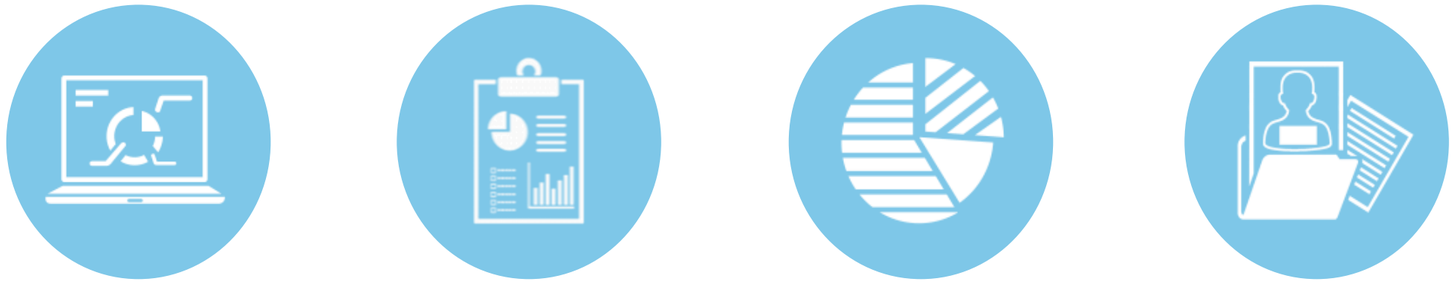
Deep Learning

Lesson 1—Introduction to Deep Learning



Learning Objectives

- Understand the evolution of Deep Learning from Artificial Intelligence and Machine Learning
- Describe the meaning and definition of Deep Learning with the help of a case study
- Explore the meaning, process, and types of neural networks with a comparison to human neurons
- Identify the platforms and programming stacks used in Deep Learning

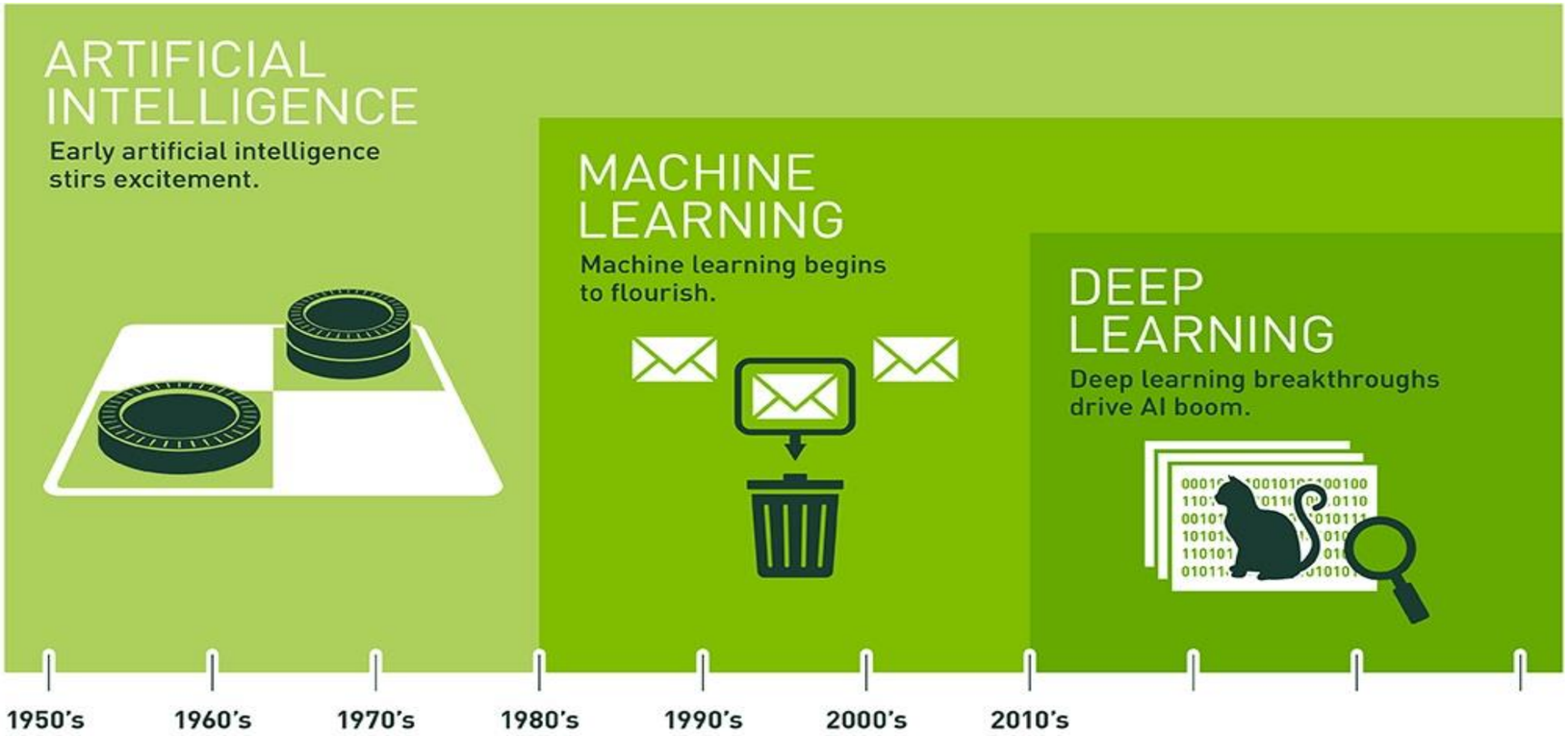
Introduction to Deep Learning

Topic 1: Evolution of Deep Learning

Artificial Intelligence and Machine Learning

- Traditional analytics relies on hard-coded rules.
- Artificial Intelligence (AI) systems learn by extracting patterns from input and output data.
- Machine Learning (ML) relies on learning patterns based on sample data.
- Programs learn from labeled data (supervised learning), unlabelled data (unsupervised learning), or a combination of both (semi-supervised learning).

Evolution of Deep Learning



Artificial Intelligence (AI) came around in the middle of 1900s when scientists tried to envision intelligent machines. Machine Learning evolved in late 1900s. This allowed scientists to train machines for AI. In early 2000s, certain breakthroughs in multi-layered neural networks facilitated the advent of Deep Learning. It aids in developing more complex applications, like image processing or language modeling.

Image Source: Nvidia

Relationship between Artificial Intelligence and Deep Learning

Machine Learning is an approach or subset of Artificial Intelligence that is based on the idea that machines can be given access to data along with the ability to learn from it. Deep Learning takes Machine Learning to the next level.

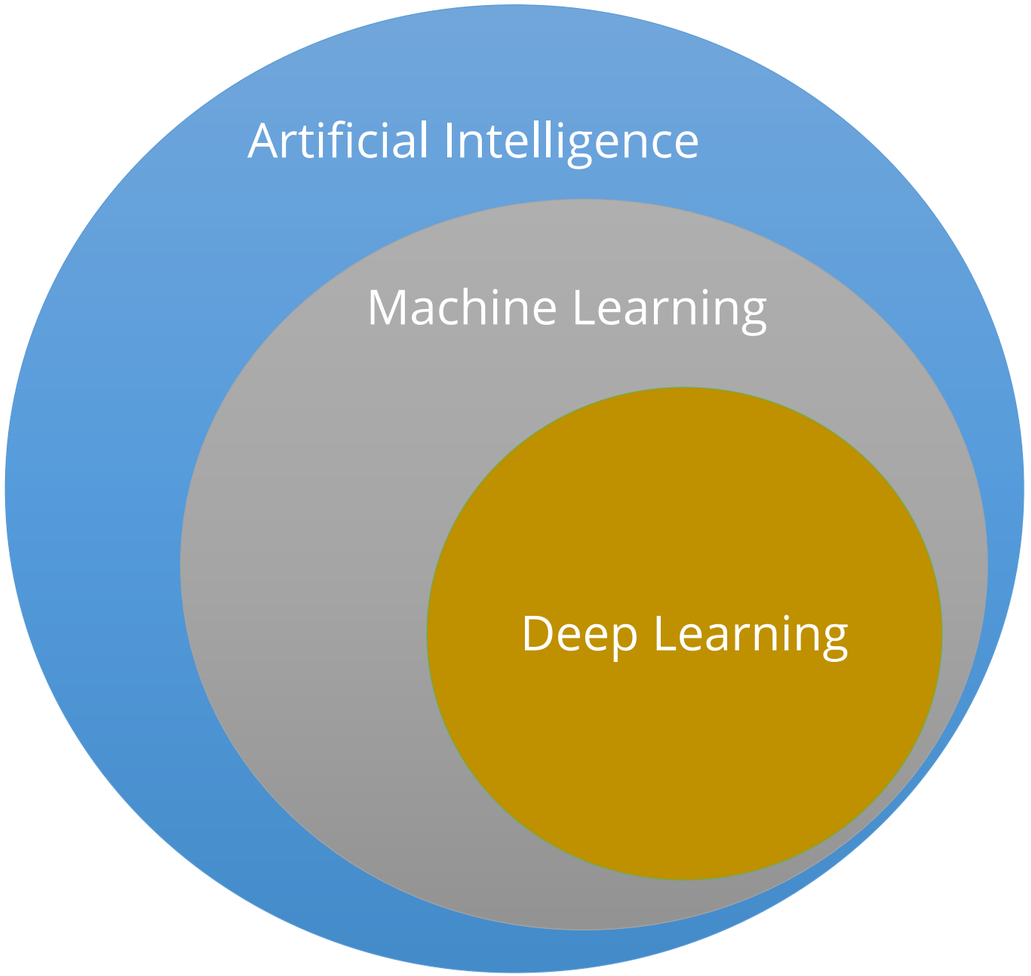
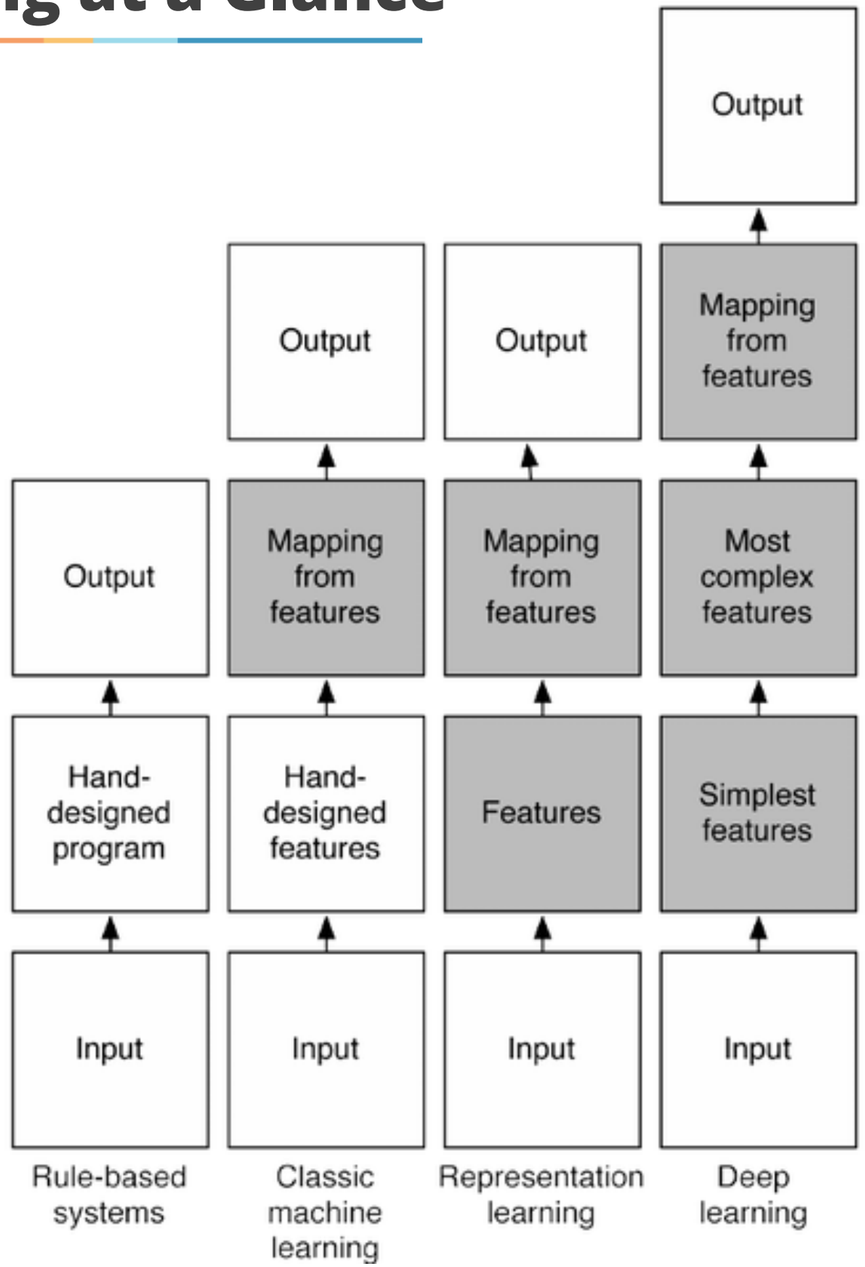


Image Source : Nvidia

Traditional to Deep Learning at a Glance

As you go from the rule-based systems to the deep learning ones, more complex features and input-output relationships become learnable.



Source: "Deep learning" by Ian Goodfellow

Use Cases of Artificial Intelligence

- Self driving cars
- Chatbots
- Amazon Echo and Alexa
- Amazon GO retail store
- Speech recognition
- Credit card fraud detection
- Amazon recommendations
- Concierge robot Connie
- Email spam
- Google AlphaGo
- Call center agent match
- Image tagging
- Baidu AI medical assistant
- Face recognition
- Apple's Siri

Introduction to Deep Learning

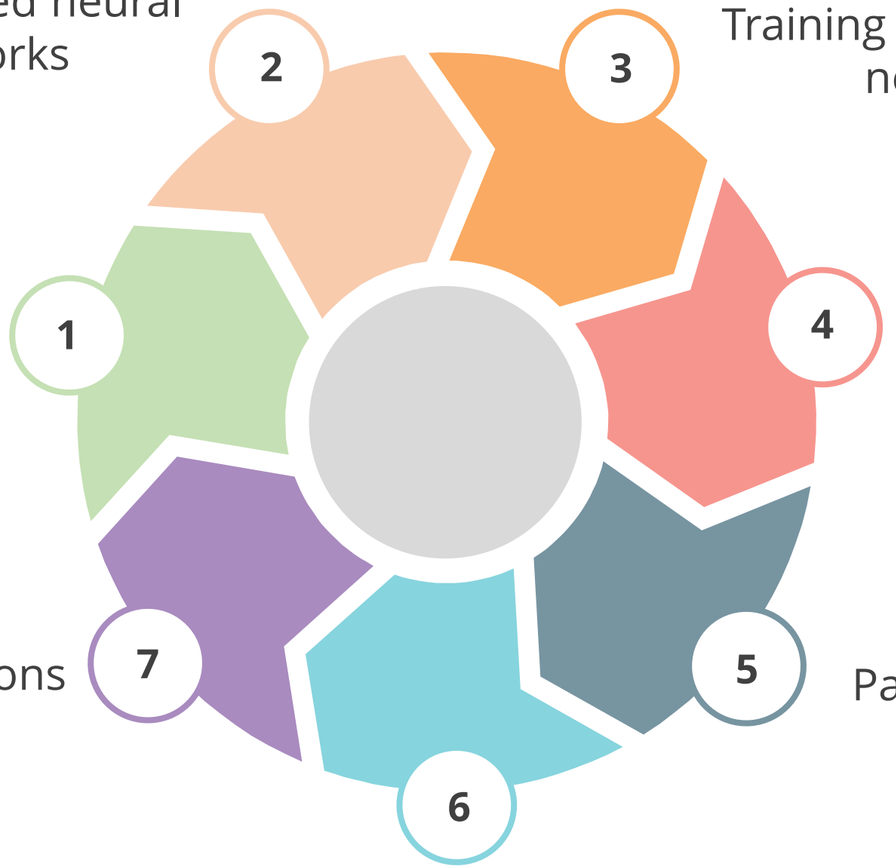
Topic 2: What is Deep Learning?

What Is Deep Learning?

Deep Learning is a specialized form of Machine Learning that uses supervised, unsupervised, or semi-supervised learning to learn from data representations. It is similar to the structure and function of the human nervous system, where a complex network of inter-connected computation units work in a coordinated fashion to process complex information.

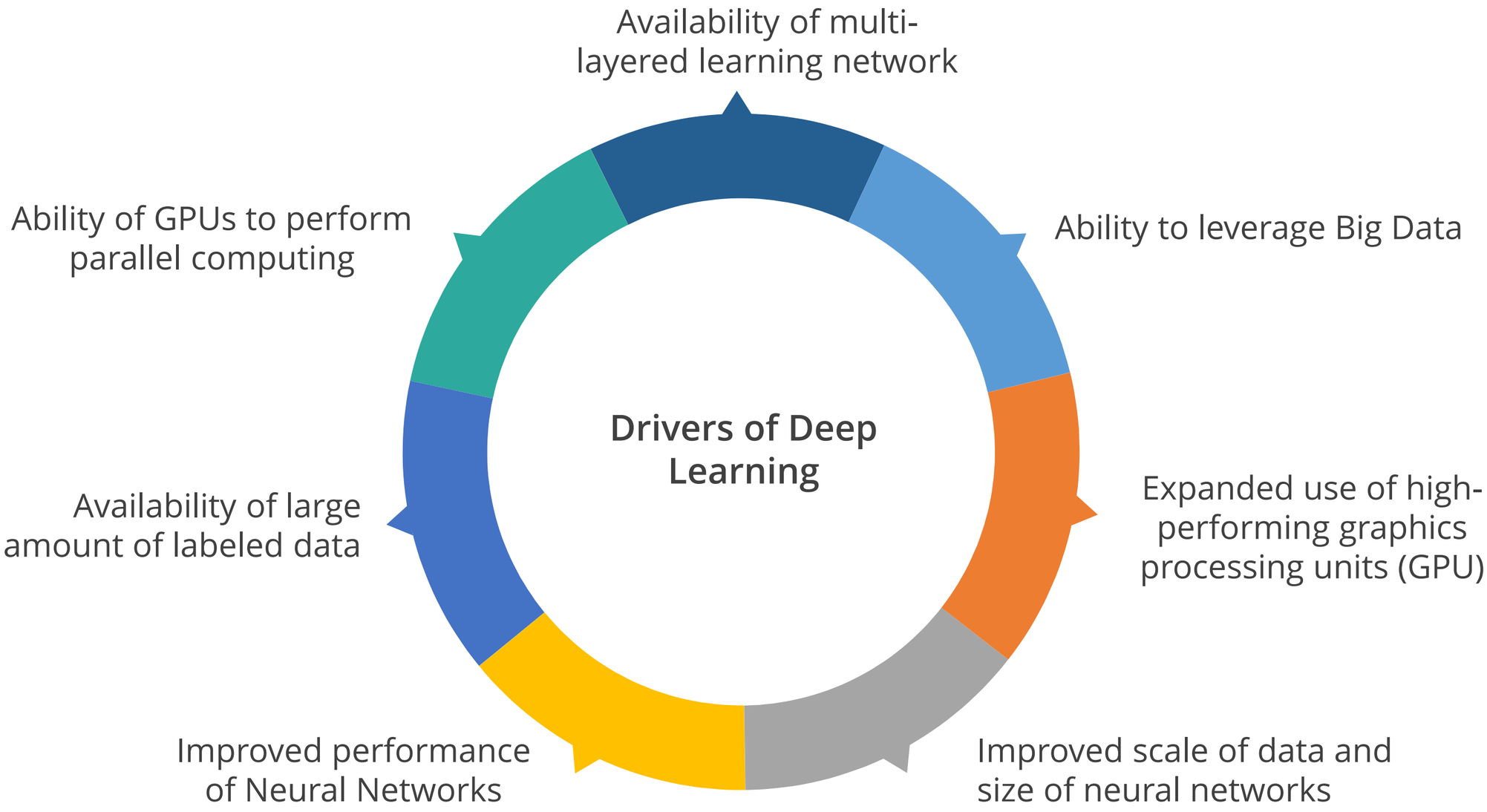
Deep Learning at a Glance

There are many aspects of Deep Learning as shown below. These will be covered in detail in subsequent chapters of this course.



1. Multiple levels of hierarchical representations
2. Multi-layered neural networks
3. Training of large neural networks
4. Multiple non-linear transformations
5. Pattern recognition
6. Feature extraction
7. High-level data abstractions model

Drivers of Deep Learning



Case Study: Sowing App

What?

Microsoft India collaborated with ICRISAT (International Crop Research Institute for the Semi-Arid Tropics) to develop a ***"Sowing App."***

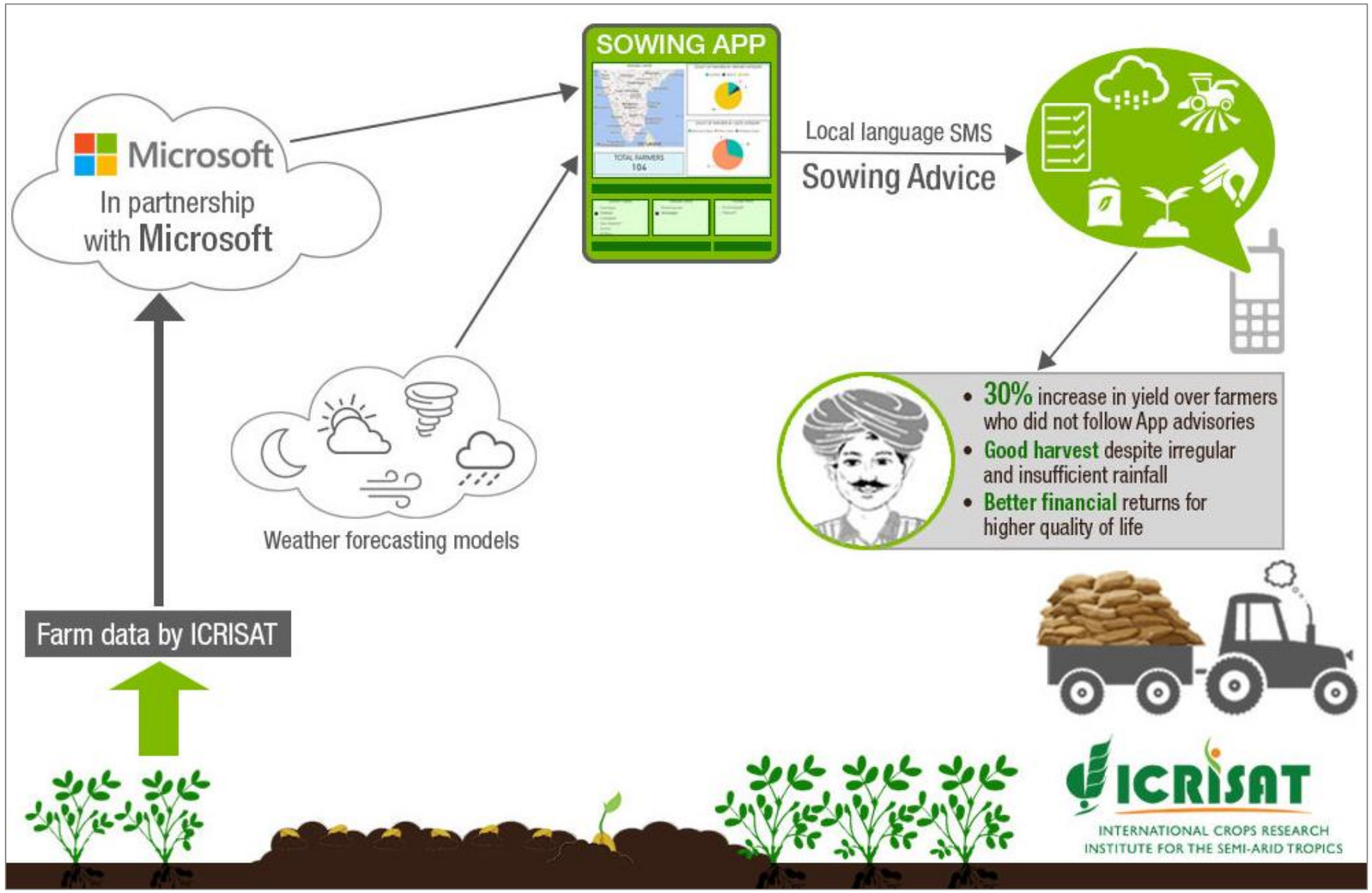


Image Source: ICRISAT

Case Study: Sowing App

What?

- The timing of sowing is the biggest differentiator between a good and a failed crop, especially for rainfed crops.
- The app guides farmers on soil conditions and weather and provides rainfall predictions.
- It helps them get a higher crop yield and have better price control.
- The app calculates crop yield using data from geostationary satellite images.

Case Study: Sowing App

What?

Notifications are sent to farmers on their phones in their native language:

- Short term weather prediction, especially rainfall
- Soil quality data
- Previous crop history
- When to sow
- When not to sow
- When soil moisture is sufficient for seed gemination
- Pest threats to the crops
- Price forecasts for the crops

Farmers who followed the prediction benefited by reaping a 30% higher yield.

Case Study: Sowing App

Where?

- The pilot was implemented in Devanakonda Mandal in Kurnool district of Andhra Pradesh for the groundnut crop.
- The Sowing advisory was developed in 2016 and used by 175 farmers in a pilot phase. The app is now being scaled in all 13 districts.
- Farmers in a few villages in the following states are now using this app:
  - Karnataka
  - Maharashtra
  - Andhra Pradesh
  - Madhya Pradesh
  - Telangana

Case Study: Sowing App

How?

- Azure cloud platform was used to deploy this app, along with Artificial Intelligence, Machine Learning, Big Data, and Analytics.
- The technologies that are used to power the app are:
  - Cloud Machine Learning
  - Satellite imagery
  - Advanced analytics
  - Microsoft Cortana Intelligence Suite
  - Machine Learning
  - Power BI
- Climate data for the Devanakonda area of Andhra Pradesh from 1986 to 2015 was collected to predict the crop sowing period.

Deep Learning Path

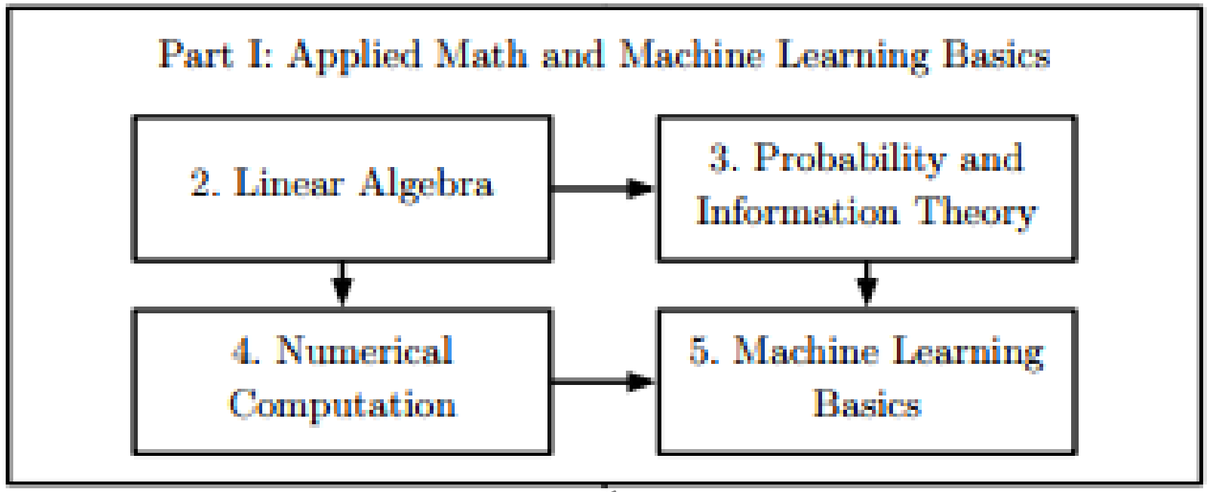
The path to master Deep Learning can be divided into four phases:

Introduction	Applied Math and Machine Learning Basics	Deep Networks: Modern Practices	Deep Learning Research

You begin by an introduction to the idea of Deep Learning.

Deep Learning Path

Introduction	Applied Math and Machine Learning Basics	Deep Networks: Modern Practices	Deep Learning Research

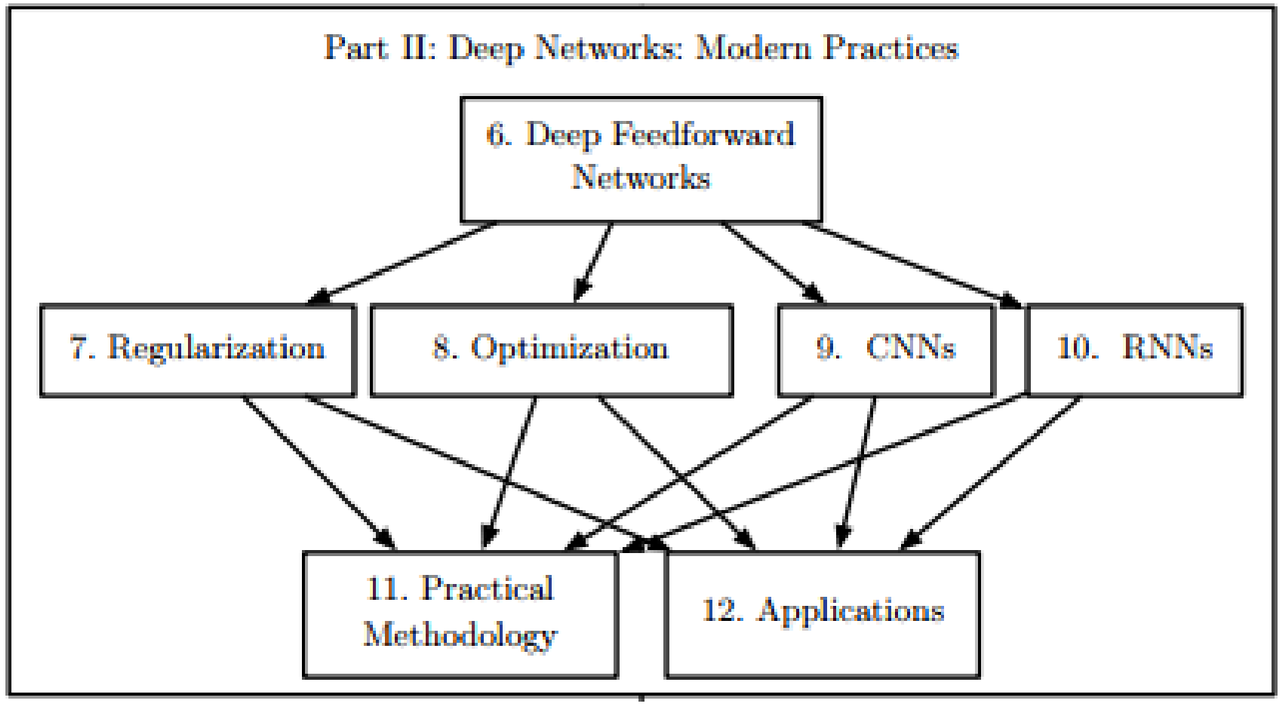


Next, review basics of Math and core Machine Learning algorithms used later in Deep Learning.

Deep Learning Path

Introduction | Applied Math and Machine Learning Basics | **Deep Networks: Modern Practices** | Deep Learning Research

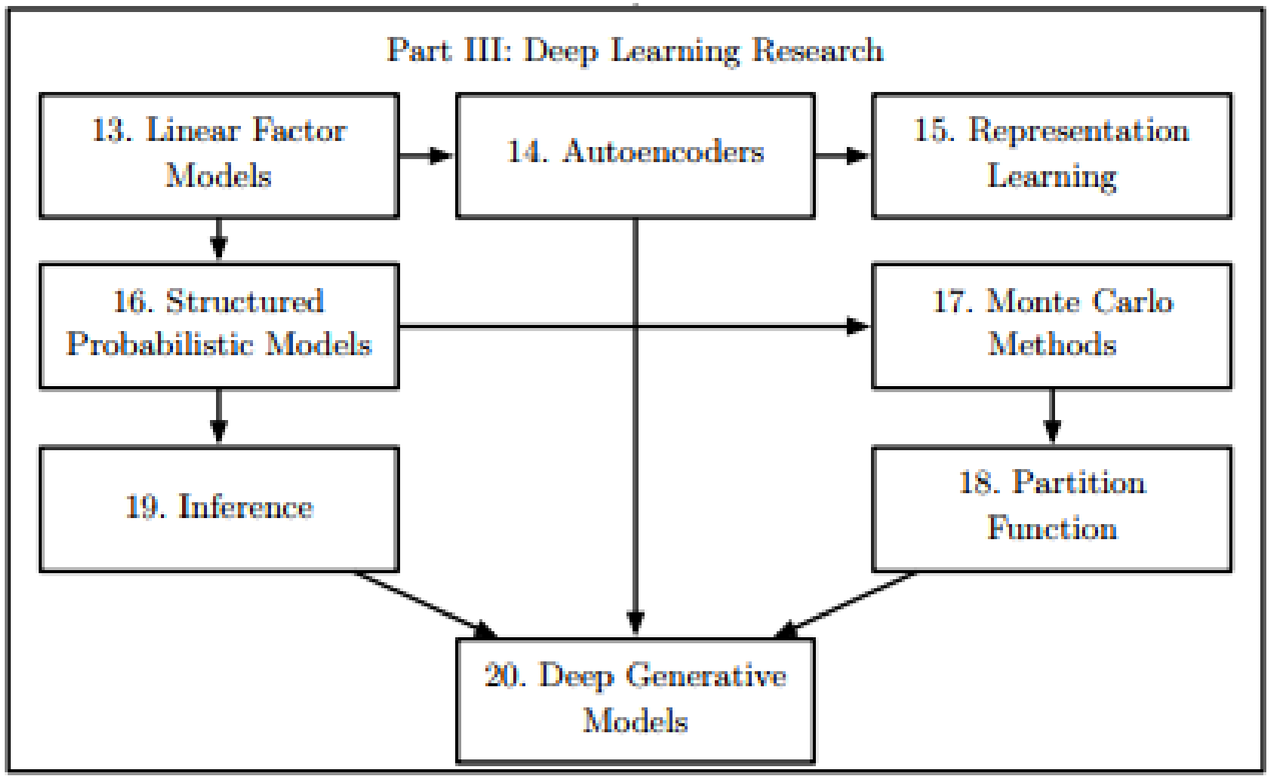
After that, learn the most popular forms of Deep Learning neural networks prevalent currently.



Deep Learning Path

Introduction | Applied Math and Machine Learning Basics | Deep Networks: Modern Practices | Deep Learning Research

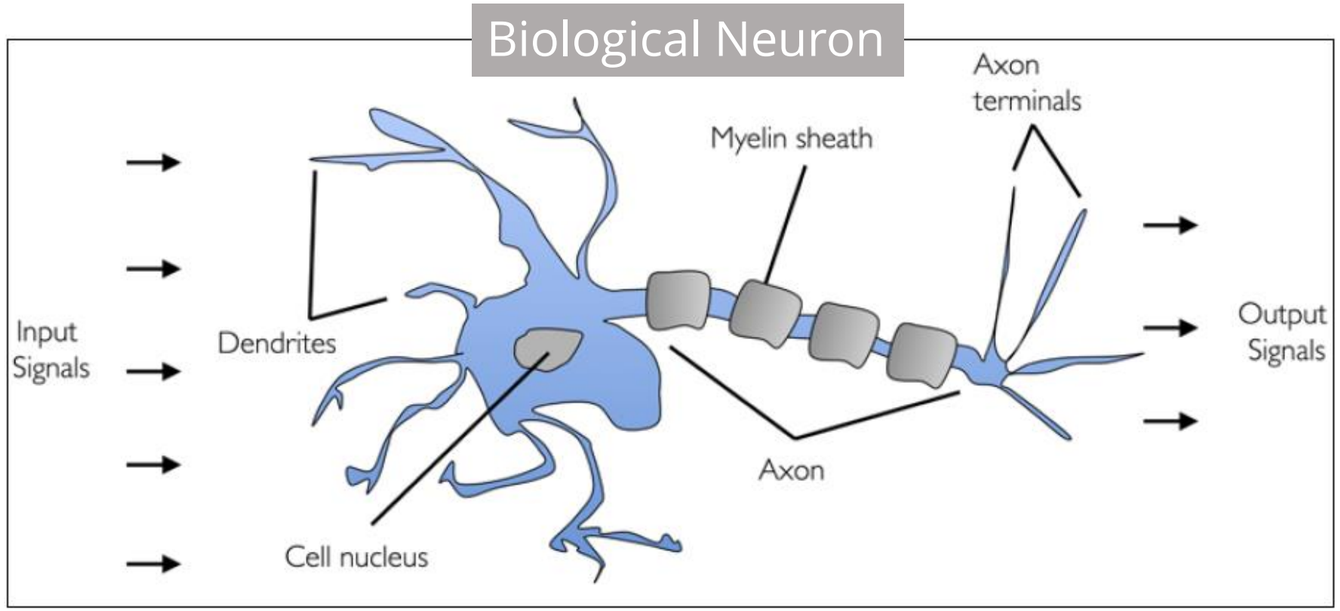
Finally, review some of the more recent advances in Deep Learning.



Introduction to Deep Learning

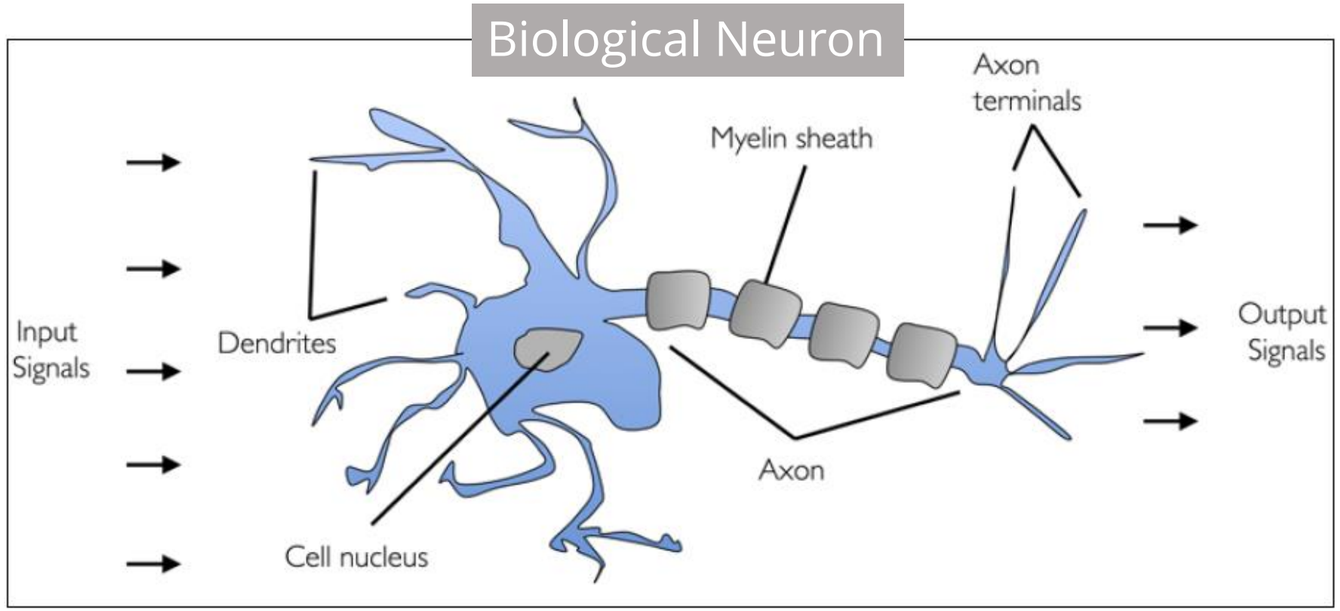
Topic 3: Artificial Neural Networks

A Peek into the Human Brain



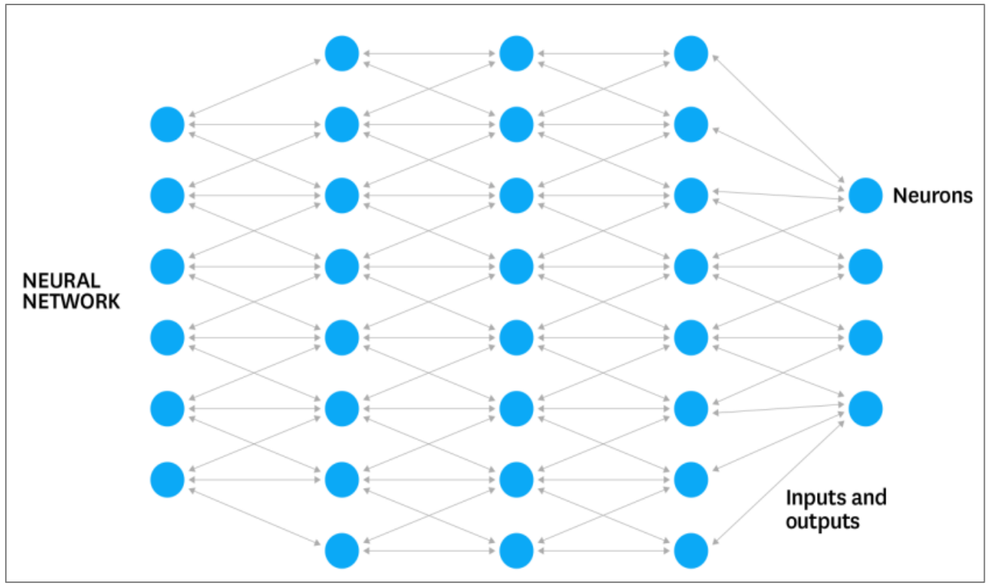
- A mammalian brain has billions of neurons.
- Neurons are interconnected nerve cells in the human brain that are involved in processing and transmitting chemical and electrical signals.
- They take input and pass along outputs.
- A human brain can learn how to identify objects from photos.
- For example, it can learn to identify the characteristics of chairs and thereby increase its probability of identifying them over time.

A Peek into the Human Brain



- **Dendrites** are branches that receive information from other neurons.
- **Cell nucleus or Soma** processes the information received from dendrites.
- **Axon** is a cable that is used by neurons to send information.
- **Synapse** is the connection between an axon and other neuron dendrites.

Human Brain Vs. Artificial Neural Networks



- The computational models in Deep Learning are loosely inspired by the human brain.
- The multiple layers of training are called Artificial Neural Networks (ANN).
- ANNs are processing devices (algorithms or actual hardware) that are modelled on the neuronal structure of the mammalian cerebral cortex but on a much smaller scale.

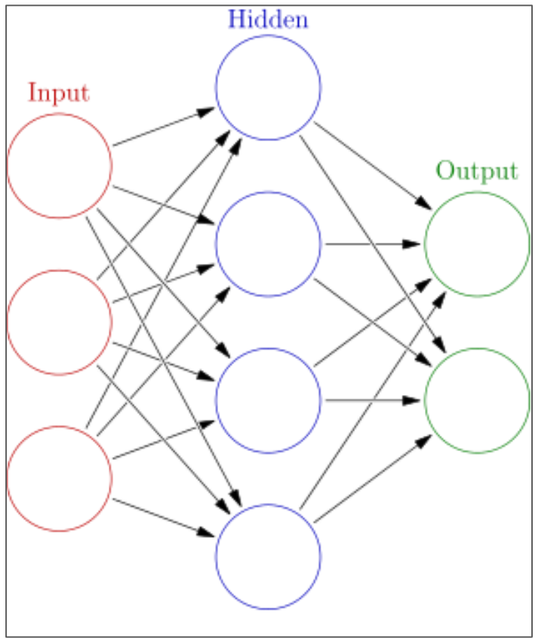
Note: In second and third lessons, you will learn more about Artificial Neural Network, Neurons and Perceptron.

Artificial Neural Network: Definition

> "Artificial Neural Network is a computing system made up of a number of simple, highly interconnected processing elements which process information by their dynamic state response to external inputs."
>
> - Robert Hecht-Nielsen

Artificial Neural Network: Process

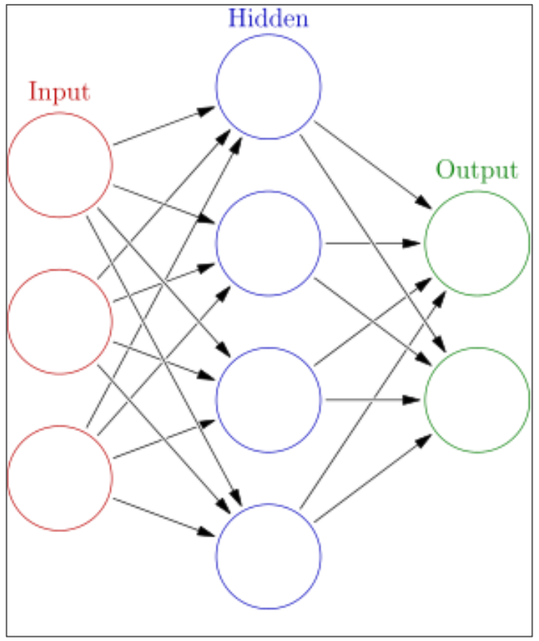
Neurons



- Artificial Neural Networks contain layers of neurons.
- A neuron is a computational unit that calculates a piece of information based on weighted input parameters.
- Inputs accepted by neuron are separately weighted.
- Inputs are summed and passed through a non-linear function to produce output.
- Each layer of neurons detects some additional information, such as edges of things in a picture or tumors in a human body.
- Multiple layers of neurons can be used to detect additional information about input parameters.

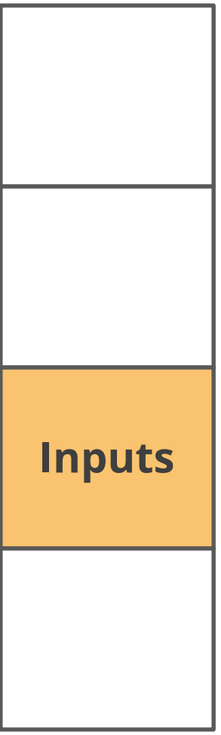
Artificial Neural Network: Process

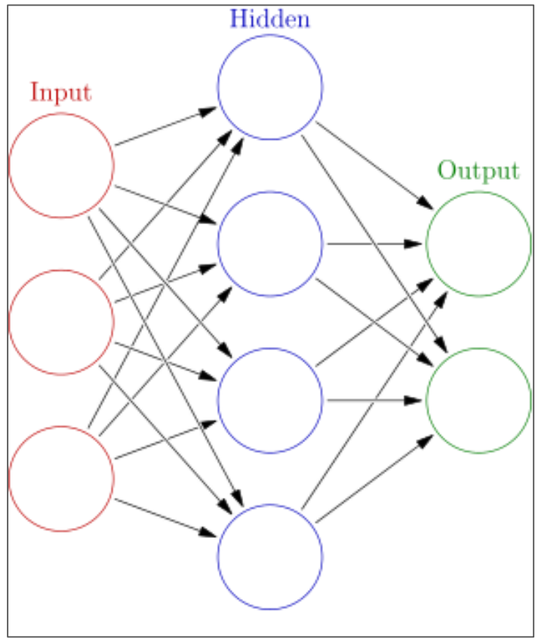
Nodes



- Artificial Neural Network is an interconnected group of nodes akin to the vast network of layers of neurons in a brain.
- Each circular node represents an artificial neuron and an arrow represents a connection from the output of one neuron to the input of another.

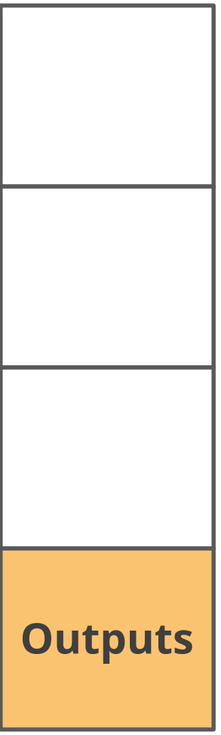
Artificial Neural Network: Process

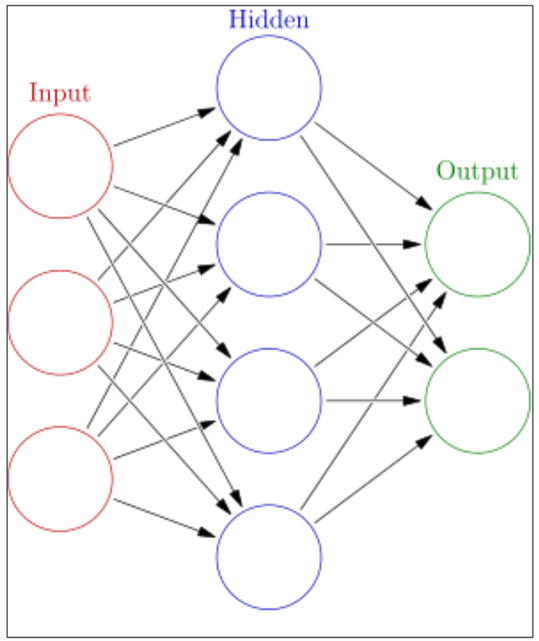




- Inputs are passed into the first layer.
- Individual neurons receive the inputs, with each of them receiving a specific value.
- After this, an output is produced based on these values.

Artificial Neural Network: Process

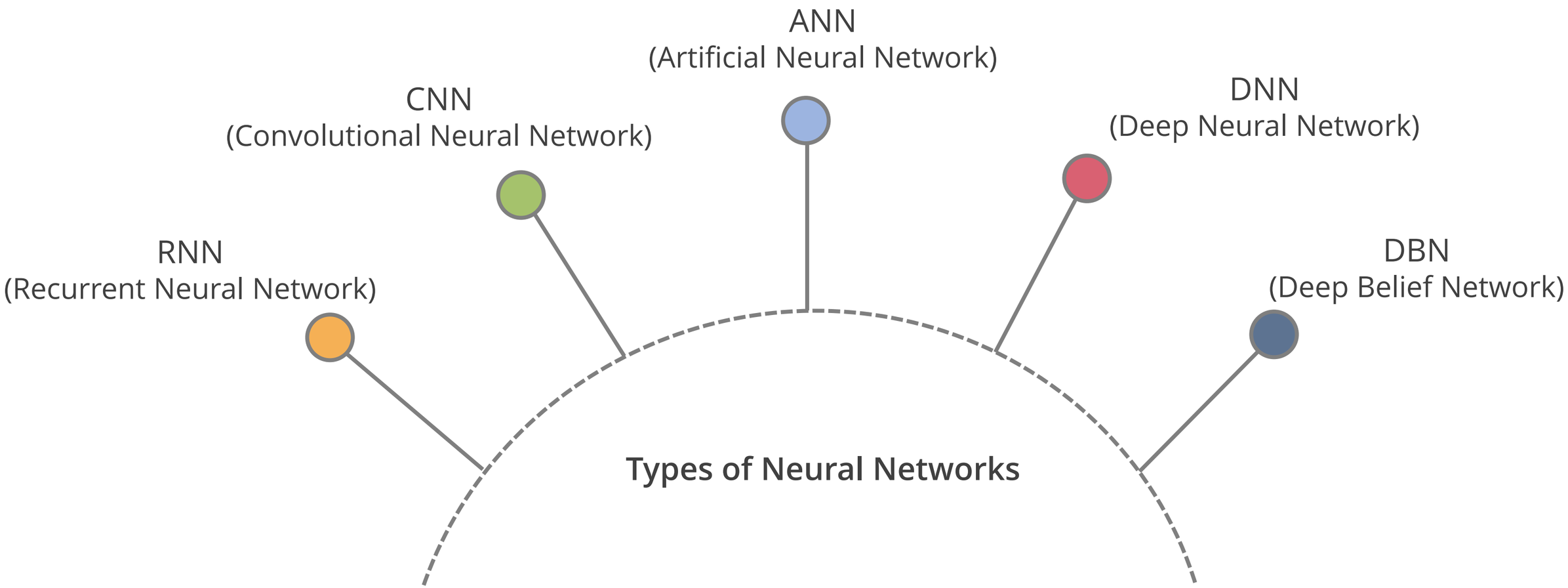




- The outputs from the first layer are then passed into the second layer to be processed.
- This continues until the final output is produced.
- The assumption is that the correct output is predefined.
- Each time data is passed through the network, the end result is compared with the correct one, and tweaks are made to their values until the network creates the correct final output each time.

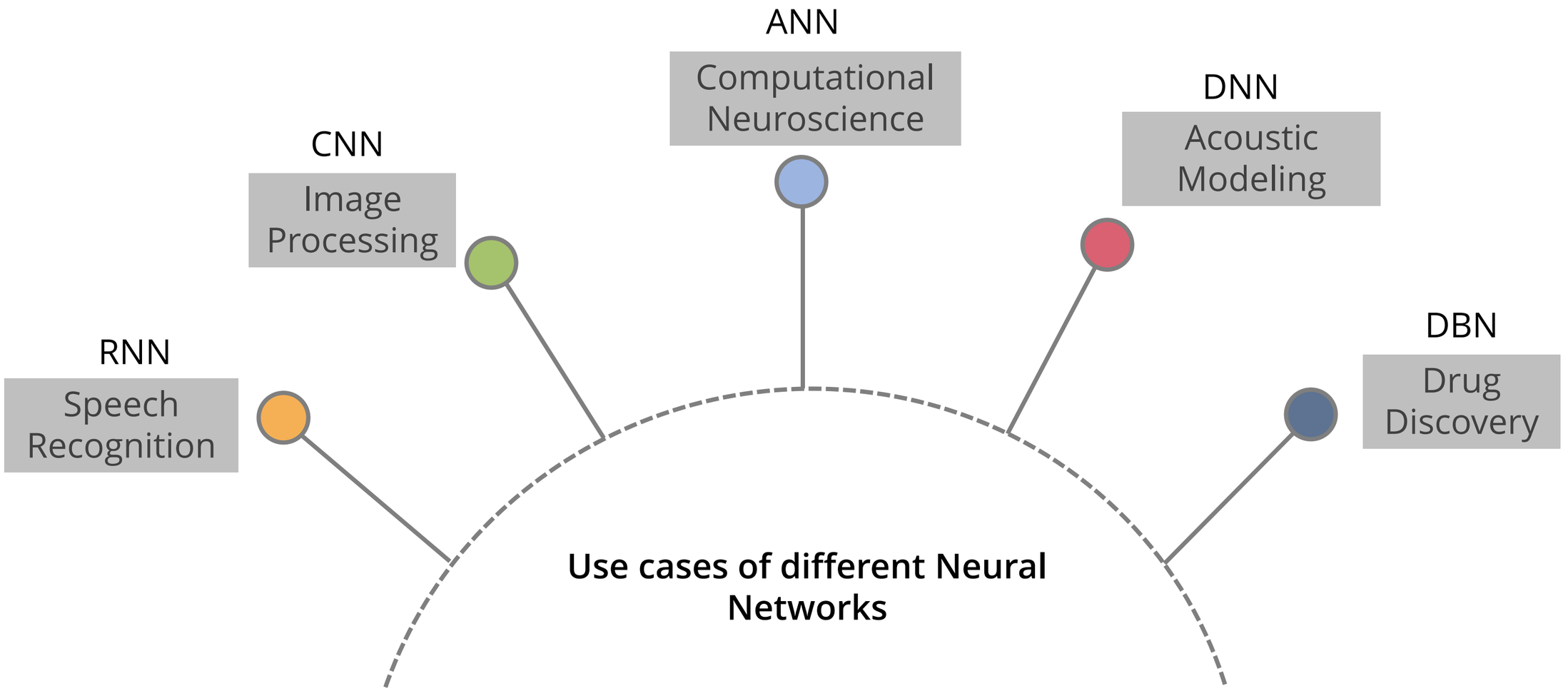
Types of Neural Networks

Some of the commonly used neural networks are as follows:



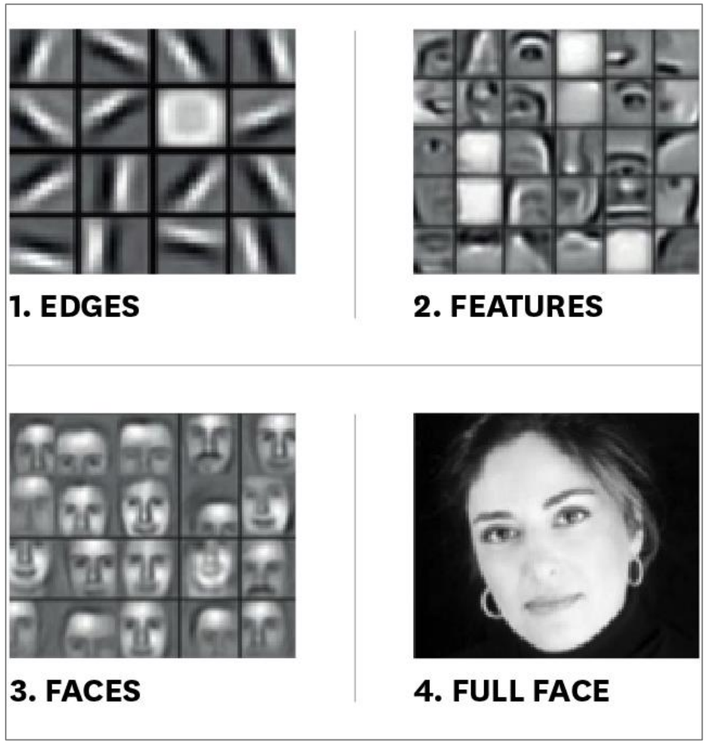
Types of Neural Networks

Use Cases



Case Study: DeepFace

What?

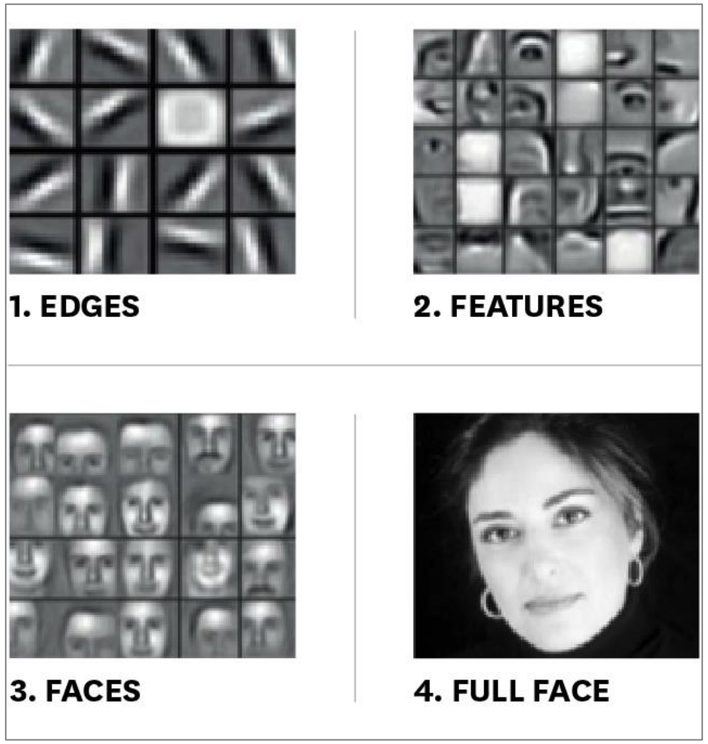


- DeepFace is Facebook's facial recognition system created using Deep Learning.
- It uses a nine layer neural network with more than 120 million connection weights.
- The researchers used four million images uploaded by Facebook users.
- Facebook has been using this technology since 2015.

Source: hbr.org

Case Study: DeepFace

How?



- Layers of virtual neurons are trained to identify edges, features, a face, and so on.
- In the example given on the left, the first layer recognizes edges.
- The second layer recognizes facial features like a nose or an ear.
- The third layer recognizes faces. The full face is eventually recognized in the fourth layer.
- The layers of a neural network work in coordination with each other to progressively add more insight as the data passes from input layers toward the output layers.

Source: hbr.org

Introduction to Deep Learning

Topic 4: Deep Learning Platforms

CPU and GPU Specifications

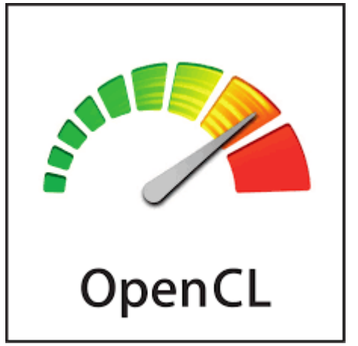
The table below shows that GPUs (right column) are cheaper than modern CPUs (middle column) for deep learning tasks. In addition, they support a lot more cores and calculations.

Specifications	Intel® Core™ i7-6900K Processor Extreme Ed.	NVIDIA GeForce® GTX™ 1080 Ti
Base Clock Frequency	3.2 GHz	< 1.5 GHz
Cores	8	3584
Memory Bandwidth	64 GB/s	484 GB/s
Floating-Point Calculations	409 GFLOPS	11300 GFLOPS
Cost	~ $1000.00	~ $700.00

Python Specifications

- Python is limited to execution on one core due to the Global Interpreter Lock (GIL).
- Multiprocessing library in Python allows distributed computation over several cores, but most advanced desktop hardware comes only with a maximum of 8 to 16 cores.

GPU: Special Packages



- In image processing, there can be an explosion in number of parameters.
- Single processor units cannot handle these easily, but GPUs can. Each GPU is akin to a small computer cluster.
- However, one has to use special packages like CUDA or OpenCL to write code for GPUs.
- Deep Learning library like TensorFlow makes it easy to write code for either OpenCL or CUDA-enabled GPUs.
- Deep Learning platforms include: Tensorflow (Python Based), Keras (Python), Torch(C/C++), and Deeplearning4j(JAVA).

Key Takeaways

- Deep Learning is a subset of Machine Learning and Artificial Intelligence and makes complex features and input-output relationships learnable.
- New breakthroughs in neural networks, availability of Big Data, and low-cost high-performance GPU chips are driving the Deep Learning revolution.
- Deep Learning is useful for complex intelligence tasks like face recognition, speech recognition, machine translation etc.
- Artificial Neural Network is a computing system made up of a number of simple, highly interconnected processing elements that process information by their dynamic state response to external inputs. It is modeled on the inter-connected neurons in the human brain.
- Each circular node represents an artificial neuron, and an arrow represents a connection from the output of one neuron to the input of another.
- Some of the commonly used neural networks are RNN, CNN, ANN, DNN, and DBN.
- GPUs are cheaper than modern CPUs now, in addition to supporting a lot more cores and calculations.

This concludes “Introduction to Deep Learning”

The next lesson is “Perceptron.”