AI Deep Learning: An Introduction

Thuan L Nguyen, PhD

Slide 2: AI Deep Learning: An Introduction

AI Deep learning (Source: mindovermachines.com)

Slide 3: AI Deep Learning: An Introduction

1. AI Deep Learning: Biological Neural Networks

2. AI Deep Learning: Earliest Neural Networks

3. AI Deep Learning: Single-Layer and Multi-Layer Neural Networks

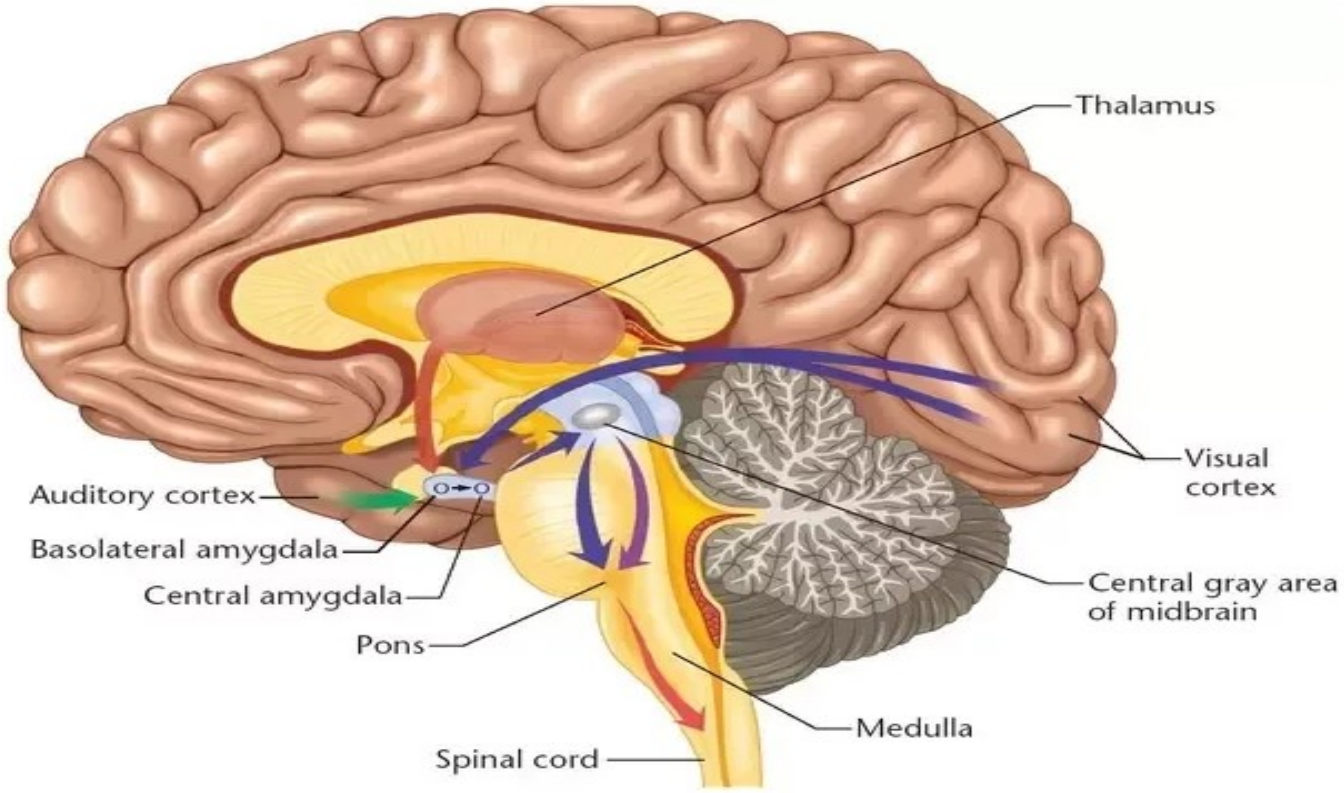
4. AI Deep Learning: What Does “Deep” Mean?

5. AI Deep Learning: Powerful Applications

6. AI Deep Learning: WHY?

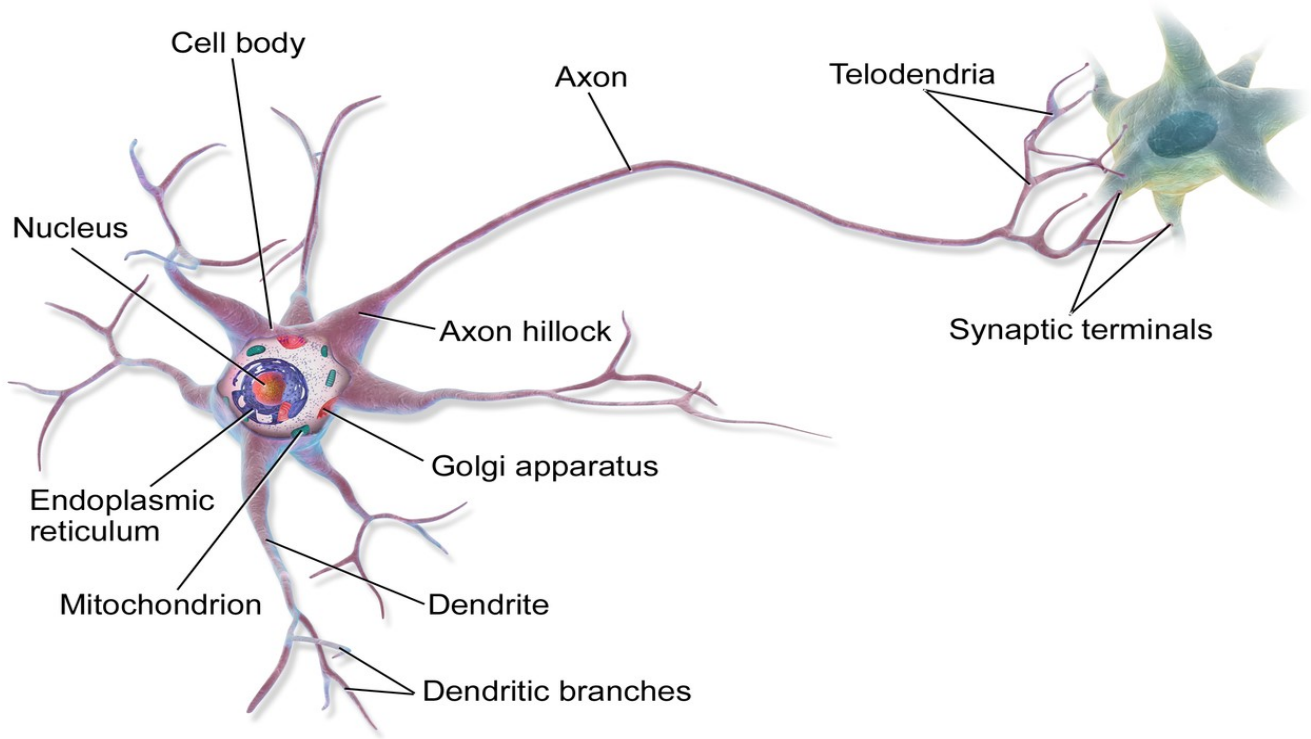
7. AI Deep Learning: WHY NOW?

Slide 4: AI Deep Learning: An Introduction



Human Brain (Source: Quora.com)

Slide 5: AI Deep Learning: An Introduction



Human Neuron (Source: by Bruce Blaus, is licensed under CC BY 3.0)

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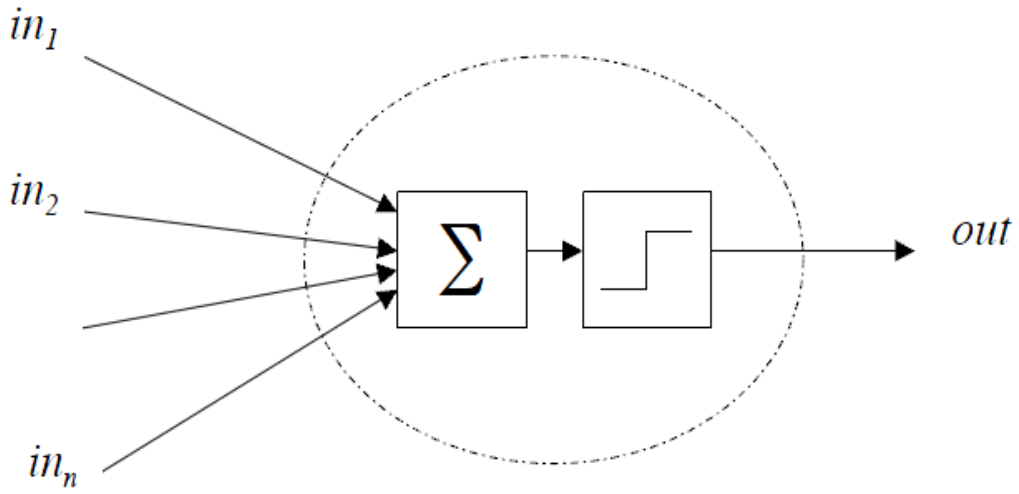
Deep Learning: The Earliest Neural Networks

The earliest neural network was developed in the 1940s:

- In 1943, a seminal paper - *A Logical Calculus of Ideas Immanent in Nervous Activity* (McCulloch & Pitts, 1943) - was published, which proposed the first mathematical model of a neural network .
- The unit of this model is a simple formalized neuron: a McCulloch–Pitts neuron.



McCulloch-Pitts Model (Source: Wikipedia)

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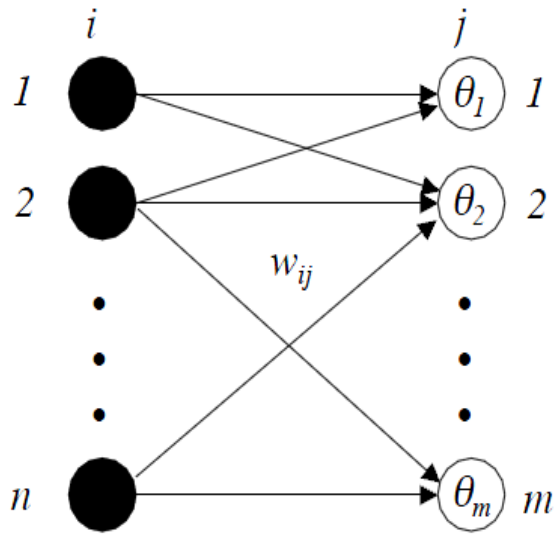
Deep Learning: Simple Single-Layer Neural Networks

Perceptron:

- The fundamental unit of an artificial neural network
- A simple – single-layer – artificial neural network:
  - A simple neural network that has one layer of input neurons feeding forward to one output layer of McCulloch-Pitts neurons, with full connectivity.



$$out_j = step(\sum_{i=1}^{n} in_i w_{ij} - \theta_j)$$

AI Deep Learning: Perceptron (Source: Wikipedia)

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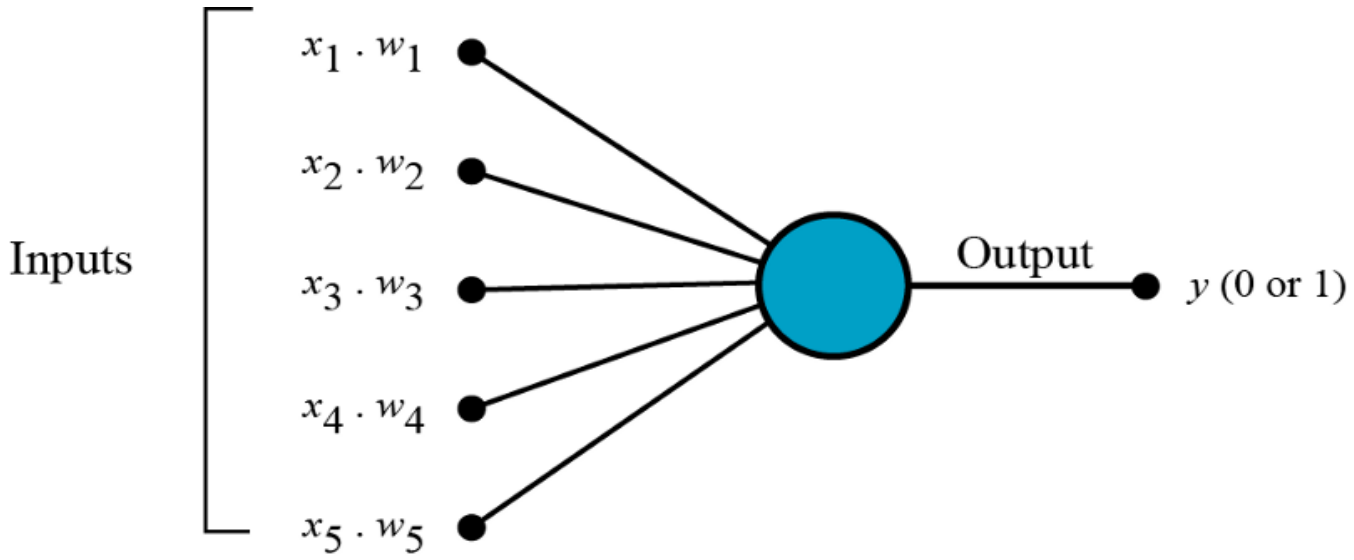
Deep Learning: Simple Single-Layer Neural Networks

Perceptron:

- The McCulloch-Pitts neuron model is actually the **simplest** single-layer neural network.
  - One or more inputs → One output
- Therefore, the McCulloch-Pitts neuron model represents a **perceptron,** the simplest neural network.



Sources: https://towardsdatascience.com

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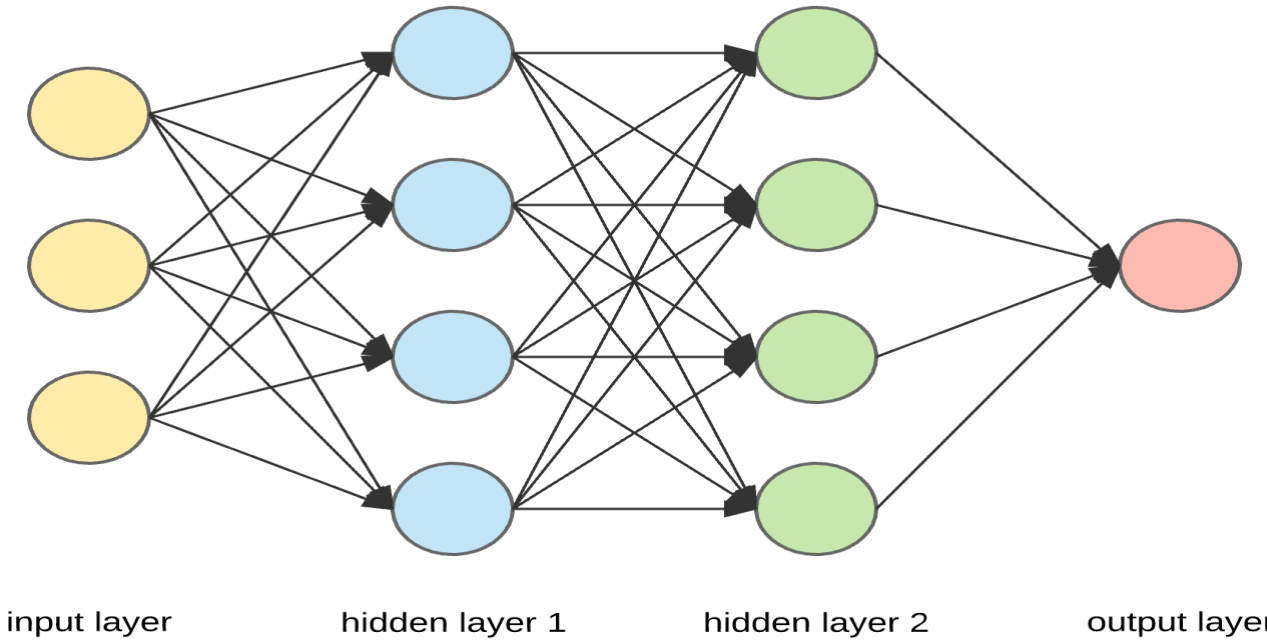
Deep Learning: Multi-Layer Neural Networks

- Single-layer perceptrons: very limited regarding the computation power
- Multi-layer perceptrons, i.e., multi-layer neural networks, were constructed.



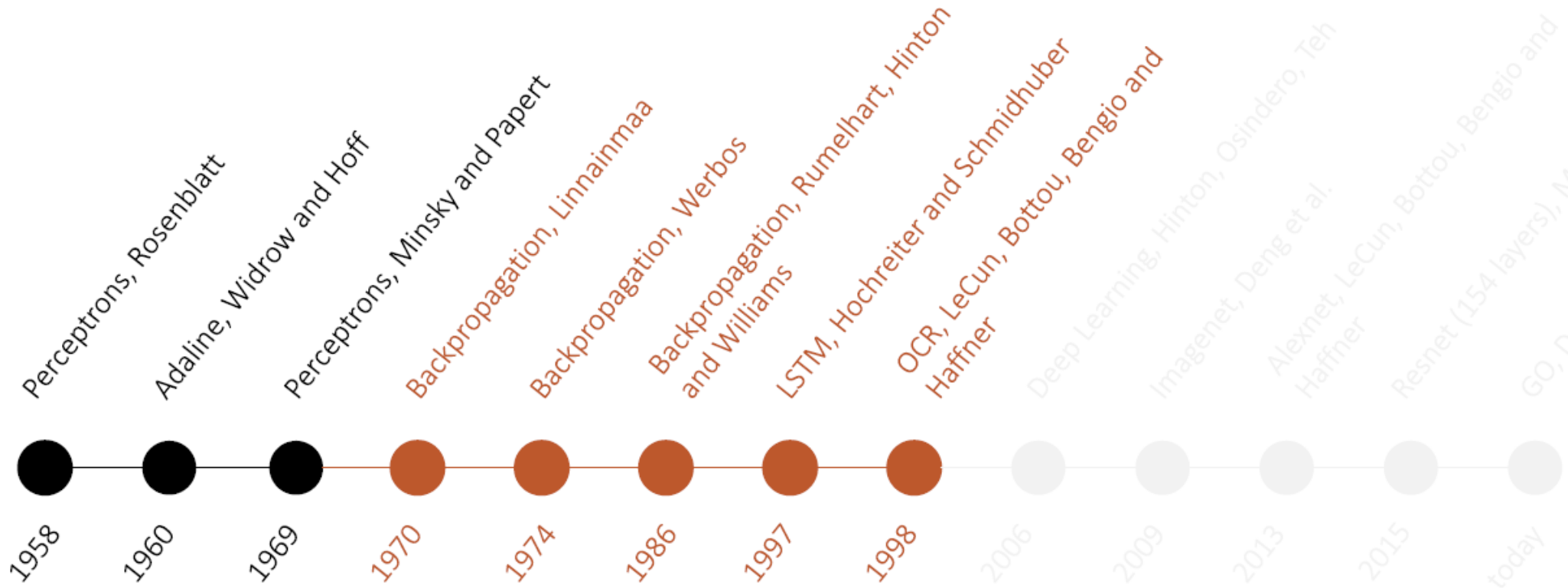
AI Deep Learning: Multi-layer Neural network (Source: medium.com)

Overview of AI – Machine Learning & Deep Learning

AI: Machine Learning & Deep Learning: First Wave (1958 – 1969)

Overview of AI – Machine Learning & Deep Learning

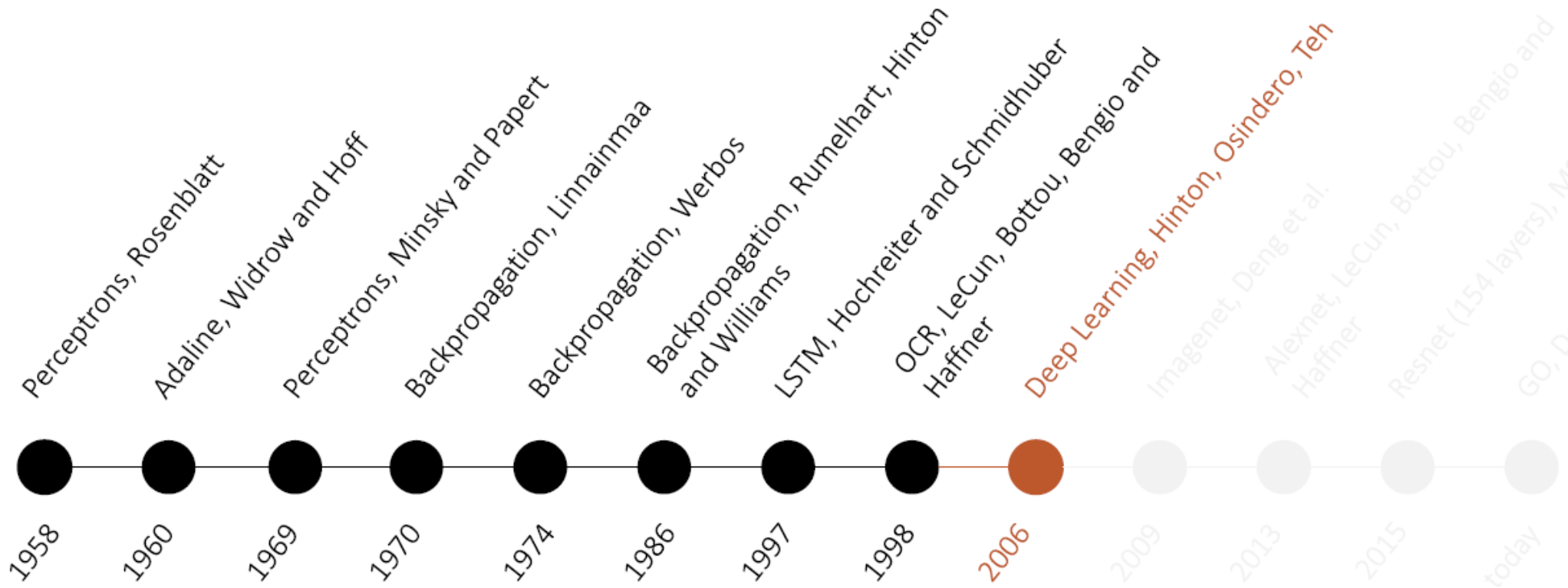
Multi-Layered Perceptrons (Proposed by Minsky): Second Wave (1970 – 2000)



Overview of AI – Machine Learning & Deep Learning

AI: Machine Learning & Deep Learning: Third Wave (2006 – Present)

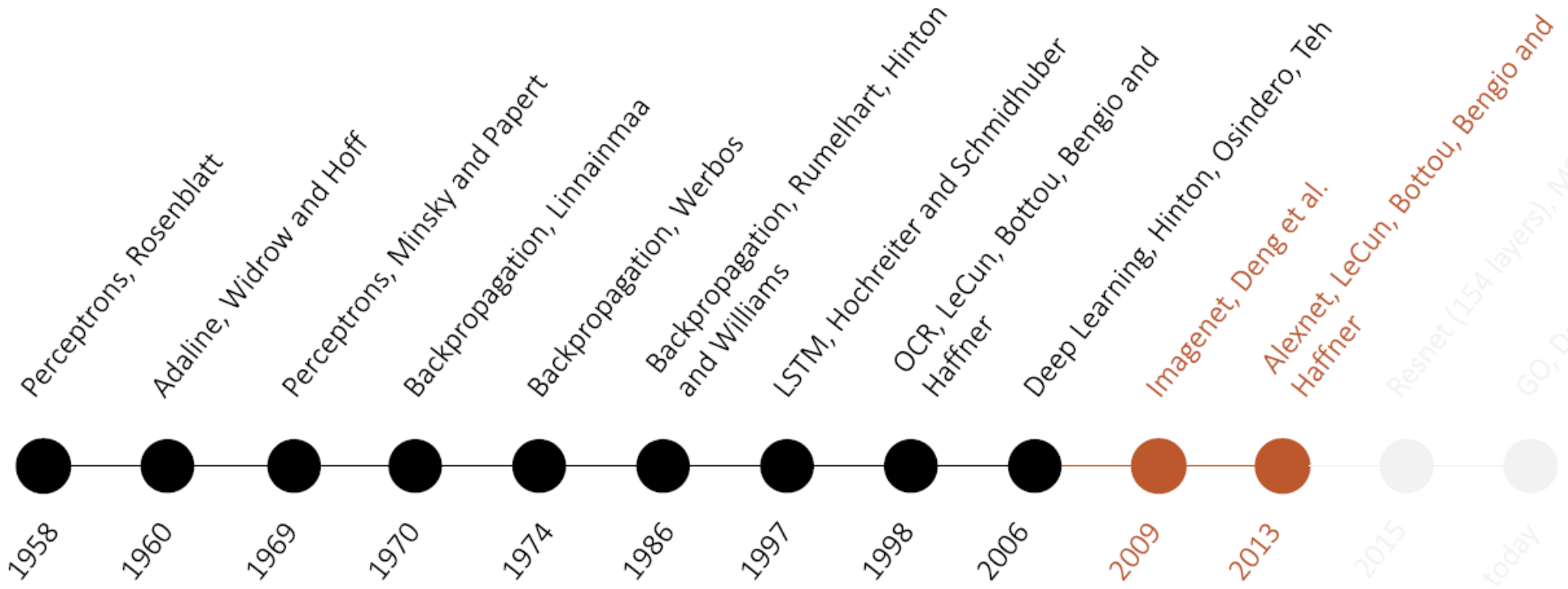
- The “Breakthrough”



Overview of AI – Machine Learning & Deep Learning

AI: Machine Learning & Deep Learning: Third Wave (2006 – Present)

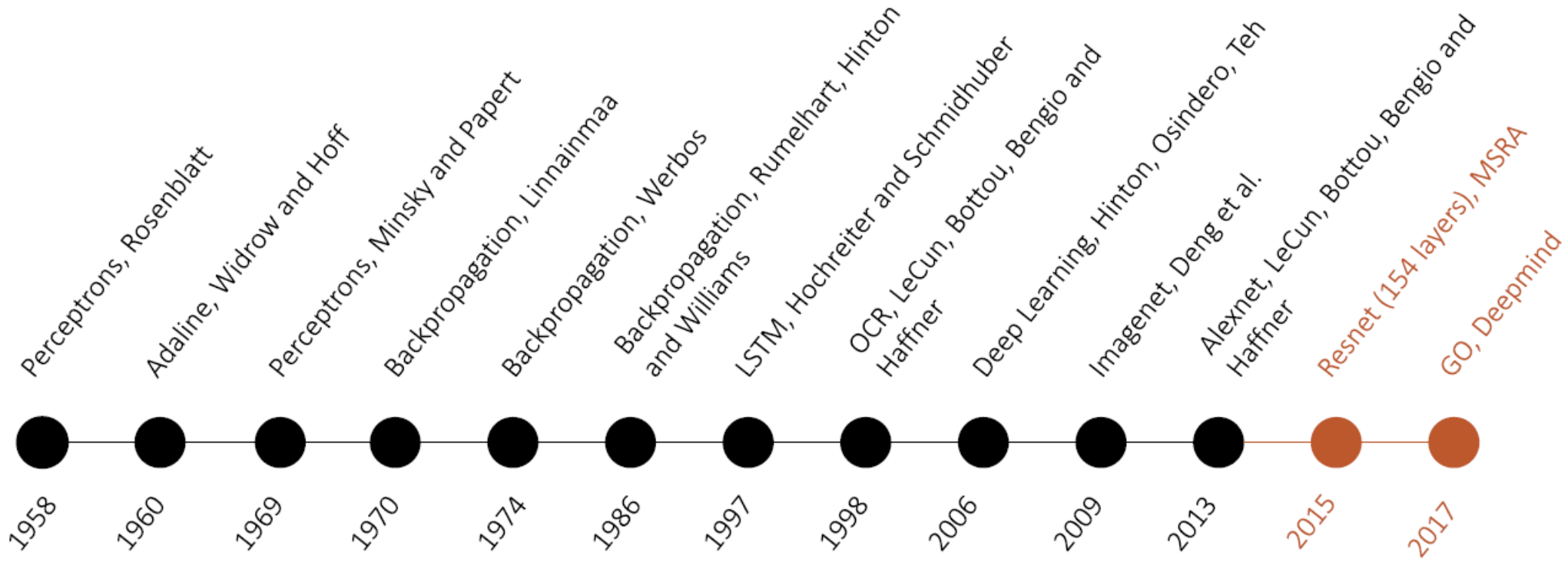
- The Breakthrough: The Advent of Deep Learning



Overview of AI – Machine Learning & Deep Learning

AI: Machine Learning & Deep Learning: Third Wave (2006 – Present)

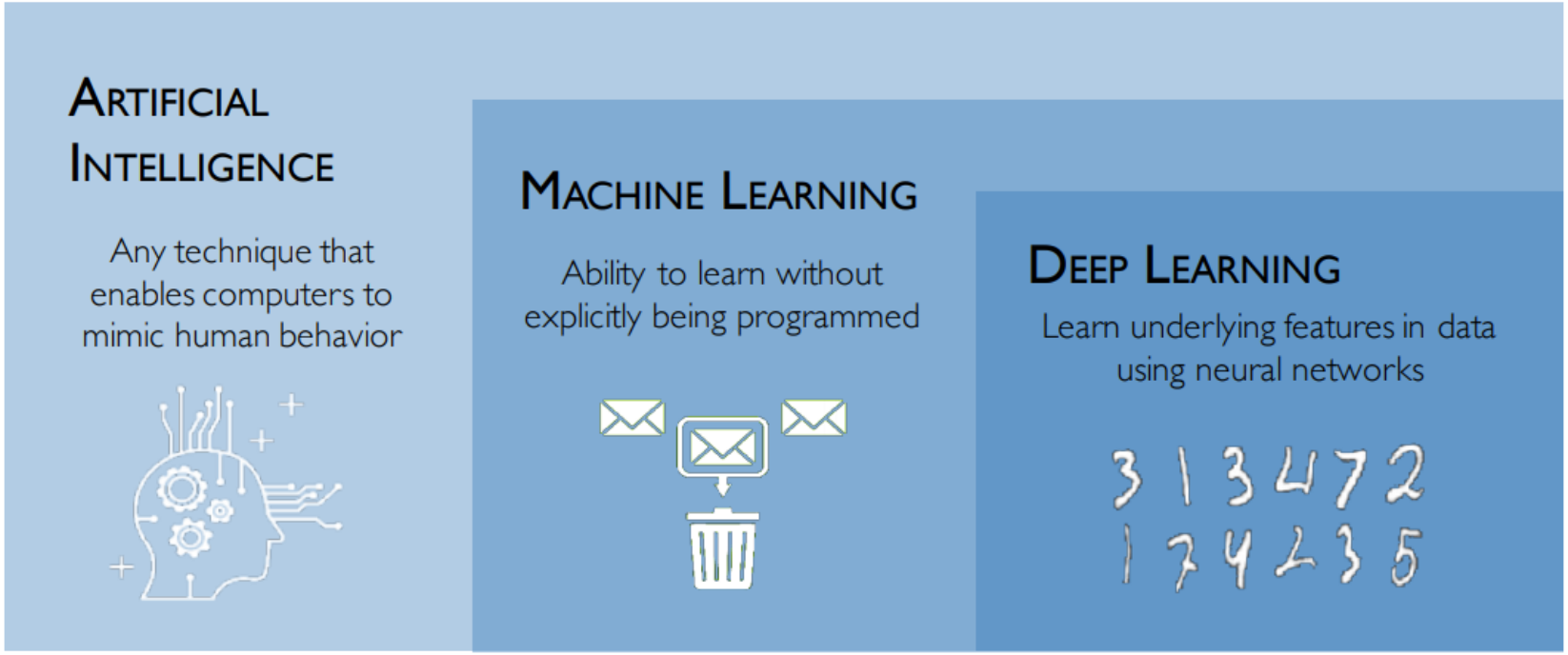
- Deep Learning & Big Data: Deep Learning Era



Slide 10: AI Deep Learning: An Introduction

Deep Learning: What is it?

- Deep Learning: A subfield of AI machine learning that studies to train computers to learn underlying features in data using artificial neural networks.



AI, Machine Learning, and Deep Learning (Sources: MIT)

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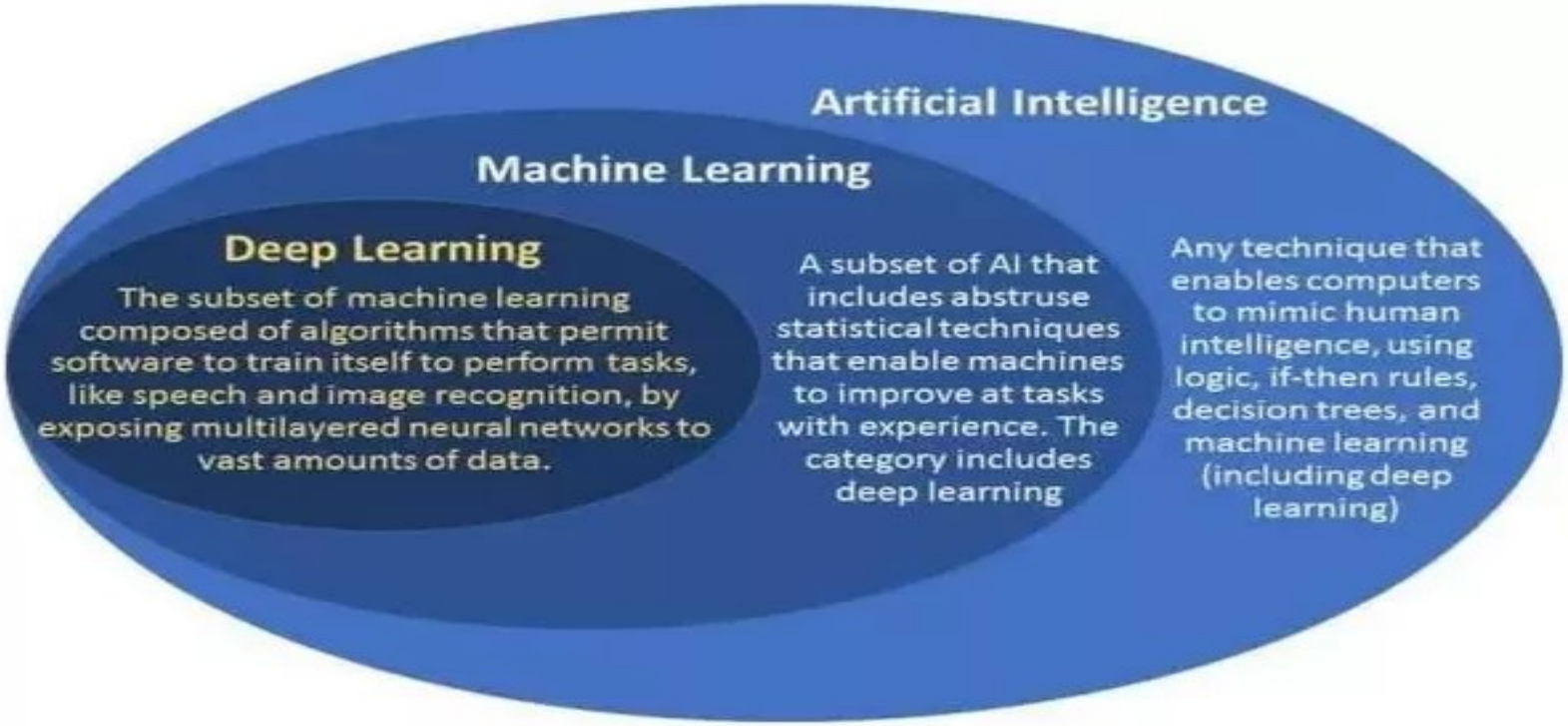
Deep Learning & Big Data: The Powerful Relationship

- Deep Learning: A subfield of AI machine learning that studies algorithms that can train themselves to perform tasks by exposing multilayered neural networks to vast amount of data.

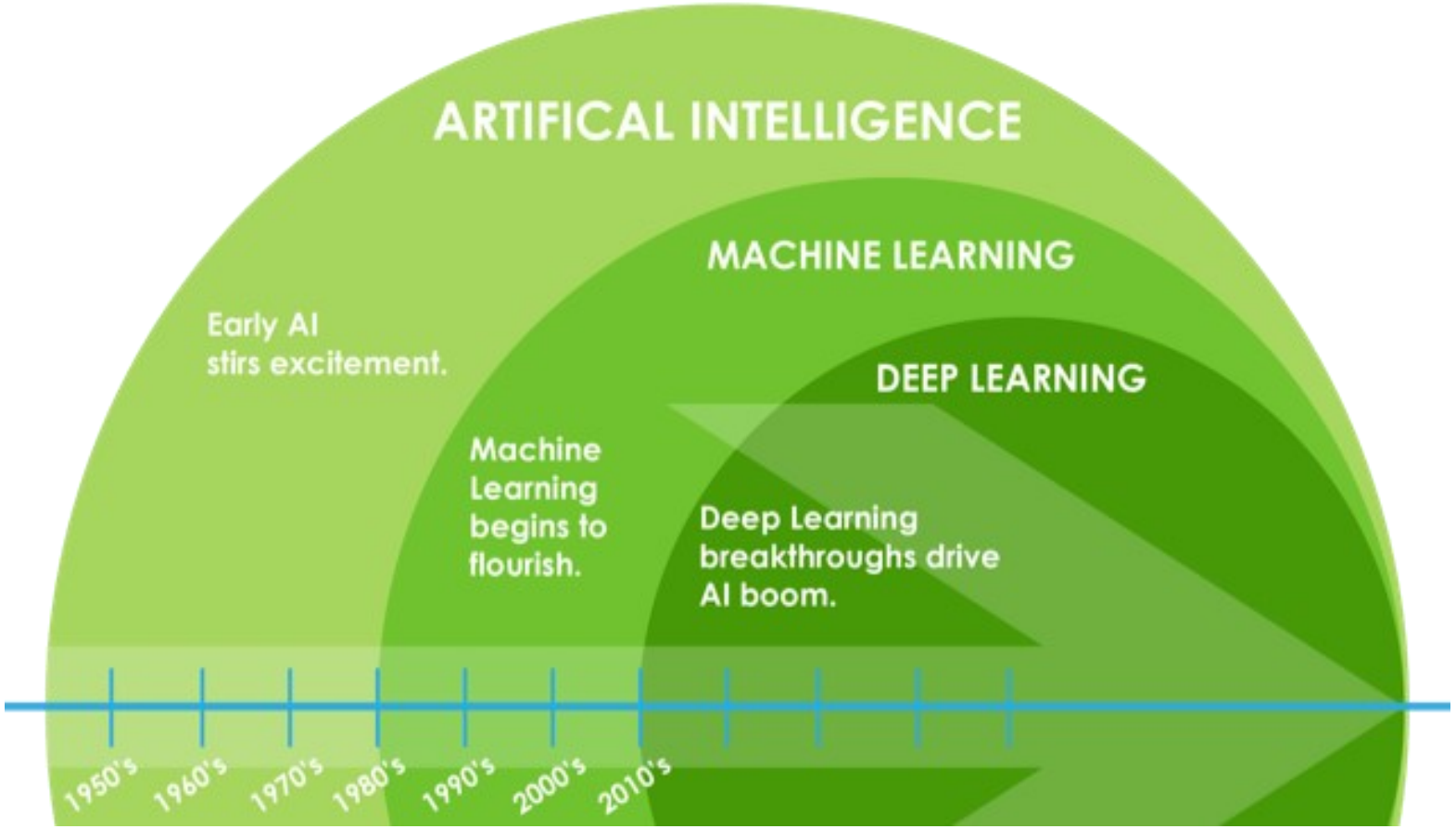


Sources: Quora.com

Slide 17: AI Deep Learning: An Introduction

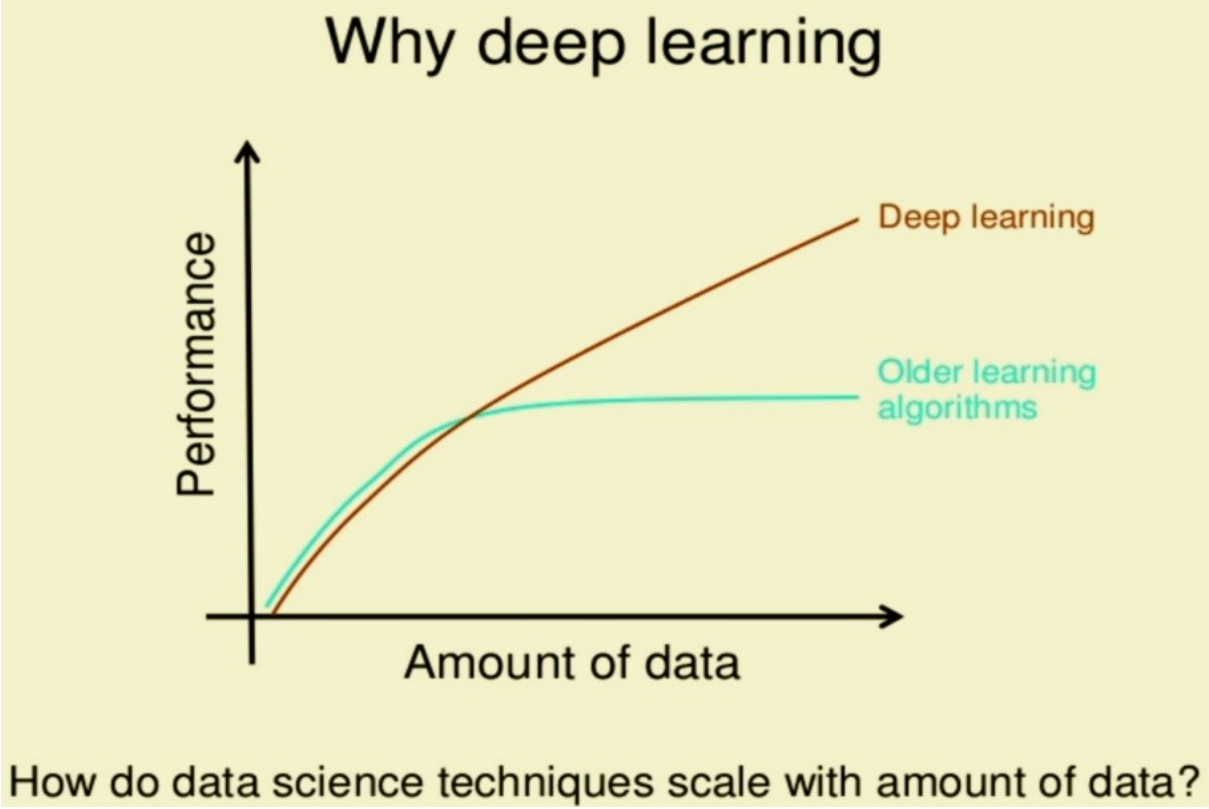
Deep Learning: Why?

- Deep Learning and Other AI Approaches



Slide 17: AI Deep Learning: An Introduction

Deep Learning: Why?



Sources: Wikipedia.com

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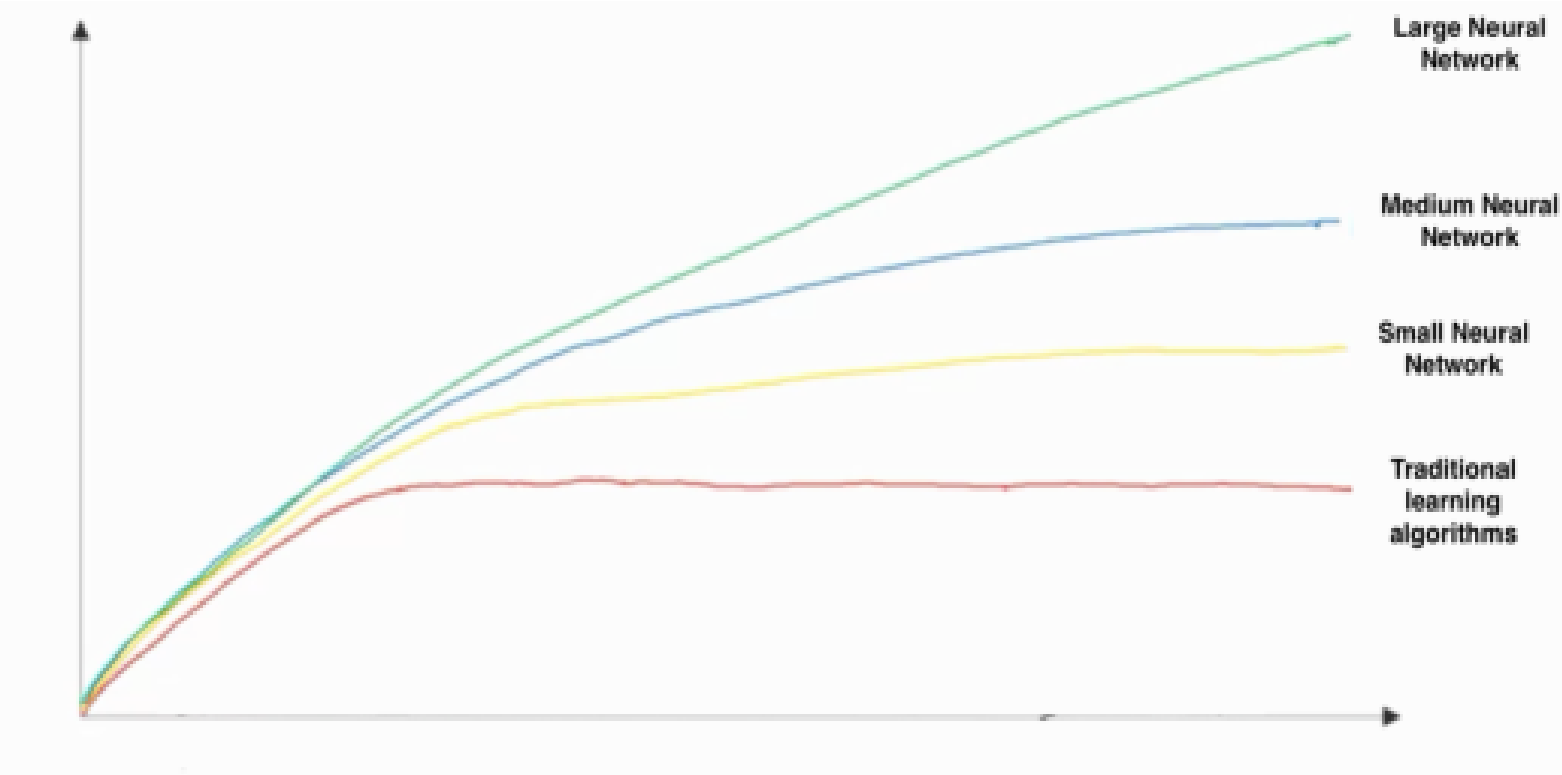
Deep Learning: Why?



Sources: Wikipedia.com

Slide 13: AI Deep Learning: An Introduction

Deep Learning & Big Data: Successes: Vision

- Deep Learning: Very powerful in the applications of image recognition.

AI Deep Learning and Computer Vision (Sources: MIT)

Slide 14: AI Deep Learning: An Introduction

Deep Learning & Big Data: Successes: Audio

- Deep Learning: Can be used for music generation

Sources: MIT

Slide 15: AI Deep Learning: An Introduction

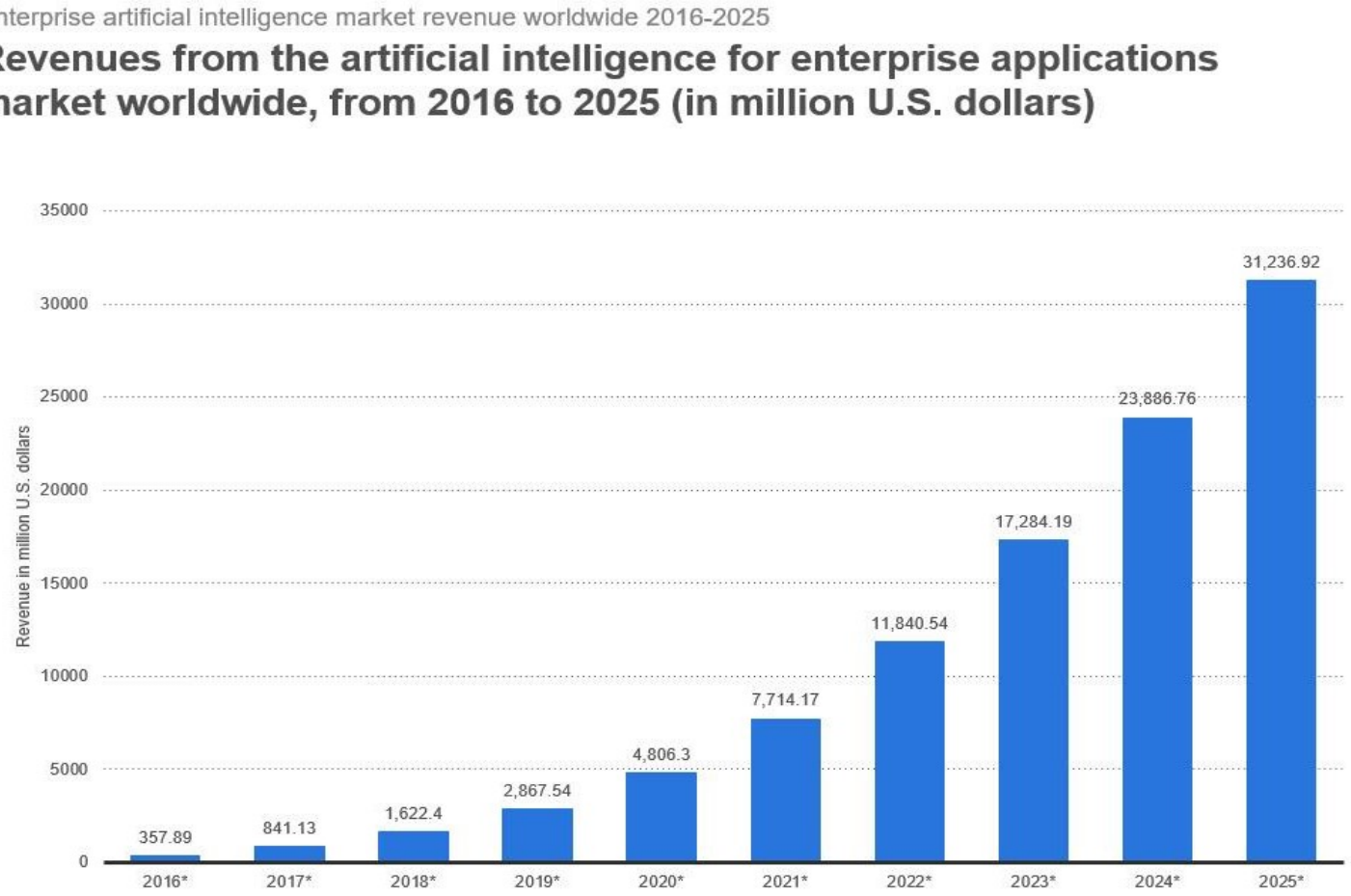
Deep Learning & Big Data: Successes: Many More …

- Deep Learning: Can be also successfully applied in art or games and many more

Sources: MIT

Slide 15: AI Deep Learning: An Introduction

Deep Learning & Big Data: Successes: Many More …



Sources: Statista.com

Slide 17: AI Deep Learning: An Introduction

AI: Deep Learning: Applications

Medical

- Skin cancer identification
- FDA approval for death prediction
- Radiology
- Predict disease from patient records

Agriculture

- Identify Plant Pests
- Create more efficient seeds
- Monitor crops in real time
- Identify soil defects & nutrients deficiencies

Pharma

- Design drugs
- Bioinformatics
- Predict the chemical reactions between candidate compounds and target molecules
- Identify one or more genes responsible for a disease

Autonomous Vehicles

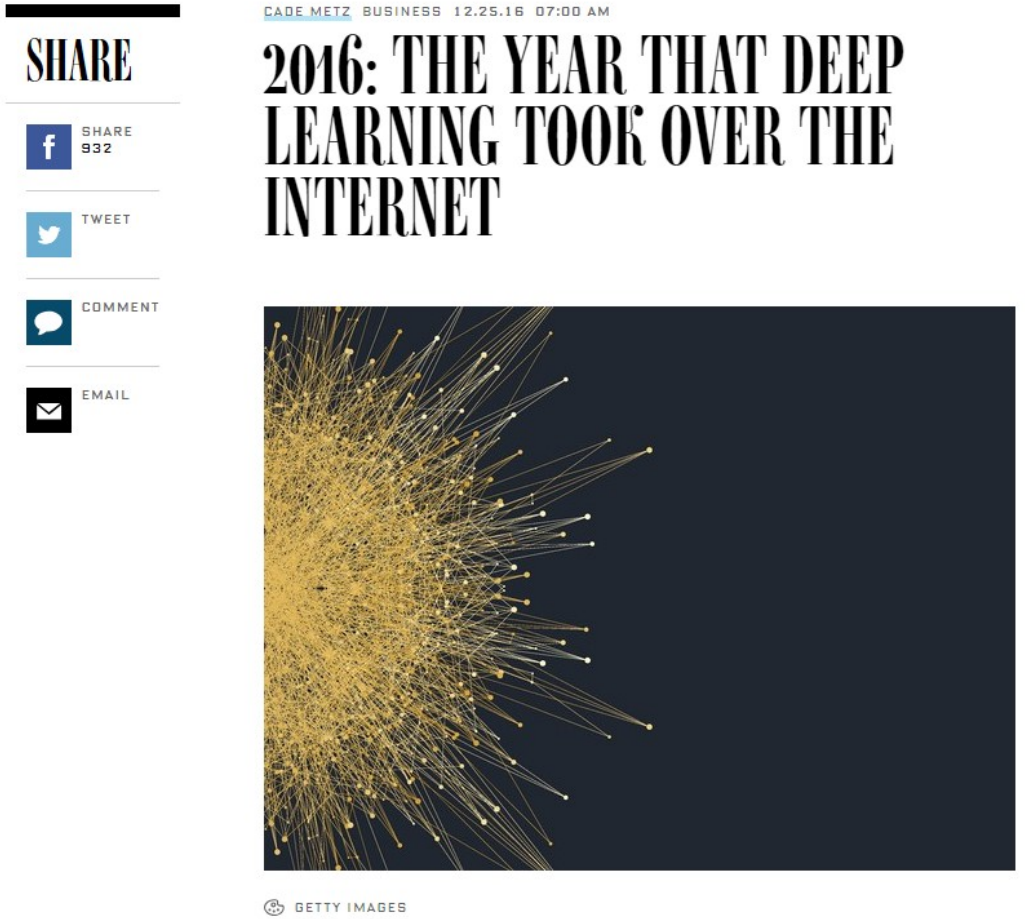
- Map raw pixels from camera directly to steering commands
- Drive in unstructured conditions
- Car and lane detection
- Motion control & planning
- Optimization of AV traffic

Data Centers

- Data center security
- Reduce electricity usage
- Server optimization

Slide 16: AI Deep Learning: An Introduction

Deep Learning & Big Data: 2016: The Year of Deep Learning

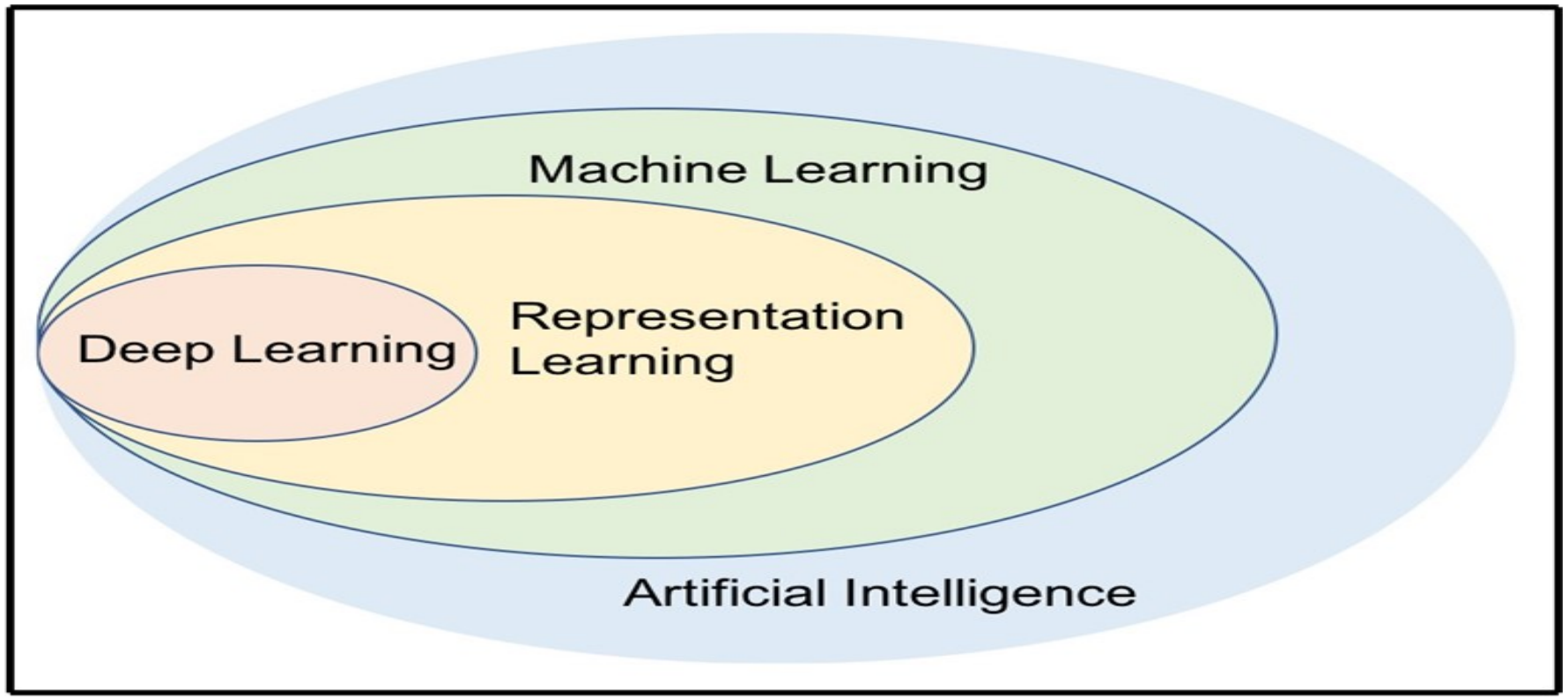


The Year of Deep Learning (Source: wire.com)

Slide 17: AI Deep Learning: An Introduction

Deep Learning: Why?

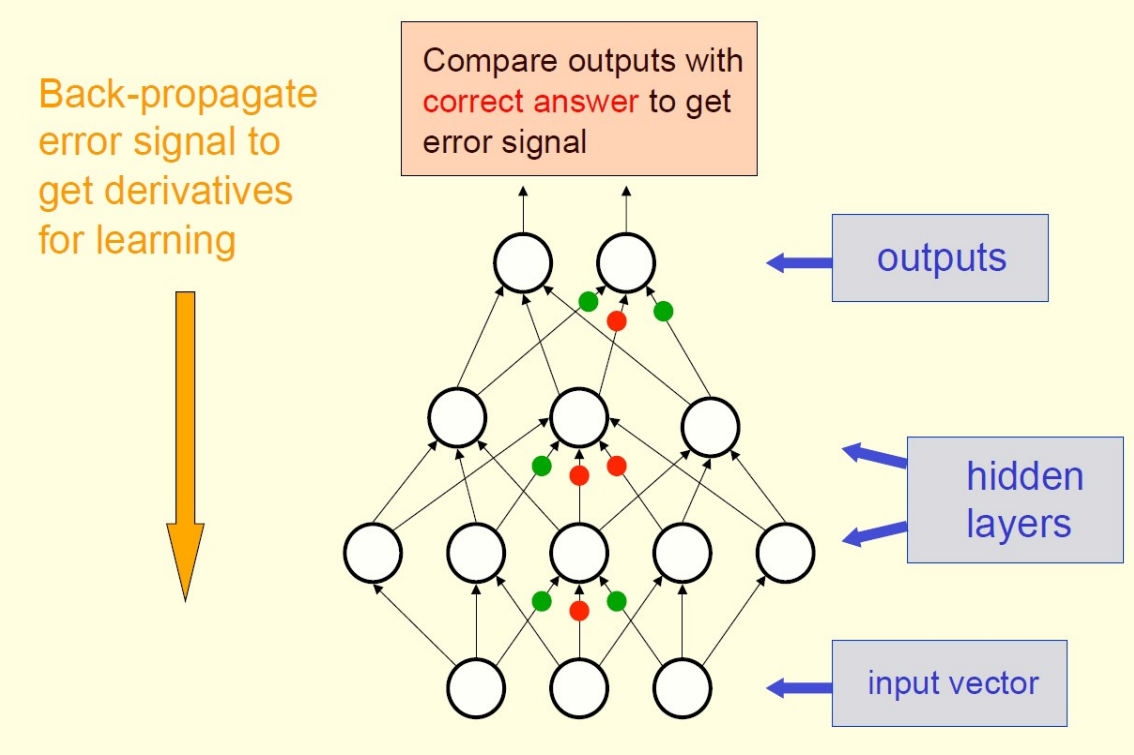
- Deep Learning and Other AI Approaches



Sources: Di, Bhardwaj, & Wei (2018)

Slide 12: AI Deep Learning: An Introduction

Deep Learning: "Deep" – What Does It Mean?



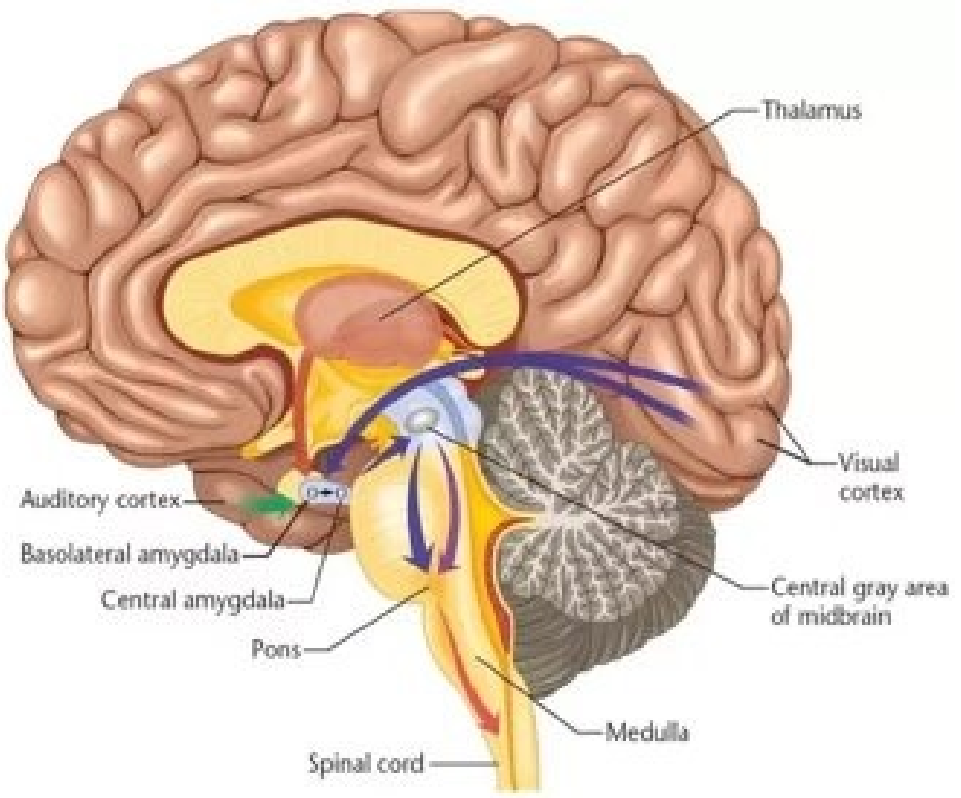
Deep learning (Sources: G. E. Hilton, 1997)

- "Deep Learning" stands for the concept of successive layers of representations.
  - How many layers contribute to a model of the data is called the **depth** of the model.
  - Other appropriate names for the field could have been **layered representations learning** and **hierarchical representations learning**.
  - **Modern deep learning** often involves tens or even hundreds of **successive layers** of **representations** that are all learned automatically from exposure to training data.

Slide 18: AI Deep Learning: An Introduction

Deep Learning: Why? From a Biological Neural Viewpoint

- An architecture for learning is biologically inspired.
- The human brain has deep architecture:
  - The cortex seems to have a generic learning approach.
- A given input is perceived at multiple levels of abstraction.
  - Each level corresponds to a different area of the cortex.
- We process information in hierarchical ways.
  - With multi-level transformation and representation.
- Therefore, we learn simple concepts first then compose them together.



Human Brain (Source: Quora.com)

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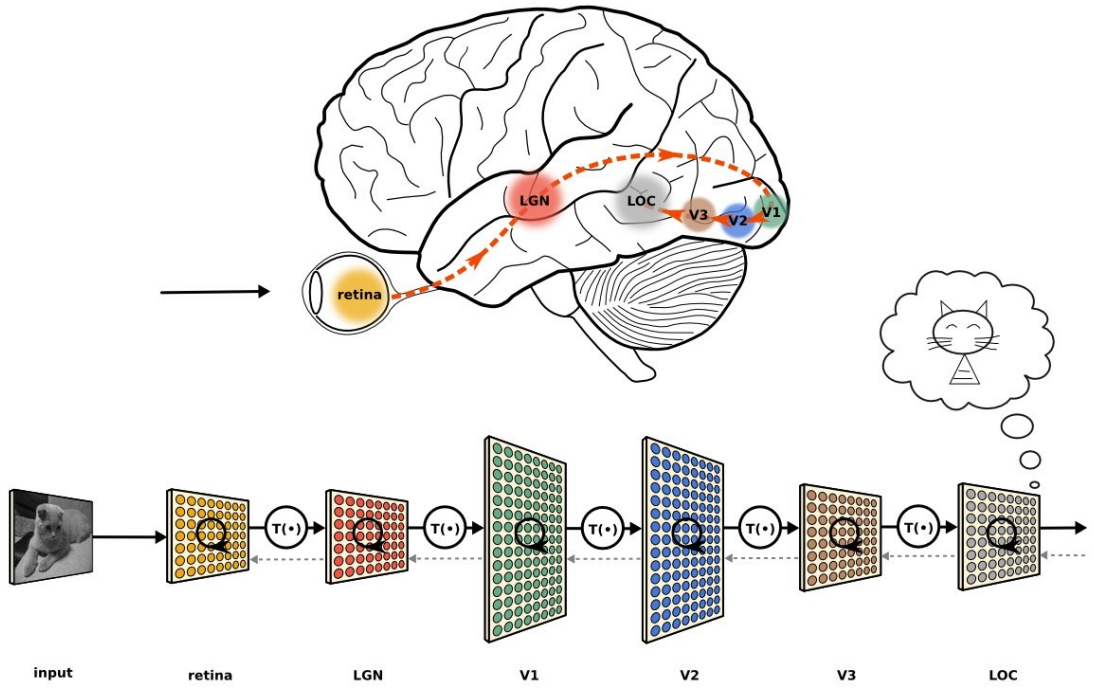
Deep Learning: Why? From a Biologocal Neural Viewpoint



Biologocal Neural Viewpoint (Source: Wikipedia)

- The structure of understanding can be found in a human's vision system as shown in the figure:
  - Signal path from the retina to human lateral occipital cortex (LOC)
  - The path which finally recognizes the object
  - The ventral visual cortex comprises a set of areas that process images in increasingly more abstract ways, from edges, corners and contours, shapes, object parts to object
  - This path allows us to learn, recognize, and categorize three-dimensional objects from arbitrary two-dimensional views.

Slide 20: AI Deep Learning: An Introduction

Deep Learning: Why? From a Representation Viewpoint

- For most traditional machine learning algorithms, their performance depends heavily on the representation of the data they are given.
  - Therefore, domain prior knowledge, feature engineering, and feature selection are critical to the performance of the output.
  - But hand- crafted features lack the flexibility of applying to different scenarios or application areas.
  - Also, they are not data-driven and cannot adapt to new data or information comes in.

- For many tasks related to various input formats such as **image**, **video**, **audio**, and **text**:
  - It is very difficult to know what kind of features should be extracted
    - Let alone their generalization ability for other tasks that are beyond the current application.
  - Manually designing features for a complex task requires a great deal of domain understanding, time, and effort.
    - Sometimes, it can take decades for a large group of researchers to make progress in this area.

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Deep Learning: Why? From a Representation Viewpoint

- Representation Learning:
  - It is a data driven type of approach using machine learning to discover the representation.
    - Such representation can represent the mapping from representation to output (supervised), or simply representation itself (unsupervised).

  - Learned representations often result in much better performance as compared to what can be obtained with hand-designed representations.
    - This also allows AI systems to rapidly adapt to new areas, without much human intervention.

  - With a representation learning algorithm, we can discover a good set of features for a simple task in minutes or a complex task in hours to months.
    - It may take vastly more time and effort if using hand-craft and design features.

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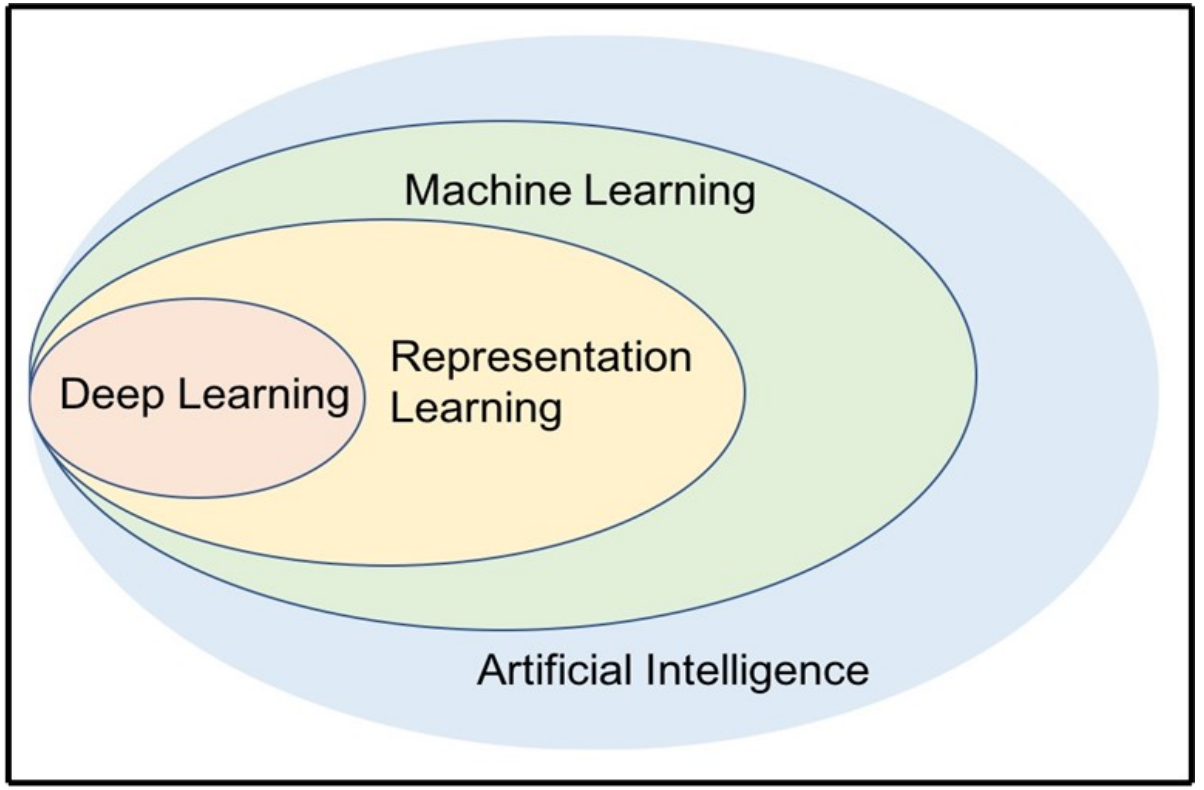
Deep Learning: Why? From a Representation Viewpoint

- Deep Learning is Representation Learning
  - Deep learning feature extraction happens automatically when the deep architecture tries to process the data, learning, and understanding the mapping between the input and the output.
  - This brings significant improvements in accuracy and flexibility since human designed feature/feature extraction lacks accuracy and generalization ability.
  - In addition to this automated feature learning, the learned representations are both distributed and with a hierarchical structure.
  - Such successful training of intermediate representations helps feature sharing and abstraction across different tasks.



AI Deep Learning (Sources: Di, Bhardwaj, & Wei, 2018)

Slide 23: AI Deep Learning: An Introduction

Deep Learning: Why Now?

1952 Stochastic Gradient Descent

1958 Perceptron
- Learnable Weights

1986 Backpropagation
- Multi-Layer Perceptron

1995 Deep Convolutional NN
- Digit Recognition

Neural Networks date back decades, so why the resurgence?

1. Big Data
- Larger Datasets
- Easier Collection & Storage

IMAGENET

WIKIPEDIA
The Free Encyclopedia

2. Hardware
- Graphics Processing Units (GPUs)
- Massively Parallelizable

3. Software
- Improved Techniques
- New Models
- Toolboxes

TensorFlow

New Technology and Deep Learning (Sources: MIT)