

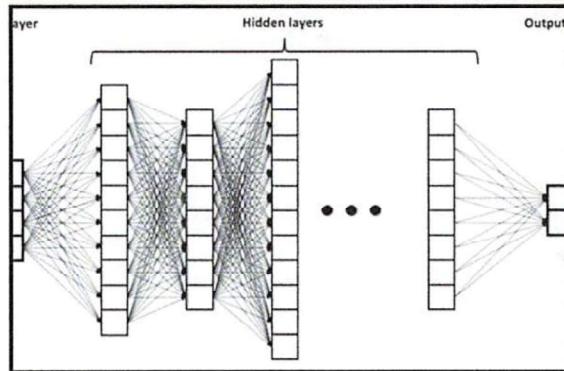
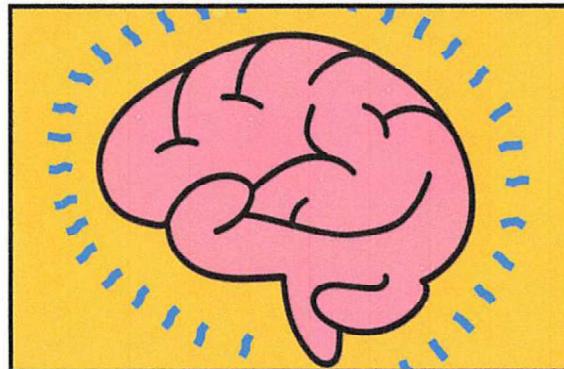
Introduction to Artificial Neural Networks

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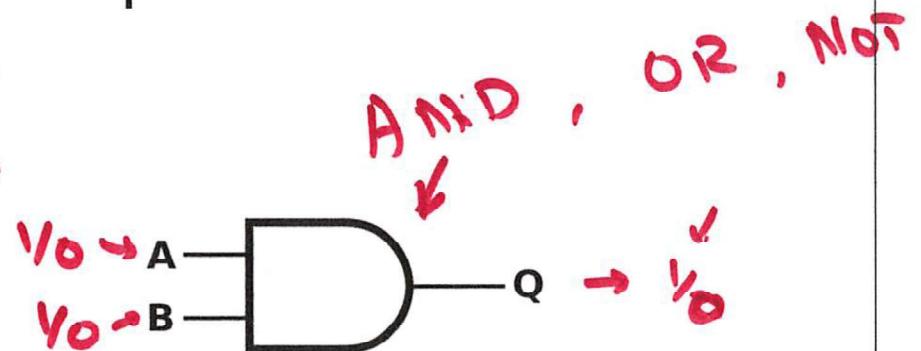
Agenda

- Introduction
- Perceptron
- Multi Layer Perceptron 
- An Example - MNIST 
- Training
 - Gradient Descent
 - Local vs Global
 - Back Propagation
- Other
 - Activation functions  $\sigma =$
 - Loss functions  $L =$

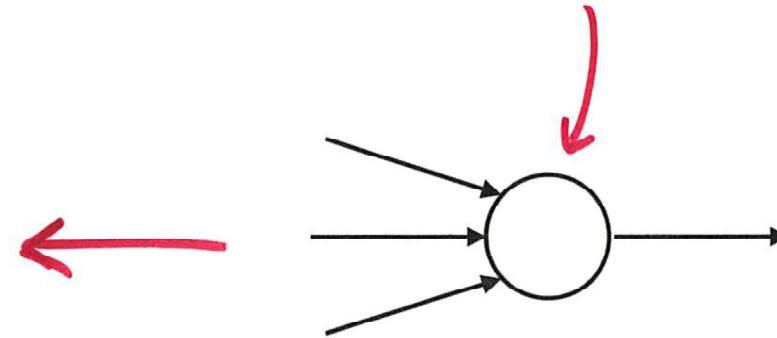
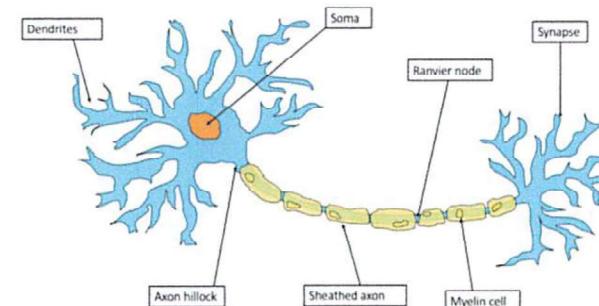
Building towards a complex task!



$11 \rightarrow 1$
 $\{0\} \rightarrow 0$
 $01 \rightarrow 0$
 $00 \rightarrow 0$



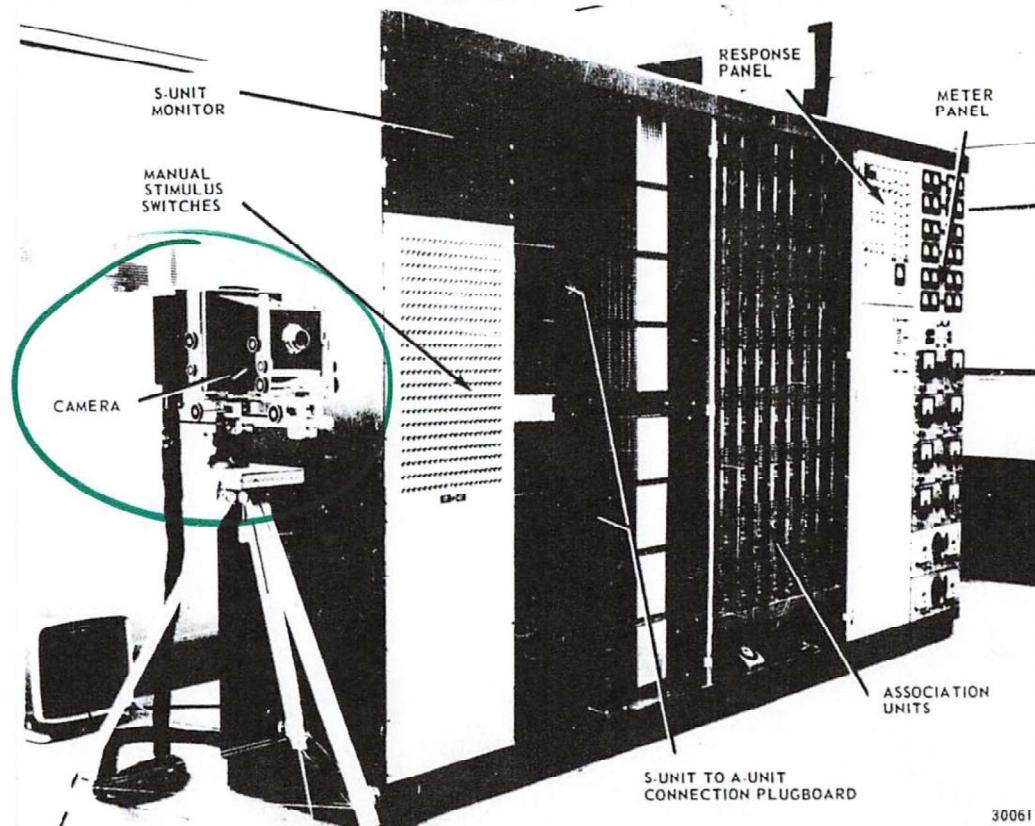
~~86 B~~



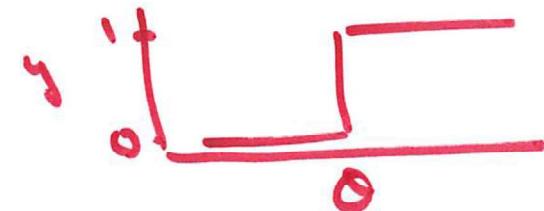
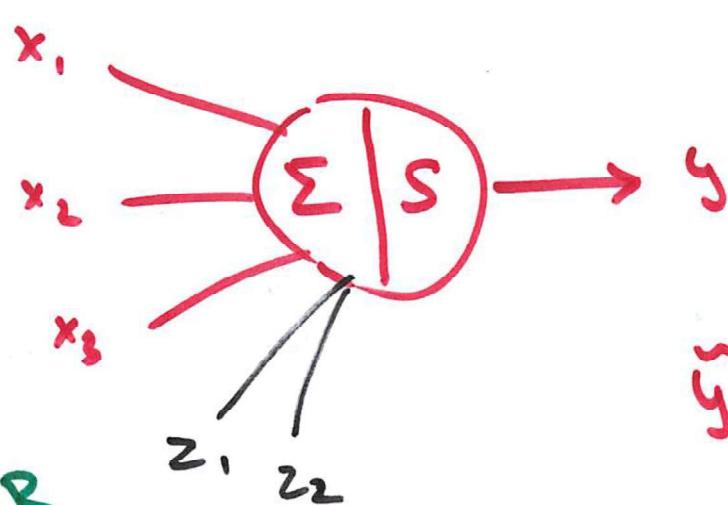
History

- McCulloch-Pitts Neuron, 1940
- "the embryo of an electronic computer that [the Navy] expects will be able to walk, talk, see, write, reproduce itself and be conscious of its existence." - Rosenblatt, 1958

MARK I
Perception machine



MP



$$\tilde{y} = \begin{cases} 1 & \text{if } \sum x_i \geq 0 \\ 0 & \text{if } \sum x_i < 0 \end{cases}$$

~~AND, OR~~

$0=3 \rightarrow \text{'and'}$
 $0=1 \rightarrow \text{'or'}$

NOT

$$y = \begin{cases} \tilde{y} & \text{only if all } z_i = 0 \\ 0 & \text{if any } z_i = 1 \end{cases}$$

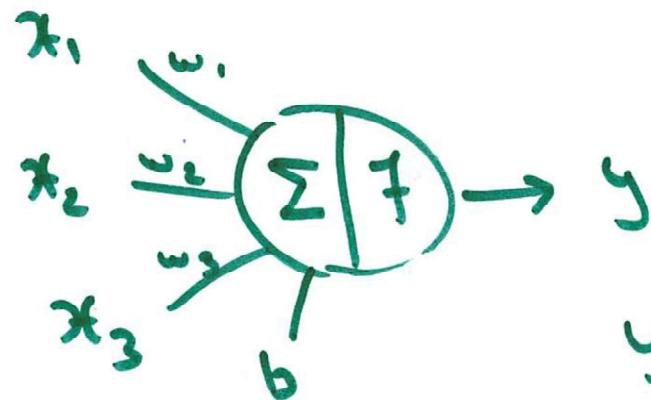
Perceptron!

5

$$y = \text{f}(\sum x_i w_i)$$

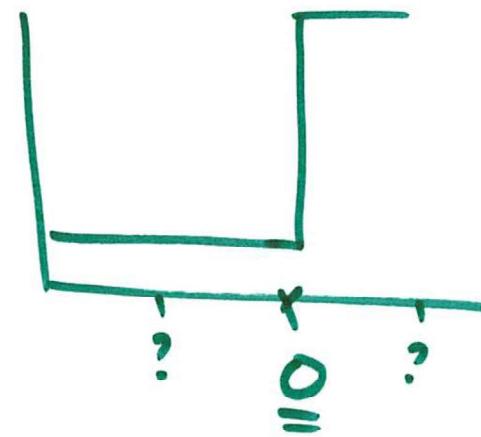
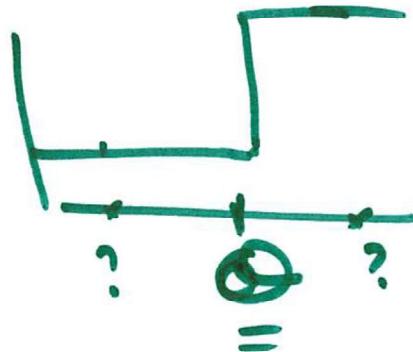
- What does it do?

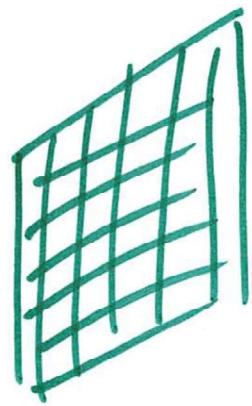
1958



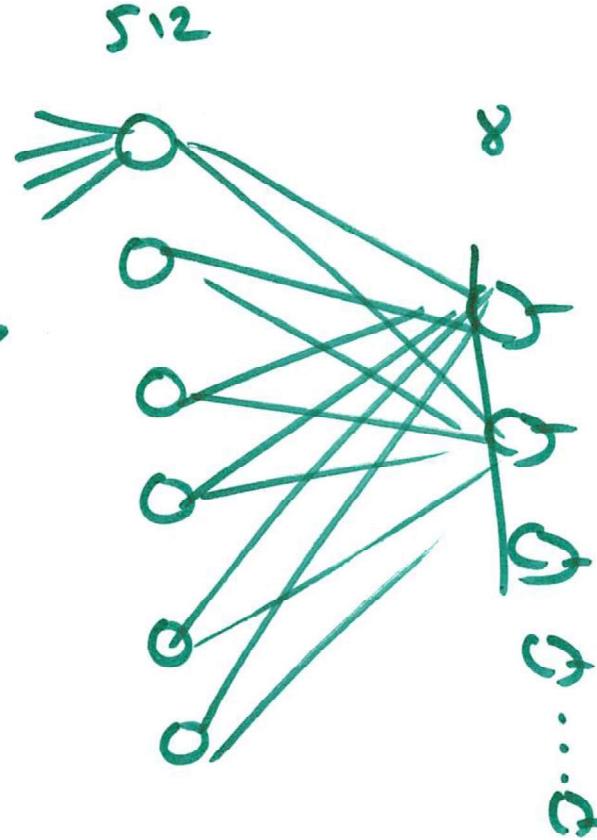
$$y = f(\sum x_i w_i + b)$$

- Bias

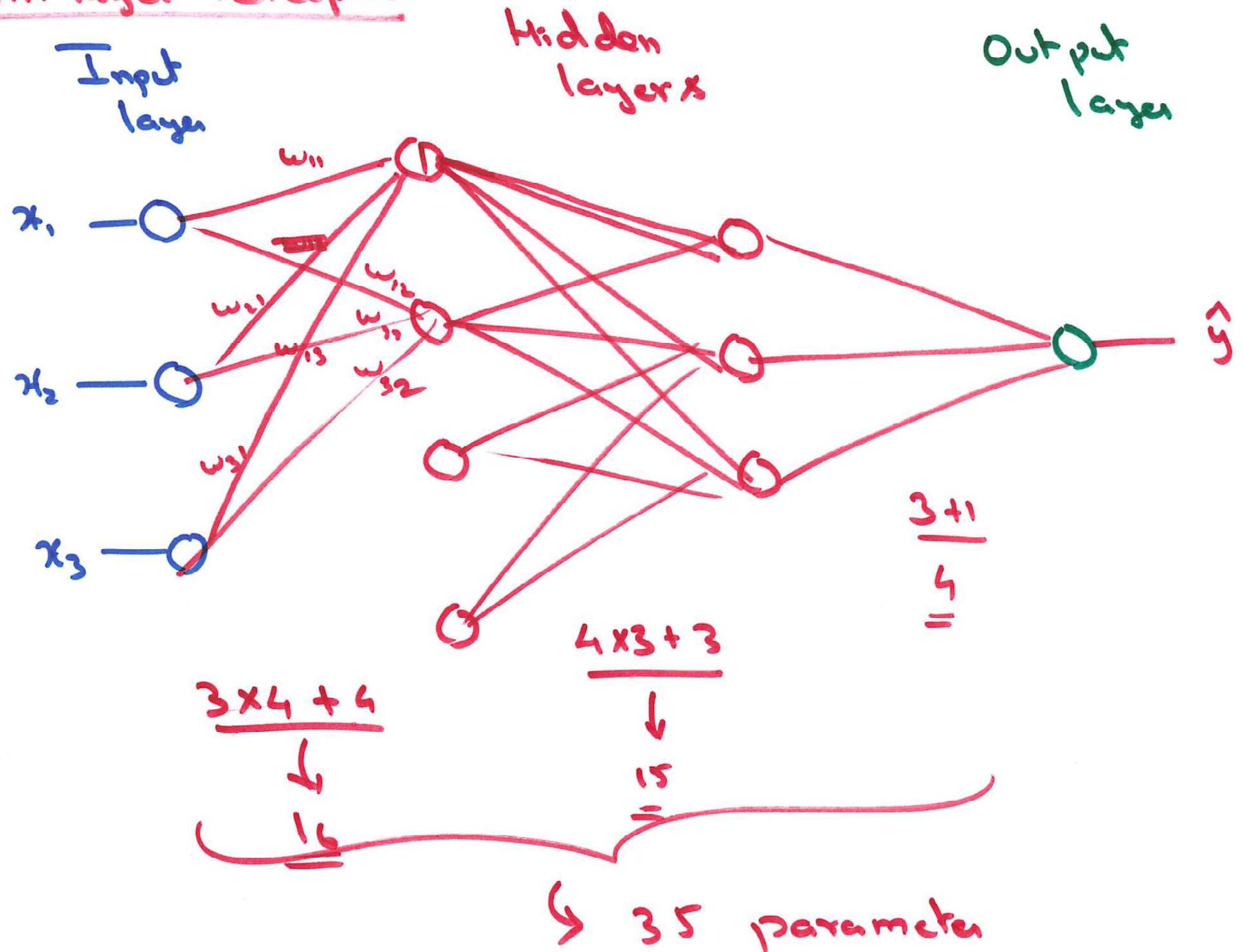


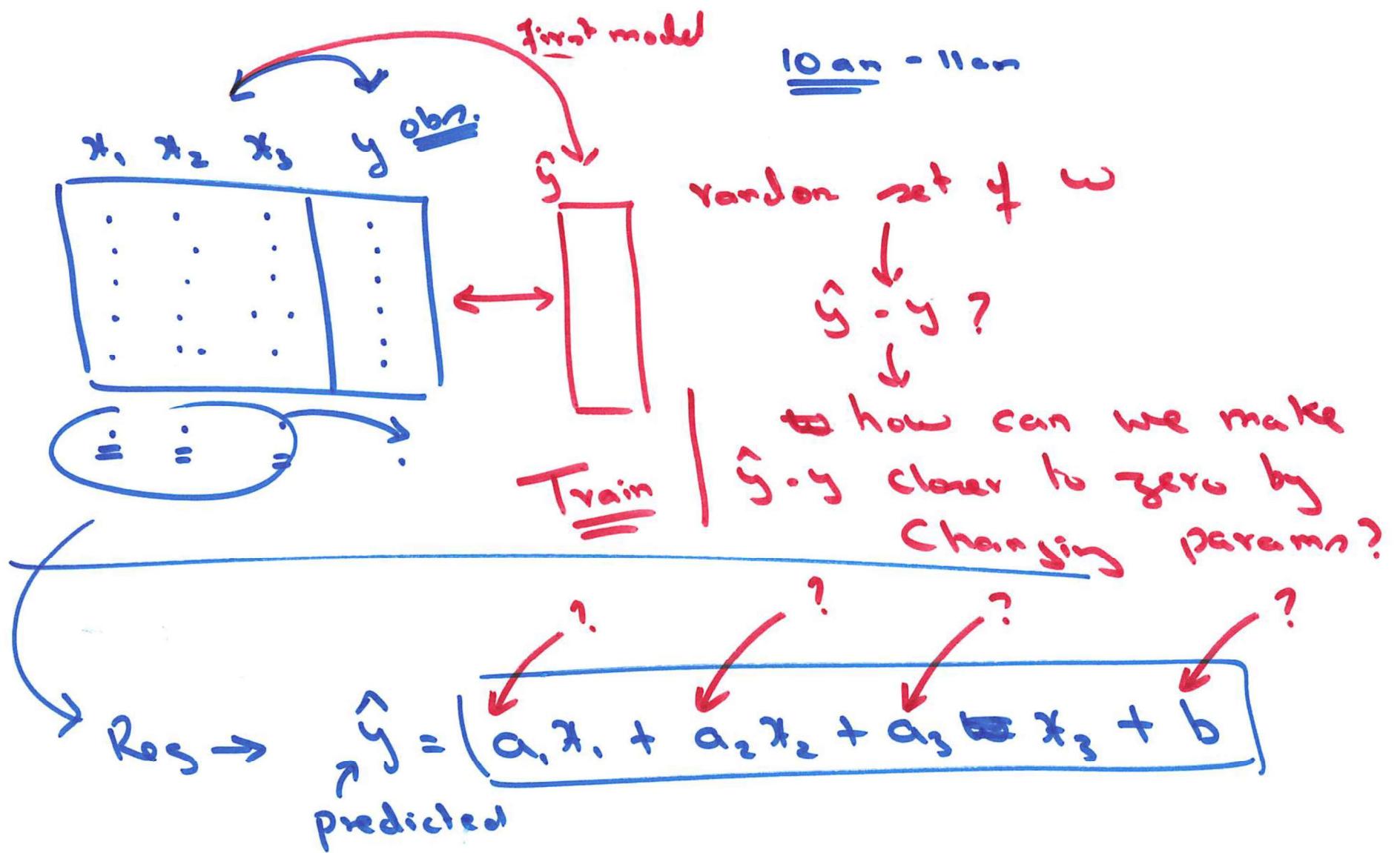


20×20



Multi layer Perceptron





An Example

5 0 4 1 9 2 1 3 1 4
=

M NIST

database

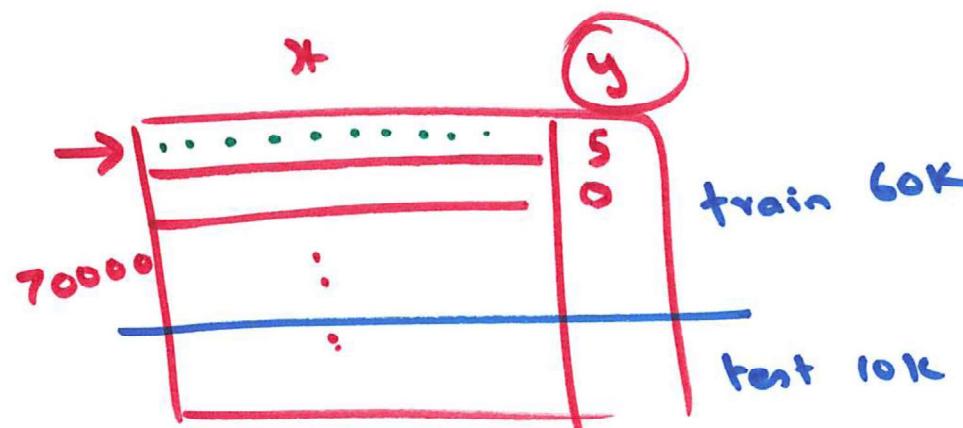
70000

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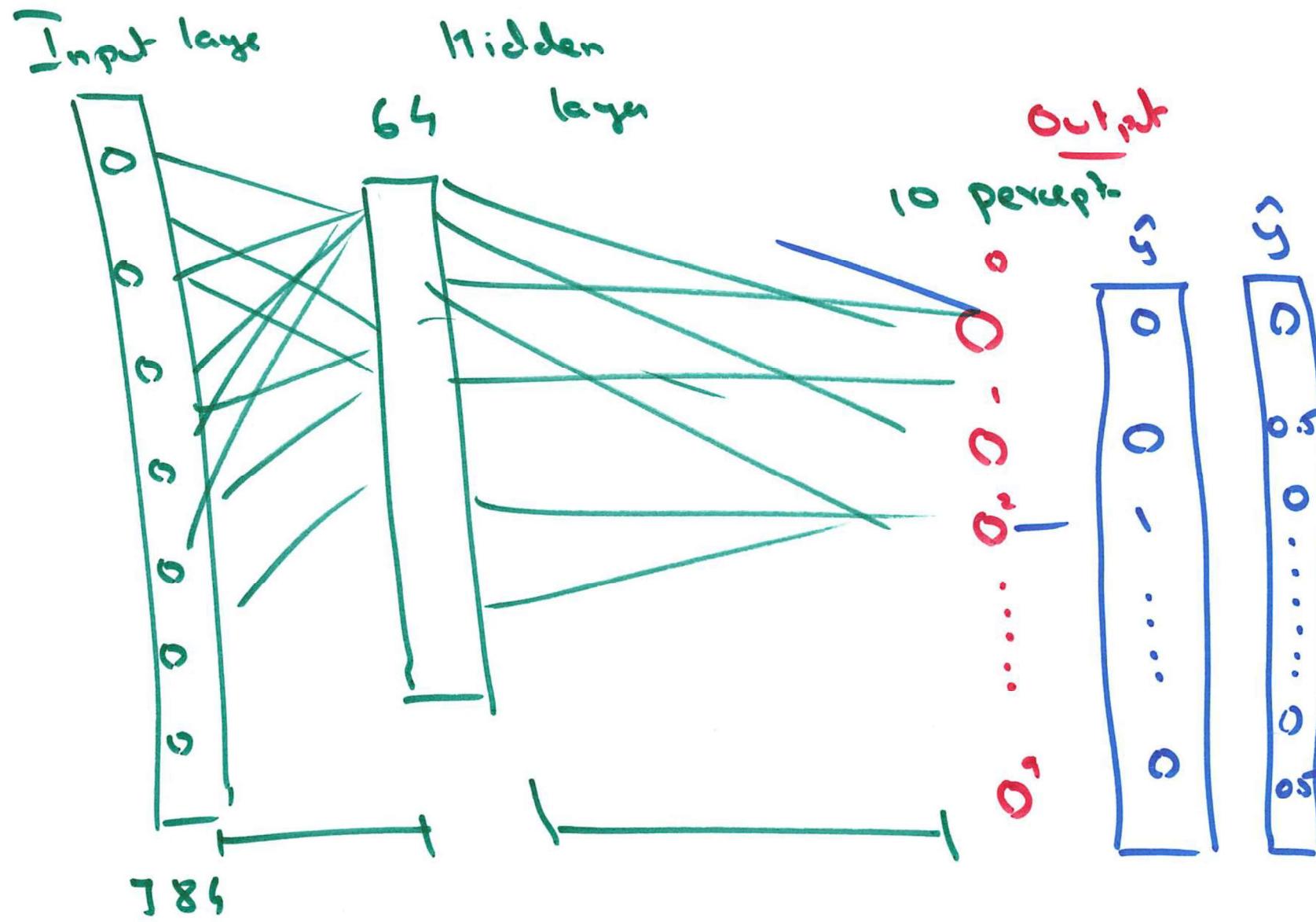


$$28 \times 28 = 784$$

Classification

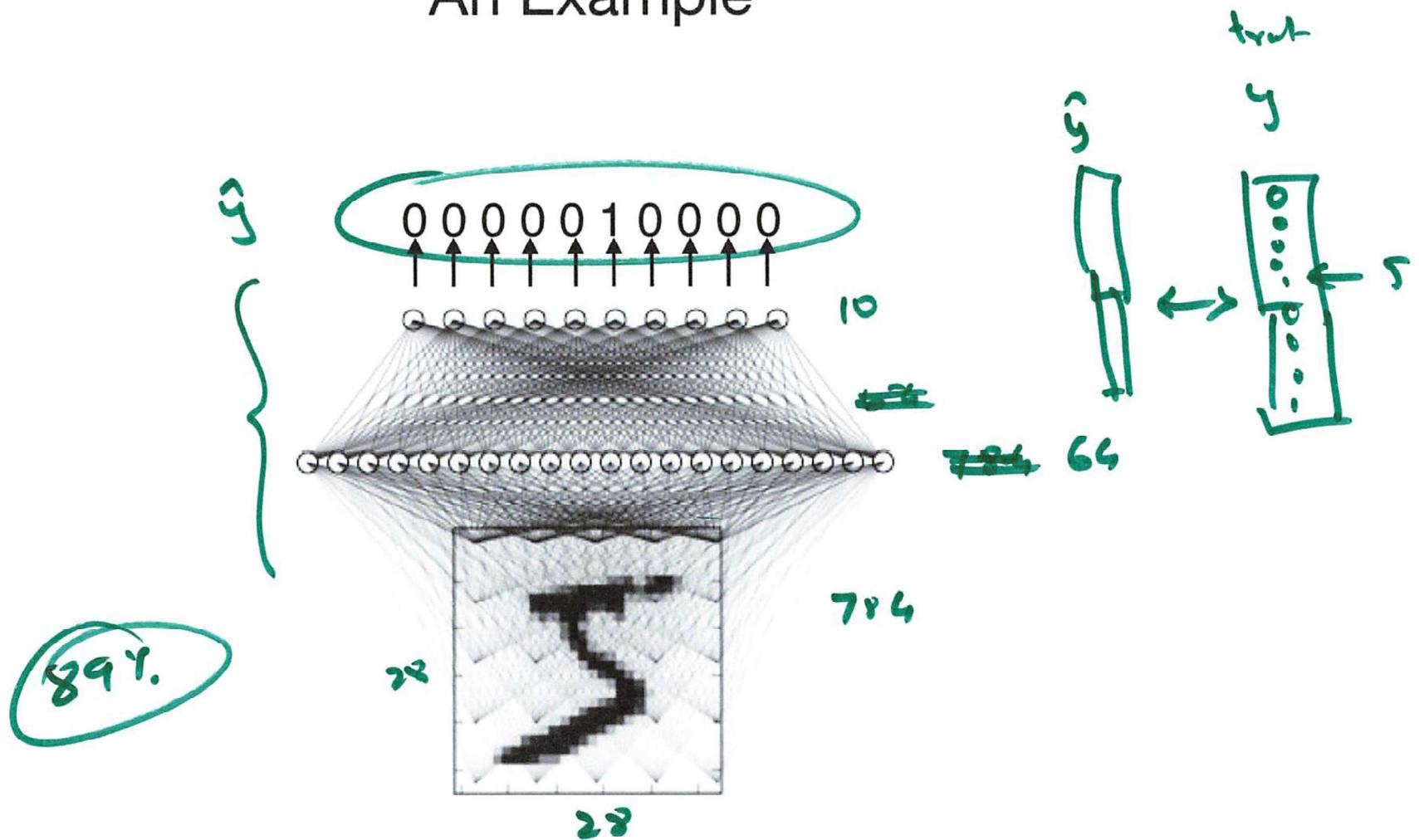


9



$$(784 \times 64 + 64) + ((64 \times 10) + 10) = \underline{\underline{50890}}$$

An Example



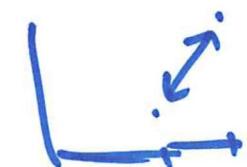
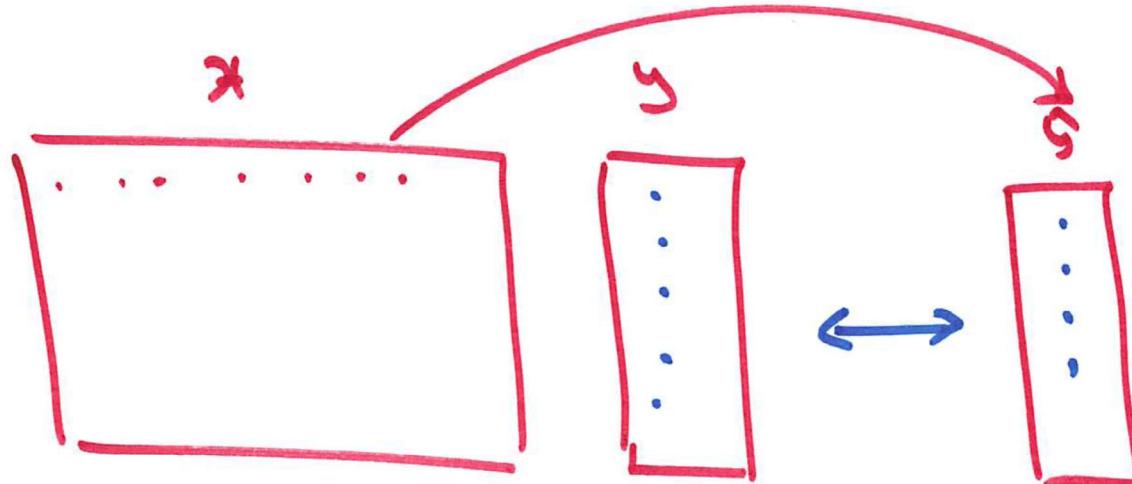
Activation Function

$$\sigma()$$

$$f()$$

$$(z_i = \sigma(\sum w_i x_i + b))$$

$$f(f(f(\dots)))$$



$$\hat{y} = w_1 x_1 + w_2 x_2 + w_3 x_3 + b$$

how far are \hat{y} & y ?

$$\frac{1}{N} \sum_i (y_i - \hat{y}_i)^2$$

Loss Function

$$\frac{1}{N} \sum_i |y_i - \hat{y}_i|$$

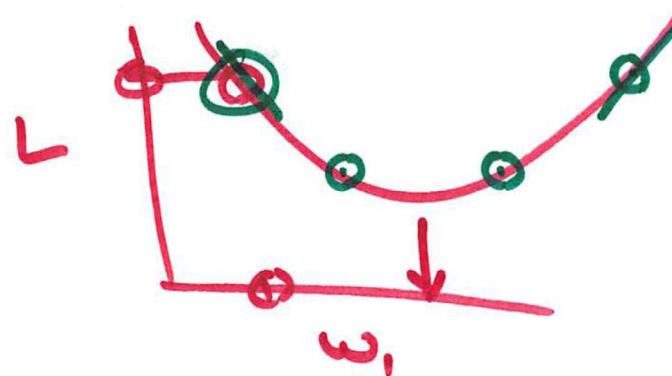


Training

$$\min \sum (\hat{y}_i - y_i)^2 \text{ by changing } w_1, w_2, w_3, b$$



$$\min \sum_i ((w_1 x_{1i} + w_2 x_{2i} + w_3 x_{3i} + b) - y_i)^2 = L(w, b) \text{ by changing } w_1, w_2, w_3, b$$

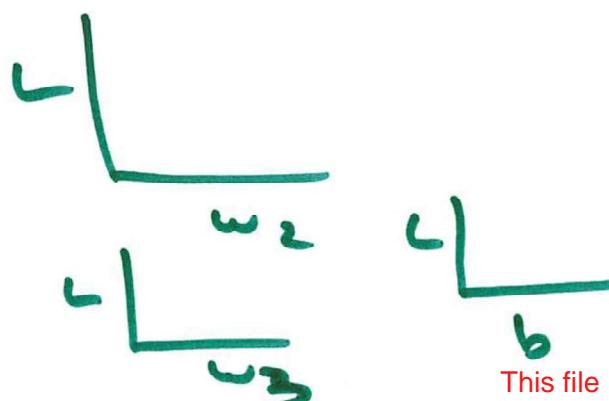


if Slope ~~↓~~ Neg then more $w_1 \rightarrow$
 if Slope ~~↑~~ Pos then more $w_1 \leftarrow$

$$w_i^{new} = w_i^{old} - \eta \text{ (slope day } w_i \text{)}$$

↑ learning rate

Gradient Descent



$$\omega^{\text{new}} = \omega^{\text{old}} - \eta \frac{\nabla \omega}{\|\nabla \omega\|}$$

vector of slopes

