



Deep Learning Workshop

Pepe Bonet Giner

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- Topic 5: Types of Neural Networks and their applications.
- Topic 6: How Deep Learning is changing /will change the world?

Who am I?



UNIVERSITAT
POLITÈCNICA
DE VALÈNCIA



Maastricht
University



B.Sc. Biotechnology

M.Sc.
Computational Biology



Universitat
Pompeu Fabra
Barcelona

ETH zürich



P.hD. @ BbgLab
Computational Biology
EMIBA



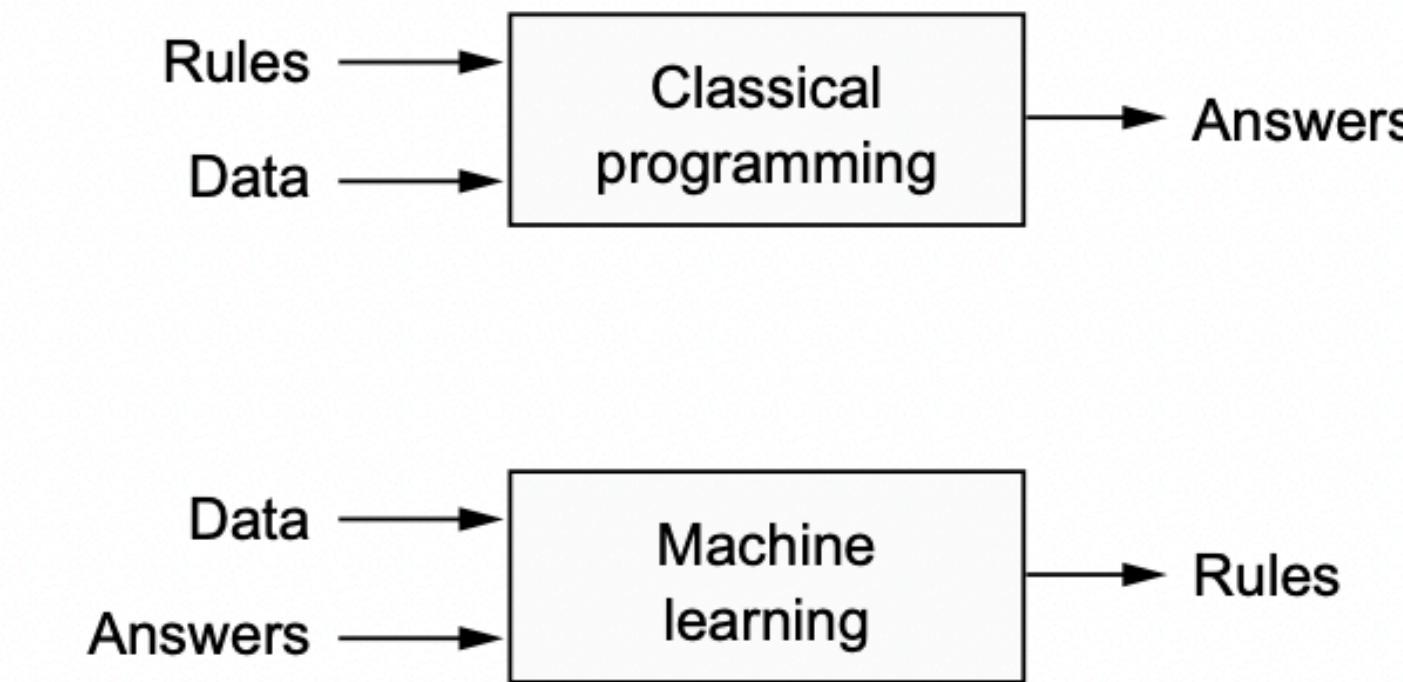
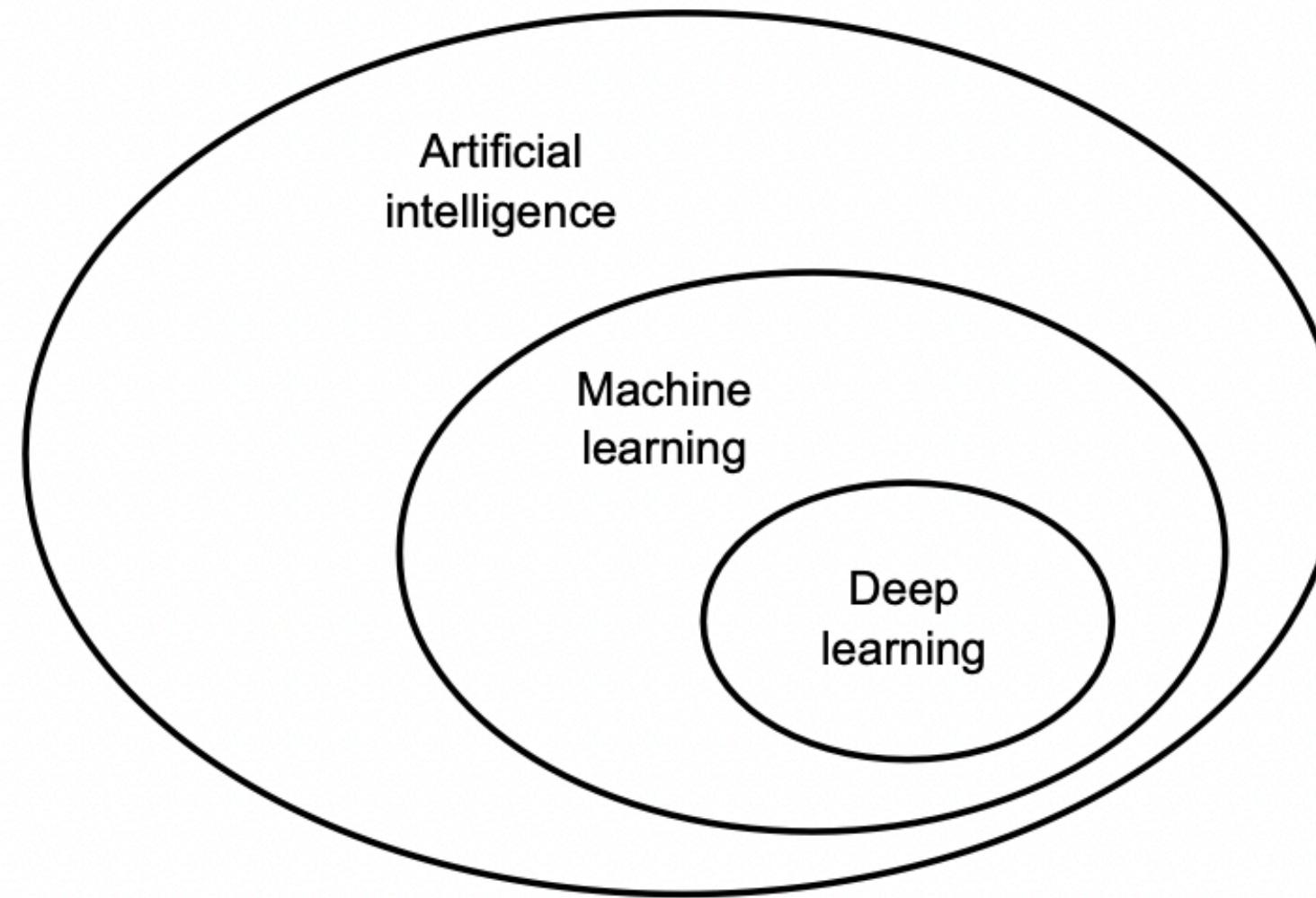
hynts

Hynts Analytics



What is Deep Learning?

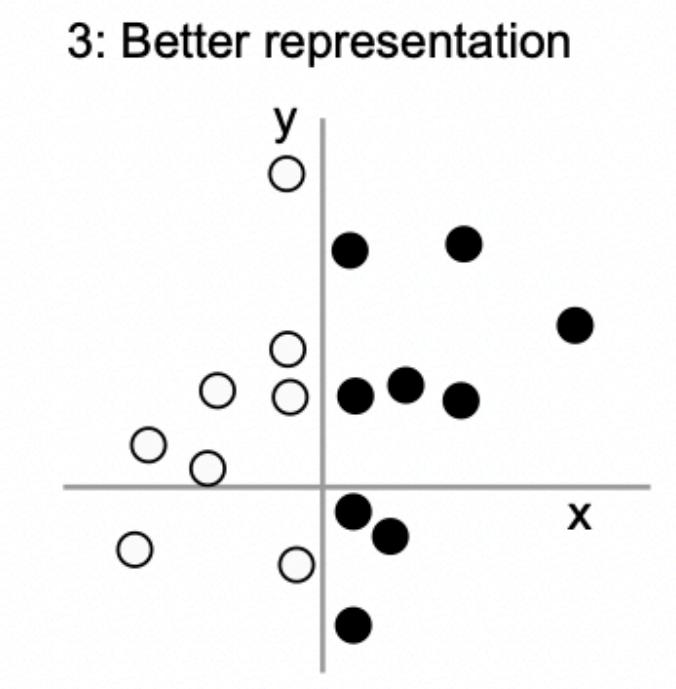
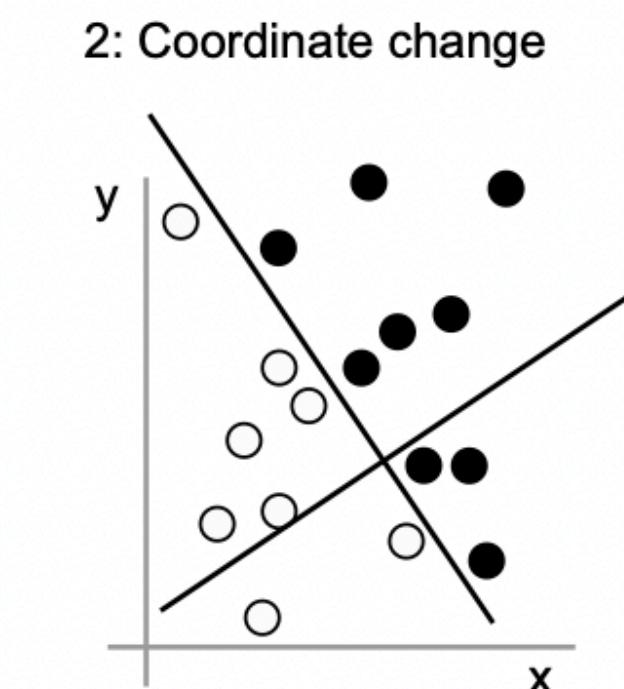
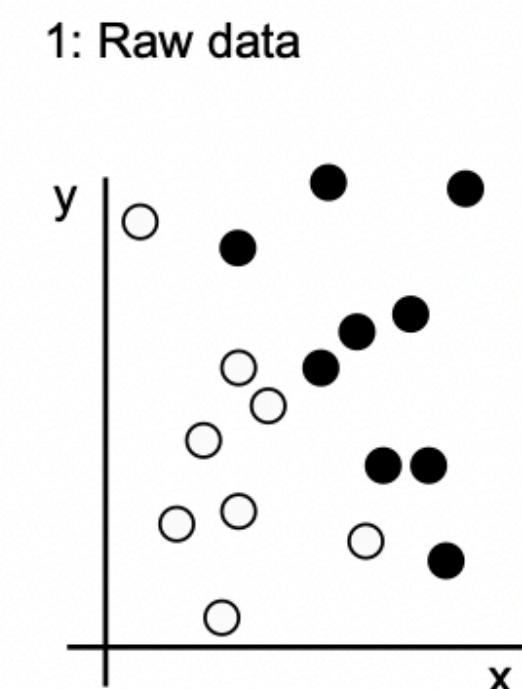
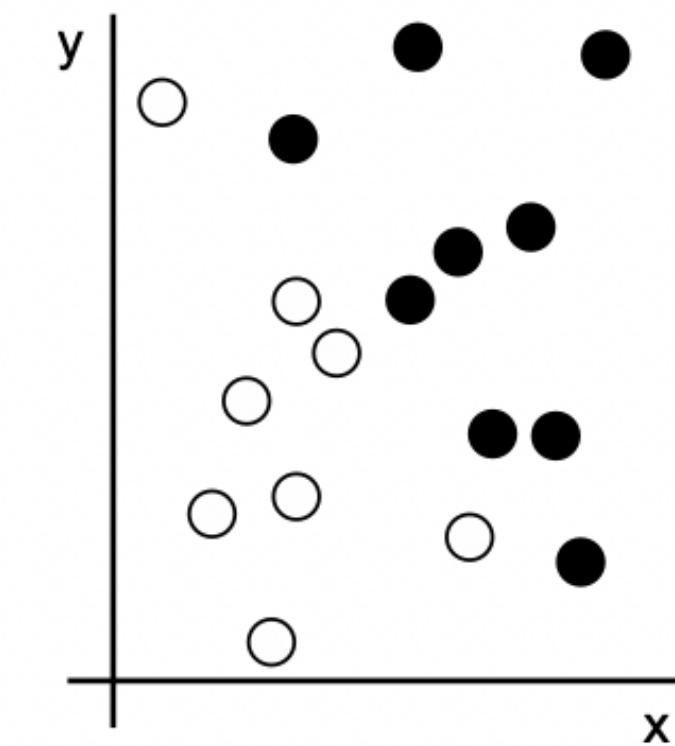
Differences between symbolic AI and Machine Learning



- AI: Effort to automate intellectual tasks normally performed by humans
- ~ 1950-1980 Symbolic AI. Rules + Data → Answers
- ML: Data + Answers → Rules

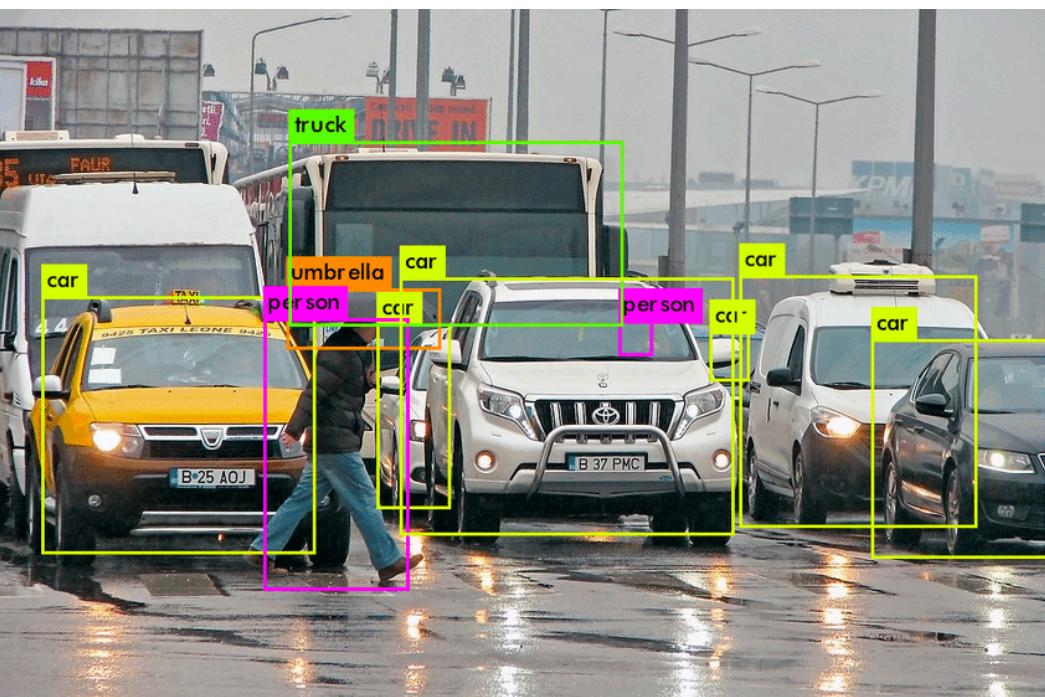
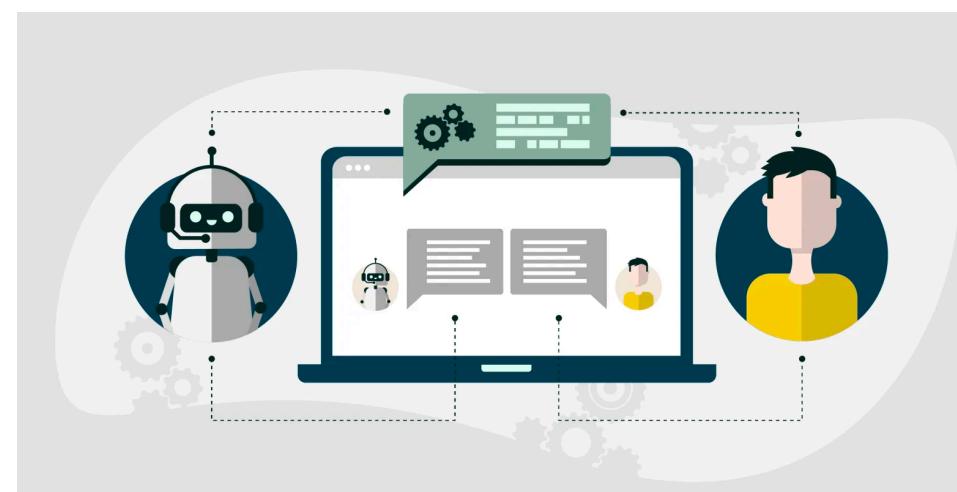
ML Recap

- ML: Data + Answers \rightarrow Rules
- What do we need:
 1. Input data points
 2. Examples of the expected output
 3. A way to measure whether the algorithm is doing a good job
- Transform data into meaningful outputs
(Learning from exposure to known examples)
- Meaningfully transform data: learn representations



Limitations of ML. What makes DL different?

Better performance for many problems



Easier Problem-solving

Automation of feature engineering

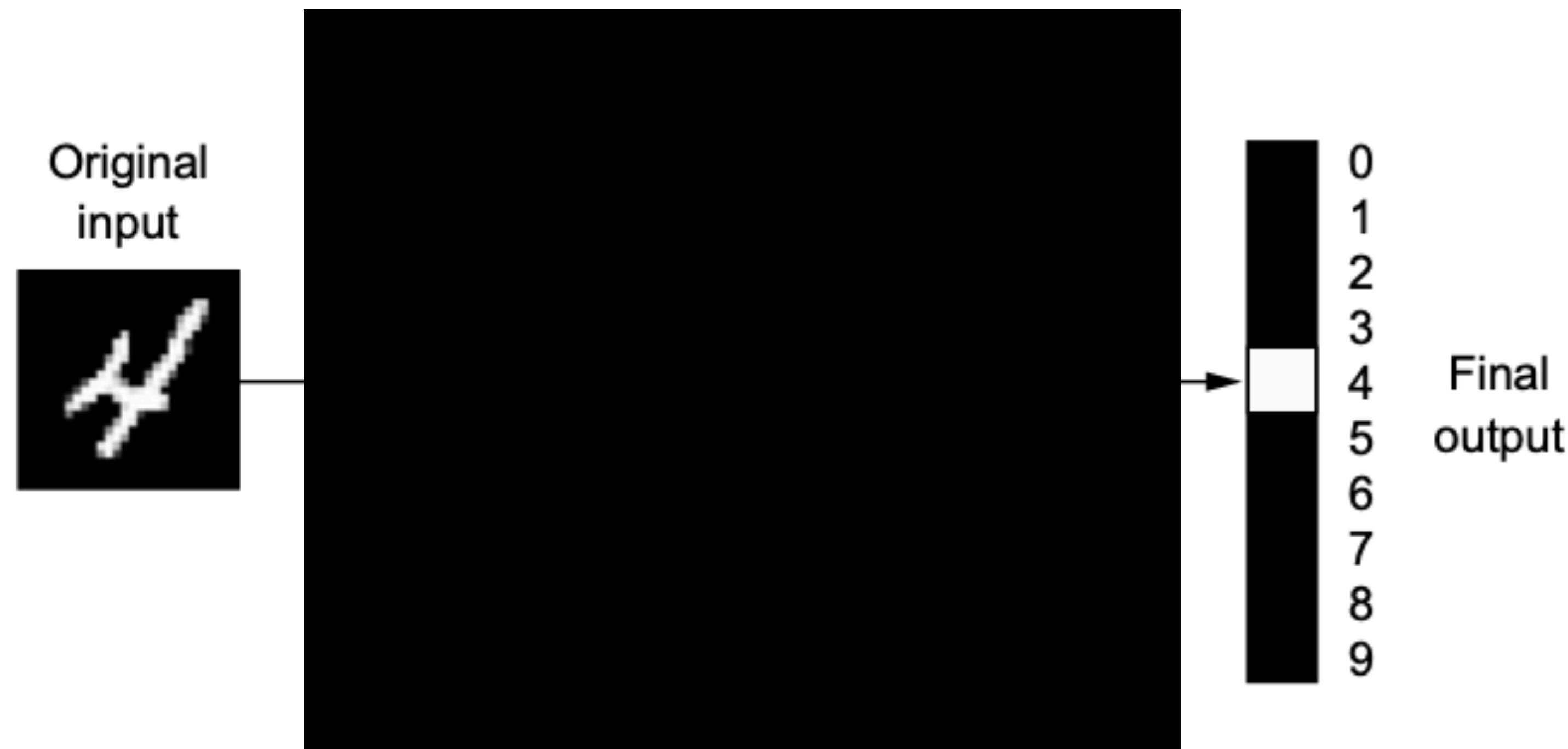
3	4	2	1	9	5	6	2	1	8
8	9	1	2	5	0	0	6	4	
6	7	0	1	6	3	6	3	7	0
3	7	7	9	4	6	6	1	8	2
2	9	3	4	3	9	8	7	2	5
1	5	9	8	3	6	5	7	2	3
9	3	1	9	1	5	8	0	8	4
5	6	2	6	8	5	8	8	9	9
3	7	7	0	9	4	8	5	4	3
7	9	6	4	7	0	6	9	2	3

SVM,
Decision Trees...

Neural Nets

A first glance at Deep Learning

Neural Networks

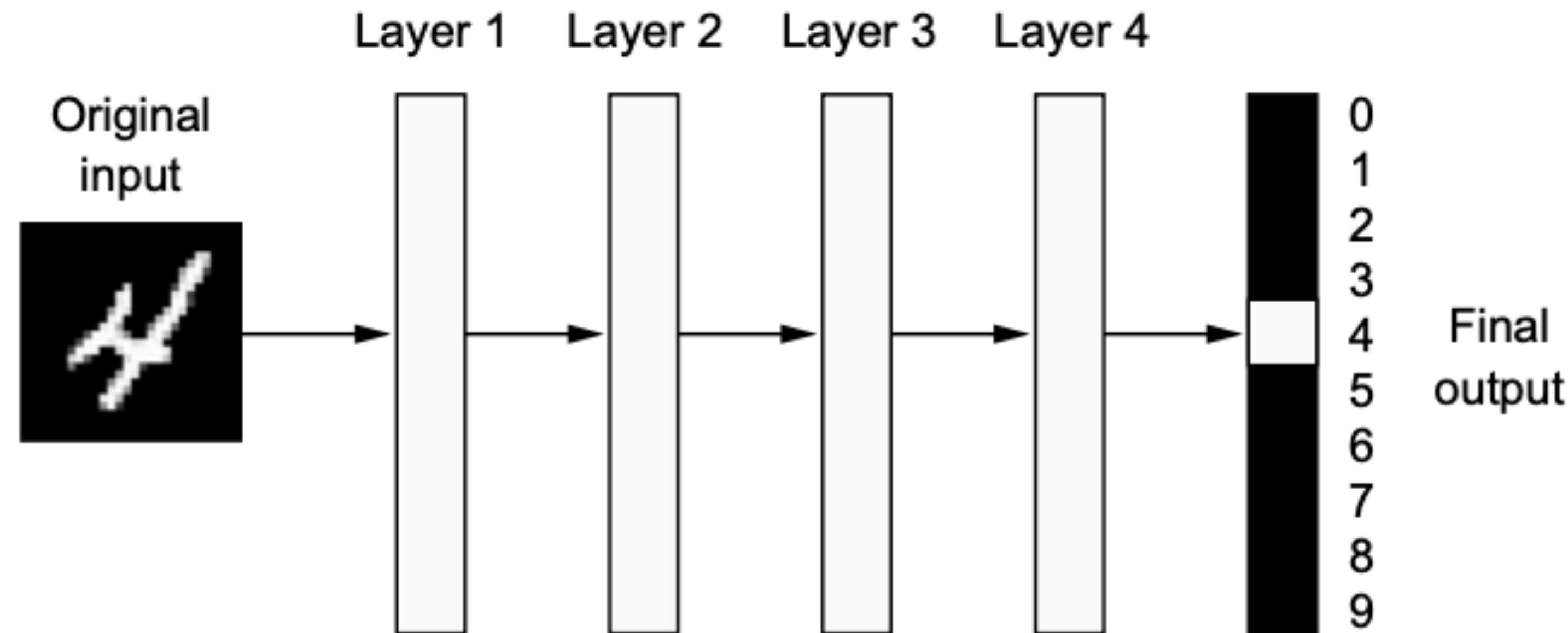


A first glance at Deep Learning

Neural Networks

Hidden Layers

Deep (Depth):
Successive Layers

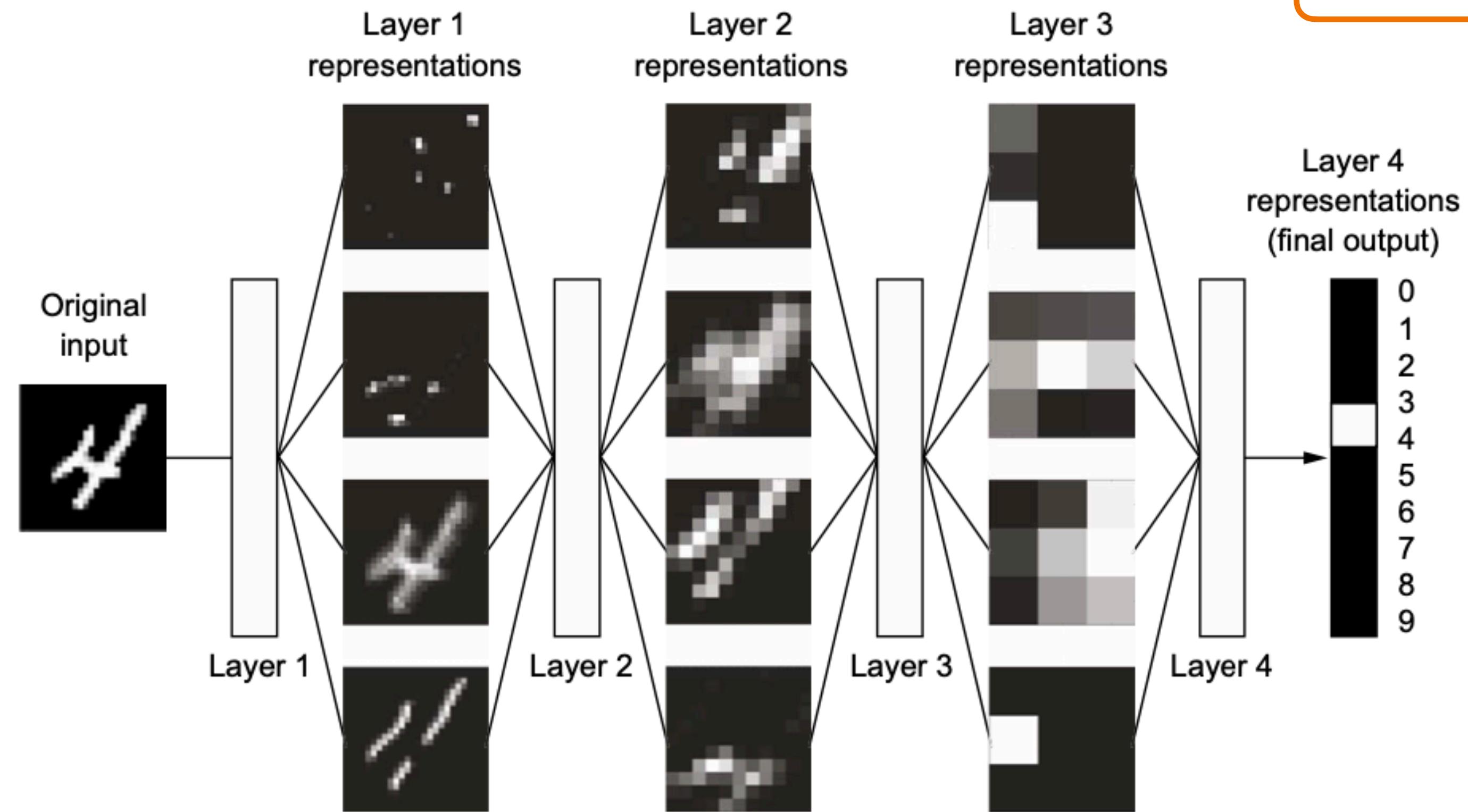


A first glance at Deep Learning

Neural Networks

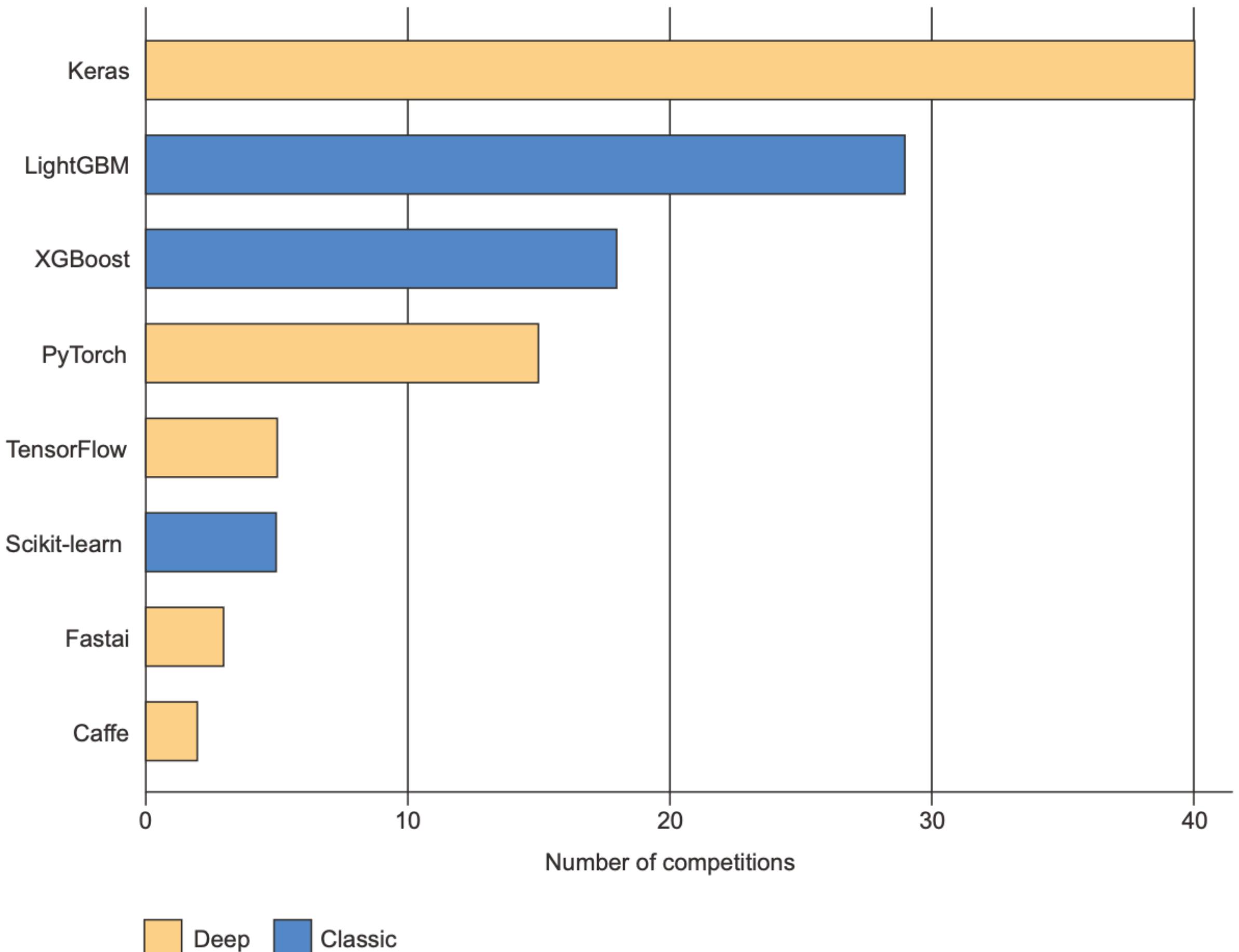
Hidden Layers

*Multistage (several layers)
way to learn data
representations*



What deep learning has achieved so far?

- Near-human-level image classification
- Near-human-level speech transcription
- Near-human-level handwriting transcription
- Dramatically improved machine translation
- Dramatically improved text-to-speech conversion
- Google assistant - Alexa
- Near-human-level autonomous driving
- Superhuman game-playing (AlphaGo, Alphazero, AlphaStar, etc...)



Why Deep Learning and why now?

- CNNs were well understood already in 1990.
Why did this not happen earlier?

1. Hardware:

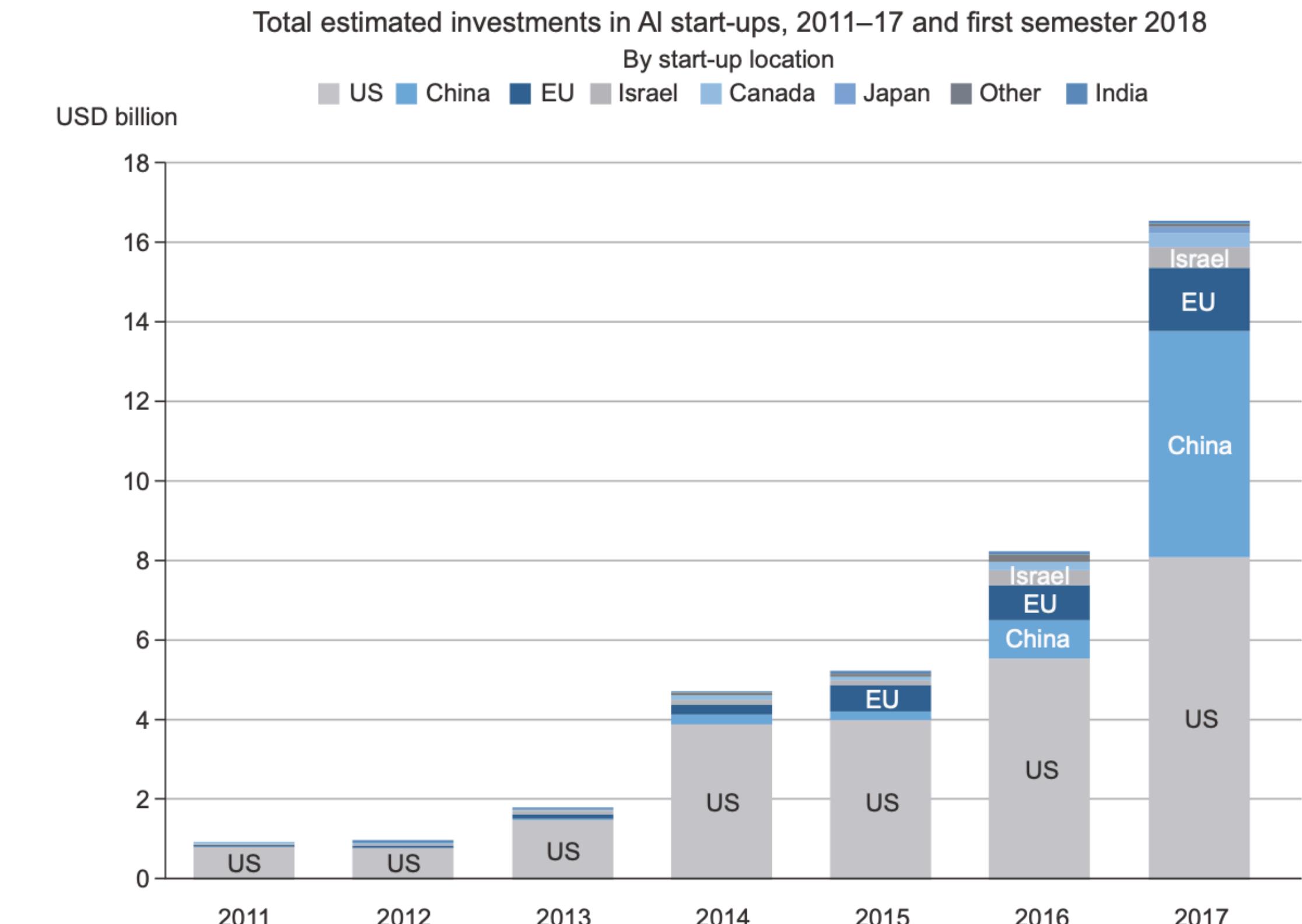
- Development of GPUs, TPUs

2. Data (ImageNet)

- Kaggle competitions

3. Algorithmic advances

- Extensive research





The building blocks of Neural Networks

Back to the hand-written digits



Label: 3



Label: 3



Label: 3

Could you write a
program that takes the pixels
as input and tells you the
number?

Back to the hand-written digits



Label: 3



Label: 3

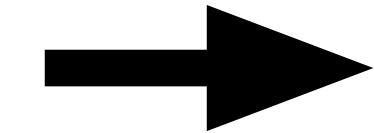


Label: 3

Could you write a
program that takes the pixels
as input and tells you the
number?



Label: 3



0	1	2	3	4	5	6	7	8	9
---	---	---	---	---	---	---	---	---	---

Neural Network
to recognize hand-
written digits

What is a neuron?

Neural Networks

What are neurons?

How are they linked together?

28

A thing that holds a number between 0 and 1

0.8

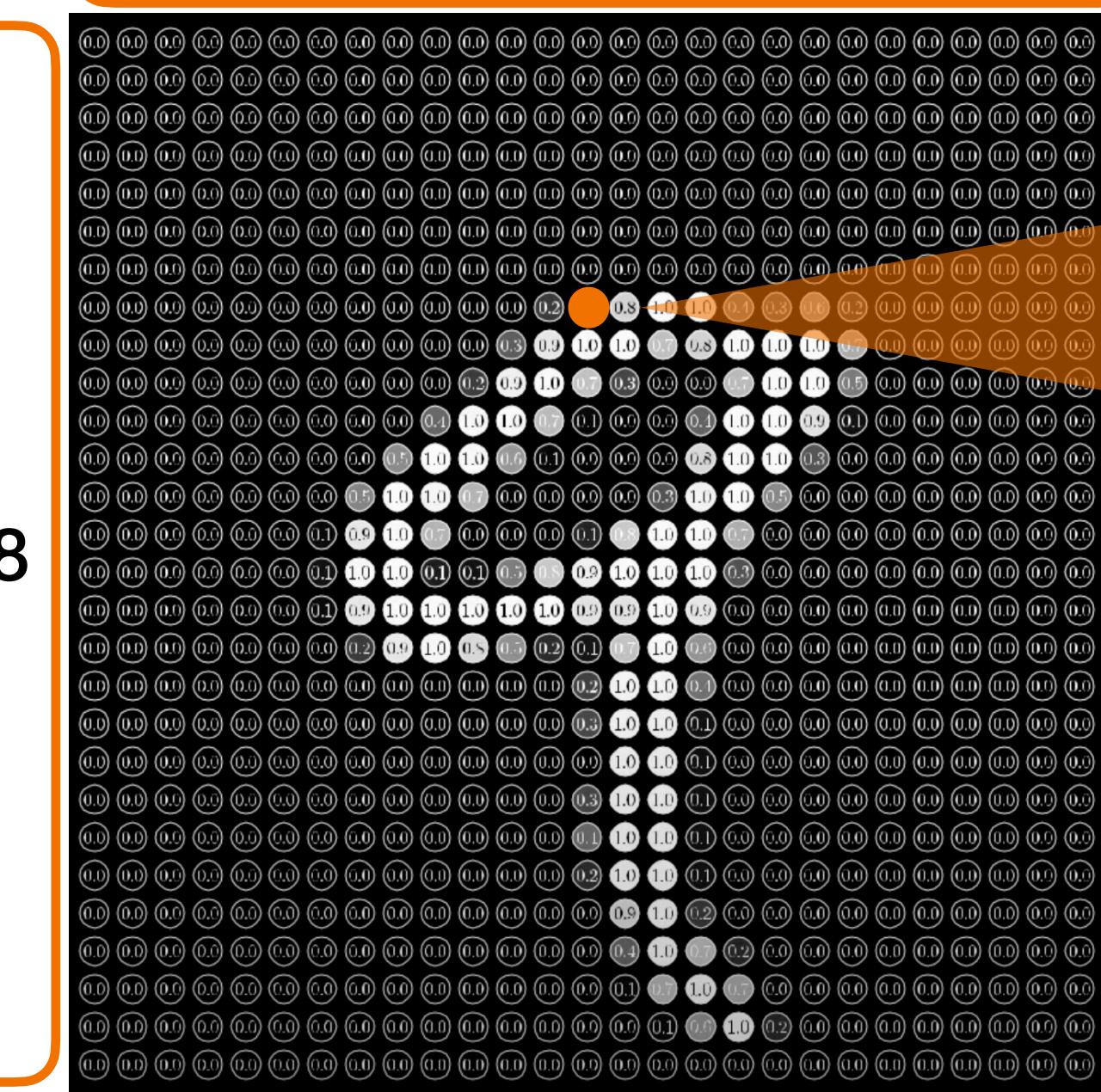
28

$28 \times 28 = 784$

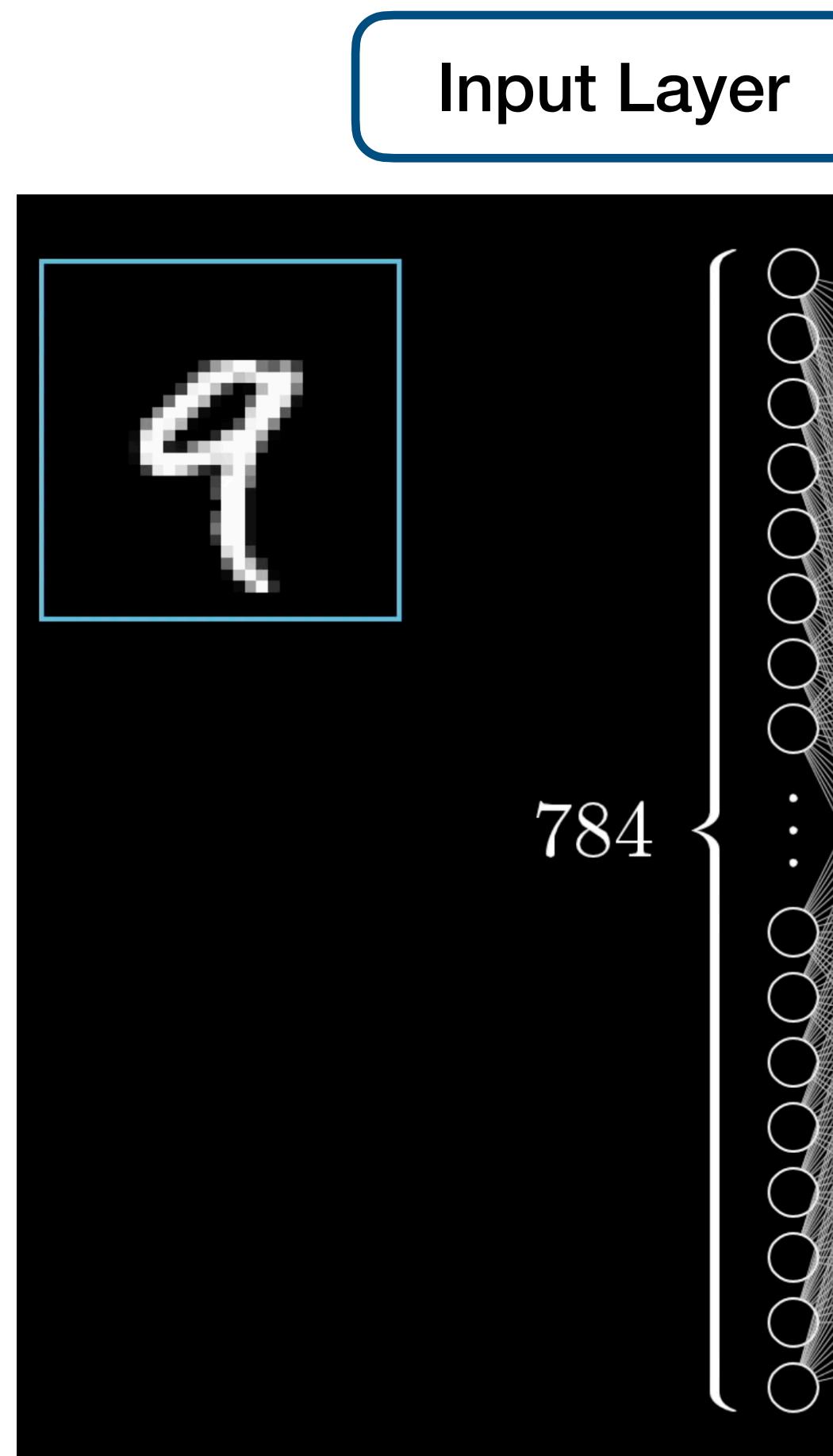
0.9

Activation

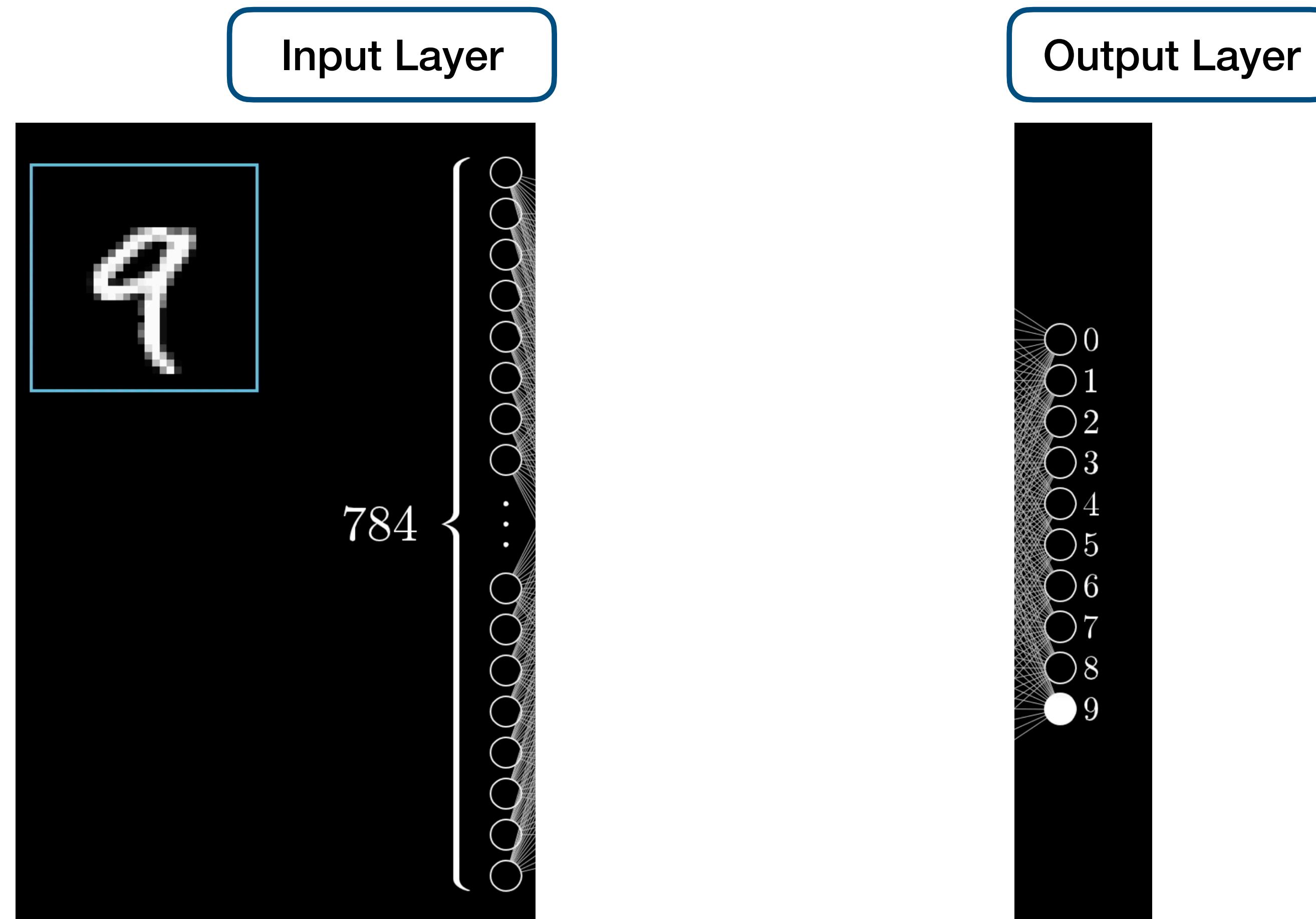
0.1



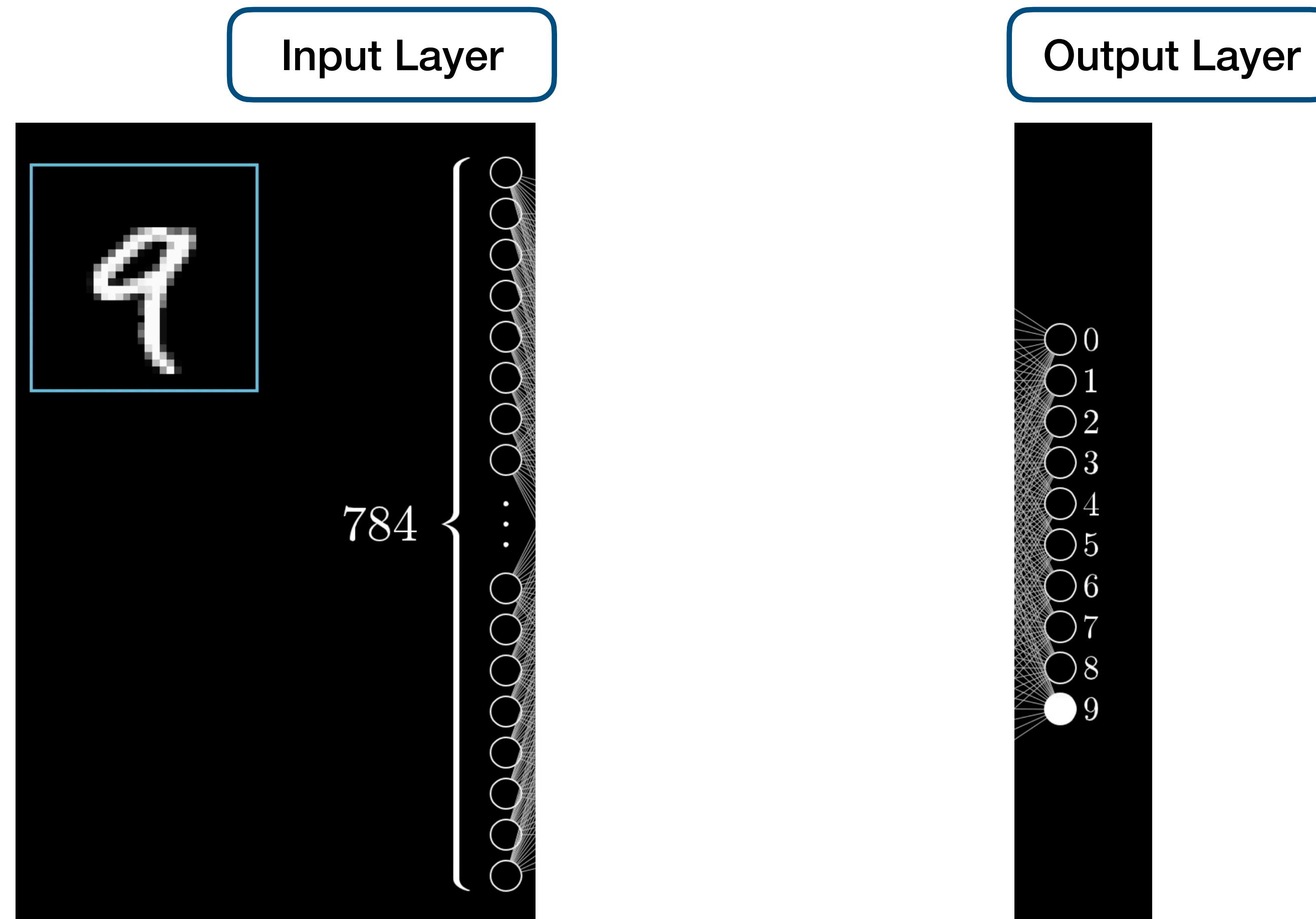
Layers of Neurons lead to the Neural network structure



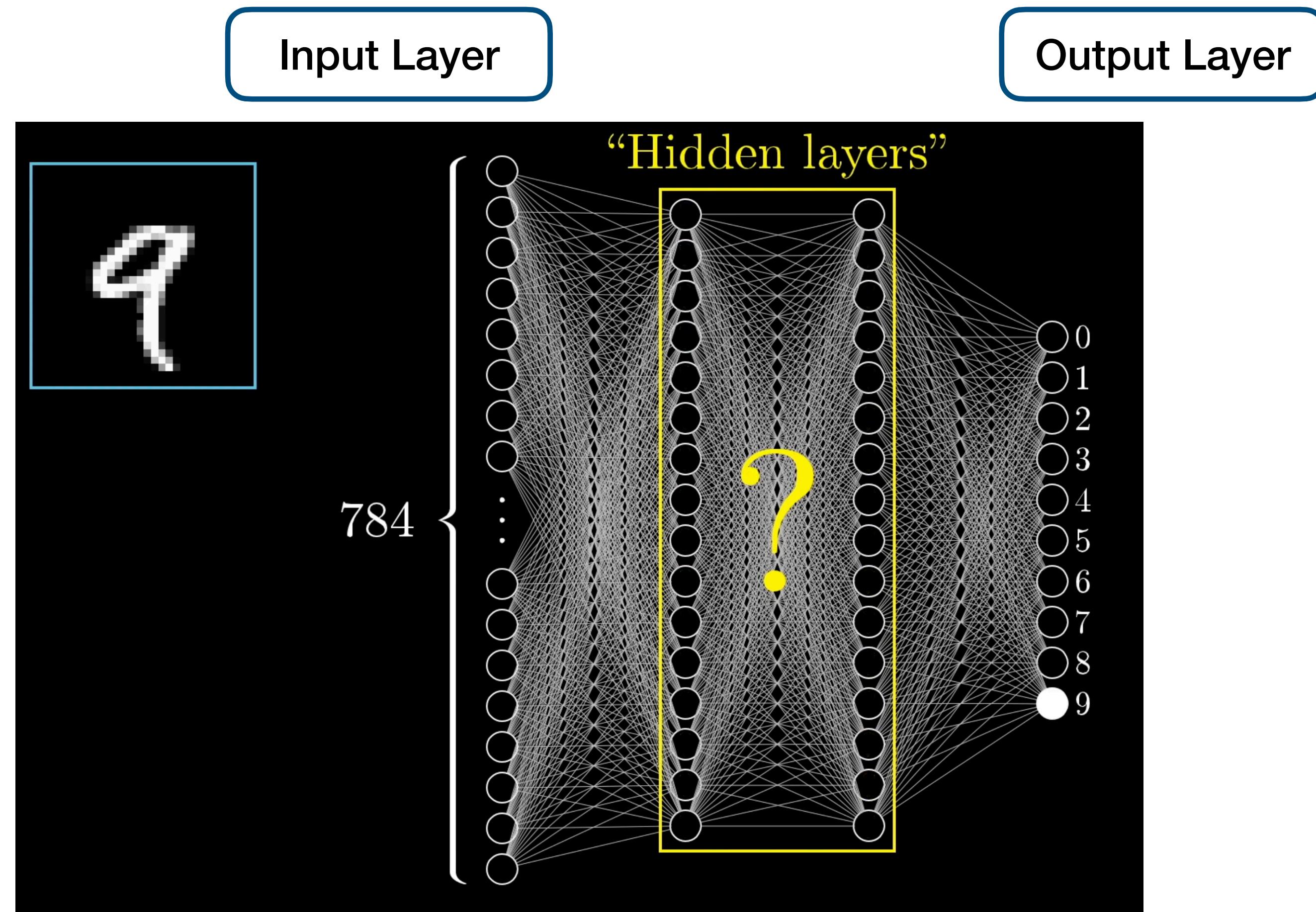
Layers of Neurons lead to the Neural network structure



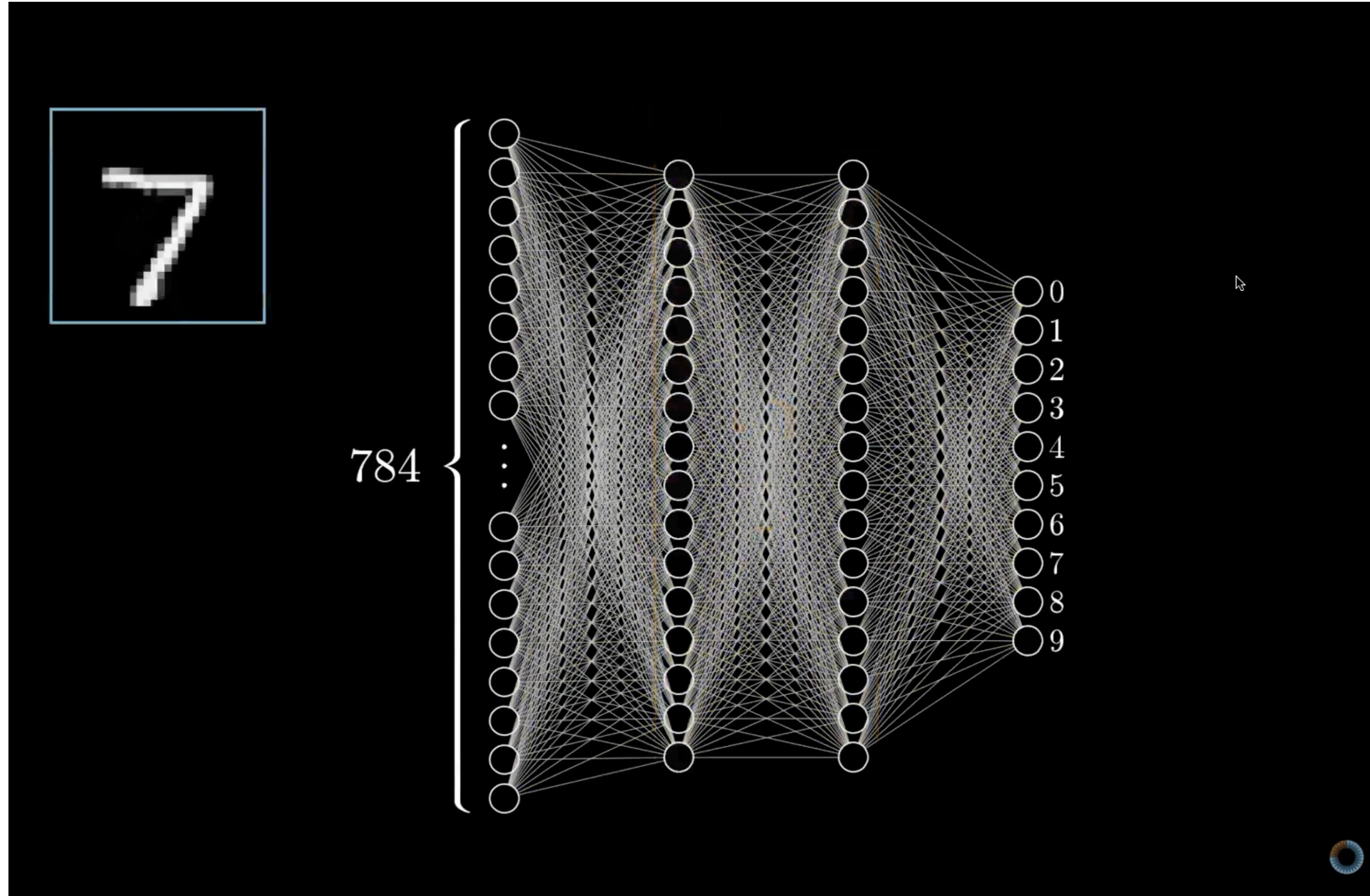
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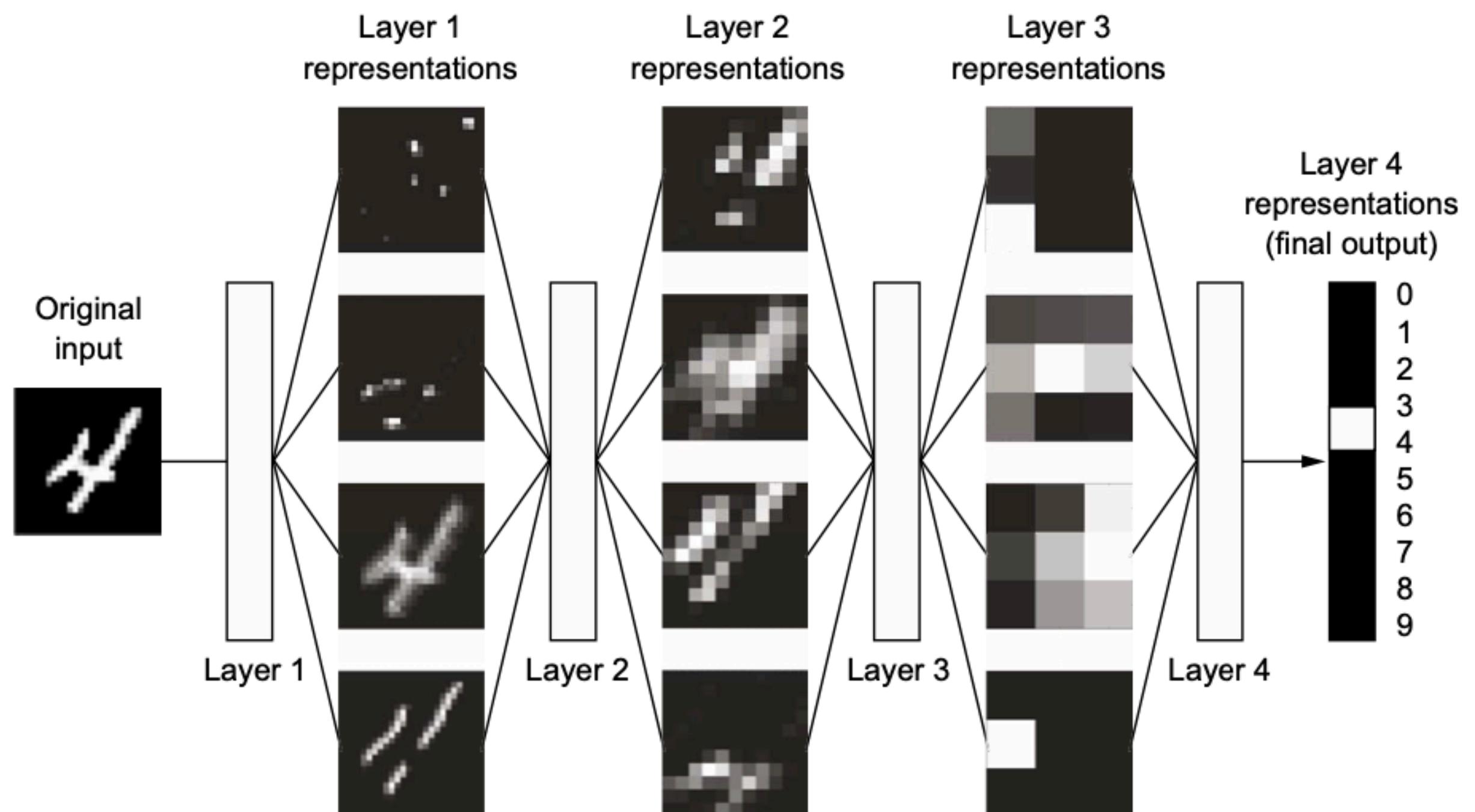


Layers of Neurons lead to the Neural network structure



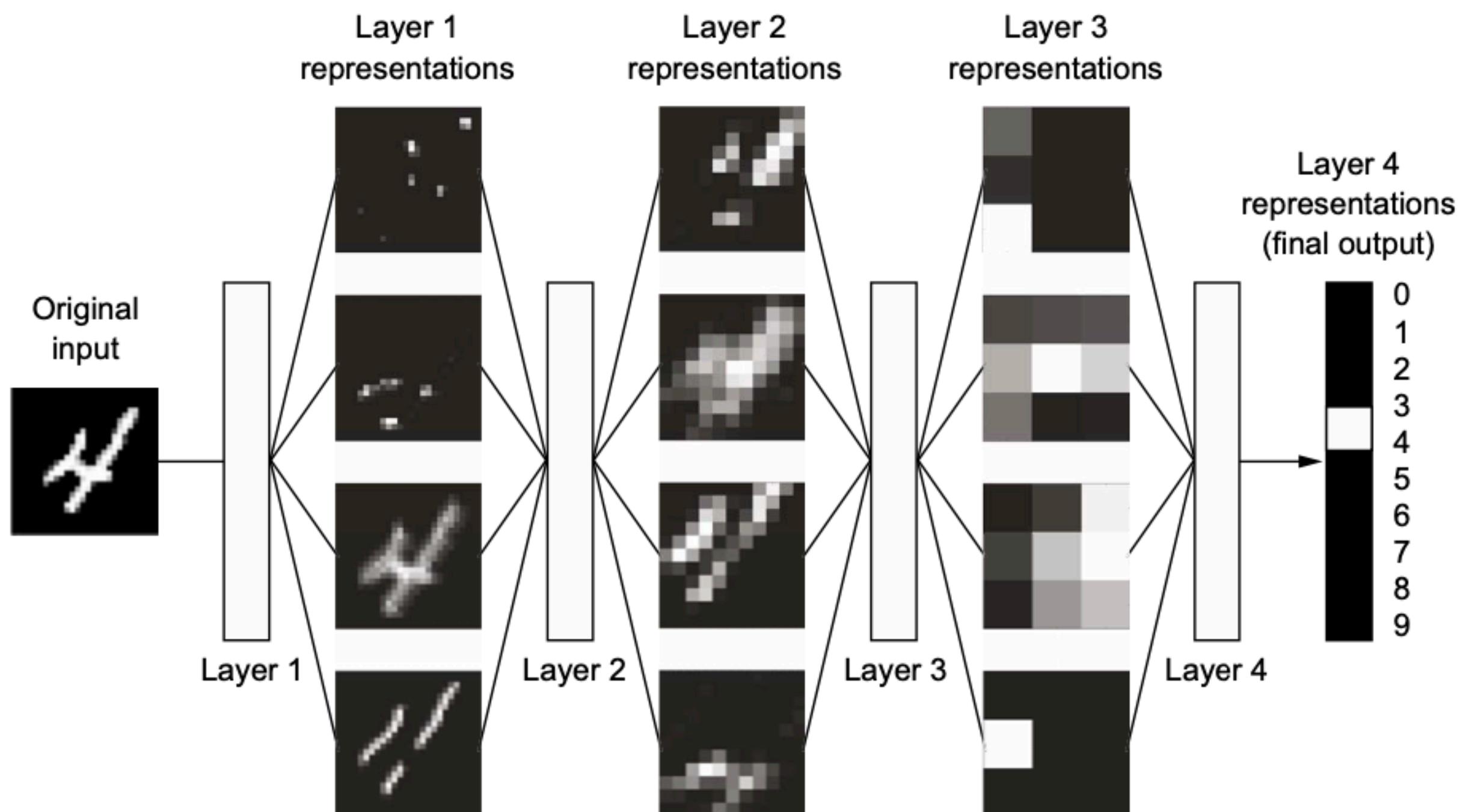
Why layers?

Find data representations



Why layers?

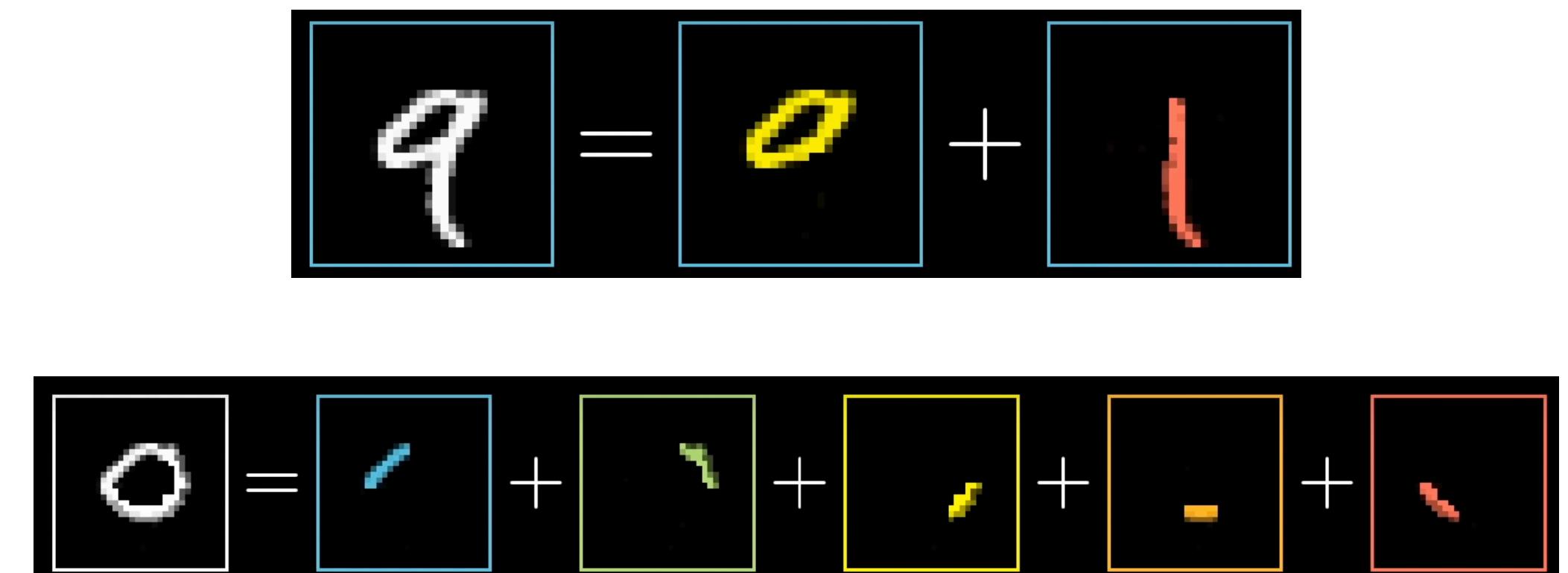
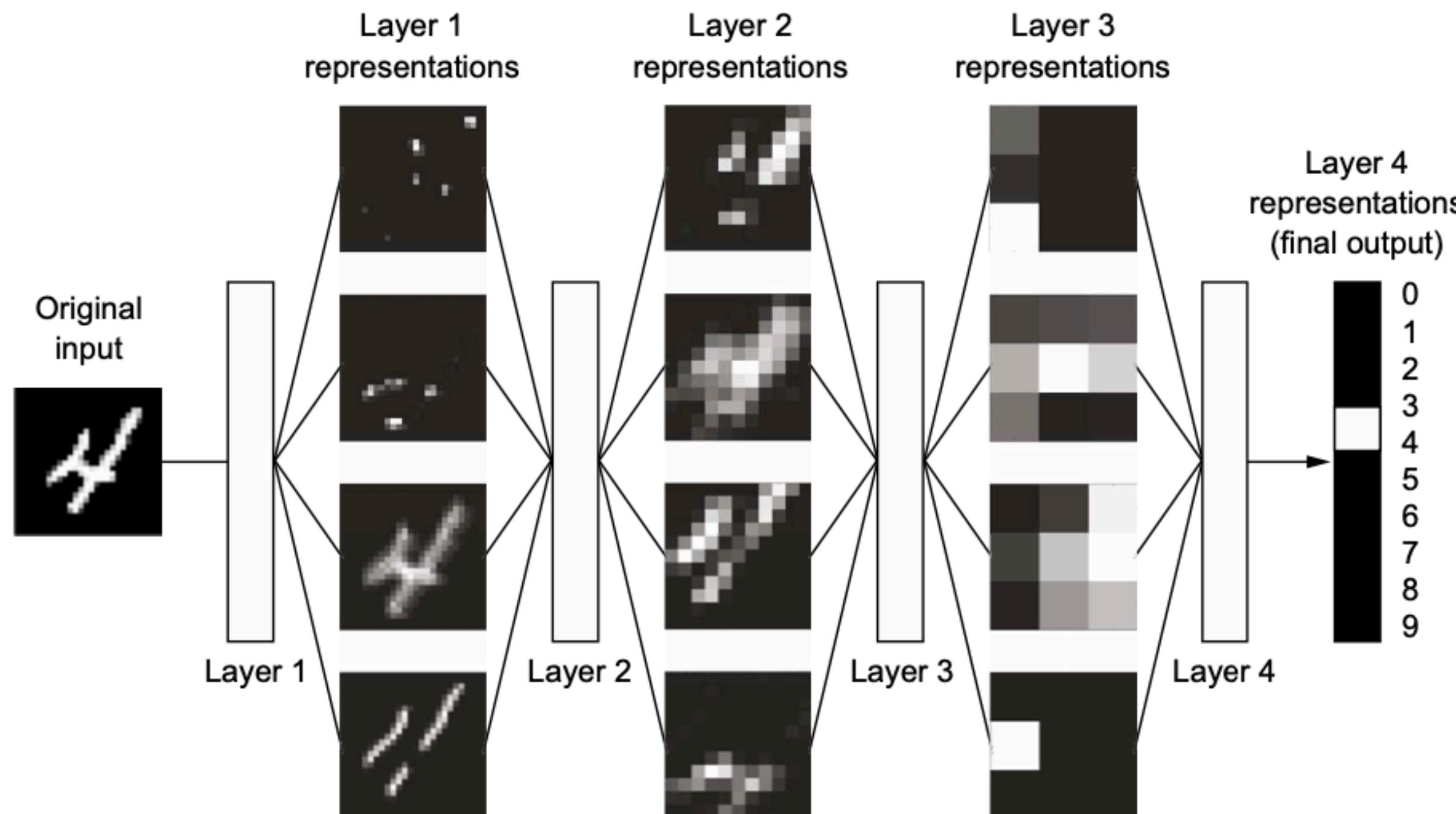
Find data representations



$$\begin{aligned} \text{Digit } 4 &= \text{Feature } 1 + \text{Feature } 2 \\ \text{Digit } 0 &= \text{Feature } 1 + \text{Feature } 2 + \text{Feature } 3 + \text{Feature } 4 + \text{Feature } 5 \end{aligned}$$

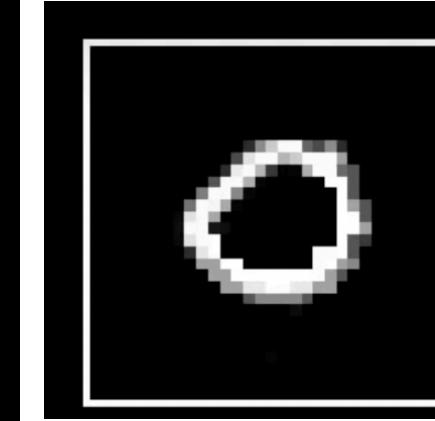
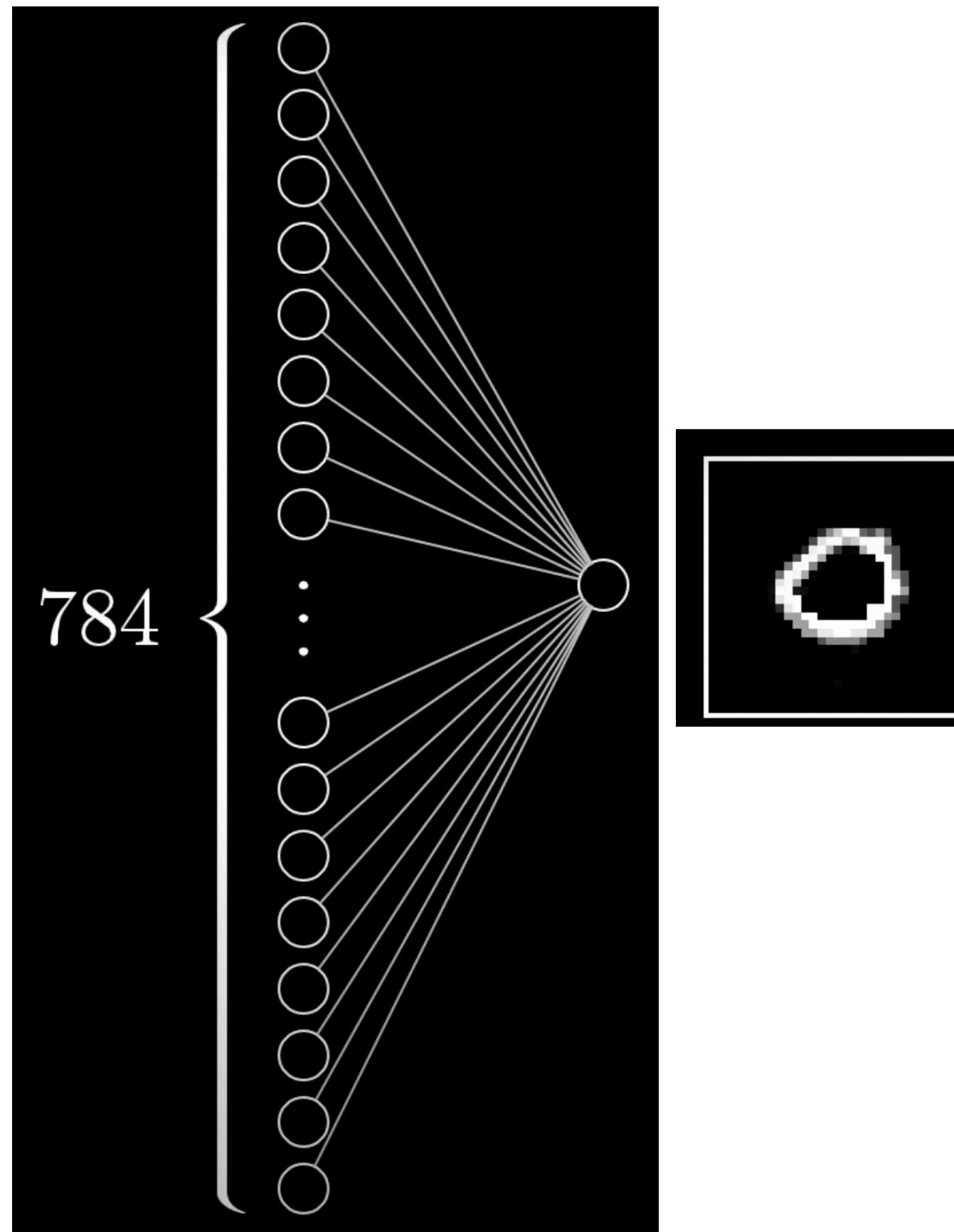
Why layers?

Find data representations



How connections in one layer may determine the activations in the next layer?

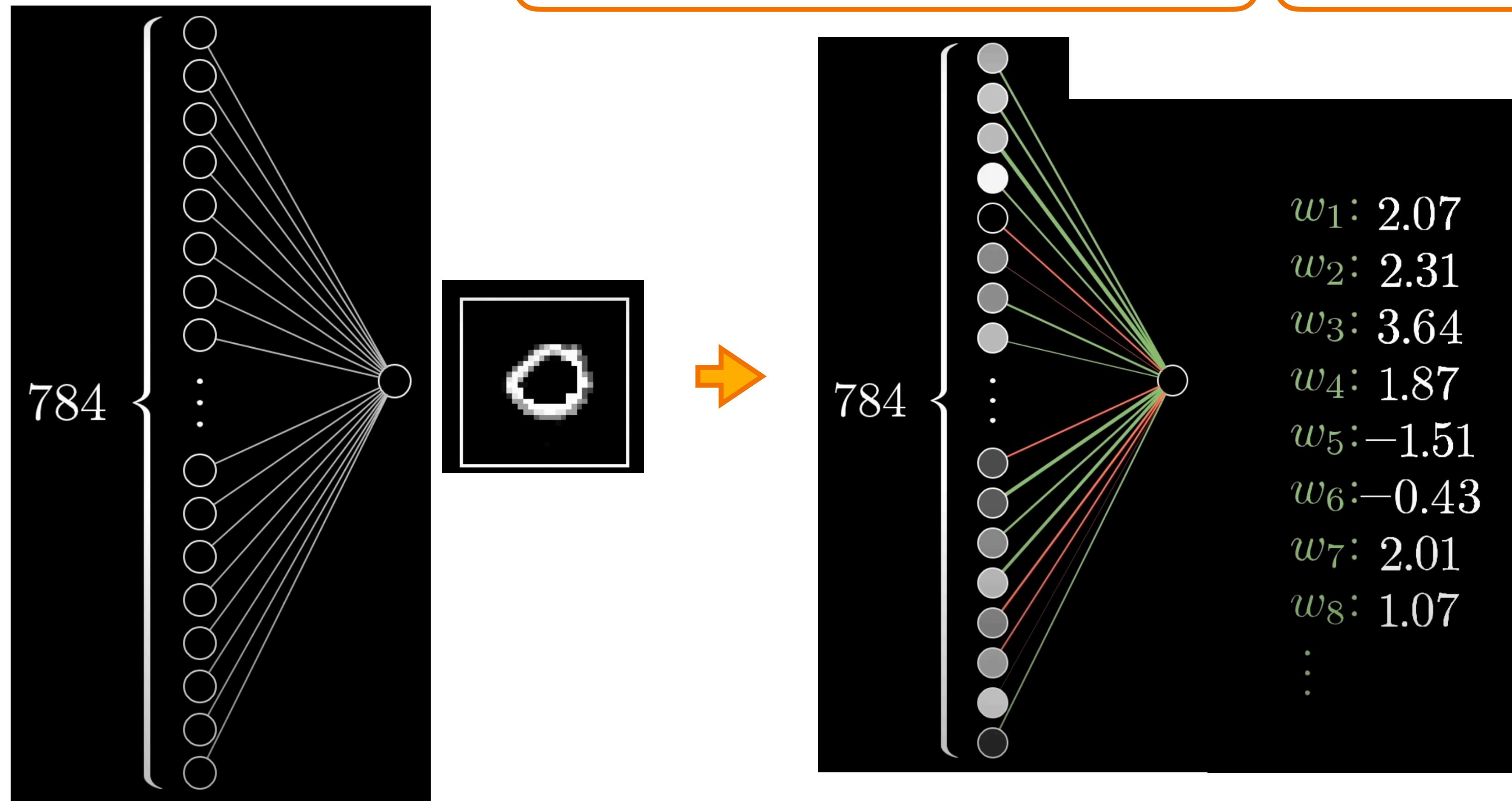
The parameters of the Network (Weights and Biases)



Which pixels are more important to recognize the circle?

What parameters does the network need to detect that circle?

The parameters of the Network (Weights and Biases)

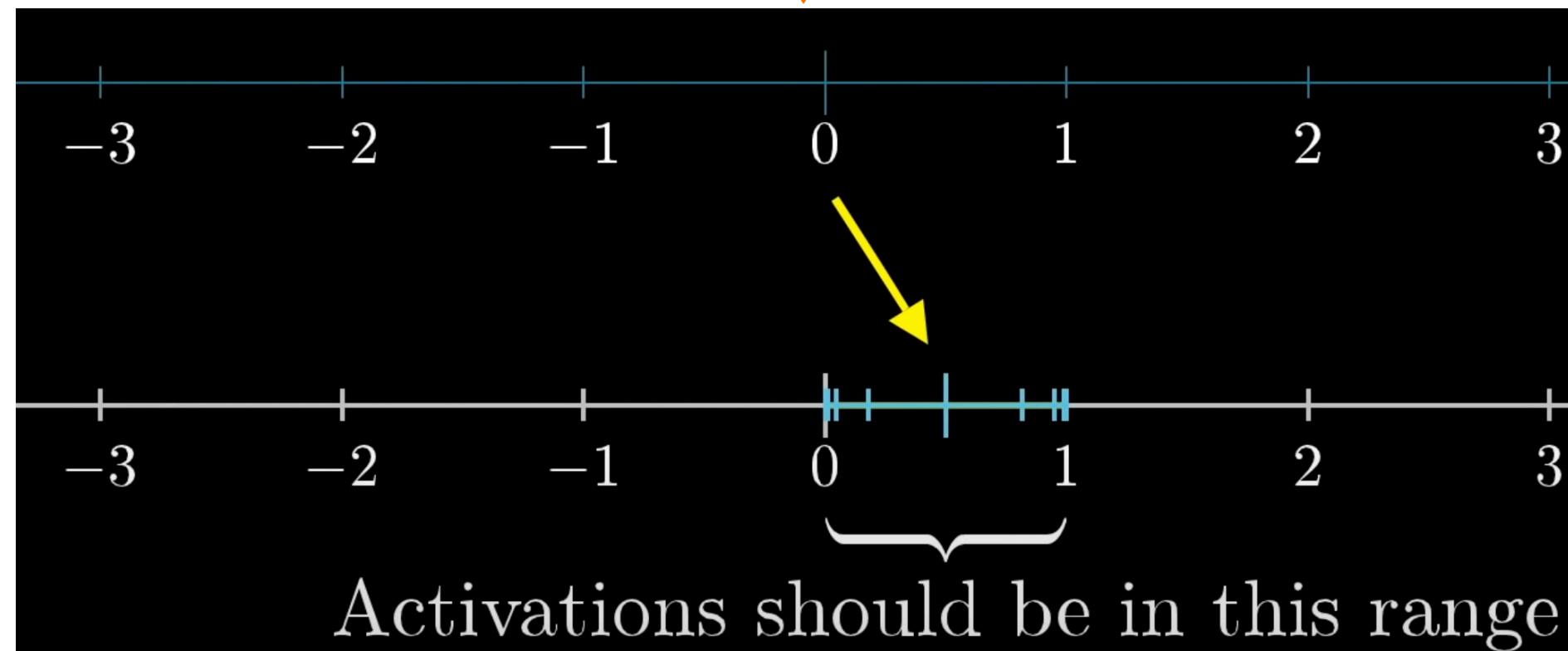


The parameters of the Network (Weights and Biases)

$$w_1 a_1 + w_2 a_2 + w_3 a_3 + w_4 a_4 + \dots + w_n a_n$$

But we need to combine the activations and the weights

We also need values between 0 and 1 for the activation of our new neuron therefore we need an additional step

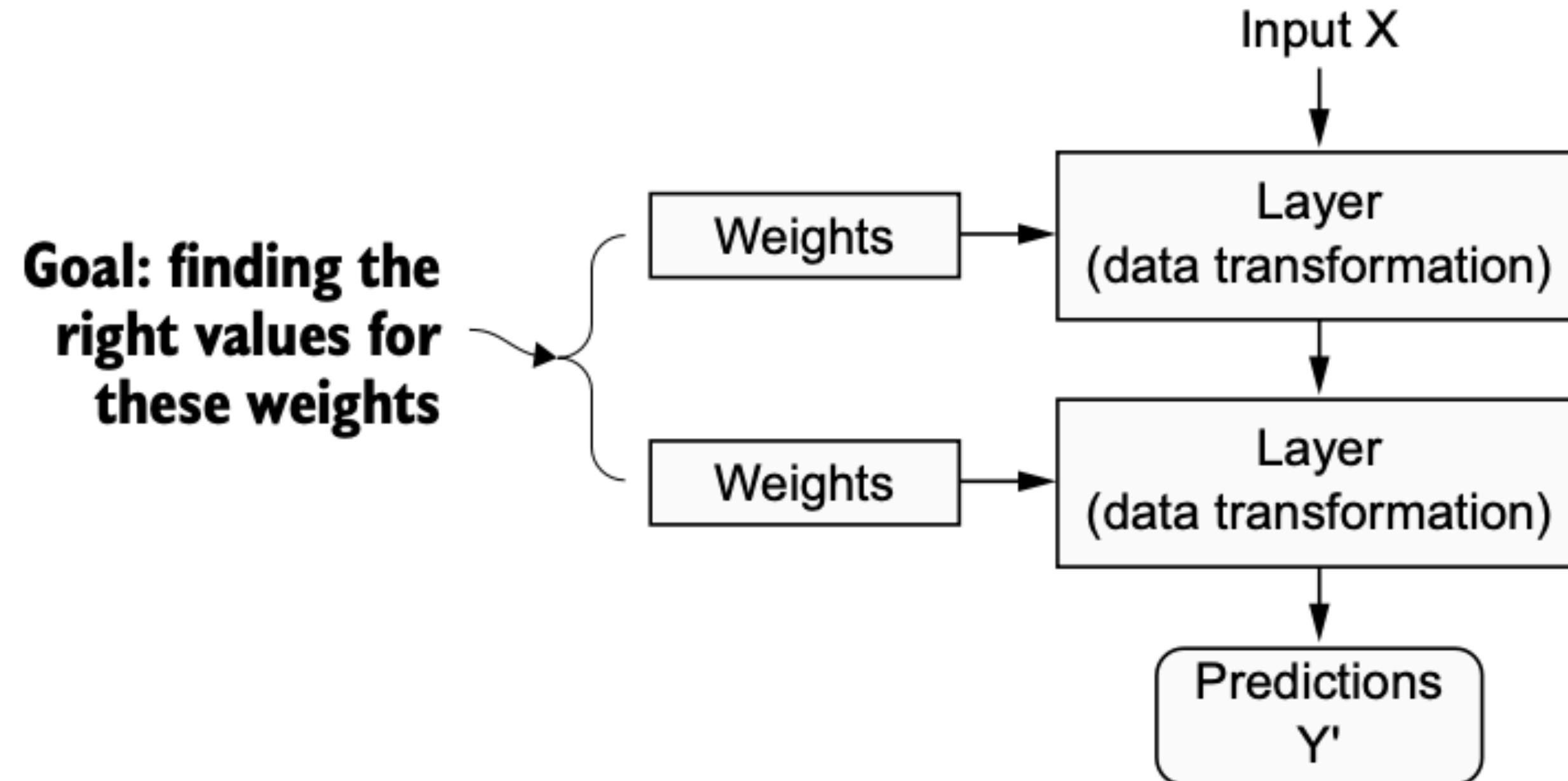


Sigmoid
 \downarrow
 $\sigma(w_1 a_1 + w_2 a_2 + w_3 a_3 + \dots + w_n a_n)$

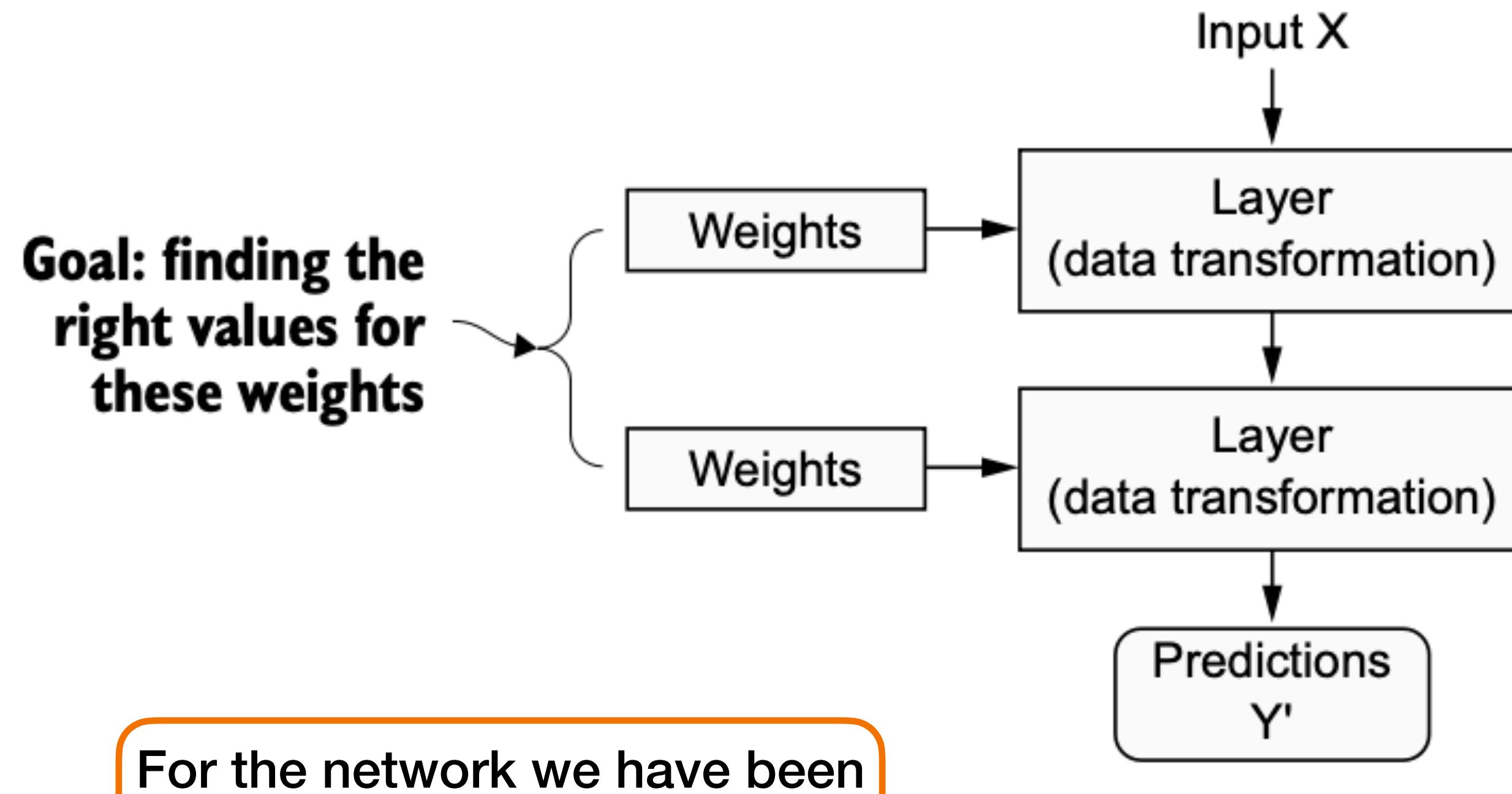
How positive is this?

Neural Networks also present a bias parameter (How high the Weighted sum needs to be before the neuron becomes active)

Recap



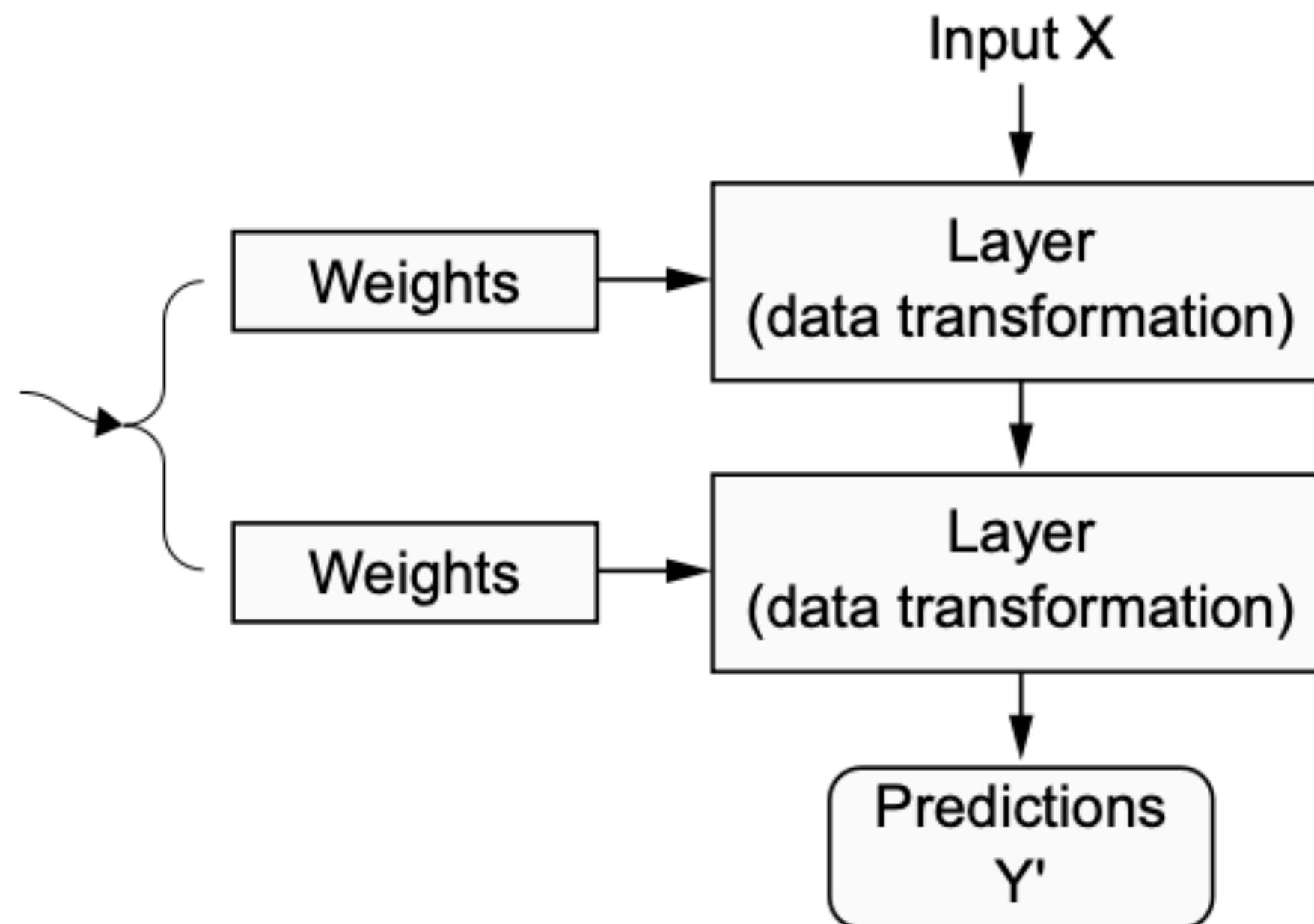
Recap



For the network we have been using we have $> 13\text{ K}$ weights and biases

Recap

Goal: finding the right values for these weights



New Neuron Definition

Is a function that squeezes all the activations from the neurons in the previous layers and their corresponding weights to a value between 0 and 1

$$\mathbf{a}^{(1)} = \sigma(\mathbf{W}\mathbf{a}^{(0)} + \mathbf{b})$$



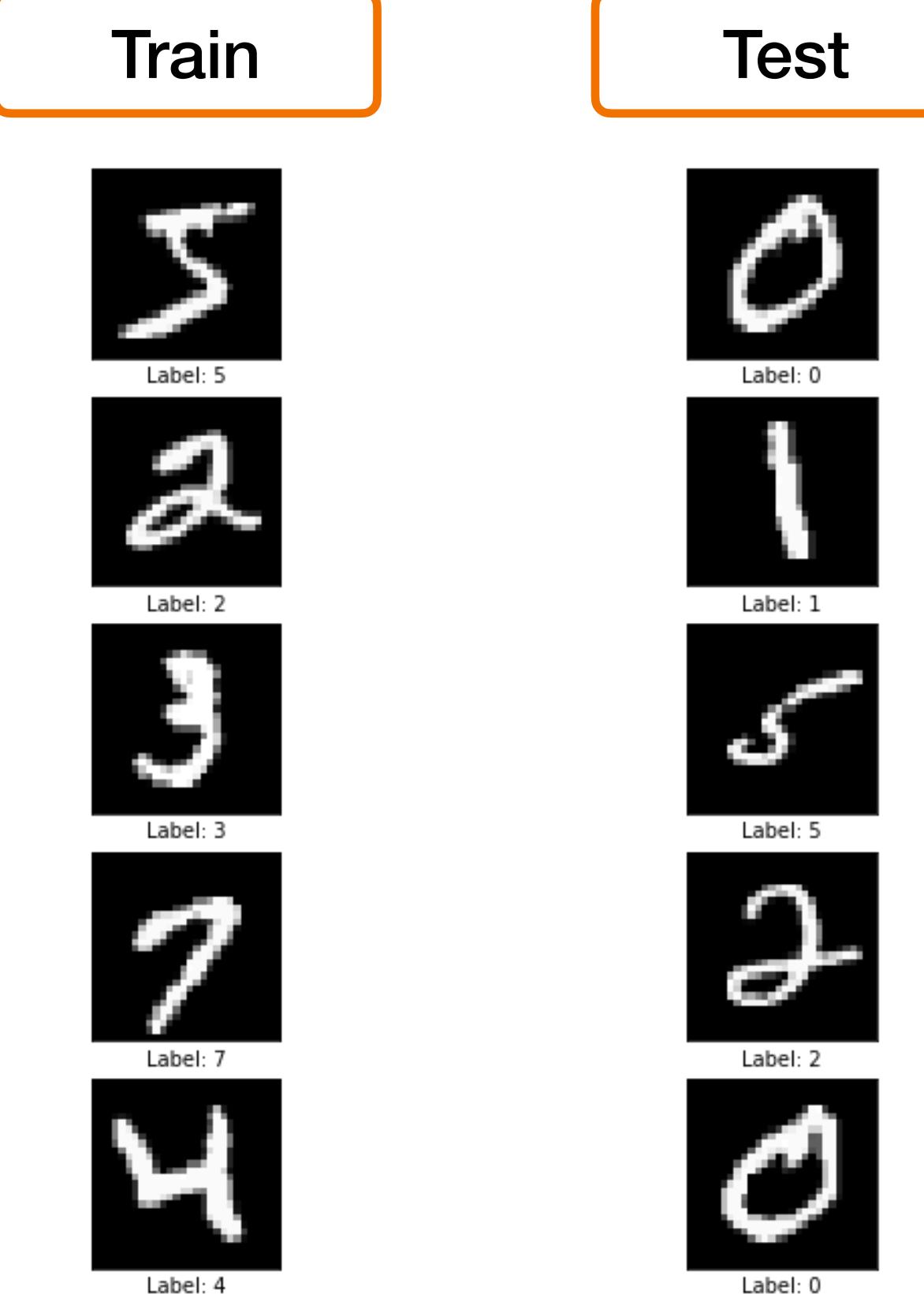
How do Neural Networks learn?

What are we gonna learn?

- 1. Forward Pass**
- 2. Backward Pass**
- 3. Update Weights**

What are we gonna learn?

- 1. Forward Pass**
- 2. Backward Pass**
- 3. Update Weights**



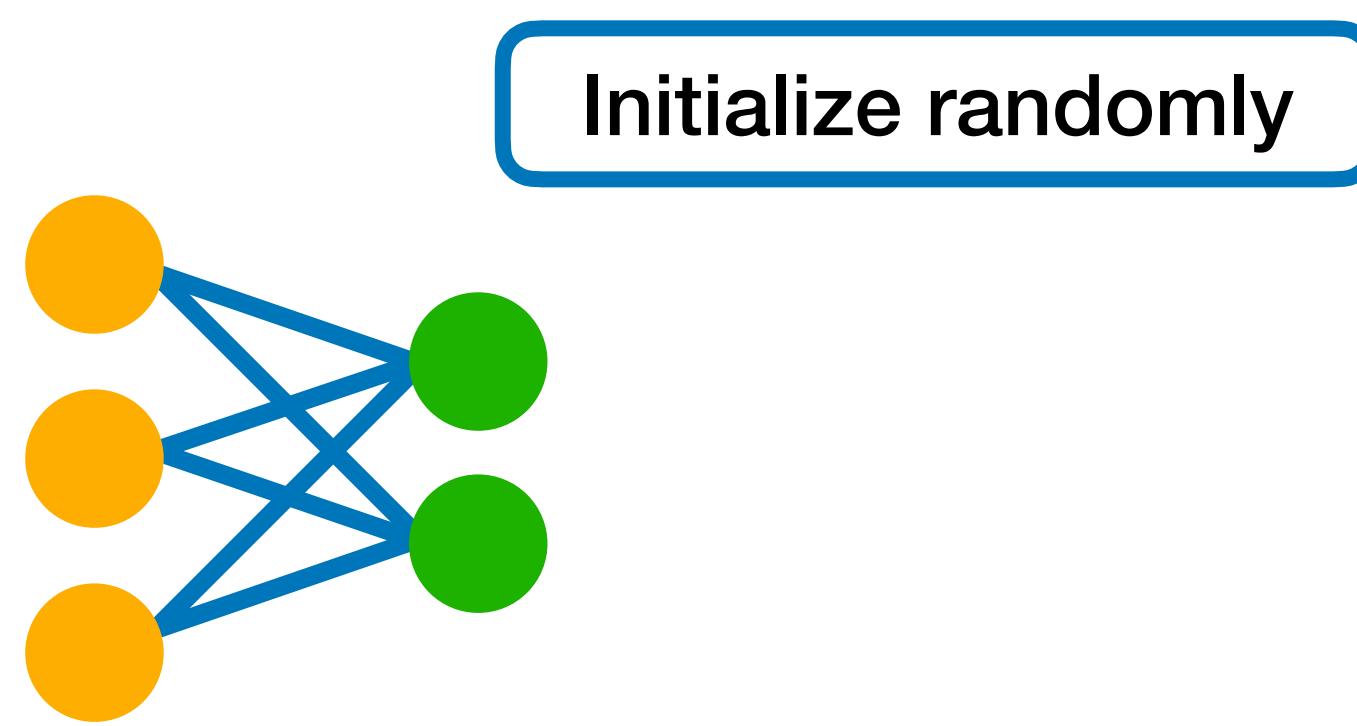
The objective is twofold:

- To train the network to recognize images of numbers
- To have a model able to generalize for images beyond that training data

How accurately does the network classify those new images?

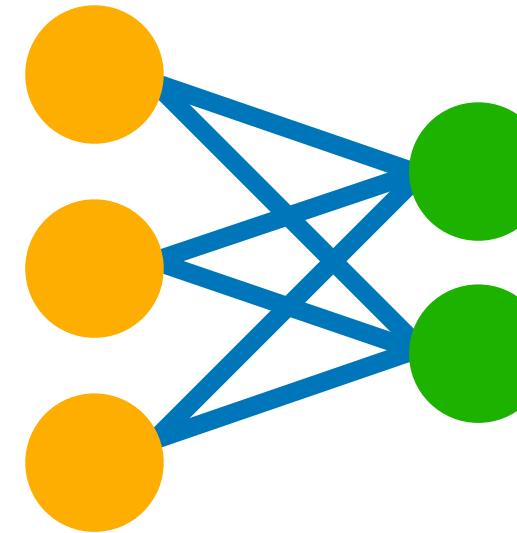
The first step: Randomly initialize the parameters of the network

$$a^{(1)} = \sigma(Wa^{(0)} + b)$$



The first step: Randomly initialize the parameters of the network

$$a^{(1)} = \sigma(Wa^{(0)} + b)$$



Initialize randomly

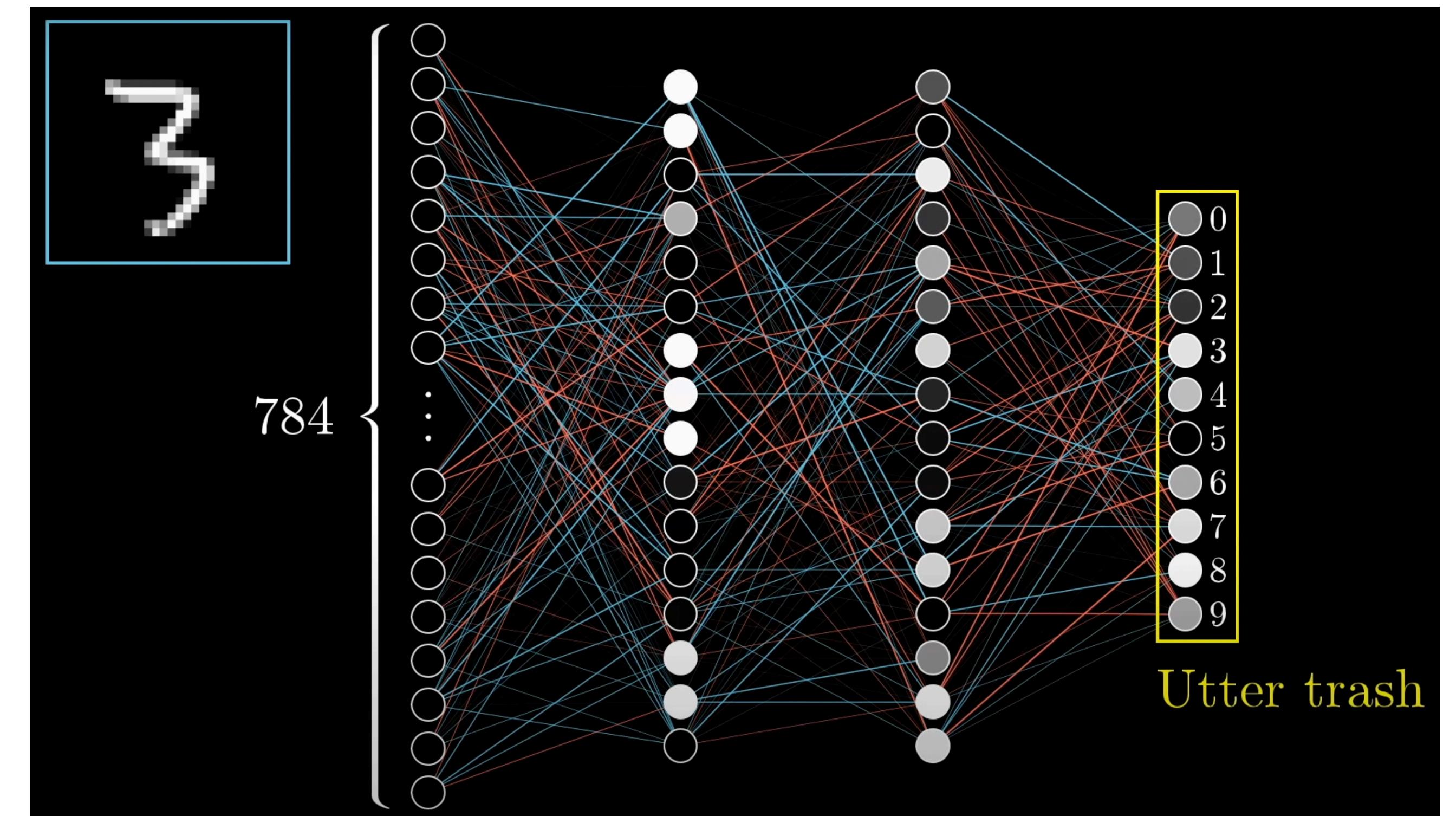
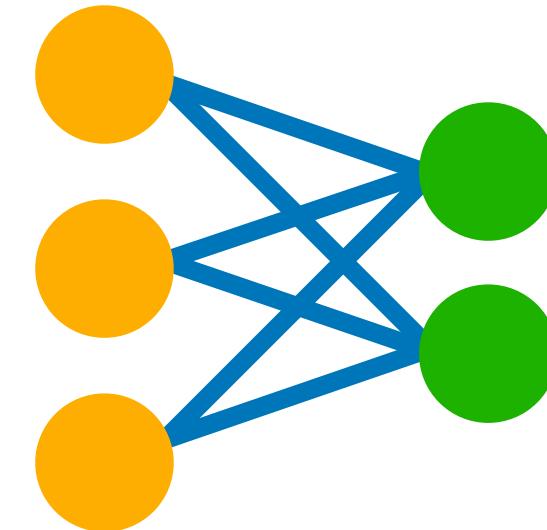
⋮

What do you think
will happen?

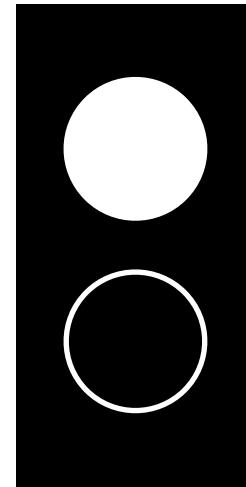
First step: Randomly initialize the parameters of the network

$$a^{(1)} = \sigma(Wa^{(0)} + b)$$

Initialize randomly

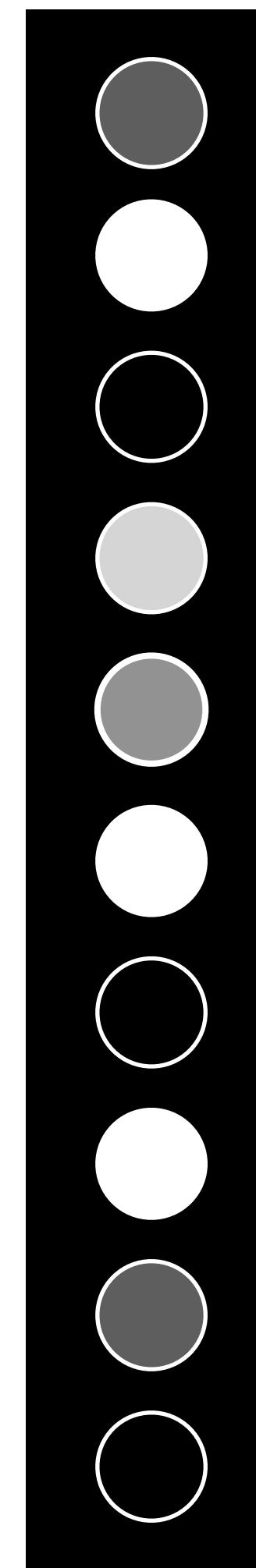


Second step: Tell the computer that is doing it wrong



Activated

Not Activated



0

1

2

3

4

5

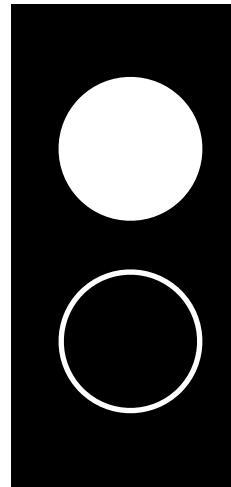
6

7

8

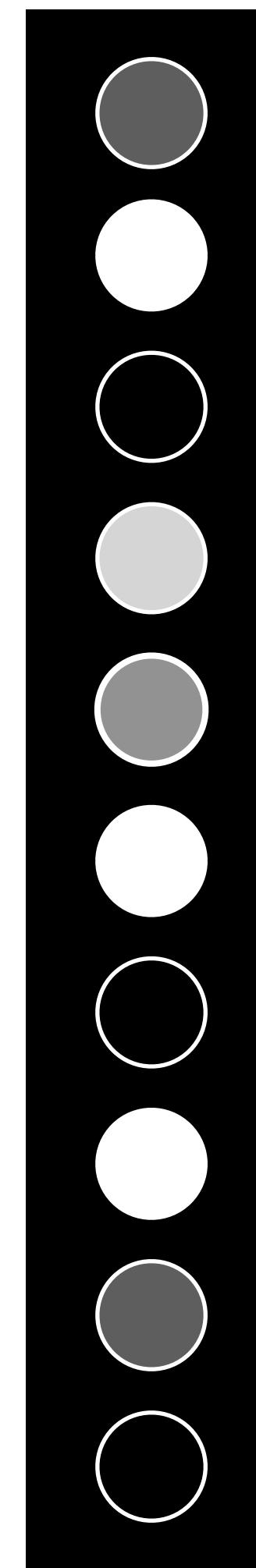
9

Second step: Tell the computer that is doing it wrong



Activated

Not Activated

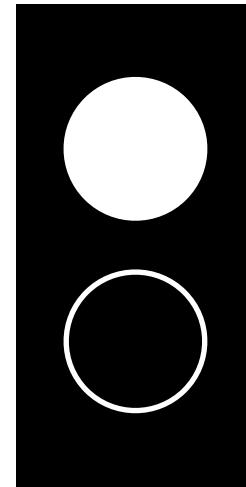


0
1
2
3
4
5
6
7
8
9

WHAT???
I GAVE YOU A 4!
WHAT ARE YOU
DOING?

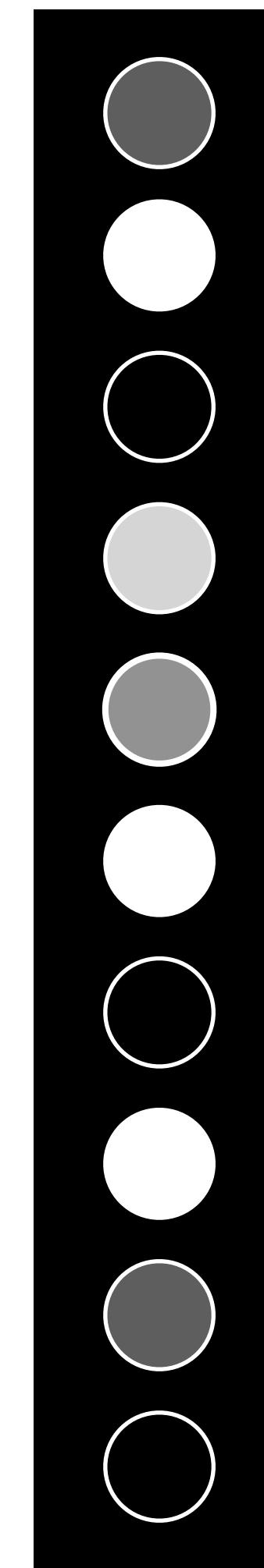


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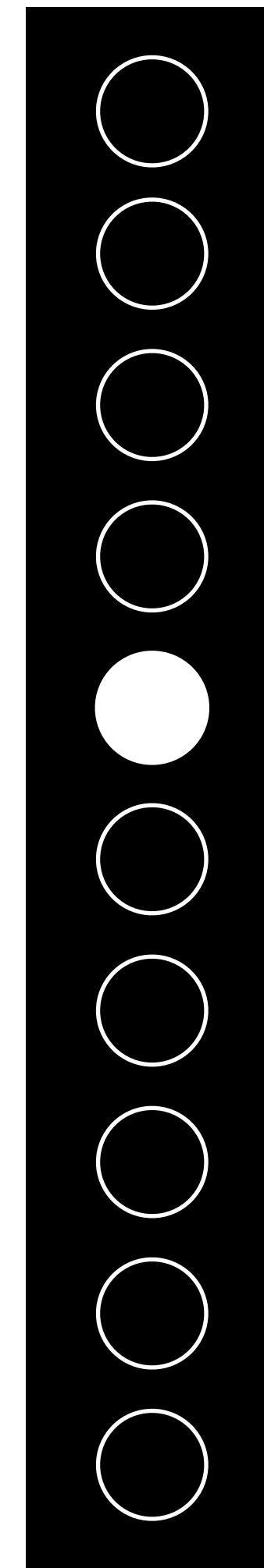
Activated

Not Activated



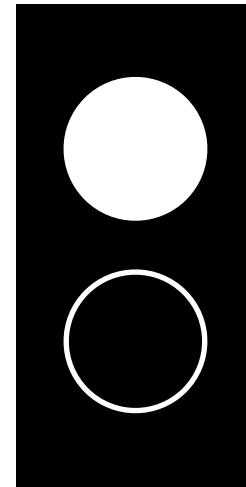
0
1
2
3
4
5
6
7
8
9

It should look like
this:



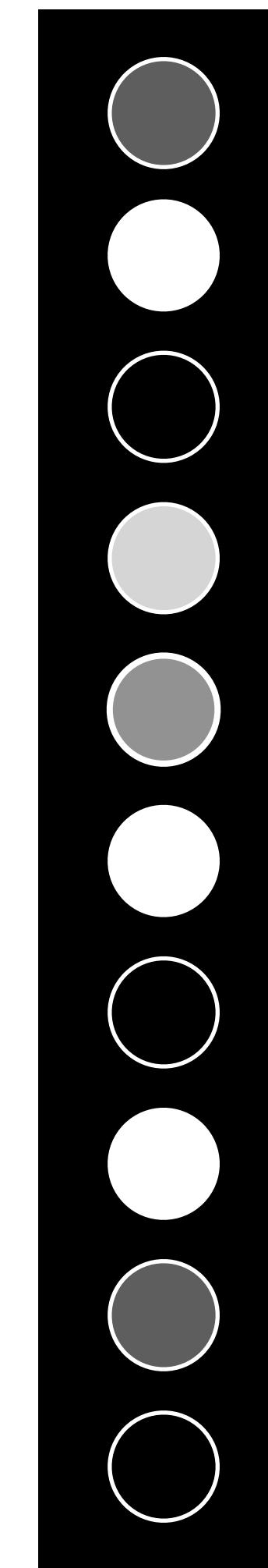
0
1
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Second step: Tell the computer that is doing it wrong



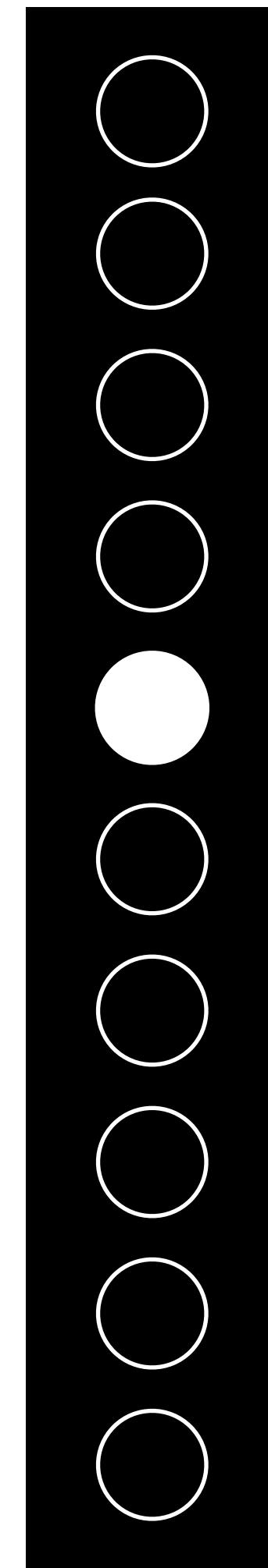
Activated

Not Activated



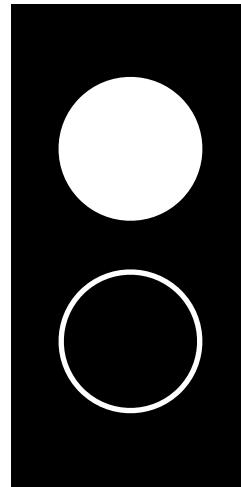
0
1
2
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8
9

What is the cost of
this difference?



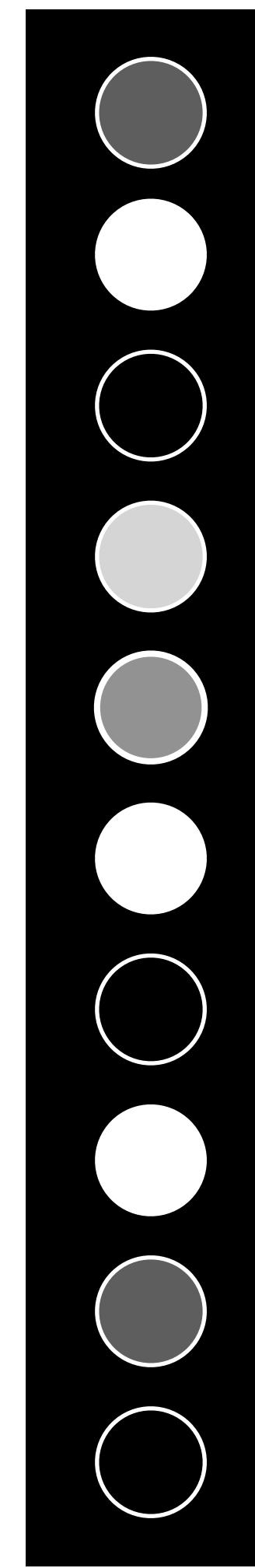
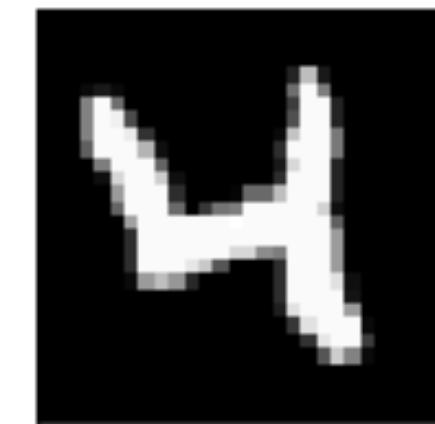
0
1
2
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4
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6
7
8
9

Second step: Tell the computer that is doing it wrong



Activated

Not Activated



0

1

2

3

4

5

6

7

8

9

What is the cost of
this difference?

$$(0.5 - 0)^2$$

$$(0.25 - 1)^2$$

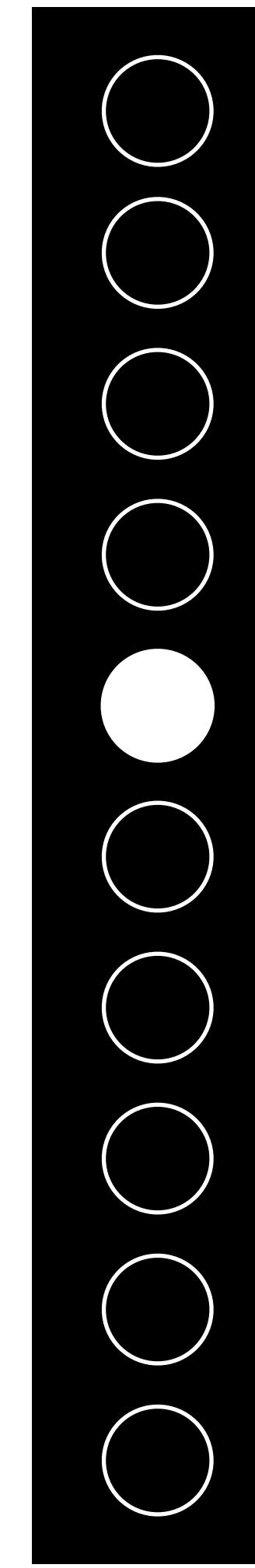
$$(1 - 0)^2$$

.

.

.

Cost small when
classification is good bad
large when it is bad



0

1

2

3

4

5

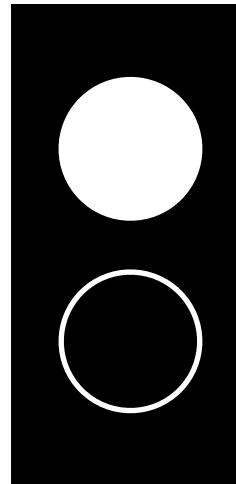
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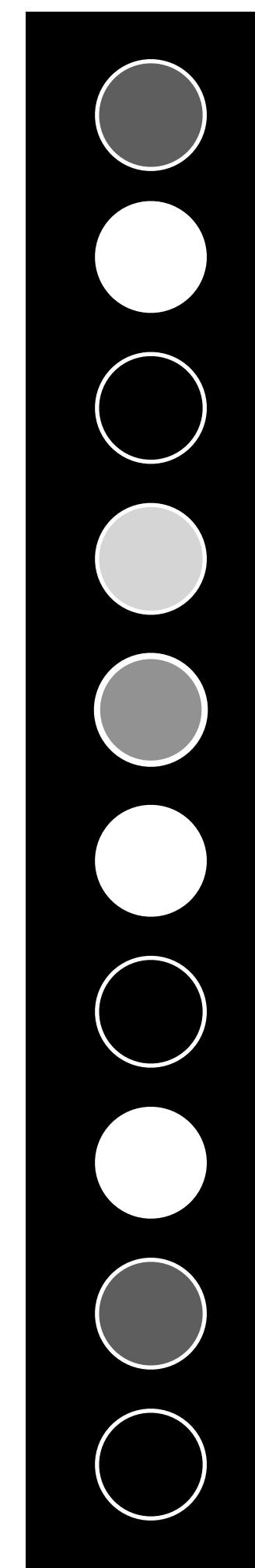
9

Second step: Tell the computer that is doing it wrong



Activated

Not Activated



0

1

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What is the cost of
this difference?

$$(0.5 - 0)^2$$

$$(0.25 - 1)^2$$

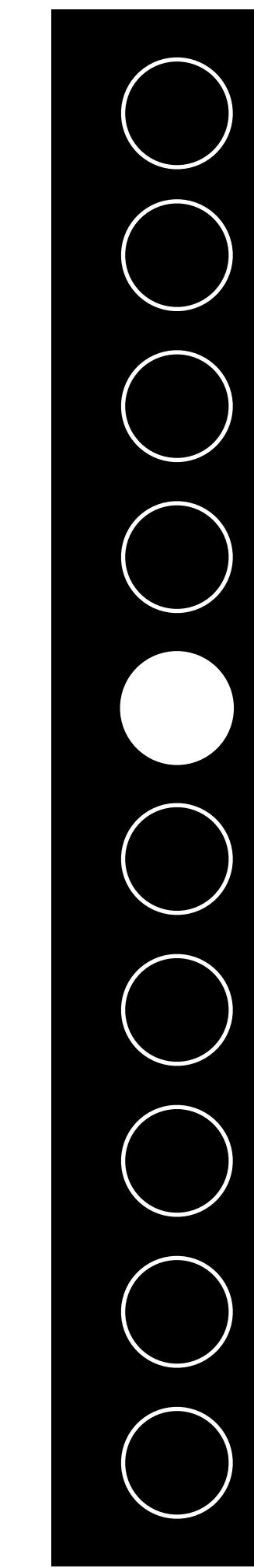
$$(1 - 0)^2$$

.

.

.

Cost small when
classification is good
large when it is bad



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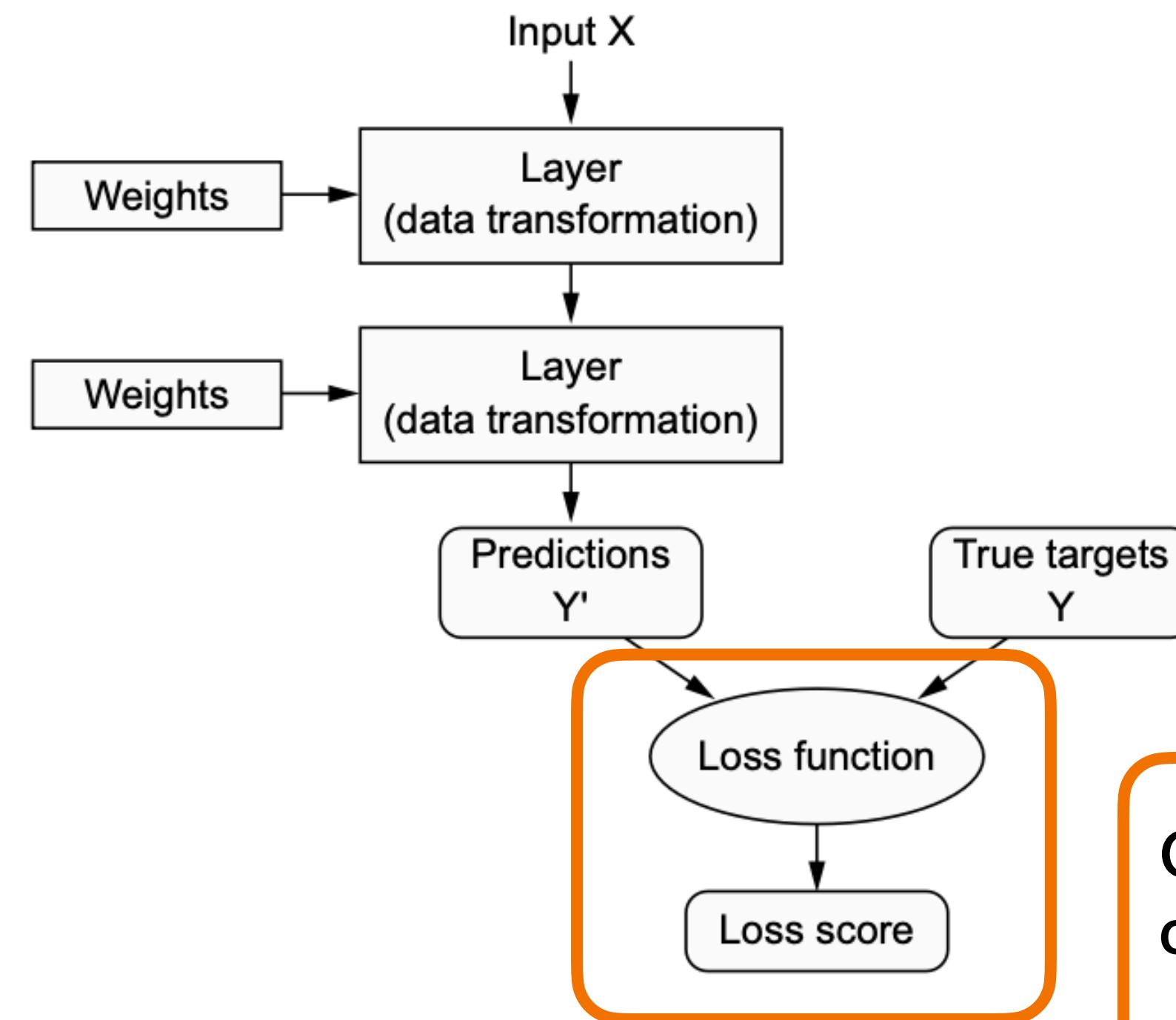
8

9

Average cost of all
the training
examples. How bad
the network should
feel about its
performance

Small Recap: We found a number to tell how the model is doing

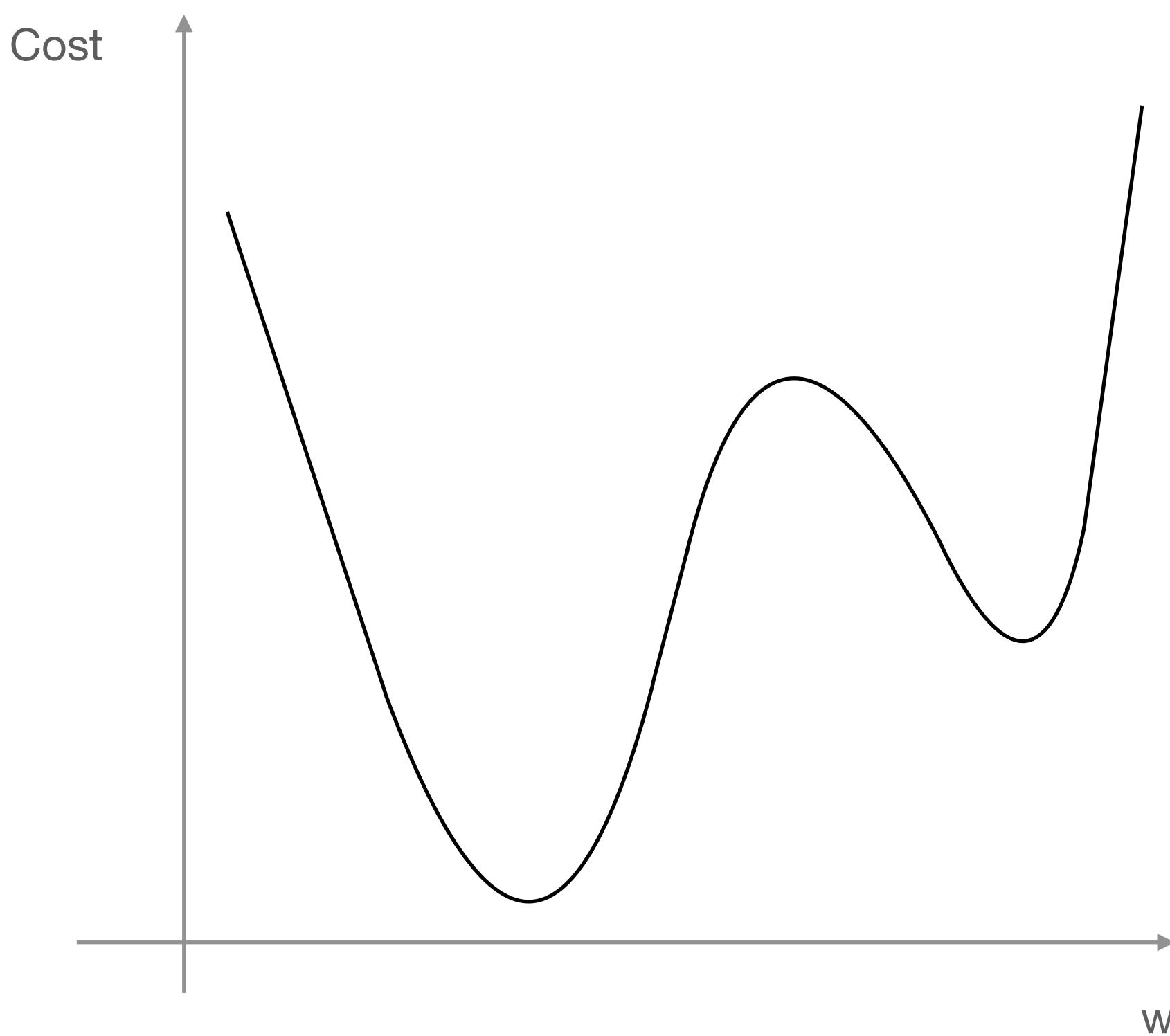
Forward Pass



Compute the average cost of all the training examples. How bad the network should feel about its performance

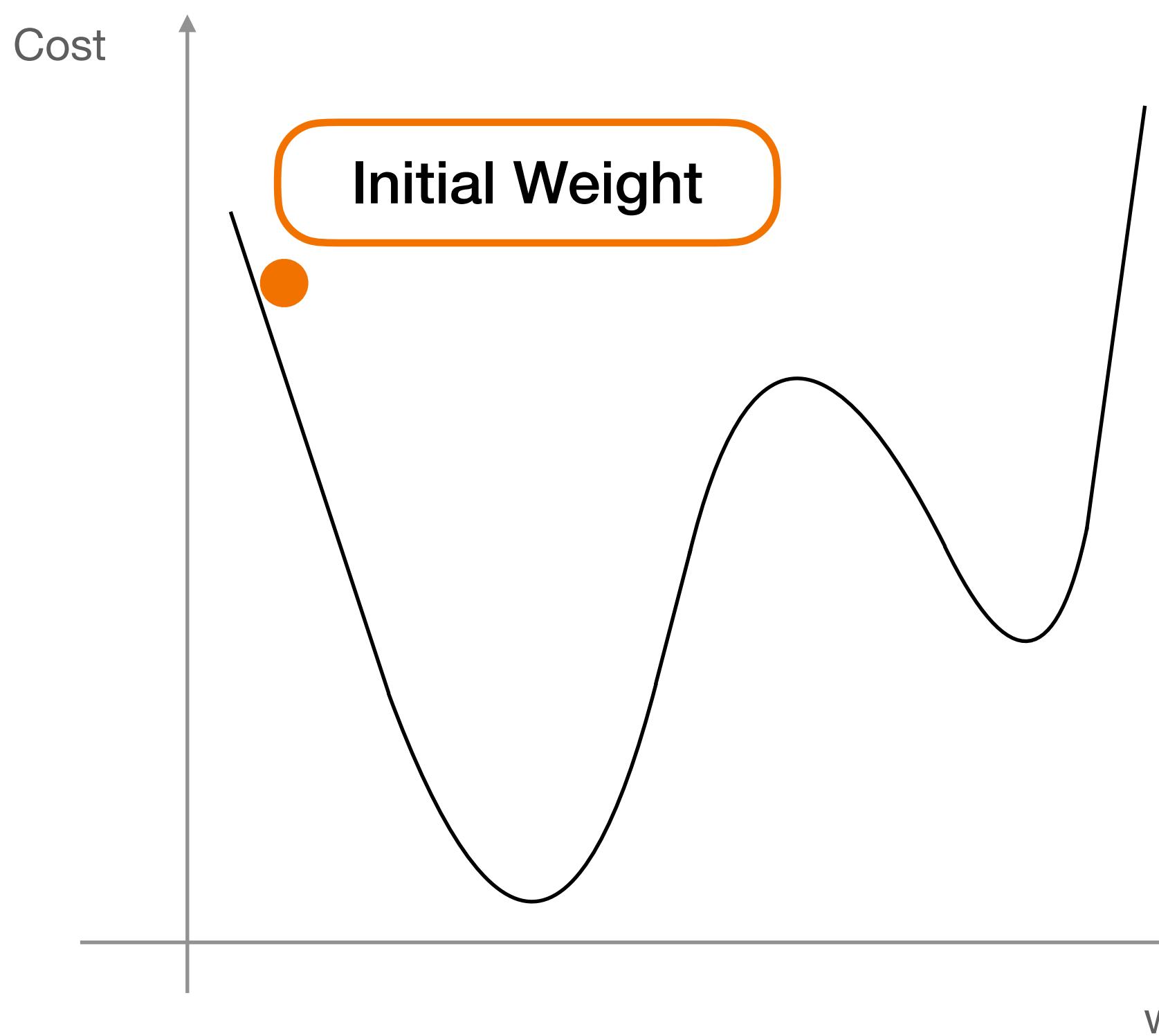
How do we propagate this cost backwards?

First, we need to look at the cost function



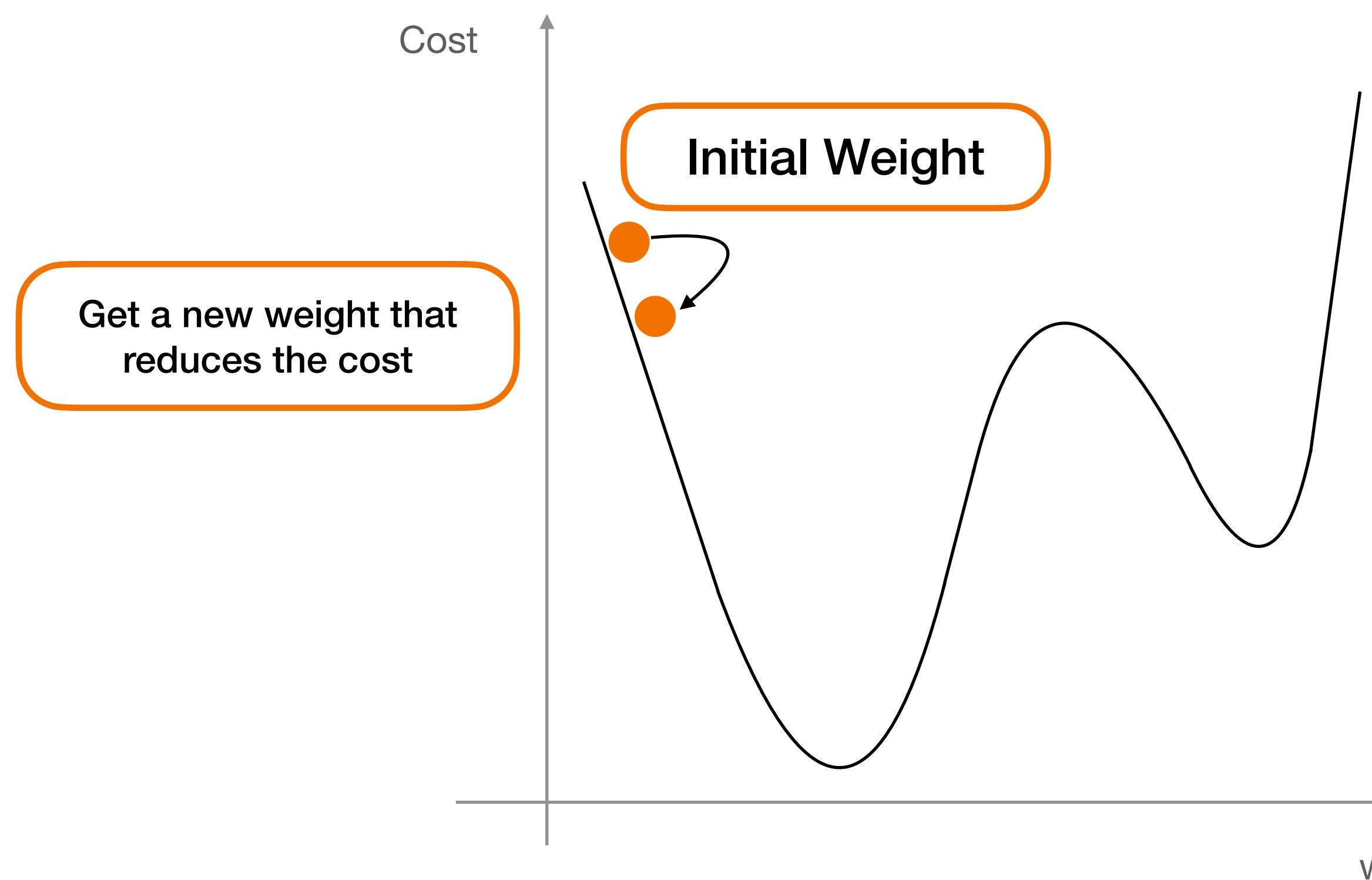
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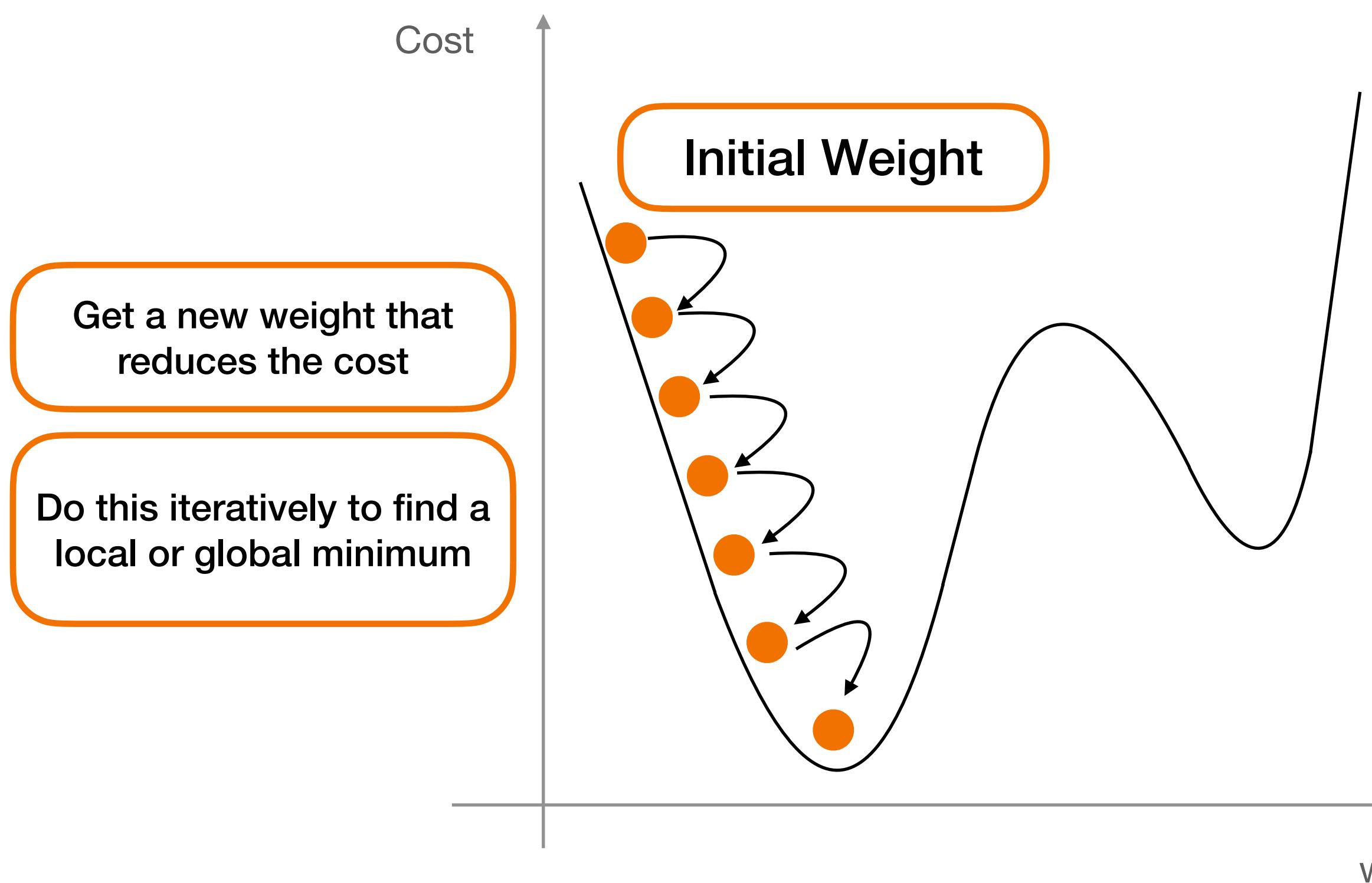
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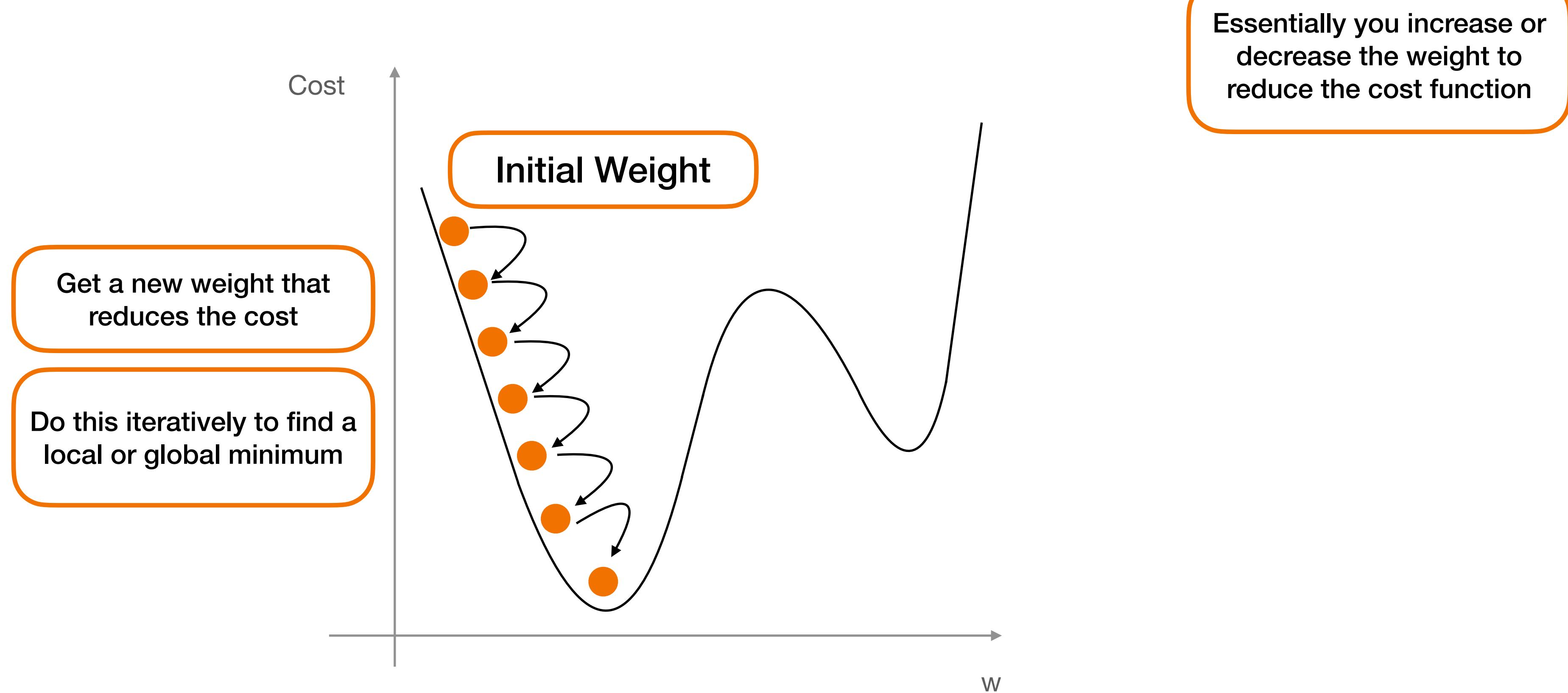
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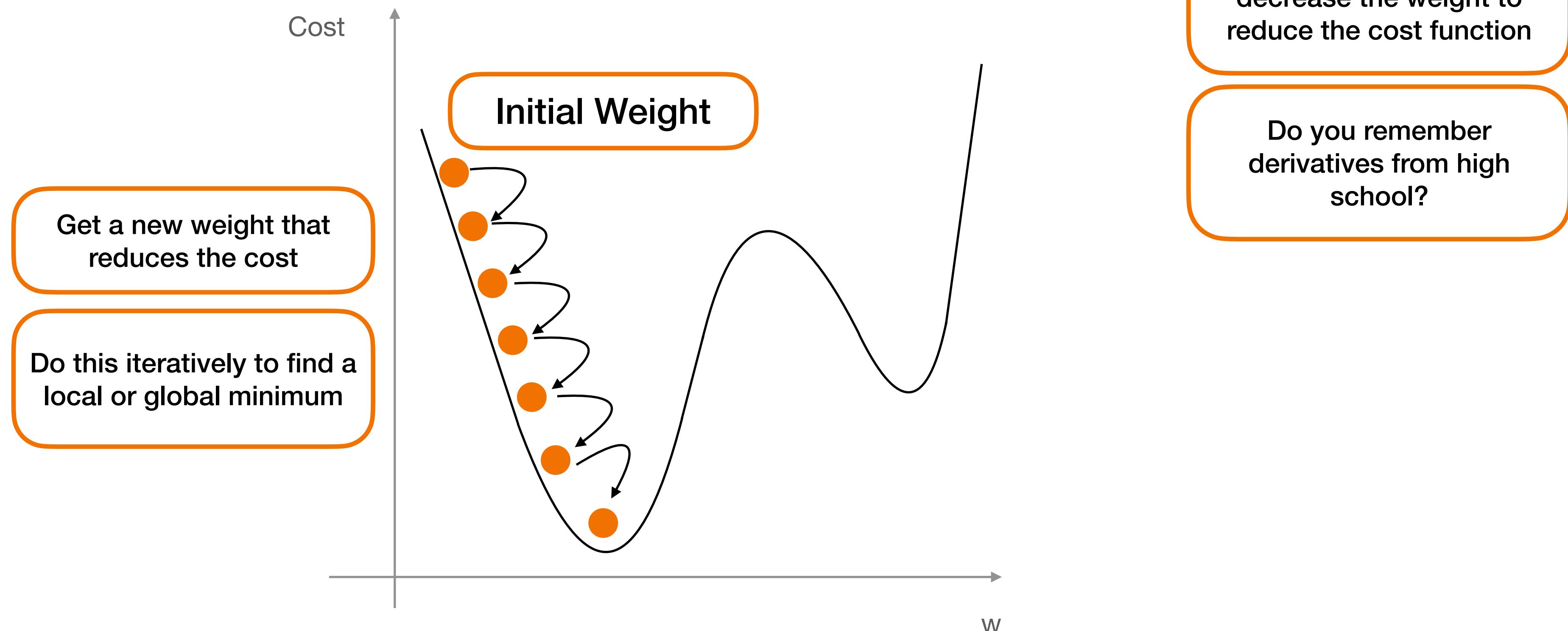
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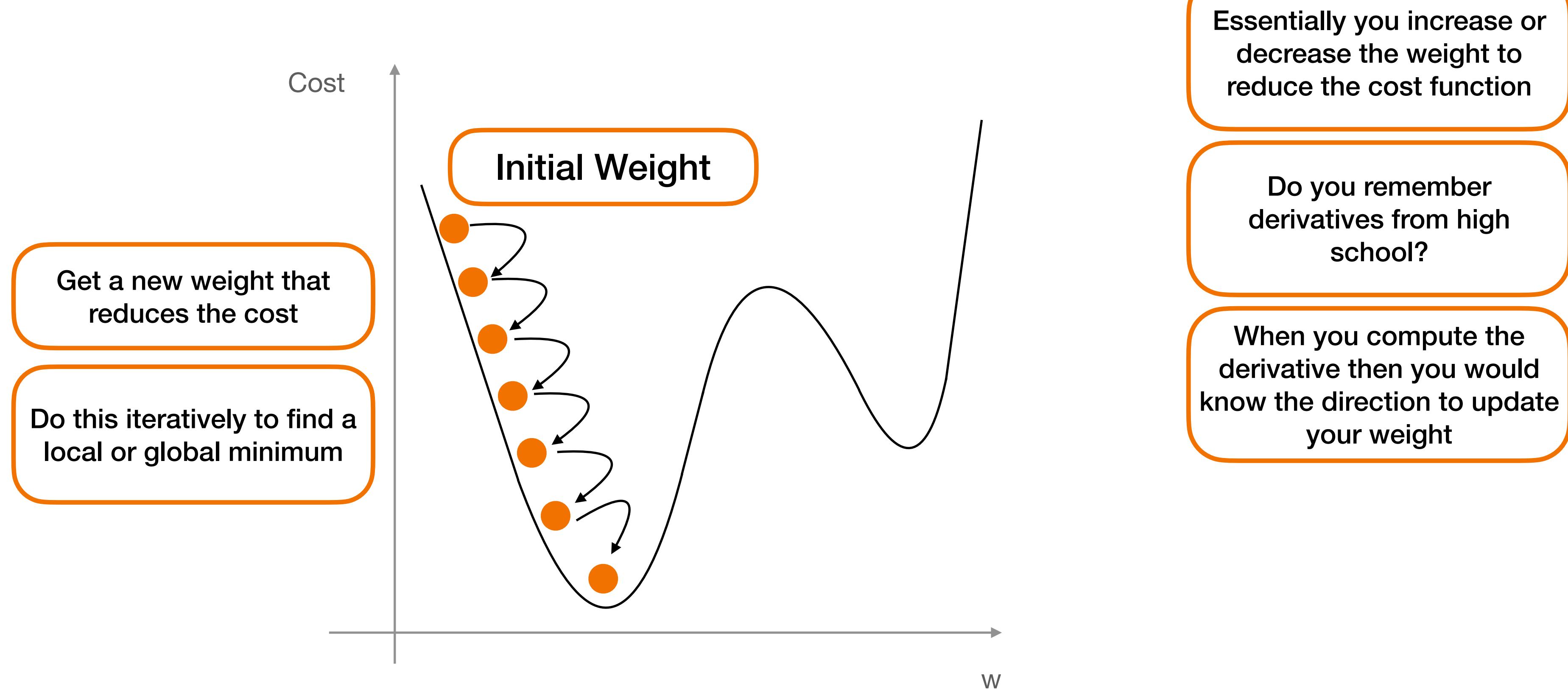
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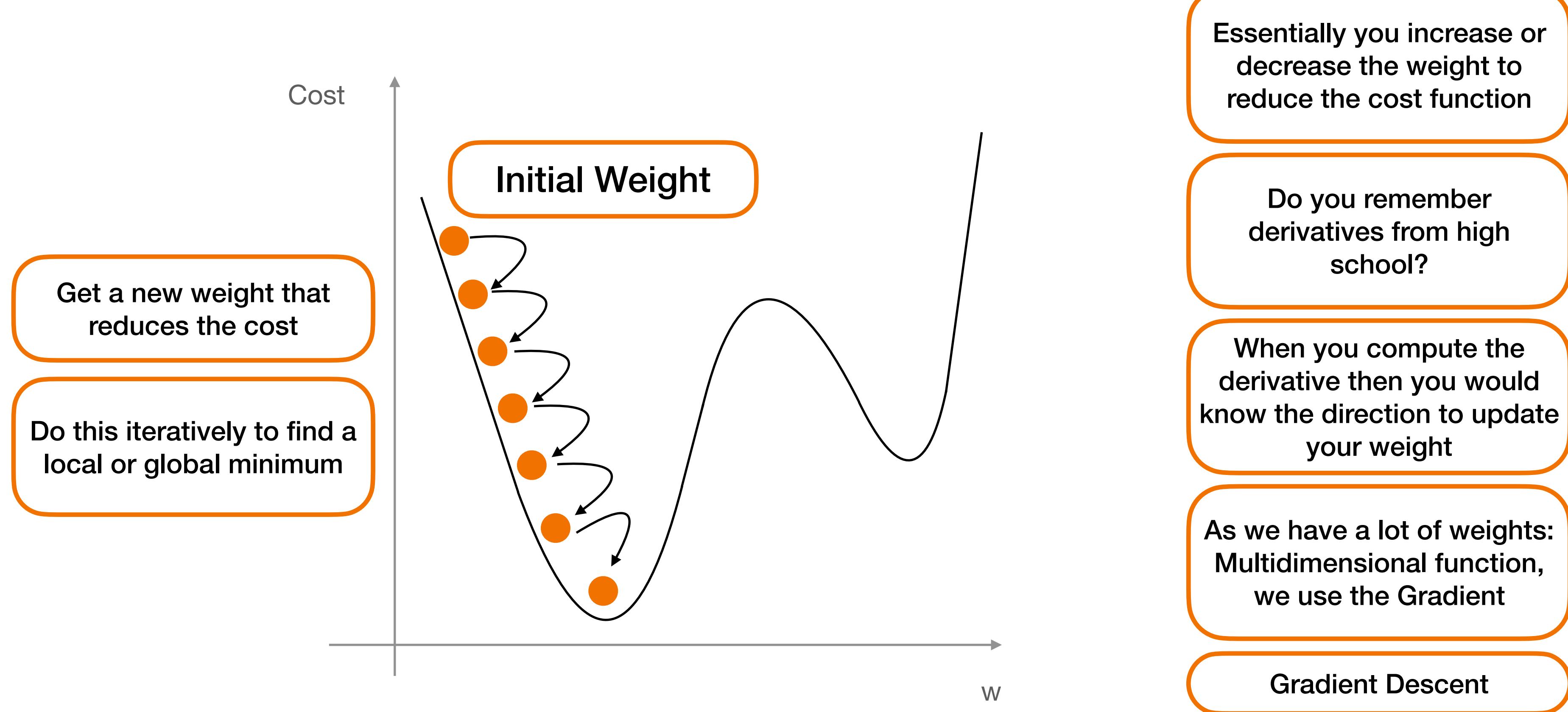
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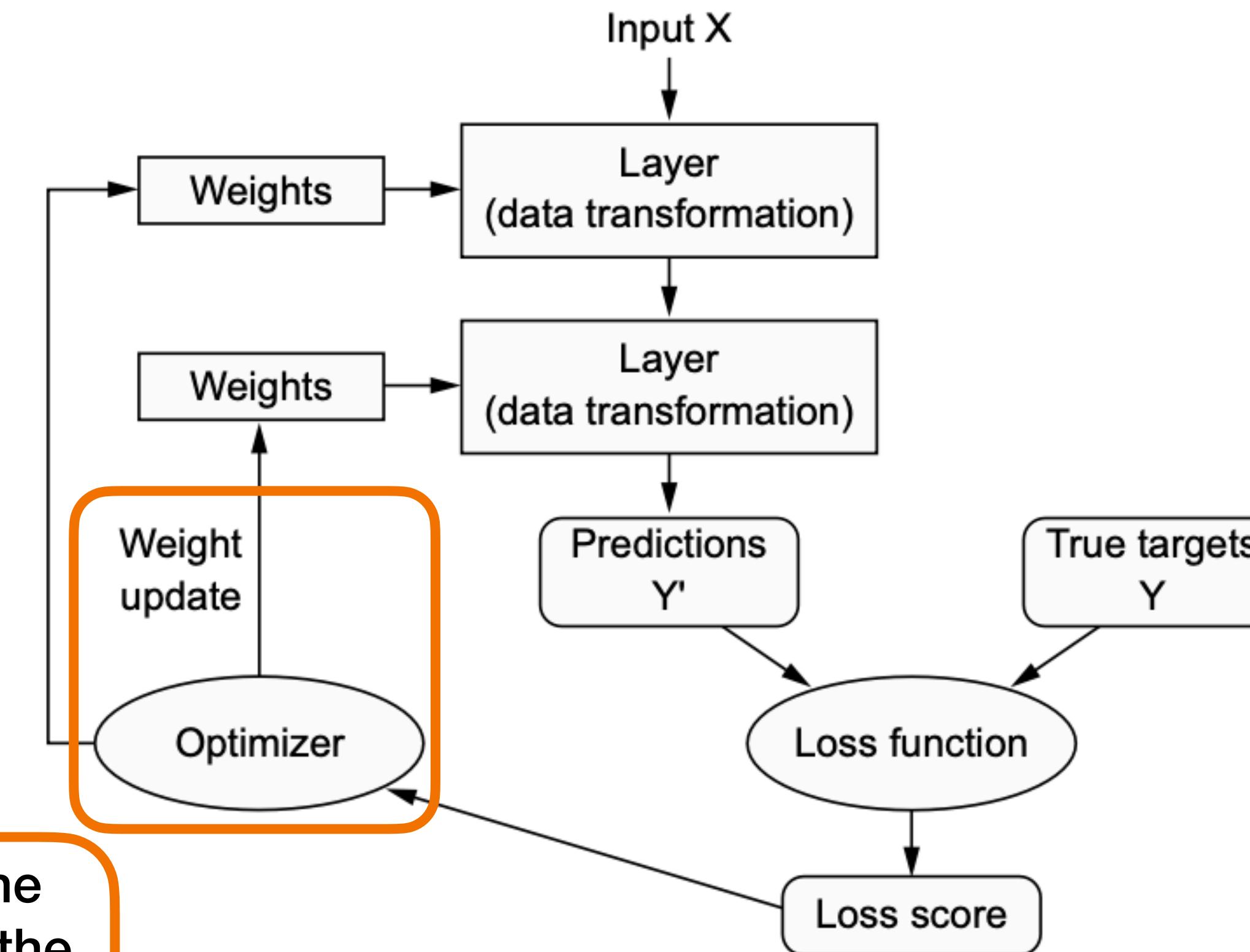
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First, we need to look at the cost function



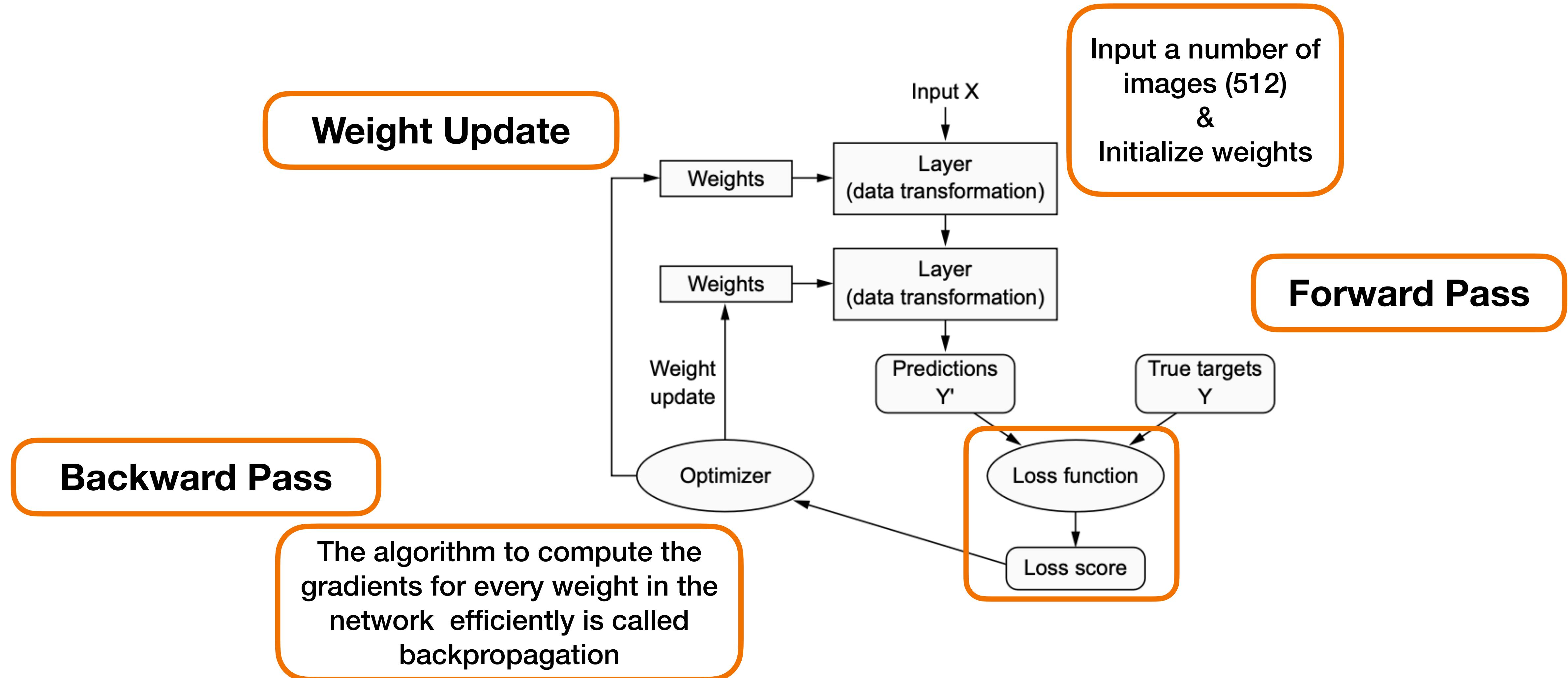
How do we propagate this cost backwards?

Backward Pass & Weight Update



The algorithm to compute the gradients for every weight in the network efficiently is called backpropagation

In reality: Stochastic Gradient Descent





Introduction to Keras. The MNIST dataset

What is Keras?

Keras building blocks: Layers

Keras building blocks: Compile

Keras building blocks: Fit

Keras building blocks: Fit

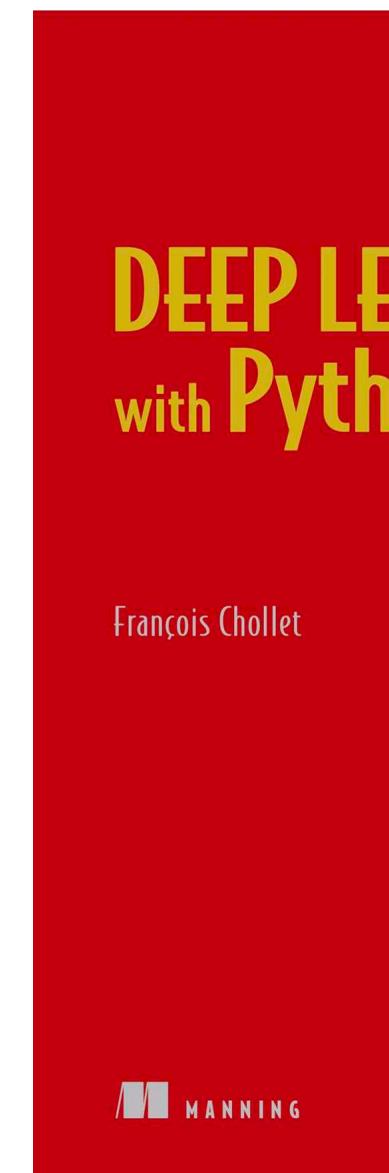
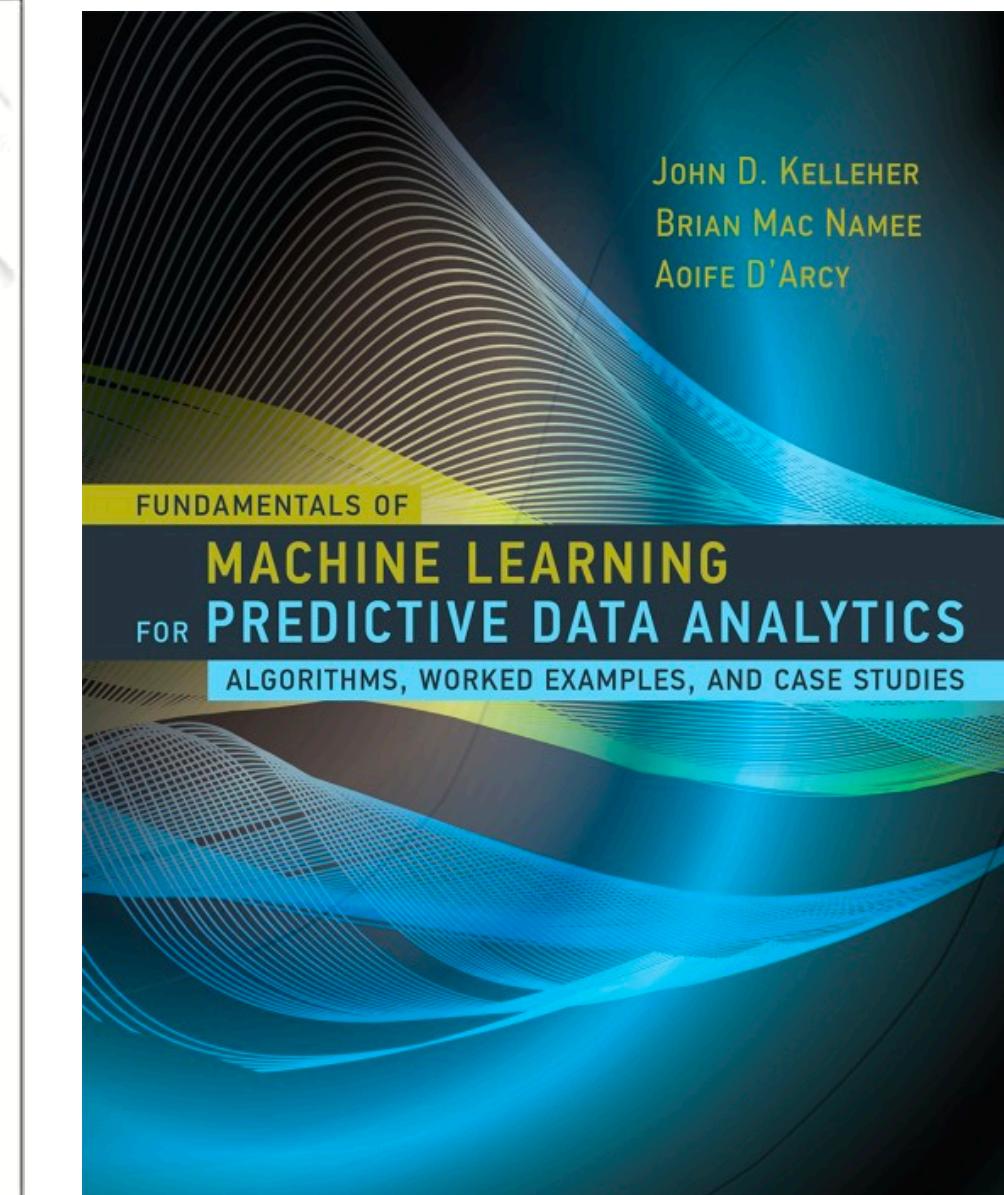
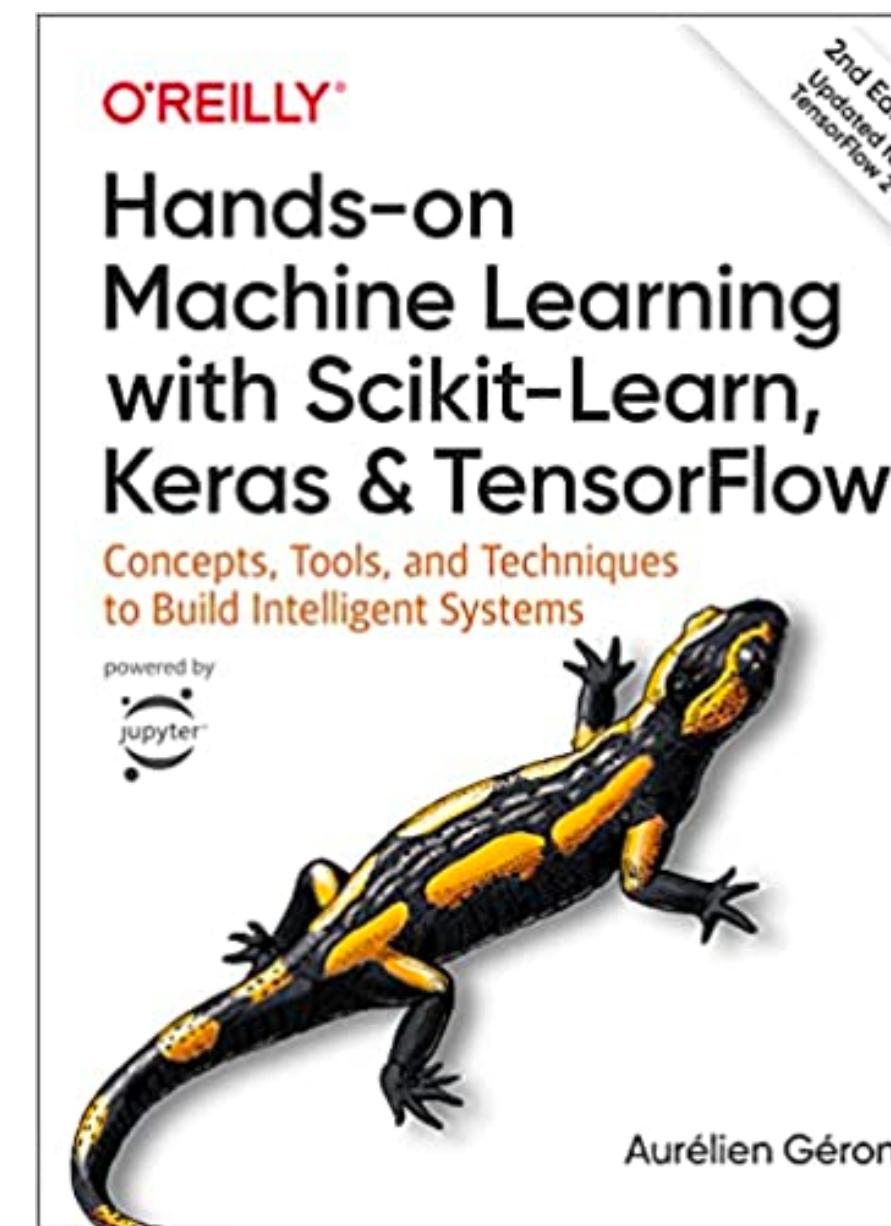
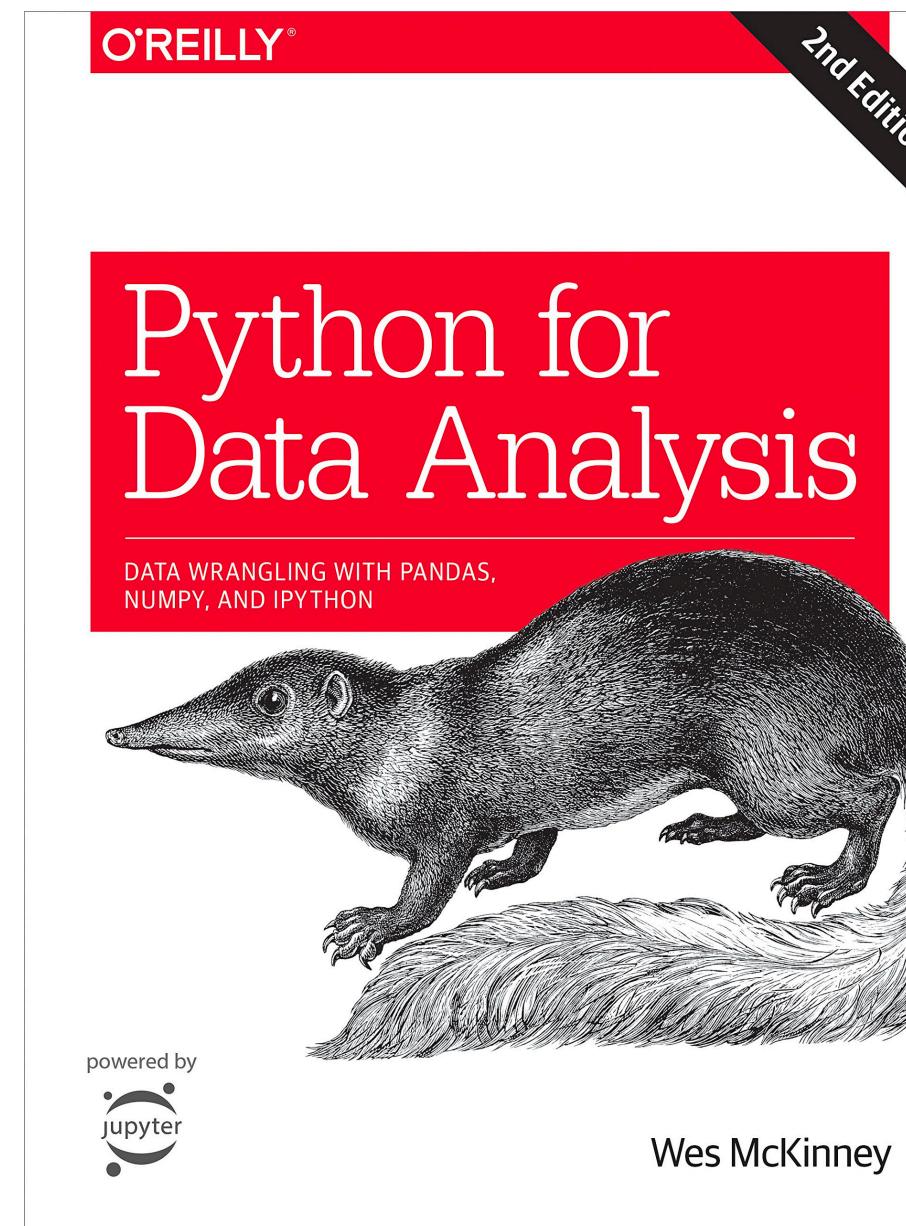


Types of Neural Networks and their applications



Last words

Free Books to learn Python, ML & DL



You are in the right place at the right moment (My Opinion)

- Analytical skills are in demand
- Companies need people who can make sense of their data and give them an edge with that.
- AI, ML, and DL are booming, and being able to apply such techniques will be increasingly important
- Math knowledge is not “strictly” necessary, instead having a general understanding and being able to build solutions on the cloud will be the key to the future (my take)
- ML engineer / Data engineer > Data Scientist



Thank you!



Feel Free to contact me!

- Linkedin: Jose Bonet Giner
- Personal mail: pepebogi5@gmail.com
- Company website: hyntsanalytics.com
- Blog: pepesjourney.com
- Twitter: [pepeb_5](https://twitter.com/pepeb_5)

The hynts logo consists of the word "hynts" in a lowercase sans-serif font. The letter "n" has a small orange dot positioned above its middle vertical stroke.