



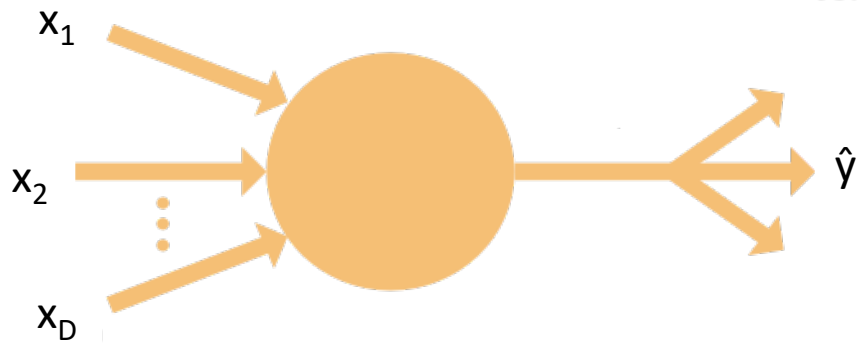
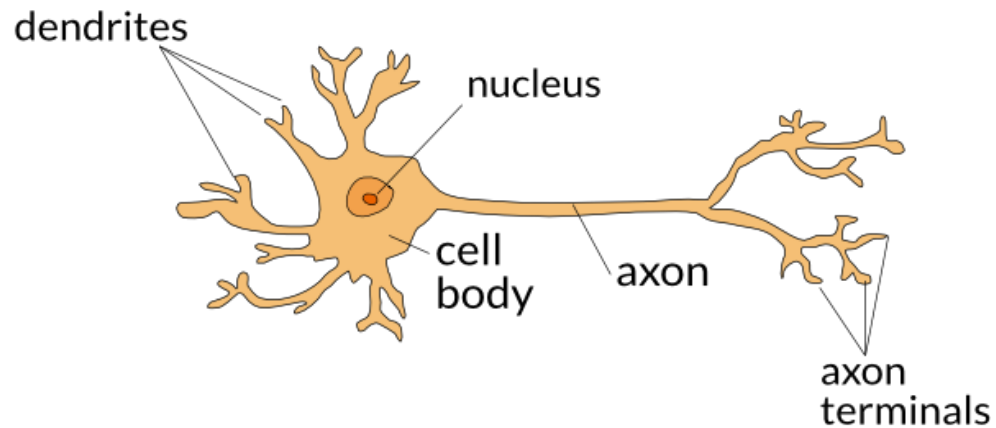
Introduction to Machine Learning

The Perceptron

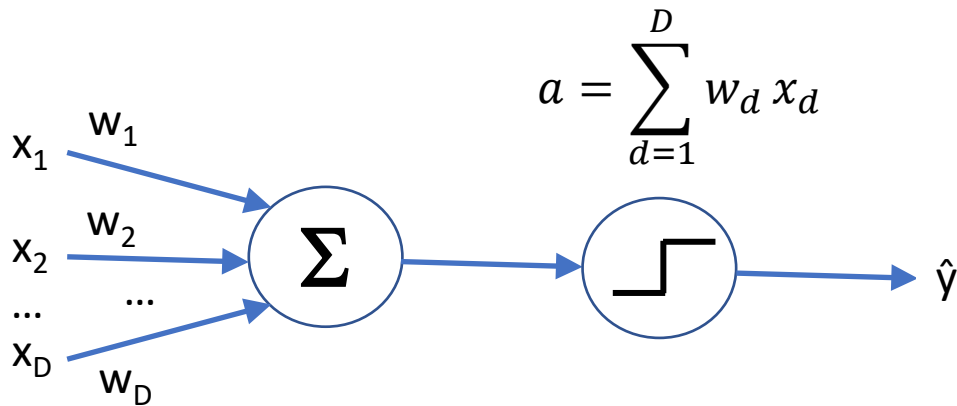
Perceptron

- Supervised learning algorithm
- Regression or classification
- Allows us to weight features

Biological inspiration



Perceptron neuron



Input to neuron

- Impact of weights

$$a = \sum_{d=1}^D w_d x_d$$

Activation function

- If $a > 0$ then output 1 (positive example)
- Else output -1 (negative example)
- Use non-zero threshold
 - If $a > \theta$ output 1, else output -1
 - Can accomplish the same thing through bias term

$$a = \sum_{d=1}^D w_d x_d$$

$$a = \sum_{d=1}^D w_d x_d + b$$

Class labels

- Binary classifier
- Classes are + and –
- Denote by $y=+1$ and $y=-1$
- Once activation is computed, output is sign of a

$$a = \sum_{d=1}^D w_d x_d + b$$

Training a Perceptron

- Intuition
 - If output -1 but should have output +1, need to increase weights
 - If output +1 but should have output -1, need to decrease weights

Algorithm 5 PERCEPTRONTRAIN(\mathbf{D} , $MaxIter$)

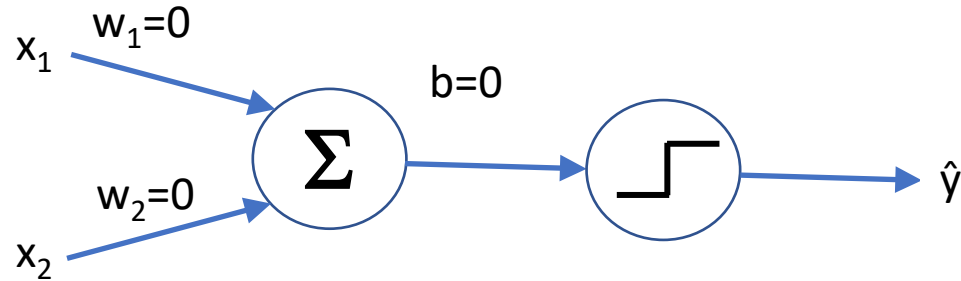
```
1:  $w_d \leftarrow 0$ , for all  $d = 1 \dots D$  // initialize weights
2:  $b \leftarrow 0$  // initialize bias
3: for  $iter = 1 \dots MaxIter$  do
4:   for all  $(x, y) \in \mathbf{D}$  do
5:      $a \leftarrow \sum_{d=1}^D w_d x_d + b$  // compute activation for this example
6:     if  $ya \leq 0$  then
7:        $w_d \leftarrow w_d + yx_d$ , for all  $d = 1 \dots D$  // update weights
8:        $b \leftarrow b + y$  // update bias
9:     end if
10:  end for
11: end for
12: return  $w_0, w_1, \dots, w_D, b$ 
```

Algorithm 6 PERCEPTRONTEST($w_0, w_1, \dots, w_D, b, \hat{x}$)

```
1:  $a \leftarrow \sum_{d=1}^D w_d \hat{x}_d + b$  // compute activation for the test example
2: return SIGN( $a$ )
```

Example: Logical AND

y	x1	x2
-1	0	0
-1	0	1
-1	1	0
+1	1	1



if $ya \leq 0$ then

$$w_d \leftarrow w_d + yx_d.$$

$$b \leftarrow b + y$$