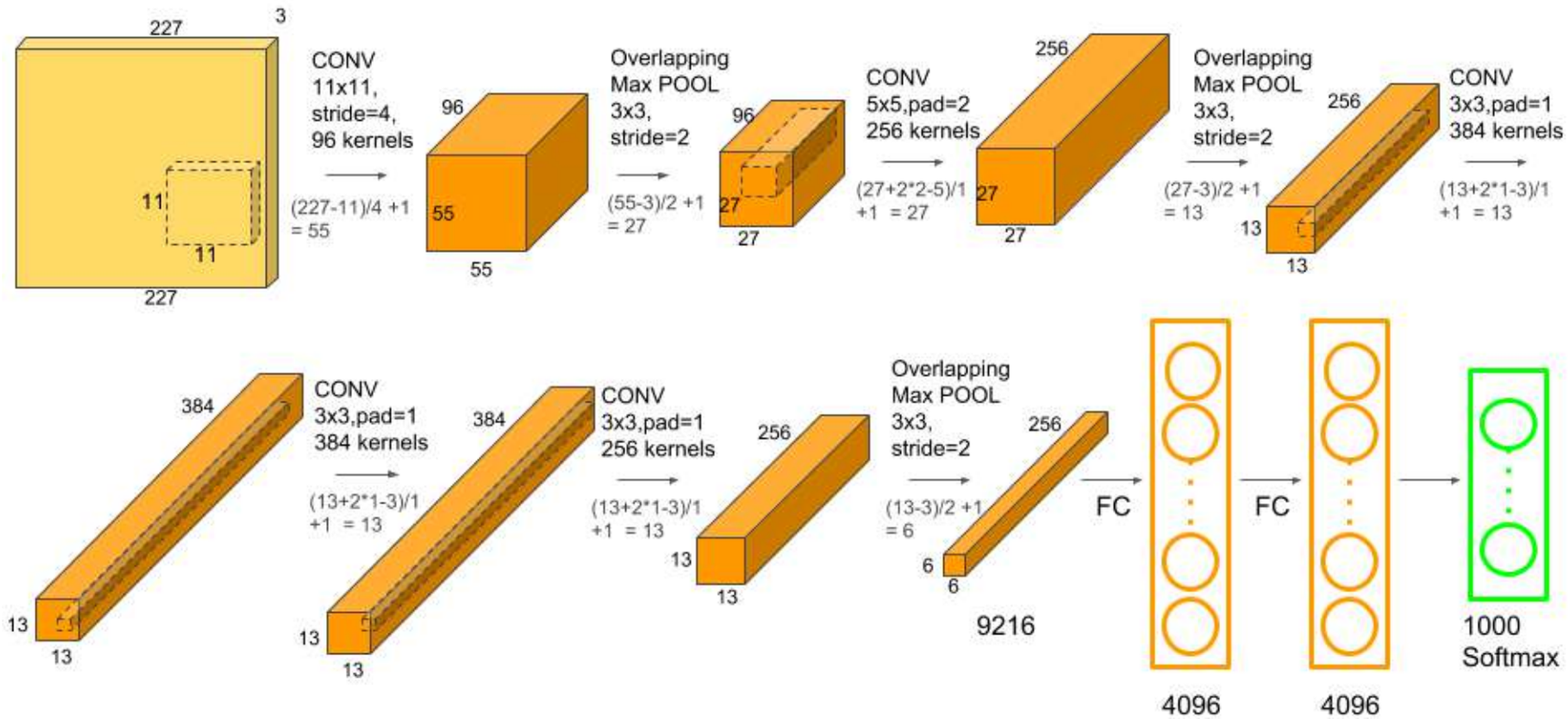
- ILSVRC training dataset: 1000 object categories, 1.2 million images

Source: http://www.image-net.org

ILSVRC2012

AlexNet

- Team Hinton entered the competition
- They achieved an error rate of 15.3%, far far better than the next closest: 26.2%



Source: https://neurohive.io/en/popular-networks/alexnet-imagenet-classification-with-deep-convolutional-neural-networks/

AlexNet

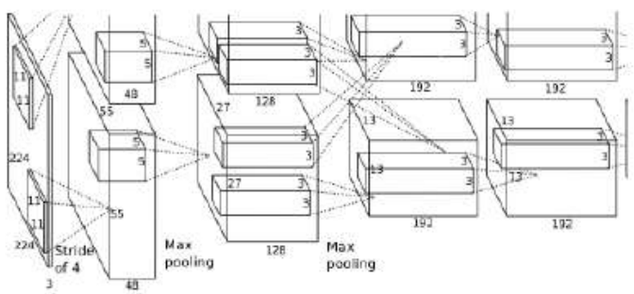
Key of success?

- The net structure is not the most important point
- Use of Rectified Linear Unit (ReLU) activation function
- Use of dropout
- GPU implementation (through CUDA)

Deep learning computer vision recipe

Lots of data

+



Deep convolutional neural network

+

Backprop on GPU

=

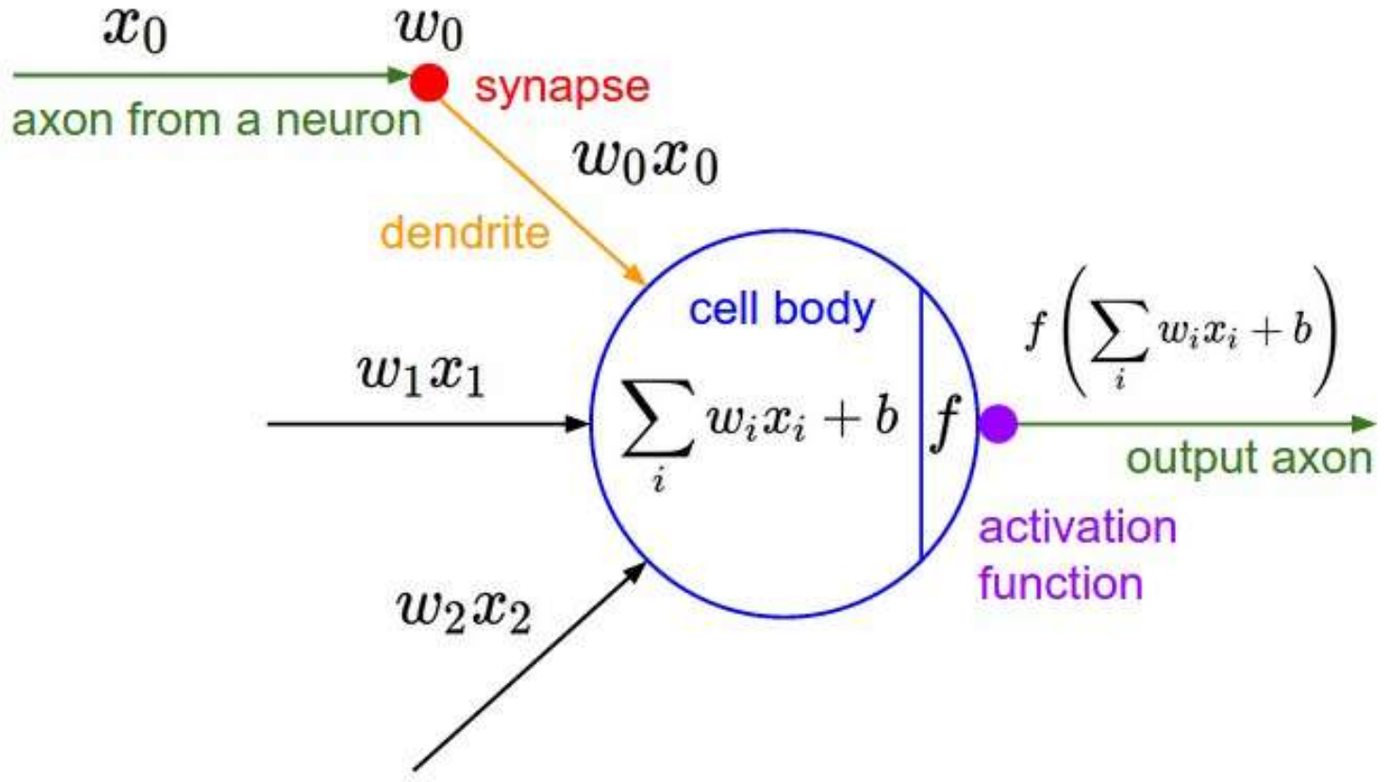
Vision

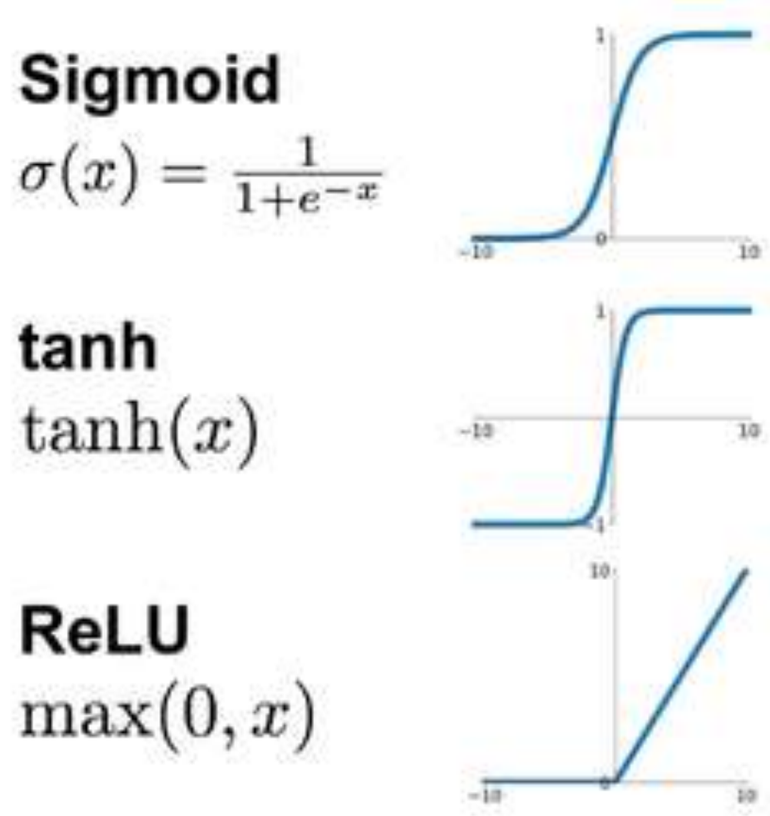
Source: http://www.computervisionblog.com/2015/05/deep-learning-vs-big-data-who-owns-what.html

ReLU

Simple is better

- The zero value output from ReLU introduces sparsity representation (more zeros in each layer, only the important neurons contribute)
- ReLU is easier to calculate





Source: http://www.andreykurenkov.com/writing/ai/a-brief-history-of-neural-nets-and-deep-learning/

The big question

Why did backpropagation fail in past?

Source: https://torontolife.com/tech/ai-superstars-google-facebook-apple-studied-guy/

- Labelled datasets were thousands times too small
- Computing power was millions times slower
- Initialized the weight in stupid ways
- Used the wrong type of non-linearity for activation function

Since then ...

theano

Keras

Caffe

DEEPLEARNING4J

TensorFlow

PYTORCH

mxnet

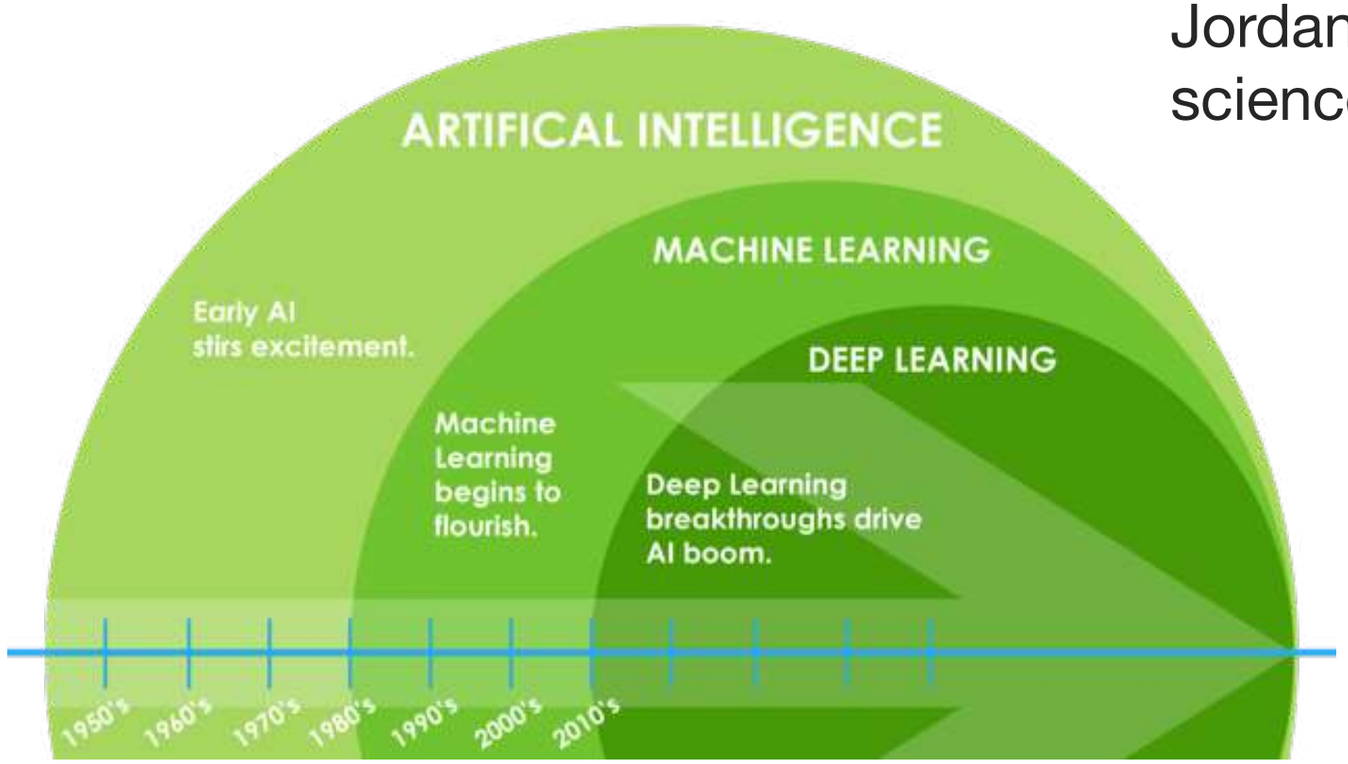
The Microsoft Cognitive Toolkit

Chainer

Deep learning: The After

Confusion?

The differences among the few terms



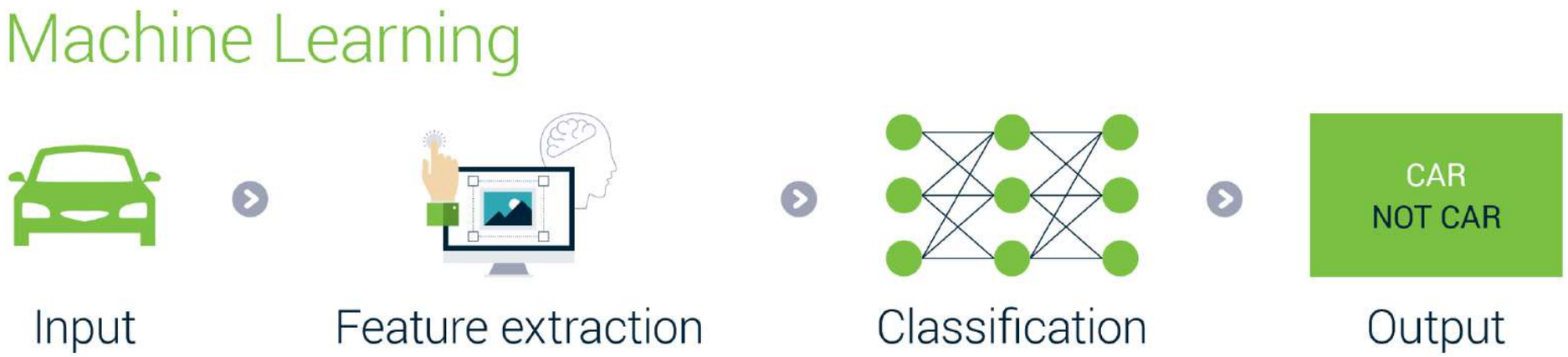
- Arthur Samuel coined the term 'machine learning' in 1959 while at IBM
- Rina Dechter introduced the term deep learning in 1986
- Machine learning and statistics are closely related, thus Michael I. Jordan suggested the term 'data science' to refer to the overall field

Source: https://buzzrobot.com/difference-between-artificial-intelligence-machine-learning-and-deep-learning-ccfd779eca7b

Confusion?

The differences among the few terms

- Feature: a number or a vector that describes something about the input

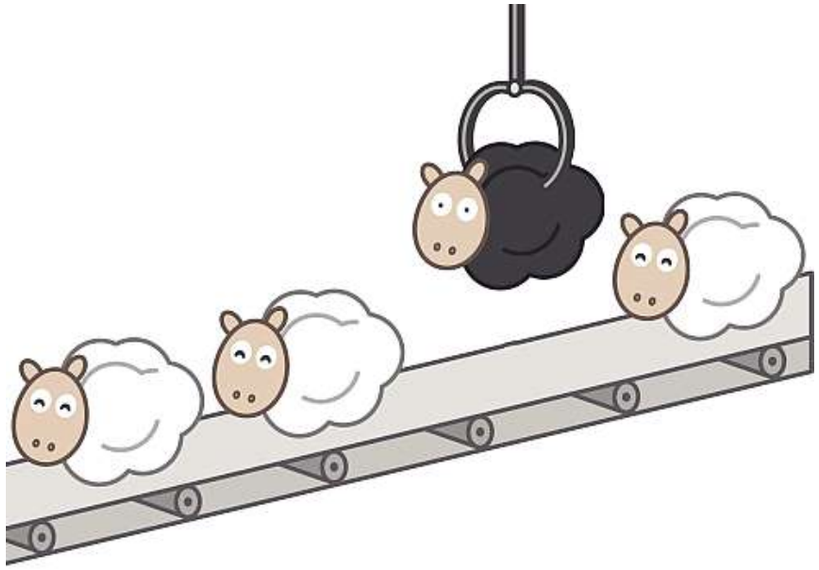


Source: https://verhaert.com/difference-machine-learning-deep-learning/

Application

Three main categories

Identify

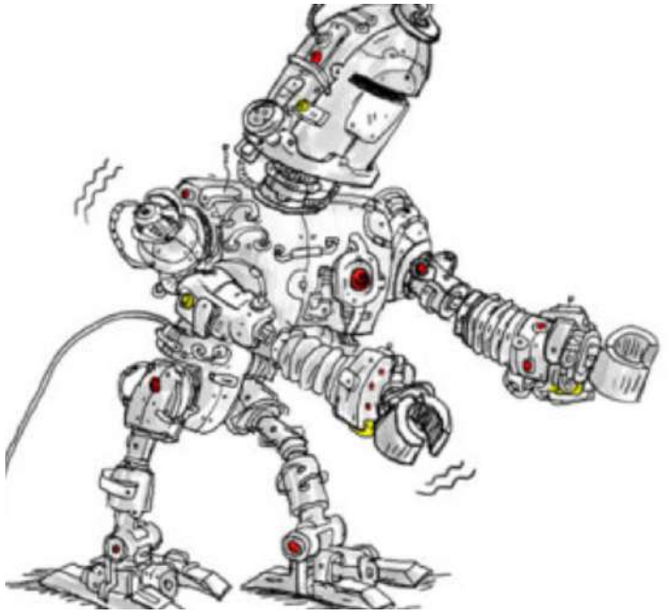


Source: http://blog.ss8.com

Create

Source: http://www.williammalone.com/articles/create-html5-canvas-javascript-drawing-app/

Act



Source: https://bitsandatoms.co/tag/reinforcement-learning/