

# ARTIFICIAL INTELLIGENCE AND DEEP LEARNING



WEEK 2  
2021 SPRING



## **CHAPTER 2: Machine Learning and Artificial Neural Networks**

### **Chapter Goals**

At the end of this chapter, you will be able to,

- Explain the Notion of machine learning
- Count the learning methods used in machine learning,
- Explain the operation of artificial neural networks and state their main properties,
- Draw the architecture of multilayer artificial neural networks
- Solve numeric problems related to multilayer artificial neural networks.



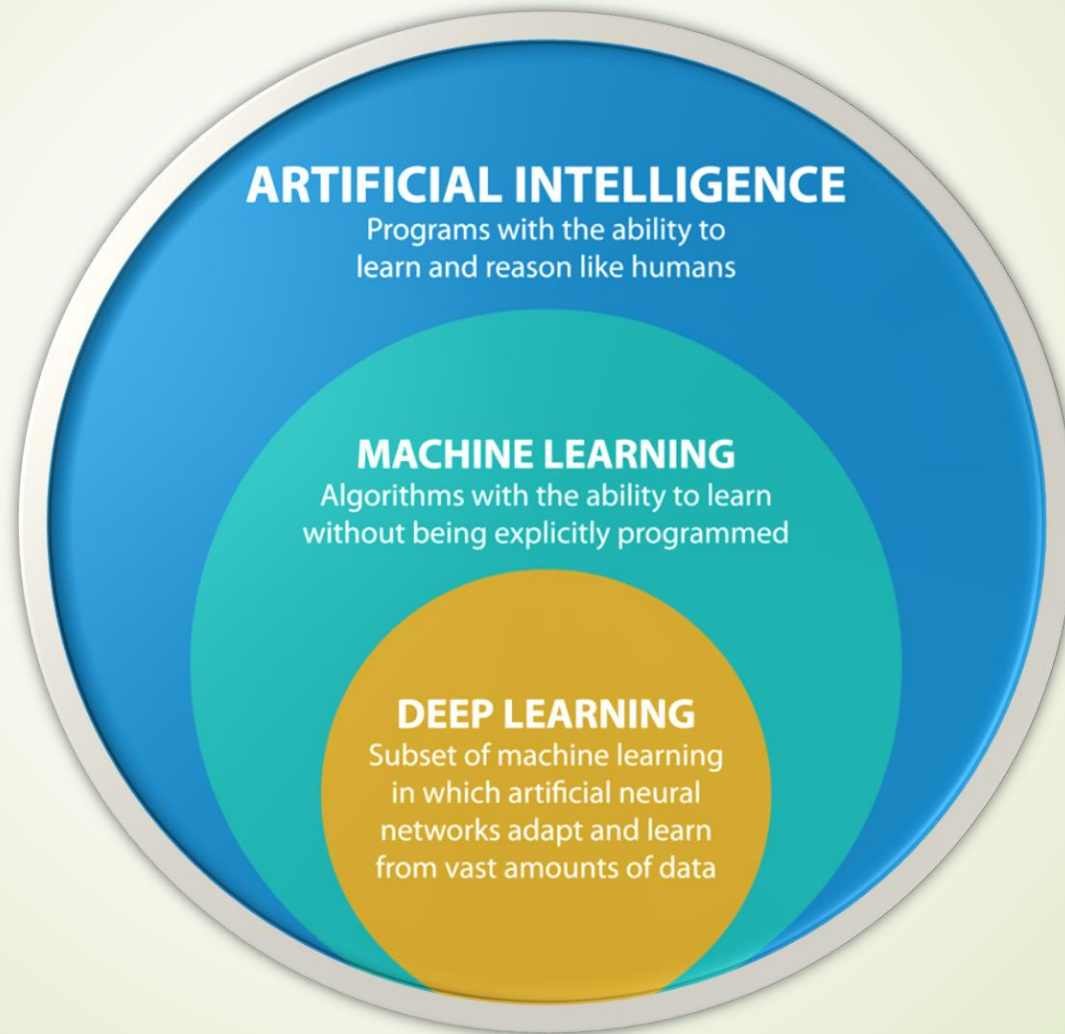
## CHAPTER 2: Machine Learning and Artificial Neural Networks

### 2.1 Machine Learning

- In the last chapter we discussed the notion of artificial intelligence. Machine learning is a sub-class of artificial intelligence.
- Machine learning is the general name of computer algorithms that model a problem with respect to the data related to that problem. In general, it applies artificial intelligence algorithms to machines.
- Artificial neural networks (ANN), on the other hand are a sub-class of machine learning. An ANN that resembles the neurons that are the main process element and the most basic element of neural system and the connections between these neurons in terms of shape and operation, with this property it is a simple simulation of biological nervous system.
- Deep learning is a sub-class of ANN. Deep learning incorporates multiple hidden layers.

# CHAPTER 2: Machine Learning and Artificial Neural Networks

## 2.1 Machine Learning





## CHAPTER 2: Machine Learning and Artificial Neural Networks

### 2.1 Machine Learning

- Machine learning generally performs learning process in order to produce a decision or prediction. Machine learning provides satisfactory results in classification and clustering tasks.
- Machine learning employs two learning methods; namely supervised and unsupervised learning.
- In supervised learning, outputs information is included alongside input.
- In unsupervised learning, the outputs information is not provided. Only the relationship between inputs are set up.



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### 2.2 Artificial Neural Networks

- Information processing is developed by the generalization of the mathematical model of human's perception system. This system contains a large number of process elements that are called neurons.
- Each neurons is connected to other neurons via direct communication links that are called weights.
- Each neurons has inner statuses that are received from input functions and named activation or treshold.

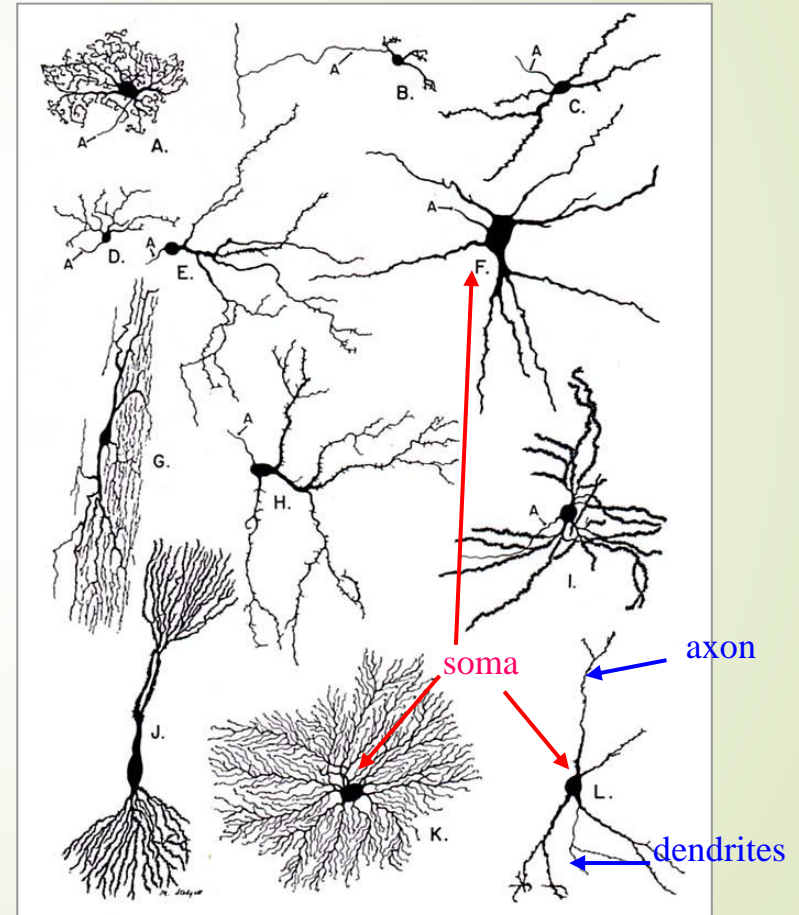


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### 2.2 Artificial Neural Networks

#### Biological Neurons

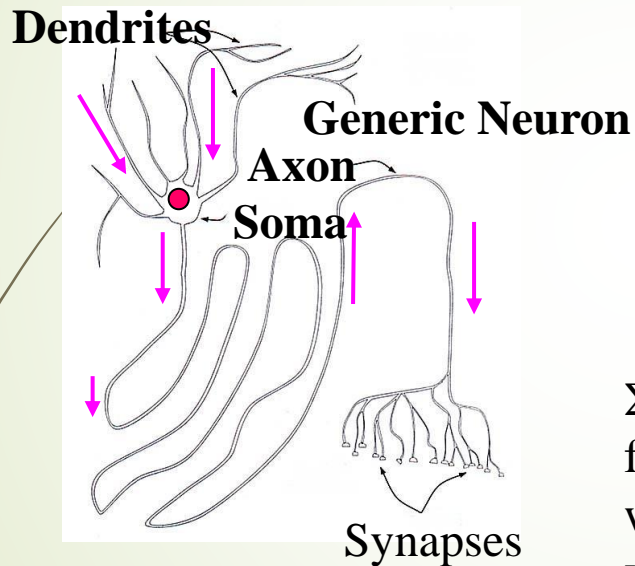
- The main component of biological neural networks are the neural cells that are called neurons. The human brain contains roughly 86 billion neurons.
- A typical neuron has 3 important parts in its structure: the cell body named soma, axon and dendrites.



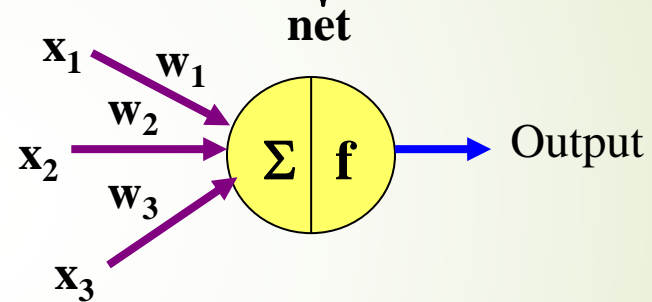
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### 2.2 Artificial Neural Networks

#### A Neuron Model



$$\text{Output} = f [(w_1 \cdot x_1) + (w_2 \cdot x_2) + (w_3 \cdot x_3)]$$



$\Sigma$  = Sum of weights= net

$f$  = Activation function

$w$  = Weights

$x$  = Inputs

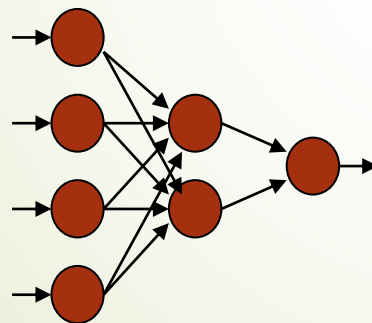


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### 2.2 Artificial Neural Networks

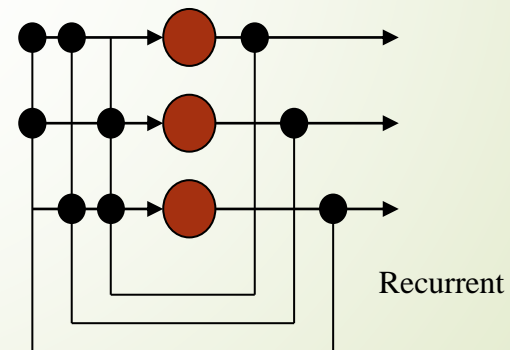
#### ANN Architecture

- Neurons are arranged in layers that exhibit similar behavior. The neurons in a layer may be fully connected or have no connections at all.
- The arrangement of neurons in a layer and the connection patterns within and between layers are called network structure.



Multilayer perceptron

● = nöron



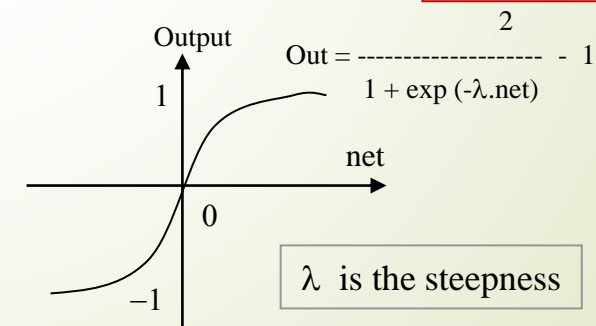
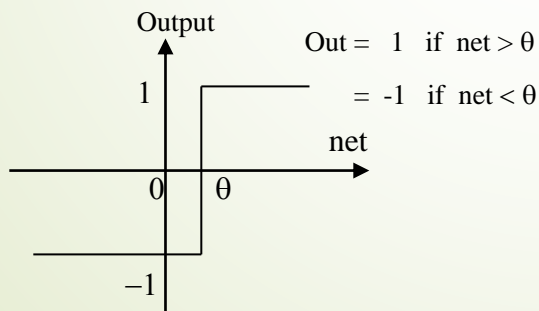
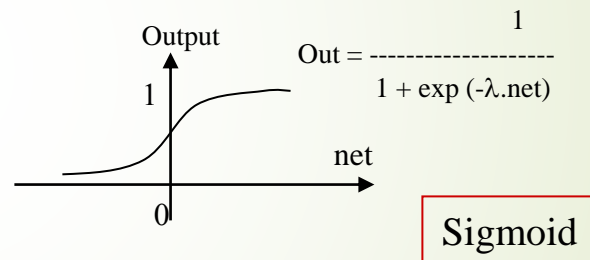
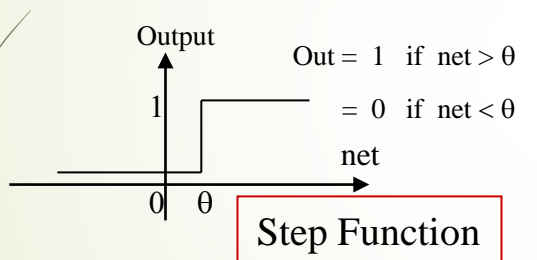
● = Connection node

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### 2.2 Artificial Neural Networks

#### Activation Function

- A nonlinear mathematical function has an important role in the input vector's behavior on total weights in order to produce an output



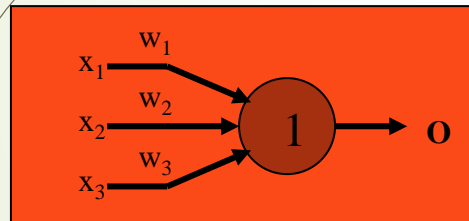
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### 2.2 Artificial Neural Networks

#### Neuron Activation

Each neurons carries out 2 main calculations:

- Provide the sum of weights:  $\text{net} = \underline{\mathbf{w}}^t \cdot \underline{\mathbf{x}}$
- Net produces an output according to «f» activation function.



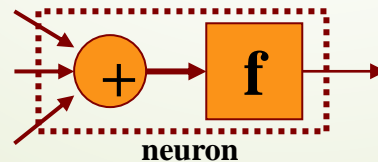
$$\underline{\mathbf{x}} = [x_1 \ x_2 \ x_3]^t$$

or

$$\begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix}$$

$$\underline{\mathbf{w}} = [w_1 \ w_2 \ w_3]^t$$

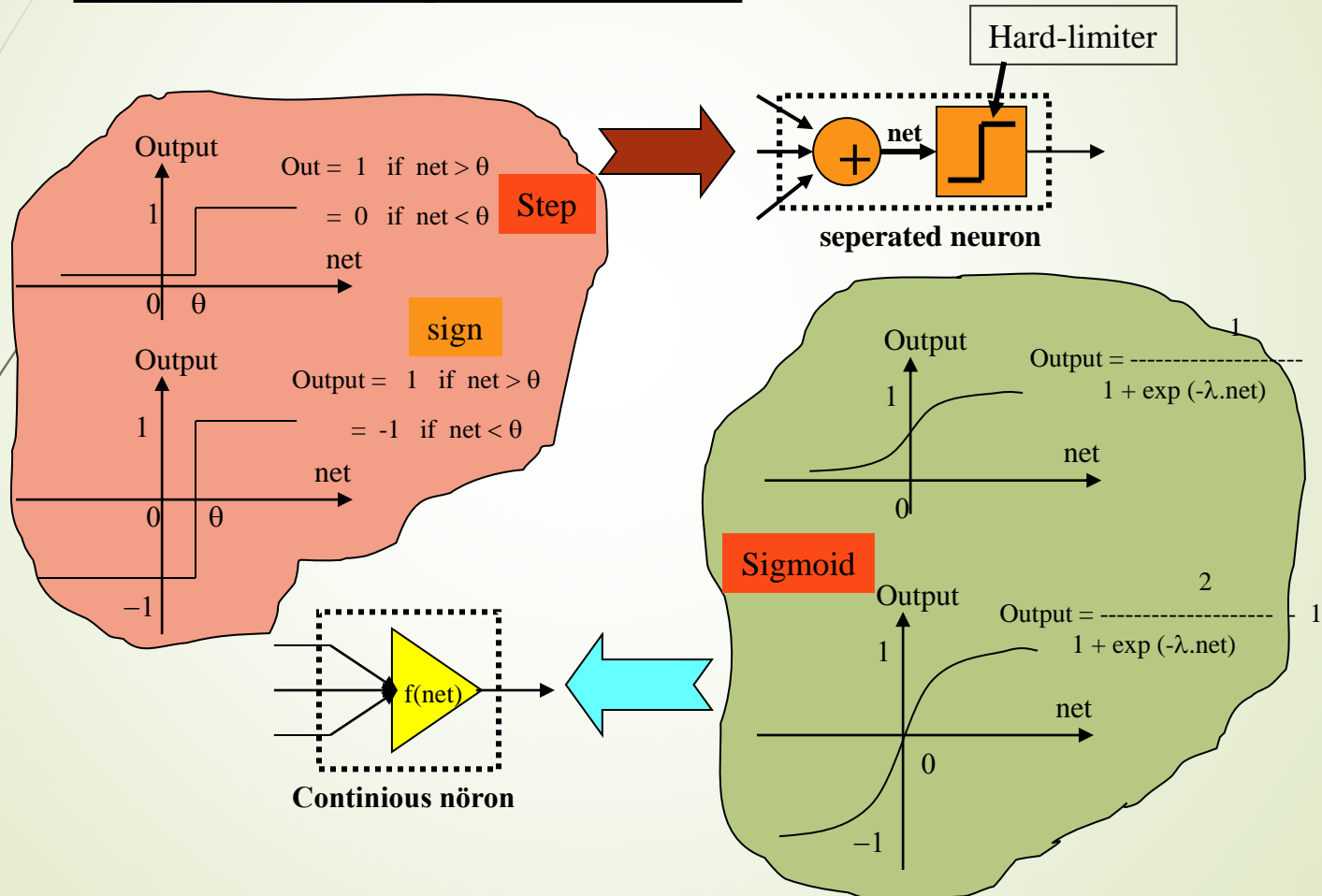
$$\text{Output } \mathbf{O} = f(\text{net}) = f(\underline{\mathbf{w}}^t \cdot \underline{\mathbf{x}}) = f(w_1 x_1 + w_2 x_2 + w_3 x_3)$$



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## 2.2 Artificial Neural Networks

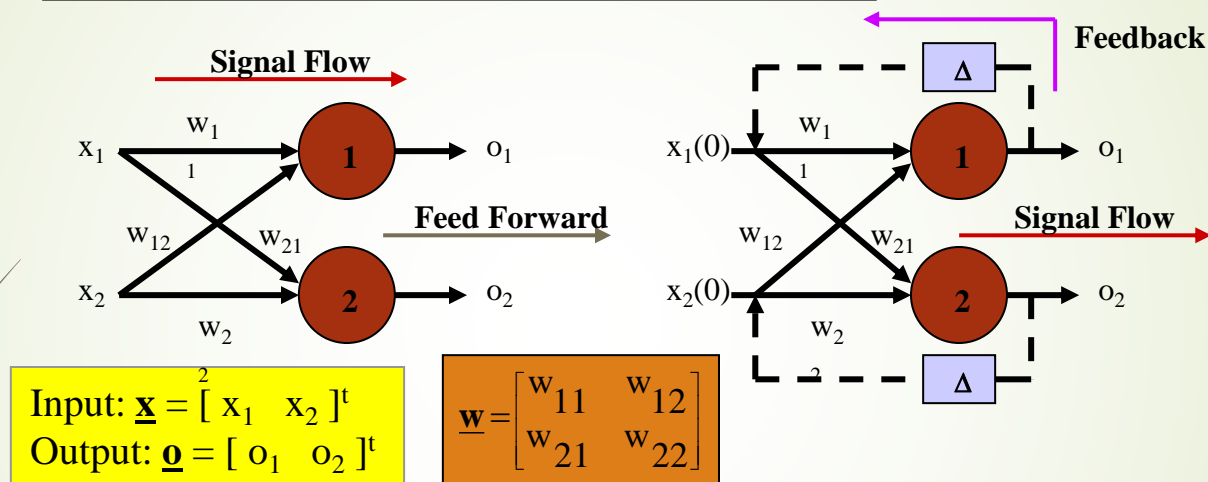
### Continuous and Separated Neurons



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## 2.2 Artificial Neural Networks

### Feedforward and Feedback Architecture



Calculation  $\underline{o} = f(\text{net}) \Rightarrow \text{net} = \underline{w} \cdot \underline{x}$

If  $\text{net}_1 = (w_{11}x_1 + w_{12}x_2)$  ve  $\text{net}_2 = (w_{21}x_1 + w_{22}x_2)$

Then  $o_1 = f(\text{net}_1)$  ve  $o_2 = f(\text{net}_2)$



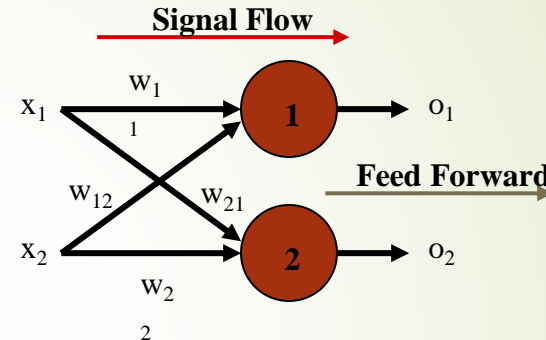
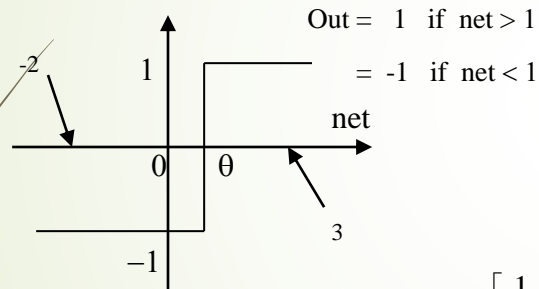
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## 2.2 Artificial Neural Networks

### Example

Given

$$\underline{x} = \begin{bmatrix} 1 \\ -1 \end{bmatrix} \quad \text{ve} \quad \underline{w} = \begin{bmatrix} 1 & 3 \\ -2 & -5 \end{bmatrix} \quad \text{using}$$



Neural network Output calculation.

$$\mathbf{net} = \underline{w} \cdot \underline{x} = \begin{bmatrix} 1 & 3 \\ -2 & -5 \end{bmatrix} \begin{bmatrix} 1 \\ -1 \end{bmatrix} = \begin{bmatrix} (1 \times 1) + (3 \times -1) \\ (-2 \times 1) + (-5 \times -1) \end{bmatrix} = \begin{bmatrix} -2 \\ 3 \end{bmatrix}$$

$$\text{Then, Output ; } \underline{o} = f(\mathbf{net}) = \begin{bmatrix} f(-2) \\ f(3) \end{bmatrix} = \begin{bmatrix} -1 \\ 1 \end{bmatrix}$$



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### QUESTIONS

- What is a network structure?
- Briefly define Machine learning.
- Explain the relationship between artificial intelligence and machine learning.
- How many neurons on average does a human brain have?
- What are the main components of a neuron?



## CHAPTER 2: Machine Learning and Artificial Neural Networks

### SOLUTIONS

1. The arrangement of neurons in a layer and the connection patterns within and between layers are called network structure.
2. Machine learning is the general name of computer algorithms that model a problem with respect to the data related to that problem.
3. It applies artificial intelligence algorithms to machines.
4. The human brain contains roughly 86 billion neurons.
5. Soma, Axon and Dendrites