Computer Vision

CVI620

Session 19
03/2025

What is Left?

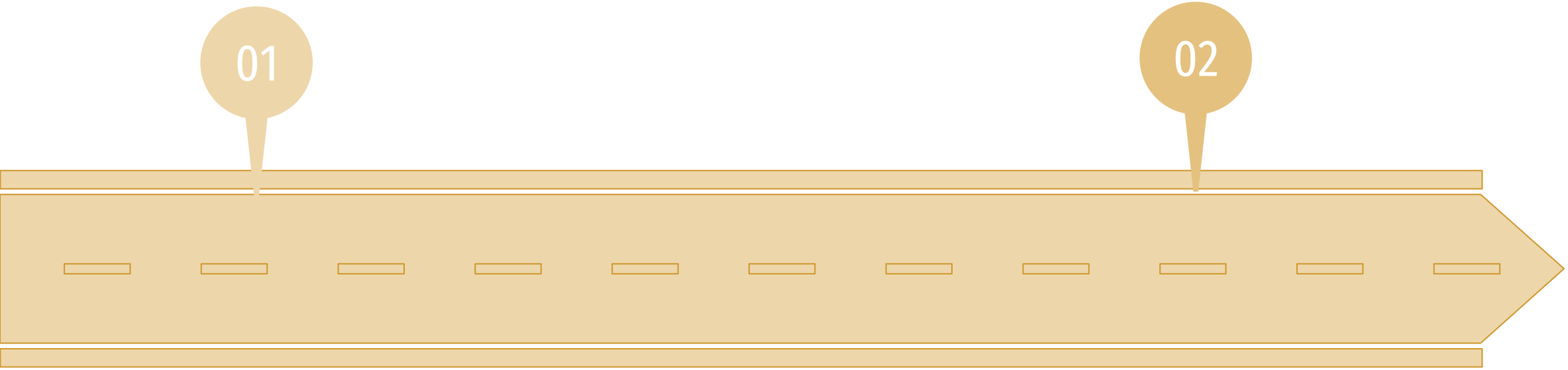
9 sessions

1. Optimization and Loss Function
2. Code + Logistic Regression
3. ML and Images
4. Perceptron and Neural Networks
5. Deep Neural Networks
6. Convolution Neural Networks (CNN)
7. Advanced CNNs
8. Project
9. Segmentation
10. Introduction to object detection and image generation methods with AI
11. Project

Agenda

Smile Detection Project

Perceptron



Smile Detection

Dataset

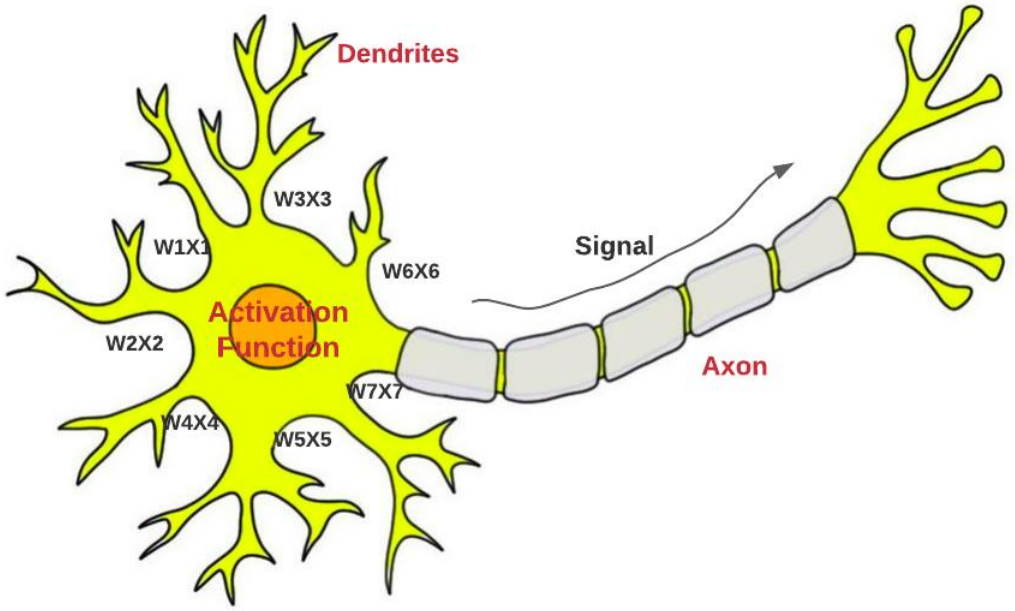
MTCNN

- pip install mtcnn

Or use haarcascades

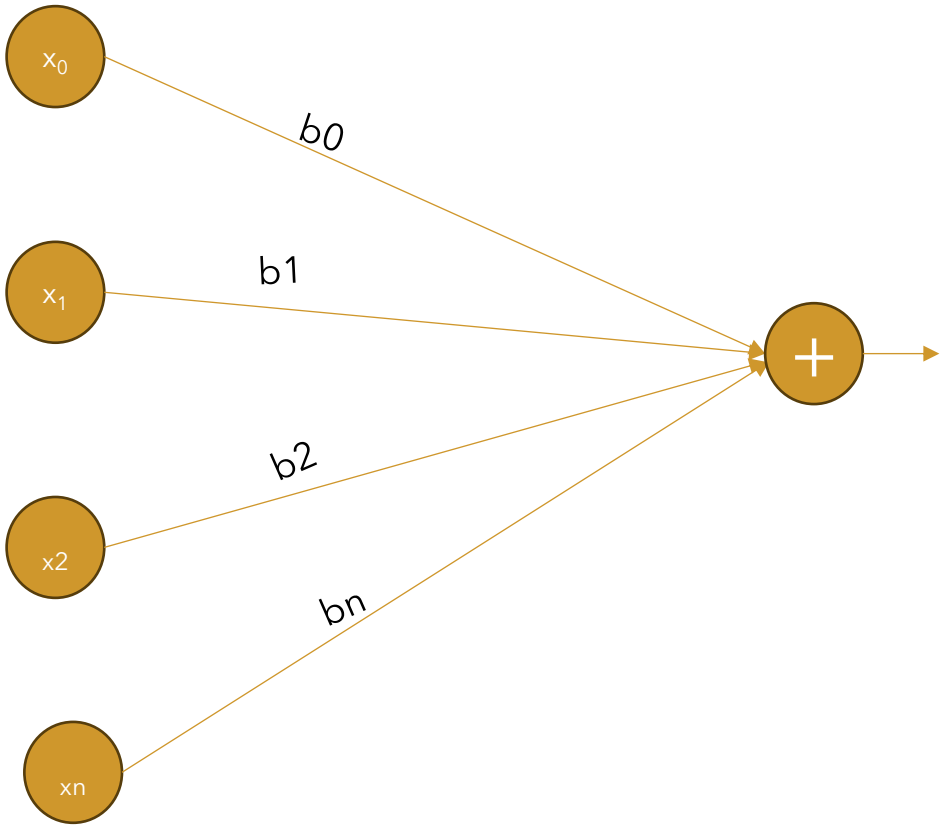

Brain

Perceptron


Dendrites
W3X3
W1X1
W6X6
Signal
Activation
Function
W2X2
Axon
W7X7
W4X4
W5X5

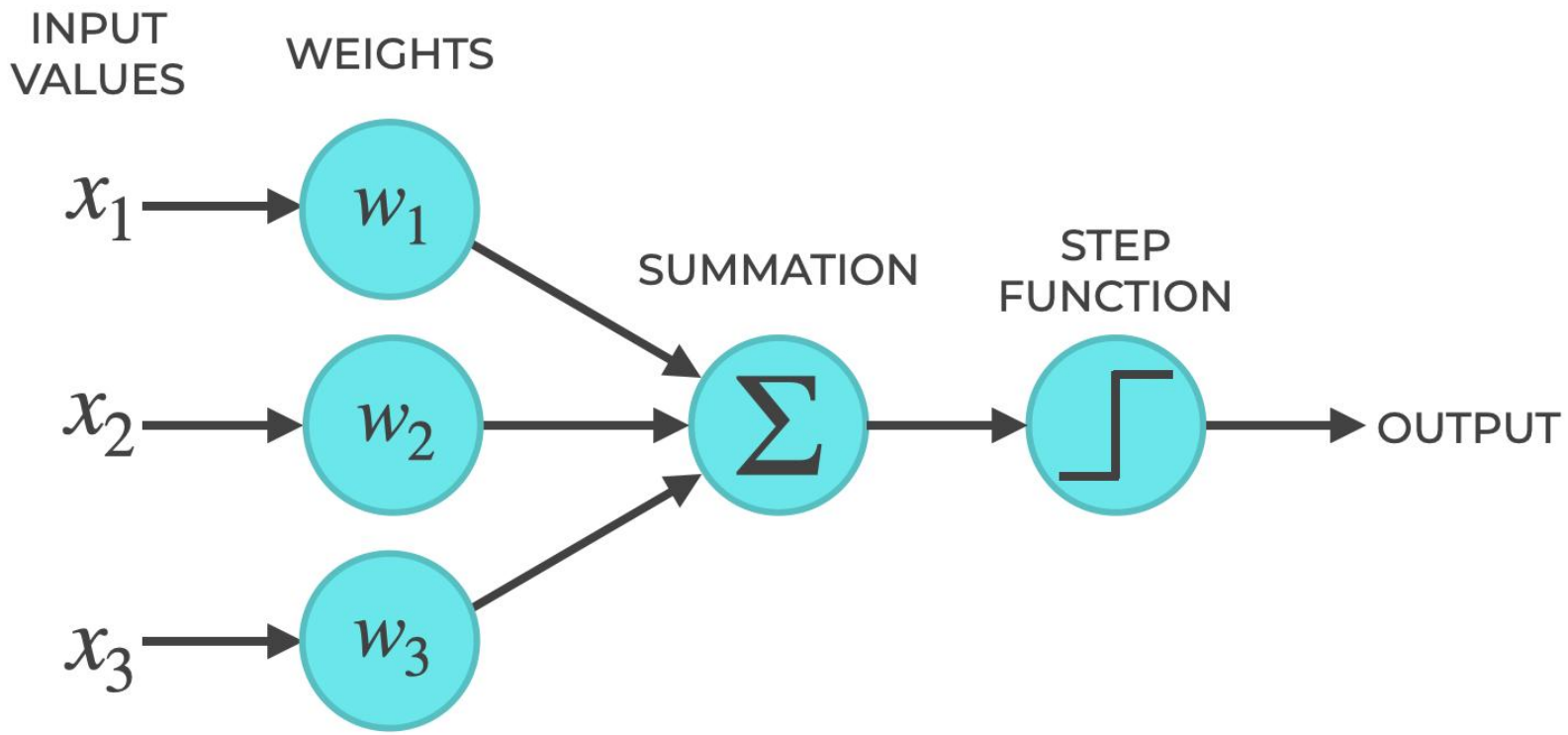
The upcoming algorithm is going to bring up lots of questions!

MLR

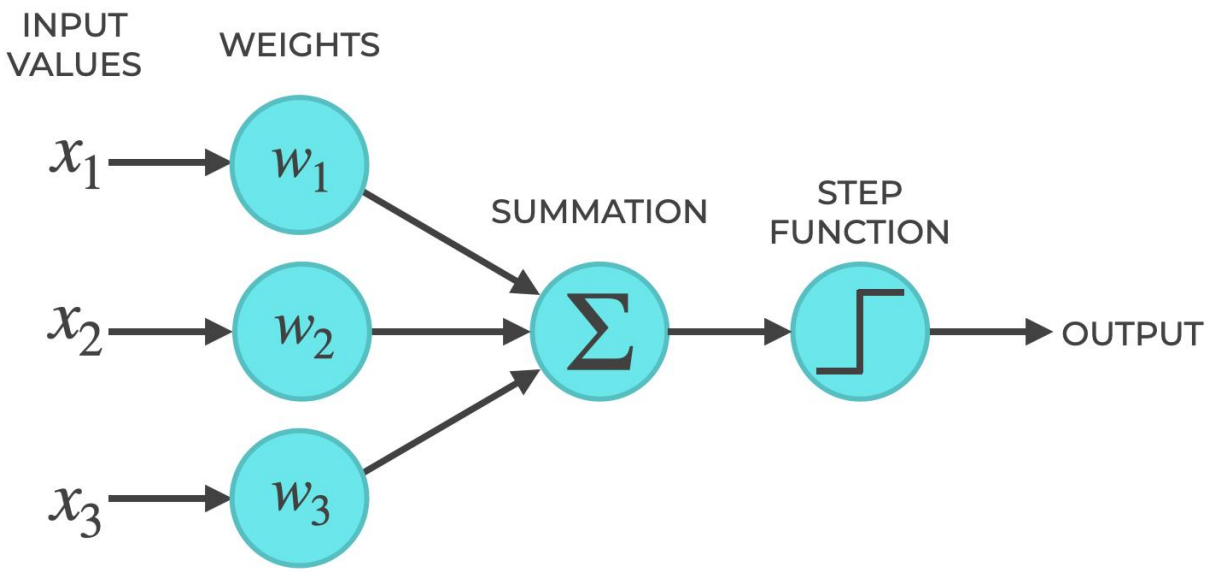


$$y = b_0 + b_1*x_1 + b_2*x_2 + \ldots + b_n*x_n$$

Perceptron Algorithm



Perceptron Algorithm

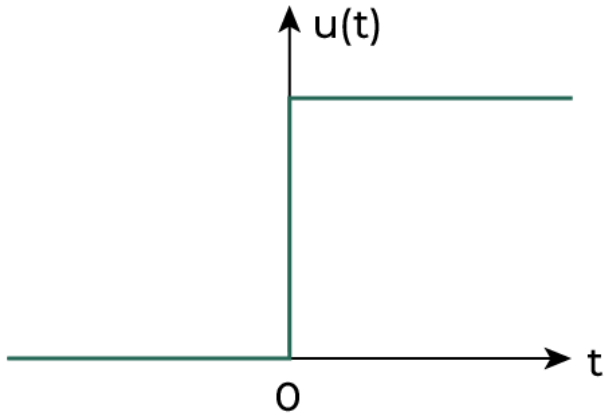


$f(x_0w_0 + x_1w_1 + x_2w_2 + x_3w_3)$

$f(\sum w_i\, x_i)$

$f(net)$

Step Function

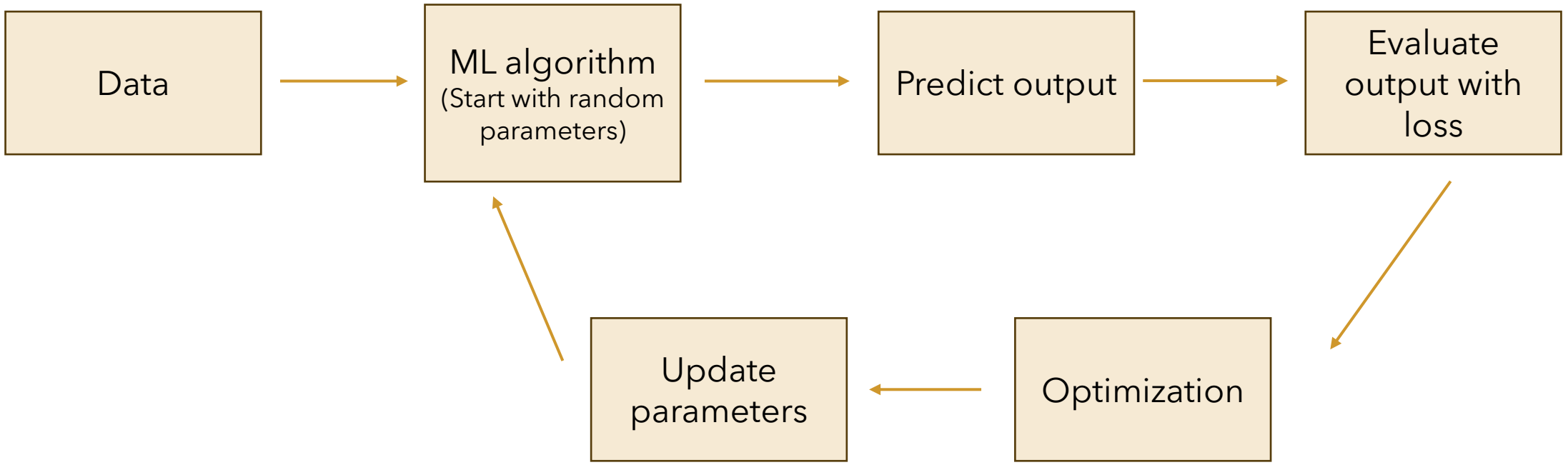


$$u(t) = \begin{cases} 1 & t > 0 \\ 0 & t > 0 \end{cases}$$

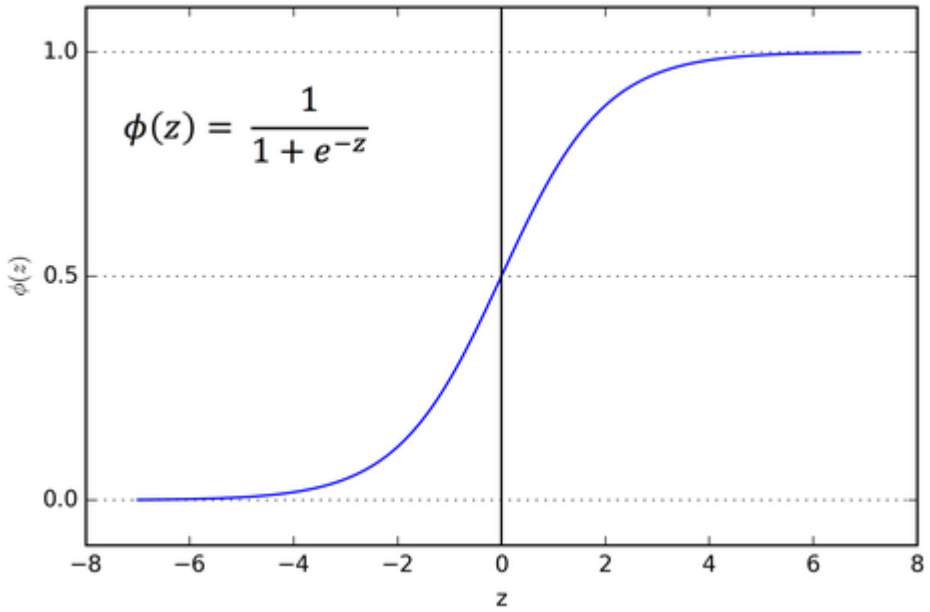
Pros: simple

Cons: no derivates

Framework


Data
ML algorithm
(Start with random parameters)
Predict output
Evaluate output with loss
Optimization
Update parameters

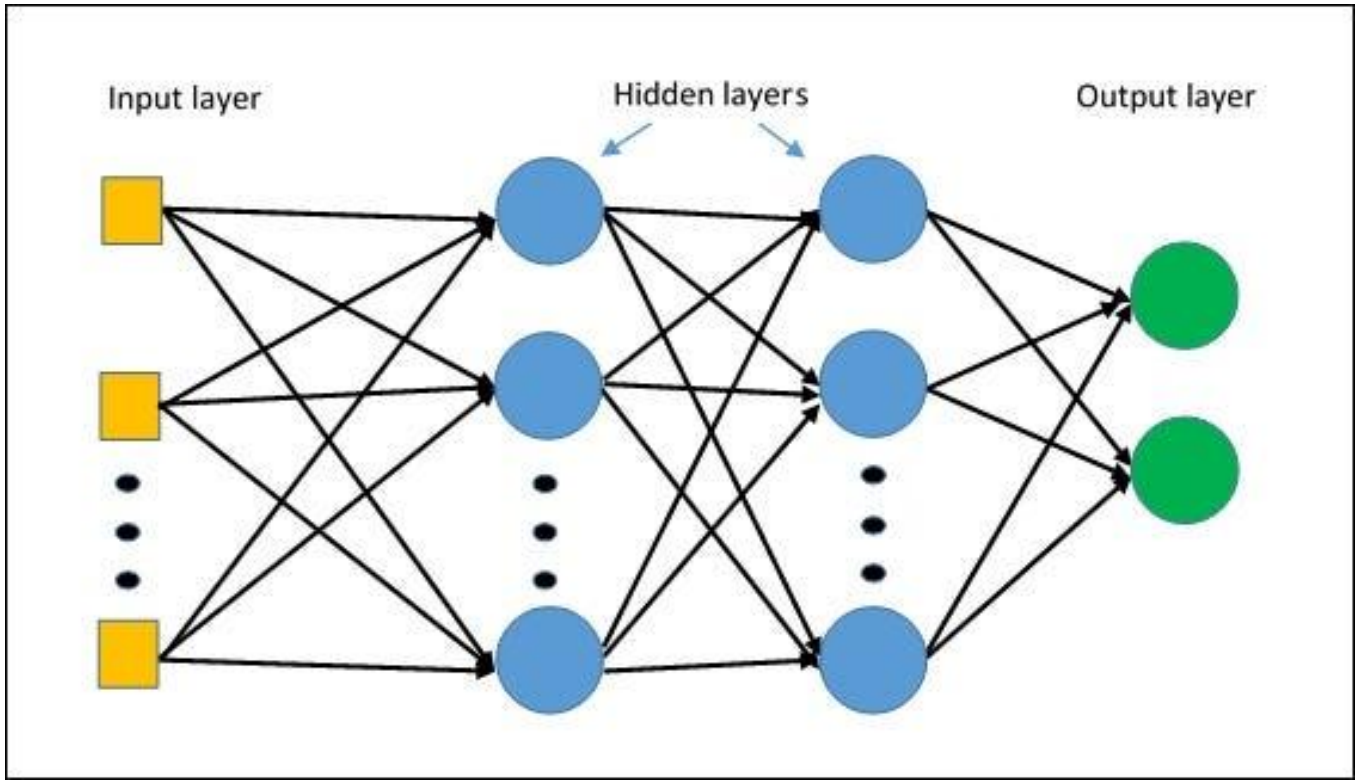
Sigmoid



Pros: derivative at all points

Cons: small derivatives at end points

Multi Layer Perceptron



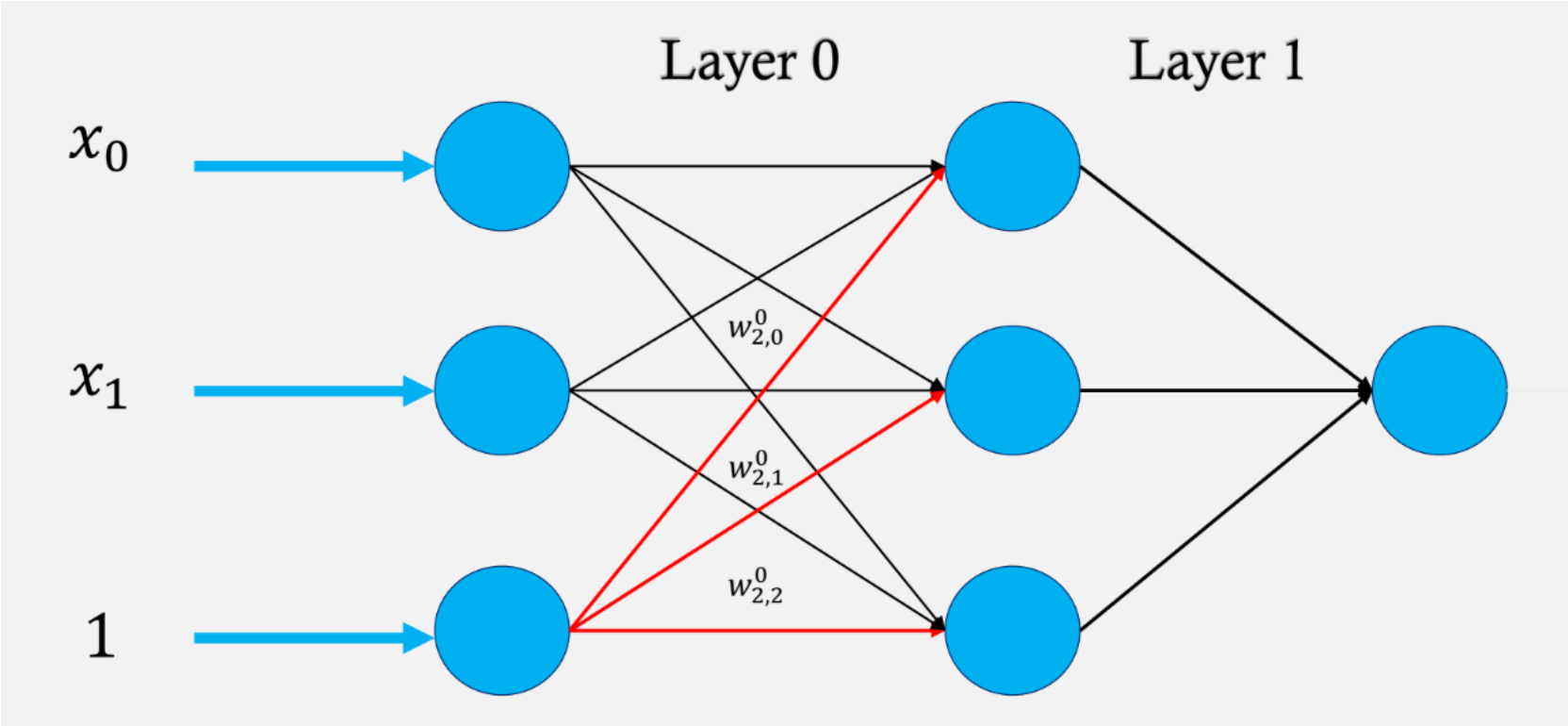
2 main steps

Forward Pass

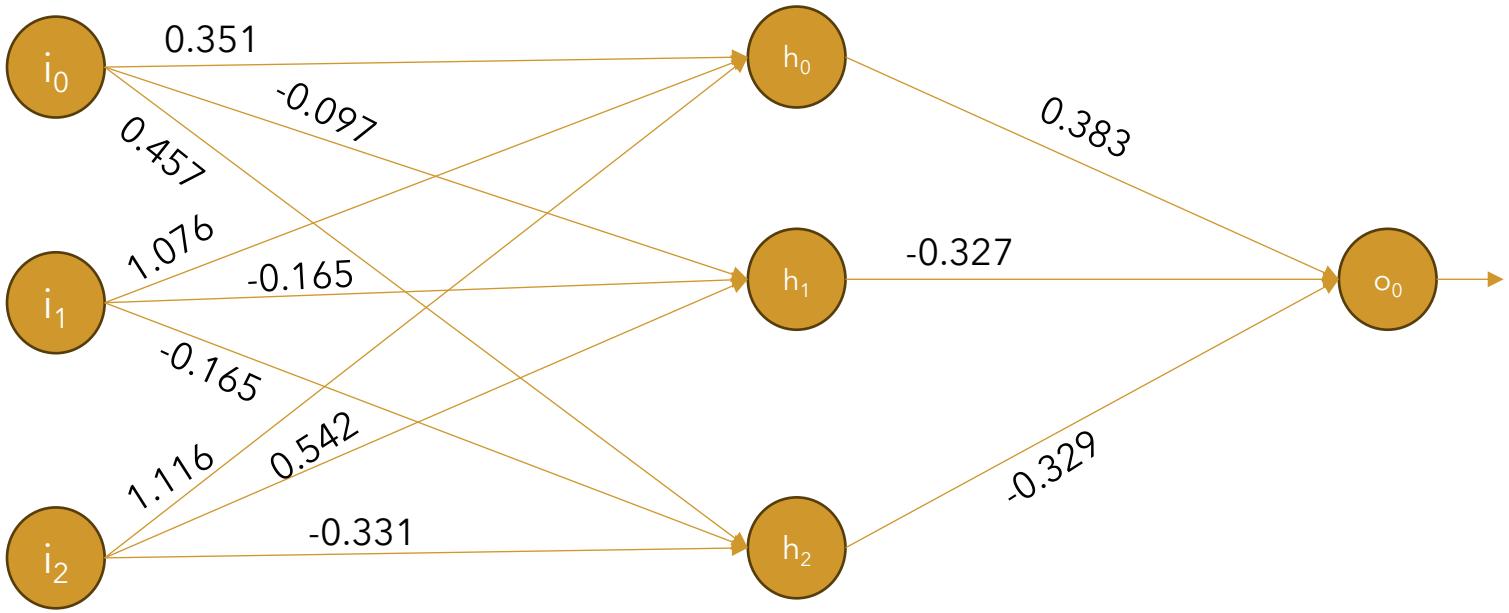
Backward Pass

Forward Pass

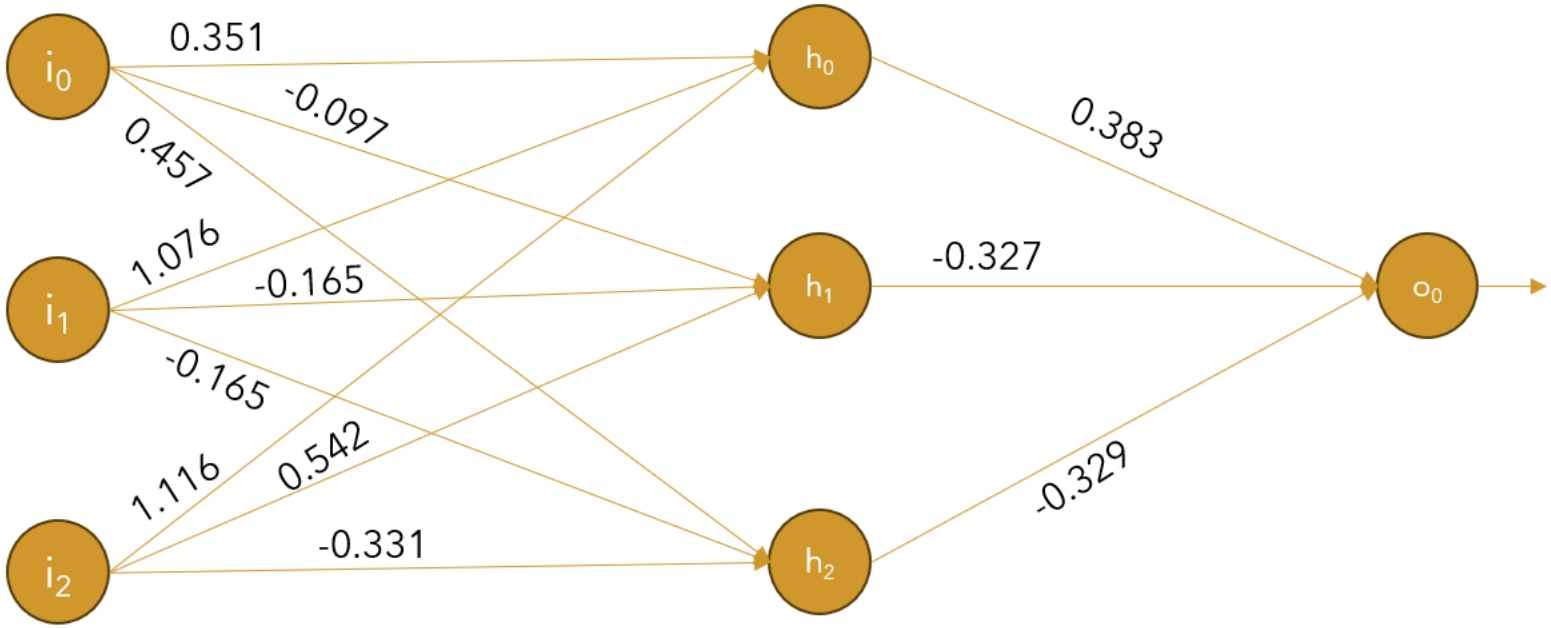
Forward Pass



Example

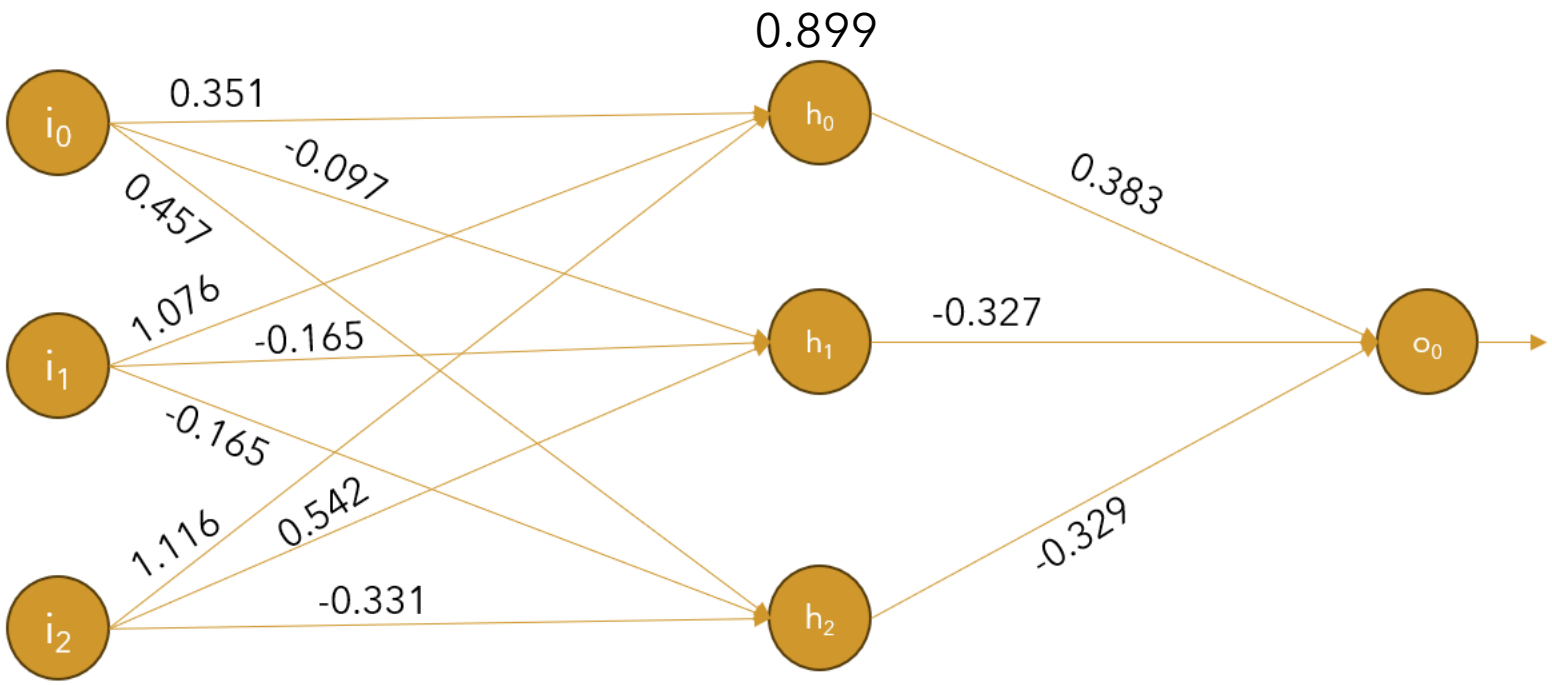

i_0
i_1
i_2
h_0
h_1
h_2
o_0
0.351
-0.097
0.457
1.076
-0.165
-0.165
1.116
0.542
-0.331
0.383
-0.327
-0.329

Example



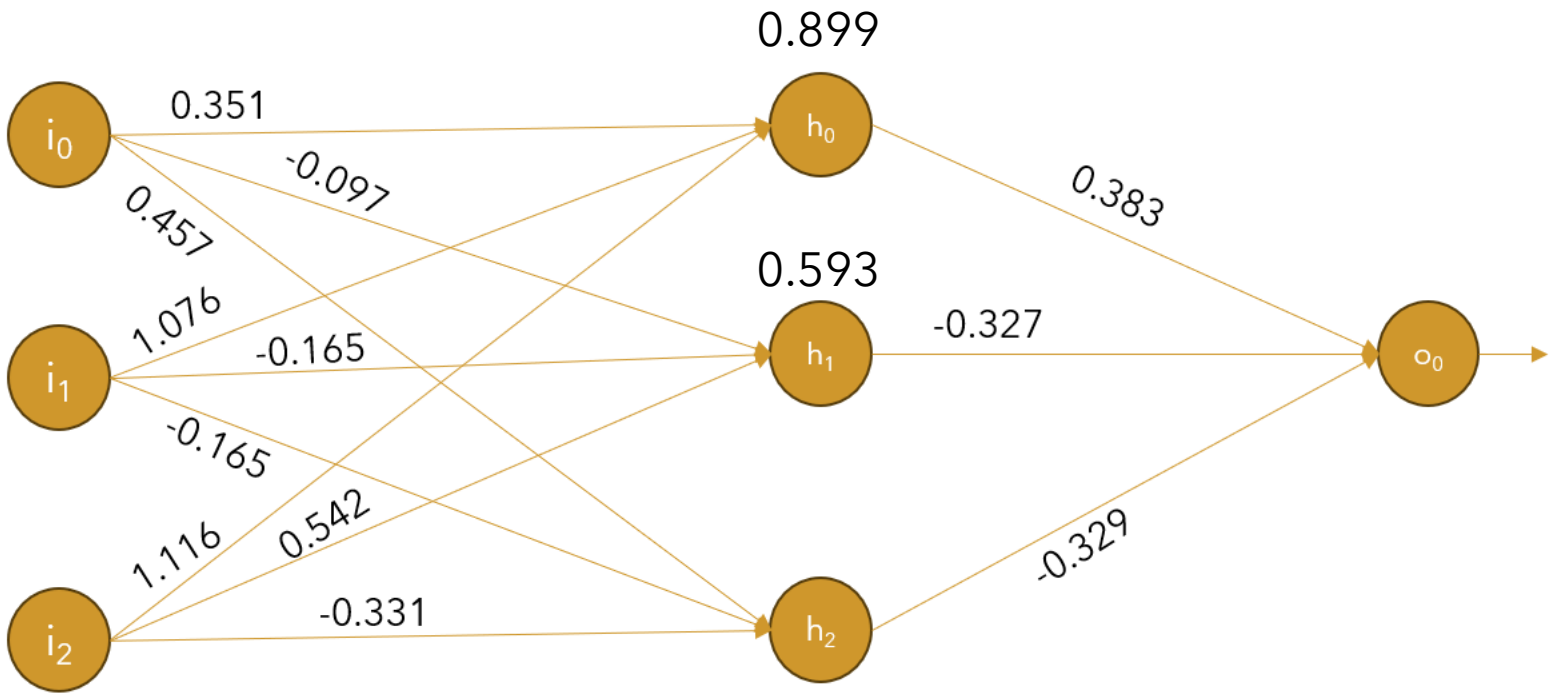
$$h_0 = 0(0.351) + 1(1.076) + 1(1.116) = 2.192$$

Example

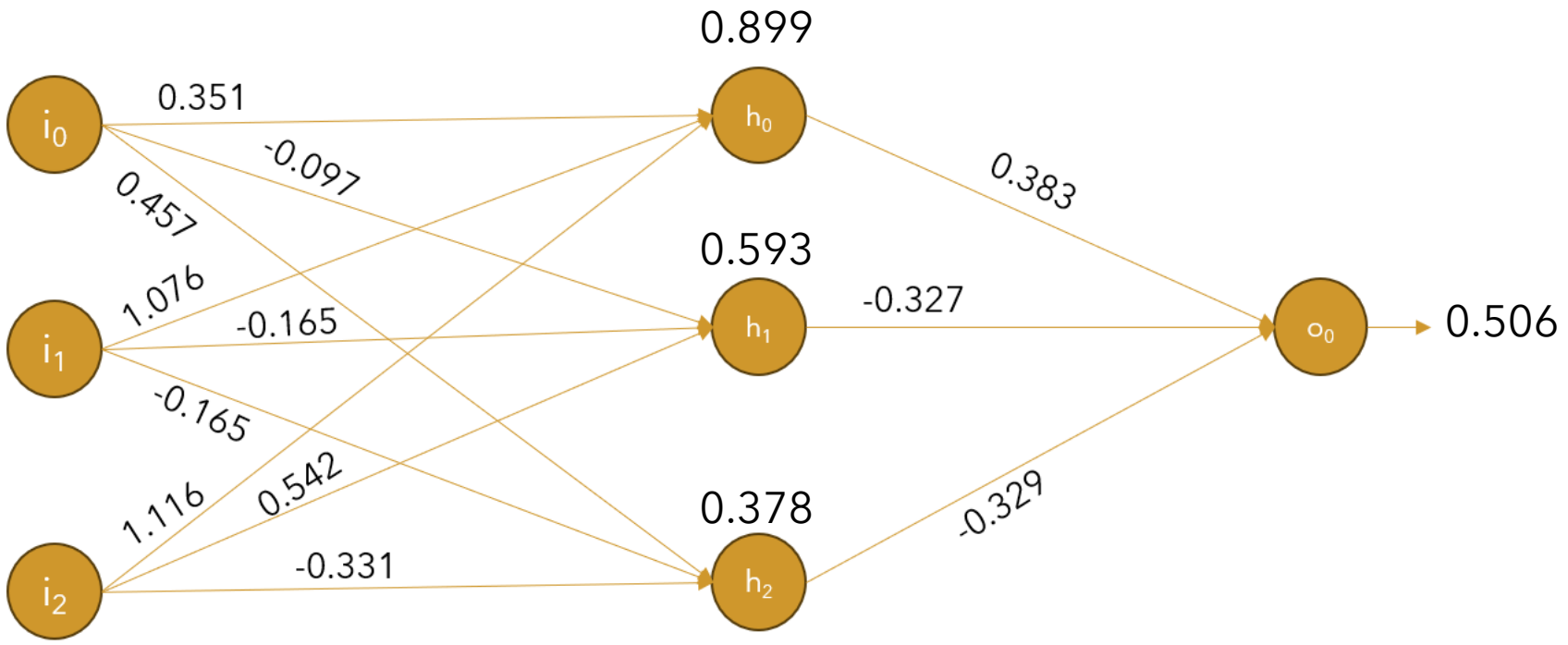


$$\frac{1}{1 + e^{-2.192}} = 0.899$$

Exmaple

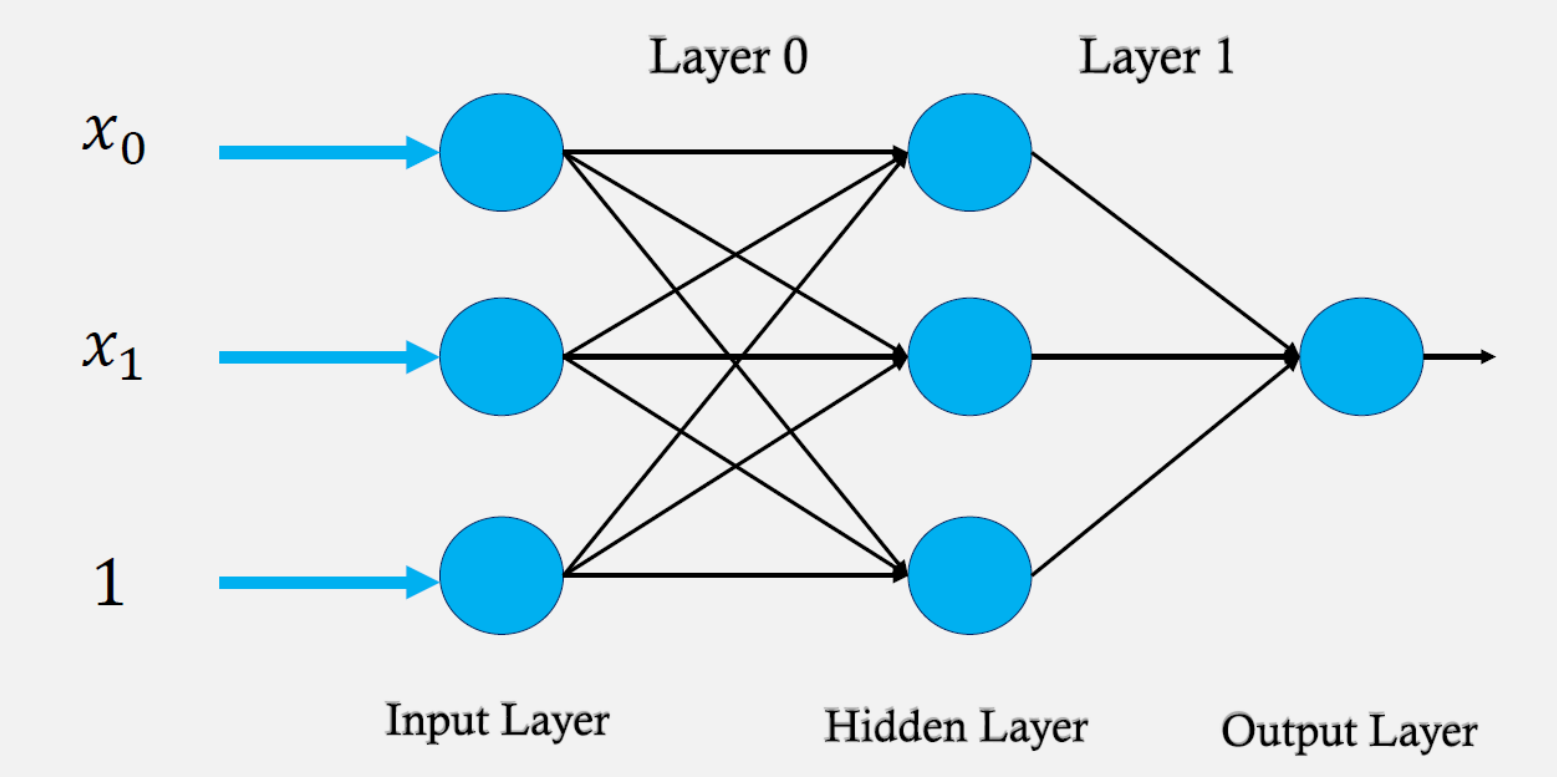

0.899
0.593
i0
i1
i2
h0
h1
h2
o0
0.351
-0.097
0.457
1.076
-0.165
-0.165
1.116
0.542
-0.331
0.383
-0.327
-0.329

Exmaple


0.899
0.593
0.378
i0
i1
i2
h0
h1
h2
o0
0.351
-0.097
0.457
1.076
-0.165
-0.165
1.116
0.542
-0.331
0.383
-0.327
-0.329
0.506

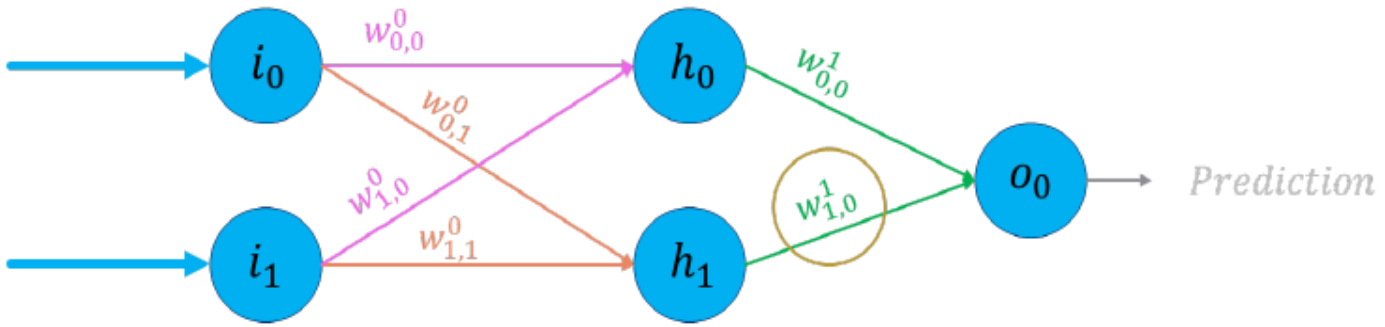
Backward Pass

Backpropagation

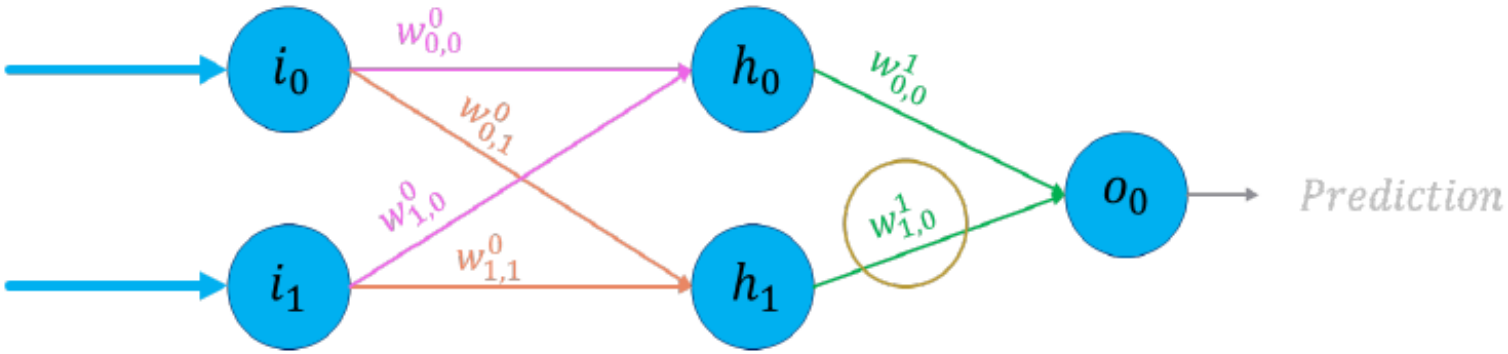


Simpler Backpropagation

For simplicity let's only consider summation and multiplications (no activation or bias)



Backpropagation

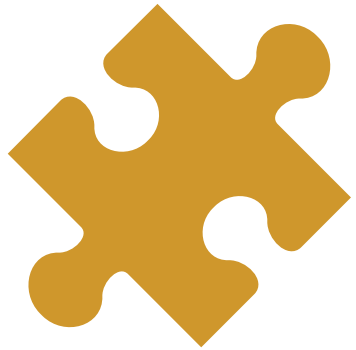


Prediction = $(x_0 w^0_{0,0} + x_0 w^0_{1,0})\, w^1_{0,0} + (x_0 w^0_{0,1} + x_0 w^0_{1,1})\, w^1_{1,0}$

$$\text{Loss} = \frac{(prediction - actual)^2}{2}$$

Goal

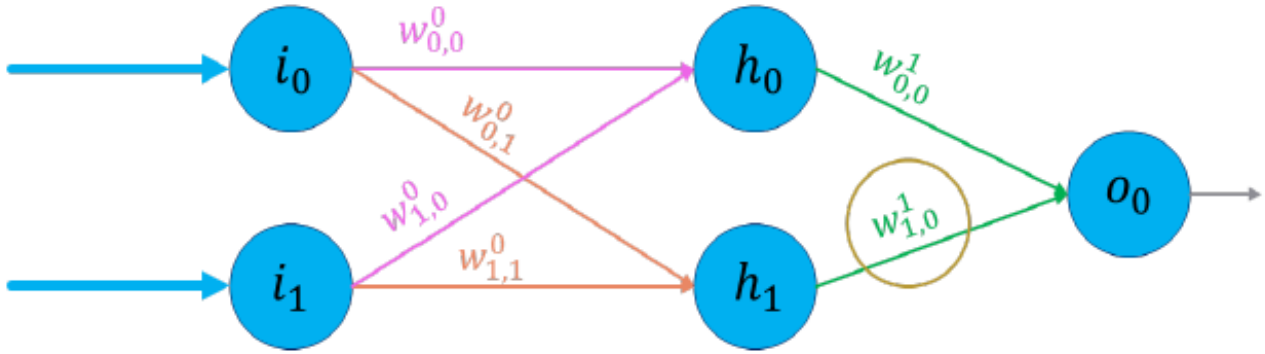
Final goal is to achieve to the best value for parameters



What are the parameters?

Backpropagation

Prediction = $(x_0 w^0_{0,0} + x_0 w^0_{1,0})\, w^1_{0,0} + (x_0 w^0_{0,1} + x_0 w^0_{1,1})\, w^1_{1,0}$

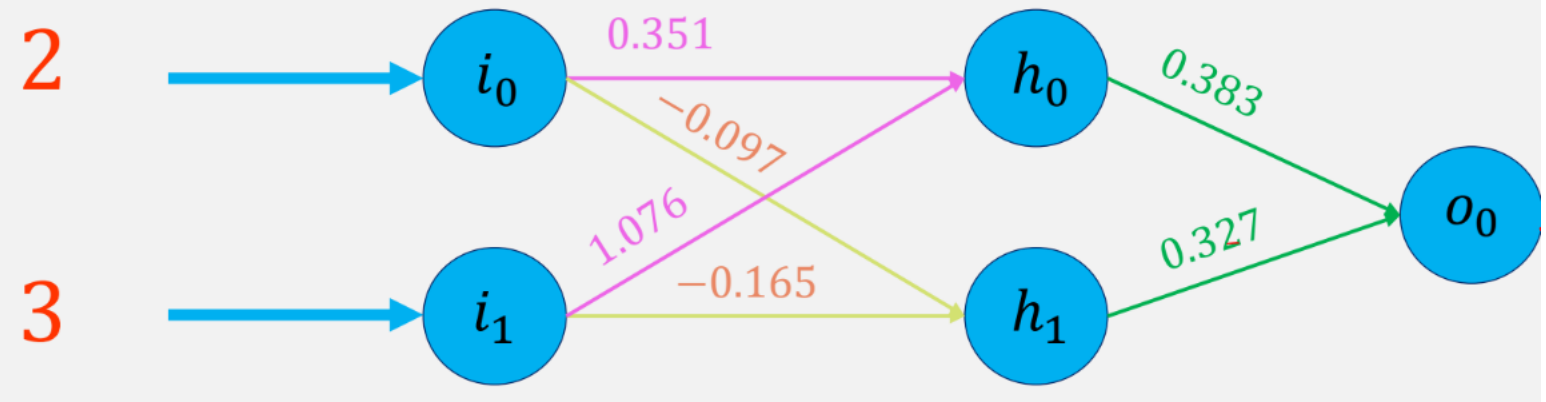


$$\text{Loss} = \frac{(prediction - actual)^2}{2}$$

$$\frac{\partial loss}{\partial w^1_{1,0}} = \frac{\partial loss}{\partial Prediction} \times \frac{\partial Prediction}{\partial w^1_{1,0}}$$

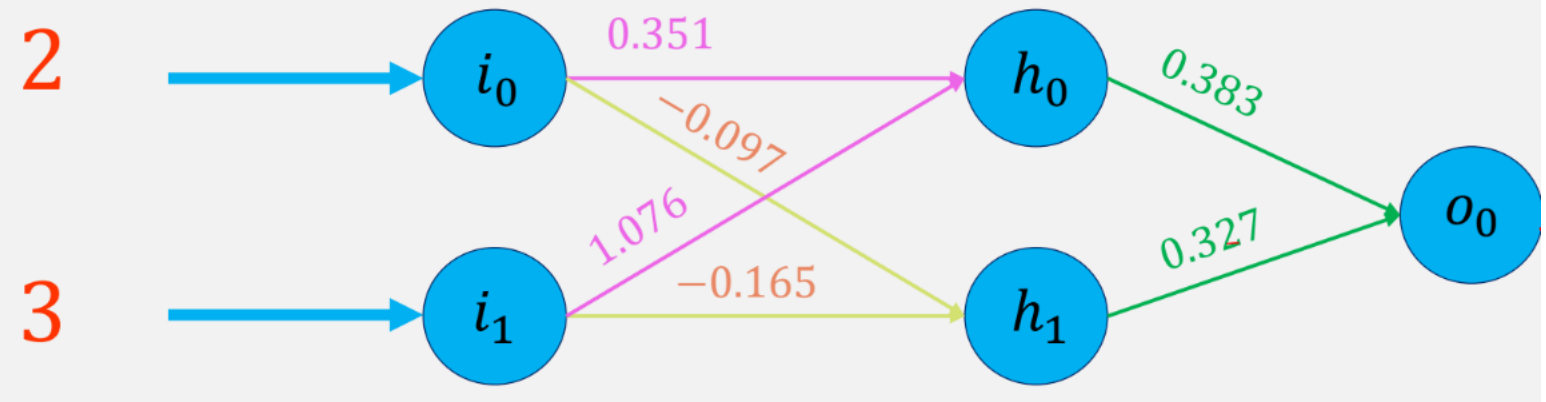
Example

$$\frac{\partial loss}{\partial w_{1,0}^{1}} = \frac{\partial loss}{\partial Prediction} \times \frac{\partial Prediction}{\partial w_{1,0}^{1}}$$

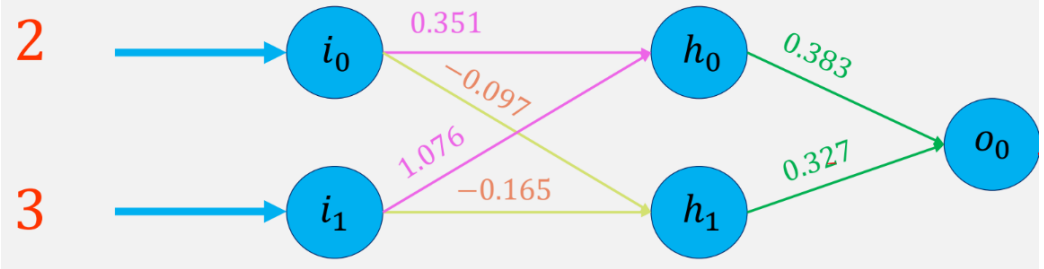


Example

$$\frac{\partial loss}{\partial w^1_{1,0}} = \frac{\partial loss}{\partial Prediction} \times \frac{\partial Prediction}{\partial w^1_{1,0}}$$



$$Prediction = (2 \times 0.351 + 3 \times 1.076)\,0.383 + (2 \times -0.097 + 3 \times -0.165)\,0.327 = 1.730$$



$$\frac{\partial loss}{\partial w^1_{1,0}} = \frac{\partial loss}{\partial Prediction} \times \frac{\partial Prediction}{\partial w^1_{1,0}}$$

$$\Delta = Prediction - actual = 1.730 - 1 = 0.730$$

$$h_1 = -0.097*2 - 3*0.165 = -0.689$$

$$\frac{\partial Error}{\partial w^1_{1,0}} = \frac{\partial Error}{\partial Prediction} \times \frac{\partial Prediction}{\partial w^1_{1,0}} \Rightarrow \Delta h_1$$

$$\frac{\partial Error}{\partial w^1_{1,0}} = (0.730) \times (-0.689) = \boxed{-0.502}$$

$$\frac{\partial Error}{\partial w_{1,0}^{1}} = \frac{\partial Error}{\partial Prediction} \times \frac{\partial Prediction}{\partial w_{1,0}^{1}} \Rightarrow \Delta h_1$$

$$\frac{\partial Error}{\partial w_{1,0}^{1}} = (0.730) \times (-0.689) = \boxed{-0.502}$$

$$w^{+} = w^{-} - \alpha \frac{\partial L}{\partial w}$$

$$w_{1,0_{new}}^{1} = 0.327 - (-0.502) = 0.829$$

Updated Weight