Artificial Neural Networks
Unit -2

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Content:

- Brief history of neural networks
- Biological Neural Networks
- Fundamentals of Biological Neural Networks
- Modeling of One Biological Neural Networks as Artificial Neural Network
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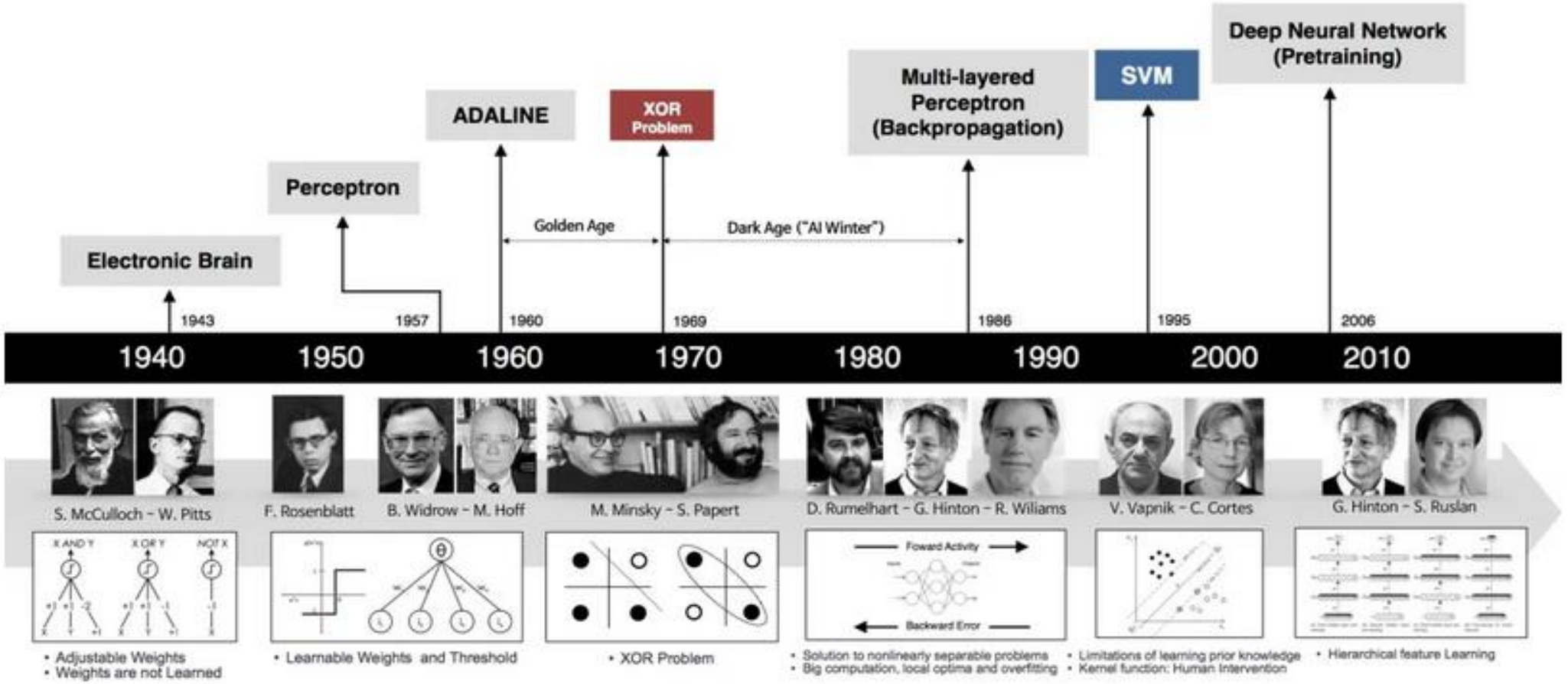
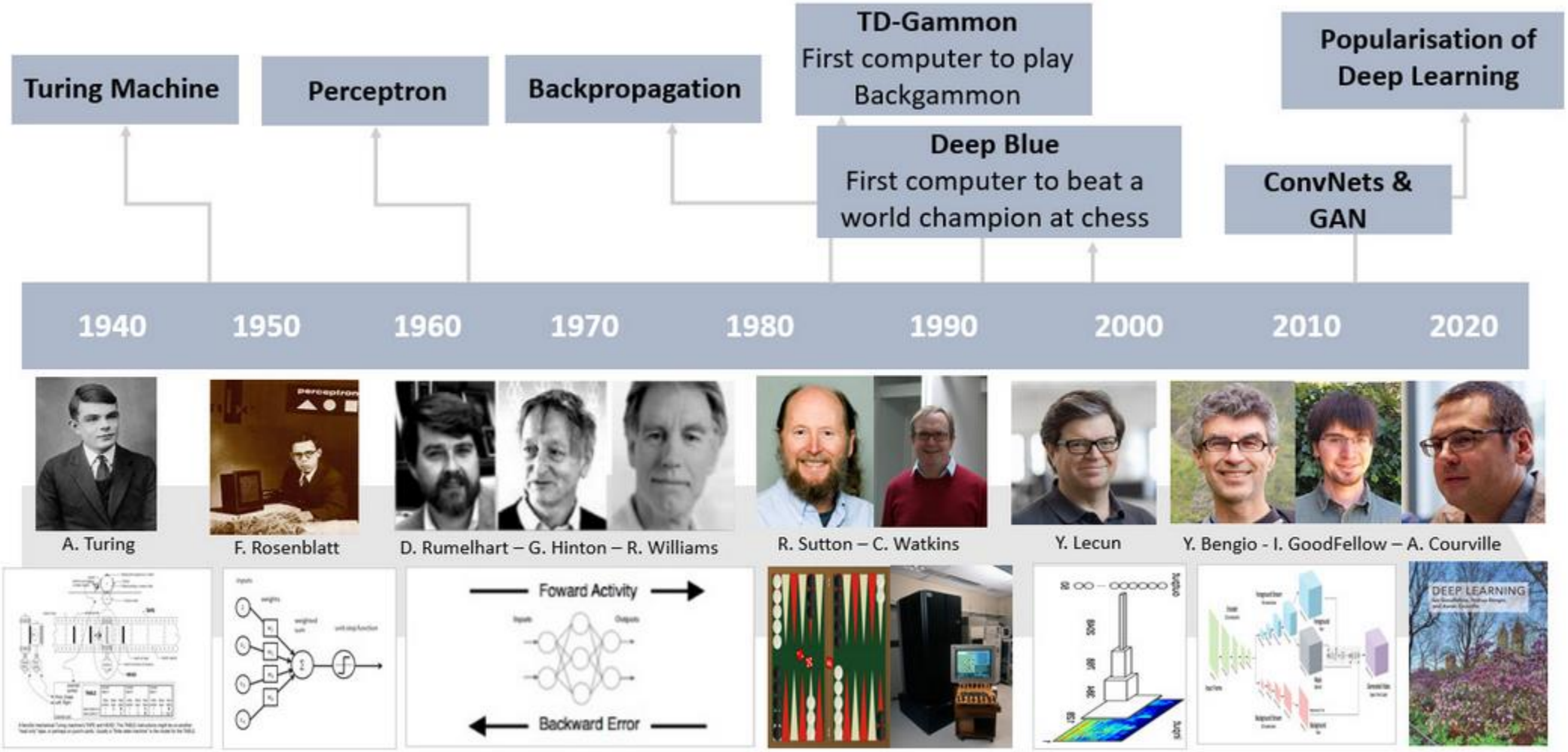
- Activation Functions in Neural Networks
- Layer in Artificial Neural Network (ANN)
- Overview of a Neural Network's Learning Process
- Image Classification with MNIST Dataset
- Human and Machine deal with information (Data)
- Human and Machine Perception
- ML and DL applications

Brief history of neural networks

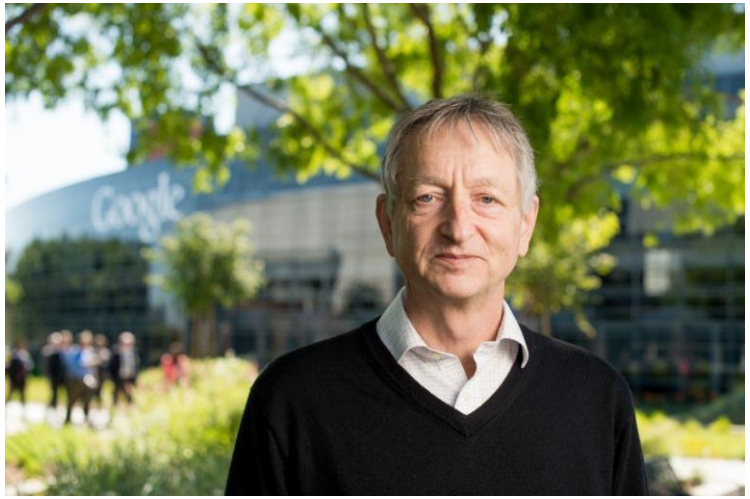


Brief history of neural networks

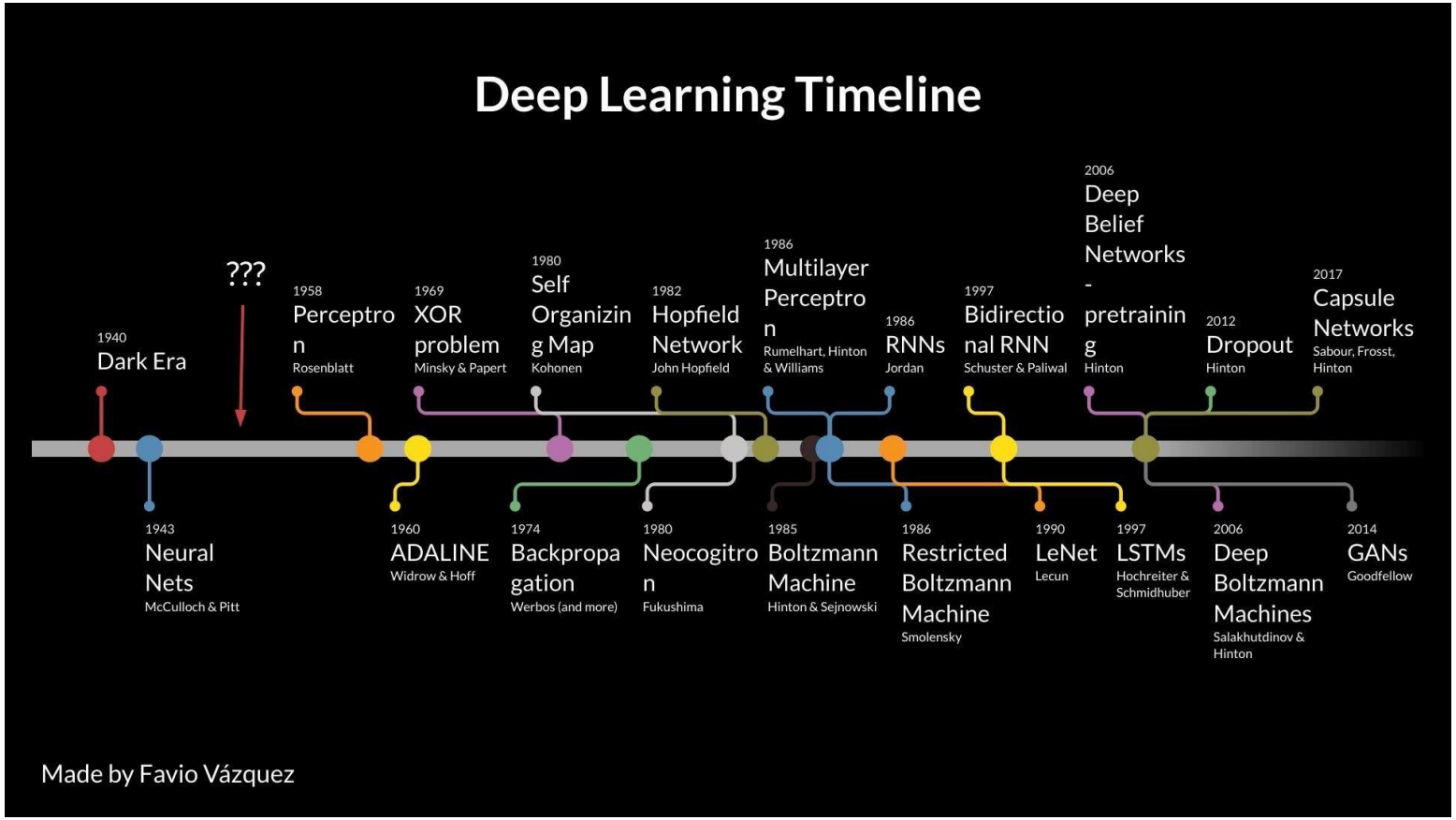


Top Most Researchers :

Geoffrey Hinton “Godfather of Deep Learning”



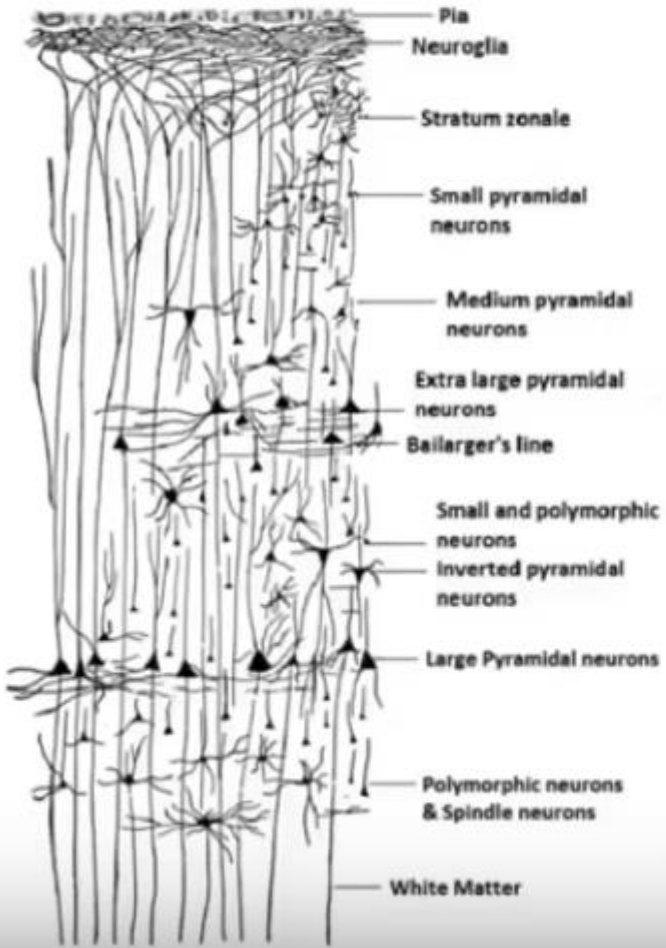
https://www.cs.toronto.edu/~hinton/

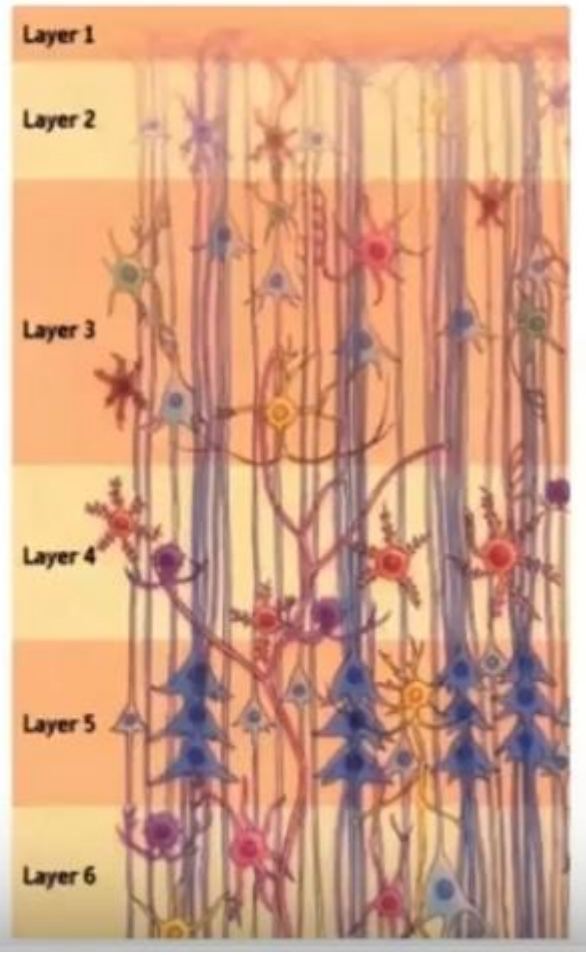


Architecture of Intelligence

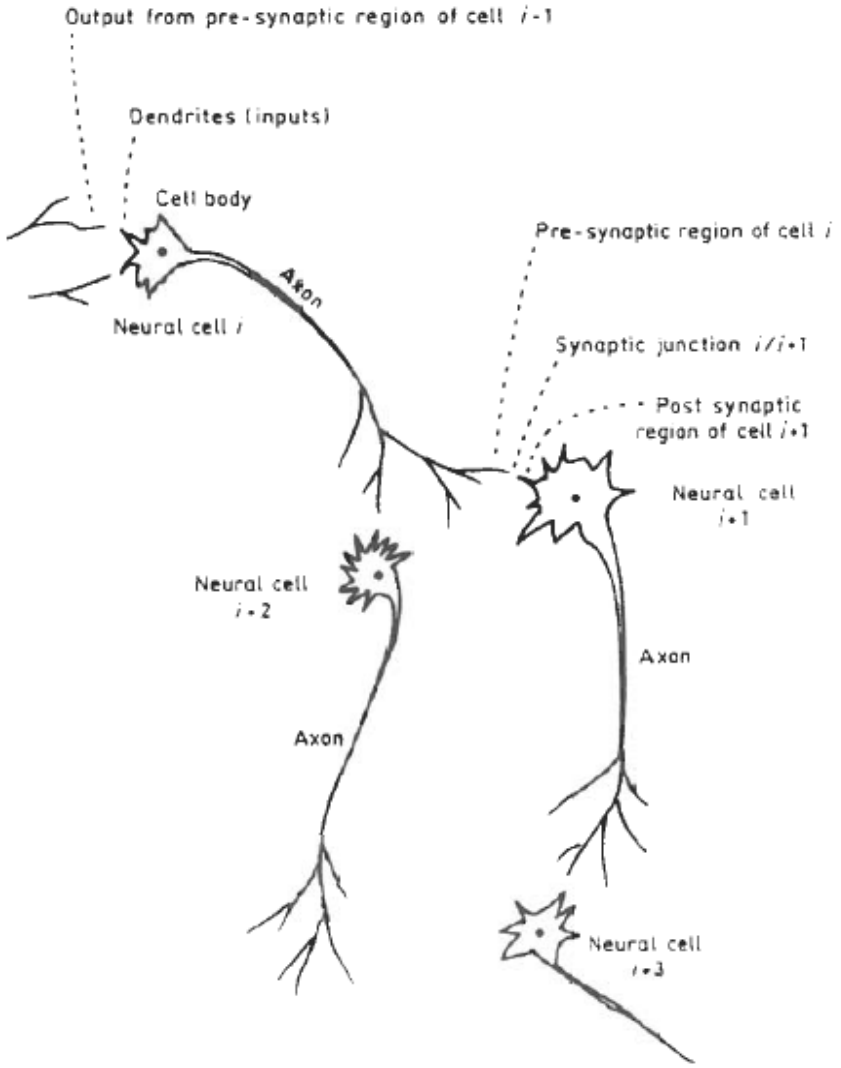
Micro Etching of Brain

Cross-section of the cortex

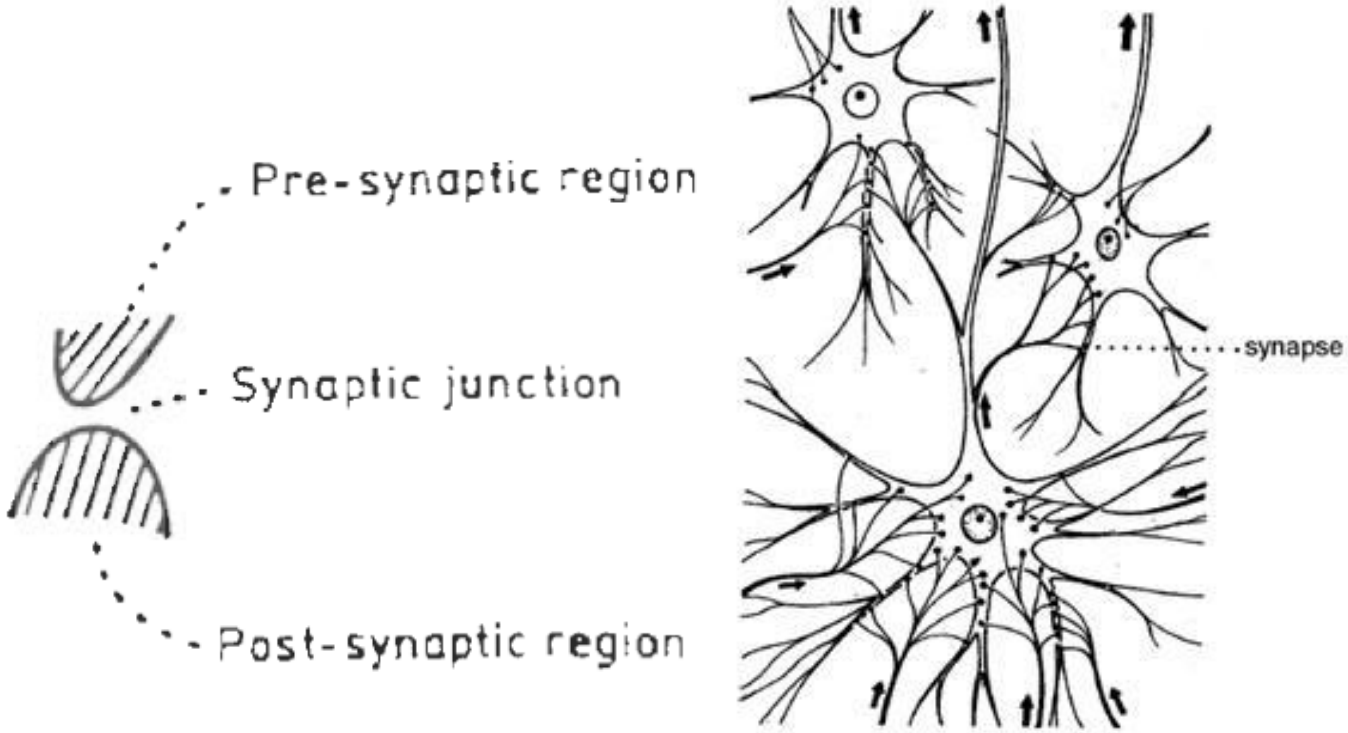




Biological Neural Networks



Interconnection of biological neural nets.



Synaptic junction — detail

Fundamentals of Biological Neural Networks

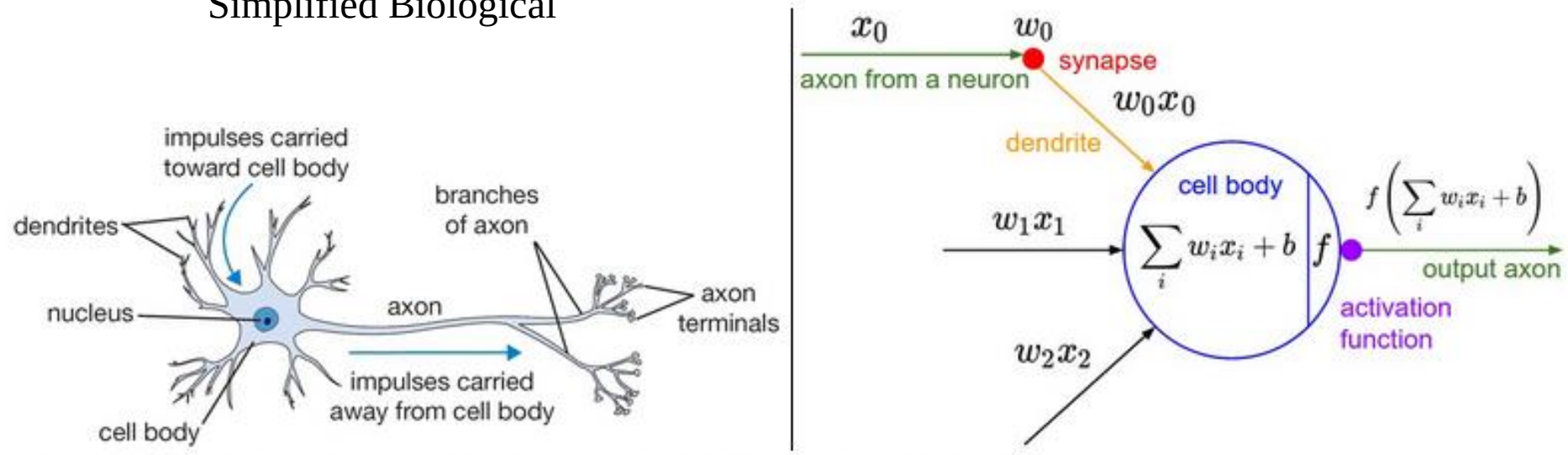
A biological neural cell (neuron)

- Robbert L. Harvey focuses very much on the biological model. His definition excludes most parts of logical neural networks from the field of neural networks.
- A neural network is a dynamical system with one-way interconnections. It carries out processing by its response to inputs. The processing elements are nodes; the interconnects are directed links. Each processing element has a single output signal from which copies fan out."
- The author of this report has the following definition which is more concerned with the fundamental ideas of neural systems and the basic properties of the brain rather than the aspect of modeling parts of the nervous system.

Modeling of One Biological Neural Networks as Artificial Neural Network

Artificial neural networks (ANNs) were designed **to simulate the biological nervous system, where information is sent via input signals to a processor, resulting in output signals**. ANNs are composed of multiple processing units that work together to learn, recognize patterns, and predict data.

Simplified Biological



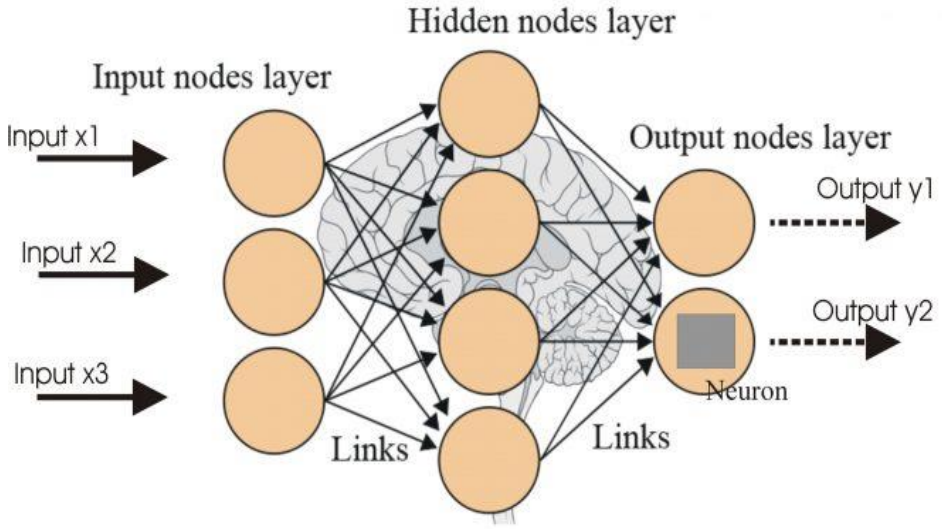
A cartoon drawing of a biological neuron (left) and its mathematical model (right).

Simplified Biological Neurons into Artificial Neural Network

The Architecture of Neural Networks

There are 3 layers mainly in neural networks.

- Input Layer
- Hidden Layers
- Output Layer

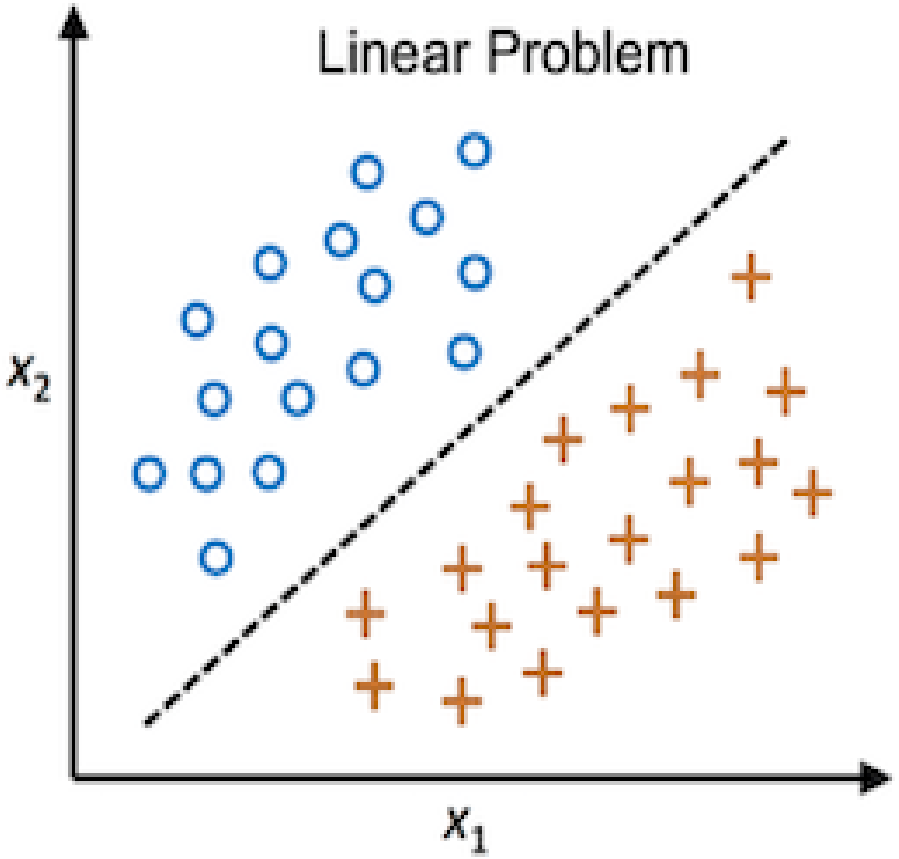


An Artificial Neural System (ANS)

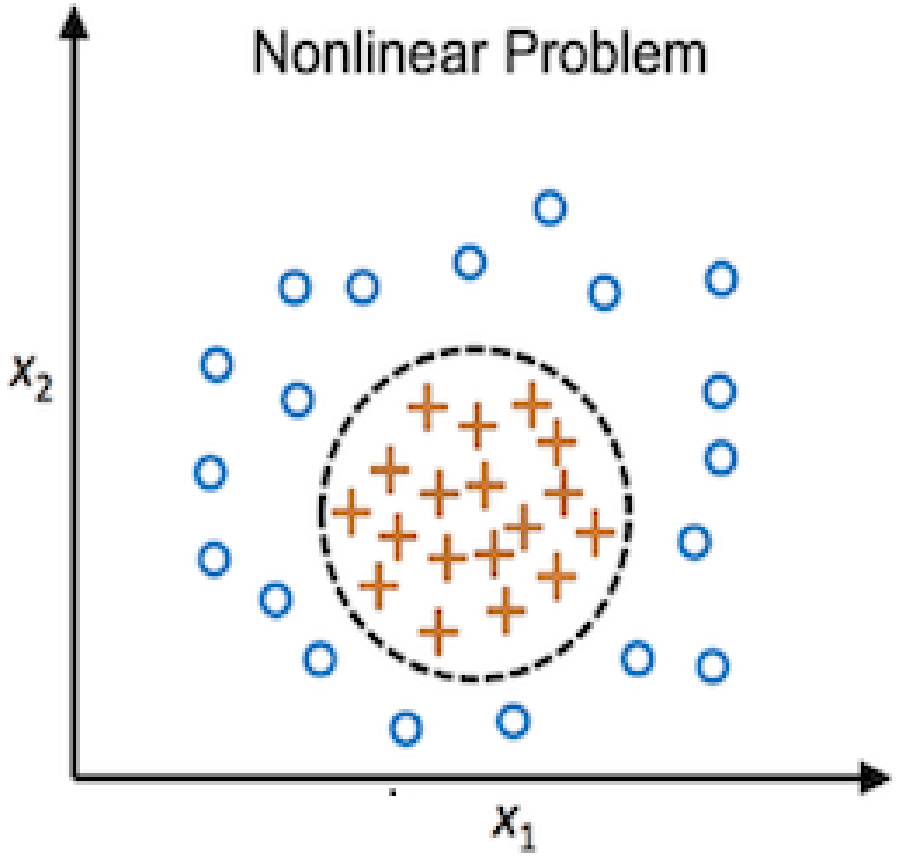
- consists of simple interconnected modules.
- is based on communication between modules.
- performs its task by parallel processing.
- is fault tolerant.
- is learning from example.
- has the ability to generalize.
- performs complex tasks due to the whole architecture.

Activation Functions in Neural Networks

Linearly/Non-Linearly Separable Data



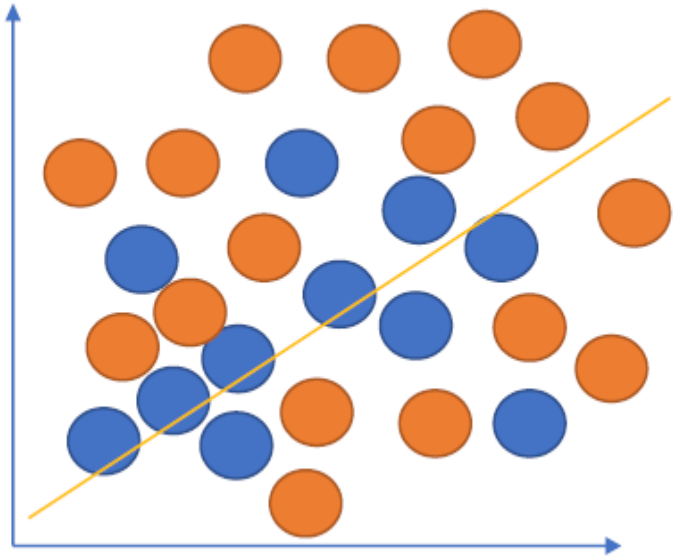
The 2 classes can be separated by a straight line

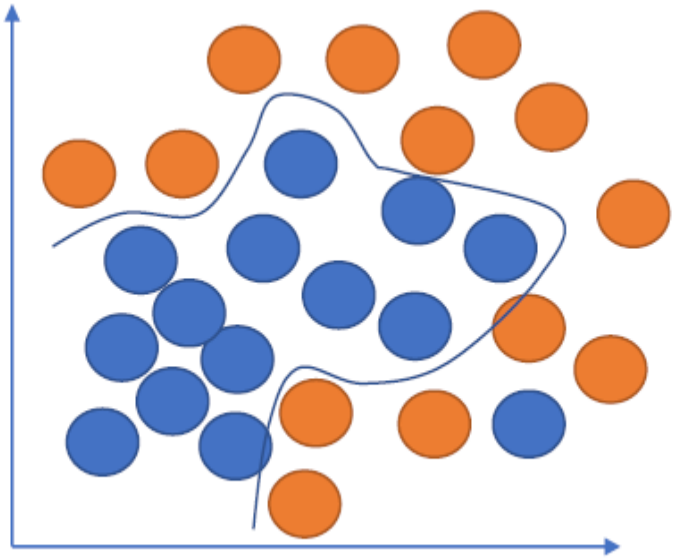


The 2 classes can be separated by a curve or a more complex function that a straight line

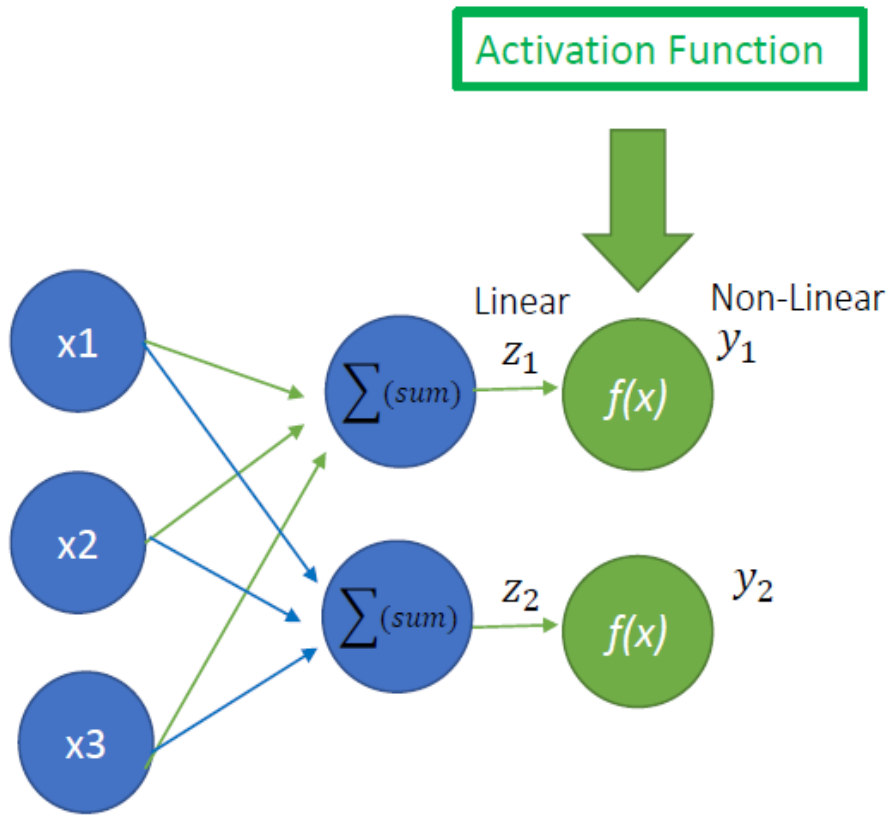
Why do we need activations?

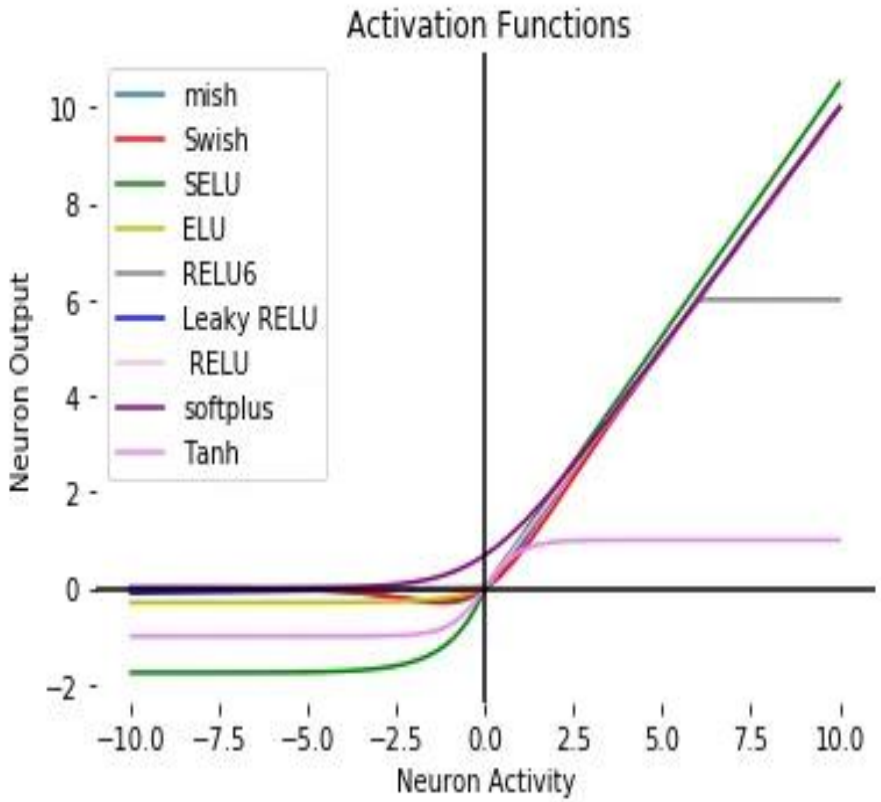
Our real world data in non-linear, and cannot be separated by a straight line. We wish to learn much more complex functions to be able to predict/classify the data we are working with.





Therefore, we need an Activation function f(x) to make our neural network more powerful and enable it to learn complex and complicated data and represent non-linear complex arbitrary functional mappings between inputs and outputs, in addition to multiple MLPs. An Activation function is a non-linear function which takes a linear scalar z_1 as its input and maps it to another numerical value y_1





Neural Network Activation Functions: a small subset!

ReLU

$$\max(0, x)$$

GELU

$$\frac{x}{2}\left(1 + \tanh\left(\sqrt{\frac{2}{\pi}}\left(x + ax^3\right)\right)\right)$$

PReLU

$$\max(0, x)$$

ELU

$$\begin{cases} x \text{ if } x > 0 \\ \alpha(x \exp x - 1) \text{ if } x < 0 \end{cases}$$

Swish

$$\frac{x}{1 + \exp -x}$$

SELU

$$\alpha(\max(0, x) + \min(0, \beta(\exp x - 1)))$$

SoftPlus

$$\frac{1}{\beta}\log\left(1 + \exp(\beta x)\right)$$

Mish

$$x \tanh\left(\frac{1}{\beta}\log\left(1 + \exp(\beta x)\right)\right)$$

RReLU

$$\begin{cases} x \text{ if } x \geq 0 \\ ax \text{ if } x < 0 \text{ with } a \sim \Re(l, u) \end{cases}$$

HardSwish

$$\begin{cases} 0 \text{ if } x \leq -3 \\ x \text{ if } x \geq 3 \\ x(x+3)/6 \text{ otherwise} \end{cases}$$

Sigmoid

$$\frac{1}{1 + \exp(-x)}$$

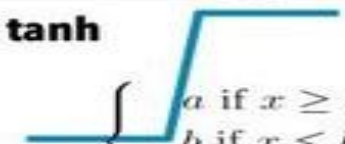
SoftSign

$$\frac{x}{1 + |x|}$$

Tanh

$$\tanh(x)$$

Hard tanh



$$\begin{cases} a \text{ if } x \geq a \\ b \text{ if } x \leq b \\ x \text{ otherwise} \end{cases}$$

Hard Sigmoid

$$\begin{cases} 0 \text{ if } x \leq -3 \\ 1 \text{ if } x \geq 3 \\ x/6 + 1/2 \text{ otherwise} \end{cases}$$

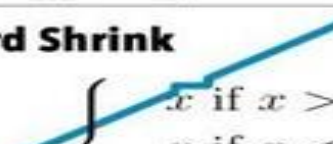
Tanh Shrink

$$x - \tanh(x)$$

Soft Shrink

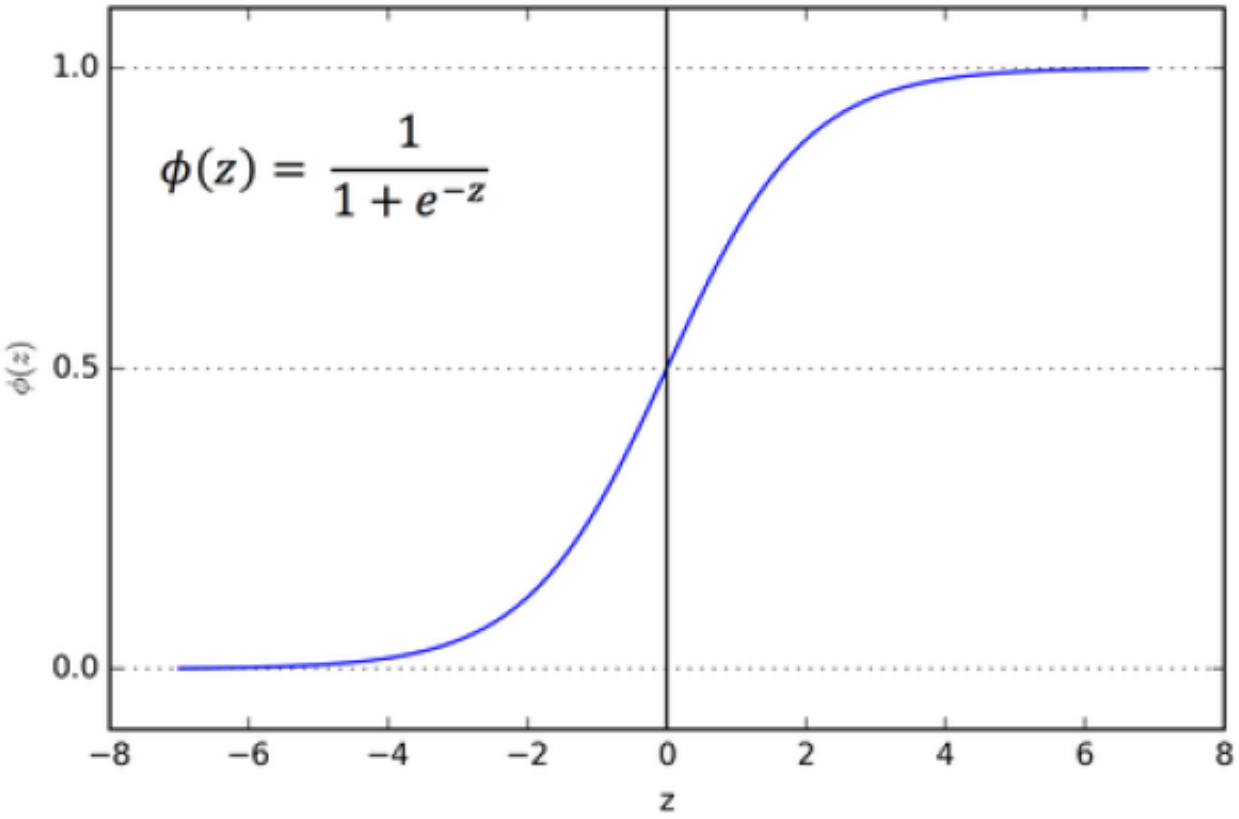
$$\begin{cases} x - \lambda \text{ if } x > \lambda \\ x + \lambda \text{ if } x < -\lambda \\ 0 \text{ otherwise} \end{cases}$$

Hard Shrink



$$\begin{cases} x \text{ if } x > \lambda \\ x \text{ if } x < -\lambda \\ 0 \text{ otherwise} \end{cases}$$

Sigmoid Function



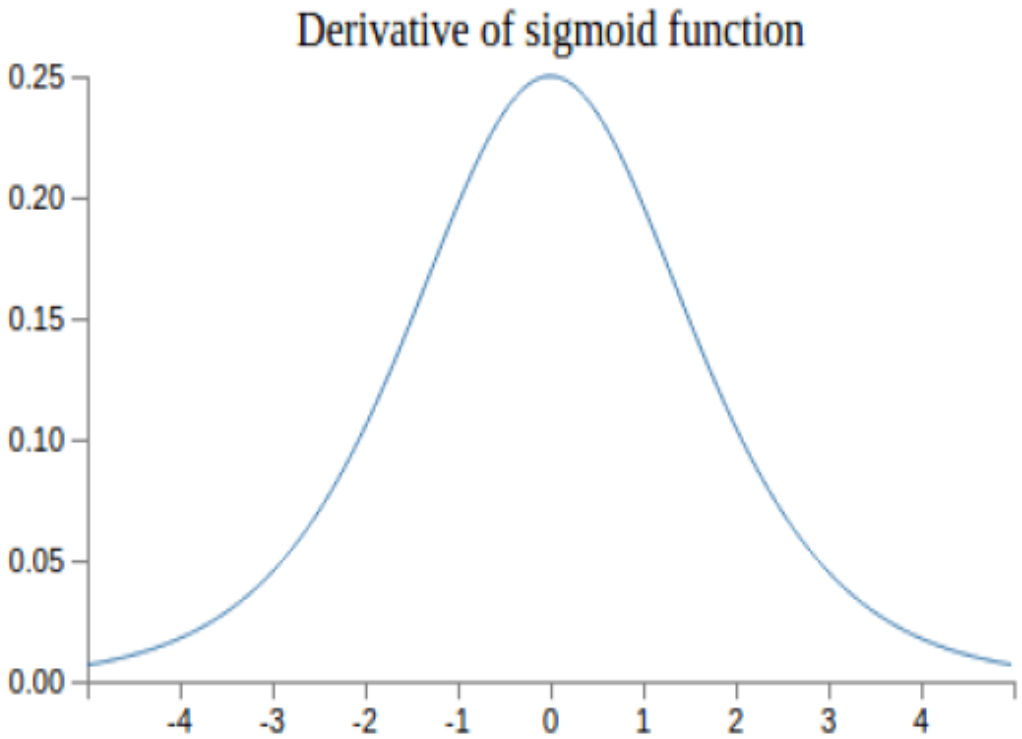
Any input will be scaled to a value between 0-1

Ex:

x = 2 → f(x) = 1 / (1 + e^{-2}) = 0.88080

x = -1 → f(x) = 1 / (1 + e^{1}) = 0.26894

Sigmoid Function Derivative

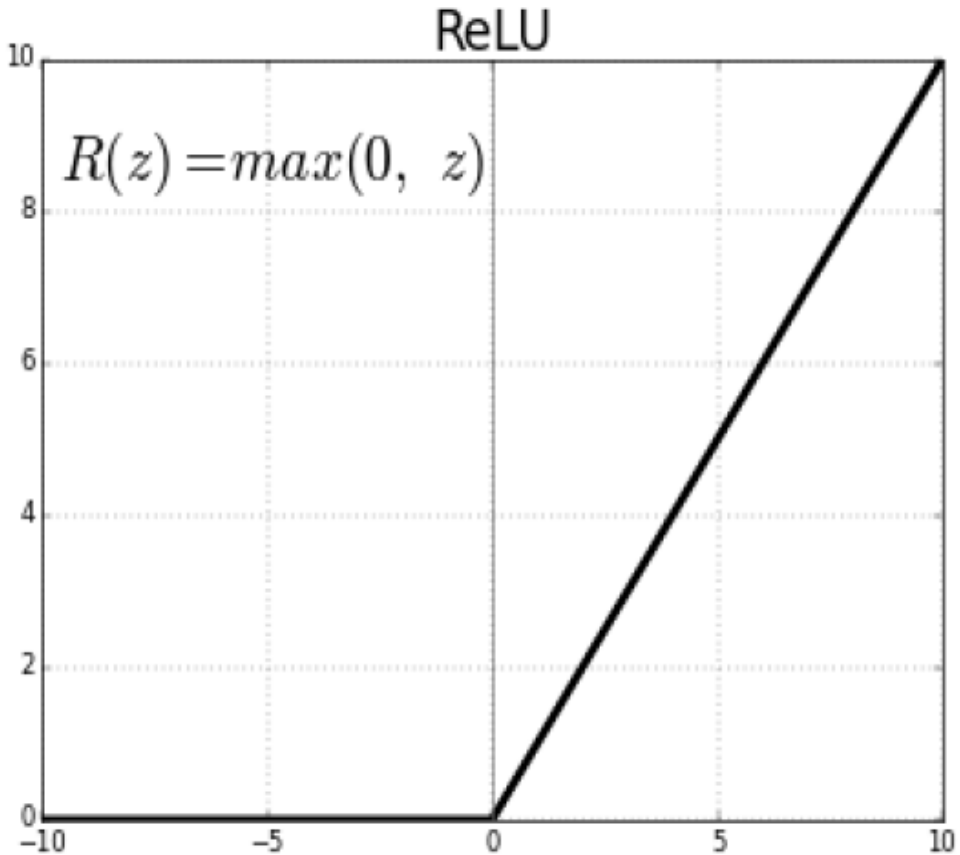


$$y = \frac{1}{1+e^{-x}}$$

$$\frac{dy}{dx} = -\frac{1}{(1+e^{-x})^2}(-e^{-x}) = \frac{e^{-x}}{(1+e^{-x})^2}$$

$$= \frac{1}{1+e^{-x}}\left(1 - \frac{1}{1+e^{-x}}\right) = y(1-y)$$

Rectified Linear Unit (ReLU)



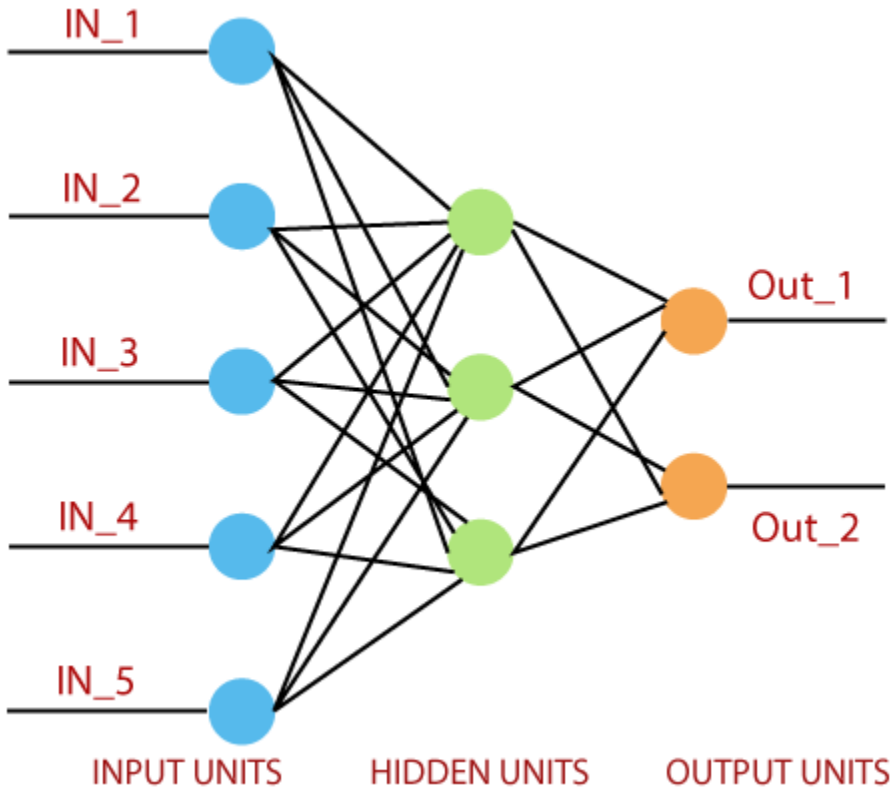
If the input is negative → Output is Zero

If the input is positive → Stays Positive

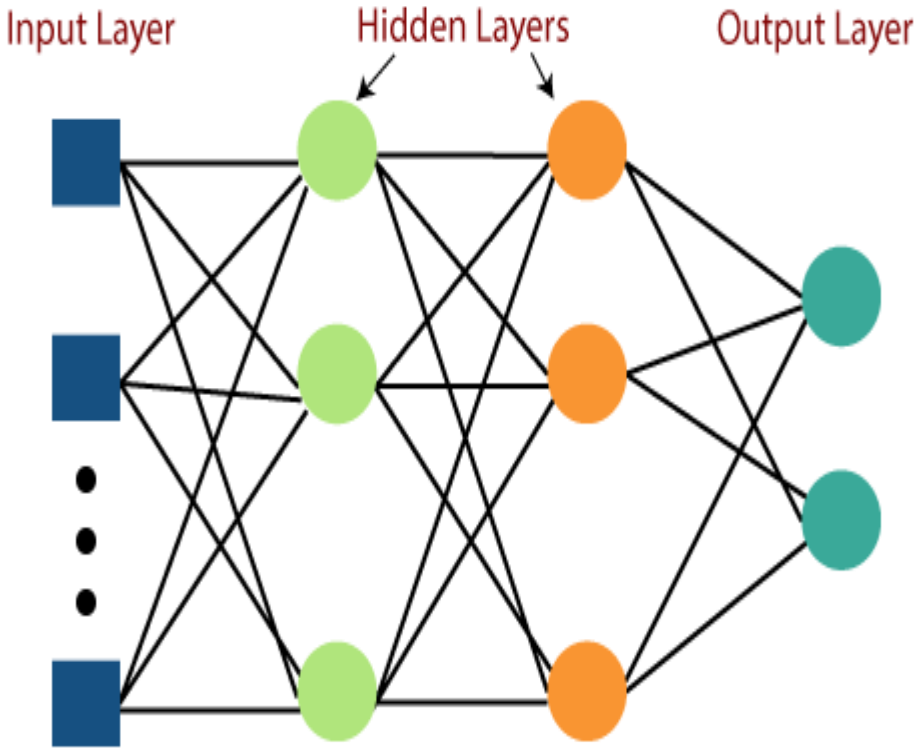
Ex: **6 → 6**
0 → 0
-3 → 0
2 → 2

$$f(x) = \begin{cases} 0 & \text{for } x < 0 \\ x & \text{for } x \geq 0 \end{cases}$$

Layer in Artificial Neural Network (ANN)

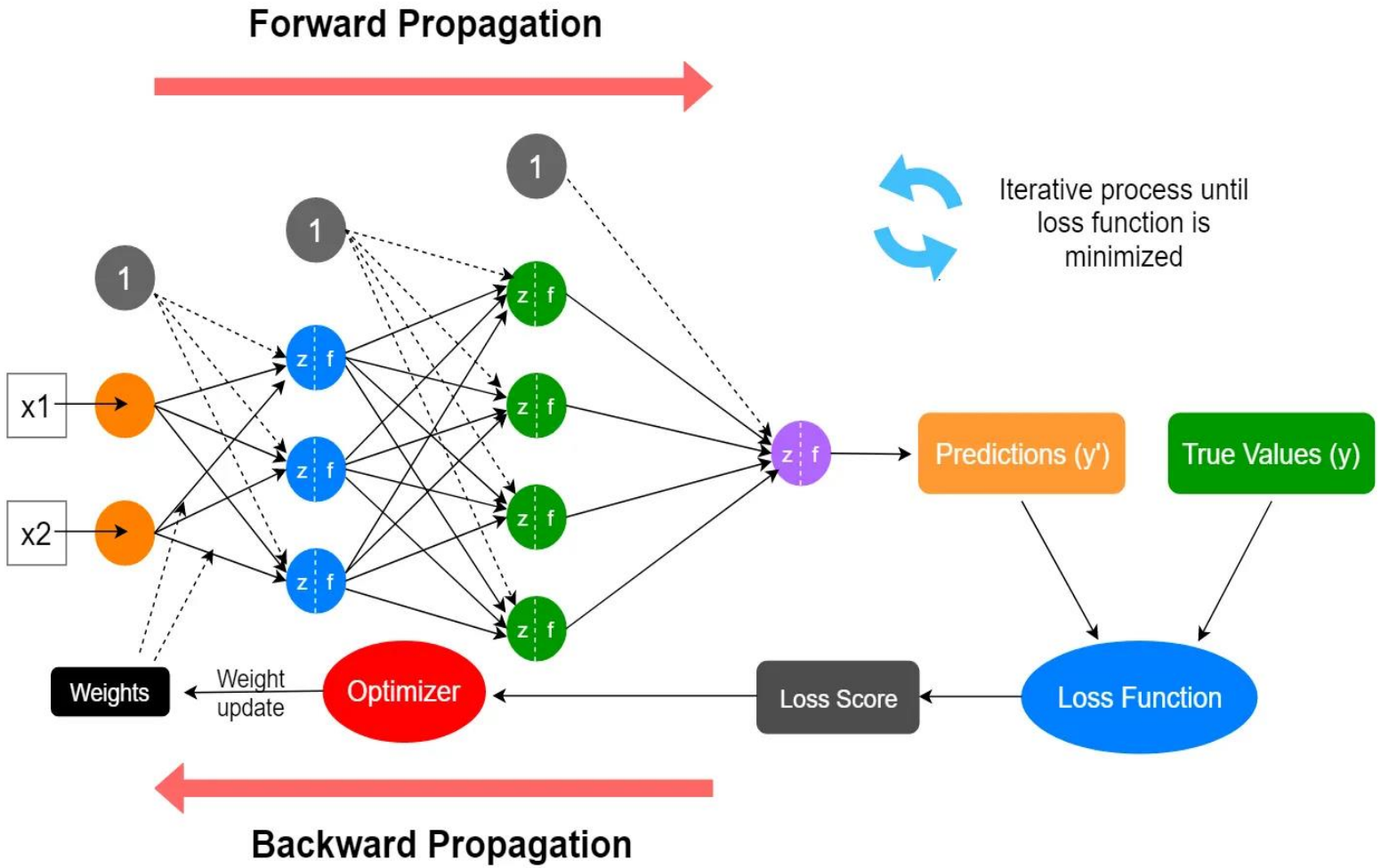


Single Layer Perceptron

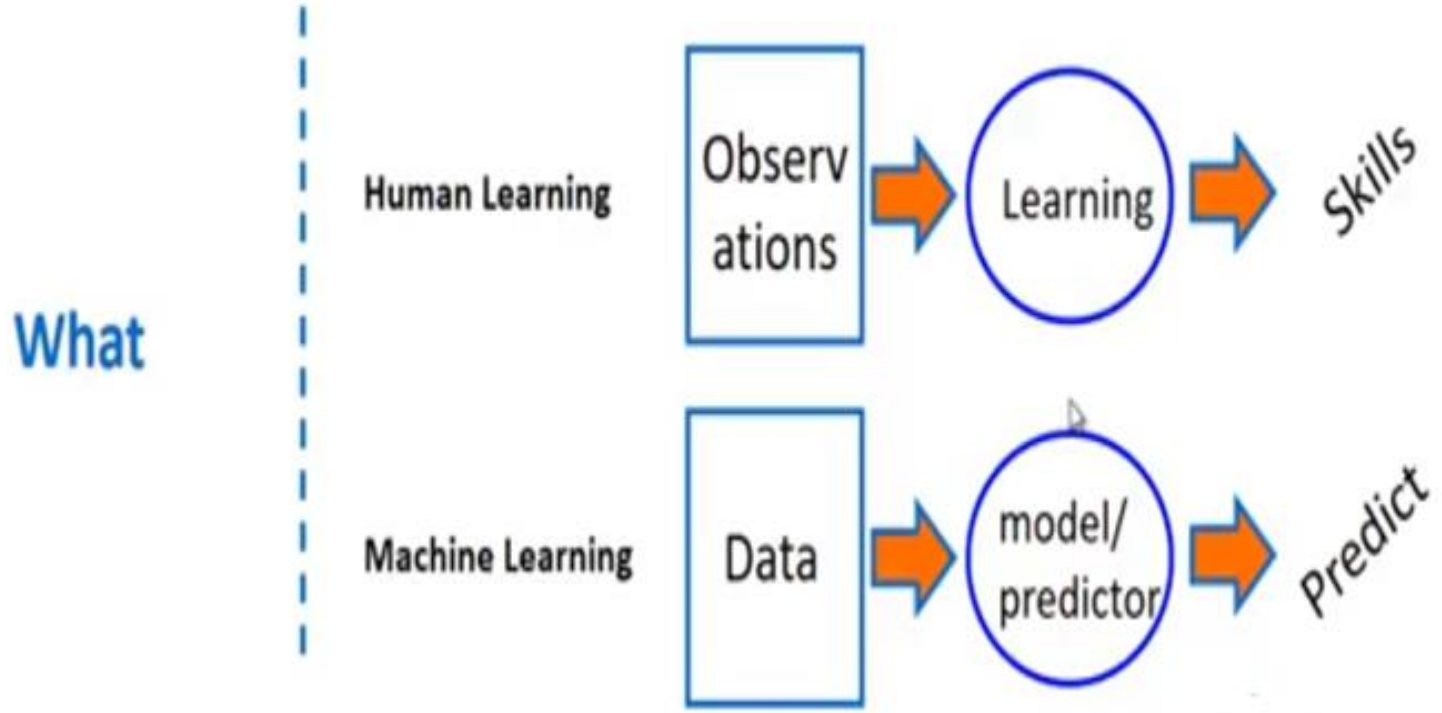


Multi-Layer perceptron

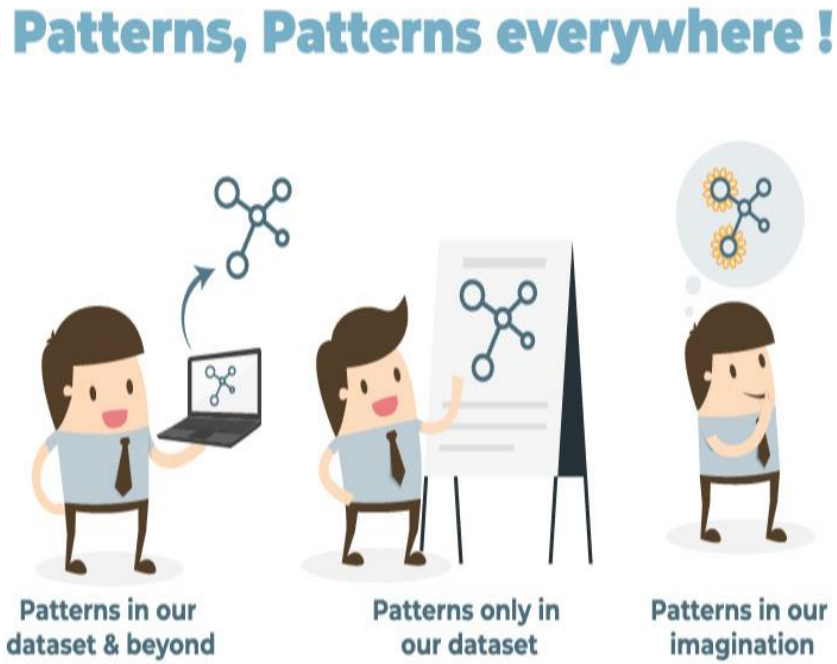
Overview of a Neural Network's Learning Process

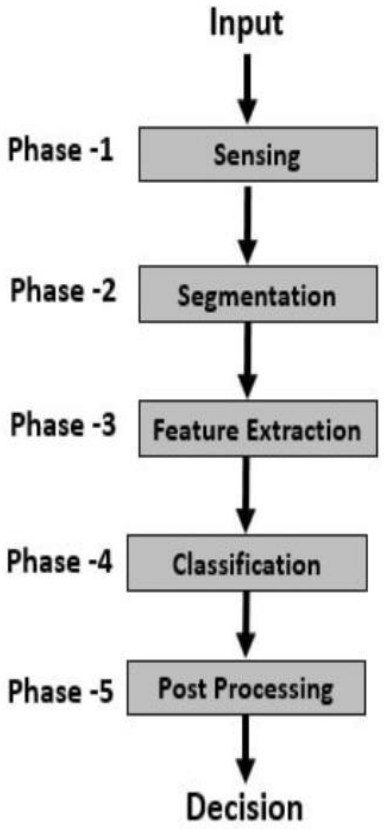


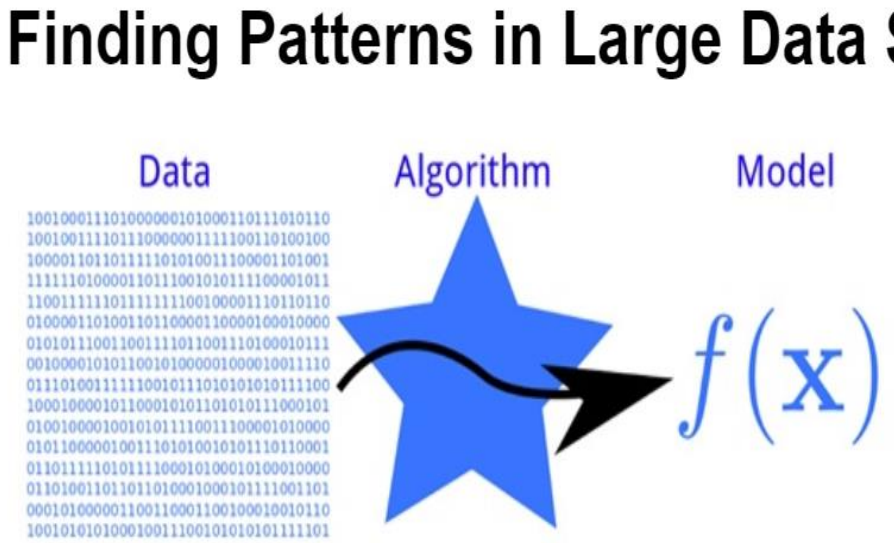
Human and Machine deal with information (Data)



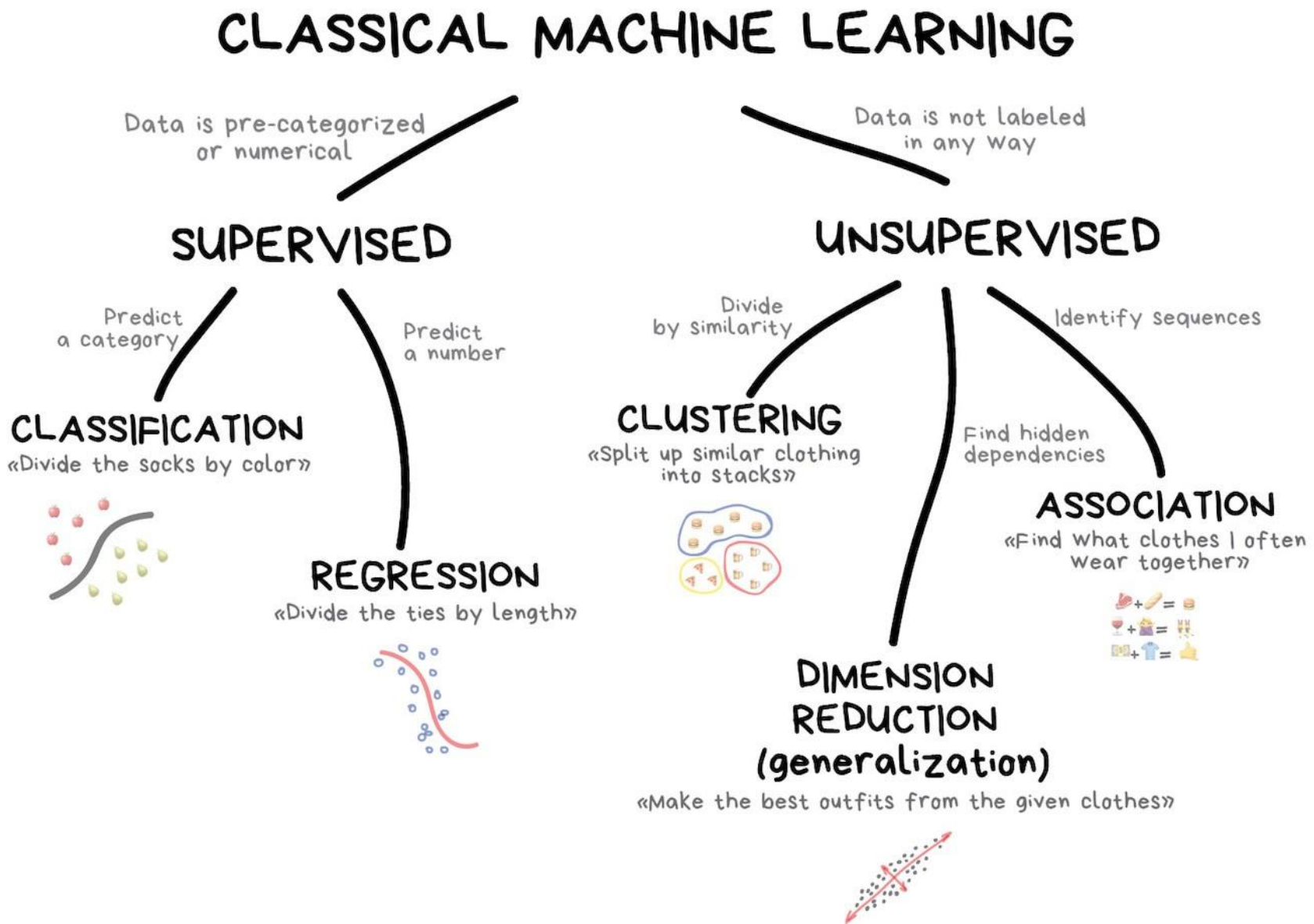
Human and Machine Perception: it is with patterns







Classification of ML/DL Algorithm:



Machine and Deep Learning Model

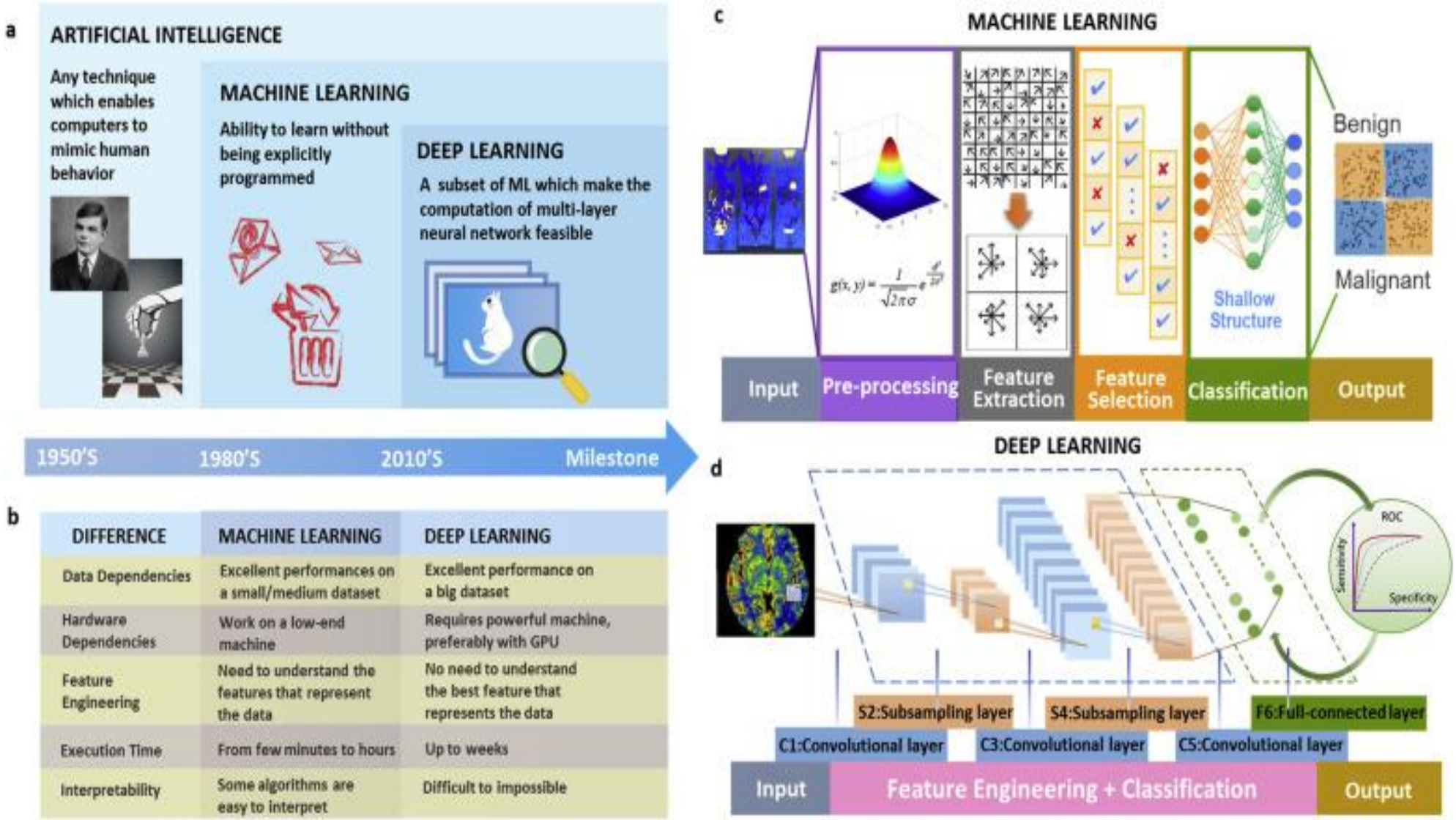
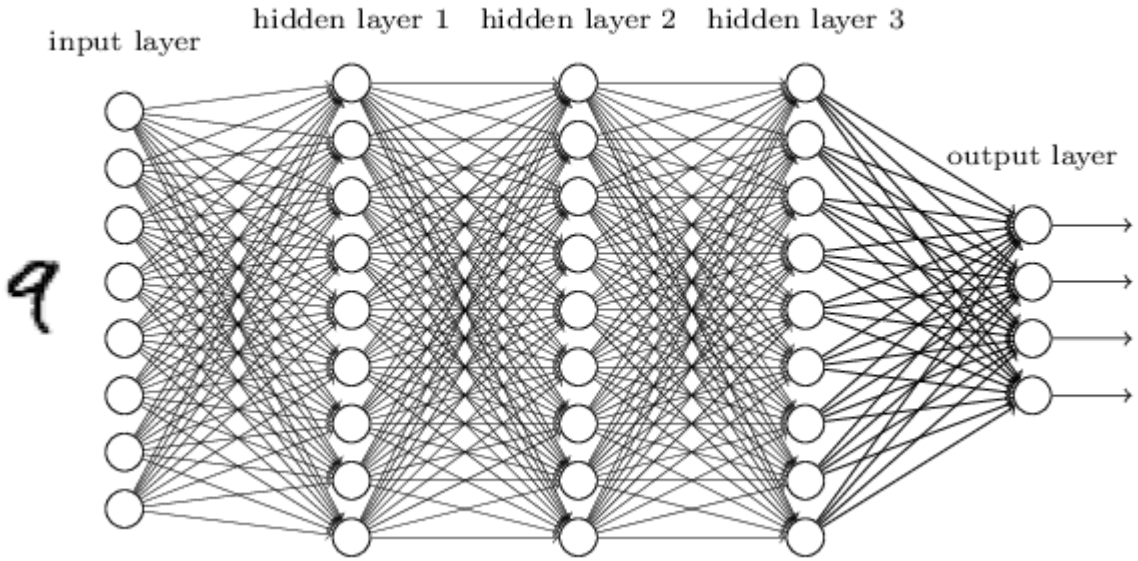
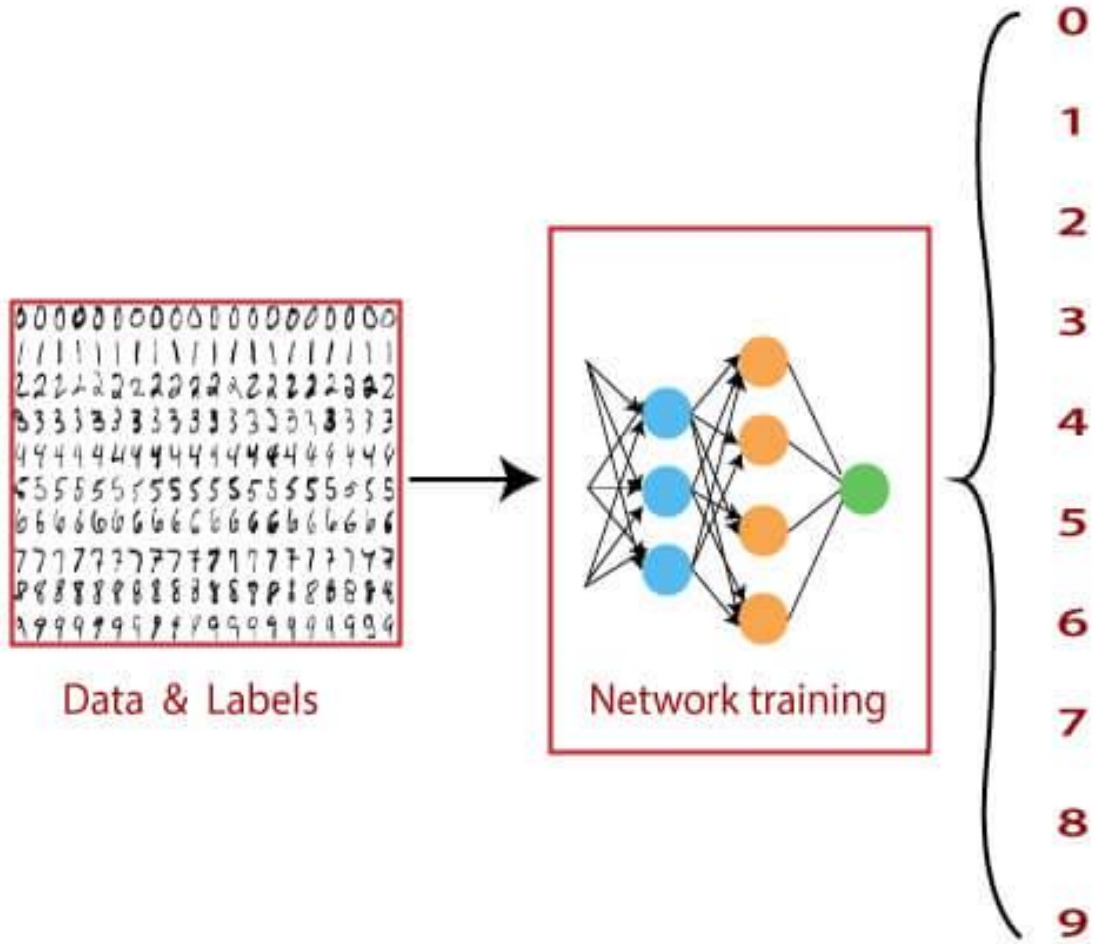
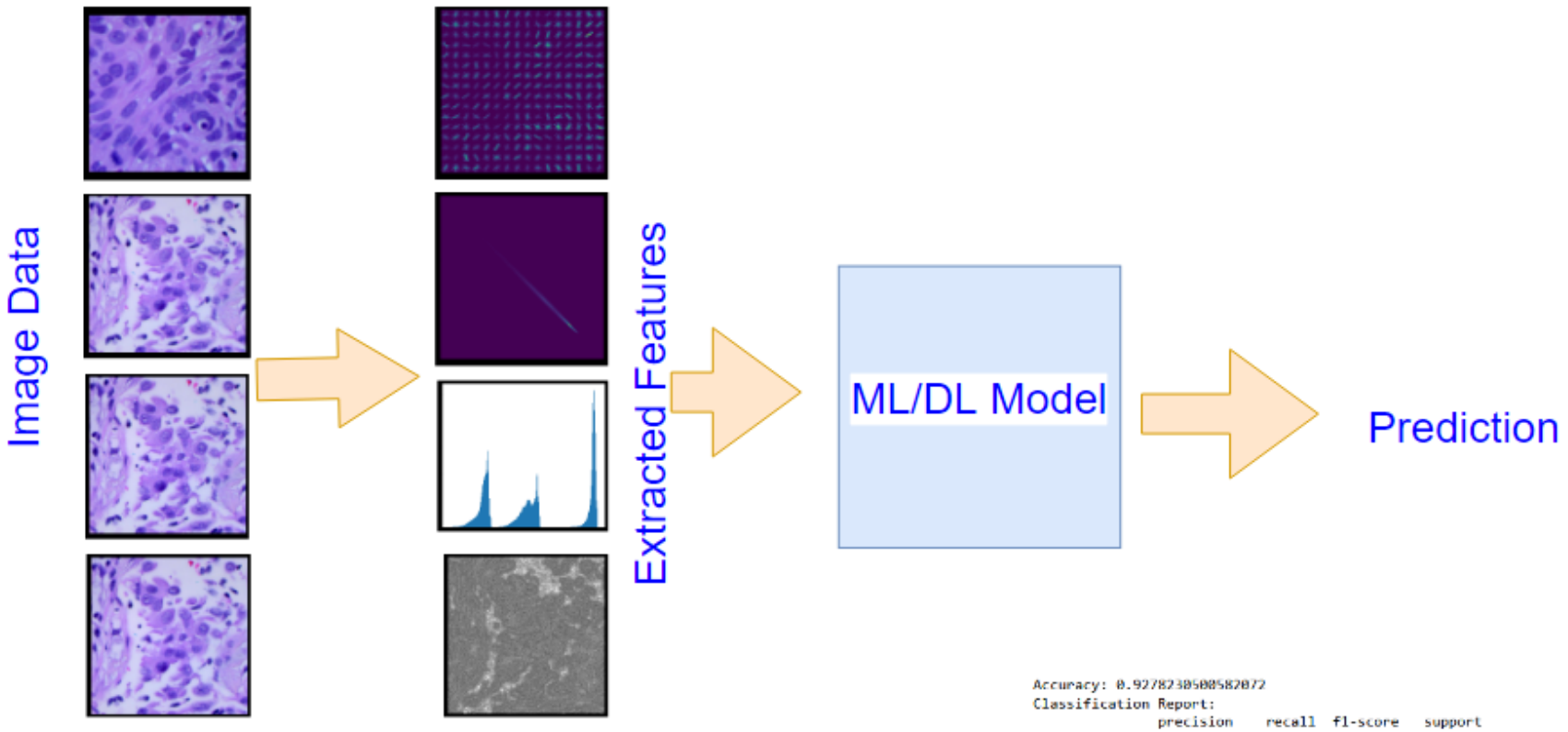


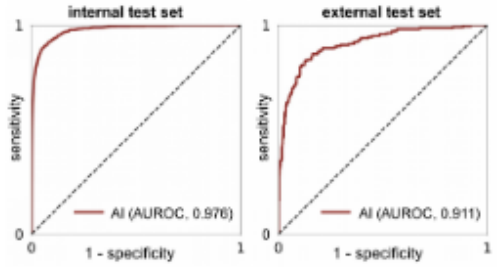
Image Classification with MNIST Dataset: Using ANN model

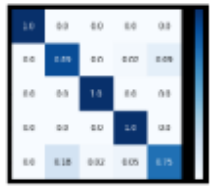




Classification of Cancer using ML/DL Algorithm:







```
Accuracy: 0.9278230500582072
Classification Report:
              precision    recall  f1-score   support

         0.0       1.00      1.00      1.00       172
         1.0       0.83      0.89      0.86       171
         2.0       0.98      1.00      0.99       172
         3.0       0.94      1.00      0.97       172
         4.0       0.89      0.75      0.81       172

    accuracy                           0.93       859
   macro avg       0.93      0.93      0.93       859
weighted avg       0.93      0.93      0.93       859

Confusion Matrix:
 [[172   0   0   0   0]
 [  0 152   0   3  16]
 [  0   0 172   0   0]
 [  0   0   0 172   0]
 [  0  31   4   8 129]]
```

Question & Answers..?

Thank you..