Neural Network and Deep Learning



Perceptron Learning

Outline

- Learning rule
- Perceptron Learning Rule
- Perceptron Learning Algorithm

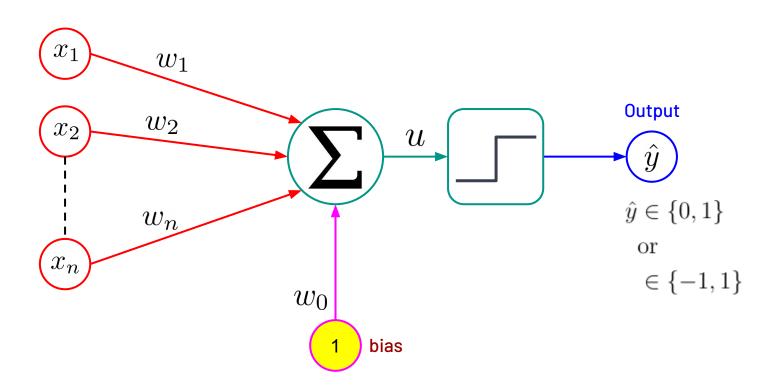
Learning rule

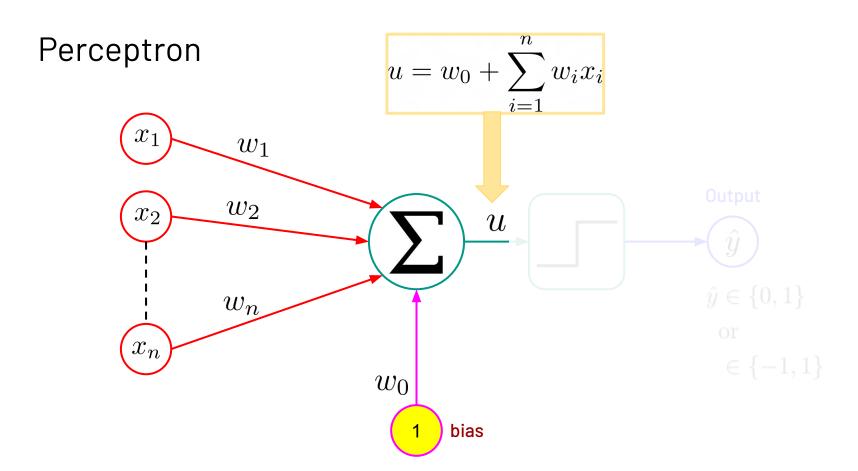
Learning rule

- Neural networks learn by mimicking the human brain's learning process, which is capable of adapting and changing behavior in response to environmental stimuli.
- Neural networks learning rules can be defined as the algorithm called Learning
 Algorithm.

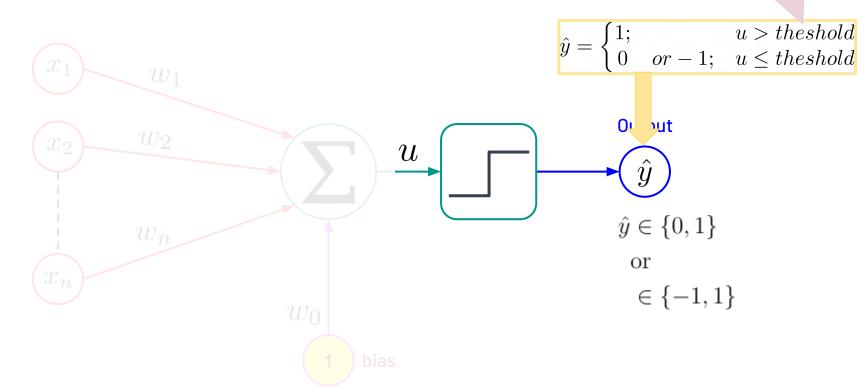
Perceptron Learning Rule

Perceptron





Perceptron



Perceptron Learning Rule

- Frank Rosenblatt published the first concept of the perceptron learning rule based on the McCulloch-Pitts neuron model in 1957
- In the perceptron learning rule, weight adjustments are made through iterative operations.
- According to convergence theory, every round, the weights of the perceptron must be adjusted to the proper weights; that is, the adjusted weights should produce an output that is as close to the actual value as possible.

Perceptron Learning Rule

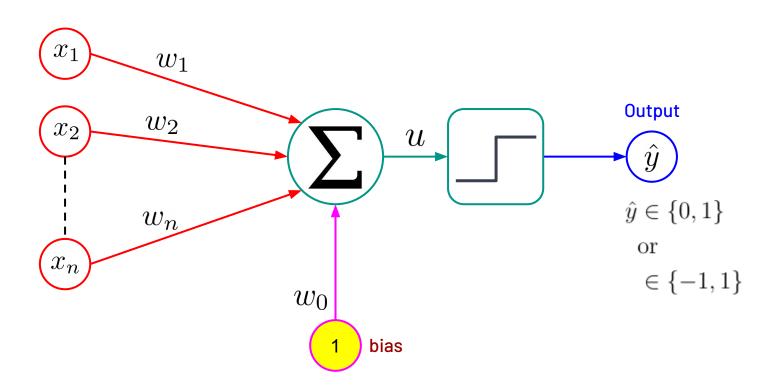
ullet In Perceptron Learning, when the learning rate η is defined, the weights are adjusted as

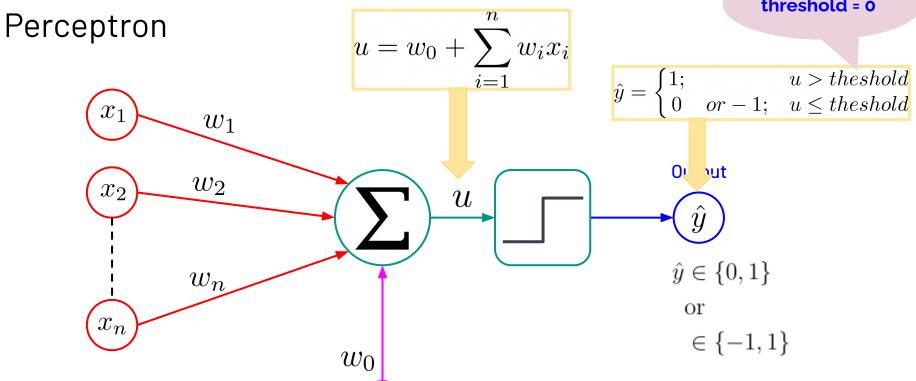
$$w_i(t+1) = w_i(t) + \eta(y - \hat{y})x_i$$

- where $0 < \eta \le 1$
- According to convergence theory, if the input vector and target values can be
 linearly separated, then when using the perceptron learning algorithm, the
 weights should be obtained within a finite number of rounds.

Perceptron Learning Algorithm

Perceptron





bias

Perceptron Learning Algorithm

Step 1:

- Initially, random the weights with small value
- ullet Define the value of **learning rate** $\,\eta=(0,1]$
- Define the stopping criteria i.e. number of round

Step 2:

- Check the stopping criteria
 - If meet the criteria, then stop
 - If far from the criteria, go to step 3

Perceptron Learning Algorithm

Step 3: Train model

- For each data point (x)
 - Step 3.1: Calculate sum-of-product between input and weight

$$u = w_0 + \sum_{i=1}^n w_i x_i$$

Step 3.2: Calculate the **output** of model
$$\hat{y} = \begin{cases} 1; & u > the shold \\ 0 & or -1; & u \leq the shold \end{cases}$$

Step 3.3: Update Weights

$$w_i(t+1) = w_i(t) + \eta(y-\hat{y})x_i$$

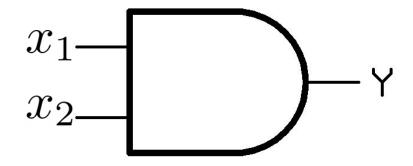
Step 4:

Go to step 2

Perceptron Learning Computation

Weights adjustment when emulate the behavior of logic gate.

x ₁	\mathbf{x}_2	у	
1	1	1	
1	-1	-1	
-1	1	-1	
-1	-1	-1	



x ₁	X ₂	у	
1	1	1	
1	-1	-1	
-1	1	-1	
-1	-1	-1	

Step 1:

• Initially, set the initial weights $w_0=0, w_1=0, w_2=0$

- Define the value of learning rate $\eta = 1$
- Define the threshold value = 0

$$\hat{y} = egin{cases} 1; & u > 0 \ -1; & u \leq 0 \end{cases}$$

- Define the stopping criteria
 - number of round = 1

			Step 3.1	Step 3.2		Step 3.3	
			n		$w_i(t+1)$	$1) = w_i(t) + \eta$	$(y-\hat{y})x_i$
x ₁	x ₂	у	$u = w_0 + \sum_{i=1}^{n} w_i x_i$	$\hat{y} = \begin{cases} 1; & u > 0 \\ -1; & u \le 0 \end{cases}$	\mathbf{w}_0	w ₁	w ₂
1	1	1	$egin{array}{ccc} w_0 & w_1 & w_2 \ {\color{red}0} + ({\color{red}0}^* \) + ({\color{red}0}^* \) \end{array}$				

			Step 3.1	Step 3.2		Step 3.3	
x ₁	X ₂	у	$u = w_0 + \sum_{i=1}^n w_i x_i$	$\hat{y}=egin{cases} 1; & u>0 \ -1; & u\leq 0 \end{cases}$	$w_i(t+1)$	$1) = w_i(t) + \eta$ \mathbf{w}_1	$egin{pmatrix} (y-\hat{y})x_i \ \mathbf{w}_2 \ \end{pmatrix}$
		1	$w_0 w_1 w_2$ $0 + (0^*1) + (0^*1) = 0$				

			Step 3.1	Step 3.2		Step 3.3	
			n	(1,)	$w_i(t+1)$	$1) = w_i(t) + \eta$	$(y-\hat{y})x_i$
x ₁	x ₂	у	$u = w_0 + \sum_{i=1}^{N} w_i x_i$	$\hat{y} = \begin{cases} 1; & u > 0 \\ -1; & u \le 0 \end{cases}$	\mathbf{w}_0	w ₁	w ₂
1	1	1	$0 + (0*1) + (0*1) \neq 0$	-1			

			Step 3.1	Step 3.2		Step 3.3	
			n		$w_i(t+1)$	$1) = w_i(t) + \eta$	$(y-\hat{y})x_i$
x ₁	x ₂	У	$u = w_0 + \sum_{i=1}^{n} w_i x_i$	$\hat{y} = egin{cases} 1; & u > 0 \ -1; & u \leq 0 \end{cases}$	\mathbf{w}_0	\mathbf{w}_{1}	w ₂
1	1	1	0 + (0*1) + (0*1) = 0	-1	$w_i(t) + \eta(y - \hat{y})x_i$	$w_i(t) + \eta(y - \hat{y})x_i$	$w_i(t) + \eta(y - \hat{y})x_i$

K	Juliu	(1 1	Step 3.1	Step 3.2	Step 3.3				
	X ₂		$u = w_0 + \sum_{i=1}^n w_i x_i$	•	· ·	$1) = w_i(t) + \eta$	$(y-\hat{y})x_i$		
x ₁		У			\mathbf{w}_0	w ₁	\mathbf{w}_2		
1	1		$0 + (0^*1) + (0^*1) = 0$	(-1)	$ \frac{\eta}{0 + 1^* (1 - (-1)) *1} $	η 0+1*(1-(-1))*1	η		
				1					

			Step 3.1	Step 3.2	Step 3.3		
			n	(1. 4 > 0	$w_i(t+1)$	$1) = w_i(t) + \eta$	$(y-\hat{y})x_i$
x ₁	x ₂	У	$u = w_0 + \sum_{i=1} w_i x_i$	$\hat{y} = egin{cases} z, & u > 0 \ -1; & u \leq 0 \end{cases}$	W_0	\mathbf{w}_1	w ₂
		1	$0 + (0^*1) + (0^*1) = 0$	-1	0 + 1* (1 - (-1)) * 1	0 + 1* (1 - (-1)) * 1	0 + 1* (1 - (-1)) * 1

			Step 3.1	Step 3.2		Step 3.3	
			n		$w_i(t+1)$	$1) = w_i(t) + \eta$	$(y-\hat{y})x_i$
x ₁	x ₂	у	$u = w_0 + \sum_{i=1}^{\infty} w_i x_i$	$\hat{y} = egin{cases} 1; & u > 0 \ -1; & u \leq 0 \end{cases}$	\mathbf{w}_0	\mathbf{w}_{1}	w ₂
1	1	1	$0 + (0^*1) + (0^*1) = 0$	-1	0 + 1*(1-(-1))*1 = 2	0 + 1*(1-(-1))*1 = 2	0 + 1*(1-(-1))*1 = 2

			Step 3.1	Step 3.2		Step 3.3	
			n		$w_i(t+1)$	$1) = w_i(t) + \eta$	$(y-\hat{y})x_i$
x ₁	x ₂	У	$u = w_0 + \sum_{i=1}^{\infty} w_i x_i$	$\hat{y} = egin{cases} 1; & u > 0 \ -1; & u \leq 0 \end{cases}$	\mathbf{w}_0	\mathbf{w}_{1}	\mathbf{w}_2
			<i>t</i> —1				
1	1	1	$0 + (0^*1) + (0^*1) = 0$	-1	$0+1*(1-(-1))*1 \neq 2$	$0+1*(1-(-1))*1 \neq 2$	$0+1*(1-(-1))*1 \neq 2$
			w_0 w_1 w_2		/		/
1	-1	-1	2 + (2*) + (2*)			and the second s	

			Step 3.1	Step 3.2		Step 3.3	
			n		$w_i(t+1) = w_i(t) + \eta(y-\hat{y})x_i$		
x ₁	x ₂	У	$u = w_0 + \sum_{i=1}^{n} w_i x_i$	$\hat{y} = egin{cases} 1; & u > 0 \ -1; & u \leq 0 \end{cases}$	\mathbf{w}_0	\mathbf{w}_1	\mathbf{w}_{2}
			t-1				
1	1	1	$0 + (0^*1) + (0^*1) = 0$	-1	0 + 1*(1-(-1))*1 = 2	0 + 1*(1-(-1))*1 = 2	$0 + 1^*(1 - (-1))^*1 = 2$
	(-1)	-1	w_0 w_1 w_2 $2 + (2^*1) + (2^*-1) = 2$				

			Step 3.1	Step 3.2		Step 3.3	
			n		$w_i(t+1)$	$1) = w_i(t) + \eta$	$(y-\hat{y})x_i$
X ₁	x ₂	у	$u = w_0 + \sum_{i=1}^{n} w_i x_i$	$\hat{y} = \left\{ egin{array}{ll} 1; & u > 0 \ -1; & u \leq 0 \end{array} ight.$	\mathbf{w}_0	\mathbf{w}_{1}	w ₂
1	1	1	$0 + (0^*1) + (0^*1) = 0$	\-1	0 + 1*(1-(-1))*1 = 2	$0 + 1^*(1 - (-1))^*1 = 2$	$0 + 1^*(1 - (-1))^*1 = 2$
1	-1	-1	$\frac{2}{2} + (\frac{2}{2} + 1) + (\frac{2}{2} + 1) + (\frac{2}{2} + 1)$, ↓ 1			

			Step 3.1	Step 3.2		Step 3.3	
			n	(1: u > 0)	$w_i(t+1)$	$1) = w_i(t) + \eta$	$(y-\hat{y})x_i$
x ₁	x ₂	у	$u = w_0 + \sum_{i=1} w_i x_i$	$\hat{y} = egin{cases} 1, & u > 0 \ -1; & u \leq 0 \end{cases}$	\mathbf{w}_0	w ₁	w ₂
1	1	1	$0 + (0^*1) + (0^*1) = 0$	-1	$0 + 1^*(1 - (-1))^*1 = 2$	$0 + 1^*(1 - (-1))^*1 = 2$	0 + 1*(1-(-1))*1 = 2
1	-1	-1	$\frac{2}{2} + (\frac{2}{2} \cdot 1) + (\frac{2}{2} \cdot -1) = 2$	1	$w_i(t) + \eta(y - \hat{y})x_i$	$w_i(t) + \eta(y - \hat{y})x_i$	$w_i(t) + \eta(y - \hat{y})x_i$

		•	Step 3.1	Step 3.2		Step 3.3	
			n		$w_i(t+1)$	$1) = w_i(t) + \eta$	$(y-\hat{y})x_i$
x ₁	x ₂	у	$u = w_0 + \sum_{i=1}^{\infty} w_i x_i$	$\hat{y} = egin{cases} 1; & u > 0 \ -1; & u \leq 0 \end{cases}$	\mathbf{w}_0	w ₁	w ₂
1	1	1	$0 + (0^*1) + (0^*1) = 0$	-1	$0 + 1^*(1 - (-1))^*1 = 2$	0 + 1*(1-(-1))*1 = 2	$0 + 1^*(1 - (-1))^* 1 = 2$
1	-1		$\frac{2}{2} + (\frac{2}{2} \cdot 1) + (\frac{2}{2} \cdot -1) = 2$		η 2 + 1* (-1 - 1) *1	η 2 + 1* (-1 · 1) *1	η 2+ 1* (-1 - 1) *-1
		1		\	1 1	/ /	1/1/

			Step 3.1	Step 3.2		Step 3.3	
			n		$w_i(t+1)$	$1) = w_i(t) + \eta$	$(y-\hat{y})x_i$
x ₁	x ₂	у	$u = w_0 + \sum_{i=1} w_i x_i$	$\hat{y} = egin{cases} 1; & u > 0 \ -1; & u \leq 0 \end{cases}$	\mathbf{w}_0	w ₁	w ₂
1	1	1	$0 + (0^*1) + (0^*1) = 0$	-1	0 + 1*(1-(-1))*1 = 2	0 + 1*(1-(-1))*1 = 2	$0 + 1^*(1 - (-1))^*1 = 2$
	(-1)	-1	$\frac{2}{2} + (\frac{2}{2} \cdot 1) + (\frac{2}{2} \cdot -1) = 2$	1	Bias 2+1*(-1-1)*1	2 +1*(-1-1)* 1	2 + 1* (-1 - 1) * -1

Stan 31

Round 1(Train model)

			Step 3.1	Step 3.2		Step 3.3	
			n		$w_i(t+1)$	$1) = w_i(t) + \eta$	$(y-\hat{y})x_i$
x ₁	x ₂	у	$u = w_0 + \sum_{i=1}^{n} w_i x_i$	$\hat{y} = egin{cases} 1; & u > 0 \ -1; & u \leq 0 \end{cases}$	\mathbf{w}_0	\mathbf{w}_{1}	W_2
			<i>t</i> —1				
1	1	1	$0 + (0^*1) + (0^*1) = 0$	-1	0 + 1*(1-(-1))*1 = 2	$0 + 1^*(1 - (-1))^*1 = 2$	0 + 1*(1-(-1))*1 = 2
1	-1	-1	$2 + (2^*1) + (2^*-1) = 2$	1	2 + 1*(-1-1)*1 = 0	2+1*(-1-1)*1=0	2 + 1*(-1-1)*-1 = 4

Stan 33

Stan 3.2

		•	Step 3.1	Step 3.2		Step 3.3				
x ₁	X ₂	у	$u = w_0 + \sum_{i=1}^n w_i x_i$	$\hat{y}=egin{cases} 1; & u>0 \ -1; & u\leq 0 \end{cases}$	$w_i(t+1)$	$\mathbf{u}_{1}(t) = w_{i}(t) + \eta$ \mathbf{w}_{1}	$(y-\hat{y})x_i$ $\mathbf{w}_{\mathbf{z}}$			
1	1	1	$0 + (0^*1) + (0^*1) = 0$	-1	0 + 1*(1-(-1))*1 = 2	0 + 1*(1-(-1))*1 = 2	0 + 1*(1-(-1))*1 = 2			
1	-1	-1	$2 + (2^*1) + (2^*-1) = 2$	1	2 + 1*(-1-1)*1 ±(0)	2 + 1*(-1-1)*1 ± (0)	2 + 1*(-1-1)*-1 ± (4)			
-1	1	-1	$egin{array}{cccccccccccccccccccccccccccccccccccc$			and the second s	and the second s			

			Step 3.1	Step 3.2		Step 3.3	
X ₁	X_2	у	$u = w_0 + \sum_{i=1}^{n} w_i x_i$	$\hat{y} = \begin{cases} 1; & u > 0 \\ -1; & u < 0 \end{cases}$	$\begin{bmatrix} w_i(t+1) \\ \mathbf{w}_0 \end{bmatrix}$	$\mathbf{w}_{i}(t) + \eta$ \mathbf{w}_{1}	$(y-\hat{y})x_i$ \mathbf{w}_2
1	2		i=1	(2,	U	1	2
1	1	1	$0 + (0^*1) + (0^*1) = 0$	-1	0 + 1*(1-(-1))*1 = 2	$0 + 1^*(1 - (-1))^*1 = 2$	0 + 1*(1-(-1))*1 = 2
1	-1	-1	$2 + (2^*1) + (2^*-1) = 2$	1	2 + 1*(-1-1)*1 = 0	2+1*(-1-1)*1=0	2 + 1*(-1-1)*-1 = 4
		-1	w_0 w_1 w_2 $0 + (0*1) + (4*1) = 4$				
		22222					

Round 1(Train model)

			Step 3.1	Step 3.2		Step 3.3	
x ₁	x ₂	у	$u = w_0 + \sum_{i=1}^n w_i x_i$	$\hat{y}=egin{cases} 1; & u>0 \ -1; & u\leq 0 \end{cases}$	$\mathbf{w}_{i}(t+1)$	$\mathbf{w}_{1} = w_{i}(t) + \eta$ \mathbf{w}_{1}	$(y - \hat{y})x_i$ \mathbf{w}_2
1	1	1	$0 + (0^*1) + (0^*1) = 0$	-1	0 + 1*(1-(-1))*1 = 2	0 + 1*(1-(-1))*1 = 2	0 + 1*(1-(-1))*1 = 2
1	-1	-1	2 + (2*1) + (2*-1) = 2/	\ 1	2+1*(-1-1)*1=0	2 + 1*(-1-1)*1 = 0	2 + 1*(-1-1)*-1 = 4
-1	1	-1	0 + (0*1) + (4*1) + (4*1)	ž			

Stan 3 3

Ston 3 2

 $\frac{0}{0} + (\frac{0}{0} + 1) + (\frac{4}{1} + 1) = 4$

Round 1(Train model)

-1

(Step 3.1	Step 3.2	Step 3.3
	<u>n</u>	(1, ,,)	$w_i(t+1) = w_i(t) + \eta(y-\hat{y})x_i$
	. 🔽	\downarrow 1; $u>0$	

i

x ₁	x ₂	у	$u = w_0 + \sum_{i=1}^{\infty} w_i x_i$	$\hat{y} = \begin{cases} 1; & u > 0 \\ -1; & u \le 0 \end{cases}$	\mathbf{w}_0	w ₁	w ₂
1	1	1	0 + (0*1) + (0*1) = 0	-1	0 + 1*(1-(-1))*1 = 2	0 + 1*(1-(-1))*1 = 2	0 + 1*(1-(-1))*1 = 2

1	2		i=1	(1,	U	1	L
1	1	1	$0 + (0^*1) + (0^*1) = 0$	-1	0 + 1*(1-(-1))*1 = 2	0 + 1*(1-(-1))*1 = 2	0 + 1*(1-(-1))*1 = 2

1	1	1	$0 + (0^*1) + (0^*1) = 0$	-1	0 + 1*(1-(-1))*1 = 2	0 + 1*(1-(-1))*1 = 2	0 + 1*(1-(-1))*1 = 2

1	1	1	$0 + (0^*1) + (0^*1) = 0$	-1	0 + 1*(1-(-1))*1 = 2	$0 + 1^*(1 - (-1))^*1 = 2$	$0 + 1^*(1 - (-1))^*1 = 2$

 $w_i(t) + \eta(y - \hat{y})x_i | w_i(t) + \eta(y - \hat{y})x_i | w_i(t) + \eta(y - \hat{y})x_i$

1	1	1	$0 + (0^*1) + (0^*1) = 0$	-1	$0 + 1^*(1 - (-1))^* 1 = 2$	$0 + 1^*(1 - (-1))^*1 = 2$	$0 + 1^*(1 - (-1))^*1 = 2$
1	-1	-1	2 + (2 *1) + (2 *-1) = 2	1	2+ 1*(-1-1)*1 = 0	2+ 1*(-1-1)*1 = 0	2 + 1*(-1-1)*-1 = 4

			Step 3.1	Step 3.2	3.2 Step 3.3				
			n		$w_i(t+1)$	$1) = w_i(t) + \eta$	$(y-\hat{y})x_i$		
x ₁ x ₂	У	$u = w_0 + \sum_{i=1} w_i x_i$	$\hat{y}=\left\{egin{array}{ll} -1; & u\leq 0 \end{array} ight.$	\mathbf{w}_0	w ₁	w ₂			
1	1	1	$0 + (0^*1) + (0^*1) = 0$	-1	$0 + 1^*(1 - (-1))^*1 = 2$	0 + 1*(1-(-1))*1 = 2	0 + 1*(1-(-1))*1 = 2		
1	-1	-1	$2 + (2^*1) + (2^*-1) = 2$	1	2 + 1*(-1-1)*1 = 0	2 + 1*(-1-1)*1 = 0	2 + 1*(-1-1)*-1 = 4		
-1	1		0 + (0*1) + (4*1) = 4	(<u>1</u>)	η 0+1*(-1-1)*1	η 0+1*(-1-1)*-1	η 4+ 1* (-1 - 1) *1		
			****	1000			and a second		

		•	Step 3.1	Step 3.2	Step 3.3			
x ₁	X ₂	у	$u = w_0 + \sum_{i=1}^n w_i x_i$	$\hat{y}=egin{cases} 1; & u>0 \ -1; & u\leq 0 \end{cases}$	$w_i(t+1)$	$1) = w_i(t) + \eta$ \mathbf{w}_1	$(y-\hat{y})x_i$ \mathbf{w}_2	
1	1	1	$0 + (0^*1) + (0^*1) = 0$	-1	0 + 1*(1-(-1))*1 = 2	0 + 1*(1-(-1))*1 = 2	0 + 1*(1-(-1))*1 = 2	
1	-1	-1	$2 + (2^*1) + (2^*-1) = 2$	1	2 + 1*(-1-1)*1 = 0	2 + 1*(-1-1)*1 = 0	2 + 1*(-1-1)*-1 = 4	
		-1	0 + (0*1) + (4*1) = 4	1	Bias 0+ 1* (-1 - 1) *1	0 + 1* (-1 - 1) * -1	4 + 1* (-1 - 1) * 1	
``	*****							

2 + (2*1) + (2*-1) = 2

 $\mathbf{0} + (\mathbf{0}^* - 1) + (\mathbf{4}^* 1) = 4$

1 / Train no a dal

-1

-1

1

-1

Round I (Irain i	nodel)				
	Step 3.1	Step 3.2	Step 3.		
			$(w_i(t+1) = w_i(t))$		

1

			n		u	$v_i(t+1) = w_i(t) + v_i(t) +$	$\eta(y-\hat{y})x_i$
x ₁	x ₂	у	$u = w_0 + \sum_{i=1} w_i x_i$	$\hat{y} = egin{cases} 1; & u > 0 \ -1; & u \leq 0 \end{cases}$	W	\mathbf{w}_1	w ₂

x ₁	x ₂	у	$u = w_0 + \sum_{i=1} w_i x_i$	$\hat{y} = \begin{cases} 1; & u > 0 \\ -1; & u \le 0 \end{cases}$	\mathbf{w}_0	w ₁	w ₂
1	1	1	0 + (0*1) + (0*1) = 0	1	0 1*(1 (1))*1	0 1*(1 (1))*1 2	0 + 1*(1 (1))*1

			i=1				
1	1	1	$0 + (0^*1) + (0^*1) = 0$	-1	$0 + 1^*(1 - (-1))^*1 = 2$	$0 + 1^*(1 - (-1))^*1 = 2$	0 + 1*(1-(-1))*1 = 2

1	1	1	$0 + (0^*1) + (0^*1) = 0$	-1	0 + 1*(1-(-1))*1 = 2	0 + 1*(1-(-1))*1 = 2	0 + 1*(1-(-1))*1 = 2

2+1*(-1-1)*1=0

0+1*(-1-1)*1=-2

2+1*(-1-1)*1=0

0+1*(-1-1)*-1=2

2+1*(-1-1)*-1=4

4+1*(-1-1)*1=2

			Step 3.1	Step 3.2	Step 3.3				
x ₁	x ₂	у	$u = w_0 + \sum_{i=1}^n w_i x_i$	$\hat{y}=egin{cases} 1; & u>0 \ -1; & u\leq 0 \end{cases}$	$w_i(t+1)$	$\mathbf{u}_{1} = w_{i}(t) + \eta$ \mathbf{w}_{1}	$(y - \hat{y})x_i$ \mathbf{w}_2		
1	1	1	$0 + (0^*1) + (0^*1) = 0$	-1	0 + 1*(1-(-1))*1 = 2	0 + 1*(1-(-1))*1 = 2	0 + 1*(1-(-1))*1 = 2		
1	-1	-1	$2 + (2^*1) + (2^*-1) = 2$	1	2 + 1*(-1-1)*1 = 0	2 + 1*(-1-1)*1 = 0	2 + 1*(-1-1)*-1 = 4		
-1	1	-1	$0 + (0^* - 1) + (4^* 1) = 4$	1	0 + 1*(-1-1)*1=(-2)	0 + 1*(-1-1)*-1 2	4 + 1*(-1-1)*1 = 2		
-1	-1	-1	$w_0 \ w_1 \ w_2$ -2 + (2*) + (2*)						

			Step 3.1	Step 3.2		Step 3.3		
			n	į	$w_i(t+1) = w_i(t) + \eta(y-\hat{y})x_i$			
х ₁	x ₂	у	$u = w_0 + \sum_{i=1}^{n} w_i x_i$	$\hat{y}=egin{cases} 1; & u>0 \ -1; & u\leq 0 \end{cases}$	\mathbf{w}_0	\mathbf{w}_1	W_2	
1	1	1	$0 + (0^*1) + (0^*1) = 0$	-1	$0 + 1^*(1 - (-1))^*1 = 2$	0 + 1*(1-(-1))*1 = 2	$0 + 1^*(1 - (-1))^*1 = 2$	
1	-1	-1	$2 + (2^*1) + (2^*-1) = 2$	1	2 + 1*(-1-1)*1 = 0	2 + 1*(-1-1)*1 = 0	2 + 1*(-1-1)*-1 = 4	
-1	1	-1	$0 + (0^* - 1) + (4^* 1) = 4$	1	0 + 1*(-1-1)*1= -2	0 + 1*(-1-1)*-1 = 2	4 + 1*(-1-1)*1 = 2	
			$egin{array}{cccc} w_0 & w_1 & & w_2 \end{array}$					

			Step 3.1	Step 3.2		Step 3.3	
$\begin{bmatrix} x_1 & x_2 \end{bmatrix}$		у	$u = w_0 + \sum_{i=1}^n w_i x_i \hat{y}$	$\hat{y}=egin{cases} 1; & u>0 \ -1; & u\leq 0 \end{cases}$	$\begin{bmatrix} w_i(t+1) \\ \mathbf{w}_0 \end{bmatrix}$	$1) = w_i(t) + \eta$ \mathbf{w}_1	$(y-\hat{y})x_i$ \mathbf{w}_2
1 2 3	J	0			1	2	
1	1	1	$0 + (0^*1) + (0^*1) = 0$	-1	0 + 1*(1-(-1))*1 = 2	$0 + 1^*(1 - (-1))^* 1 = 2$	0 + 1*(1-(-1))*1 = 2
1	-1	-1	$2 + (2^*1) + (2^*-1) = 2$	\\1	2 + 1*(-1-1)*1 = 0	2+1*(-1-1)*1=0	2 + 1*(-1-1)*-1 = 4
-1	1	-1	$0 + (0^* - 1) + (4^* 1) = 4$	1	0 + 1*(-1-1)*1= -2	0 + 1*(-1-1)*-1 = 2	4 + 1*(-1-1)*1 = 2
-1	-1	-1	$-2 + (2*-1) + (2*-1) \neq -6$	-1			

Sten 3.1

 $\mathbf{0} + (\mathbf{0}^*1) + (\mathbf{0}^*1) = 0$

2 + (2*1) + (2*-1) = 2

 $\mathbf{0} + (\mathbf{0}^* - 1) + (\mathbf{4}^* 1) = 4$

-2 + (2*-1) + (2*-1) = -6

Round 1	Train model
Roulla I	Hallilliouei

-1

-1

-1

1

-1

-1

-1

-1

		otep 0.1	Otep 0.2		Otcp 0.0		
x ₁ x ₂	у	$u = w_0 + \sum_{i=1}^n w_i x_i$	$\hat{y}=egin{cases} 1; & u>0 \ -1; & u\leq 0 \end{cases}$	$egin{pmatrix} w_i \ w_0 \end{pmatrix}$	$\mathbf{w}_{1}(t+1) = w_{i}(t) + \eta$ \mathbf{w}_{1}	$\begin{bmatrix} y - \hat{y} \\ w_2 \end{bmatrix}$	
	1	I .	I .	l .			

Sten 3.2

-1

1

1

-1

		n			$w_i(t+1)$	$1) = w_i(t) + \eta$	$y(y-\hat{y})x_i$	
x ₂	у	$u = w_0 + \sum_{i=1} w_i x_i$	$\hat{y}=egin{cases} 1; & u>0 \ -1; & u\leq 0 \end{cases}$	V	v ₀	\mathbf{w}_1	w ₂	

0+1*(1-(-1))*1=2

2+1*(-1-1)*1=0

0+1*(-1-1)*1=-2

Sten 3.3

0+1*(1-(-1))*1=2

2+1*(-1-1)*1=0

0+1*(-1-1)*-1=2

 $w_i(t) + \eta(y - \hat{y})x_i |w_i(t) + \eta(y - \hat{y})x_i| w_i(t) + \eta(y - \hat{y})x_i$

0+1*(1-(-1))*1=2

2+1*(-1-1)*-1=4

4+1*(-1-1)*1=2

			Step 3.1	Step 5.2		Step 3.3		
x ₁	x ₂	у	$u = w_0 + \sum_{i=1}^n w_i x_i$	$\hat{y}=egin{cases} 1; & u>0 \ -1; & u\leq 0 \end{cases}$	$\mathbf{w}_{i}(t+\mathbf{w}_{0})$	$1) = w_i(t) + \eta$ $\mathbf{w_1}$	$(y-\hat{y})x_i$ \mathbf{w}_2	
1	1	1	$0 + (0^*1) + (0^*1) = 0$	-1	0 + 1*(1-(-1))*1 = 2	0 + 1*(1-(-1))*1 = 2	$0 + 1^*(1 - (-1))^*1 = 2$	
1	-1	-1	$2 + (2^*1) + (2^*-1) = 2$	1	2 + 1*(-1-1)*1 = 0	2 + 1*(-1-1)*1 = 0	2 + 1*(-1-1)*-1 = 4	
-1	1	-1	$0 + (0^* - 1) + (4^* 1) = 4$	1	0+1*(-1-1)*1= -2	0 + 1*(-1-1)*-1 = 2	4 + 1*(-1-1)*1 = 2	
-1	-1		$\frac{-2}{2} + (\frac{2}{2} - 1) + (\frac{2}{2} - 1) = -6$	(-1)	η -2+1*(-1 ¹ / ₂ (-1)) *1	2+ 1* (-1 - (-1)) *-1	2+1*(-1-(-1)) *-1	

Round 1(Train model)

			ann modern				
			Step 3.1	Step 3.2		Step 3.3	
			n		$w_i(t +$	$1) = w_i(t) + \eta$	$(y \cdot$
x ₁	x ₂	у	$u = w_0 + \sum_{i=1}^{\infty} w_i x_i$	$\hat{y} = egin{cases} 1; & u > 0 \ -1; & u \leq 0 \end{cases}$	\mathbf{w}_0	w ₁	
1	1	1	$0 + (0^*1) + (0^*1) = 0$	-1	$0 + 1^*(1 - (-1))^*1 = 2$	0 + 1*(1-(-1))*1 = 2	0-

x ₁	x ₂	у	$u = w_0 + \sum_{i=1}^{\infty} w_i x_i$	$\int_{0}^{y} \int_{0}^{z} (-1); u \leq 0$	0	vv ₁	vv ₂
1	1	1	$0 + (0^*1) + (0^*1) = 0$	-1	0 + 1*(1-(-1))*1 = 2	0 + 1*(1-(-1))*1 = 2	0 + 1*(1-(-1))*1 = 2

 $-\hat{y})x_i$

1 1 1
$$0 + (0*1) + (0*1) = 0$$
 -1 $0 + 1*(1-(-1))*1 = 2$ $0 + 1*(1-(-1))*1 = 2$ $0 + 1*(1-(-1))*1 = 2$
1 -1 -1 $2 + (2*1) + (2*-1) = 2$ 1 $2 + 1*(-1-1)*1 = 0$ $2 + 1*(-1-1)*1 = 0$ $2 + 1*(-1-1)*-1 = 4$

1 -1 -1
$$2 + (2*1) + (2*-1) = 2$$
 1 $2 + 1*(-1-1)*1 = 0$ $2 + 1*(-1-1)*1 = 0$ $2 + 1*(-1-1)*-1 = 4$ -1 $1 -1 0 + (0*-1) + (4*1) = 4$ 1 $0 + 1*(-1-1)*1 = 2$ $0 + 1*(-1-1)*-1 = 2$ $4 + 1*(-1-1)*1 = 2$

Round 1(Train model)

1

-1

-1

-1

-1

-1

-1

-1

x ₁	X ₂	у		$\hat{y}=egin{cases} 1; & u>0 \ -1; & u\leq 0 \end{cases}$	$w_i(t+w_0)$	$1) = w_i(t) + \eta$ \mathbf{w}_1	$(y-\hat{y})x_i$ \mathbf{w}_2
			i=1				

-1

1

1

-1

0+1*(1-(-1))*1=2

2+1*(-1-1)*1=0

0+1*(-1-1)*1=-2

-2+1*(-1-(-1))*1=**-2**

Step 3.3

0+1*(1-(-1))*1=2

2+1*(-1-1)*1=0

0+1*(-1-1)*-1=2

2+1*(-1-(-1))*-1=2

0+1*(1-(-1))*1=2

2+1*(-1-1)*-1=4

4+1*(-1-1)*1=2

2+ 1*(-1-(-1))*-1(= **2**

Step 3.1 Step 3.2

 $\mathbf{0} + (\mathbf{0}^*1) + (\mathbf{0}^*1) = 0$

2 + (2*1) + (2*-1) = 2

 $\mathbf{0} + (\mathbf{0}^* - 1) + (\mathbf{4}^* 1) = 4$

-2 + (2*-1) + (2*-1) = -6

After finish round 1, we obtained

$$w_0 = -2$$
 $w_1 = 2$ $w_2 = -2$

According to linear equation, we can get a linear line from our weights

$$w_0 + w_1 x_1 + w_2 x_2 = 0$$
$$-2 + 2x_1 + 2x_2 = 0$$

Discuss!!

If the round number is 2, how to continue?



Round 2 (Train model)

			Step 3.1	Step 3.2		Step 3.3	
x ₁	x ₂	у	$u = w_0 + \sum_{i=1}^n w_i x_i$	$\hat{y}=egin{cases} 1; & u>0 \ -1; & u\leq 0 \end{cases}$	$\mathbf{w}_{i}(t+1)$	$1) = w_i(t) + \eta$ \mathbf{w}_1	$\begin{bmatrix} (y-\hat{y})x_i \end{bmatrix}$ \mathbf{w}_2
1	1	1	w_0 w_1 w_2 -2 \div $(2^*$ $)$ $+$ $(2^*$ $)$				

Obtained from round 1

Hands On