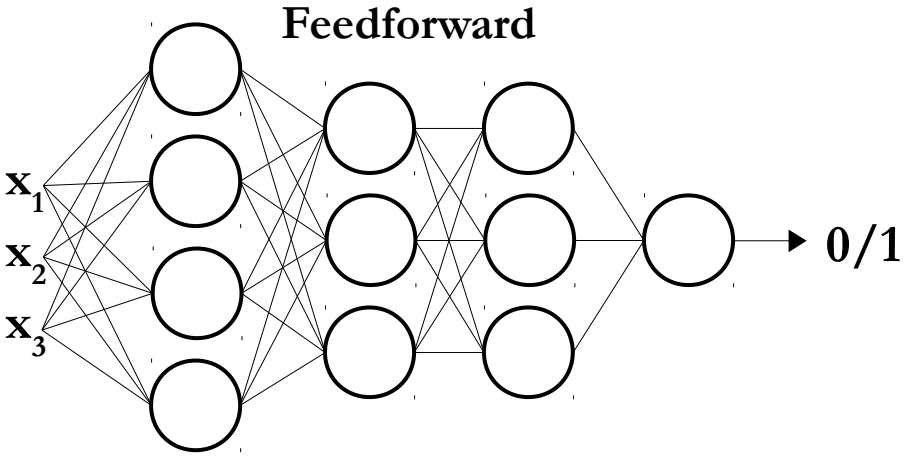
Deep Learning

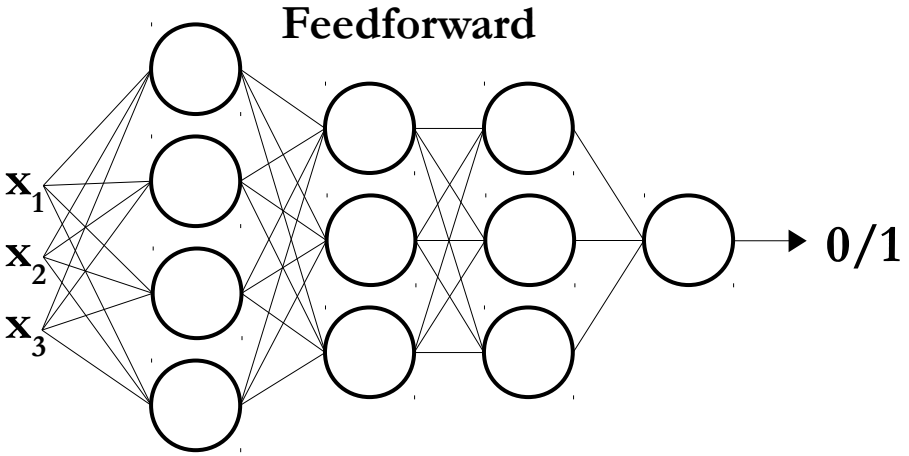
How does the algorithm make a decision?



How do you determine the right parameters for the algorithm?

Deep Learning

How does the algorithm make a decision?



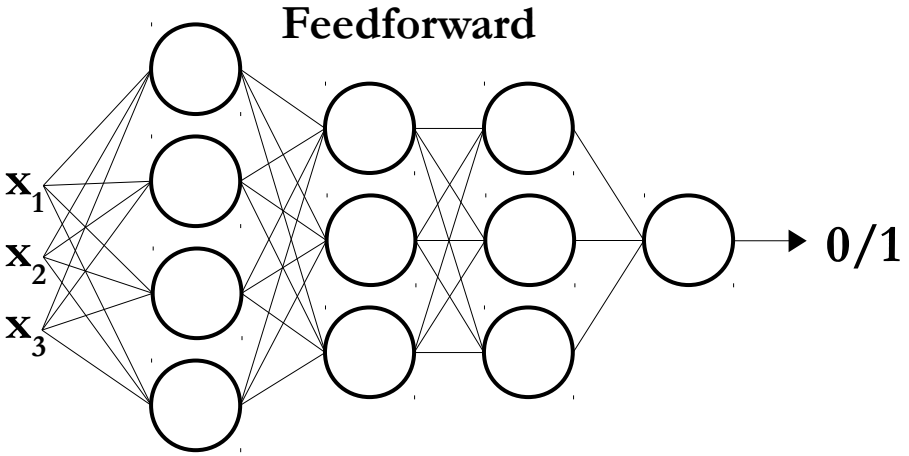
How do you determine the right parameters for the algorithm?

Cost function/Loss function:

Deep Learning

Output - Label = Error

How does the algorithm make a decision?



Cost function/Loss function:

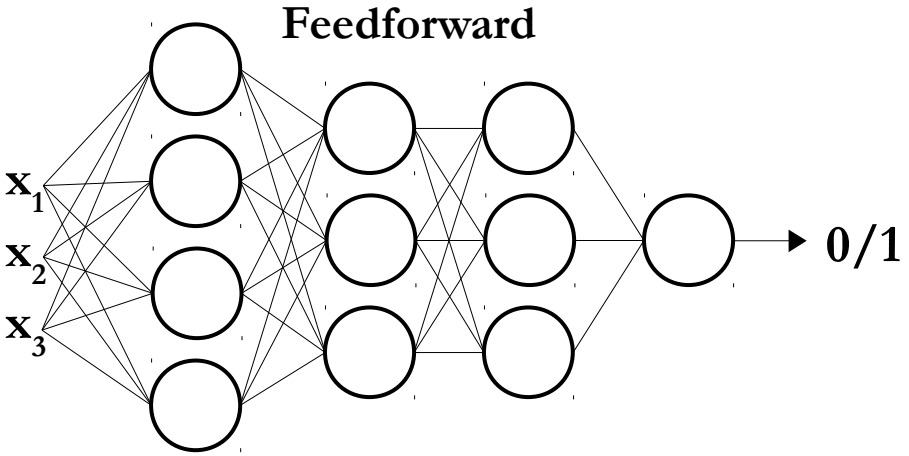
How do you determine the right parameters for the algorithm?

Deep Learning

Output - Label = Error

[[1]
[0]
[1]
[0]]

How does the algorithm make a decision?

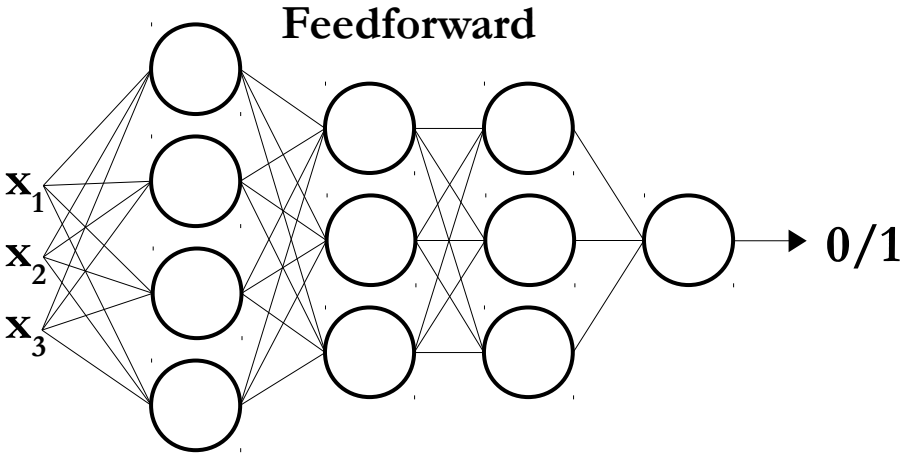


Cost function/Loss function:

How do you determine the right parameters for the algorithm?

Deep Learning

How does the algorithm make a decision?



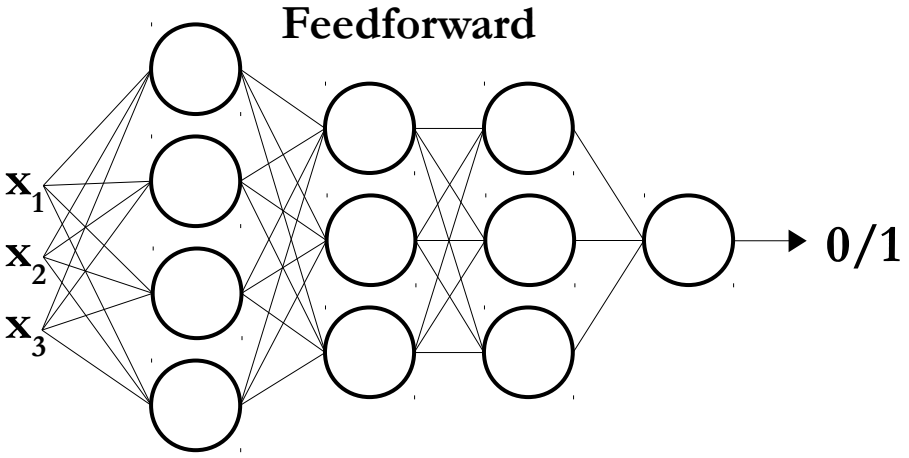
Output	-	Label	=	Error
[[1] [0] [1] [0]]	-	[[1] [0] [0] [1]]	=	[[0] [0] [1] [-1]]

Cost function/Loss function:

How do you determine the right parameters for the algorithm?

Deep Learning

How does the algorithm make a decision?



Output	-	Label	=	Error
[[1] [0] [1] [0]]	-	[[1] [0] [0] [1]]	=	[[0] [0] [1] [-1]] 0

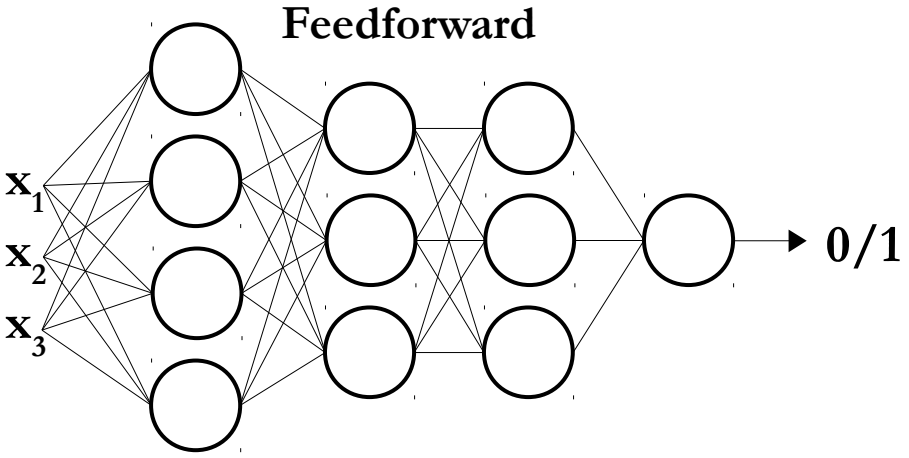
How do you determine the right parameters for the algorithm?

Cost function/Loss function:

Sum of Errors

Deep Learning

How does the algorithm make a decision?



(Output - Label)² = Squared Error

$$\left(\begin{bmatrix}[1]\\[0]\\[1]\\[0]]\end{bmatrix} - \begin{bmatrix}[1]\\[0]\\[0]\\[1]]\end{bmatrix}\right)^2 = \begin{bmatrix}[0]\\[0]\\[1]\\[1]]\end{bmatrix}$$

$$\frac{\begin{bmatrix}[0]\\[0]\\[1]\\[1]]\end{bmatrix}}{2}$$

Cost function/Loss function:

Sum of Squared Errors

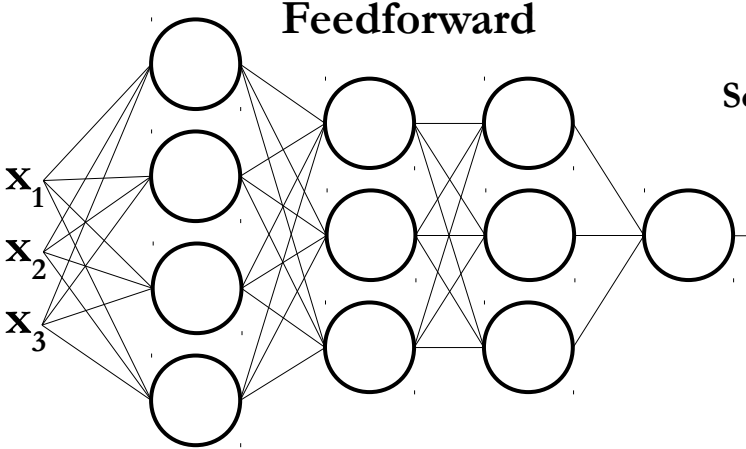
How do you determine the right parameters for the algorithm?

Deep Learning

How does the algorithm make a decision?

How do you determine the right parameters for the algorithm?

Feedforward



Cost function/Loss function:

Sum of Squared Errors

Scenario A

(Output - Label)² = Squared Error

$$\begin{pmatrix} [[1]\\ [0]\\ [1]\\ [0]] \end{pmatrix} - \begin{pmatrix} [[1]\\ [0]\\ [0]\\ [1]] \end{pmatrix}^2 = \begin{matrix} [[0]\\ [0]\\ [1]\\ [1]] \end{matrix}$$

$$\frac{}{2}$$

Scenario B

(Output - Label)² = Squared Error

$$\begin{pmatrix} [[1]\\ [1]\\ [1]\\ [0]\\ [1]\\ [0]\\ [0]\\ [0]\\ [1]\\ [0]] \end{pmatrix} - \begin{pmatrix} [[1]\\ [1]\\ [1]\\ [0]\\ [1]\\ [0]\\ [0]\\ [1]\\ [0]\\ [1]] \end{pmatrix}^2 = \begin{matrix} [[0]\\ [0]\\ [0]\\ [0]\\ [0]\\ [0]\\ [0]\\ [1]\\ [1]\\ [1]] \end{matrix}$$

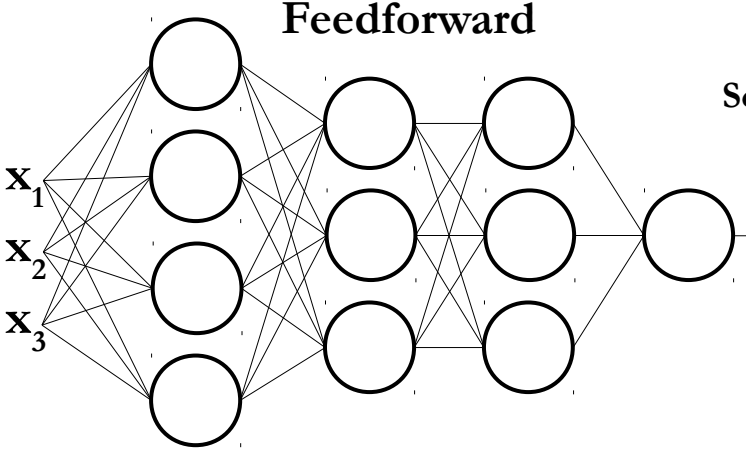
$$\frac{}{3}$$

Deep Learning

How does the algorithm make a decision?

How do you determine the right parameters for the algorithm?

Feedforward



Cost function/Loss function:

Mean Squared Error

Scenario A

(Output - Label)² = Squared Error

$$\begin{pmatrix} [[1]\\ [0]\\ [1]\\ [0]] \end{pmatrix} - \begin{pmatrix} [[1]\\ [0]\\ [0]\\ [1]] \end{pmatrix}^2 = \begin{matrix} [[0]\\ [0]\\ [1]\\ [1]] \end{matrix}$$

2 : 4 = 0.5

Scenario B

(Output - Label)² = Squared Error

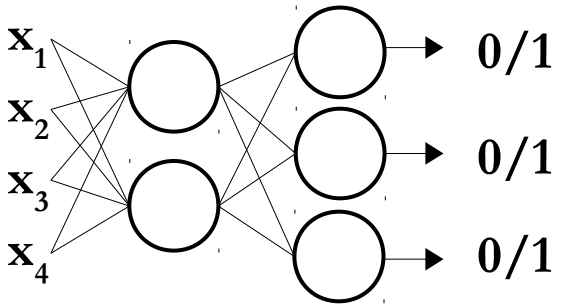
$$\begin{pmatrix} [[1]\\ [1]\\ [1]\\ [0]\\ [1]\\ [0]\\ [0]\\ [0]\\ [1]\\ [0]] \end{pmatrix} - \begin{pmatrix} [[1]\\ [1]\\ [1]\\ [0]\\ [1]\\ [0]\\ [0]\\ [1]\\ [0]\\ [1]] \end{pmatrix}^2 = \begin{matrix} [[0]\\ [0]\\ [0]\\ [0]\\ [0]\\ [0]\\ [0]\\ [1]\\ [1]\\ [1]] \end{matrix}$$

3 : 10 = 0.3

Deep Learning

(Output - Label)² = Squared Error

Feedforward



How does the algorithm make a decision?

Cost function/Loss function:

Mean Squared Error

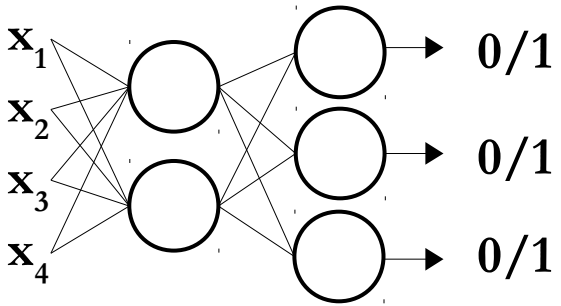
How do you determine the right parameters for the algorithm?

Deep Learning

How does the algorithm make a decision?

How do you determine the right parameters for the algorithm?

Feedforward



Cost function/Loss function:

Mean Squared Error

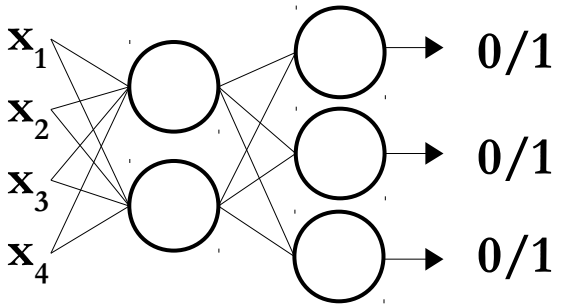
(Output - Label)² = Squared Error

```
[[1 0 0]
 [0 1 0]
 [0 1 0]
 [0 0 1]]
```

Deep Learning

How does the algorithm make a decision?

Feedforward



(Output - Label)² = Squared Error

$$\left(\begin{bmatrix}1&0&0\\0&1&0\\0&1&0\\0&0&1\end{bmatrix} - \begin{bmatrix}0&0&1\\0&1&0\\1&0&0\\0&1&0\end{bmatrix}\right)^2 = \begin{bmatrix}1&0&1\\0&0&0\\1&1&0\\0&1&1\end{bmatrix}$$

Cost function/Loss function:

Mean Squared Error

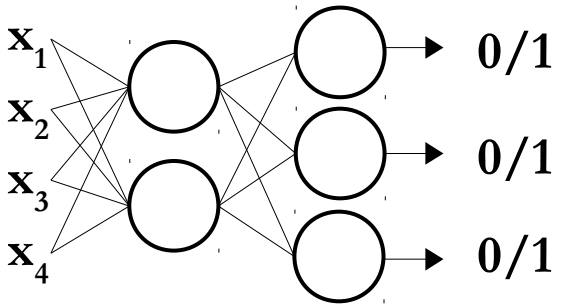
How do you determine the right parameters for the algorithm?

Deep Learning

How does the algorithm make a decision?

How do you determine the right parameters for the algorithm?

Feedforward



Cost function/Loss function:

Mean Squared Error

(Output - Label)² = Squared Error

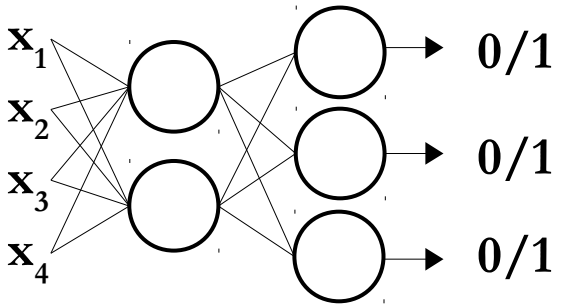
$$\left(\begin{bmatrix}1&0&0\\0&1&0\\0&1&0\\0&0&1\end{bmatrix} - \begin{bmatrix}0&0&1\\0&1&0\\1&0&0\\0&1&0\end{bmatrix}\right)^2 = \begin{bmatrix}1&0&1\\0&0&0\\1&1&0\\0&1&1\end{bmatrix}$$

$$\begin{bmatrix}2&2&2\end{bmatrix}$$

Deep Learning

How does the algorithm make a decision?

Feedforward



(Output - Label)² = Squared Error

$$\left(\begin{bmatrix}1&0&0\\0&1&0\\0&1&0\\0&0&1\end{bmatrix} - \begin{bmatrix}0&0&1\\0&1&0\\1&0&0\\0&1&0\end{bmatrix}\right)^2 = \begin{bmatrix}1&0&1\\0&0&0\\1&1&0\\0&1&1\end{bmatrix}$$

$$\begin{bmatrix}2&2&2\end{bmatrix} \Rightarrow 6$$

How do you determine the right parameters for the algorithm?

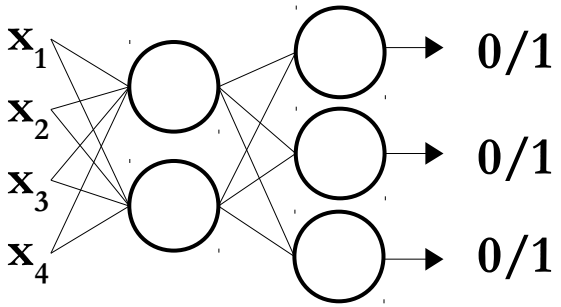
Cost function/Loss function:

Mean Squared Error

Deep Learning

How does the algorithm make a decision?

Feedforward



(Output - Label)² = Squared Error

$$\left(\begin{bmatrix}1&0&0\\0&1&0\\0&1&0\\0&0&1\end{bmatrix} - \begin{bmatrix}0&0&1\\0&1&0\\1&0&0\\0&1&0\end{bmatrix}\right)^2 = \begin{bmatrix}1&0&1\\0&0&0\\1&1&0\\0&1&1\end{bmatrix}$$

$$[2\ \ 2\ \ 2] \Rightarrow 6 : 12 = 0.5$$

How do you determine the right parameters for the algorithm?

Cost function/Loss function:

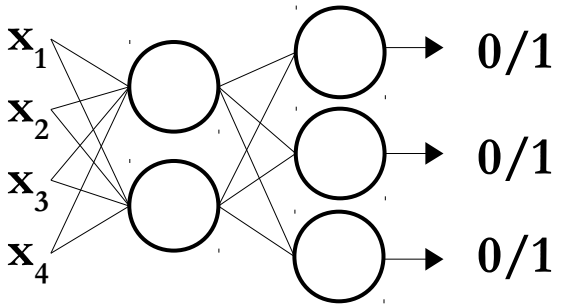
Mean Squared Error

Deep Learning

How does the algorithm make a decision?

How do you determine the right parameters for the algorithm?

Feedforward



Cost function/Loss function:

Mean Squared Error

(Output - Label)² = Squared Error

Scenario C

$$\left(\begin{bmatrix}1&0&0\\0&1&0\\0&1&0\\0&0&1\end{bmatrix} - \begin{bmatrix}0&0&1\\0&1&0\\1&0&0\\0&1&0\end{bmatrix}\right)^2 = \begin{bmatrix}1&0&1\\0&0&0\\1&1&0\\0&1&1\end{bmatrix}$$

[2 2 2] ➡ 6 : 12 = 0.5

(Output - Label)² = Squared Error

Scenario A

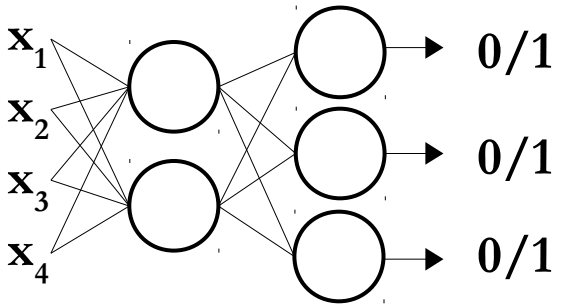
$$\left(\begin{bmatrix}1\\0\\1\\0\end{bmatrix} - \begin{bmatrix}1\\0\\0\\1\end{bmatrix}\right)^2 = \begin{bmatrix}0\\0\\1\\1\end{bmatrix}$$

2 : 4 = 0.5

Deep Learning

How does the algorithm make a decision?

Feedforward



(Output - Label)² = Squared Error

$$\left(\begin{bmatrix}1&0&0\\0&1&0\\0&1&0\\0&0&1\end{bmatrix} - \begin{bmatrix}0&0&1\\0&1&0\\1&0&0\\0&1&0\end{bmatrix}\right)^2 = \begin{bmatrix}1&0&1\\0&0&0\\1&1&0\\0&1&1\end{bmatrix}$$

$$[2\ \ 2\ \ 2] \Rightarrow 6 : 12 = \underline{0.5}$$

How do you determine the right parameters for the algorithm?

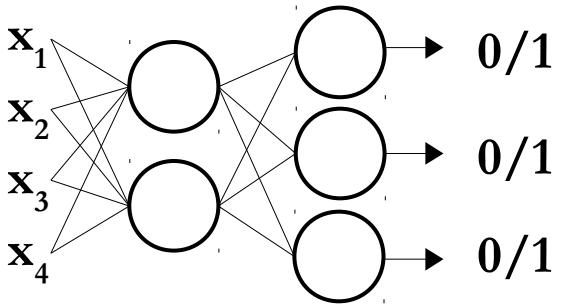
Cost function/Loss function:

Mean Squared Error = $O - Y$

Deep Learning

How does the algorithm make a decision?

Feedforward



(Output - Label)² = Squared Error

$$\left(\begin{bmatrix}1&0&0\\0&1&0\\0&1&0\\0&0&1\end{bmatrix} - \begin{bmatrix}0&0&1\\0&1&0\\1&0&0\\0&1&0\end{bmatrix}\right)^2 = \begin{bmatrix}1&0&1\\0&0&0\\1&1&0\\0&1&1\end{bmatrix}$$

$$\begin{bmatrix}2&2&2\end{bmatrix} \Rightarrow 6 : 12 = \underline{0.5}$$

How do you determine the right parameters for the algorithm?

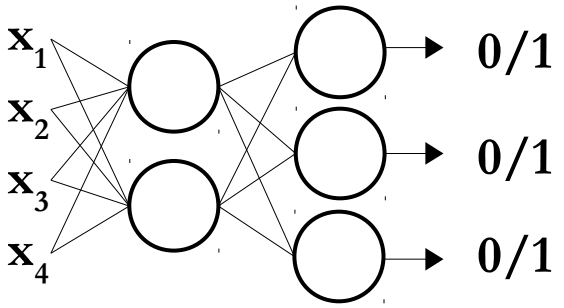
Cost function/Loss function:

Mean Squared Error = $(O - Y)^2$

Deep Learning

How does the algorithm make a decision?

Feedforward



(Output - Label)² = Squared Error

$$\left(\begin{bmatrix}1&0&0\\0&1&0\\0&1&0\\0&0&1\end{bmatrix} - \begin{bmatrix}0&0&1\\0&1&0\\1&0&0\\0&1&0\end{bmatrix}\right)^2 = \begin{bmatrix}1&0&1\\0&0&0\\1&1&0\\0&1&1\end{bmatrix}$$

$$[2\ \ 2\ \ 2] \Rightarrow 6 : 12 = \underline{0.5}$$

Cost function/Loss function:

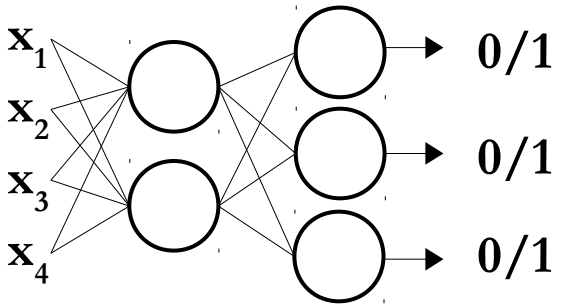
How do you determine the right parameters for the algorithm?

Mean Squared Error = $\sum_e (O_e - Y_e)^2$

Deep Learning

How does the algorithm make a decision?

Feedforward



(Output - Label)² = Squared Error

$$\left(\begin{bmatrix}1&0&0\\0&1&0\\0&1&0\\0&0&1\end{bmatrix} - \begin{bmatrix}0&0&1\\0&1&0\\1&0&0\\0&1&0\end{bmatrix}\right)^2 = \begin{bmatrix}1&0&1\\0&0&0\\1&1&0\\0&1&1\end{bmatrix}$$

$$\begin{bmatrix}2&2&2\end{bmatrix} \Rightarrow 6 : 12 = \underline{0.5}$$

How do you determine the right parameters for the algorithm?

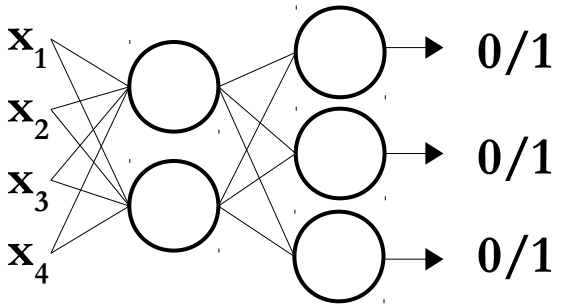
Cost function/Loss function:

Mean Squared Error = $\sum_n \sum_e (O_{e,n} - Y_{e,n})^2$

Deep Learning

How does the algorithm make a decision?

Feedforward



(Output - Label)² = Squared Error

$$\left(\begin{bmatrix}1&0&0\\0&1&0\\0&1&0\\0&0&1\end{bmatrix} - \begin{bmatrix}0&0&1\\0&1&0\\1&0&0\\0&1&0\end{bmatrix}\right)^2 = \begin{bmatrix}1&0&1\\0&0&0\\1&1&0\\0&1&1\end{bmatrix} \quad \begin{bmatrix}2\\0\\2\\2\end{bmatrix}$$

6 : 12 = 0.5

How do you determine the right parameters for the algorithm?

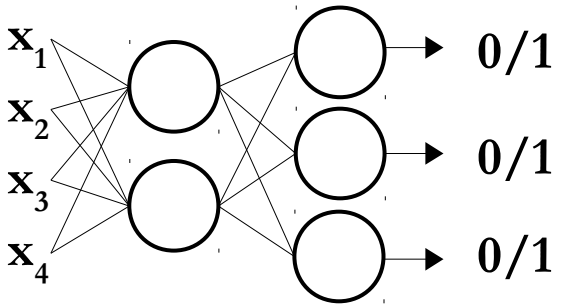
Cost function/Loss function:

Mean Squared Error = $\sum_e \sum_n (O_{e,n} - Y_{e,n})^2$

Deep Learning

How does the algorithm make a decision?

Feedforward



How do you determine the right parameters for the algorithm?

Cost function/Loss function:

$$\text{Mean Squared Error} = \frac{1}{e*n} \sum_{e} \sum_{n} (O_{e,n} - Y_{e,n})^2$$

(Output - Label)² = Squared Error

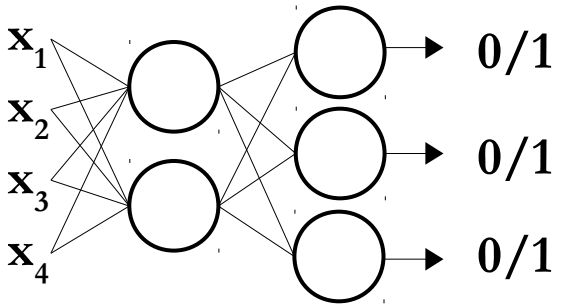
$$\left(\begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix} - \begin{bmatrix} 0 & 0 & 1 \\ 0 & 1 & 0 \\ 1 & 0 & 0 \\ 0 & 1 & 0 \end{bmatrix} \right)^2 = \begin{bmatrix} 1 & 0 & 1 \\ 0 & 0 & 0 \\ 1 & 1 & 0 \\ 0 & 1 & 1 \end{bmatrix} \begin{bmatrix} 2 \\ 0 \\ 2 \\ 2 \end{bmatrix}$$

6 : 12 = 0.5

Deep Learning

How does the algorithm make a decision?

Feedforward



(Output - Label)² = Squared Error

$$\left(\begin{bmatrix}1&0&0\\0&1&0\\0&1&0\\0&0&1\end{bmatrix} - \begin{bmatrix}0&0&1\\0&1&0\\1&0&0\\0&1&0\end{bmatrix}\right)^2 = \begin{bmatrix}1&0&1\\0&0&0\\1&1&0\\0&1&1\end{bmatrix} \quad \begin{bmatrix}2\\0\\2\\2\end{bmatrix}$$

6 : 12 = 0.5

How do you determine the right parameters for the algorithm?

Cost function/Loss function:

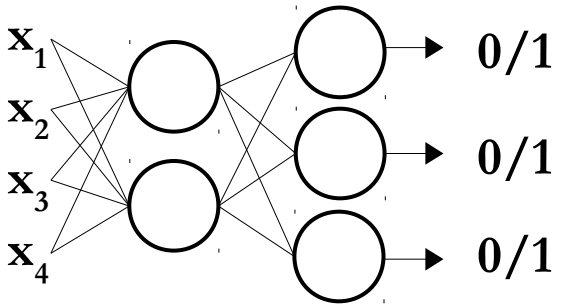
$$\text{Mean Squared Error} = \frac{1}{N}\sum_{e}\sum_{n}(O_{e,n} - Y_{e,n})^2$$

N: e * n

Deep Learning

How does the algorithm make a decision?

Feedforward



How do you determine the right parameters for the algorithm?

Cost function/Loss function:

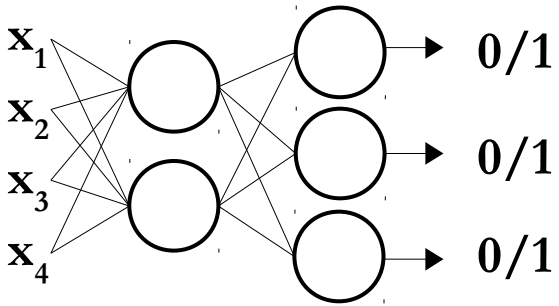
$$\text{Mean Squared Error} = \frac{1}{N} \sum_{e} \sum_{n} (O_{e,n} - Y_{e,n})^2$$

N: e * n

Deep Learning

How does the algorithm make a decision?

Feedforward



$$H_{in} = XW_1$$

How do you determine the right parameters for the algorithm?

Cost function/Loss function:

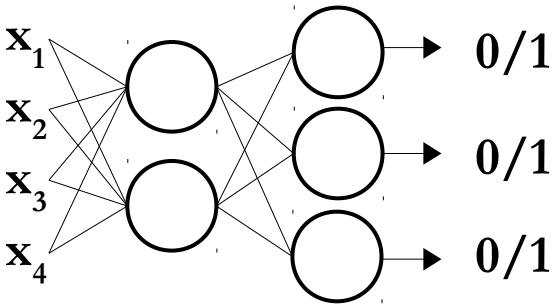
$$\text{Mean Squared Error} = \frac{1}{N} \sum_{e} \sum_{n} (O_{e,n} - Y_{e,n})^2$$

N: e * n

Deep Learning

How does the algorithm make a decision?

Feedforward



$$H_{in} = XW_1$$

$$H_{out} = \text{step}(H_{in})$$

How do you determine the right parameters for the algorithm?

Cost function/Loss function:

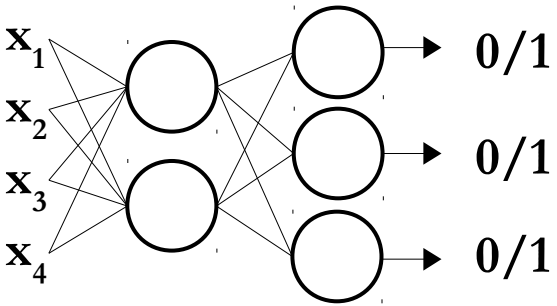
$$\text{Mean Squared Error} = \frac{1}{N} \sum_{e} \sum_{n} (O_{e,n} - Y_{e,n})^2$$

N: e * n

Deep Learning

How does the algorithm make a decision?

Feedforward



$$H_{in} = XW_1$$

$$H_{out} = \text{step}(H_{in})$$

$$O_{in} = H_{out}W_2$$

How do you determine the right parameters for the algorithm?

Cost function/Loss function:

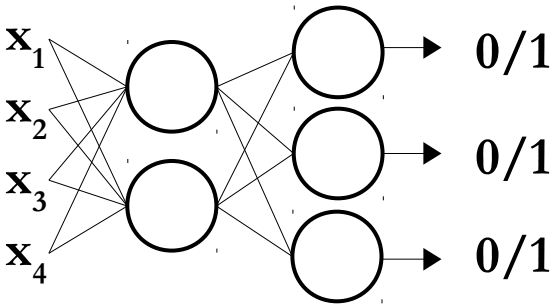
$$\text{Mean Squared Error} = \frac{1}{N}\sum_{e}\sum_{n}(O_{e,n} - Y_{e,n})^2$$

N: e * n

Deep Learning

How does the algorithm make a decision?

Feedforward



$$H_{in} = XW_1$$

$$H_{out} = \text{step}(H_{in})$$

$$O_{in} = H_{out}W_2$$

$$O_{out} = \text{step}(O_{in})$$

How do you determine the right parameters for the algorithm?

Cost function/Loss function:

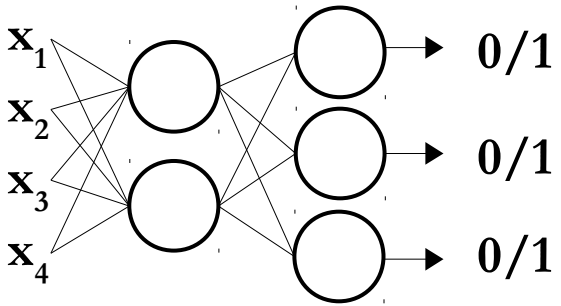
$$\text{Mean Squared Error} = \frac{1}{N}\sum_{e}\sum_{n}(O_{e,n} - Y_{e,n})^2$$

N: e * n

Deep Learning

How does the algorithm make a decision?

Feedforward



$$H_{in} = XW_1$$

$$H_{out} = step(H_{in})$$

$$O_{in} = H_{out}W_2$$

$$O_{out} = step(O_{in})$$

Cost function/Loss function:

How do you determine the right parameters for the algorithm?

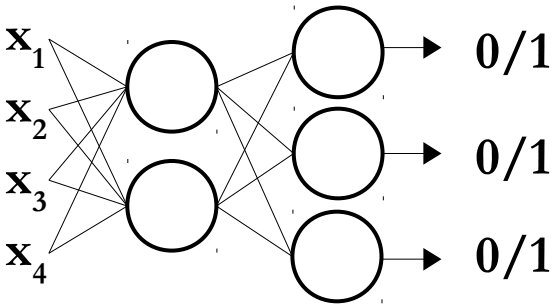
$$\text{Mean Squared Error} = \frac{1}{N}\sum_{e}\sum_{n}(O_{out\ e,n} - Y_{e,n})^2$$

N: e * n

Deep Learning

How does the algorithm make a decision?

Feedforward



$$H_{in} = XW_1$$

$$H_{out} = step(H_{in})$$

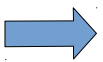
$$O_{in} = H_{out}W_2$$

$$O_{out} = step(O_{in})$$

How do you determine the right parameters for the algorithm?

Cost function/Loss function:

$$\text{Mean Squared Error} = \frac{1}{N}\sum_{e}\sum_{n}(O_{out\ e,n} - Y_{e,n})^2$$



MSE =

N: e * n

Deep Learning

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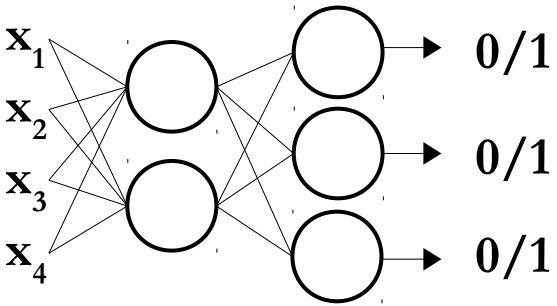
Feedforward



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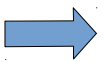

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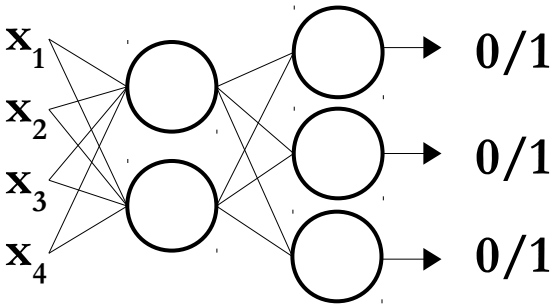

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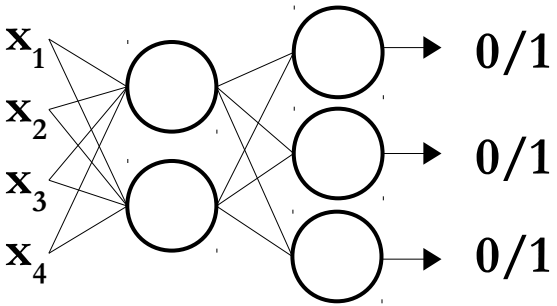

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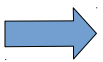


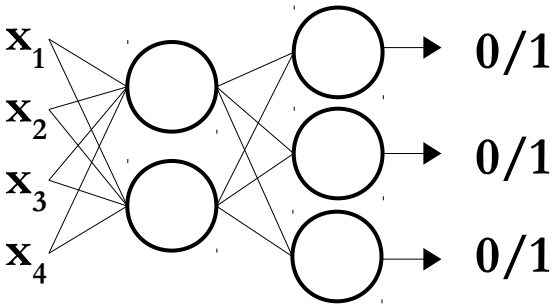
MSE = $step(XW_1)W_2$

N: e * n

Deep Learning

How does the algorithm make a decision?

Feedforward



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N: e * n

Deep Learning

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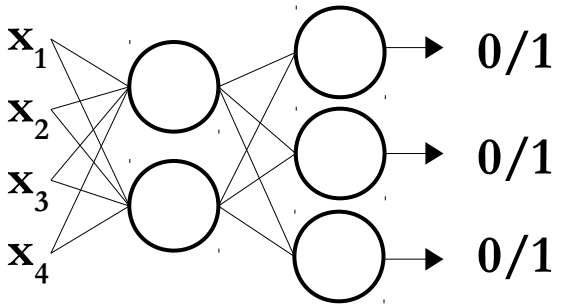
Feedforward



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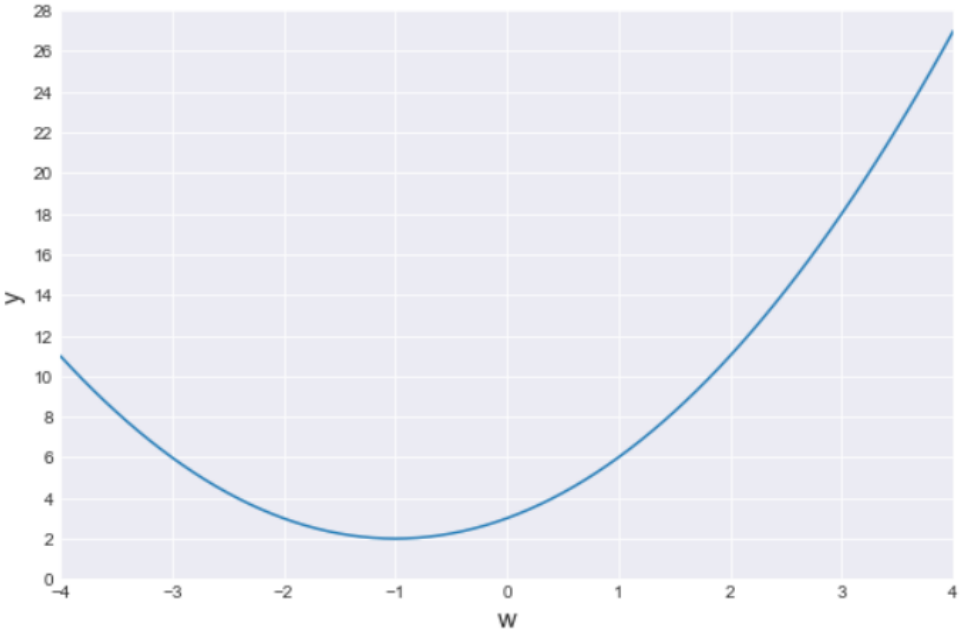
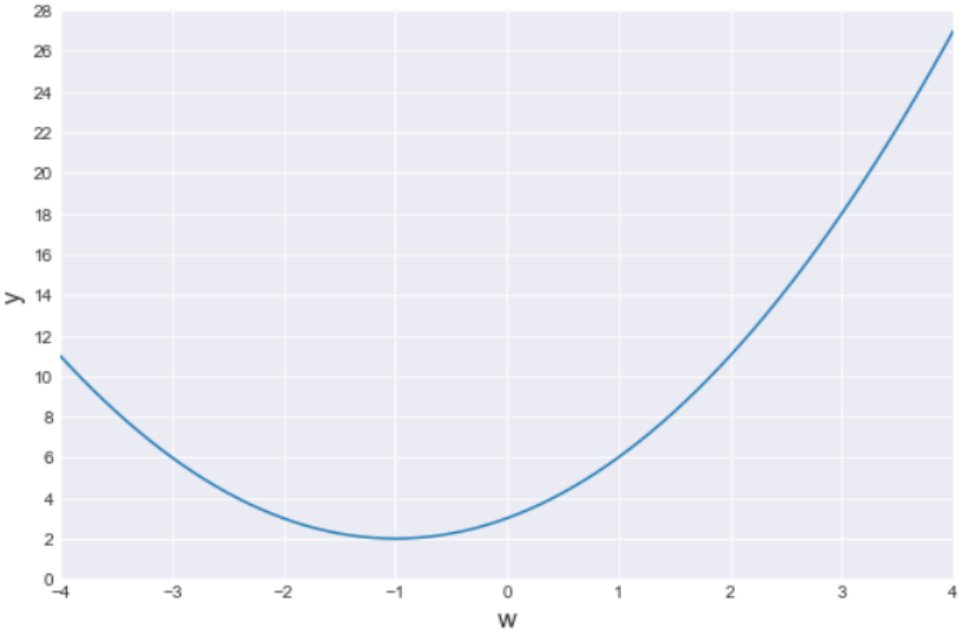
N: e * n

Derivative



$$y = f(w) = w^2 + 2w + 3$$

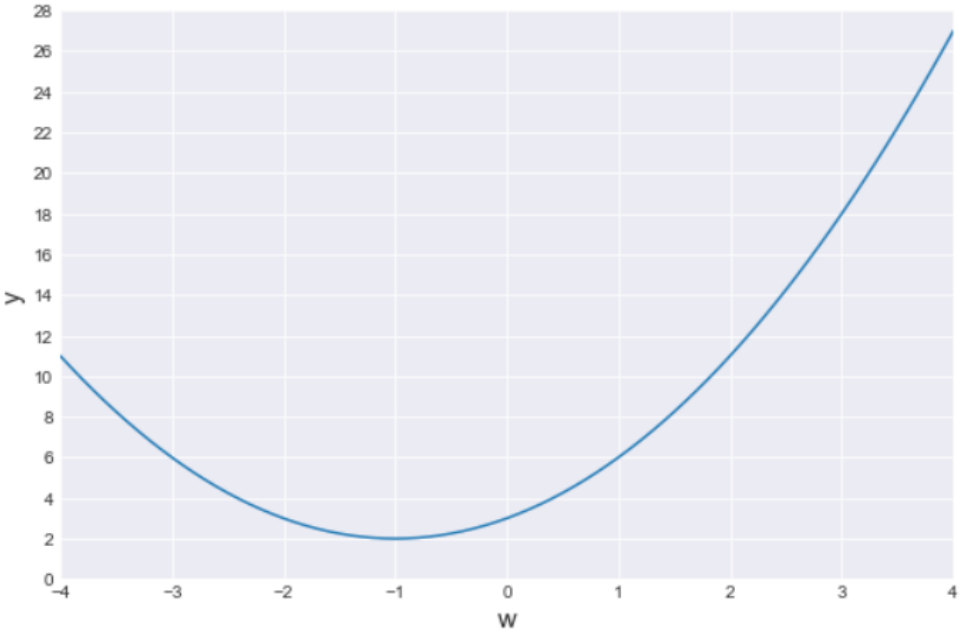
Derivative



$$y = f(w) = w^2 + 2w + 3$$

$$\frac{dy}{dw} = f'(w) =$$

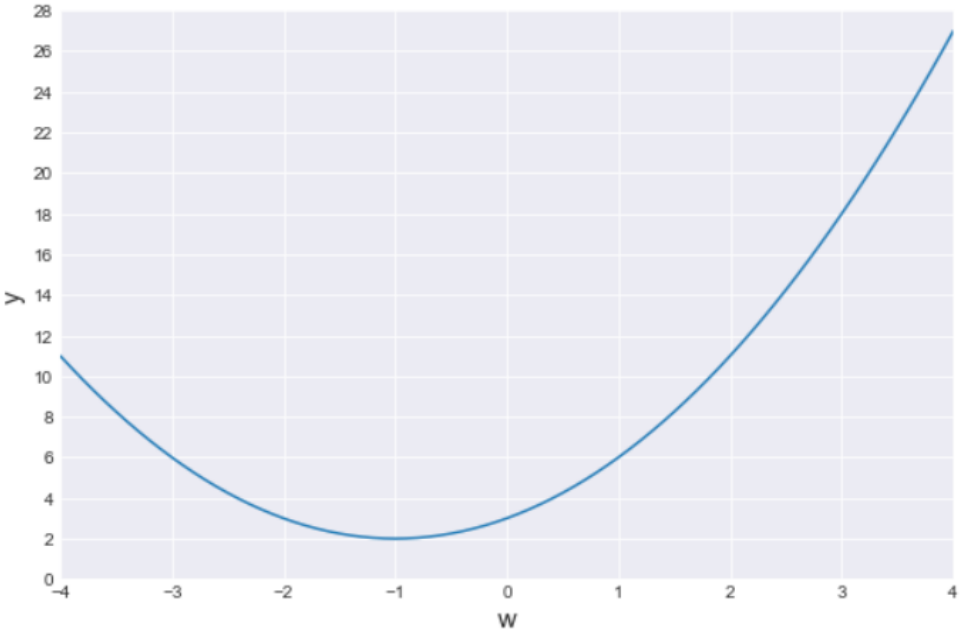
Derivative



$$y = f(w) = w^2 + 2w + 3$$

$$\frac{dy}{dw} = f'(w) = 2w$$

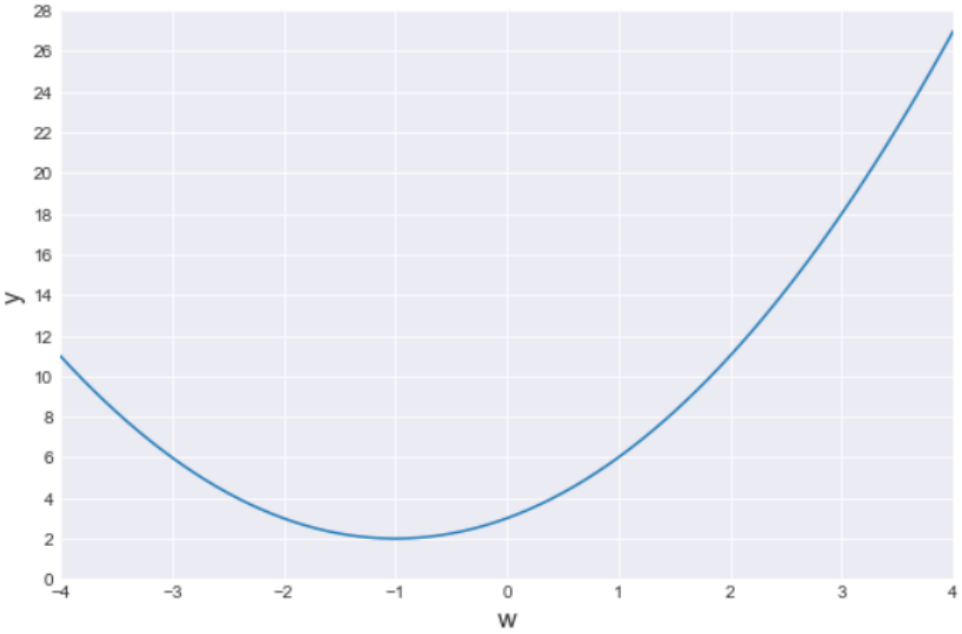
Derivative



$$y = f(w) = w^2 + 2w + 3$$

$$\frac{dy}{dw} = f'(w) = 2w + 2w^0$$

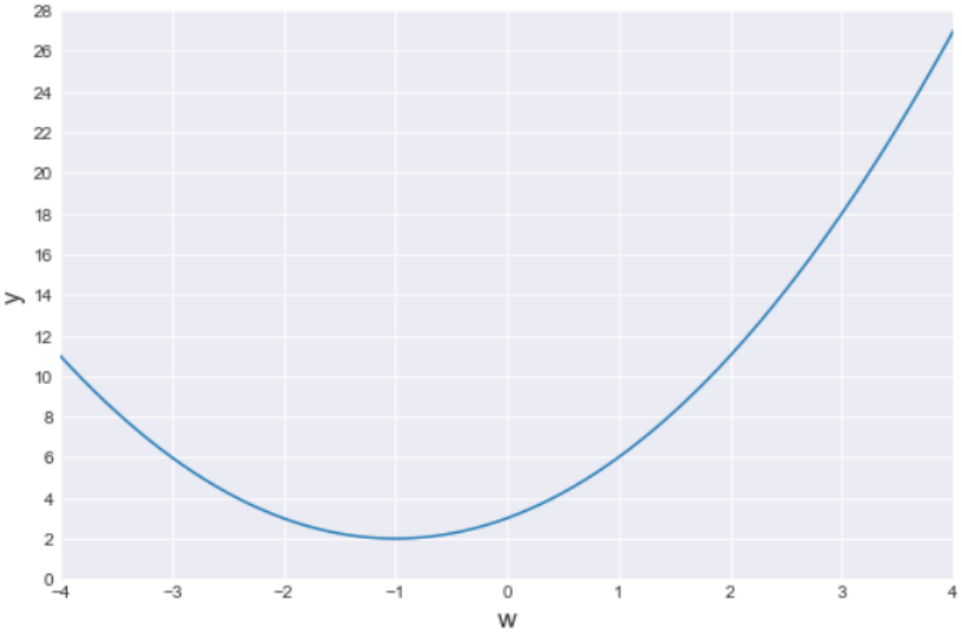
Derivative



$$y = f(w) = w^2 + 2w + 3$$

$$\frac{dy}{dw} = f'(w) = 2w + 2$$

Derivative

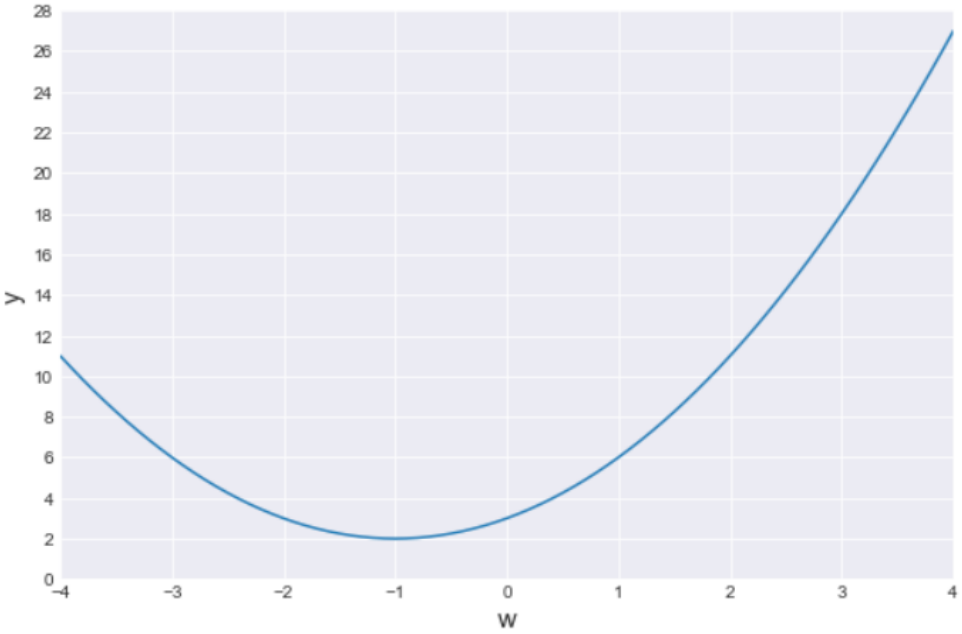


w = 1:

$$y = f(w) = w^2 + 2w + 3$$

$$\frac{dy}{dw} = f'(w) = 2w + 2$$

Derivative

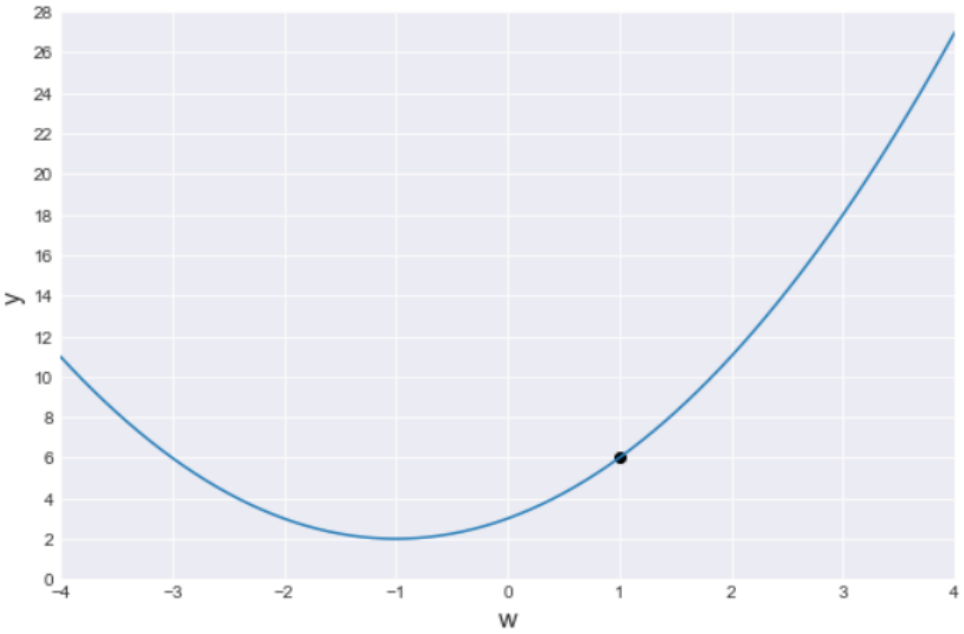


w = 1:

$$y = f(w) = w^2 + 2w + 3 \qquad y(1) = 6$$

$$\frac{dy}{dw} = f'(w) = 2w + 2$$

Derivative



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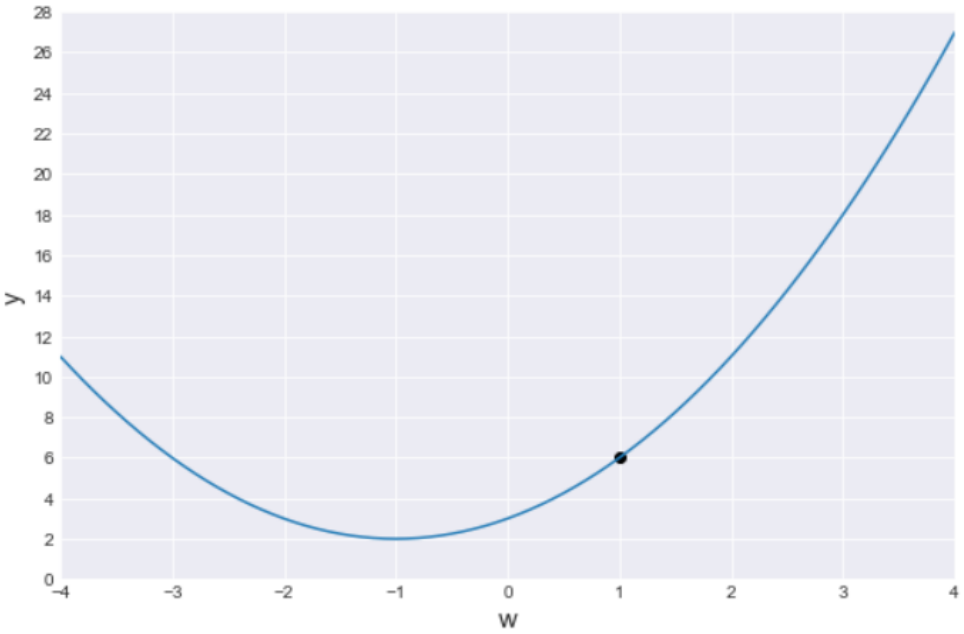
$$y = f(w) = w^2 + 2w + 3 \qquad y(1) = 6$$

$$\frac{dy}{dw} = f'(w) = 2w + 2$$

Derivative



$$y = f(w) = w^2 + 2w + 3$$

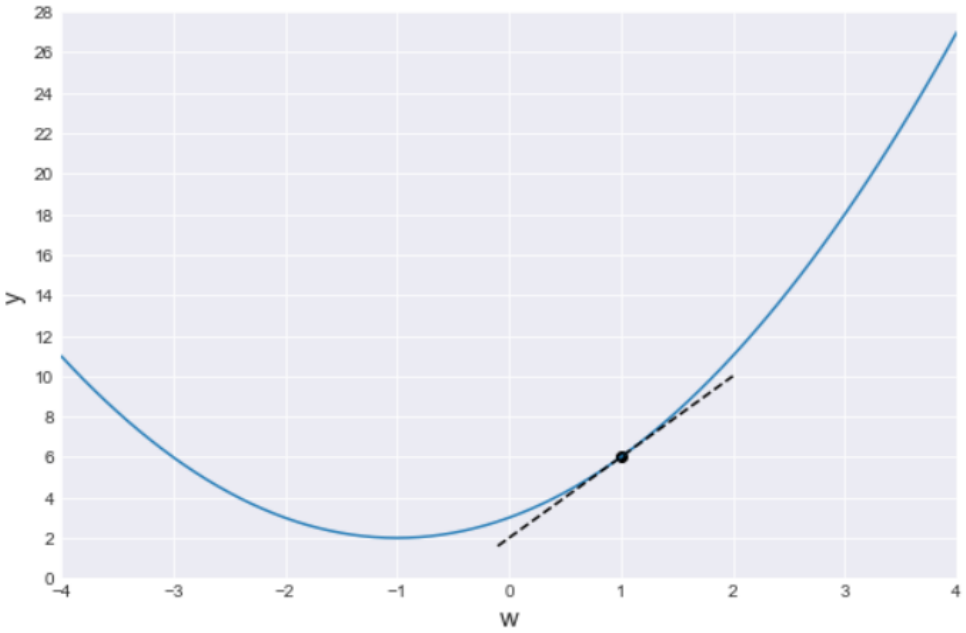
$$\frac{dy}{dw} = f'(w) = 2w + 2$$

w = 1:

$$y(1) = 6$$

$$\frac{dy}{dw}(1) = 4$$

Derivative

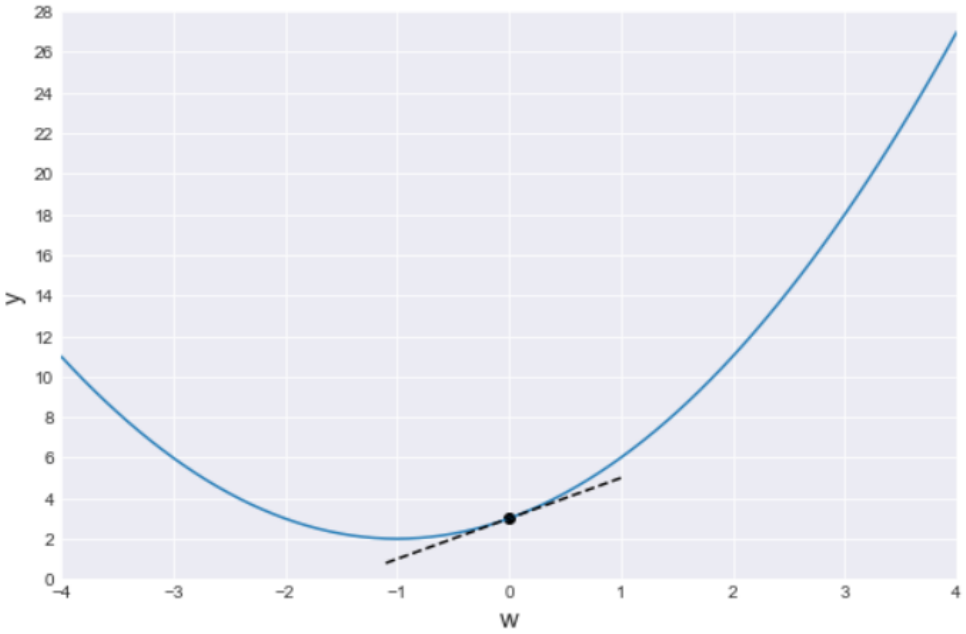


w = 1:

$$y = f(w) = w^2 + 2w + 3 \qquad y(1) = 6$$

$$\frac{dy}{dw} = f'(w) = 2w + 2 \qquad \frac{dy}{dw}(1) = 4$$

Derivative



$$y = f(w) = w^2 + 2w + 3$$

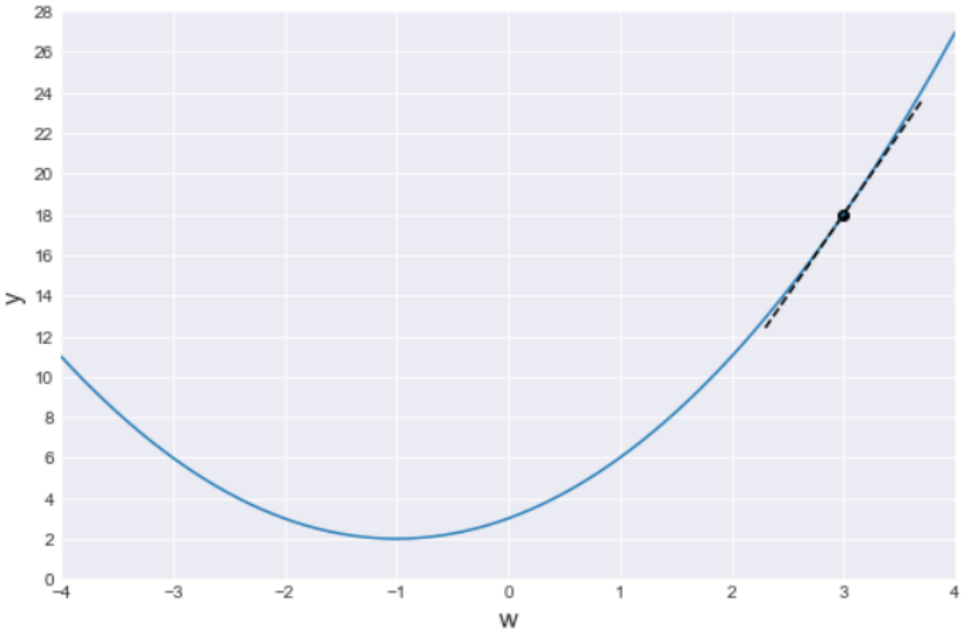
$$\frac{dy}{dw} = f'(w) = 2w + 2$$

w = 0:

$$y(0) = 3$$

$$\frac{dy}{dw}(0) = 2$$

Derivative



$$y = f(w) = w^2 + 2w + 3$$

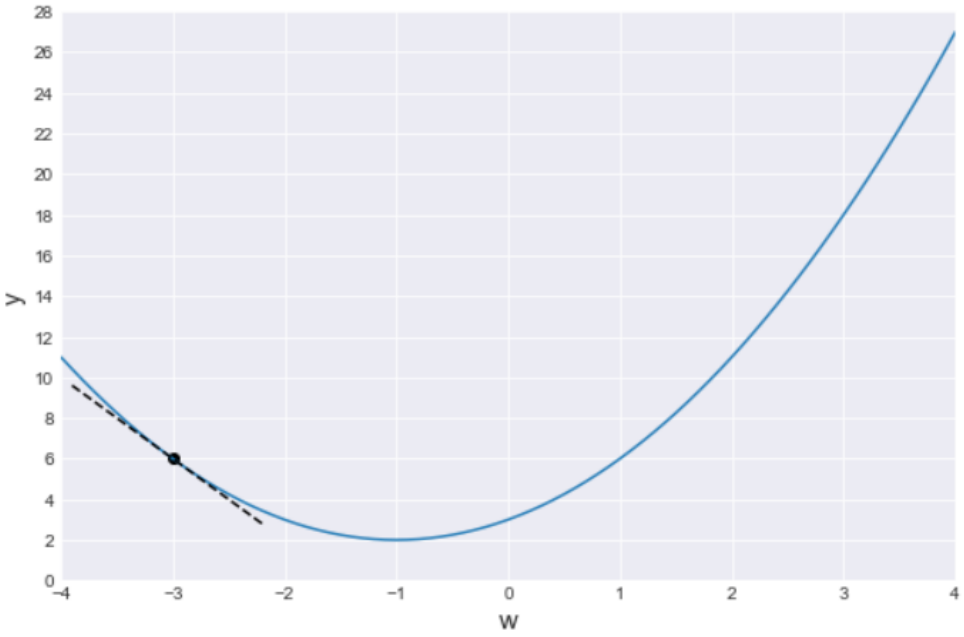
$$\frac{dy}{dw} = f'(w) = 2w + 2$$

w = 3:

$$y(3) = 18$$

$$\frac{dy}{dw}(3) = 8$$

Derivative

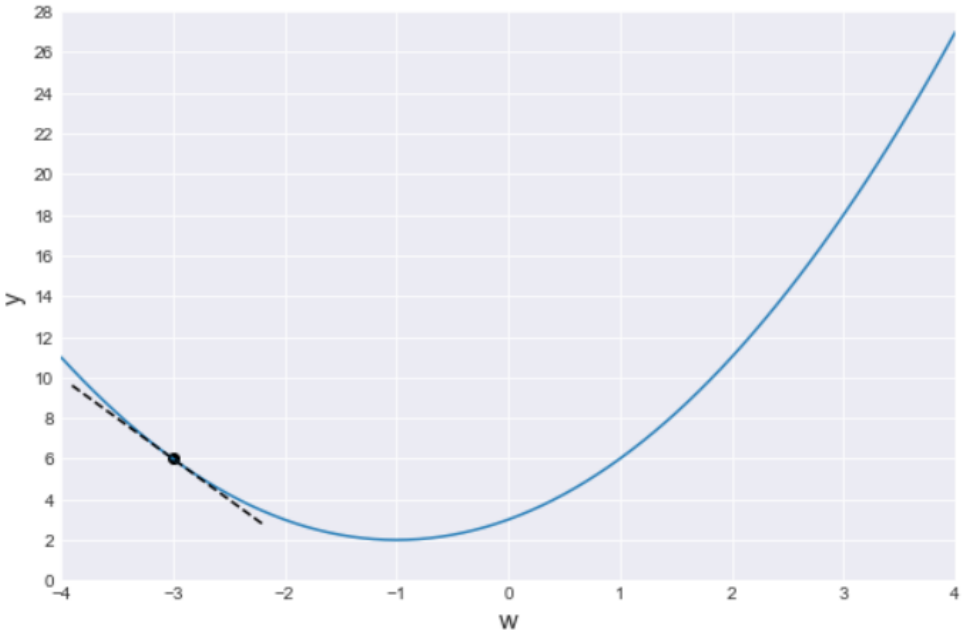


w = -3:

$$y = f(w) = w^2 + 2w + 3 \qquad y(3) = 6$$

$$\frac{dy}{dw} = f'(w) = 2w + 2 \qquad \frac{dy}{dw}(3) = -4$$

Derivative



$$y = f(w) = w^2 + 2w + 3$$

$$\frac{dy}{dw} = f'(w) = 2w + 2$$

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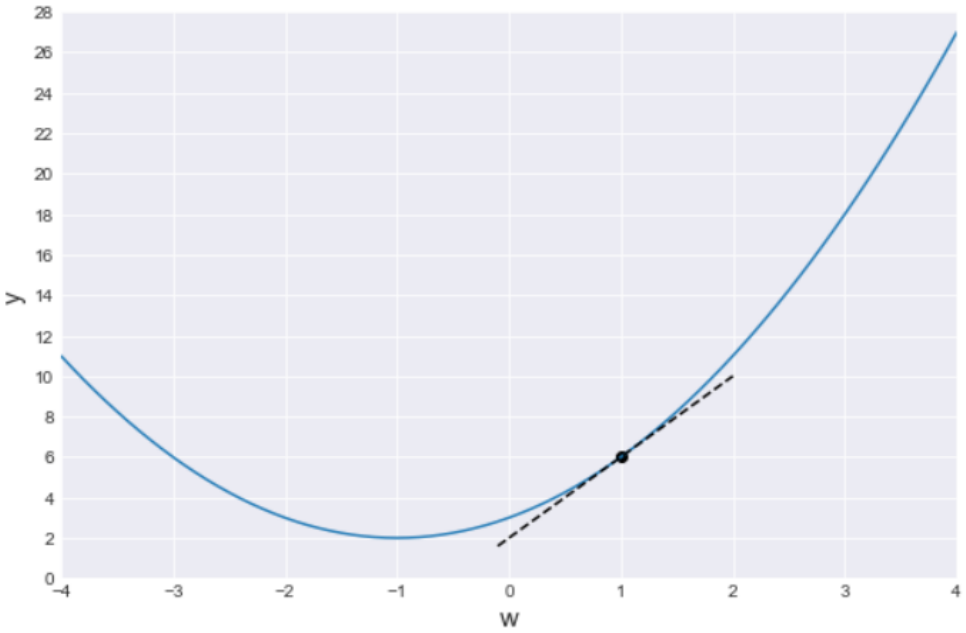
$$y(3) = 6$$

$$\frac{dy}{dw}(3) = -4$$

direction

Derivative



$$y = f(w) = w^2 + 2w + 3$$

$$\frac{dy}{dw} = f'(w) = 2w + 2$$

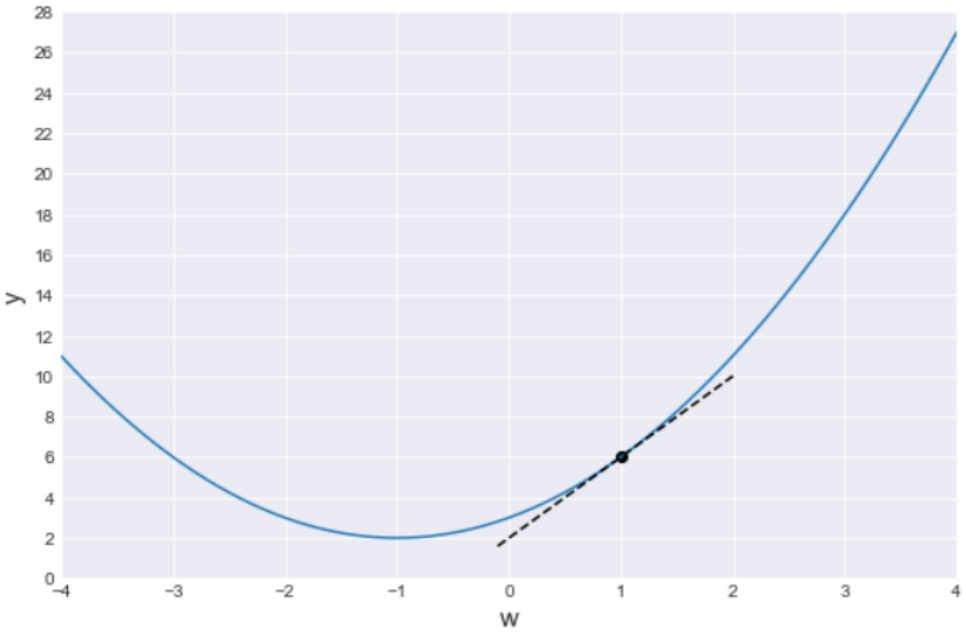
w = 1:

$$y(1) = 6$$

$$\frac{dy}{dw}(1) = +4$$

direction

Derivative



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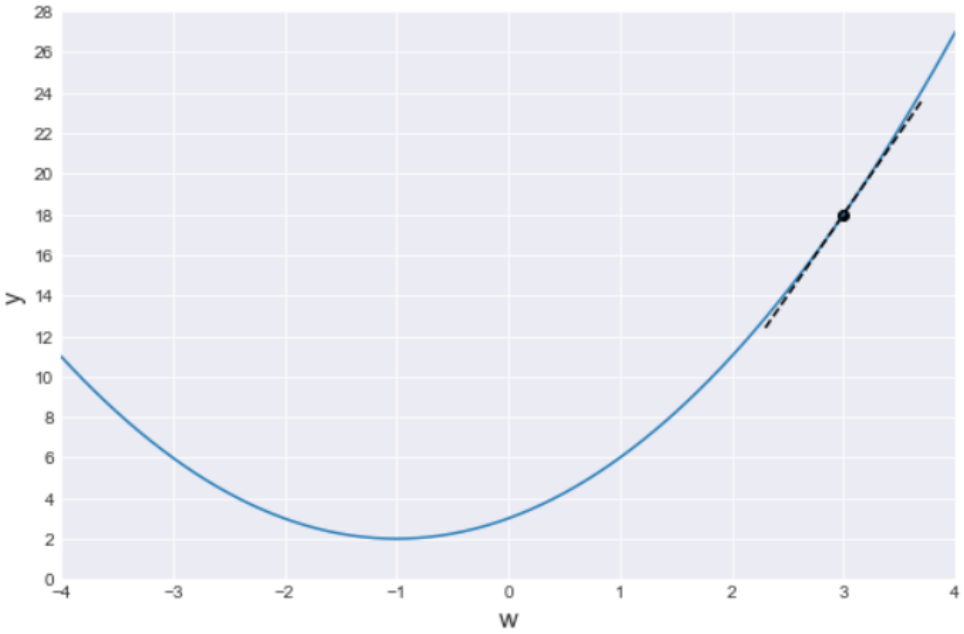
$$\frac{dy}{dw}(1) = +4$$

direction amount

Derivative



$$y = f(w) = w^2 + 2w + 3$$

$$\frac{dy}{dw} = f'(w) = 2w + 2$$

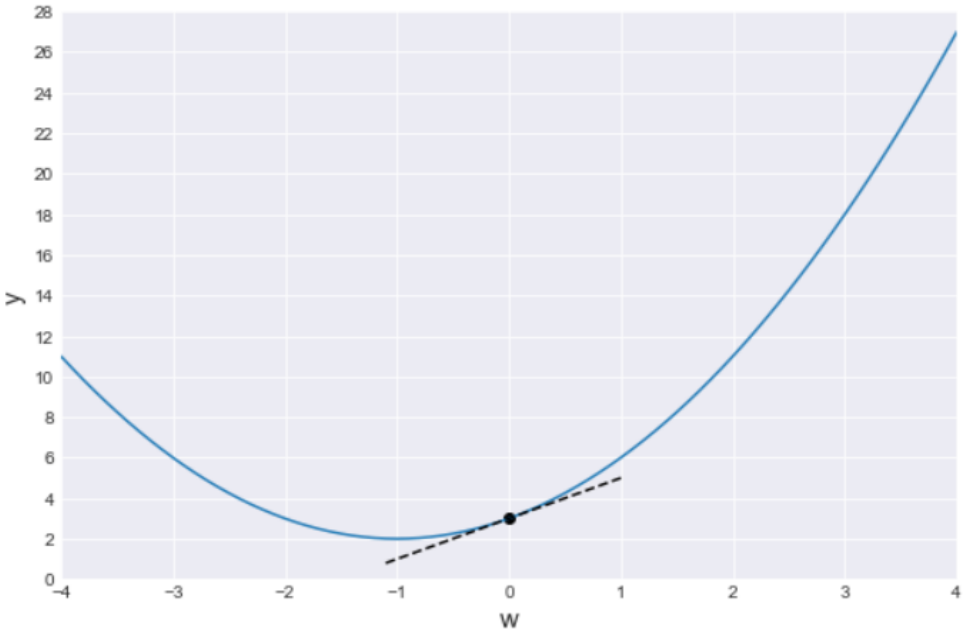
w = 3:

$$y(3) = 18$$

$$\frac{dy}{dw}(3) = +8$$

direction amount

Derivative



$$y = f(w) = w^2 + 2w + 3$$

$$\frac{dy}{dw} = f'(w) = 2w + 2$$

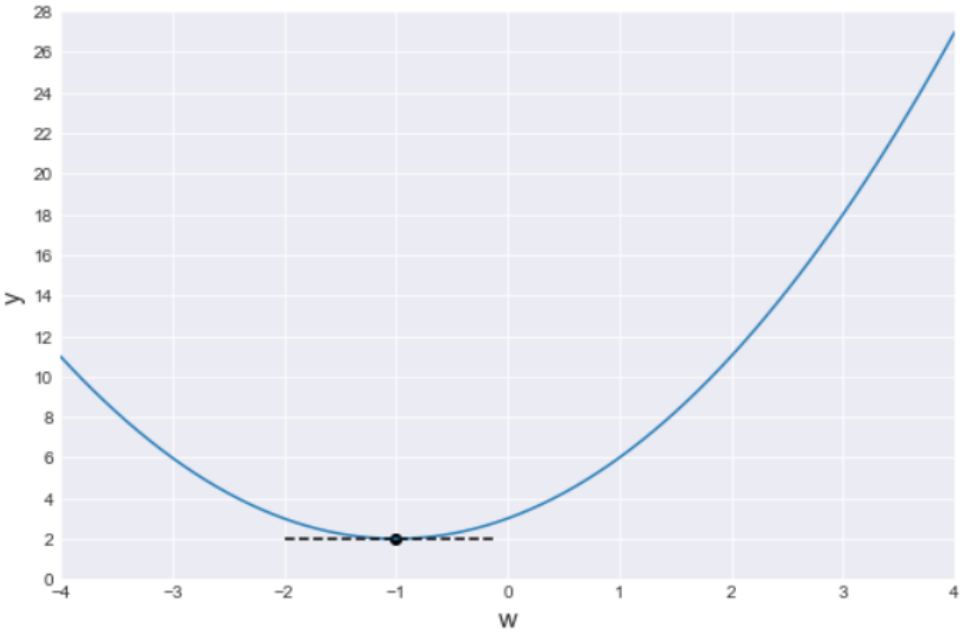
w = 0:

$$y(0) = 3$$

$$\frac{dy}{dw}(0) = +2$$

direction amount

Derivative



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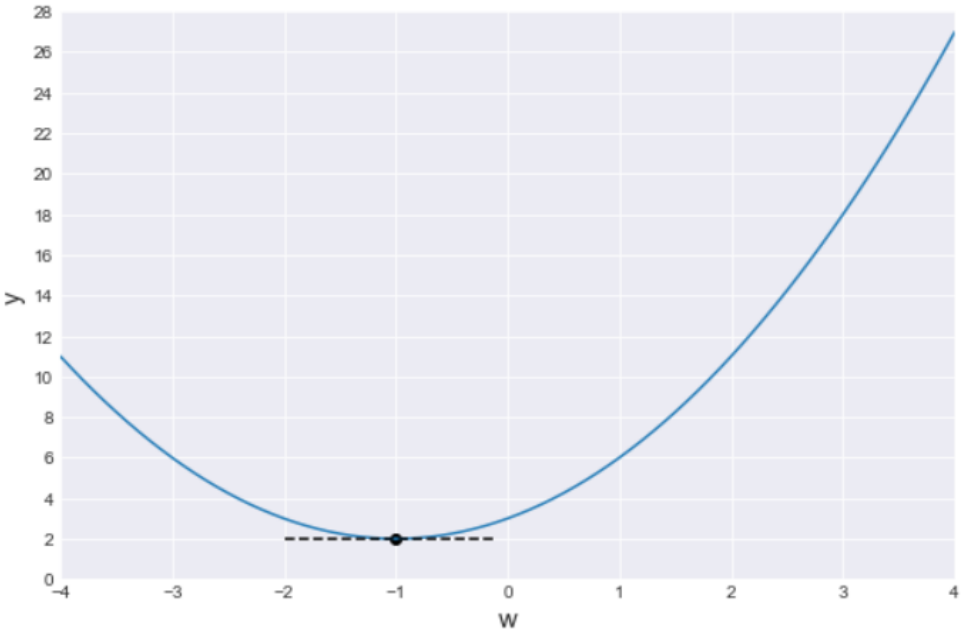
Derivative



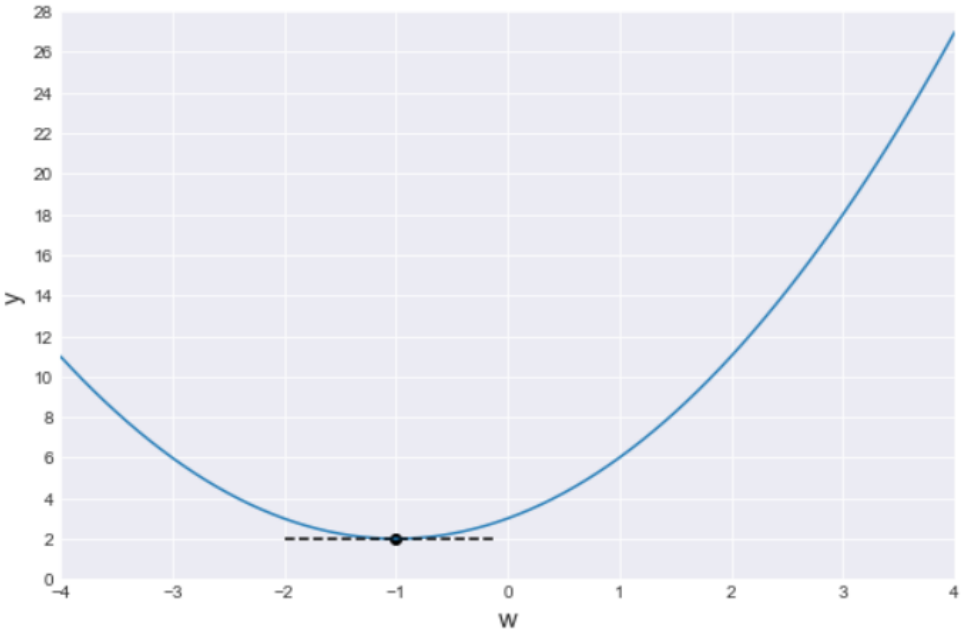
$$y = f(w) = w^2 + 2w + 3$$

$$\frac{dy}{dw} = f'(w) = 2w + 2$$

Minima/ Maxima

$$2w + 2 = 0$$

Derivative



$$y = f(w) = w^2 + 2w + 3$$

$$\frac{dy}{dw} = f'(w) = 2w + 2$$

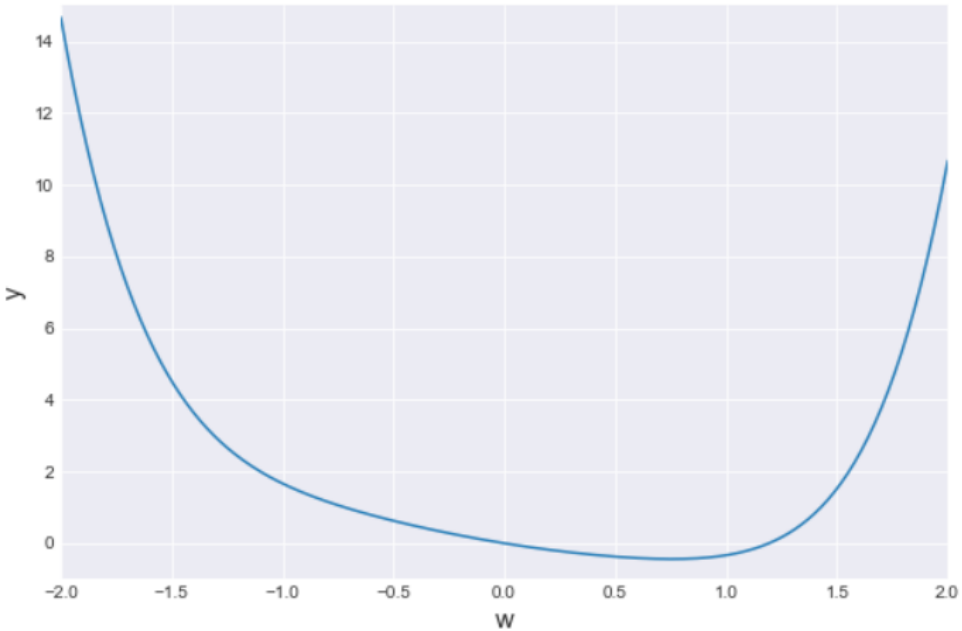
Minima/ Maxima

$$2w + 2 = 0$$

$$2w = -2$$

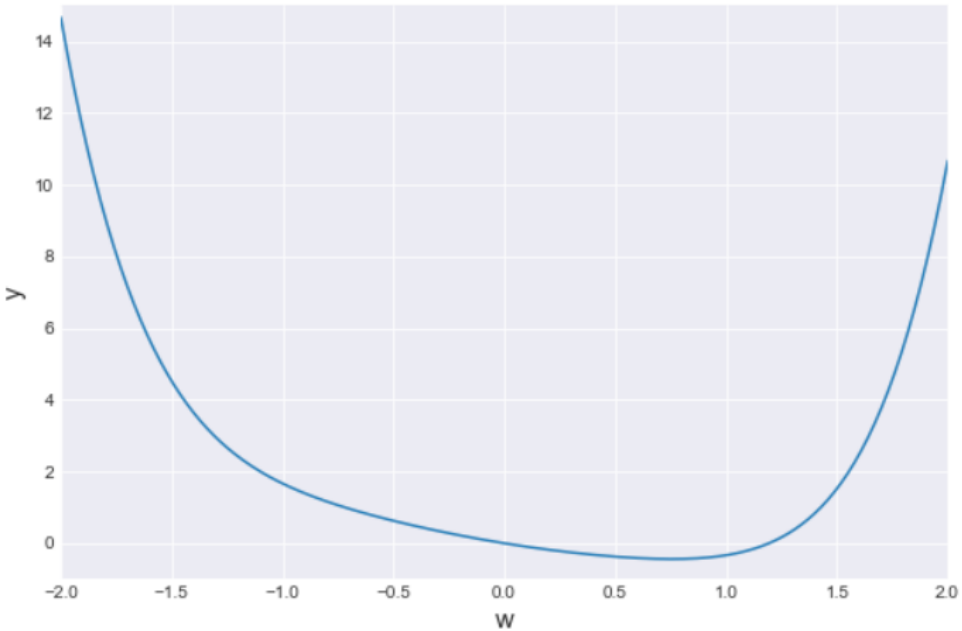
$$\underline{w = -1}$$

Derivative



$$y = f(w) = \frac{1}{6} w^6 + \frac{1}{2} w^2 - w$$

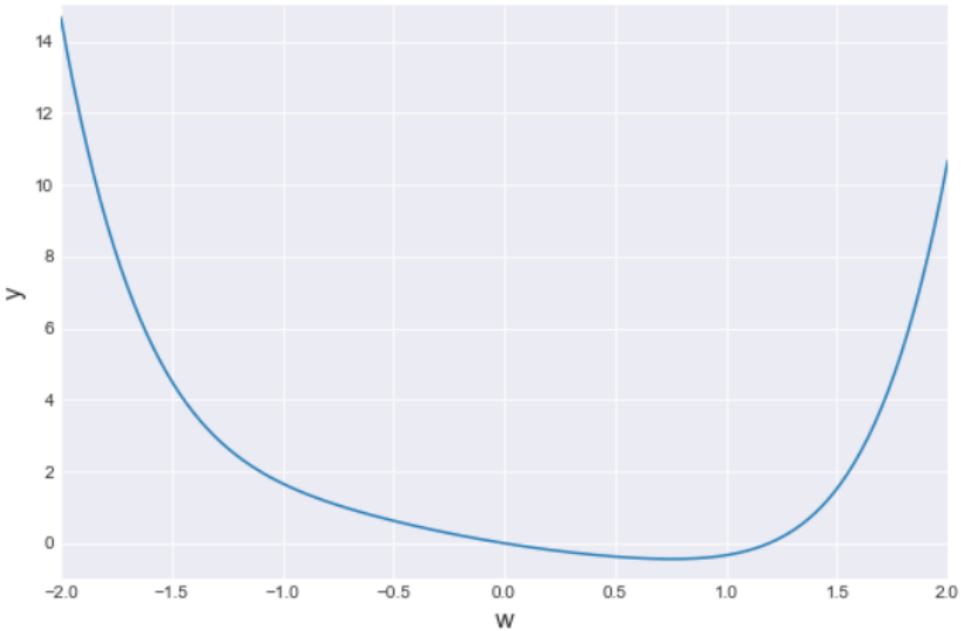
Derivative



$$y = f(w) = \frac{1}{6} w^6 + \frac{1}{2} w^2 - w$$

$$\frac{dy}{dw} = f'(w) = w^5 + w - 1$$

Derivative



$$y = f(w) = \frac{1}{6}w^6 + \frac{1}{2}w^2 - w$$

$$\frac{dy}{dw} = f'(w) = w^5 + w - 1$$

Minima/ Maxima

$$w^5 + w - 1 = 0$$

$$w^5 + w = 1$$

$$w(w^4 + 1) = 1$$

?