DEEP LEARNING

L-T-P-C: 2- 0- 3- 4

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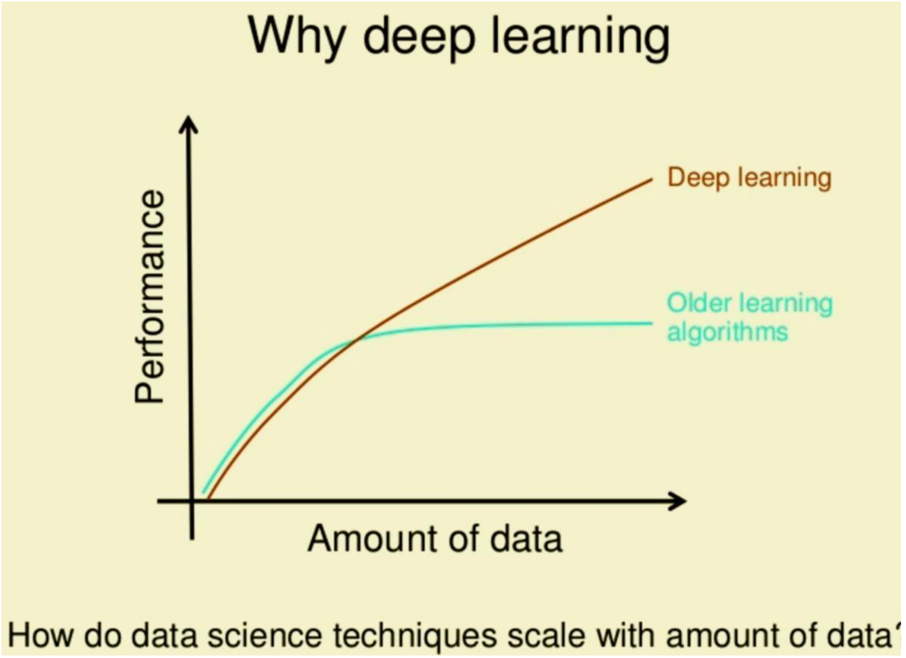
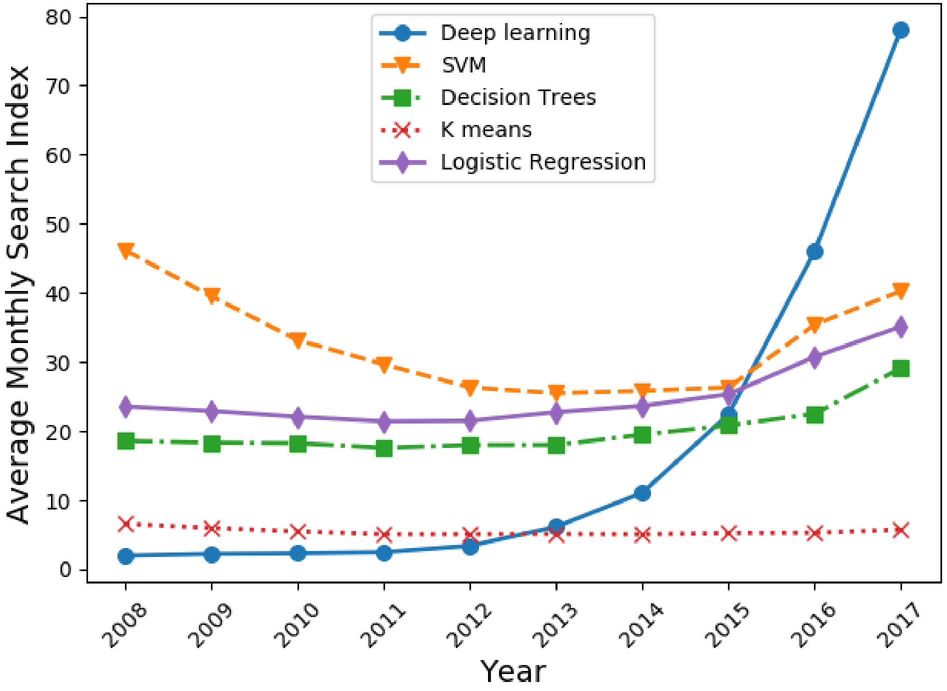
DEEMED TO BE UNIVERSITY

Deep Learning- A breakthrough

Given the Availability of Data, Deep Learning performance has surpassed all traditional algorithms

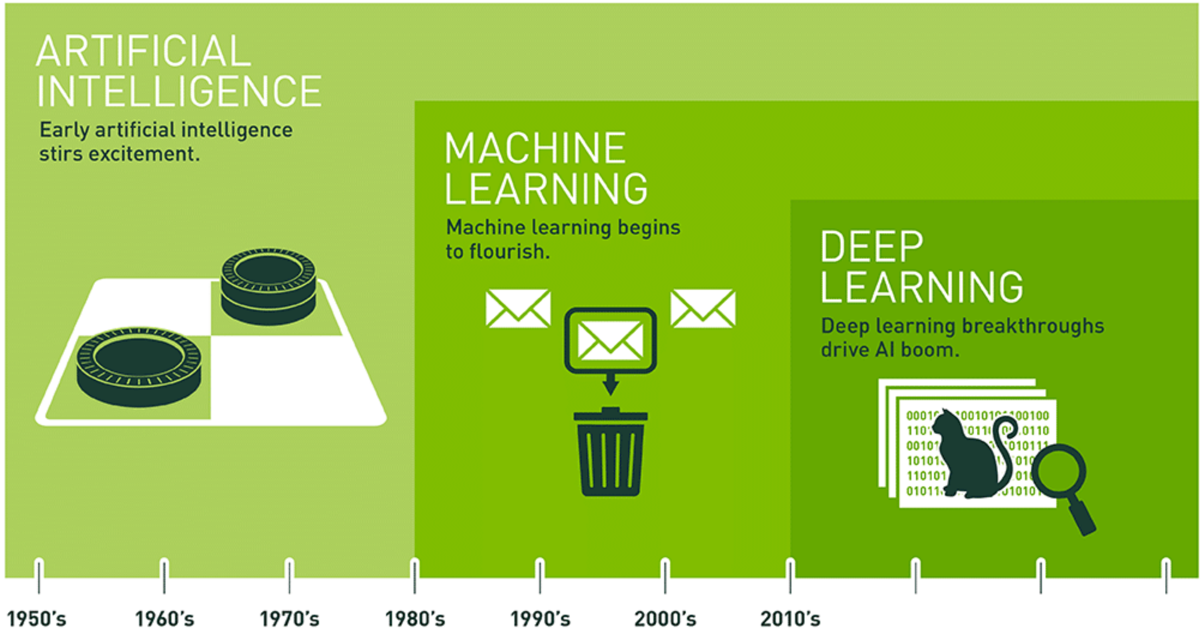
Artificial Intelligence Paradigmshift!-
Machine Learning and **Deep Learning?**



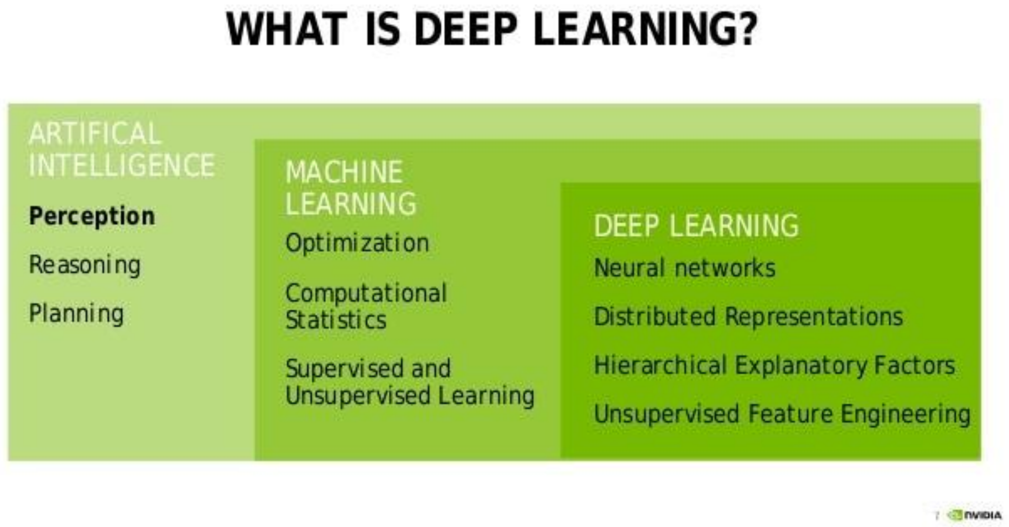


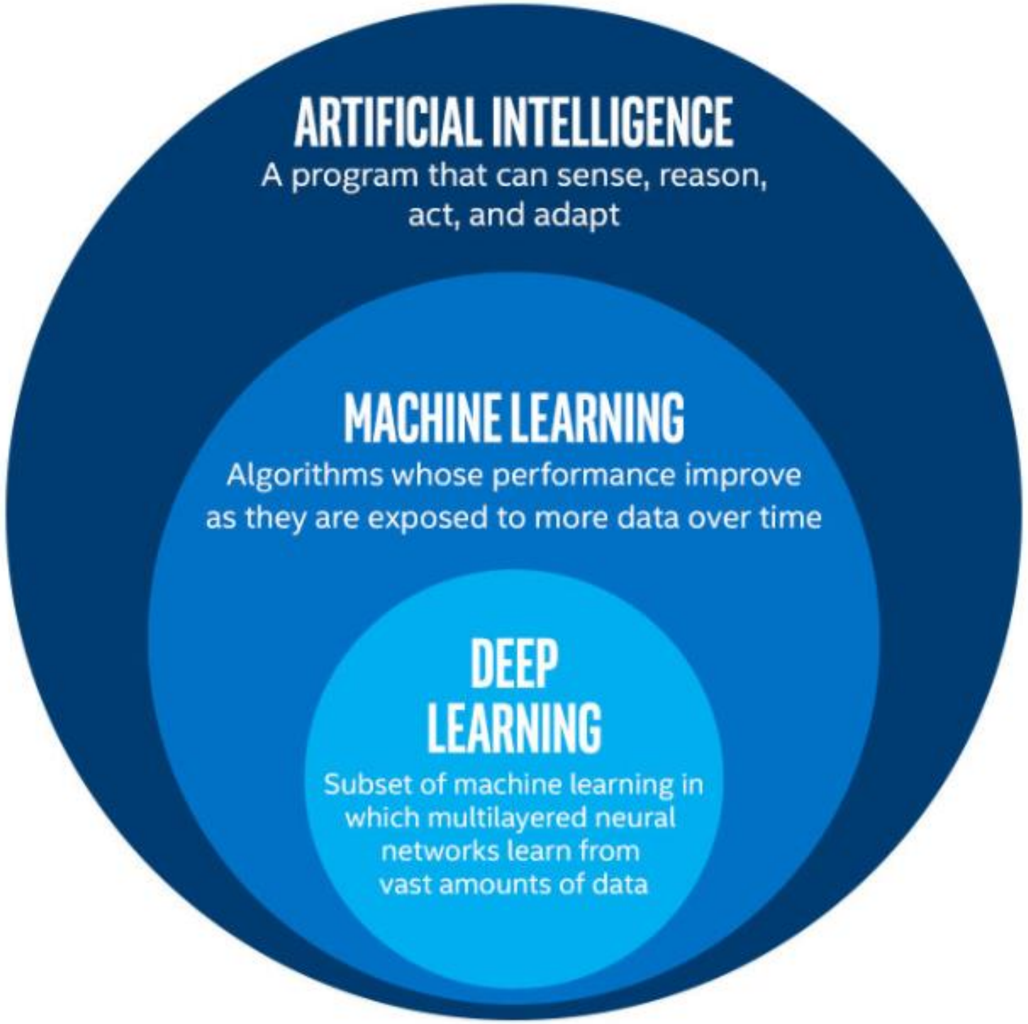
Promising results if trained with lot of data!

AMRITA VISHWA VIDYAPEETHAM



Since an early flush of optimism in the 1950s, smaller subsets of artificial intelligence – first machine learning, then deep l

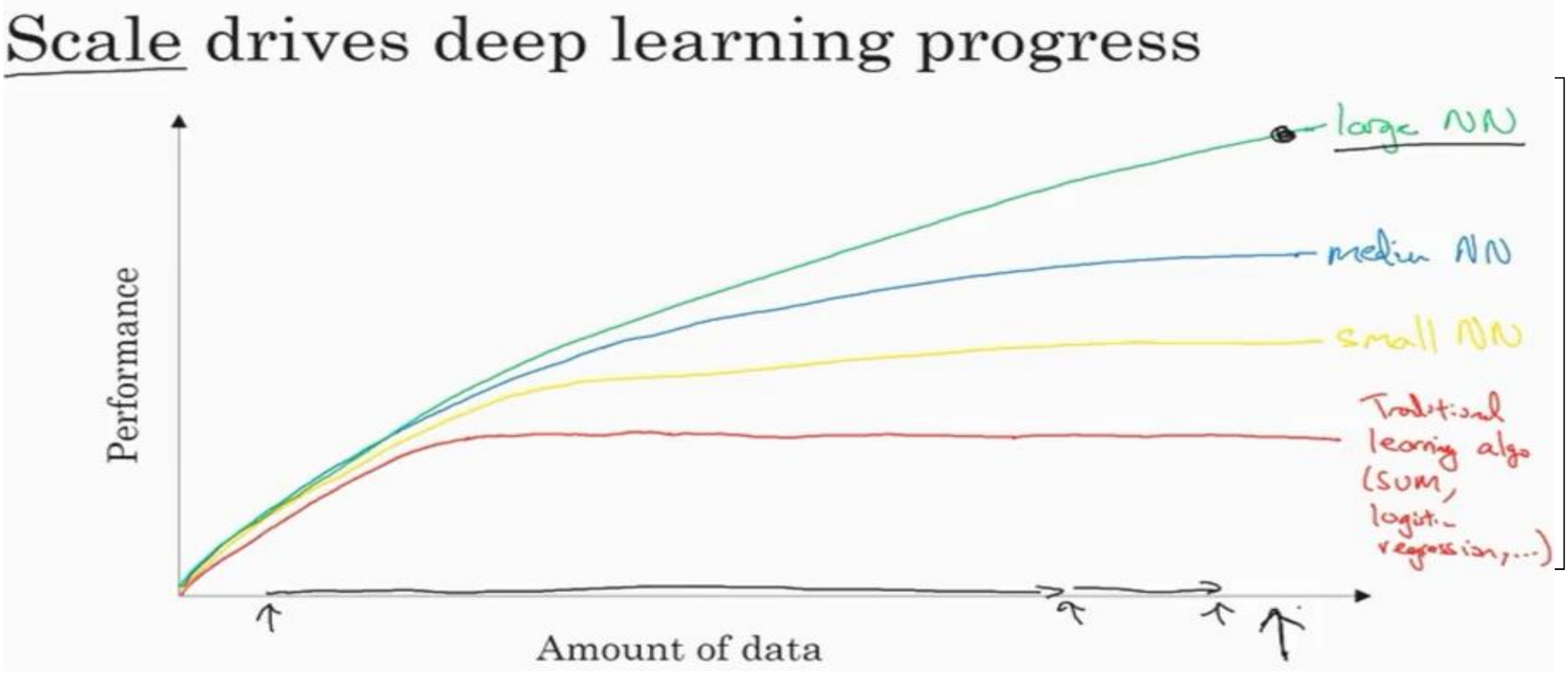




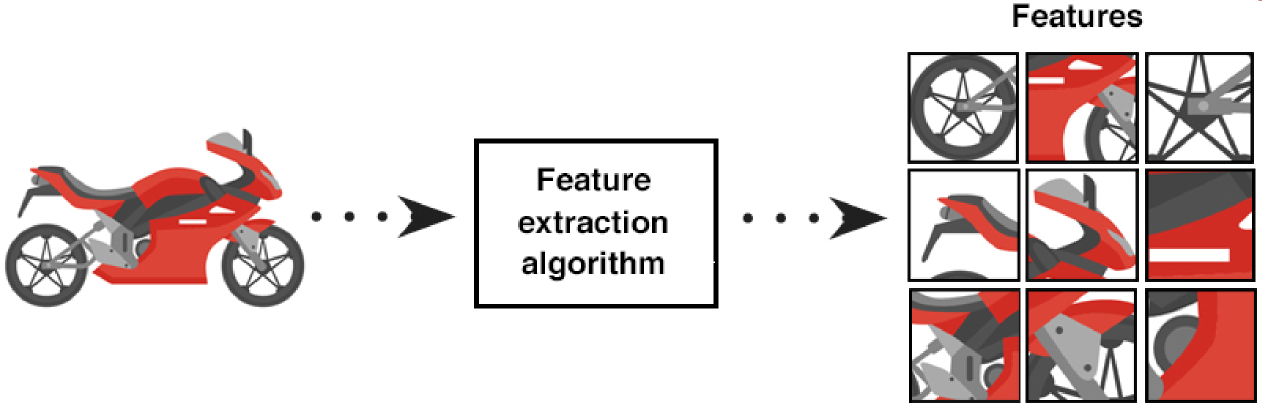
Deep Learning –

- **History**
- **Introduction**

Artificial Intelligence Paradigmshift!- Machine Learning → Deep Learning?

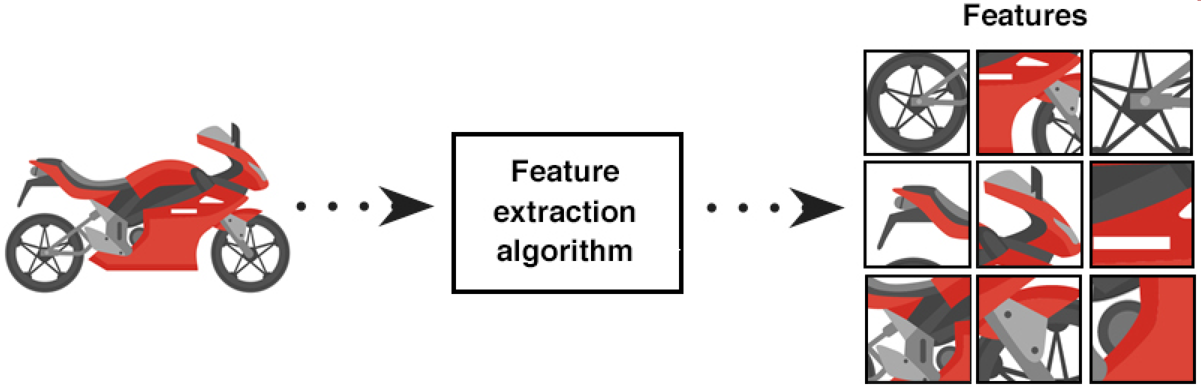


Deep Learning



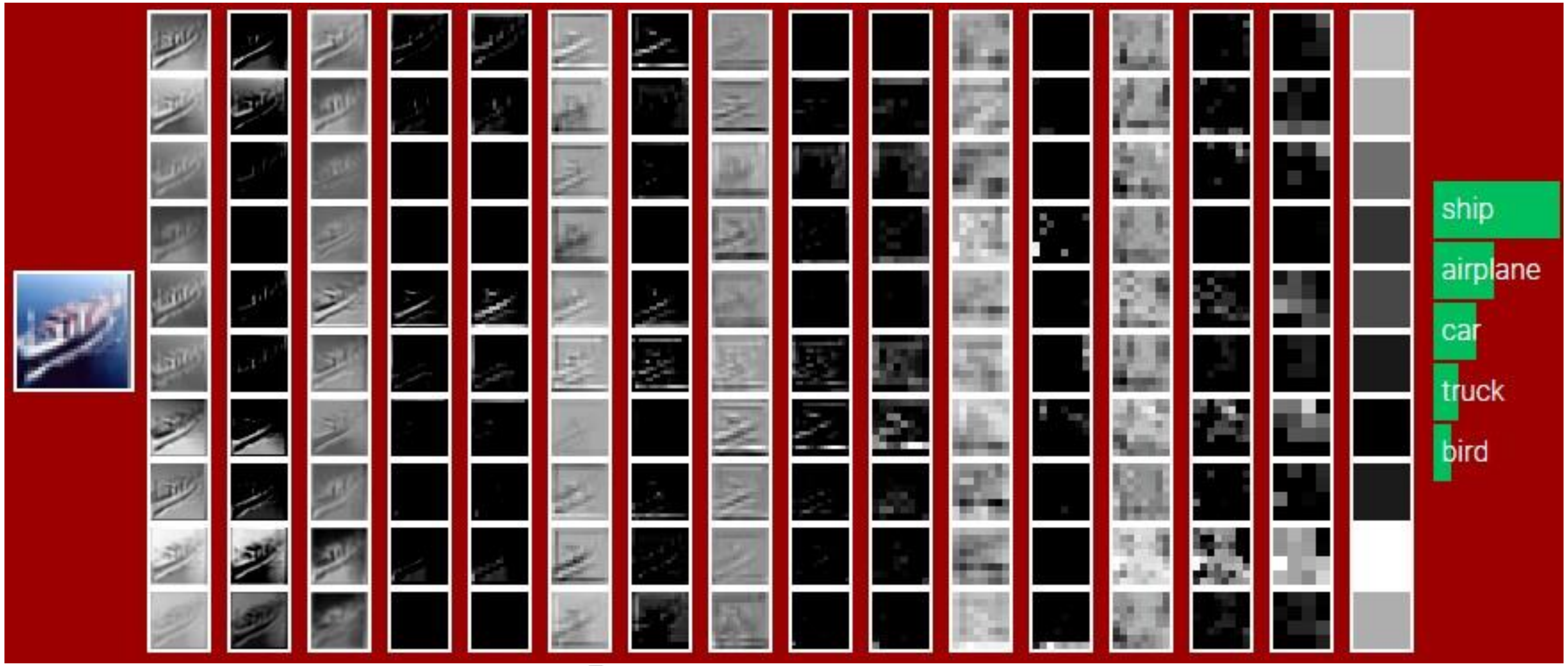
Deep Learning (DL) uses layers of algorithms to process data, understand human speech, and visually recognize objects.

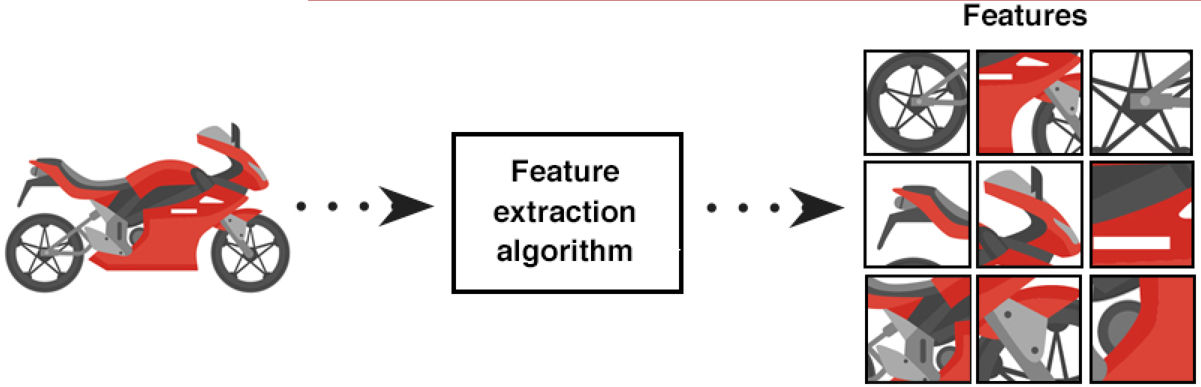
Deep Learning-



Information is passed through each layer, with the output of the previous layer providing input for the next layer. The first layer in a network is called the **input layer**, while the last is called an **output layer**. All the layers between the two are referred to as **hidden layers**

Deep Learning-





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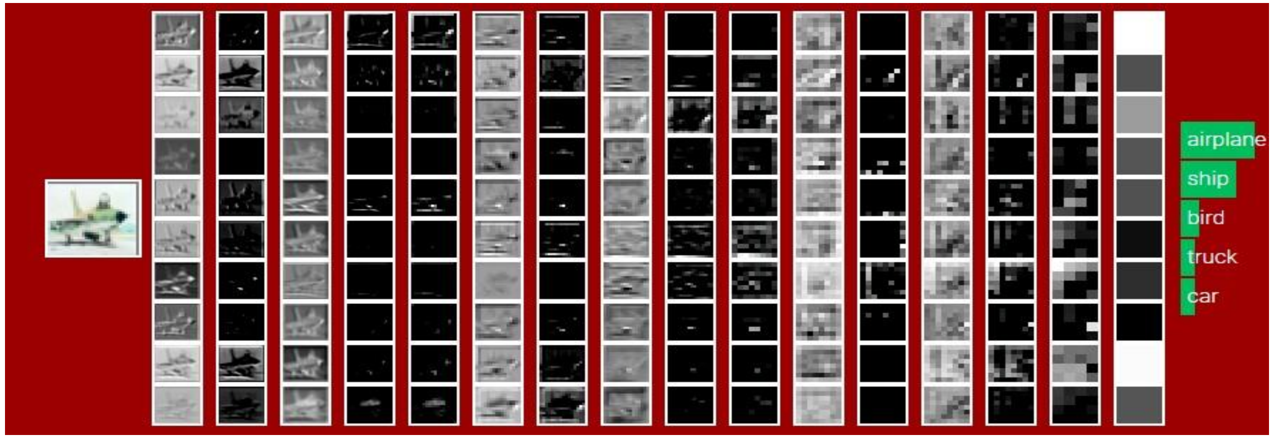
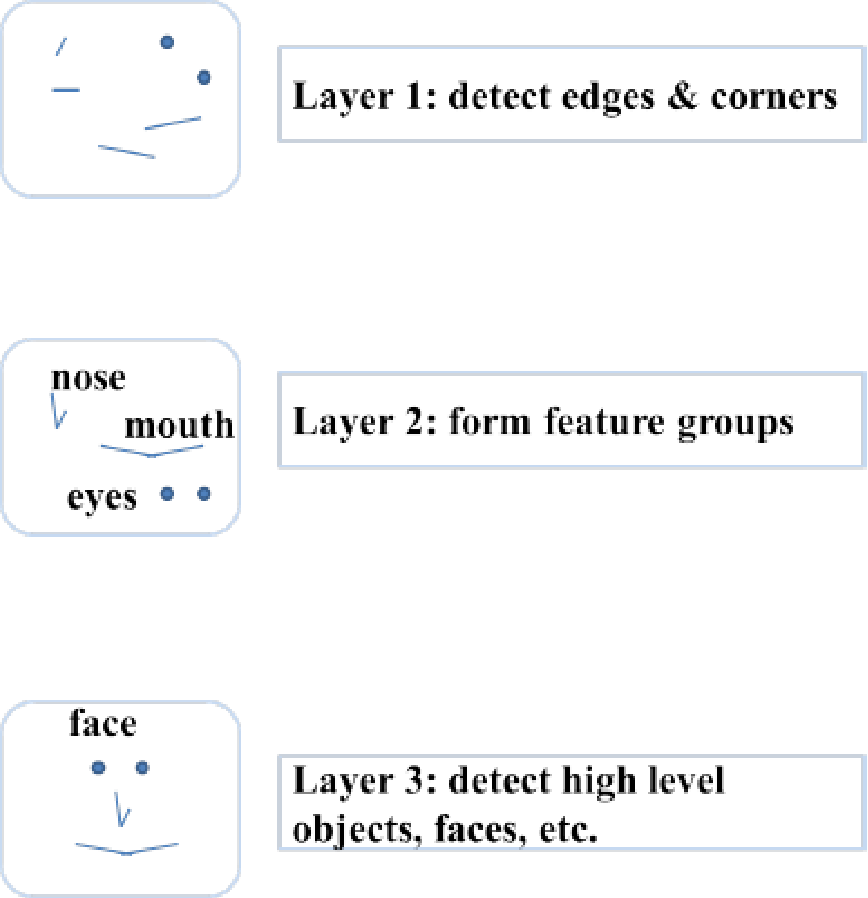
Neurons are arranged in a hierarchical fashion

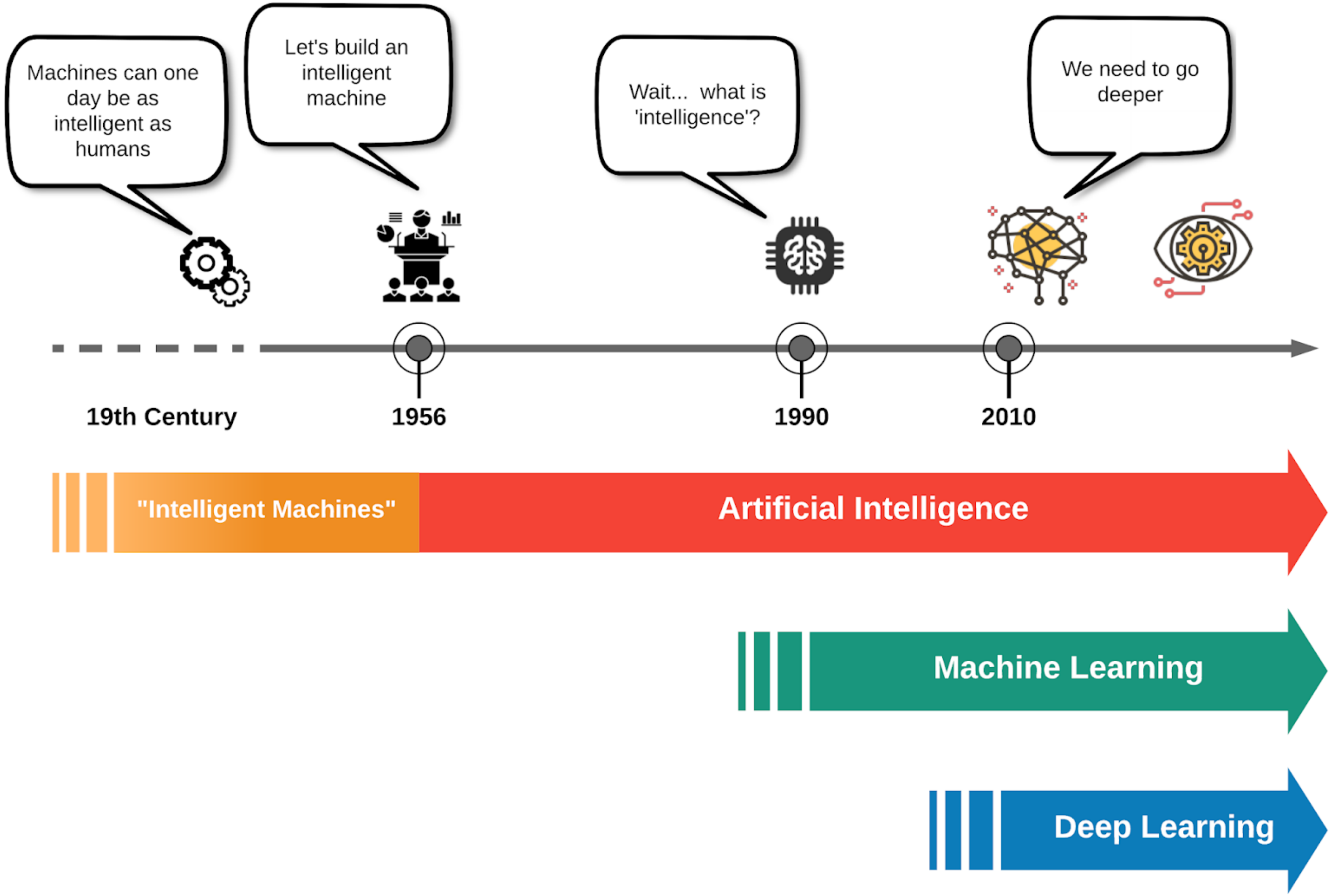
Neurons are arranged in a hierarchical fashion and each layer has its own role and responsibility.
To detect a face, the brain could be relying on the entire network and not on a single layer.



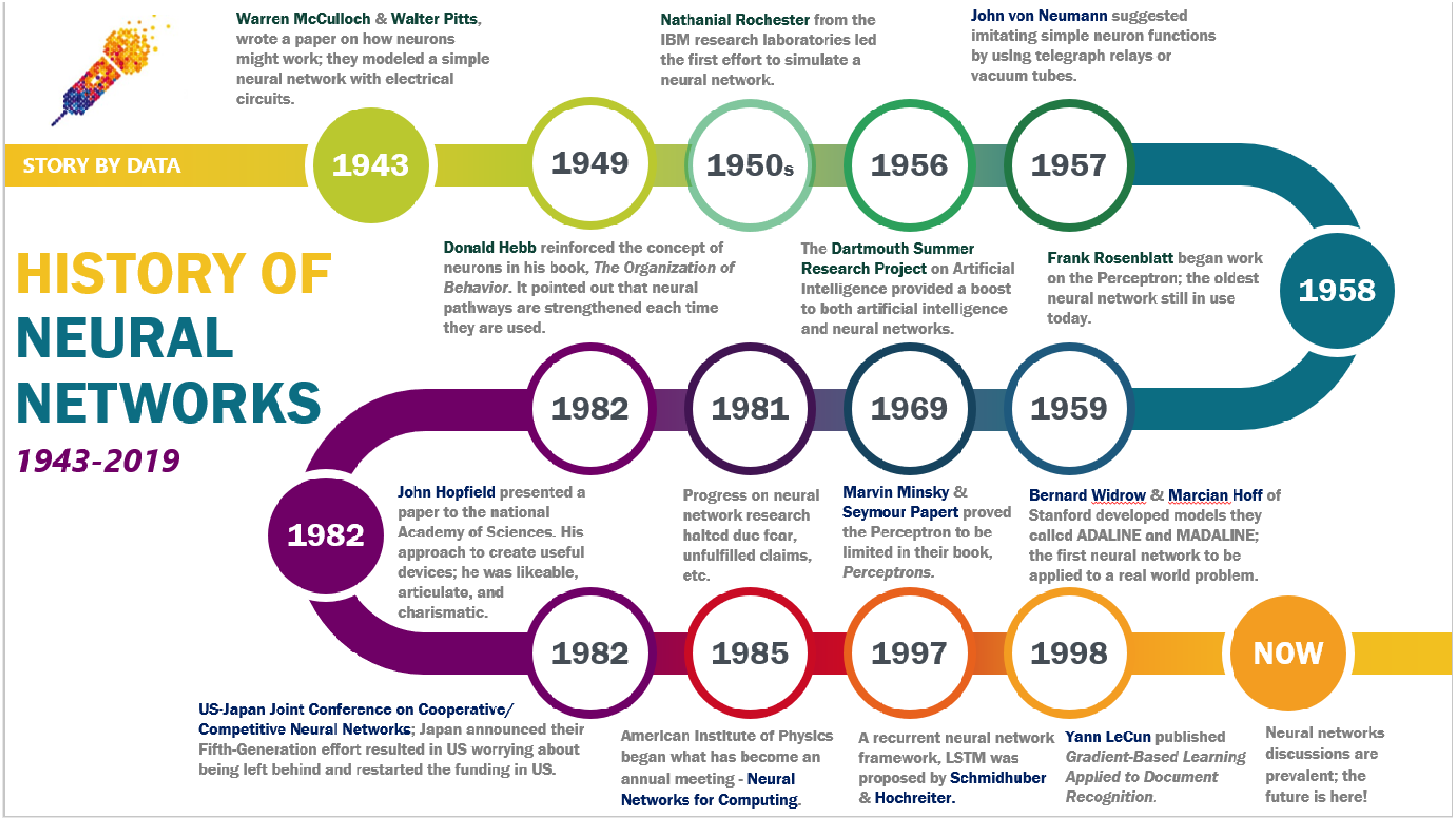


Courtesy :Sample illustration of hierarchical processing. Credits: Mitesh M. Khapra’s lecture slides

Lets have a walk through History

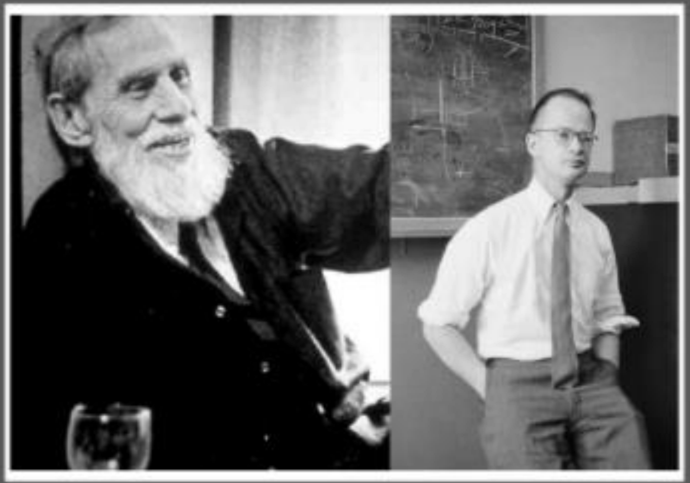


Courtesy: medium



Courtesy: medium

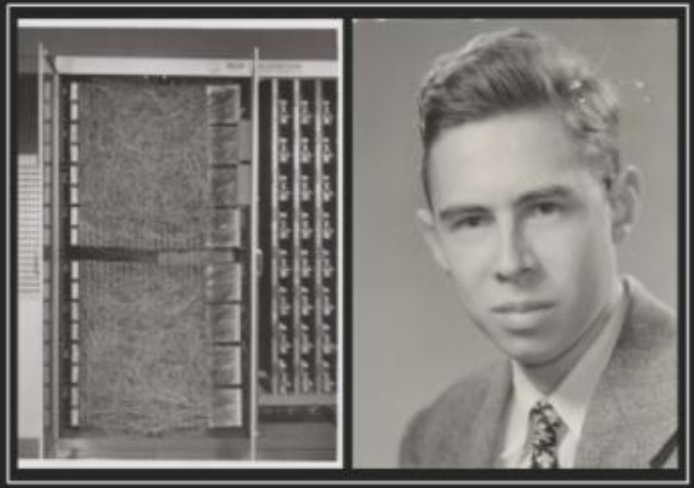
McCulloch Pitts Neuron – Beginning



Walter Pitts and Warren McCulloch in their paper, *"A Logical Calculus of the Ideas Immanent in Nervous Activity"* shows the mathematical model of biological neuron. This McCulloch Pitts Neuron has very limited capability and has no learning mechanism. Yet it will lay the foundation for artificial neural network & deep learning.

1943

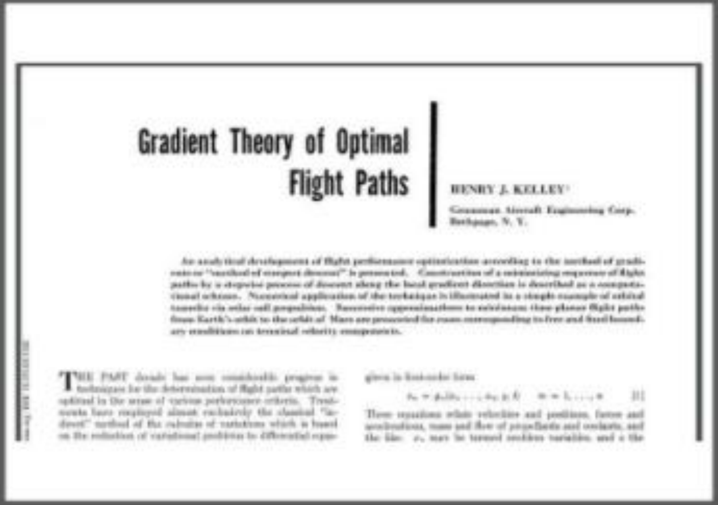
Frank Rosenblatt Creates Perceptron



In his paper "The Perceptron: A Perceiving and Recognizing Automaton", Rosenblatt shows the new avatar of McCulloch-Pitts neuron – 'Perceptron' that had true learning capabilities to do binary classification on it's own. This inspires the revolution in research of shallow neural network for years to come, till first AI winter.

1957

The First Backpropagation Model

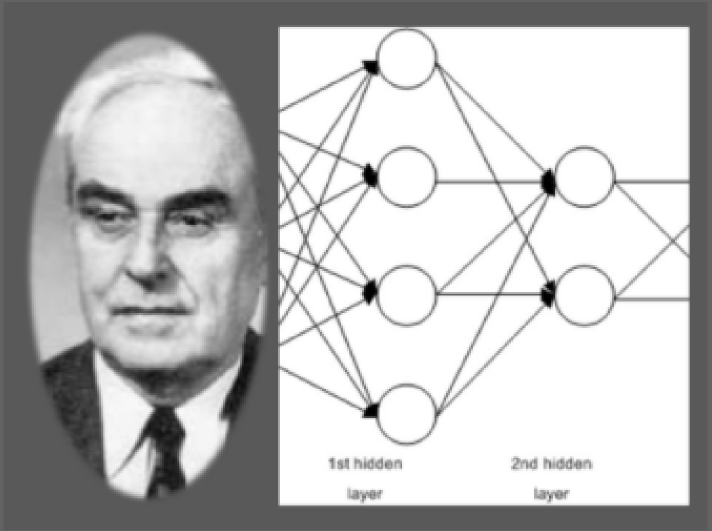


Henry J. Kelley in his paper, "Gradient Theory of Optimal Flight Paths" shows the first ever version of continuous backpropagation model. His model is in context to Control Theory, yet it lays the foundation for further refinement in the model and would be used in ANN in future years.

1960

Courtesy: machinelearningknowledge.ai

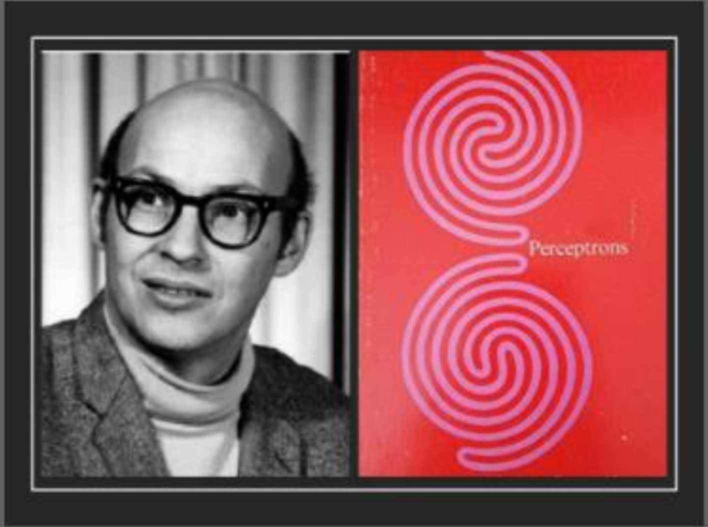
Birth Of Multilayer Neural Network



Alexey Grigoryevich Ivakhnenko along with Valentin Grigor'evich Lapa, creates hierarchical representation of neural network that uses polynomial activation function and are trained using Group Method of Data Handling (GMDH). It is now considered as the first ever multi-layer perceptron and Ivakhnenko is often considered as father of deep learning.

1965

The Fall Of Perceptron



Marvin Minsky and Seymour Papert publishes the book "Perceptrons" in which they show that Rosenblatt's perceptron cannot solve complicated functions like XOR. For such function perceptrons should be placed in multiple hidden layers which compromises perceptron learning algorithm. This setback triggers the winter of neural network research.

1969

Backpropagation Is Computer Coded

Seppo Linnainmaa publishes general method for automatic differentiation for backpropagation and also implements backpropagation in computer code. The research in backpropagation has now come very far, yet it would not be implemented in neural network till next decade.

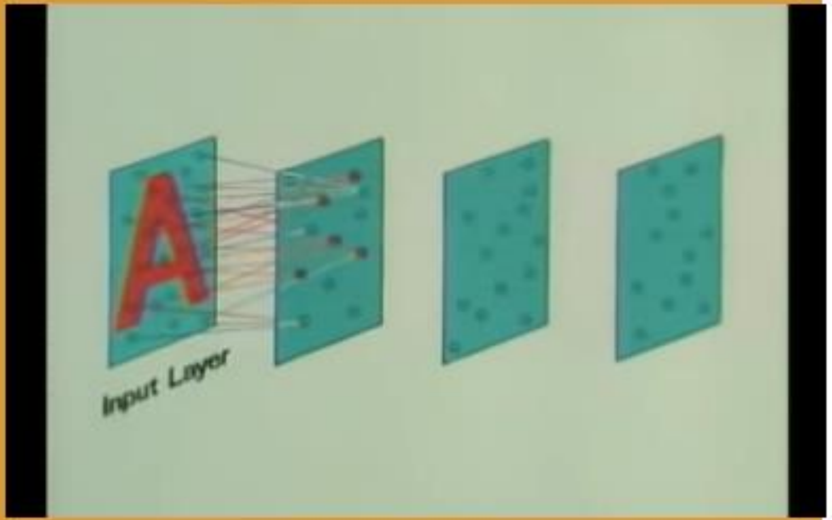
1970

Neural Network Goes Deep

Alexey Grigoryevich Ivakhnenko continues his research in Neural Network. He creates 8-layer Deep neural network using Group Method of Data Handling (GMDH).

1970

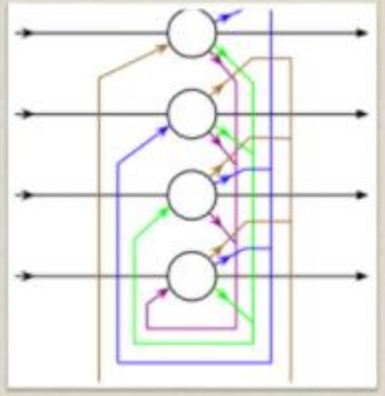
Neocognitron – First CNN Architecture



Kunihiko Fukushima comes up with Neocognitron, the first convolutional neural network architecture which could recognize visual patterns such as handwritten characters.

1980

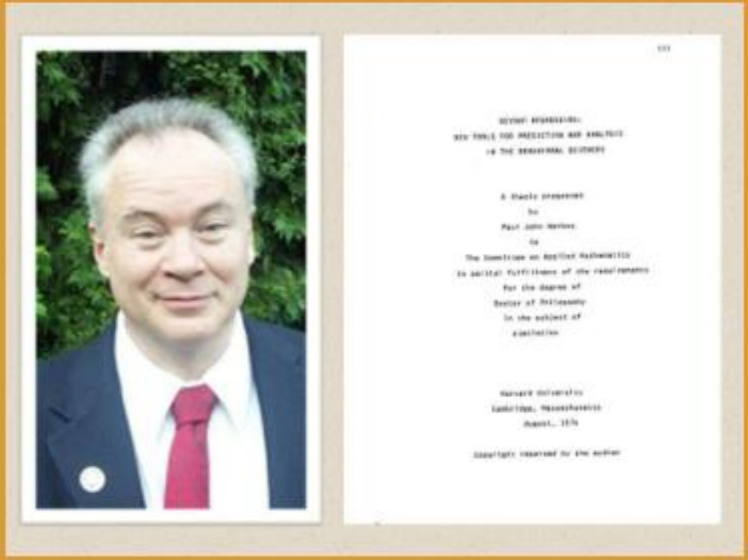
Hopfield Network – Early RNN



John Hopfield creates Hopfield Network, which is nothing but a recurrent neural network. It serves as a content-addressable memory system, and would be instrumental for further RNN models of modern deep learning era.

1982

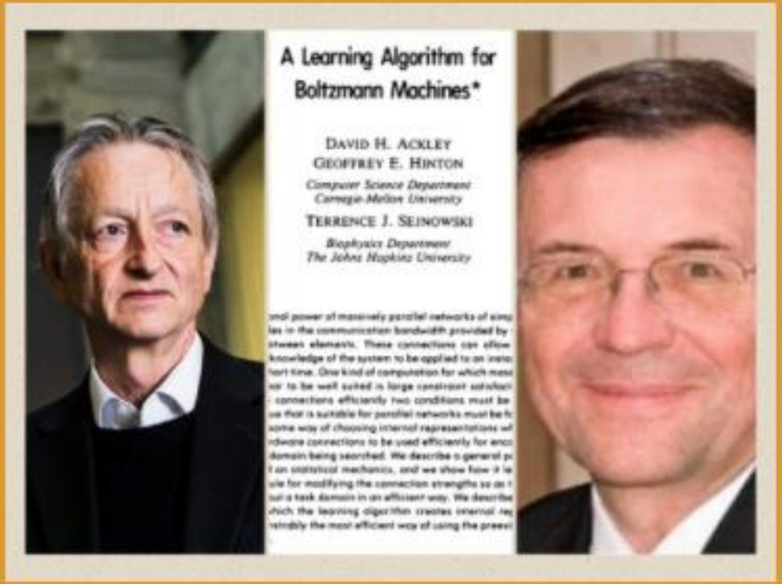
Proposal For Backpropagation In ANN



Paul Werbos, based on his 1974 Ph.D. thesis, publicly proposes the use of Backpropagation for propagating errors during the training of Neural Networks. His results of the Ph.D. thesis will eventually lead to the practical adoption of backpropagation by the neural network community in the future.

1982

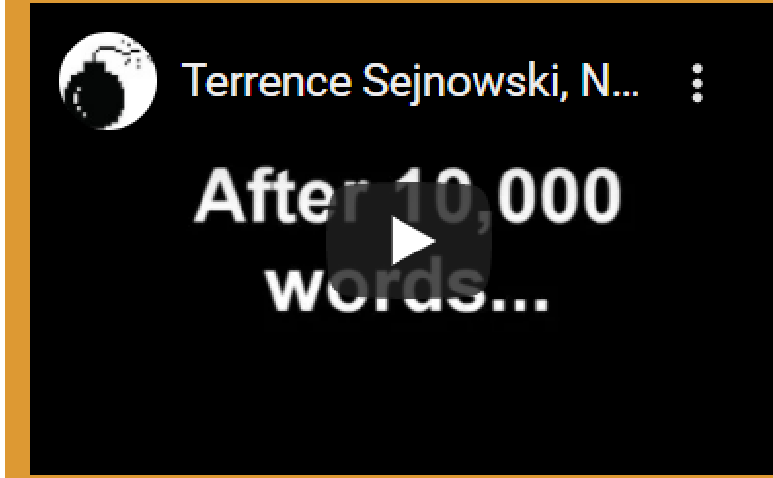
Boltzmann Machine



David H. Ackley, Geoffrey Hinton and Terrence Sejnowski create Boltzmann Machine that is a stochastic recurrent neural network. This neural network has only input layer and hidden layer but no output layer.

1985

NetTalk – ANN Learns Speech



Terry Sejnowski creates NeTalk, a neural network which learns to pronounce written English text by being shown text as input and matching phonetic transcriptions for comparison.

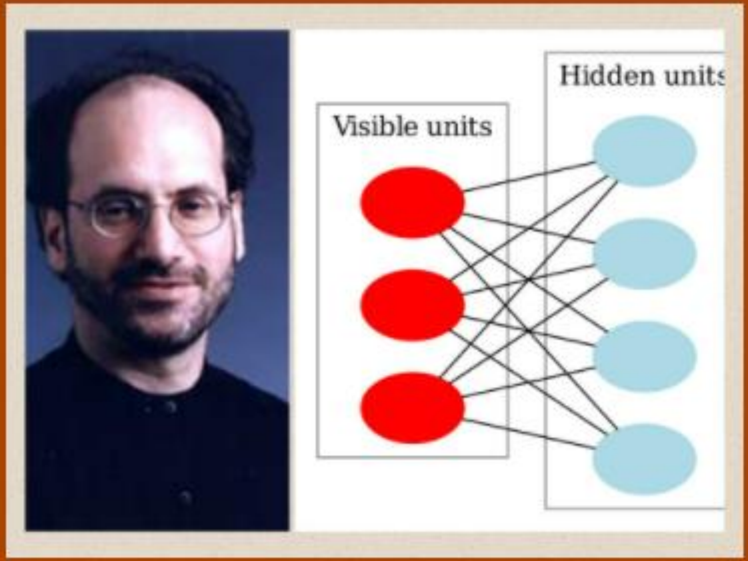
1986

Implementation Of Backpropagation

Geoffrey Hinton, Rumelhart, and Williams in their paper "Learning Representations by back-propagating errors" show the successful implementation of backpropagation in the neural network. It opened gates for training complex deep neural network easily which was the main obstruction in earlier days of research in this area.

1986

Restricted Boltzmann Machine



Paul Smolensky comes up with a variation of Boltzmann Machine where there is not intra layer connection in input and hidden layer. It is known as Restricted Boltzmann Machine (RBM). It would become popular in years to come especially for building recommender systems.

1986

CNN Using Backpropagation

Yann LeCun uses backpropagation to train convolutional neural network to recognize handwritten digits. This is a breakthrough moment as it lays the foundation of modern computer vision using deep learning.

1989

Courtesy: machinelearningknowledge.ai

Universal Approximators Theorem

George Cybenko publishes earliest version of the Universal Approximation Theorem in his paper "*Approximation by superpositions of a sigmoidal function*". He proves that feed forward neural network with single hidden layer containing finite number of neurons can approximate any continuous function. It further adds credibility to Deep Learning.

1989

Vanishing Gradient Problem Appears

Sepp Hochreiter identifies the problem of vanishing gradient which can make the learning of deep neural network extremely slow and almost impractical. This problem will continue to annoy deep learning community for many more years to come.

1990

The Milestone Of LSTM

Sepp Hochreiter and Jürgen Schmidhuber publishes a milestone paper on "Long Short-Term Memory" (LSTM). It is a type of recurrent neural network architecture which will go on to revolutionize deep learning in decades to come.

1997

Deep Belief Network

Geoffrey Hinton, Ruslan Salakhutdinov, Osindero and Teh publishes the paper *"A fast learning algorithm for deep belief nets"* in which they stacked multiple RBMs together in layers and called them Deep Belief Networks. The training process is much more efficient for large amount of data.

2006

GPU Revolution Begins

Andrew NG's group in Stanford starts advocating for the use of GPUs for training Deep Neural Networks to speed up the training time by many folds. This could bring practicality in the field of Deep Learning for training on huge volume of data efficiently.

2008

ImageNet Is Launched

Finding enough labeled data has always been a challenge for Deep Learning community. In 2009 Fei-Fei Li, a professor at Stanford, launches ImageNet which is a database of 14 million labeled images. It would serve as a benchmark for the deep learning researchers who would participate in ImageNet competitions (ILSVRC) every year.

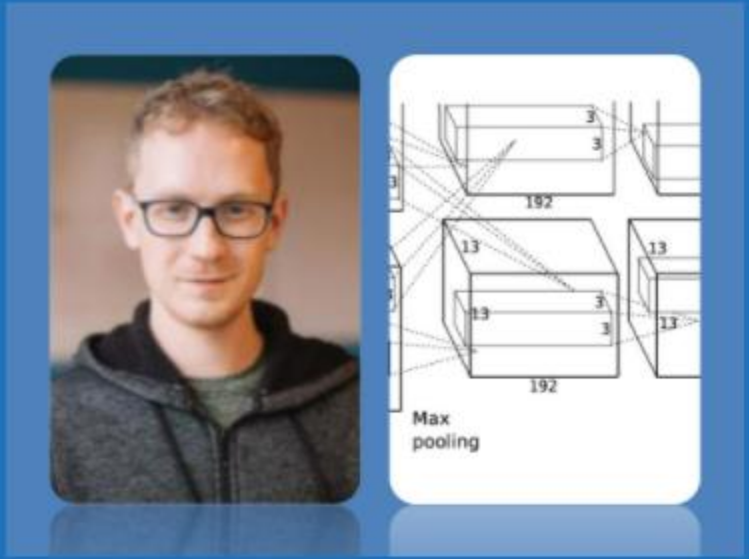
2010

Combat For Vanishing Gradient

Yoshua Bengio, Antoine Bordes, Xavier Glorot in their paper "Deep Sparse Rectifier Neural Networks" shows that ReLU activation function can avoid vanishing gradient problem. This means that now, apart from GPU, deep learning community has another tool to avoid issues of longer and impractical training times of deep neural network.

2011

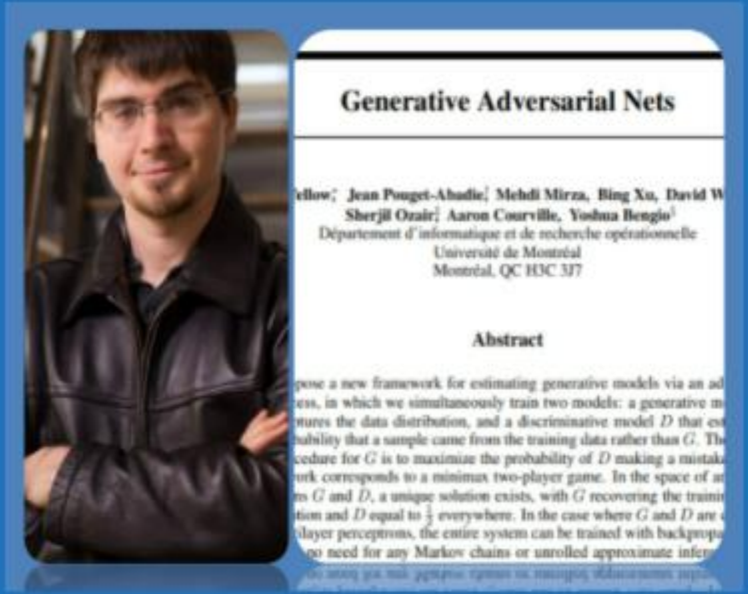
AlexNet Starts Deep Learning Boom



AlexNet, a GPU implemented CNN model designed by Alex Krizhevsky, wins Imagenet's image classification contest with accuracy of 84%. It is a huge jump over 75% accuracy that earlier models had achieved. This win triggers a new deep learning boom globally.

2012

The Birth Of GANs



Generative Adversarial Neural Network also known as GAN is created by Ian Goodfellow. GANs open a whole new doors of application of deep learning in fashion, art, science due it's ability to synthesize real like data.

2014

AlphaGo Beats Human

Deepmind's deep reinforcement learning model beats human champion in the complex game of Go. The game is much more complex than chess, so this feat captures the imagination of everyone and takes the promise of deep learning to whole new level.

2016

Geoffrey Hinton

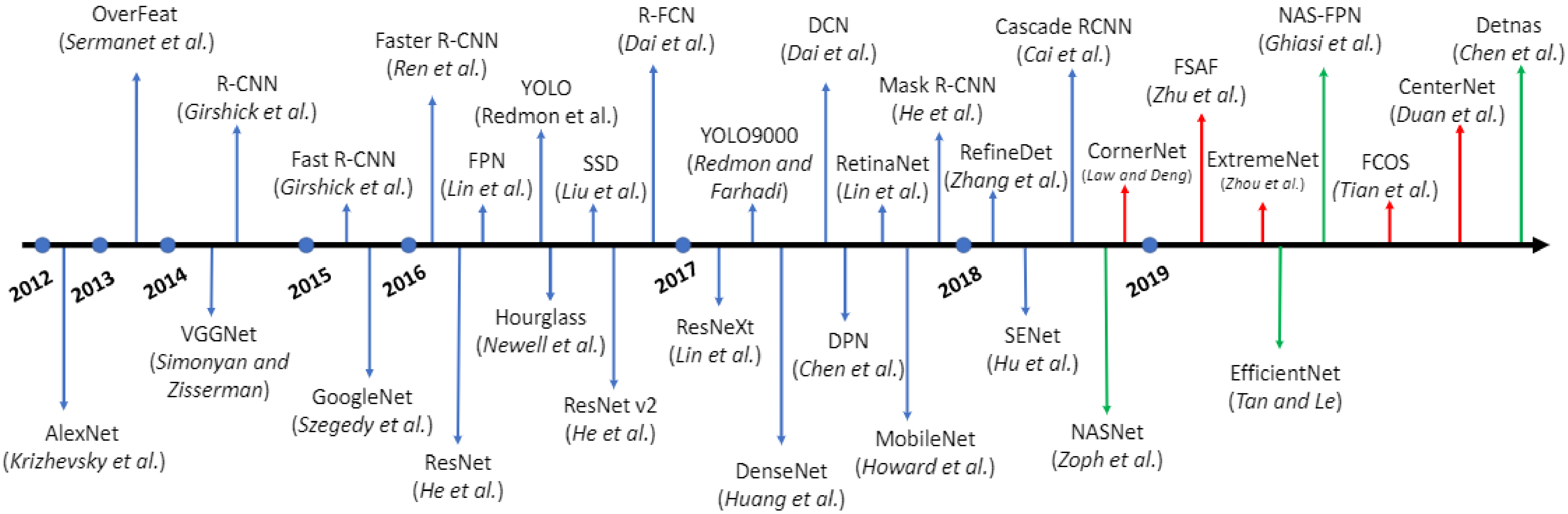
- long known as the **"Godfather of Deep Learning“**
- now a Google researcher

Trio Win Turing Award

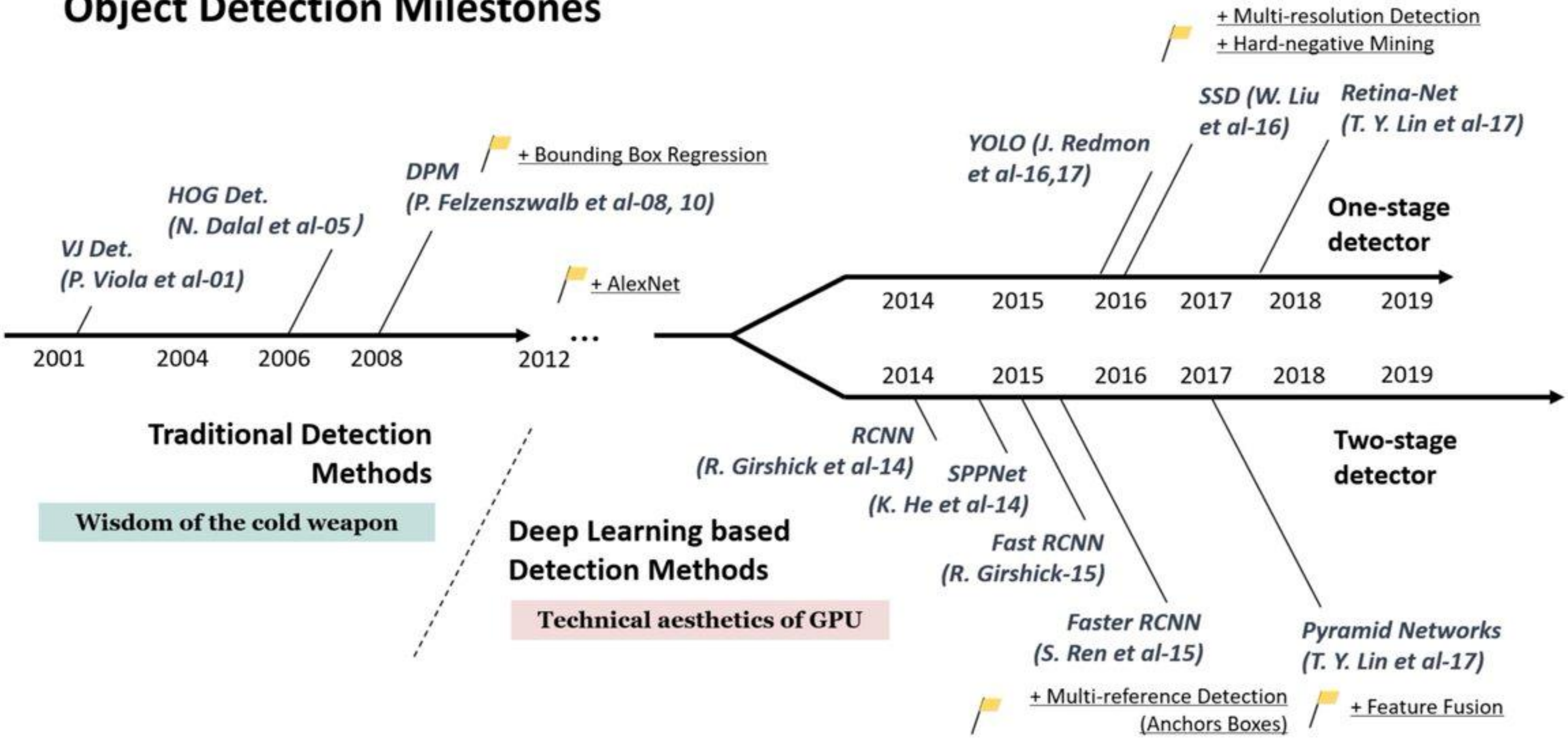
Yoshua Bengio, Geoffrey Hinton, and Yann LeCun wins Turing Award 2018 for their immense contribution in advancements in area of deep learning and artificial intelligence. This is a defining moment for those who had worked relentlessly on neural networks when entire machine learning community had moved away from it in 1970s.

2019

Evolution of Deep Learning Architectures



Object Detection Milestones



Object Detection

Deep Learning applications

Deep Learning Applications

- Language Modeling
- Speech Recognition
- Machine Translation
- Machine Transliteration
- Conversational modelling
- Time Series Forecasting.
- Question Answering
- Object Detection/ Recognition
- Visual Tracking
- Image Captioning
- Video Captioning
- Visual Question answering
- Video Qs Answering
- Video Summarisation
- Generate data sets

Deep Learning Models (Big Picture)

- **Deep Neural Networks**
  - Neural Networks
  - Deep Neural Networks/Feed forward Networks
- **Convolutional Neural Networks (CNN)**
  - LeNet
  - AlexNet
  - VGG
  - ResNet
  - GoogleNet
- **Object Detection models**
  - RCNN
  - Yolo
- **Generative models**
  - Generative Adversarial Networks,(GAN)

- **Sequential Models**
  - RNN
  - LSTM
  - Encoder – Decoder models
  - Attention mechanism
  - **Transformers**
  - **Transformers, Transformer-XL, Masked Language Modelling**
  - **Generative Pre-trained Transformer 3 (GPT-3)**
- **Autoregressive models**
  - Time series forecasting
  - **Generative Pre-trained Transformer 3 (GPT-3)**
  - **NADE, MADE(Masked Autoencoder Density Estimator), PixelRNN**

Namah Shivaya