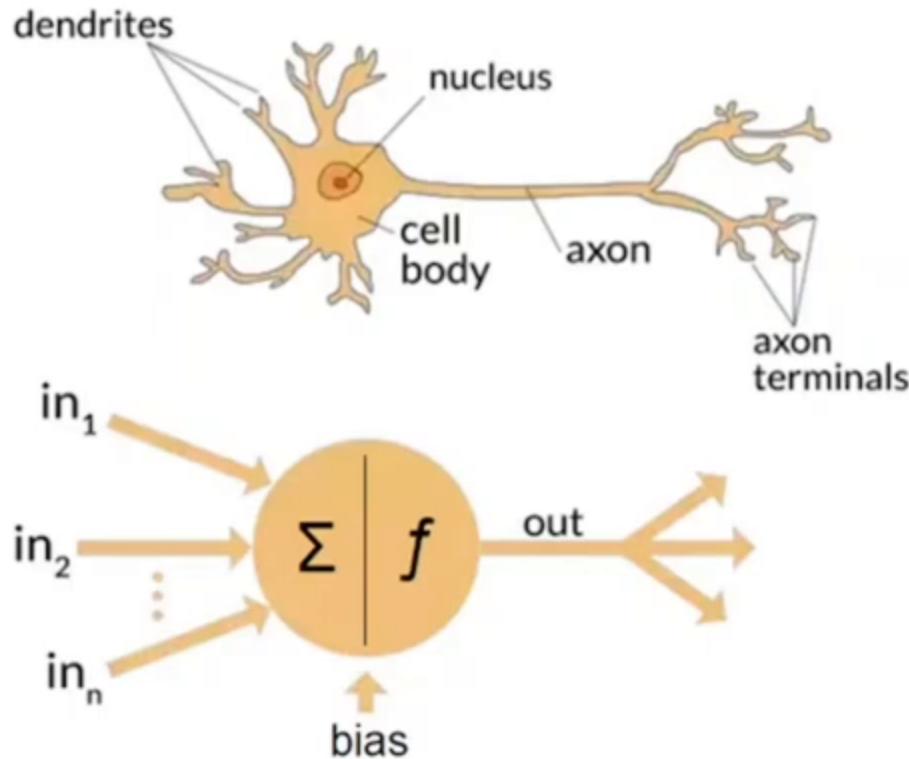
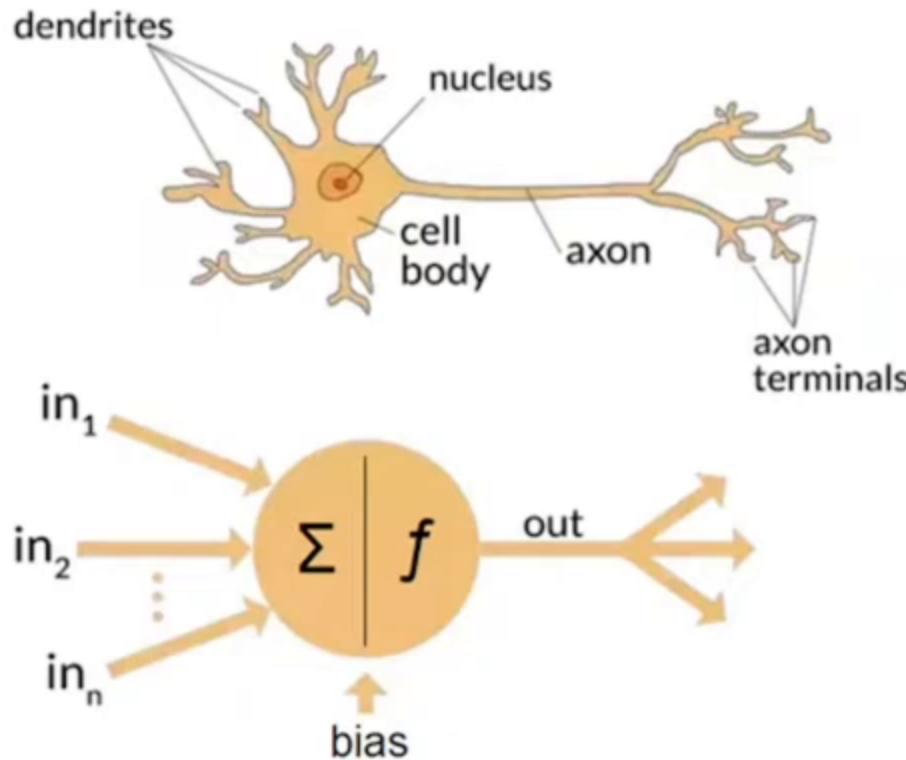


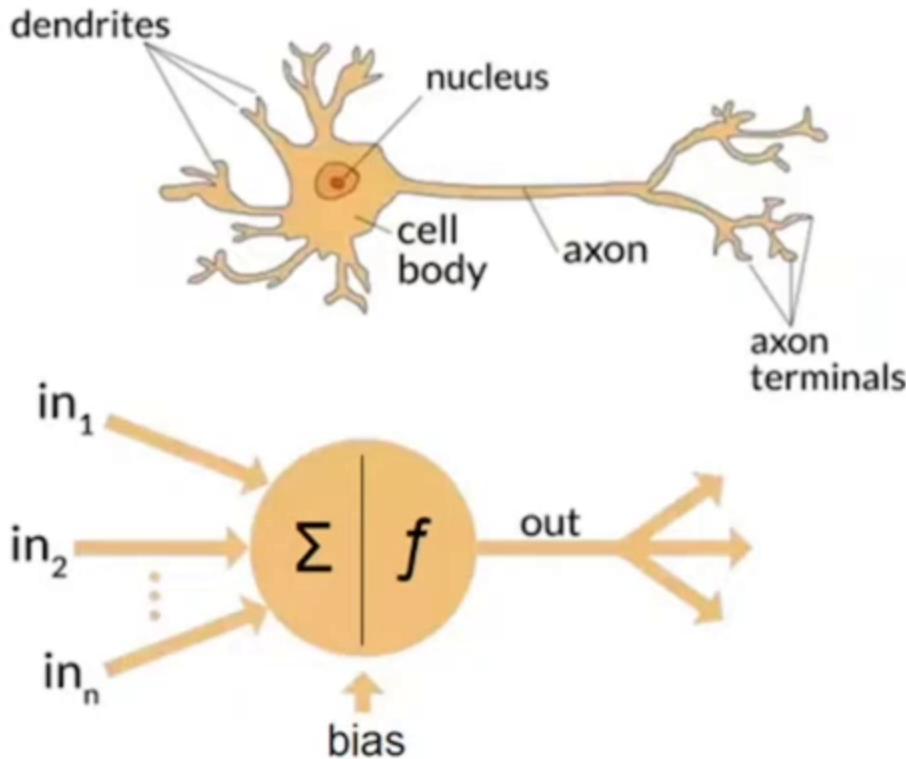
Neural Networks from Scratch



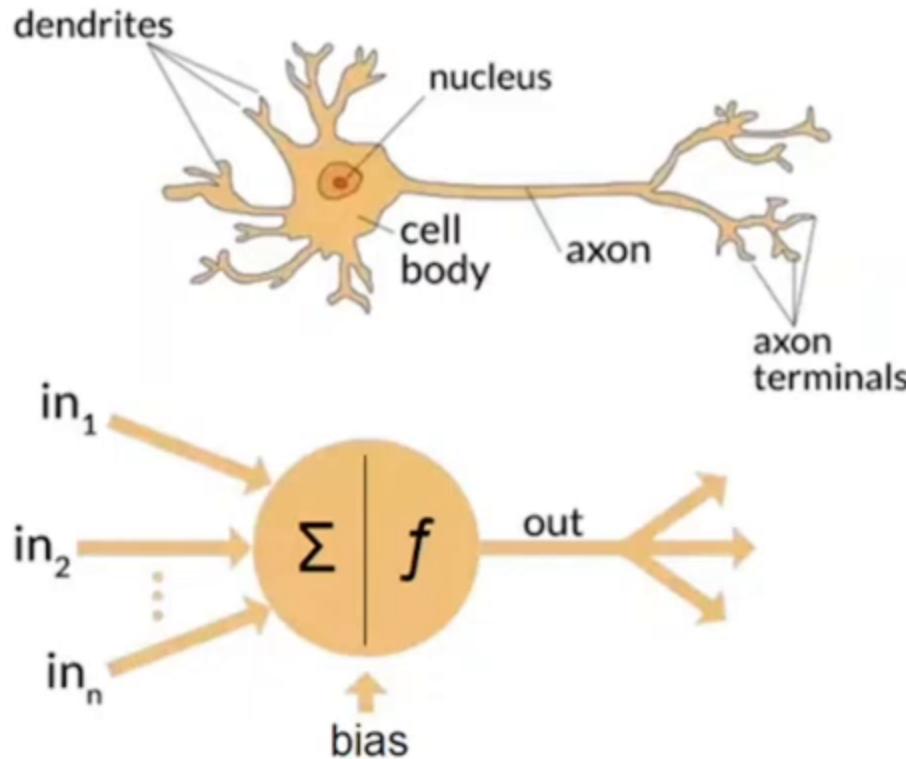
Neural Networks from Scratch



Neural Networks from Scratch

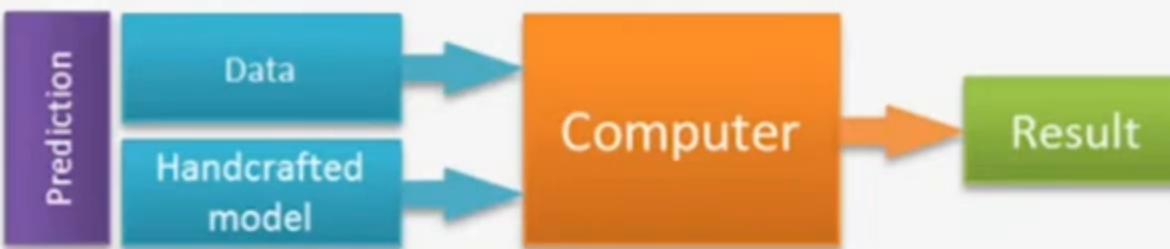


Neural Networks from Scratch

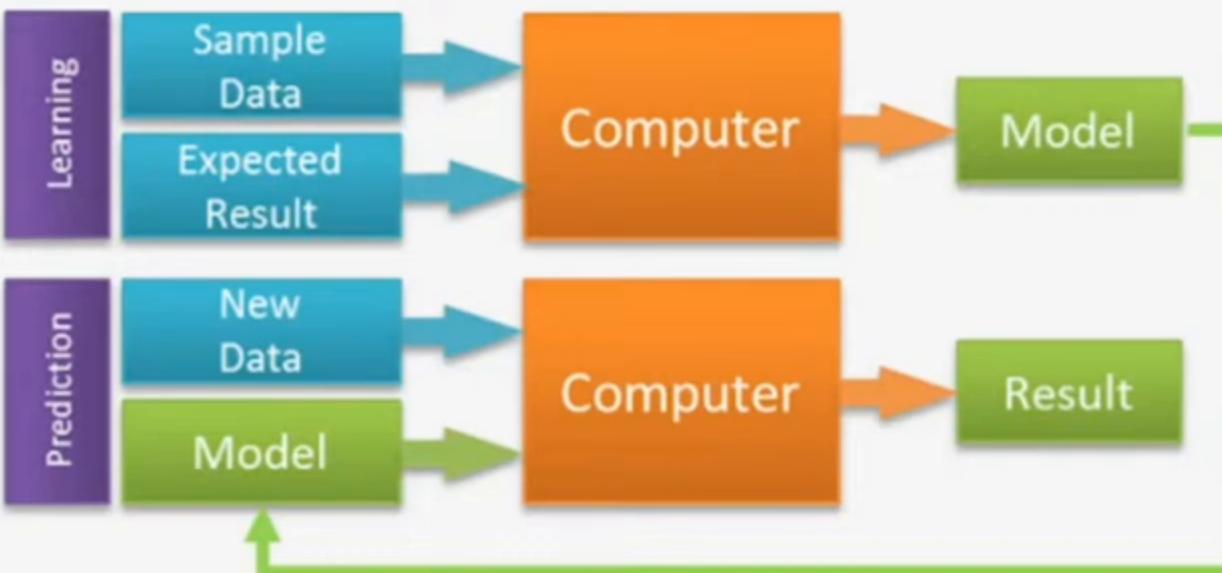


Introduction

Traditional modeling:

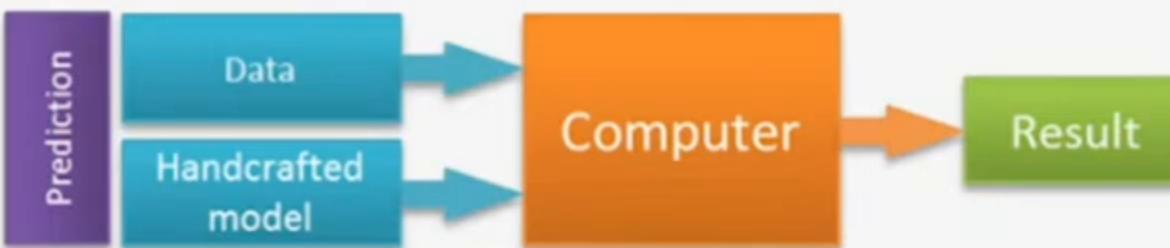


Machine Learning:

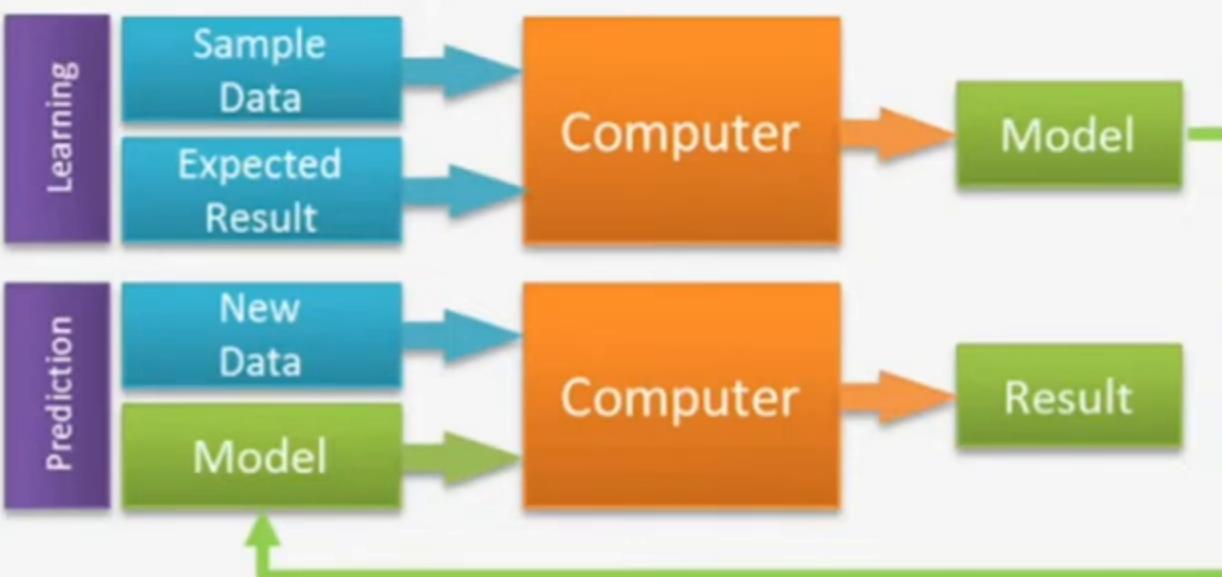


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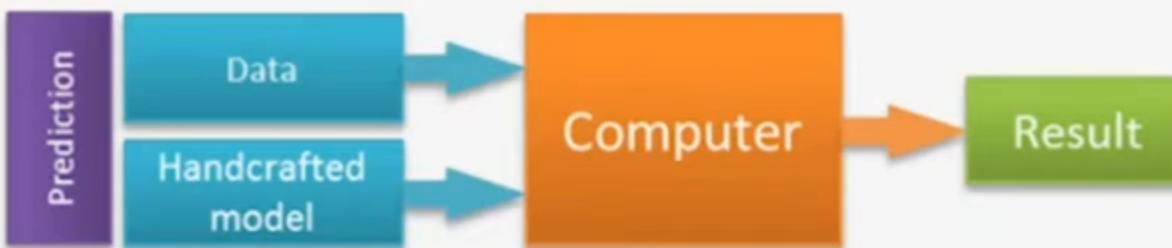


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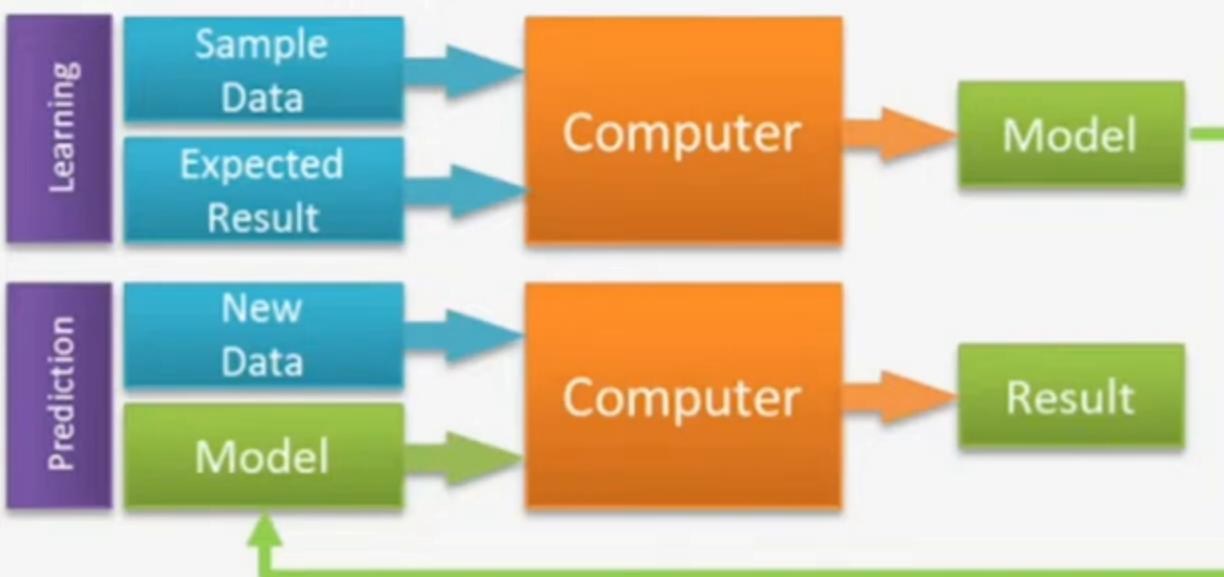


Introduction

Traditional modeling:



Machine Learning:



Example

Machine Learning:

Sample
↓
Label



dog



cat



horse

Human Learning:

We learn through



Examples

Long Ear Black nose
↓
dog



Comparisons

Example

Machine Learning:

Sample
↓
Label



dog



cat



horse

Human Learning:

We learn through



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Diagrams

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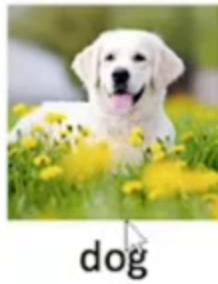
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Diagrams

Comparisons

Common Tasks



Regression

What is the temperature going to be tomorrow?

PREDICTION
84°



Classification

Will it be Cold or Hot tomorrow?

COLD

PREDICTION
HOT



CLASSIFICATION VS REGRESSION



Student Profile



Predicting Student
Pass Or Fail



Student Profile



Predicting Student Marks
Percentage

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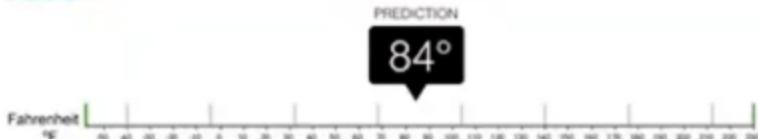
Common Tasks



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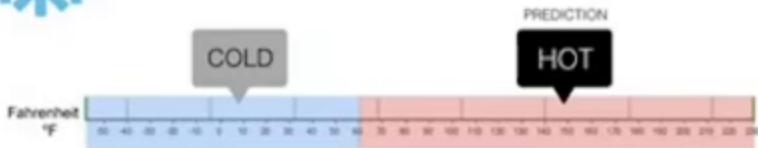


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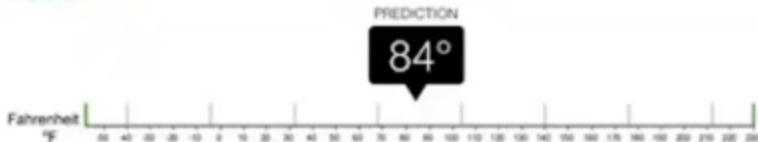
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Common Tasks



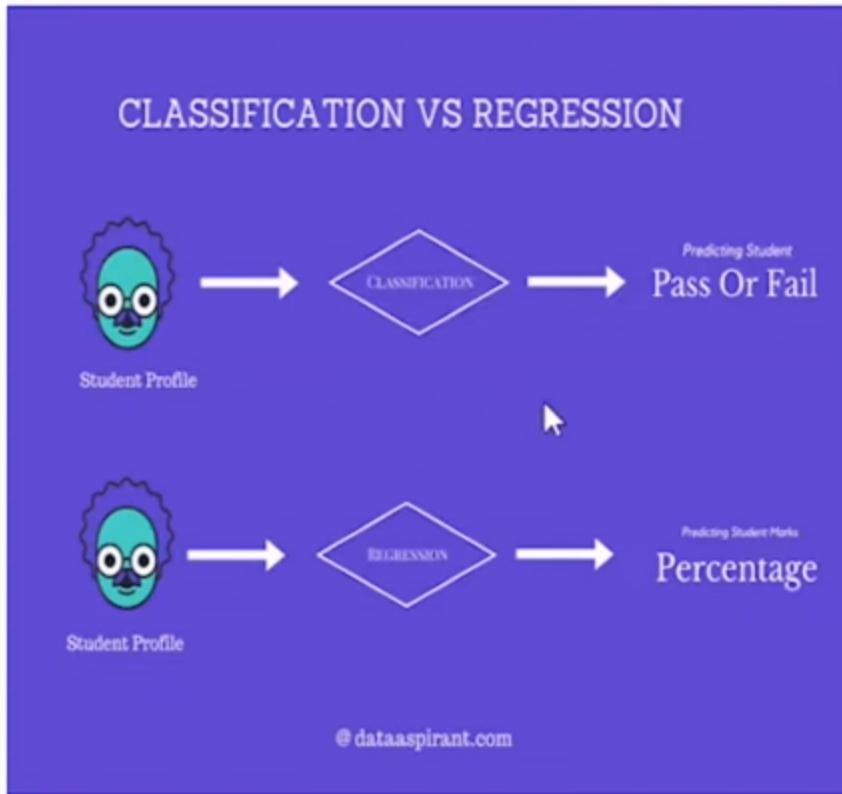
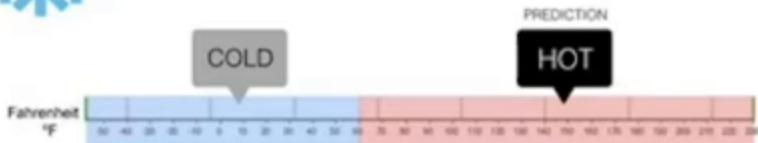
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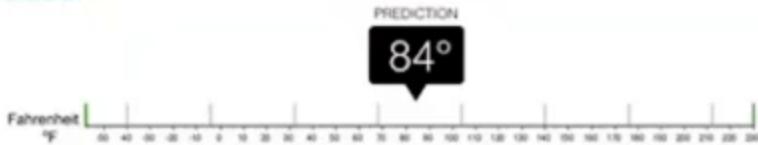


Common Tasks



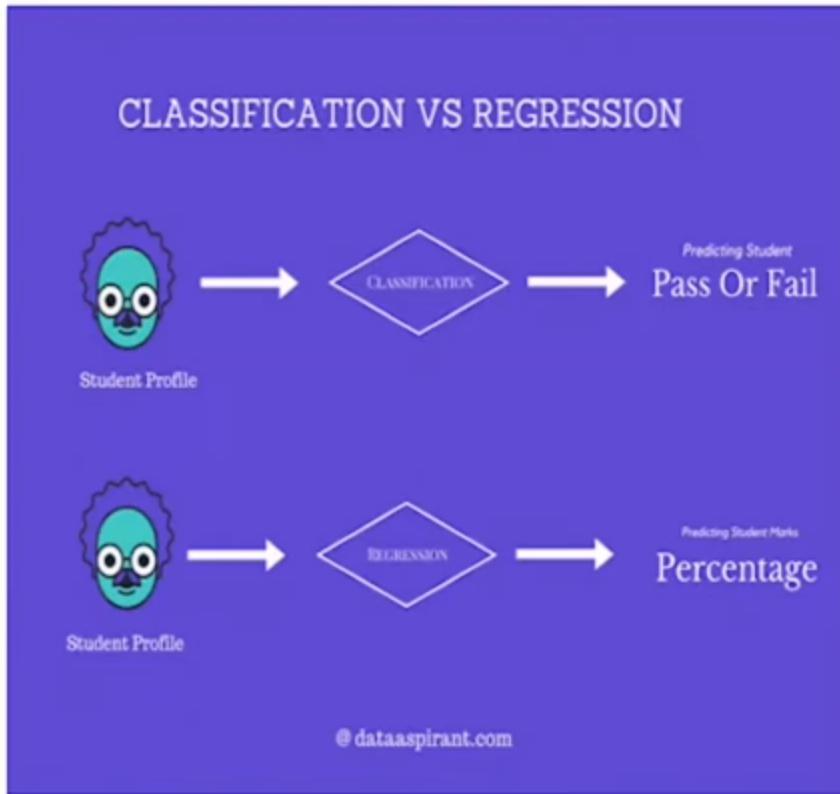
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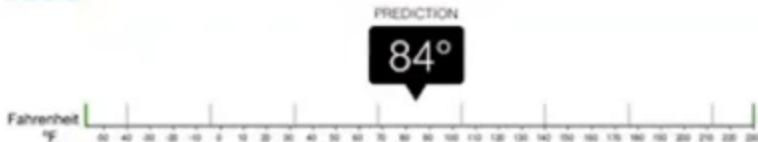


Common Tasks



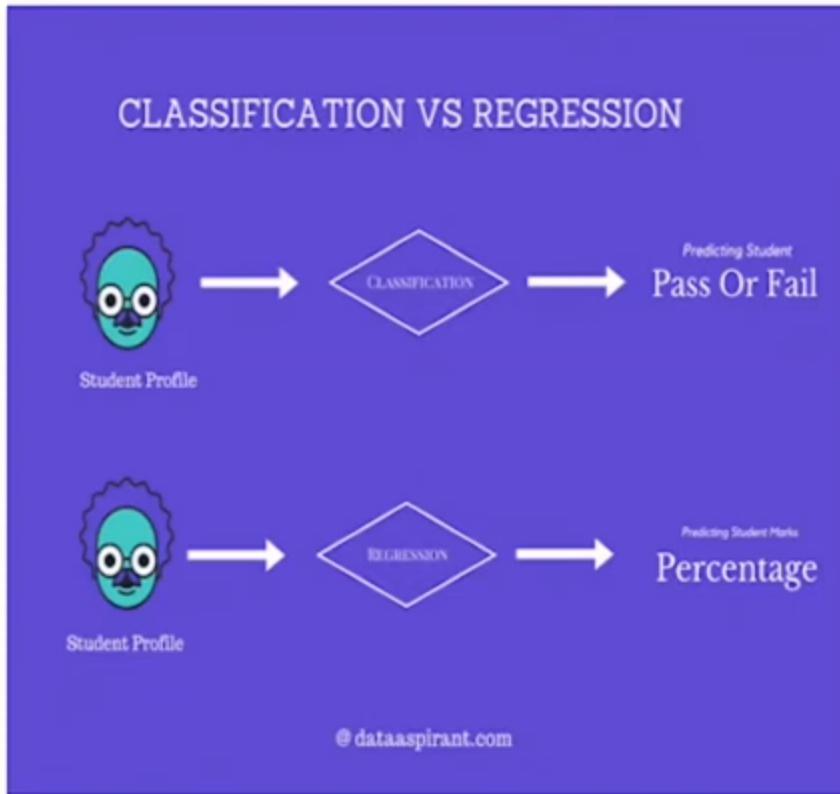
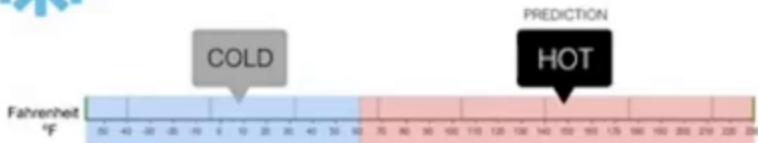
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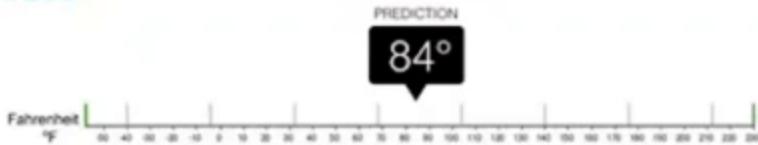


Common Tasks



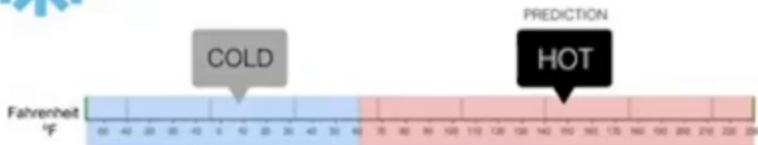
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What is the temperature going to be tomorrow?



Classification

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CLASSIFICATION VS REGRESSION



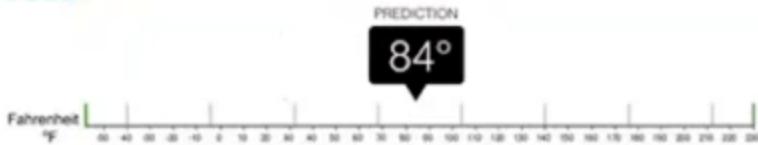
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Common Tasks



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CLASSIFICATION VS REGRESSION



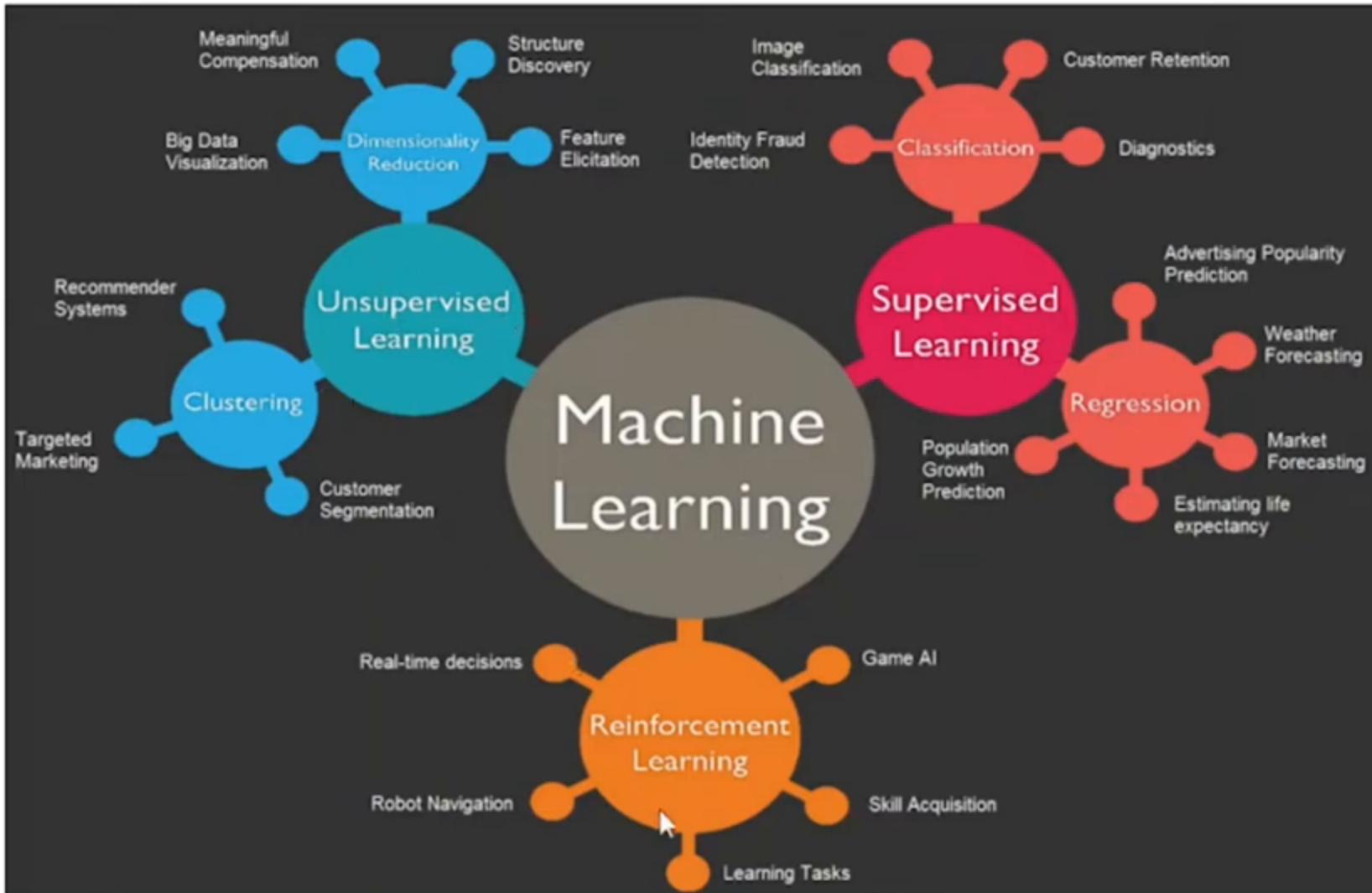
Student Profile



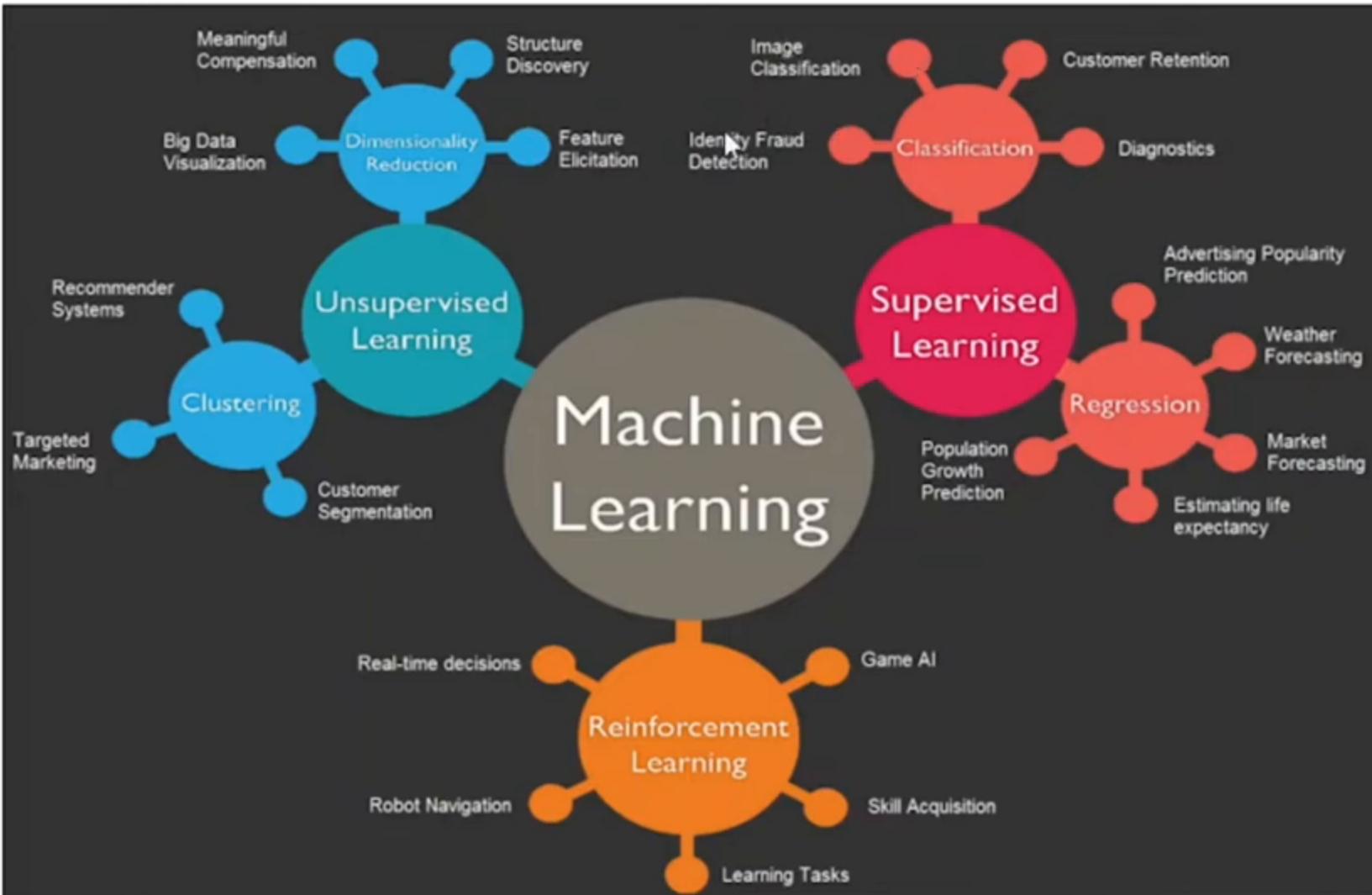
Student Profile

@dataaspirant.com

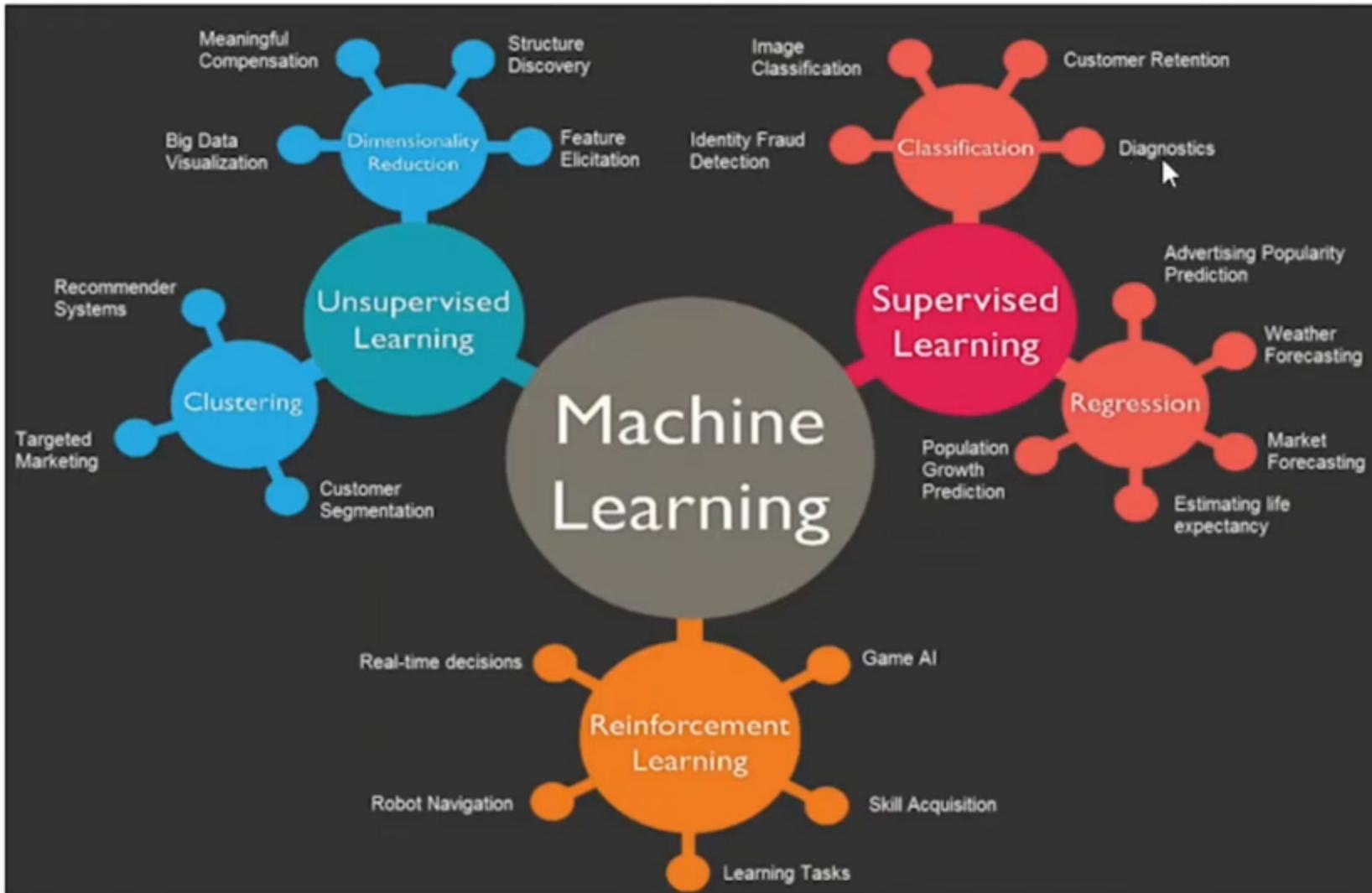
Machine Learning



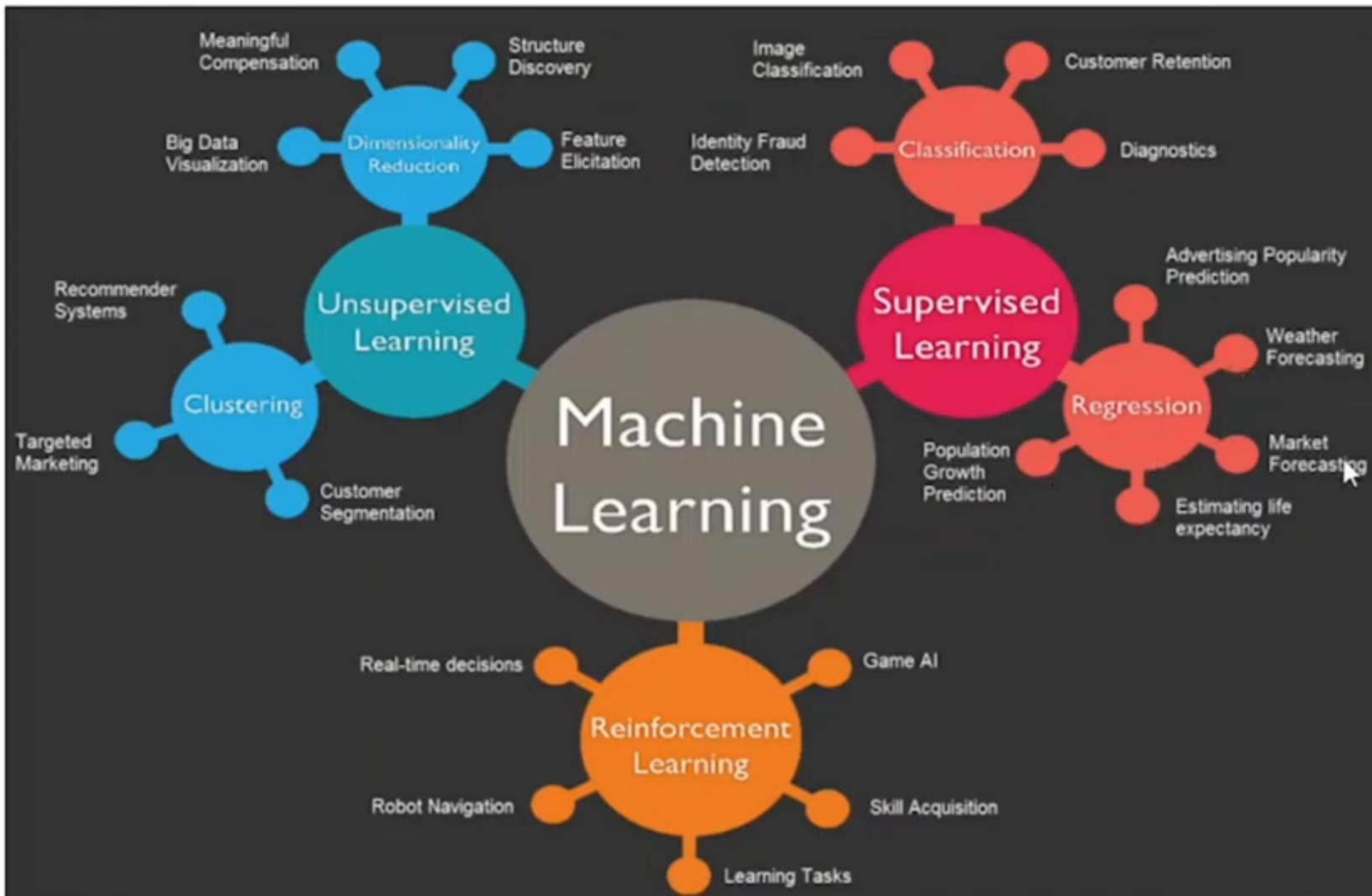
Machine Learning



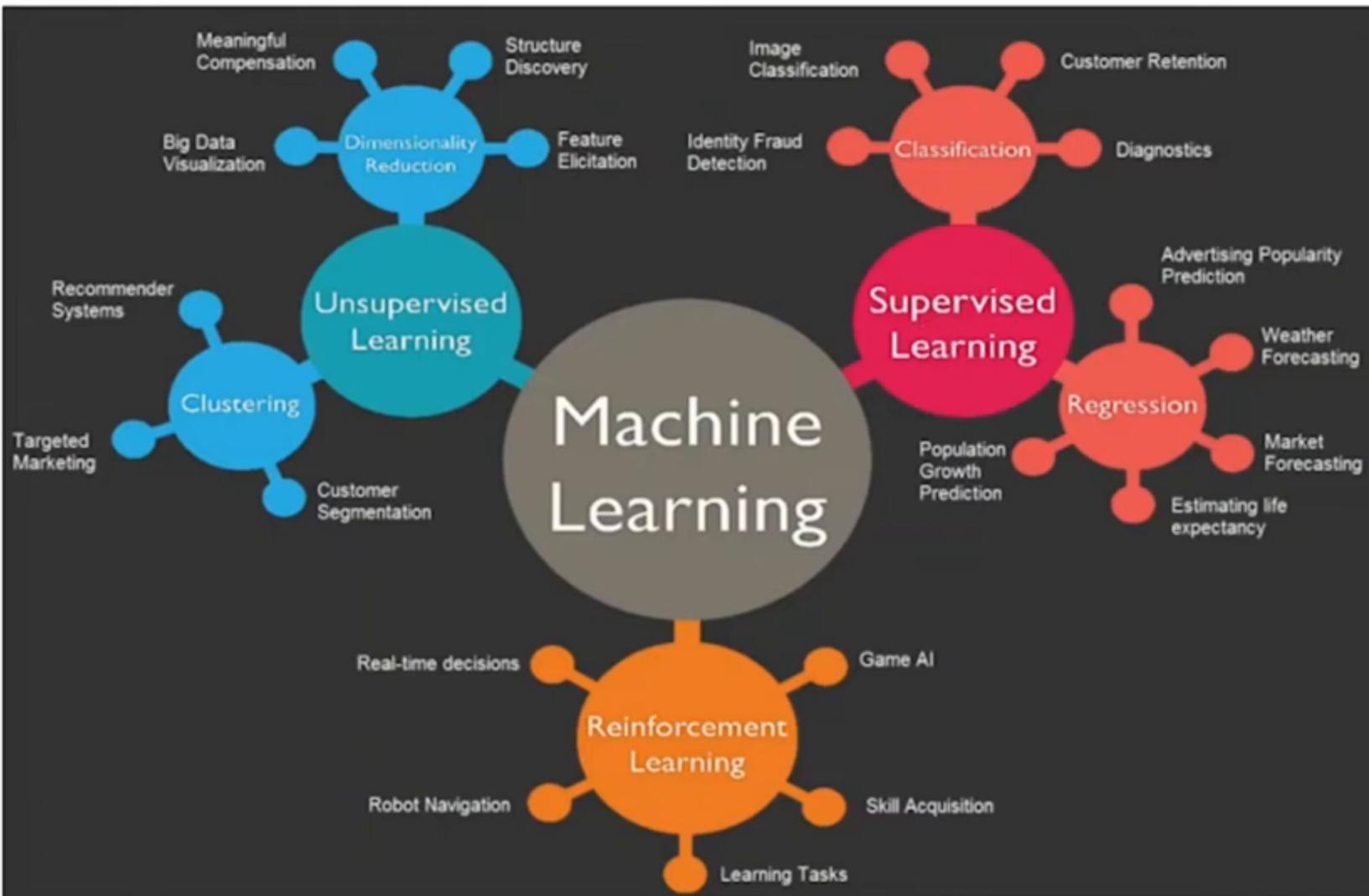
Machine Learning



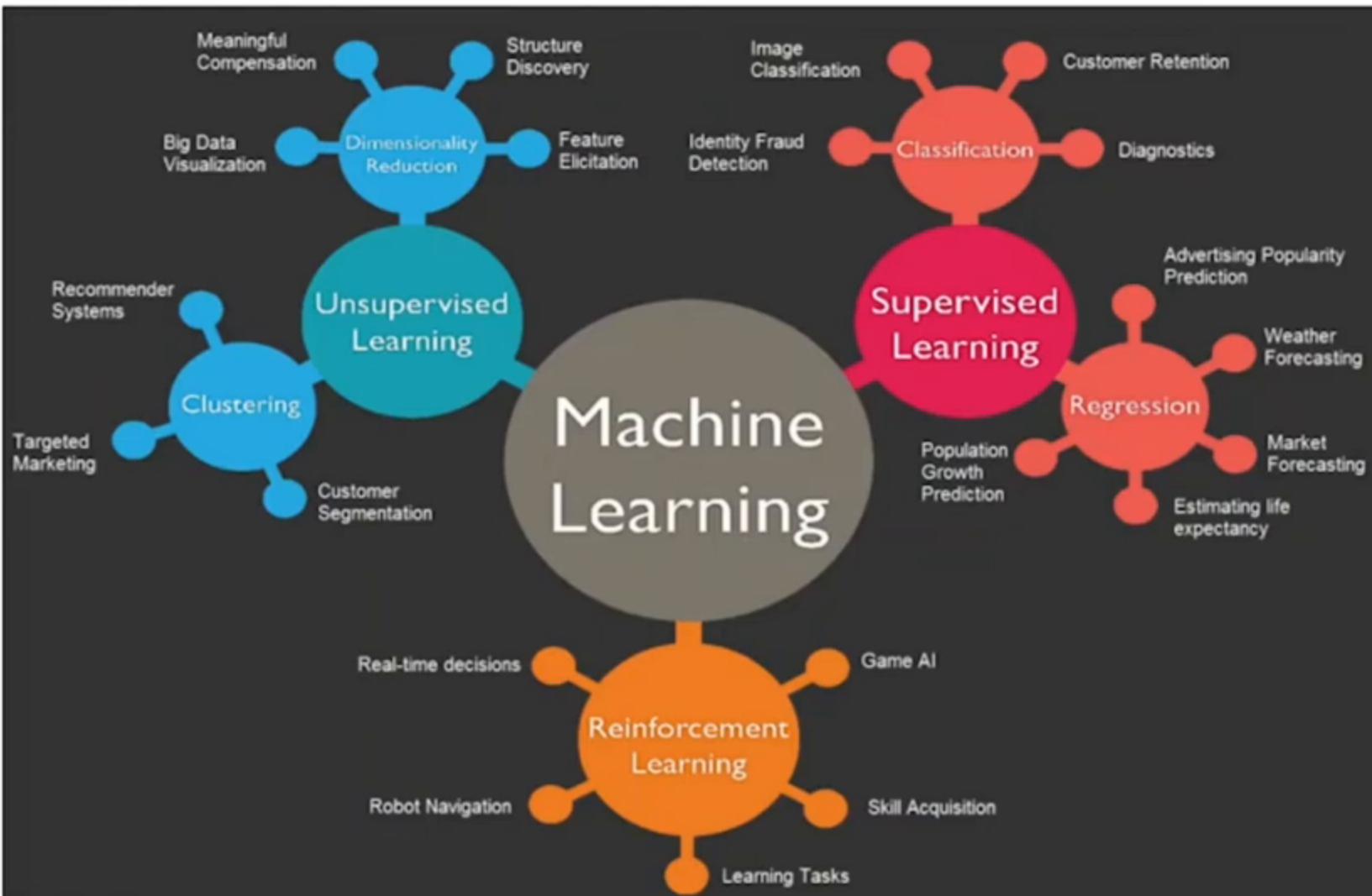
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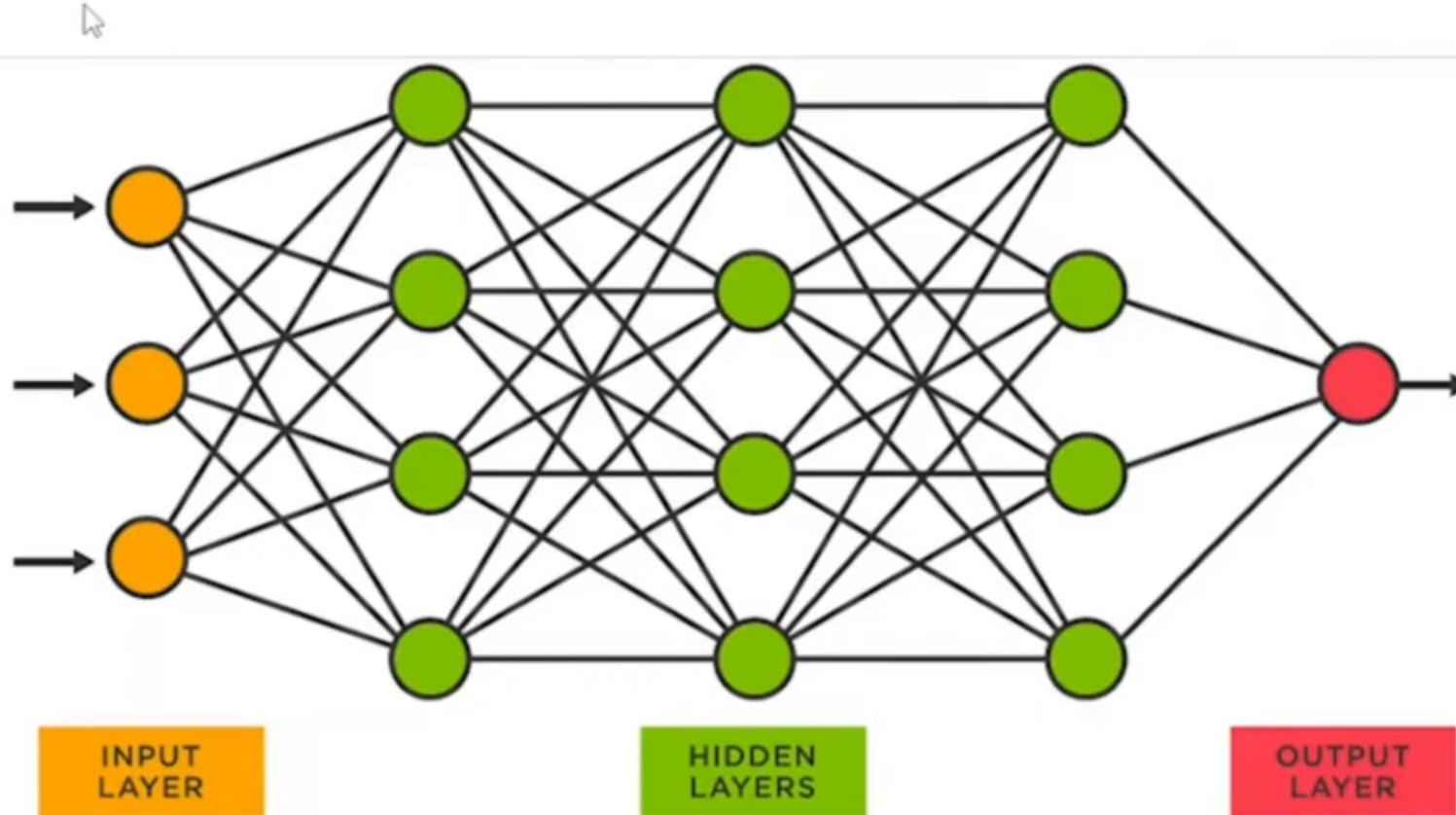
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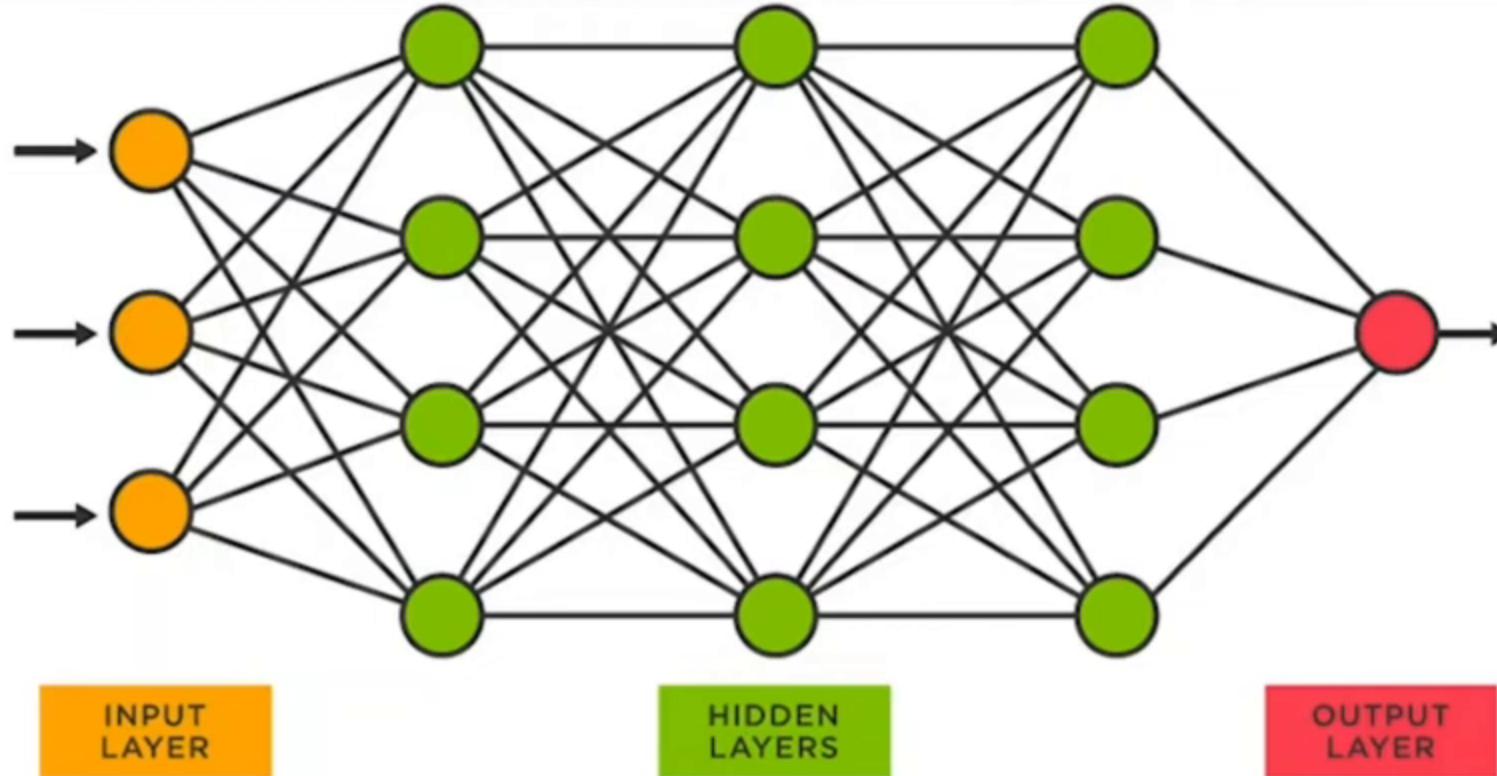
Machine Learning



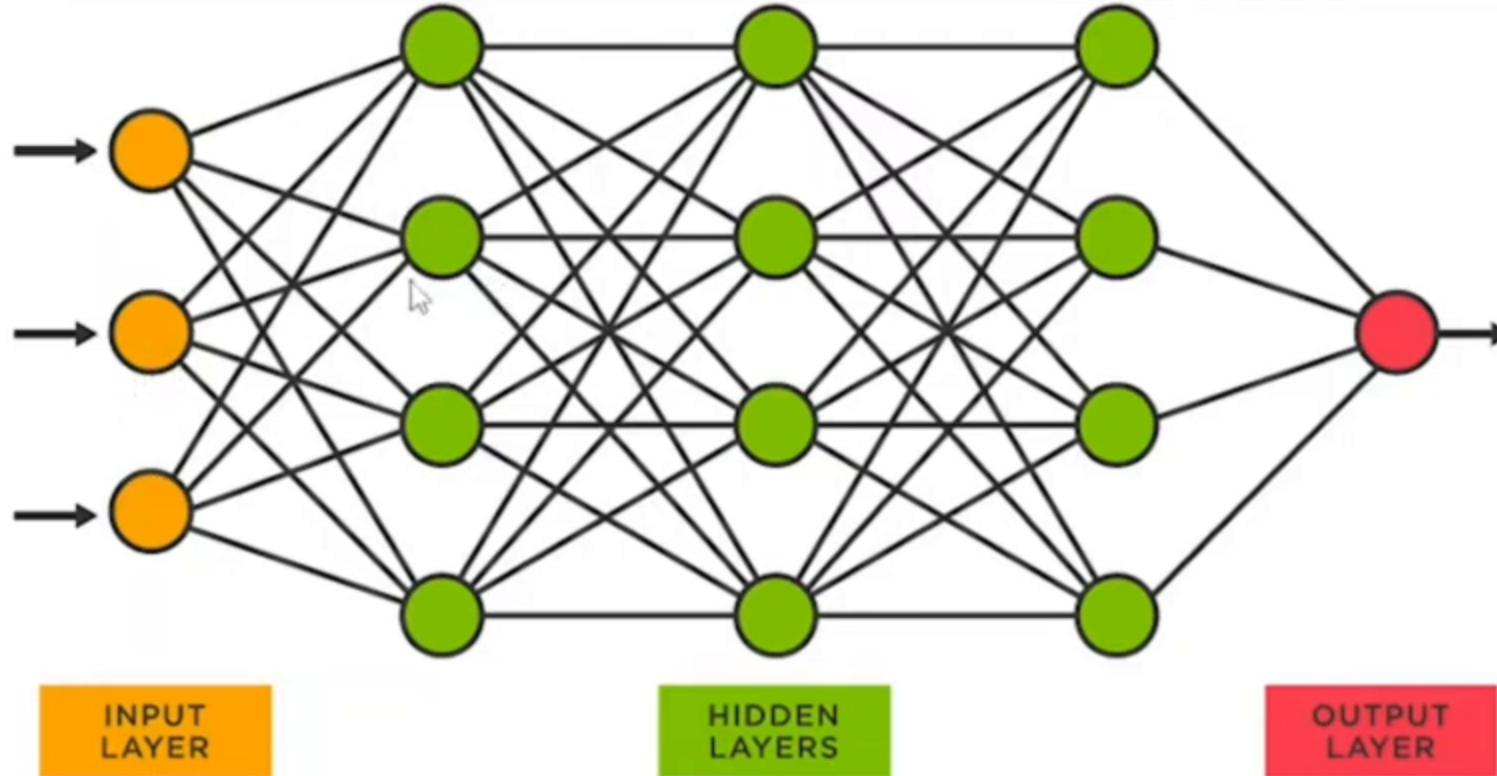
Neural Networks



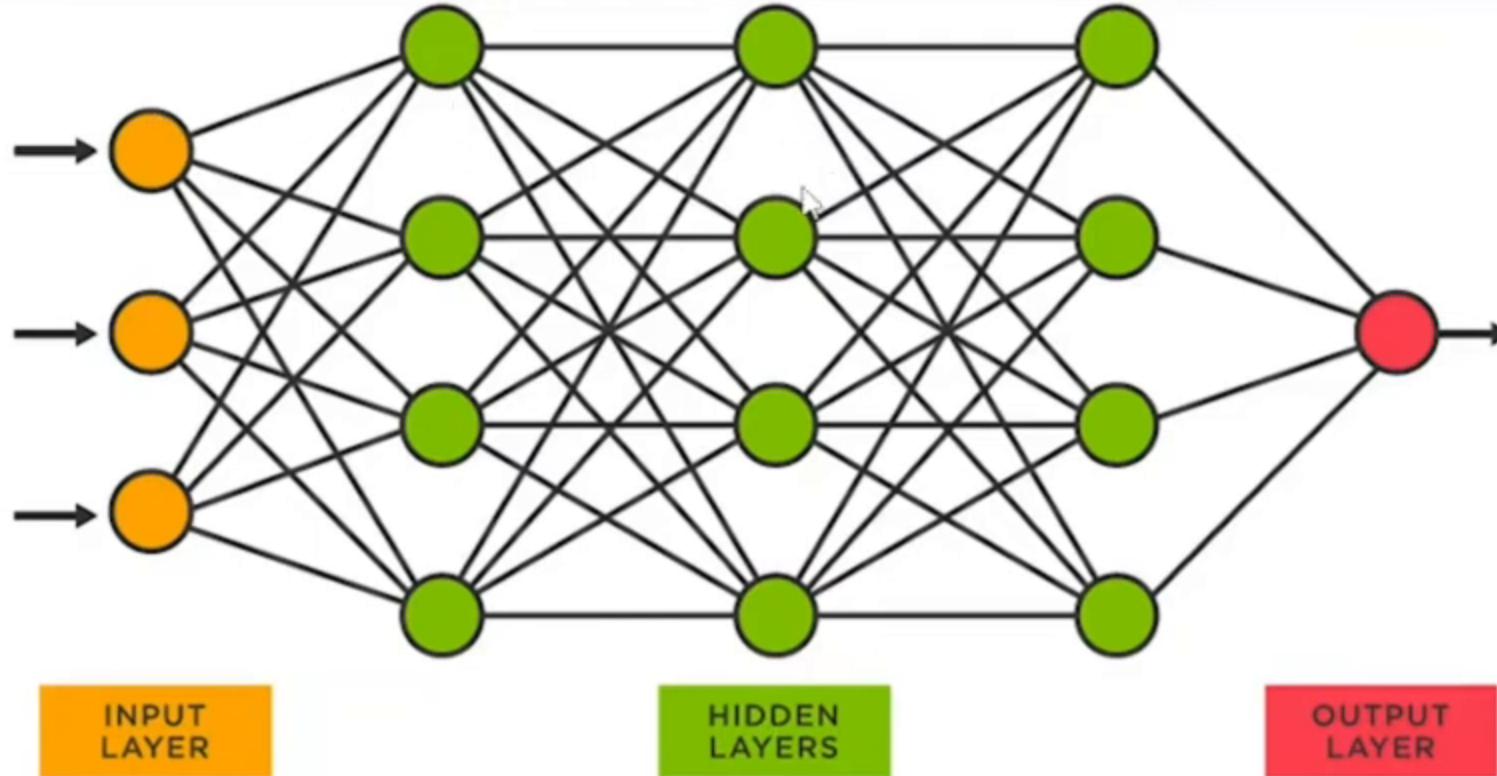
Neural Networks



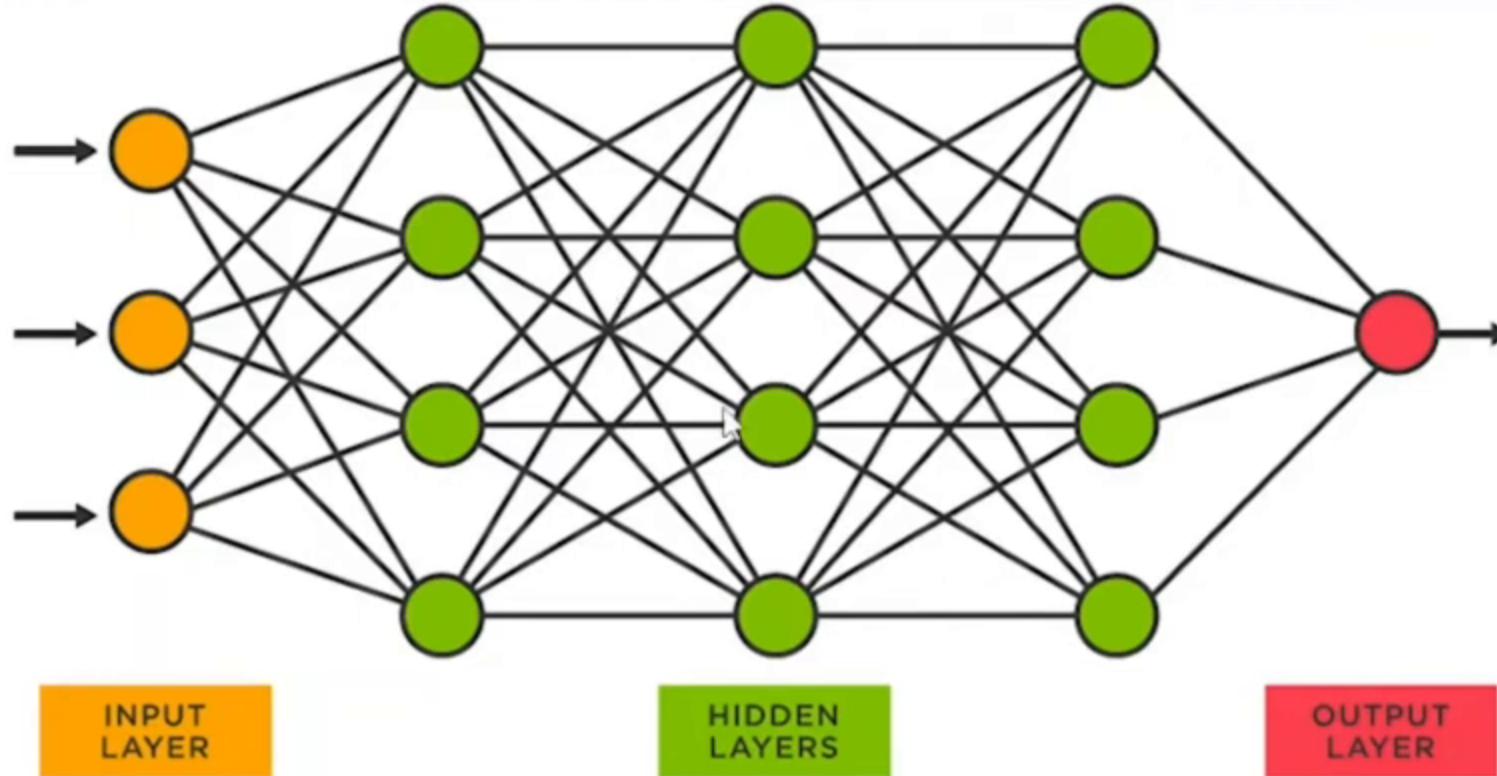
Neural Networks



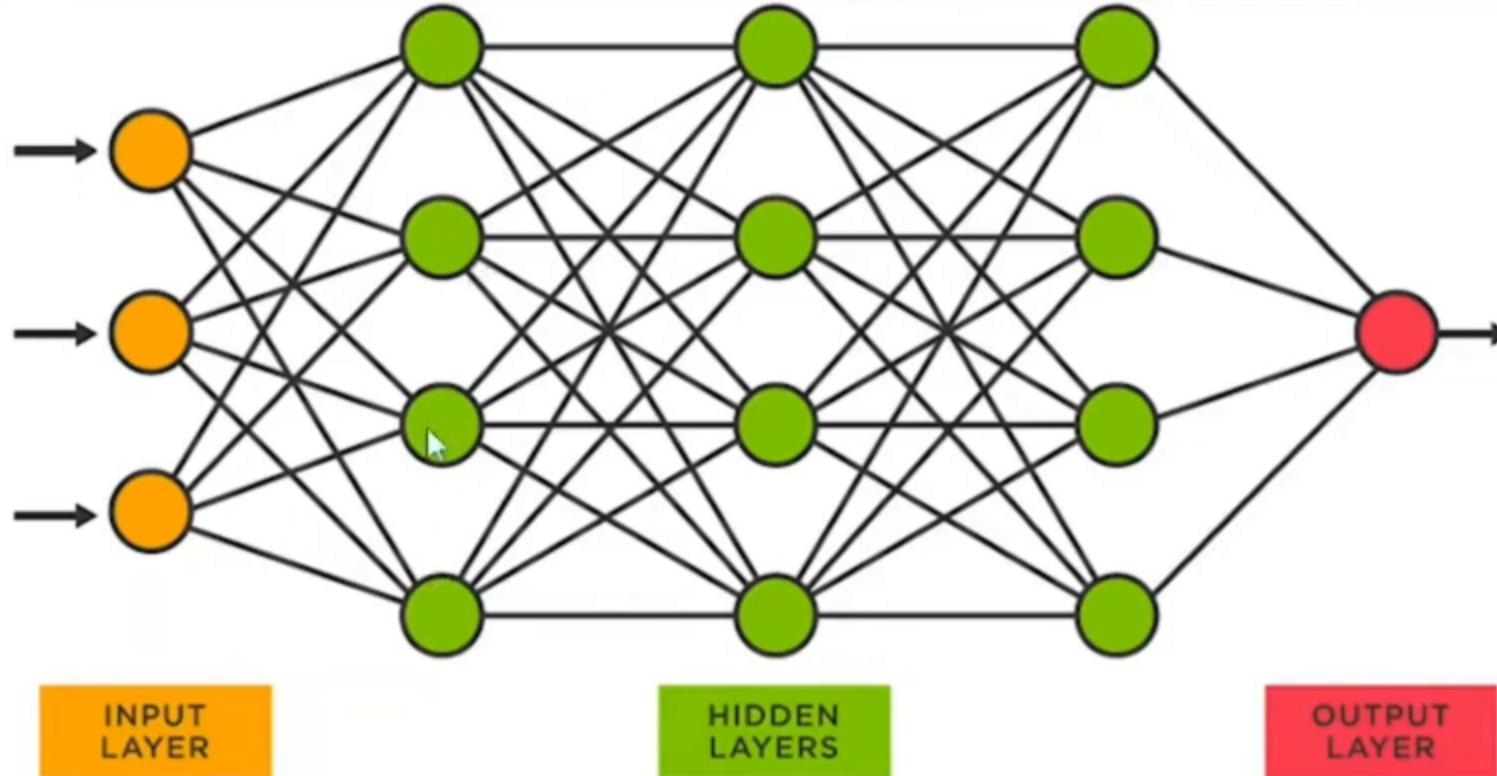
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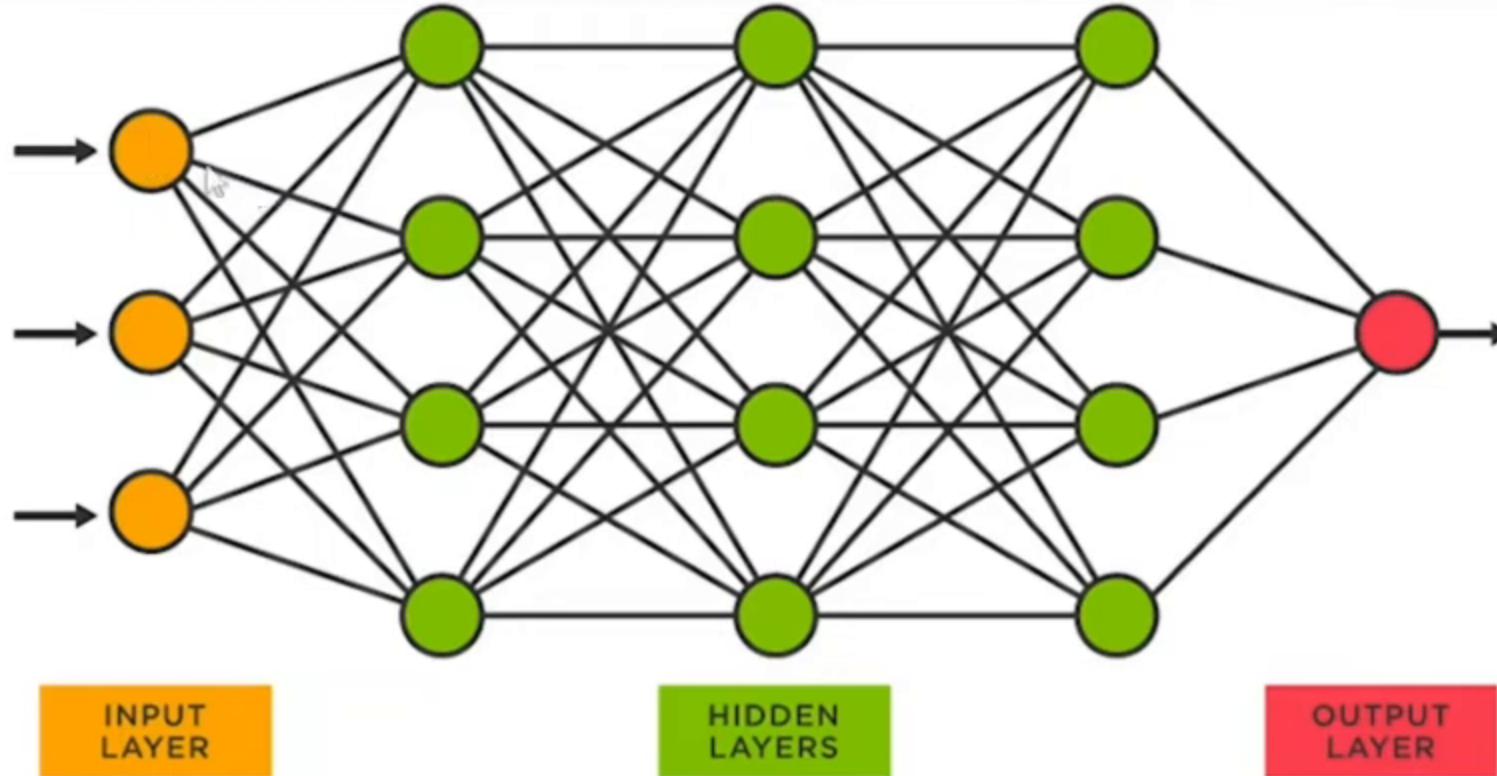
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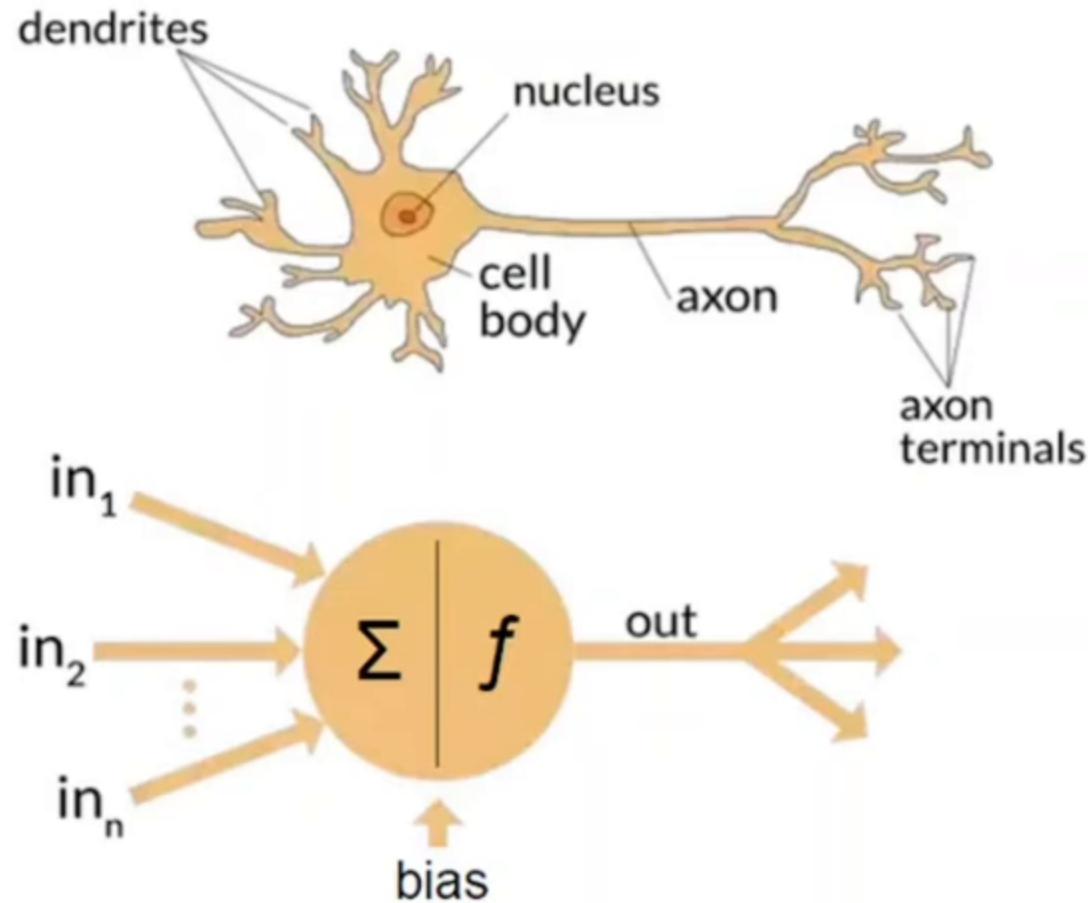
Neural Networks



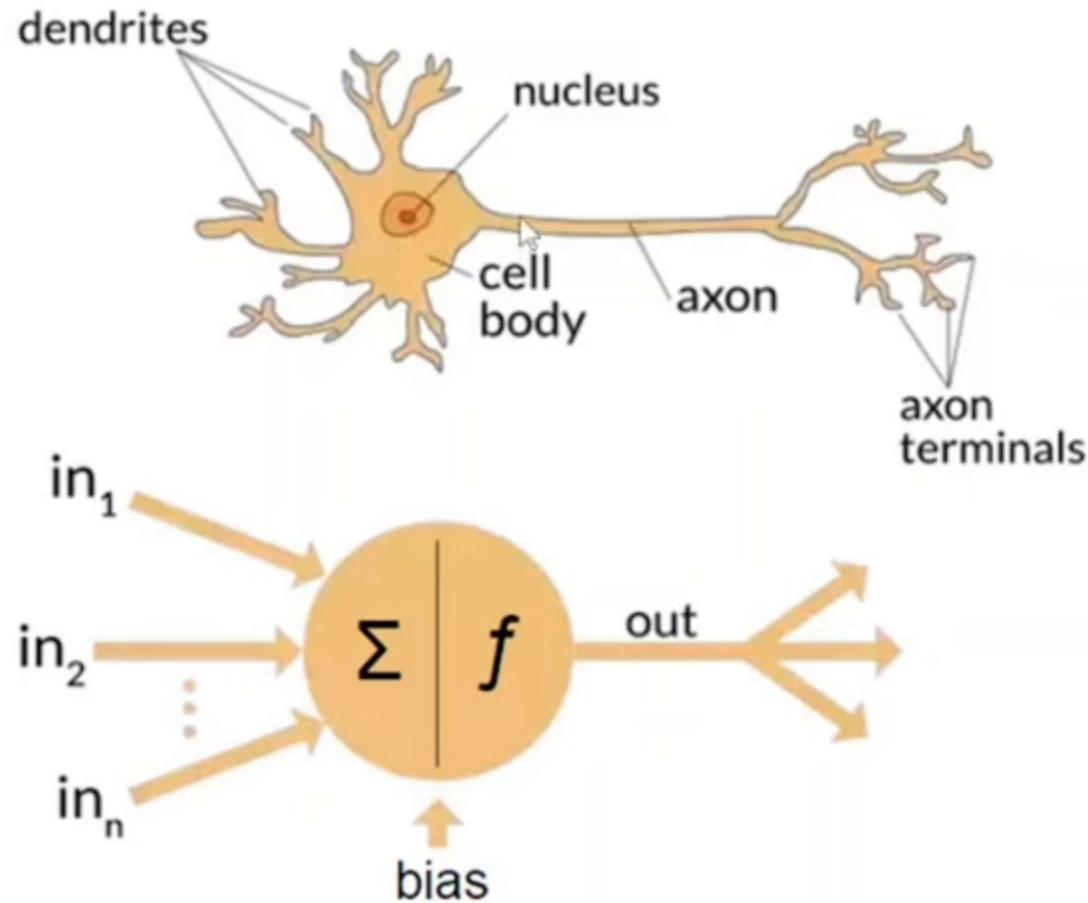
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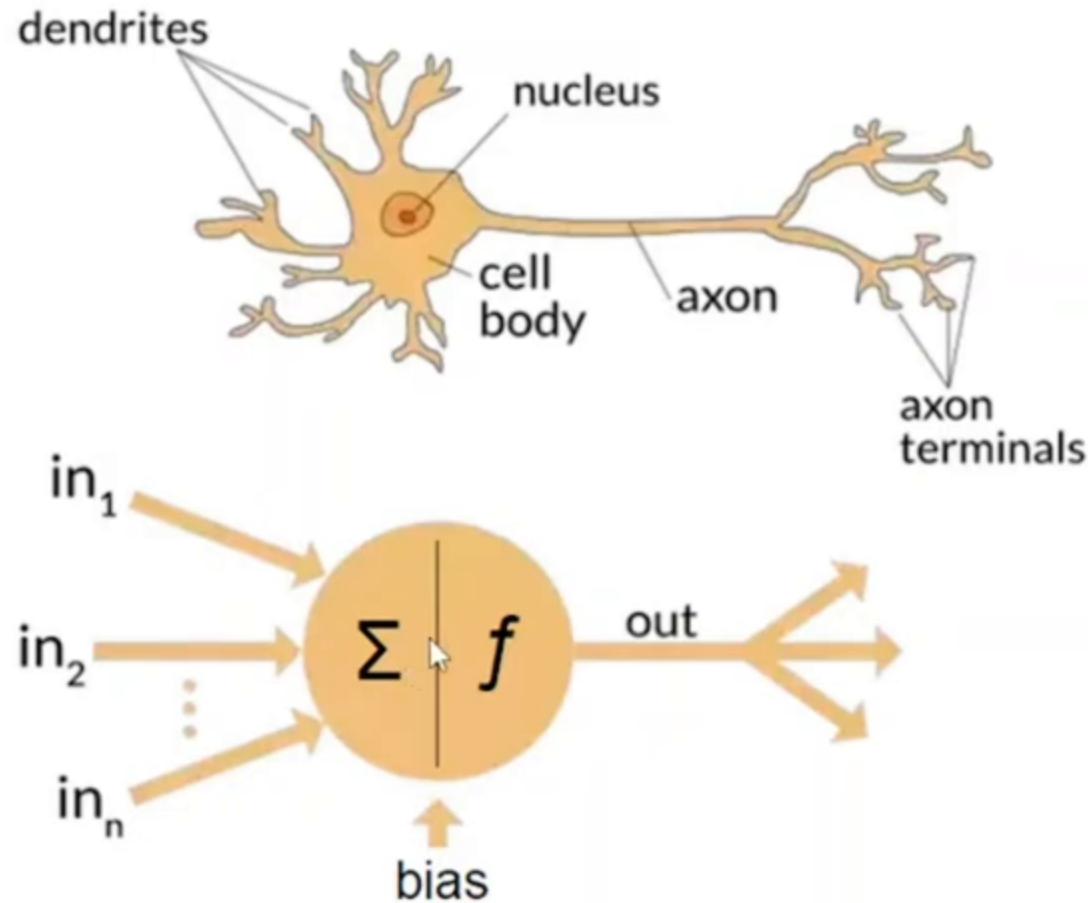
Neuron



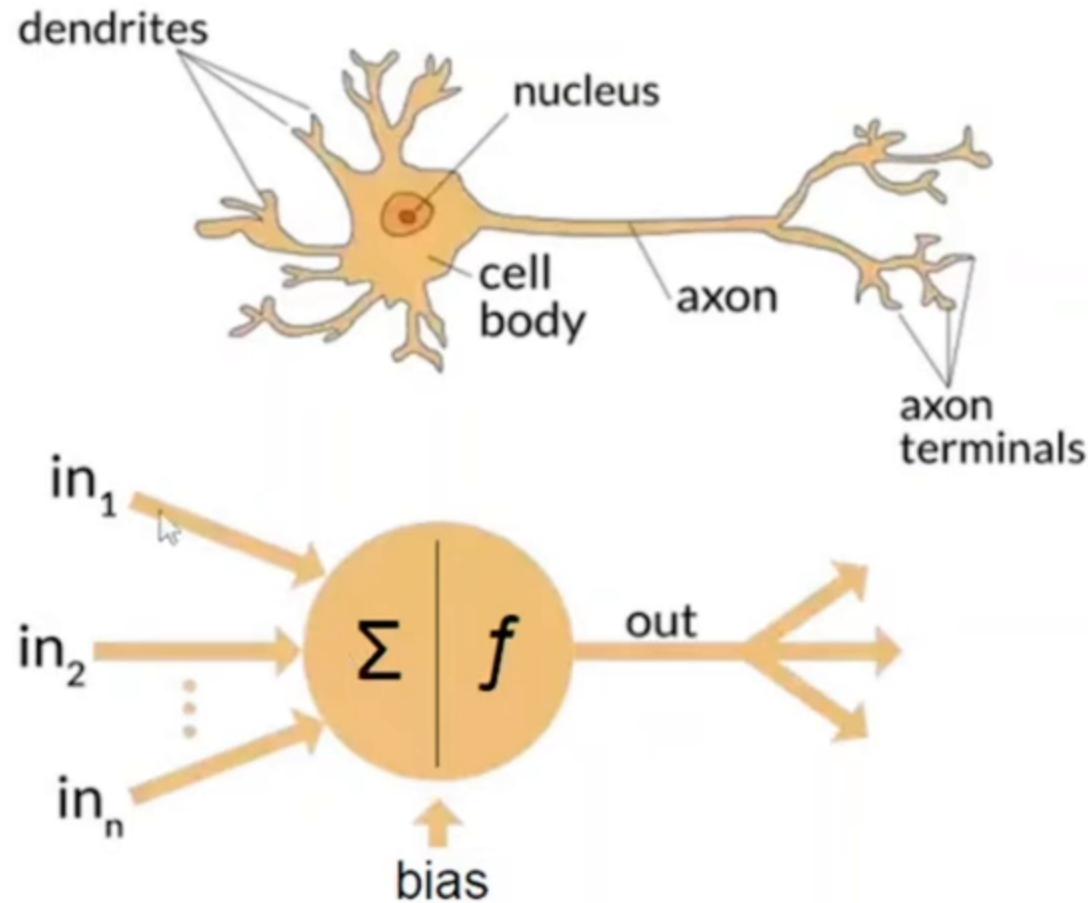
Neuron



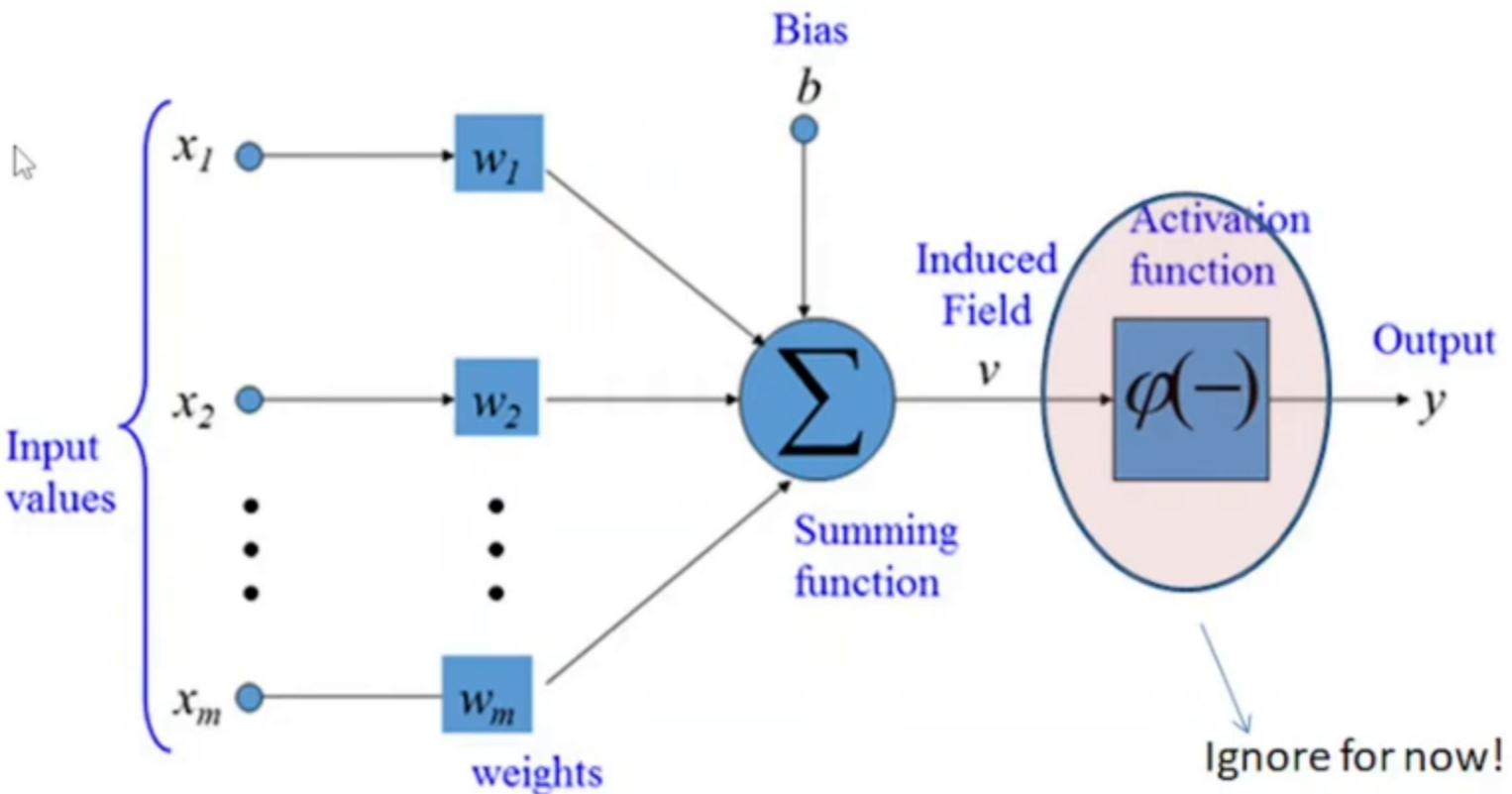
Neuron



Neuron

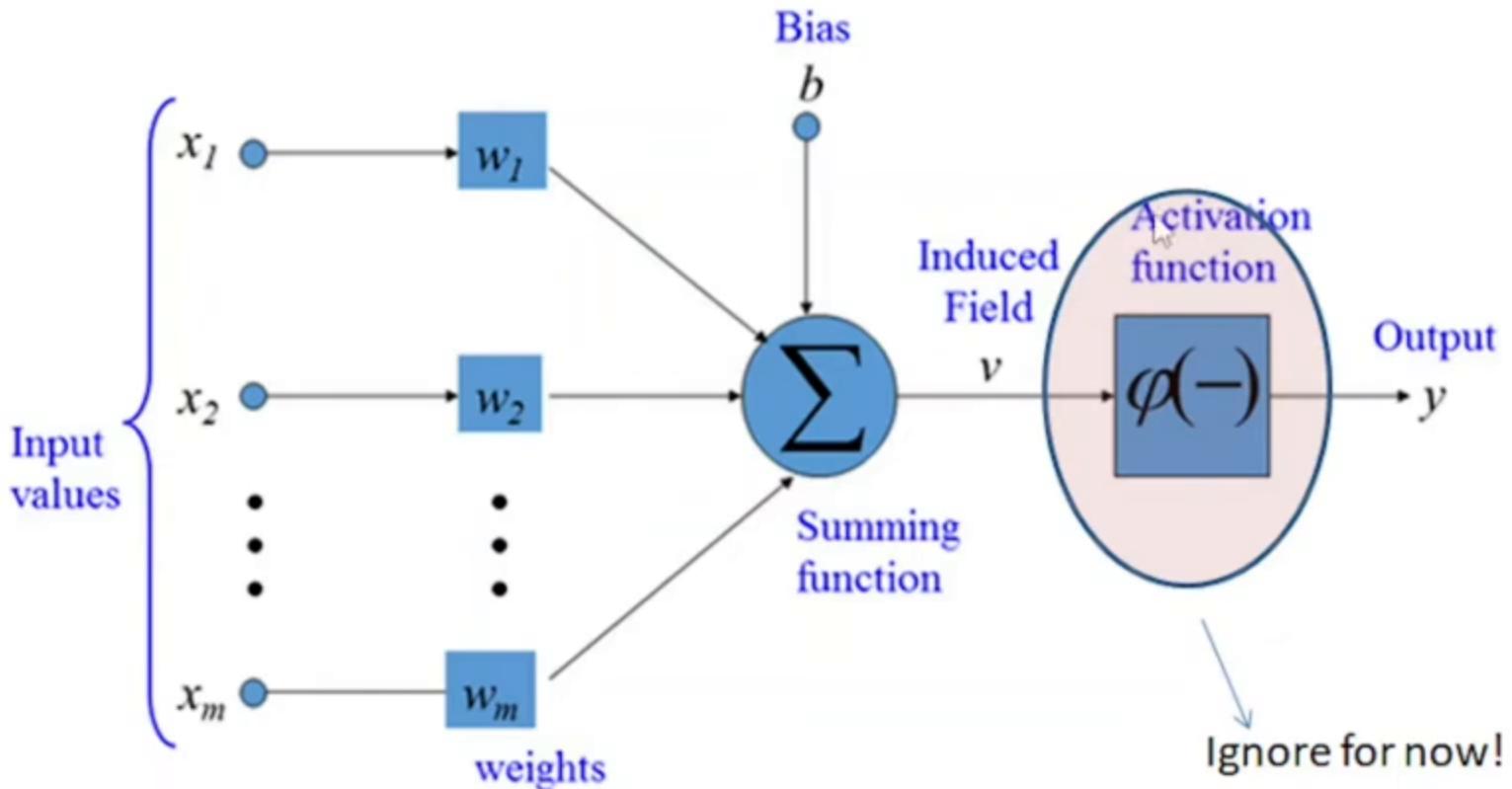


Artificial Neuron



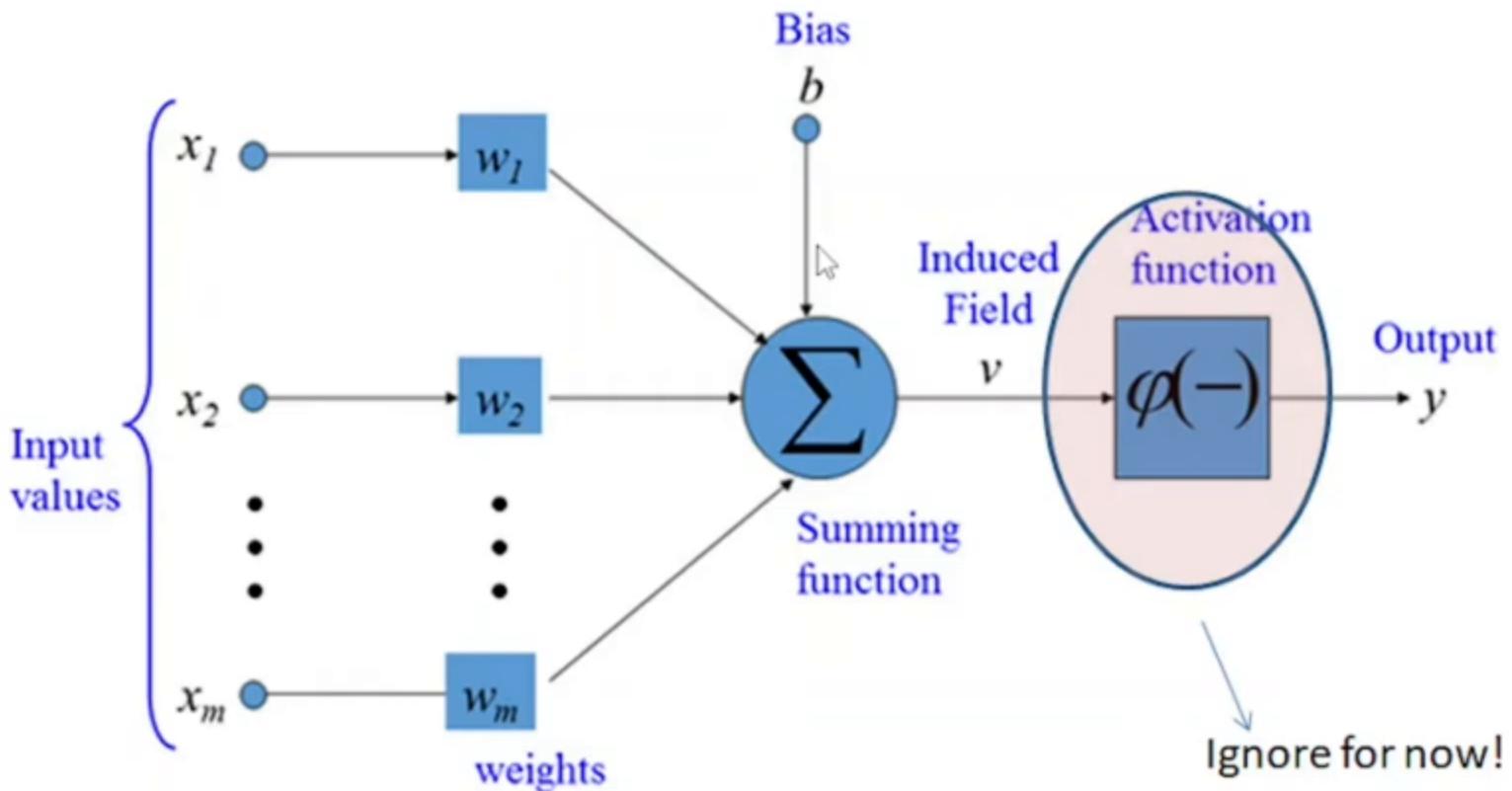
$$\text{Output} = x_1 * w_1 + x_2 * w_2 + \dots + b$$

Artificial Neuron



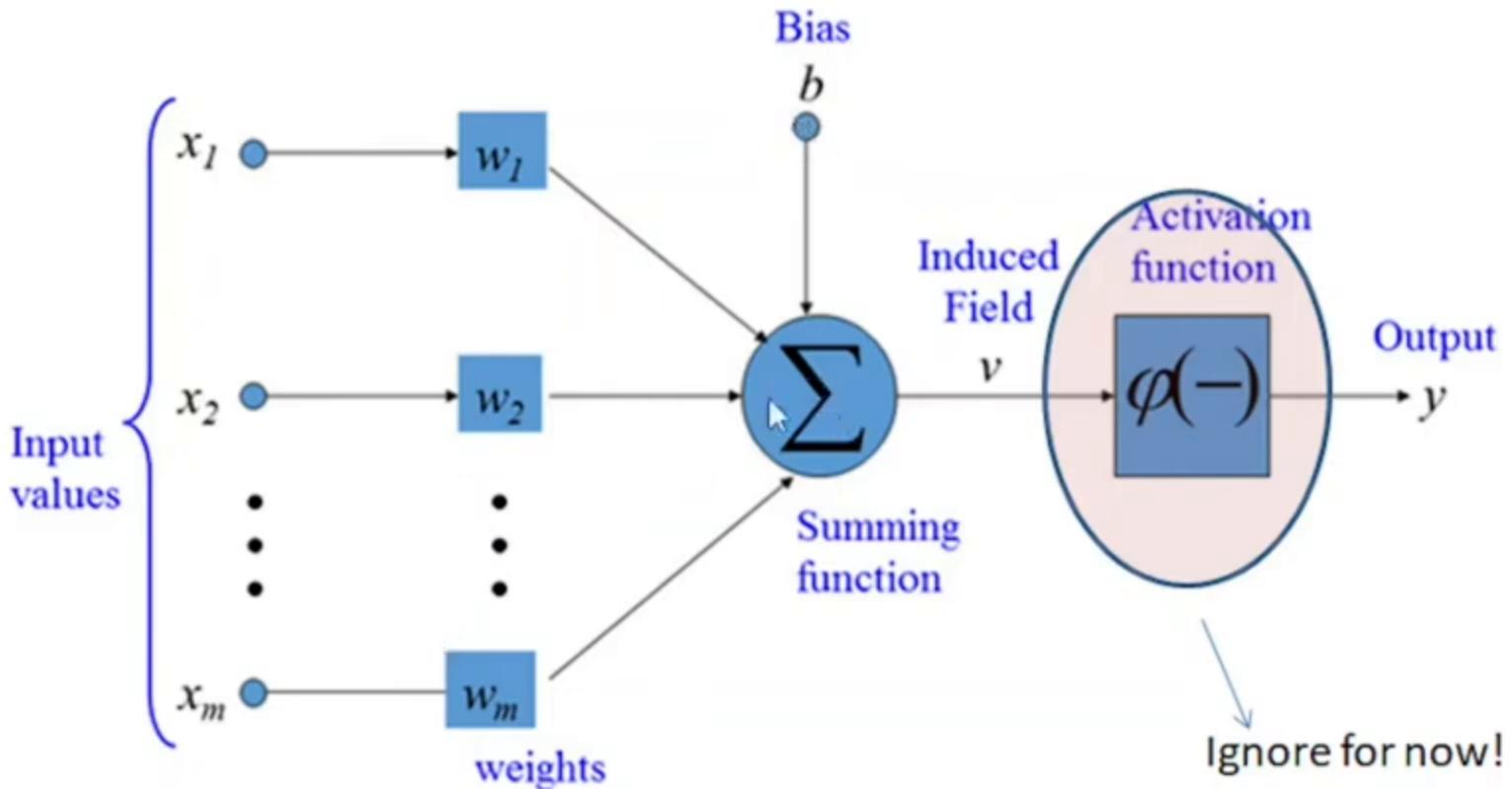
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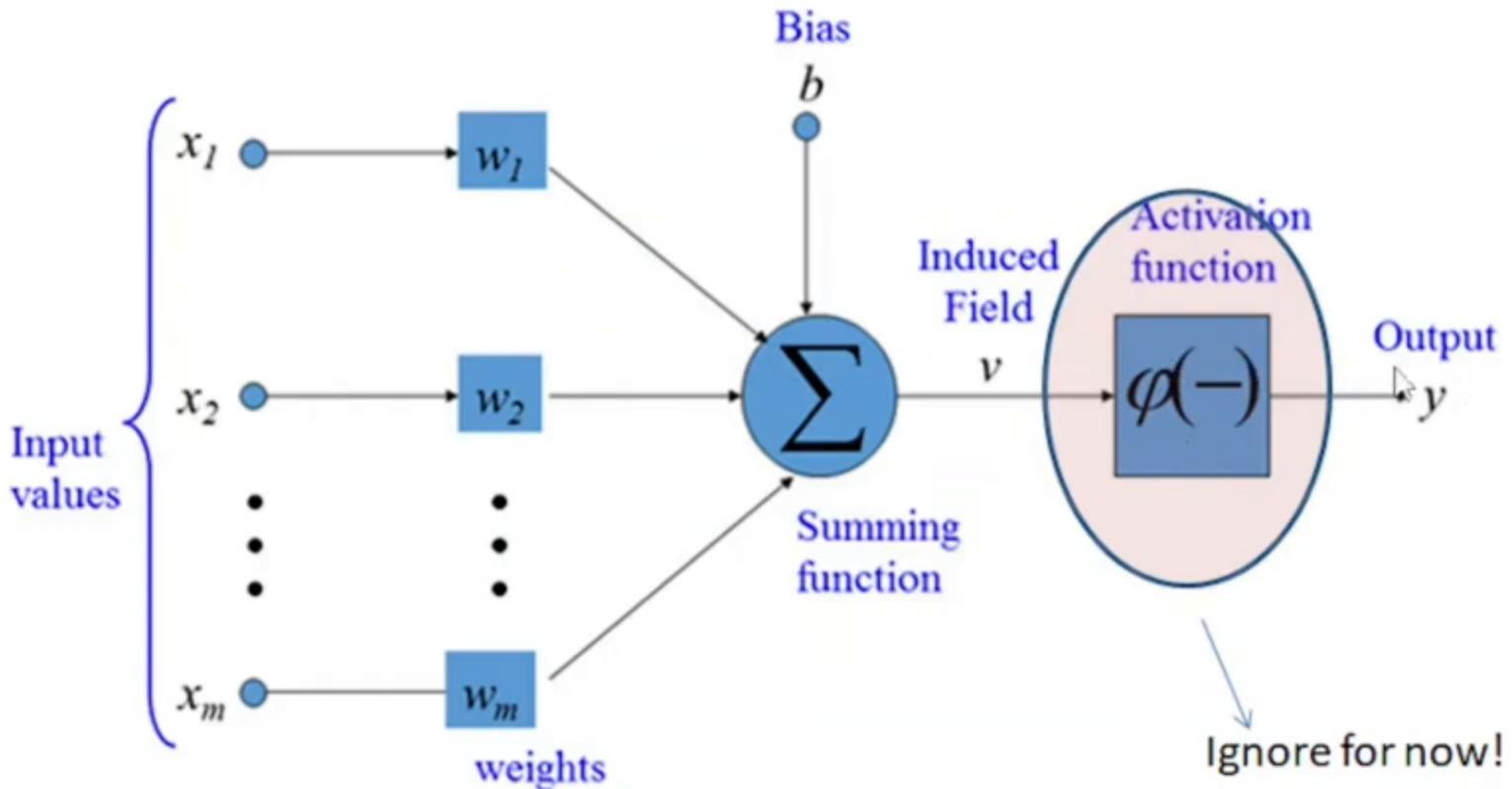
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Artificial Neuron



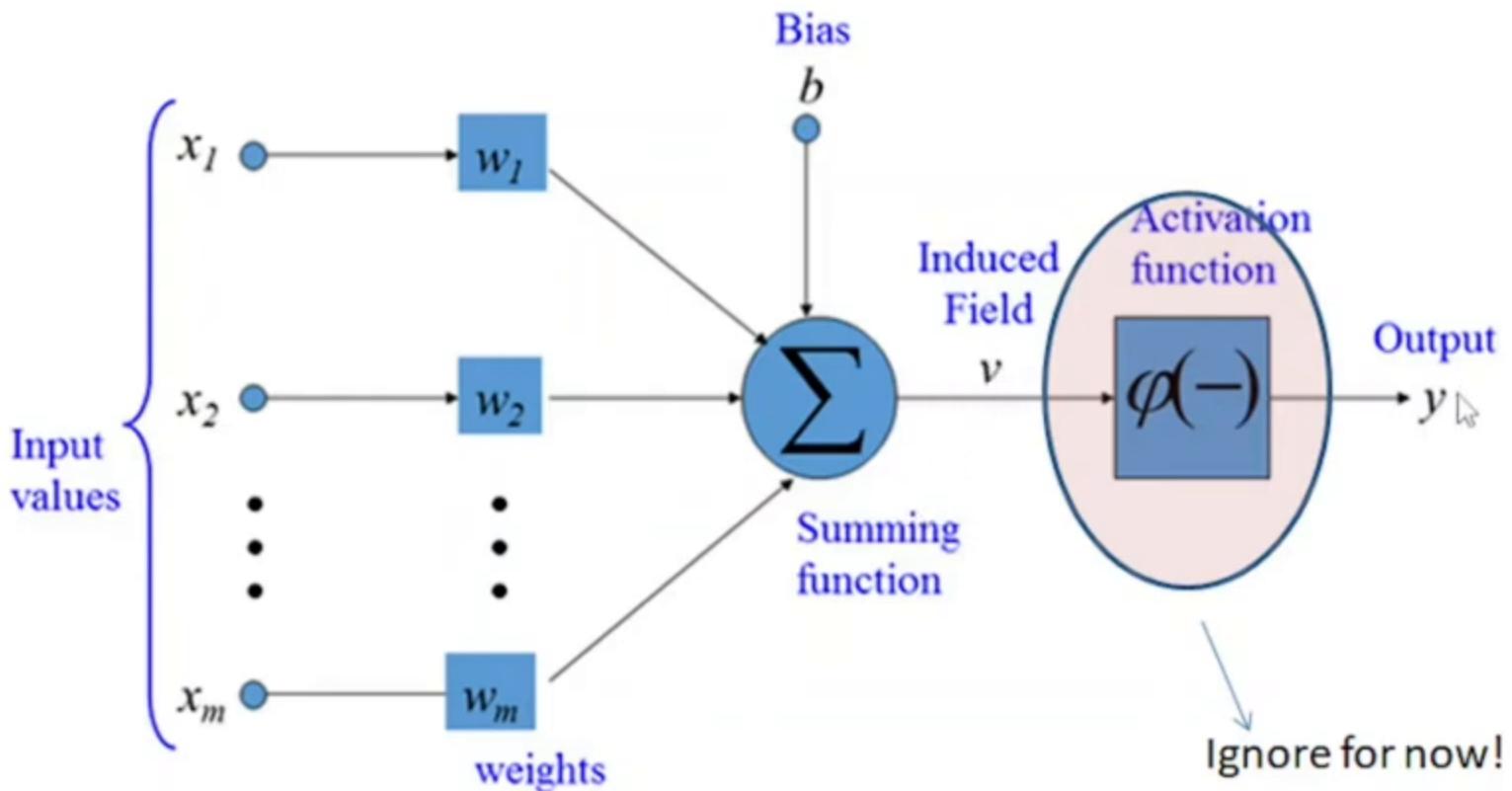
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Artificial Neuron



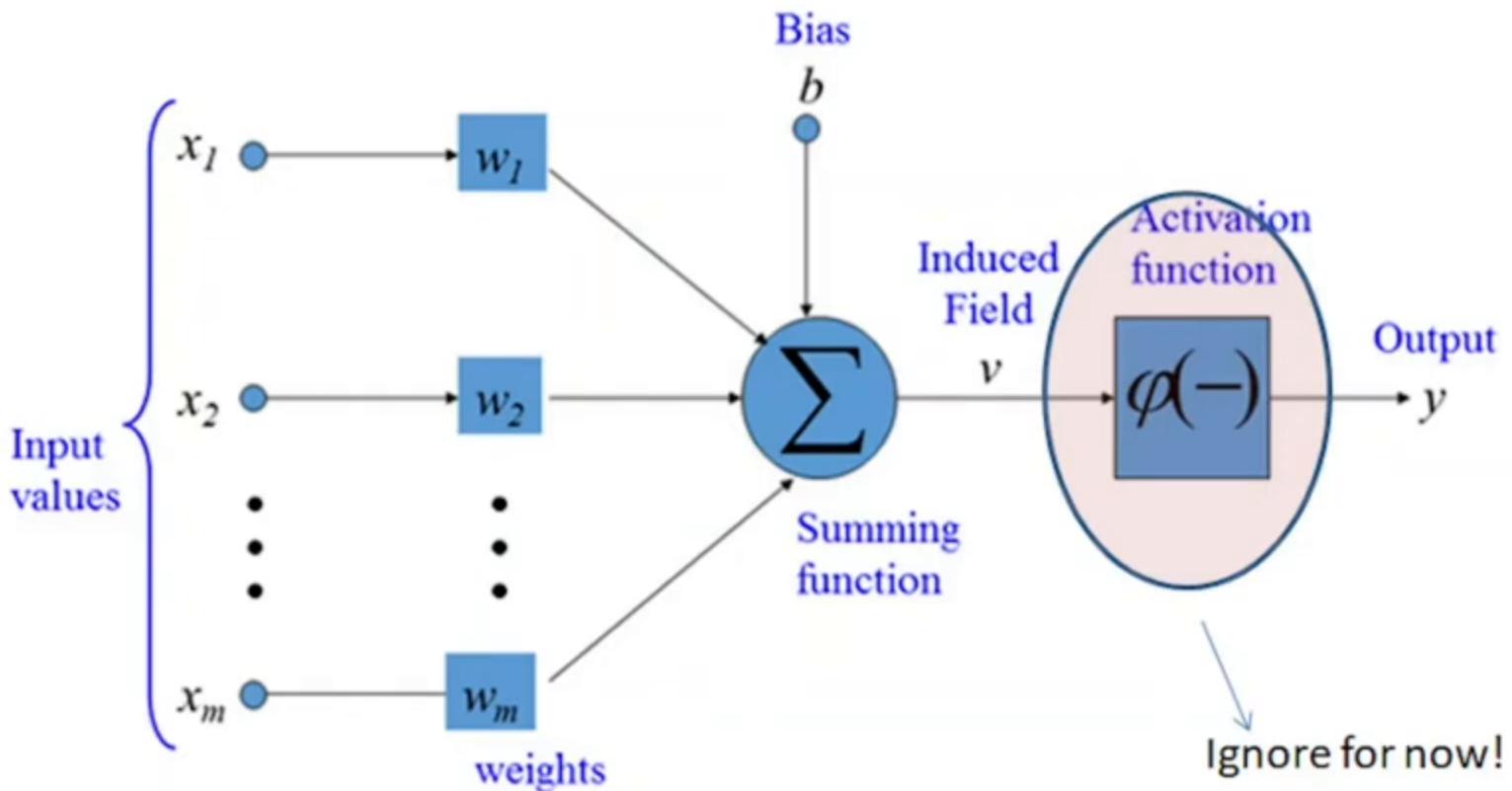
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Artificial Neuron



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Artificial Neuron



$$\text{Output} = x_1 * w_1 + x_2 * w_2 + \dots + b$$

System of linear equations

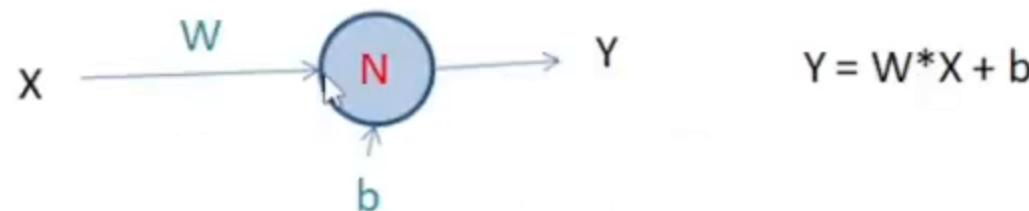
$$\begin{cases} a_1x + b_1y = c_1 \\ a_2x + b_2y = c_2 \end{cases}$$

↓ ↓ ↓
Weights Bias

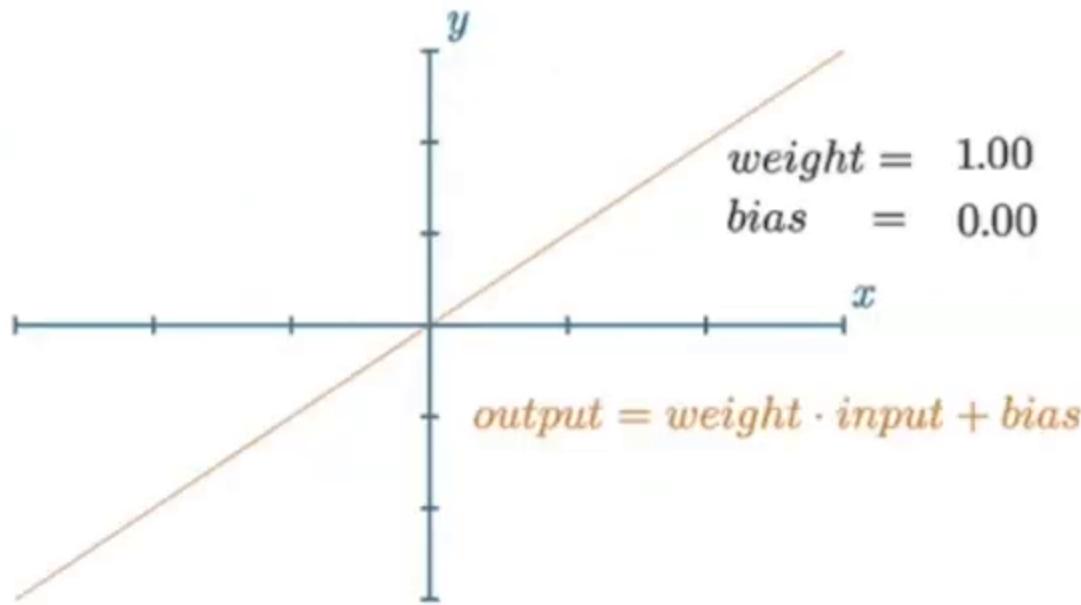
Ex:

$$\begin{aligned} -5x + 3y &= 10 \\ -3x + y &= 6 \end{aligned}$$

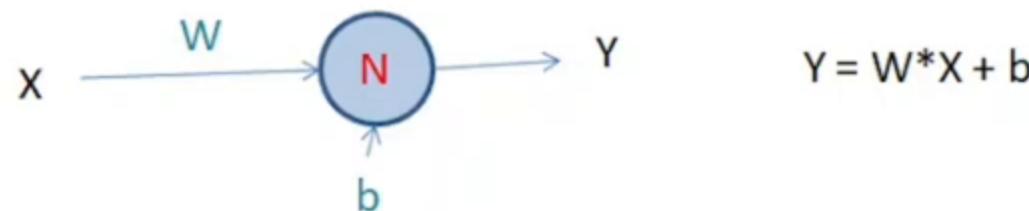
Geometric view



Ex: $y = x$; $w=1$, $b=0$

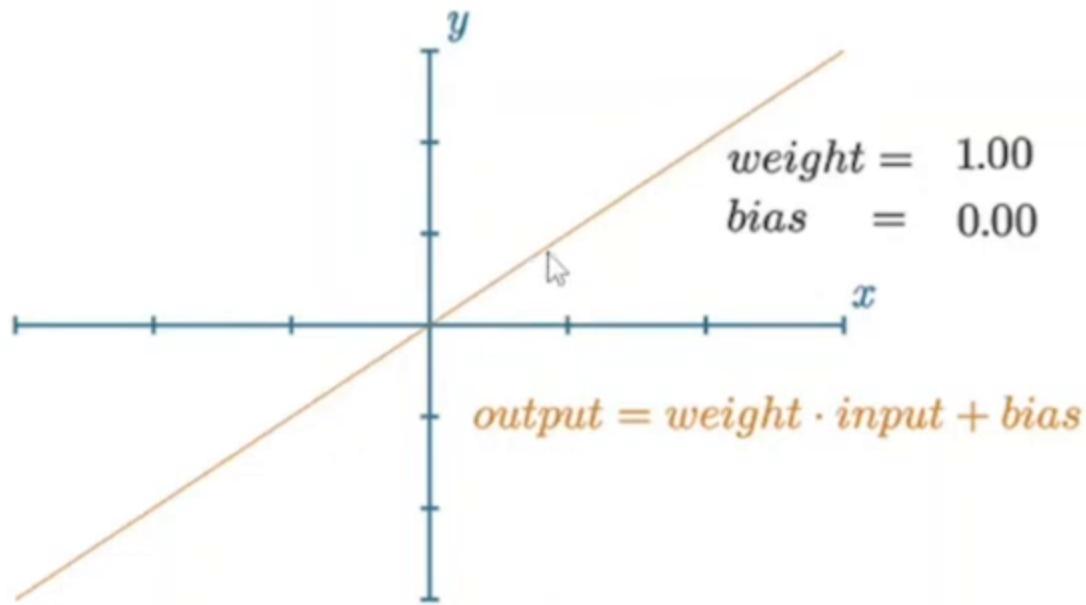


Geometric view

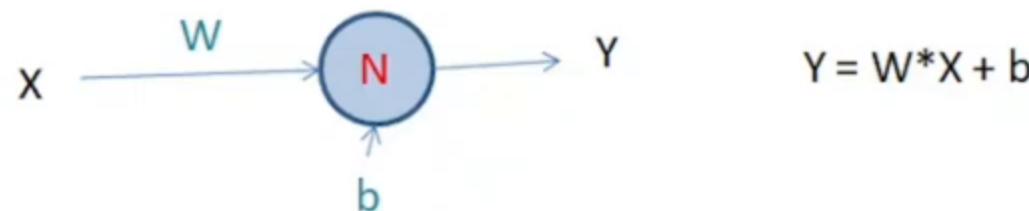


$$Y = W^*X + b$$

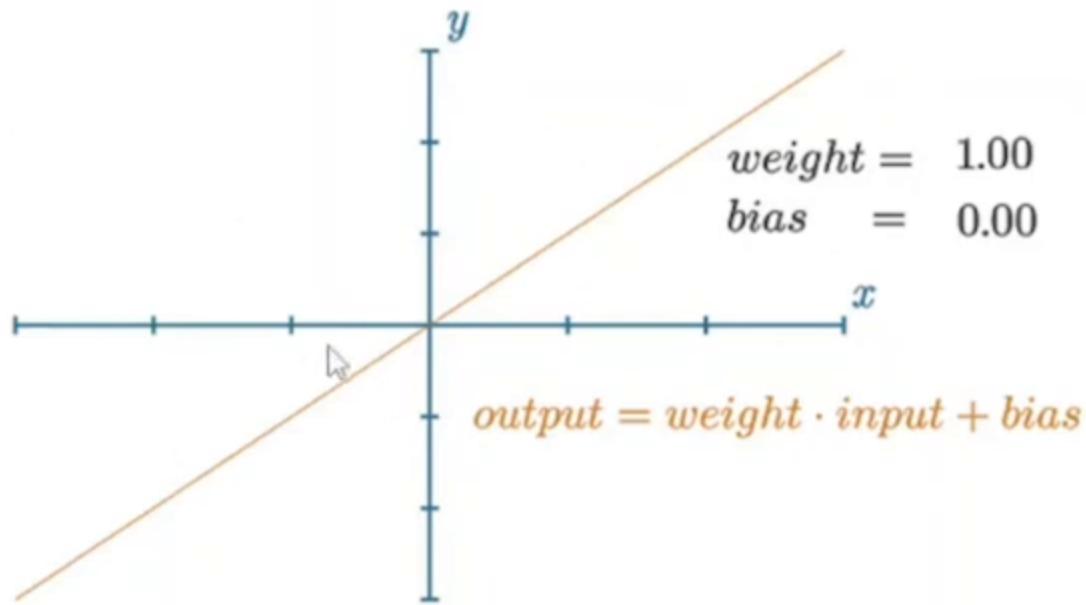
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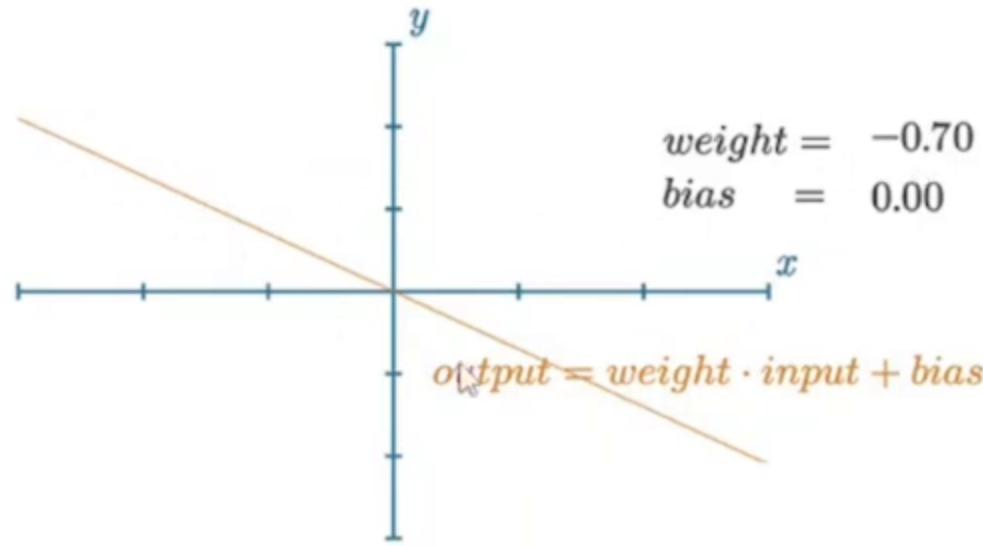
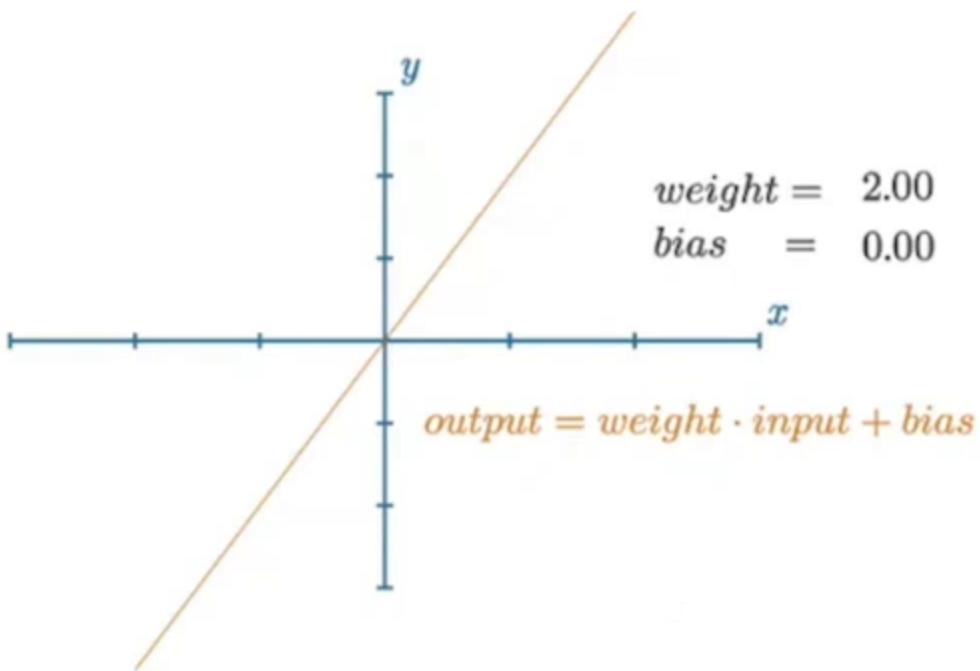
Geometric view



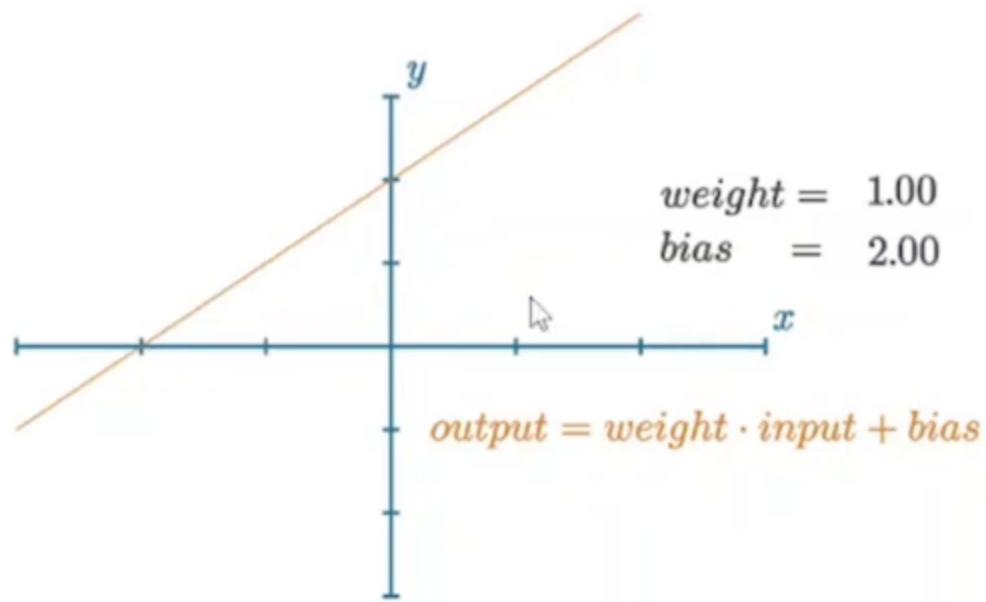
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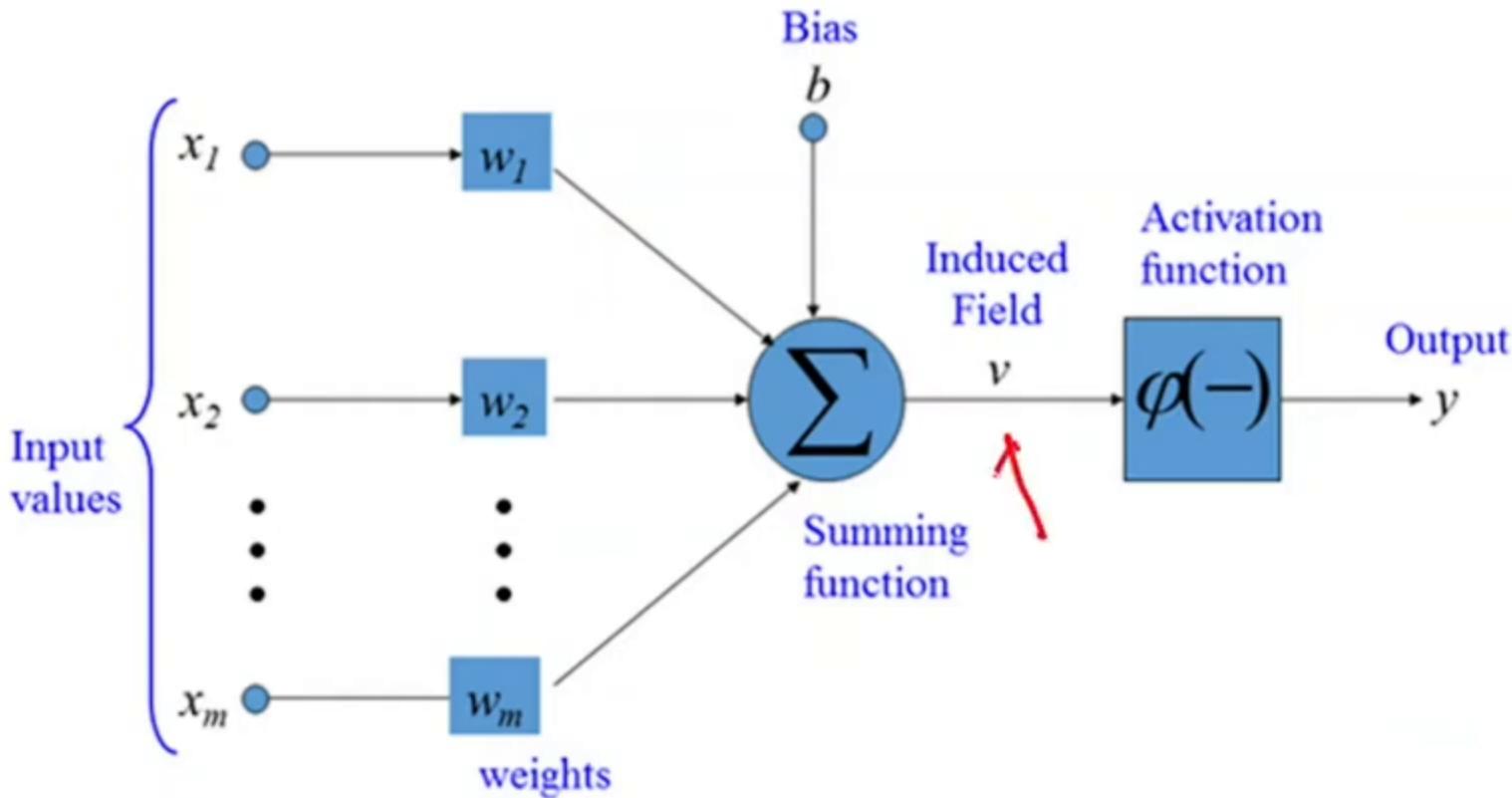
Examples



Examples

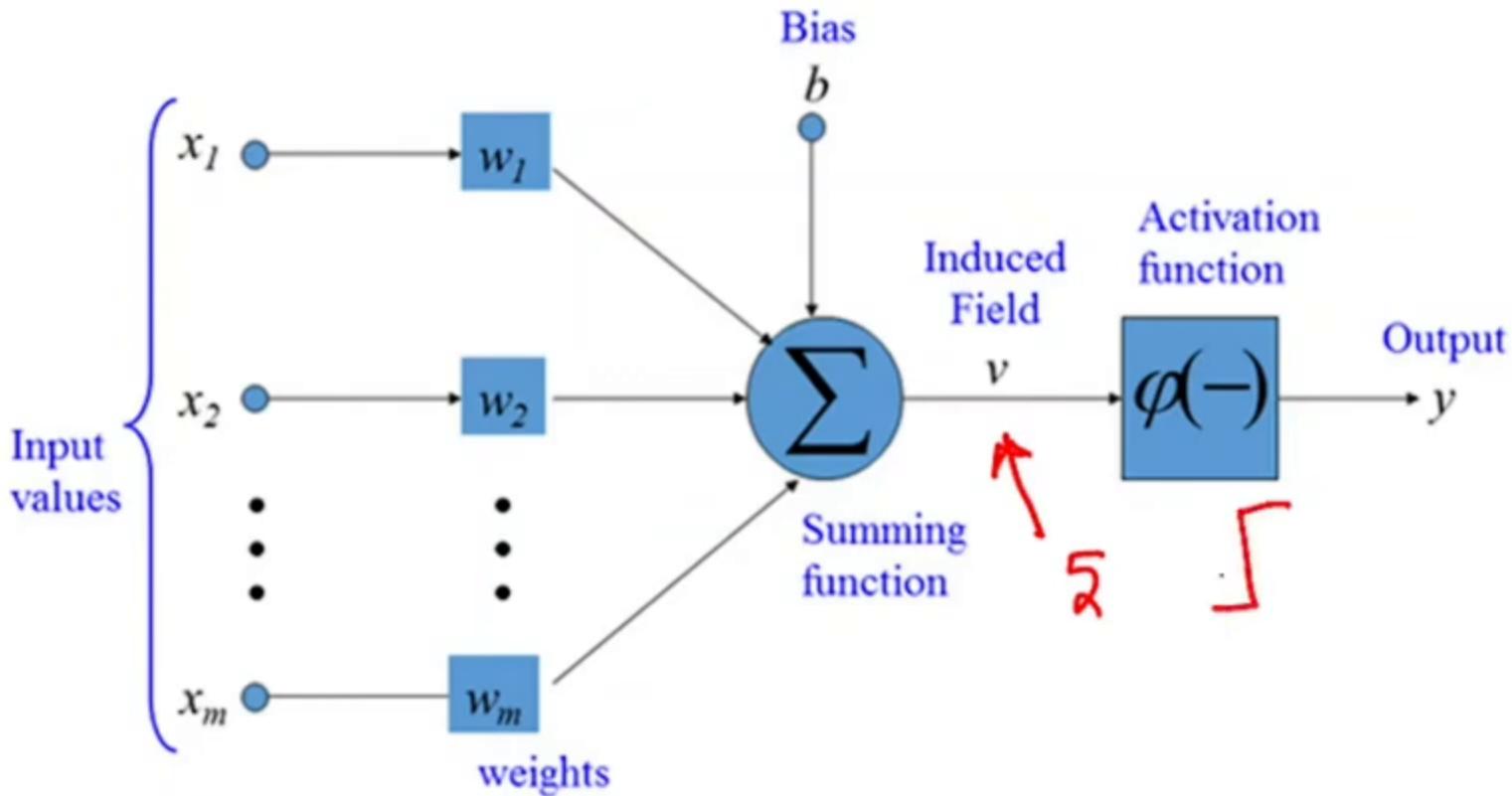


Activation Function



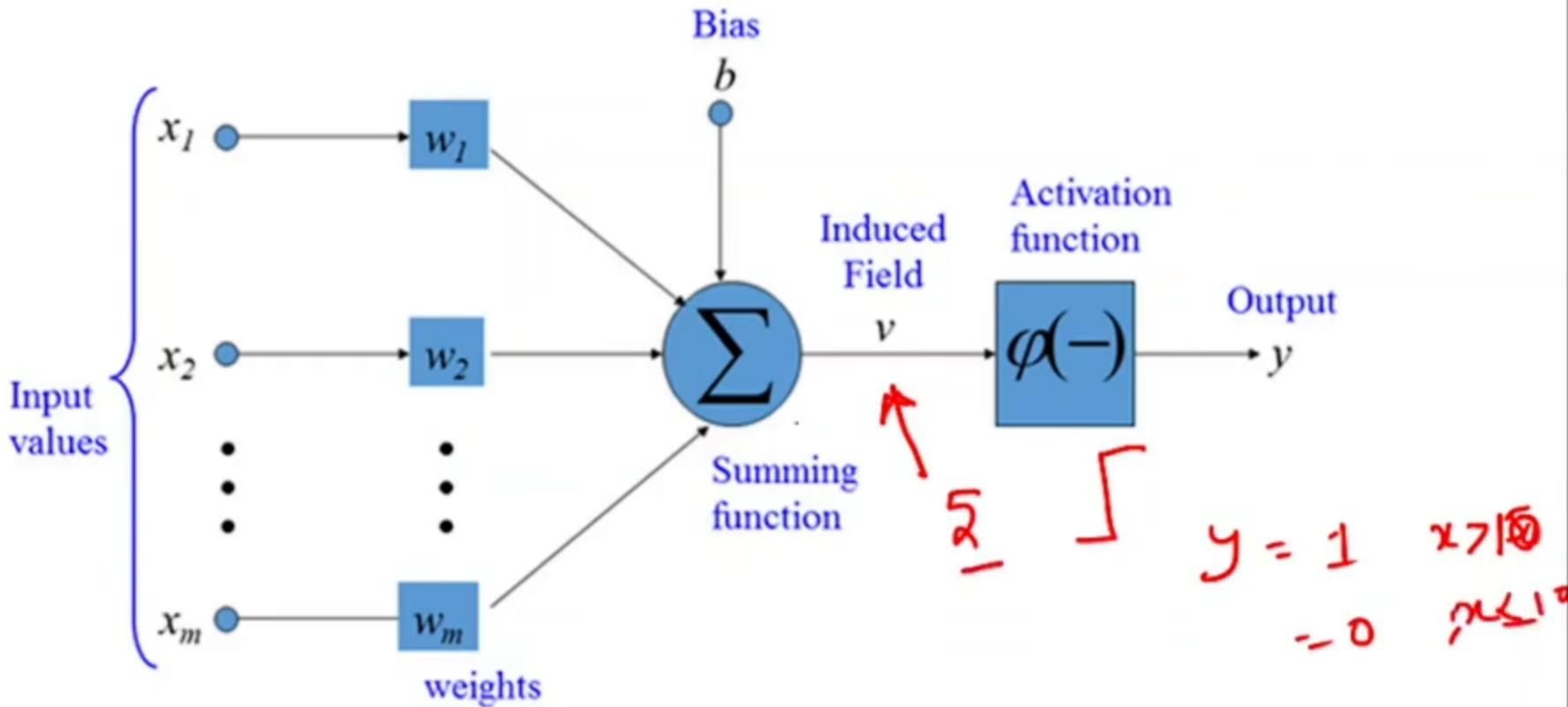
$$\text{Output } Y = \varphi(w_1*x_1 + w_2*x_2 + \dots + b)$$

Activation Function



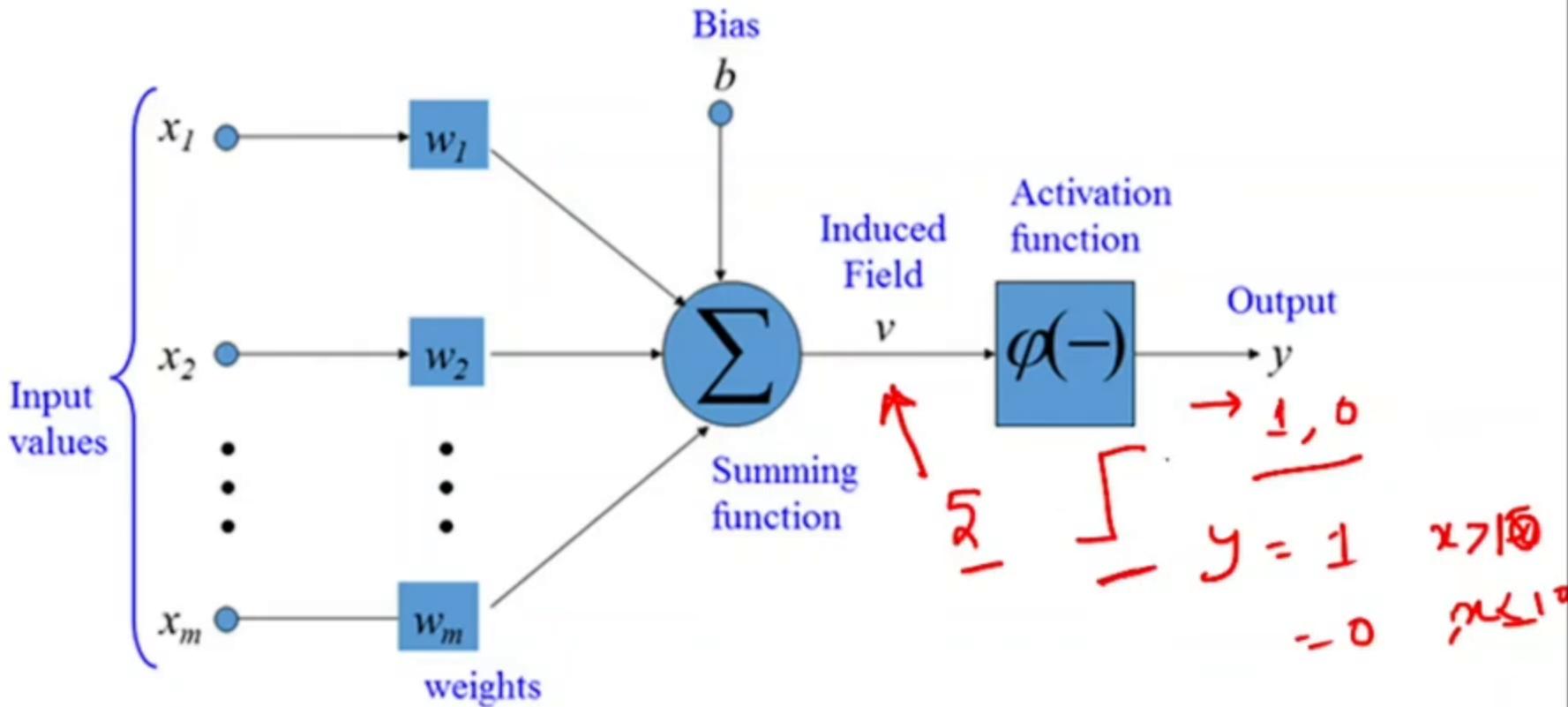
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Activation Function



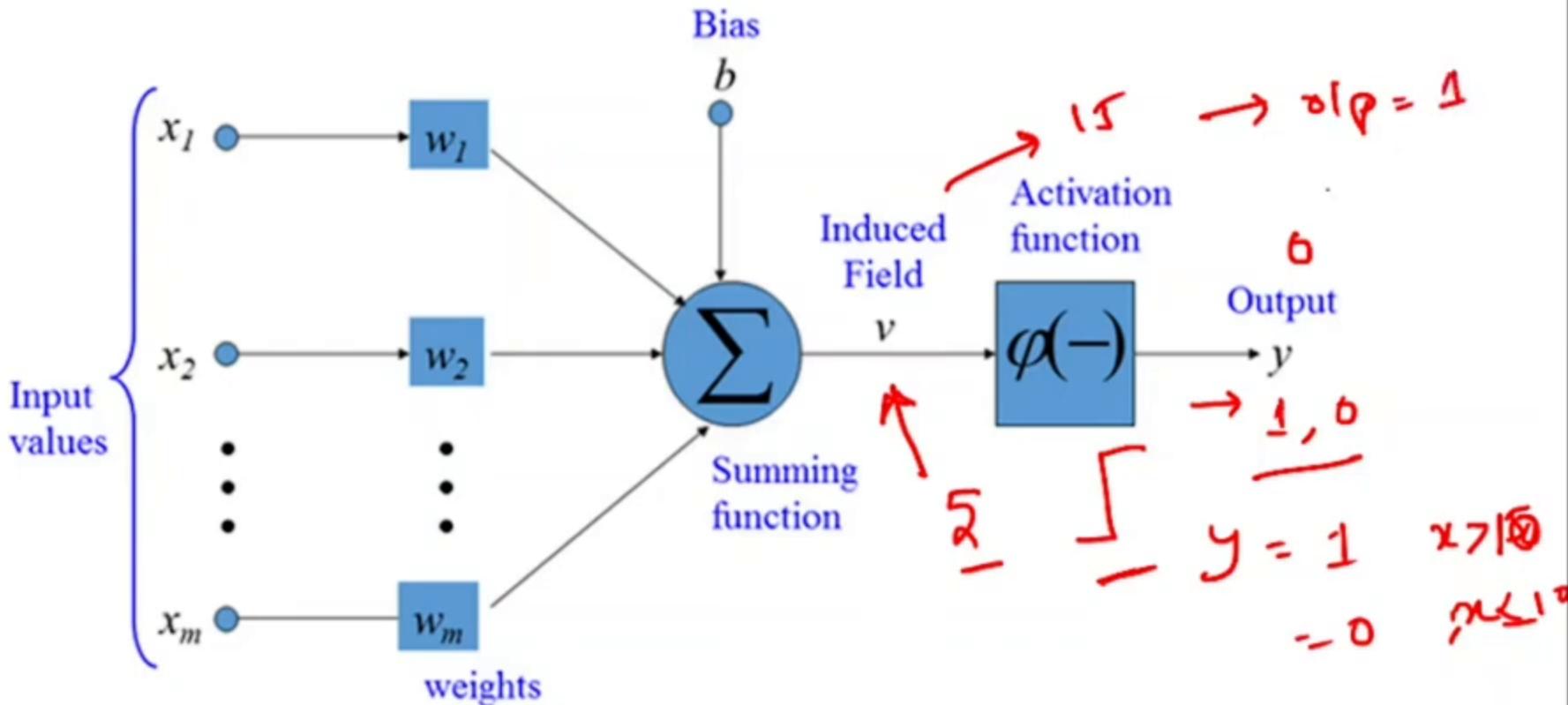
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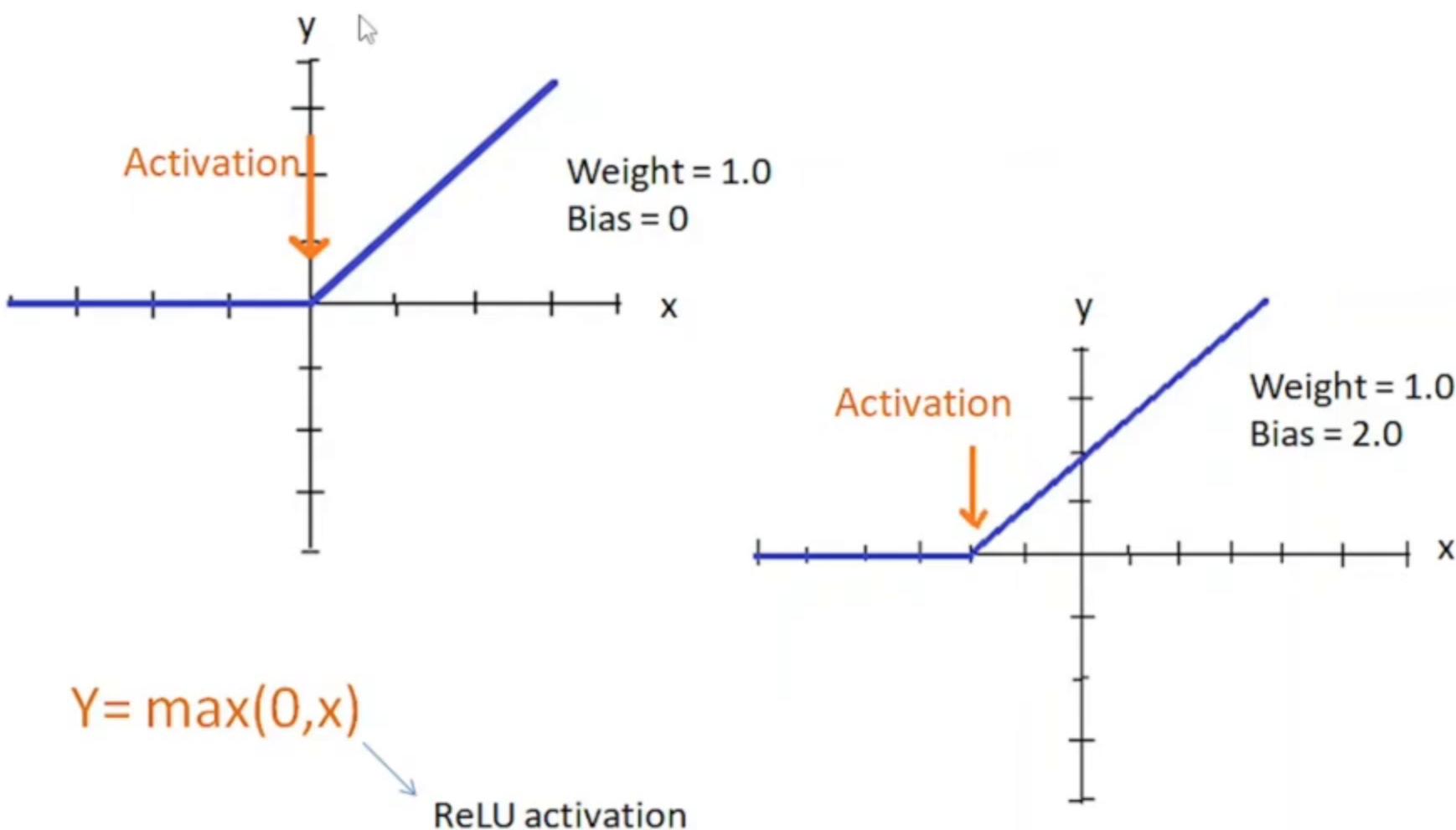
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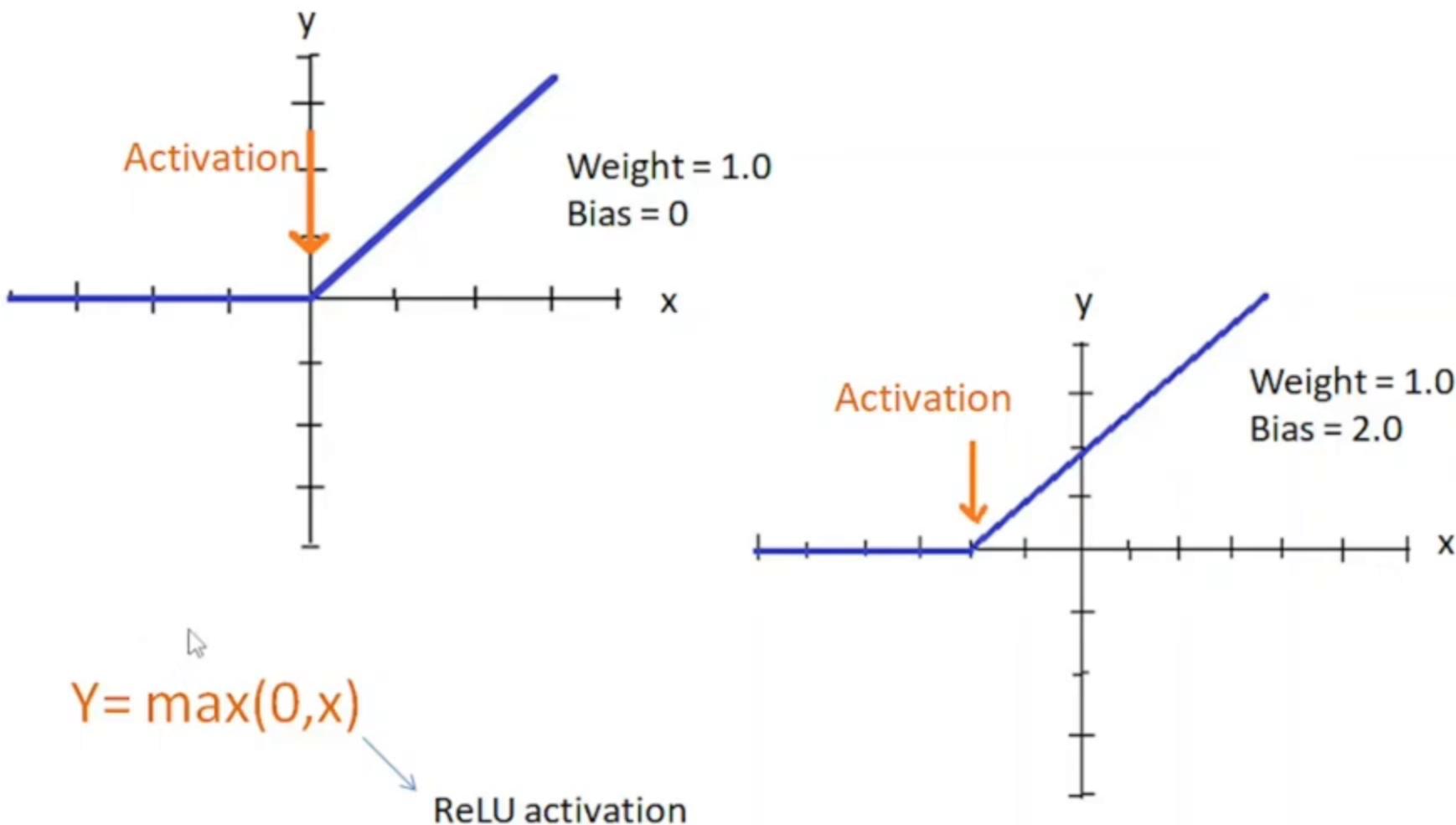


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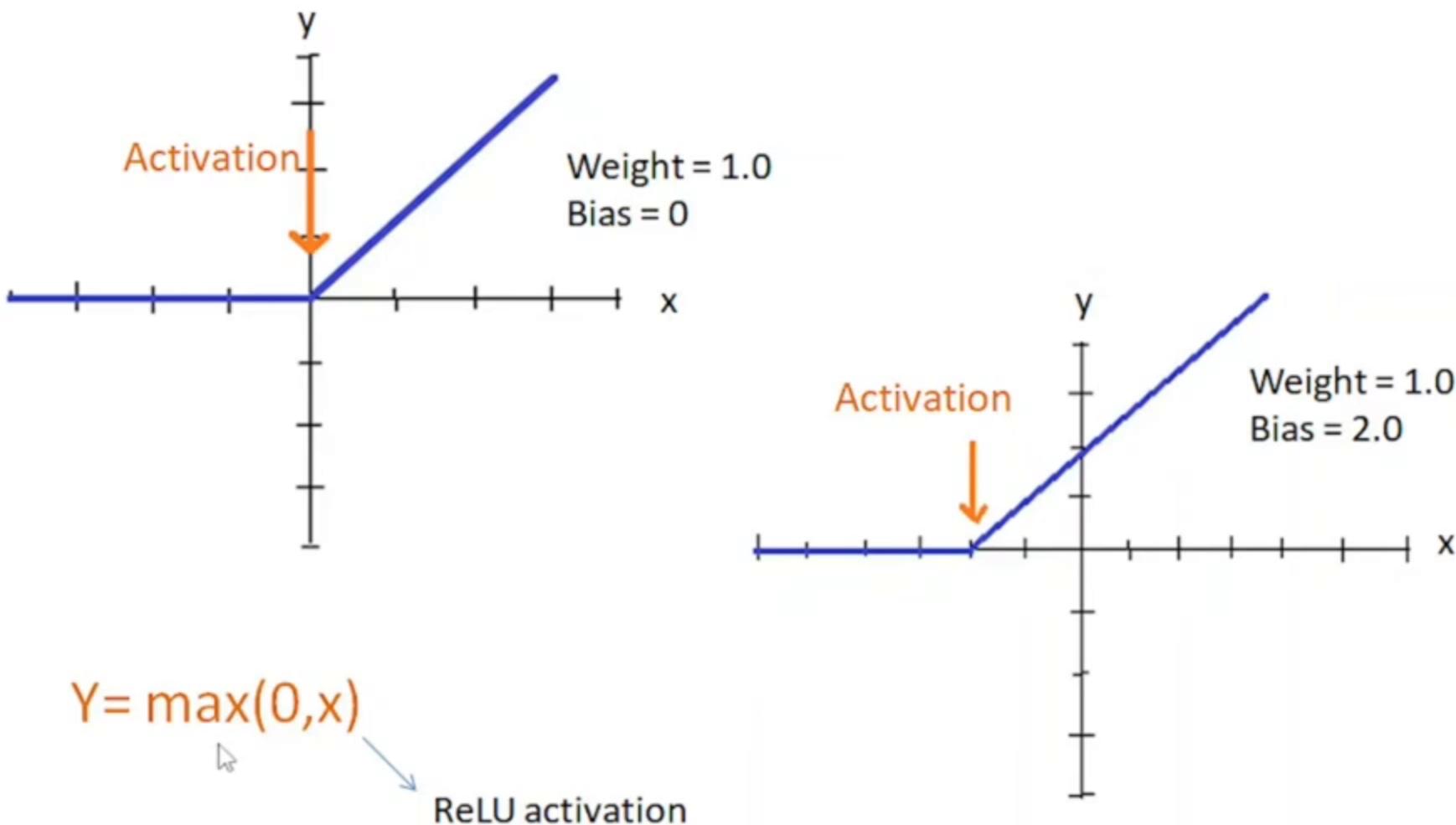
ReLU – Rectified Linear Unit



ReLU – Rectified Linear Unit



ReLU – Rectified Linear Unit



Neuron.ipynb - Colaboratory

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Neuron.ipynb

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Let's code a basic neuron

$x_1=2$

$w_1=0.3$

$x_2=4$

$w_2=0.5$

$x_3=7$

$w_3=-0.2$

$b=2$

$$Y = w_1 \cdot x_1 + w_2 \cdot x_2 + w_3 \cdot x_3 + b$$
$$Y = 0.3 \cdot 2 + 0.5 \cdot 4 + (-0.2) \cdot 7 + 2 = 3.2$$

The diagram illustrates a basic neuron model. It features a central blue circle representing the neuron. Three orange lines extend from the left side of the circle to three input nodes, each labeled with its value and weight: $x_1=2$ with weight $w_1=0.3$, $x_2=4$ with weight $w_2=0.5$, and $x_3=7$ with weight $w_3=-0.2$. A fourth orange line extends from the bottom of the circle to a bias node labeled $b=2$. The neuron's output is calculated as the weighted sum of its inputs plus the bias, resulting in $Y = 3.2$.

[]

A smaller version of the neuron diagram is shown in the bottom left corner.

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1:46 PM
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12/18/2021



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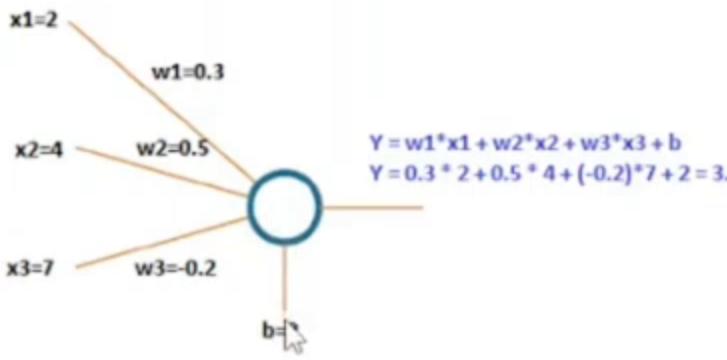




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Let's code a basic neuron



[]



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Neuron.ipynb - Colaboratory

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Neuron.ipynb

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$$Y = 0.3 \cdot 2 + 0.5 \cdot 4 + (-0.2) \cdot 7 + 2 = 3.2$$

inputs = []

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The diagram illustrates a basic neuron model. It consists of a central blue circle representing the neuron. Three orange lines extend from the left side of the circle to the left, each labeled with an input value and its corresponding weight. The first line is labeled 'x1=2' and 'w1=0.3'. The second line is labeled 'x2=4' and 'w2=0.5'. The third line is labeled 'x3=7' and 'w3=-0.2'. A single orange line extends from the bottom of the circle to the right, labeled 'b=2', representing the bias. To the right of the neuron, the mathematical formula for calculating the output Y is shown, along with the result Y = 3.2.

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8

- Let's code a basic neuron

```
inputs = [2,4,7]
weights = [0.3, 0]
```



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Neuron.ipynb - Colaboratory

colab.research.google.com/drive/109Wvb6_MPN9nDPOxf4wy2r6Ip7MZz4fs#scrollTo=n5j_GUNWwp7p

Neuron.ipynb

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Let's code a basic neuron

$x_1=2$

$w_1=0.3$

$x_2=4$

$w_2=0.5$

$x_3=7$

$w_3=-0.2$

$b=2$

$$Y = w_1 \cdot x_1 + w_2 \cdot x_2 + w_3 \cdot x_3 + b$$
$$Y = 0.3 \cdot 2 + 0.5 \cdot 4 + (-0.2) \cdot 7 + 2 = 3.2$$

inputs = [2,4,7]

weights = [0.3, 0.5, -0.2]

bias = 2

output |

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8

- Let's code a basic neuron

$x_1=2$
 $w_1=0.3$
 $x_2=4$
 $w_2=0.5$
 $x_3=7$
 $w_3=-0.2$
 $b=2$

$$Y = w_1 \cdot x_1 + w_2 \cdot x_2 + w_3 \cdot x_3 + b$$

$$Y = 0.3 \cdot 2 + 0.5 \cdot 4 + (-0.2) \cdot 7 + 2 = 3$$

```
inputs = [2,4,7]
weights = [0.3, 0.5, -0.2]
bias = 2

output = inputs[0]*weights
```

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 Neuron.ipynb 

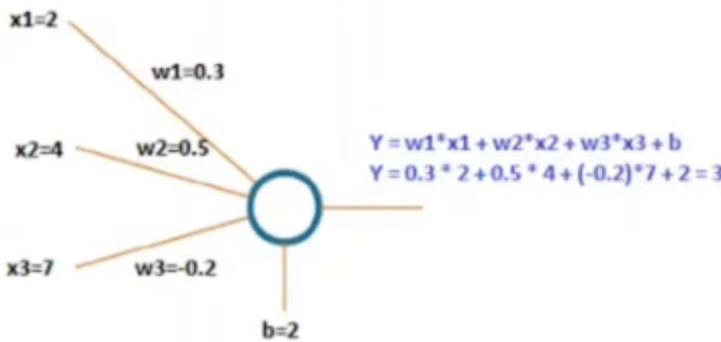
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- Let's code a basic neuron



```
inputs = [2,4,7]
weights = [0.3, 0.5, -0.2]
bias = 2

output = inputs[0]*weights[0] + inputs[1]*weights[1]
```

Neuron.ipynb - Colaboratory

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Neuron.ipynb

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Let's code a basic neuron

$x_1=2$

$w_1=0.3$

$x_2=4$

$w_2=0.5$

$x_3=7$

$w_3=-0.2$

$b=2$

$$Y = w_1 \cdot x_1 + w_2 \cdot x_2 + w_3 \cdot x_3 + b$$
$$Y = 0.3 \cdot 2 + 0.5 \cdot 4 + (-0.2) \cdot 7 + 2 = 3.2$$

inputs = [2,4,7]
weights = [0.3, 0.5, -0.2]
bias = 2
output = inputs[0]*weights[0] + inputs[1]*weights[1] + inputs[2]*weights[2]

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Neuron.ipynb

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- Let's code a basic neuron

$x_1=2$

$w_1=0.3$

$x_2=4$

$w_2=0.5$

$x_3=7$

$w_3=-0.2$

$b=2$

$$Y = w_1 \cdot x_1 + w_2 \cdot x_2 + w_3 \cdot x_3 + b$$
$$Y = 0.3 \cdot 2 + 0.5 \cdot 4 + (-0.2) \cdot 7 + 2 = 3.2$$

inputs = [2,4,7]
weights = [0.3, 0.5, -0.2]
bias = 2

output = inputs[0]*weights[0] + inputs[1]*weights[1] + inputs[2]*weights[2] + bias

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Neuron.ipynb

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x1=2
w1=0.3
x2=4
w2=0.5
x3=7
w3=-0.2
 $b=2$

$\{x\}$

$Y = w1*x1 + w2*x2 + w3*x3 + b$
 $Y = 0.3 * 2 + 0.5 * 4 + (-0.2) * 7 + 2 = 3.2$

inputs = [2,4,7]
weights = [0.3, 0.5, -0.2]
bias = 2

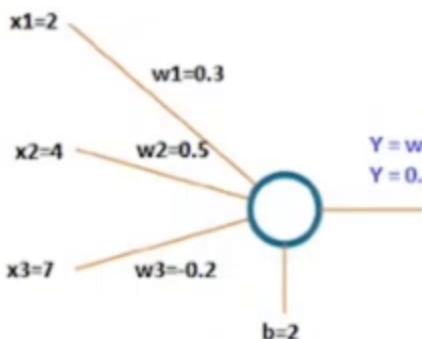
output = inputs[0]*weights[0] + inputs[1]*weights[1] + inputs[2]*weights[2] + bias
print(output)

3.2

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Neuron.ipynb - Colaboratory

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Neuron.ipynb

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RAM Disk Editing

x1=2
w1=0.3
x2=4
w2=0.5
x3=7
w3=-0.2
 $\{x\}$
 $b=2$

$Y = w1*x1 + w2*x2 + w3*x3 + b$
 $Y = 0.3 * 2 + 0.5 * 4 + (-0.2) * 7 + 2 = 3.2$

[15] inputs = [2,4,7]
weights = [0.3, 0.5, -0.2]
bias = 2

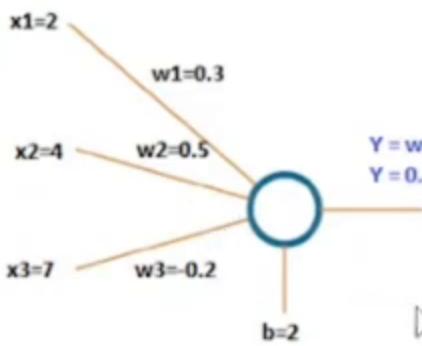
output = inputs[0]*weights[0] + inputs[1]*weights[1] + inputs[2]*weights[2] + bias
print(output)

3.2

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Neuron.ipynb

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[15] bias = 2

```
1s output = inputs[0]*weights[0] + inputs[1]*weights[1] + inputs[2]*weights[2] + bias
print(output)
```

3.2

{x}

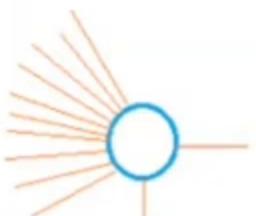
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input[]

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[15] bias = 2

```
output = inputs[0]*weights[0] + inputs[1]*weights[1] + inputs[2]*weights[2] + bias
print(output)
```

3.2

{x}

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input§ = [1,2,3,4]
weights = [2,3,4,5]
bias |

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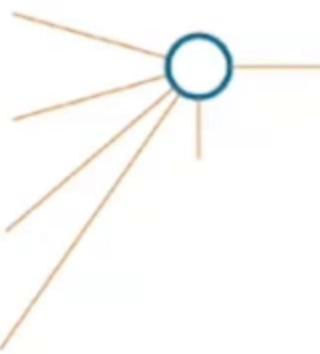
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```
bias = 2

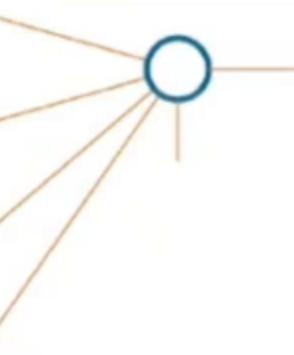
output = inputs[0]*weights[0] + inputs[1]*weights[1] + inputs[2]*weights[2] + bias
print(output)
```

E 3.2



```
[ ] inputs = [1,2,3,4]
    weights = [2,3,4,5]
    bias = 5
```

output =

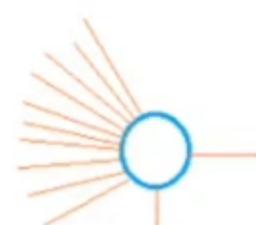


✓ 0s

```
inputs = [1,2,3,4]
weights = [2,3,4,5]
bias = 5

output = inputs[0]*weights[0] + inputs[1]*weights[1] + inputs[2]*weights[2] + inputs[3]* weights[3] + bias
print(output)
```

45



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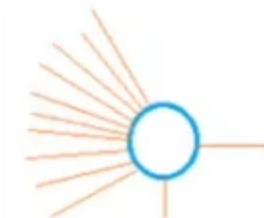
RAM Disk Editing

✓ 0s

```
inputs = [1,2,3,4]
weights = [2,3,4,5]
bias = 5

output = inputs[0]*weights[0] + inputs[1]*weights[1] + inputs[2]*weights[2] + inputs[3]* weights[3] + bias
print(output)
```

45



[]

With Numpy

[]

ReLU activation

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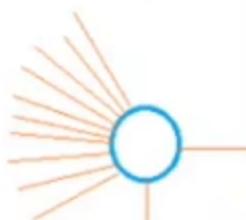
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+ Code + Text

[16] inputs = [1,2,3,4]
weights = [2,3,4,5]
bias = 5

output = inputs[0]*weights[0] + inputs[1]*weights[1] + inputs[2]*weights[2] + inputs[3]* weights[3] + bias
print(output)

45



 inputs



With Numpy

[]

ReLU activation

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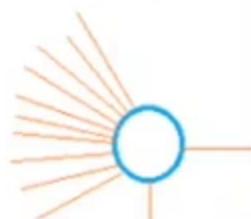
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```
[16]: inputs = [1,2,3,4]
       weights = [2,3,4,5]
       bias = 5

       output = inputs[0]*weights[0] + inputs[1]*weights[1] + inputs[2]*weights[2] + inputs[3]* weights[3] + bias
       print(output)
```

45



```
inputs = weights = list(range(0))
```

With Numpy

[]

- Rel II activation

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[16] inputs = [1,2,3,4]
weights = [2,3,4,5]
bias = 5

output = inputs[0]*weights[0] + inputs[1]*weights[1] + inputs[2]*weights[2] + inputs[3]* weights[3] + bias
print(output)

45



inputs = weights = list(range(1,11))
bias = 10

With Numpy

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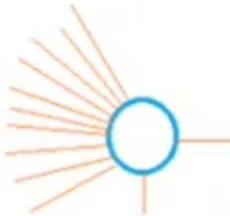
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RAM Disk Editing

[16] inputs = [1,2,3,4]
weights = [2,3,4,5]
bias = 5

output = inputs[0]*weights[0] + inputs[1]*weights[1] + inputs[2]*weights[2] + inputs[3]* weights[3] + bias
print(output)

45



inputs = weights = list(range(1,11))
bias = 10
output=0
for i in range(len(inputs)):
 ouput|

With Numpy

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Neuron.ipynb

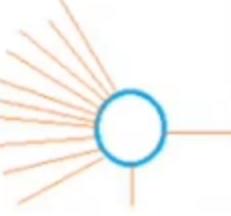
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[16] inputs = [1,2,3,4]
weights = [2,3,4,5]
bias = 5

output = inputs[0]*weights[0] + inputs[1]*weights[1] + inputs[2]*weights[2] + inputs[3]* weights[3] + bias
print(output)

45



inputs = weights = list(range(1,11))
bias = 10
output=0
for i in range(len(inputs)):
 output+=inputs[i]"

With Numpy

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Neuron.ipynb

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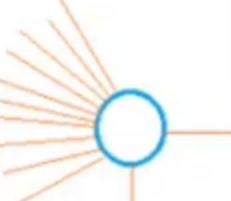
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[16] inputs = [1,2,3,4]
weights = [2,3,4,5]
bias = 5

output = inputs[0]*weights[0] + inputs[1]*weights[1] + inputs[2]*weights[2] + inputs[3]* weights[3] + bias
print(output)

45



inputs = weights = list(range(1,11))
bias =10
output=0
for i in range(len(inputs)):
 output+=inputs[i]*weights[i]
output+=|

With Numpy

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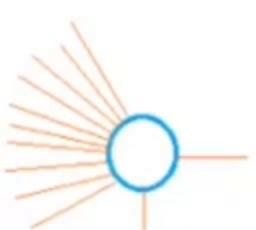
[16] print(output)

0s 45

{x}

RAM Disk Editing

45



```
inputs = weights = list(range(1,11))
bias = 10
output=0
for i in range(len(inputs)):
    output+=inputs[i]*weights[i]
output+=bias

print(output)
```

395

With Numpy

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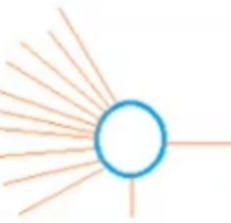
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[16] print(output)

45

{x}



inputs = weights = list(range(1,11))
print(inputs)
bias = 10
output=0
for i in range(len(inputs)):
 output+=inputs[i]*weights[i]
output+=bias

print(output)

395

With Numpy

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```
✓ {x}  inputs = weights = list(range(1,11))
       print(inputs)
       print(weights)
       bias =10
       output=0
       for i in range(len(inputs)):
           output+=inputs[i]*weights[i]
       output+=bias

       print(output)
```

```
[1, 2, 3, 4, 5, 6, 7, 8, 9, 10]
[1, 2, 3, 4, 5, 6, 7, 8, 9, 10]
395
```



With Numpy

[]

ReLU activation

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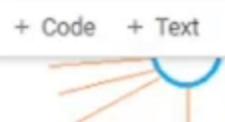
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```
✓ 0s
{x} 0s
  ▶ inputs = weights = list(range(1,11))
      print(inputs)
      print(weights)
      bias =10
      output=0
      for i in range(len(inputs)):
          output+=inputs[i]*weights[i]
      output+=bias

      print(output) ]
```

```
□ [1, 2, 3, 4, 5, 6, 7, 8, 9, 10]
  [1, 2, 3, 4, 5, 6, 7, 8, 9, 10]
  395
```



With Numpy

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ReLU activation

CO Neuron.ipynb

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```
0s ✓ {x} inputs = weights = list(range(1,11))
print(inputs)
print(weights)
bias =10
output=0
for i in range(len(inputs)):
    output+=inputs[i]*weights[i]
output+=bias
print(output)

[1, 2, 3, 4, 5, 6, 7, 8, 9, 10]
[1, 2, 3, 4, 5, 6, 7, 8, 9, 10]
395
```

With Numpy

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ReLU activation

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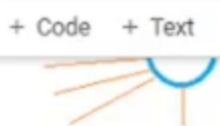
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```
[18] inputs = weights = list(range(1,11))
     print(inputs)
     print(weights)
     bias =10
     output=0
     for i in range(len(inputs)):
         output+=inputs[i]*weights[i]
     output+=bias

     print(output)
```

```
[1, 2, 3, 4, 5, 6, 7, 8, 9, 10]
[1, 2, 3, 4, 5, 6, 7, 8, 9, 10]
395
```

With Numpy

```
import numpy as np
```



ReLU activation

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Inputs = weights = list(range(1,11))
print(inputs)
print(weights)
bias = 10
output = 0
for i in range(len(inputs)):
 output += inputs[i]*weights[i]
output += bias

print(output)

[1, 2, 3, 4, 5, 6, 7, 8, 9, 10]
[1, 2, 3, 4, 5, 6, 7, 8, 9, 10]
395

With Numpy

import numpy as np

ReLU activation

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Neuron.ipynb

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[18] inputs = weights = list(range(1,11))
print(inputs)
print(weights)
bias =10
output=0
for i in range(len(inputs)):
 output+=inputs[i]*weights[i]
output+=bias

print(output)

[18]: [1, 2, 3, 4, 5, 6, 7, 8, 9, 10]
[1, 2, 3, 4, 5, 6, 7, 8, 9, 10]

(a, b, out=None) -> tuple

dot(a, b, out=None)

Dot product of two arrays. Specifically,

- If both `a` and `b` are 1-D arrays, it is inner product of vectors (without complex conjugation).
- If both `a` and `b` are 2-D arrays, it is matrix multiplication, but using `matmul` or `a @ b` is preferred.

With Numpy

import numpy as np
output = np.dot(inputs, weights)

ReLU activation

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Neuron.ipynb

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[18] inputs = weights = list(range(1,11))
0s print(inputs)
print(weights)
bias =10
output=0
for i in range(len(inputs)):
 output+=inputs[i]*weights[i]
output+=bias

print(output)

[1, 2, 3, 4, 5, 6, 7, 8, 9, 10]
[1, 2, 3, 4, 5, 6, 7, 8, 9, 10]
395

With Numpy

import numpy as np
output = np.dot(inputs, weights) + bias
print(output)

395

ReLU activation

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Neuron.ipynb

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[20] import numpy as np
output = np.dot(inputs, weights) + bias
print(output)

395

ReLU activation

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RAM Disk Editing

[20] import numpy as np
output = np.dot(inputs, weights) + bias
print(output)

395

ReLU activation

y=max(0,x)
Y = max()

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[20] import numpy as np

```
    output(*values: object, sep: str | None = ..., end: str | None = ..., file: SupportsWrite[str] | None = ..., flush: bool = ...) -> None
    print(value, ..., sep=' ', end='\n', file=sys.stdout, flush=False)
```

395

ReLU act

Prints the values to a stream, or to sys.stdout by default.
Optional keyword arguments:
file: a file-like object (stream); defaults to the current sys.stdout.
sep: string inserted between values, default a space.
end: string appended after the last value, default a newline.
flush: whether to forcibly flush the stream.

y=max
Y = max
print(Y)

Y YouTubeVideo yield

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ReLU activation

[] # $y = \max(0, x)$

```
Y = max(0, output)
print(Y)
```

395

[]

inputs = [-1, -2, -3]
weights = [0.2, 0.3, 0.4]
bias = -10

```
output = inputs[0]*weights[0] + inputs[1]*weights[1] + inputs[2]*weights[2] + bias
print(output)
```

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ReLU activation

```
[21] # y=max(0,x)
Y = max(0, output)
print(Y)

395
```

```
inputs = [-1,-2,-3]
weights = [0.2, 0.3, 0.4]
bias = -10

output = inputs[0]*weights[0] + inputs[1]*weights[1] + inputs[2]*weights[2] + bias
print(output) ▾
```

-12.0

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ReLU activation

```
[21] # y=max(0,x)
Y = max(0, output)
print(Y)

395
```

```
[22] inputs = [-1,-2,-3]
weights = [0.2, 0.3, 0.4]
bias = -10

output = inputs[0]*weights[0] + inputs[1]*weights[1] + inputs[2]*weights[2] + bias
print(output)

-12.0
```

```
Y = max(0, output)
print
```

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[21] print(Y)
395

[22] inputs = [-1,-2,-3]
weights = [0.2, 0.3, 0.4]
bias = -10

output = inputs[0]*weights[0] + inputs[1]*weights[1] + inputs[2]*weights[2] + bias
print(output)

-12.0

[23] Y = max(0, output)
print(Y)

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[]

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[20] import numpy as np
output = np.dot(inputs, weights) + bias
print(output)

395

{x} ▾ ReLU activation

[21] # $y=\max(0,x)$
Y = max(0, output)
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395

[22] inputs = [-1, -2, -3]
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-12.0

[23] Y = max(0, output)
print(Y)

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