



ARTIFICIAL NEURAL NETWORKS

HOW DO THEY WORK?

HOW NEURAL NETWORKS WORK

THOUGHT EXPERIMENT

CREDITS: I stole this example from the wonderful book "You Look Like a Thing and I Love You: How Artificial Intelligence Works and Why It's Making the World a Weirder Place" by Janelle Shane.

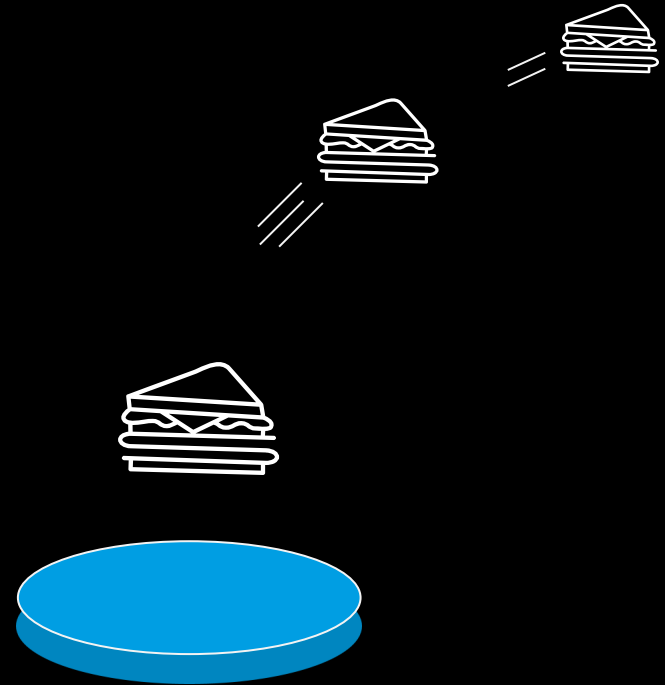
2

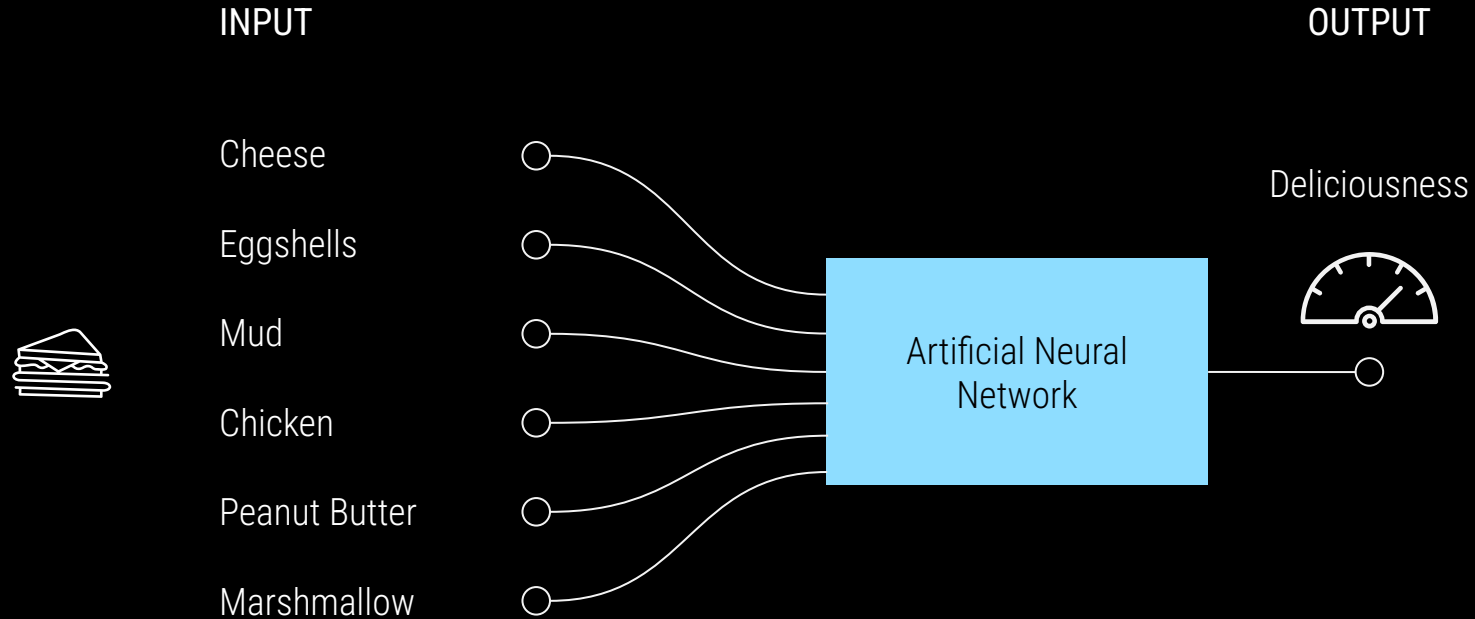
A [magic sandwich hole](#) spits out random sandwiches with a finite set of possible ingredients:

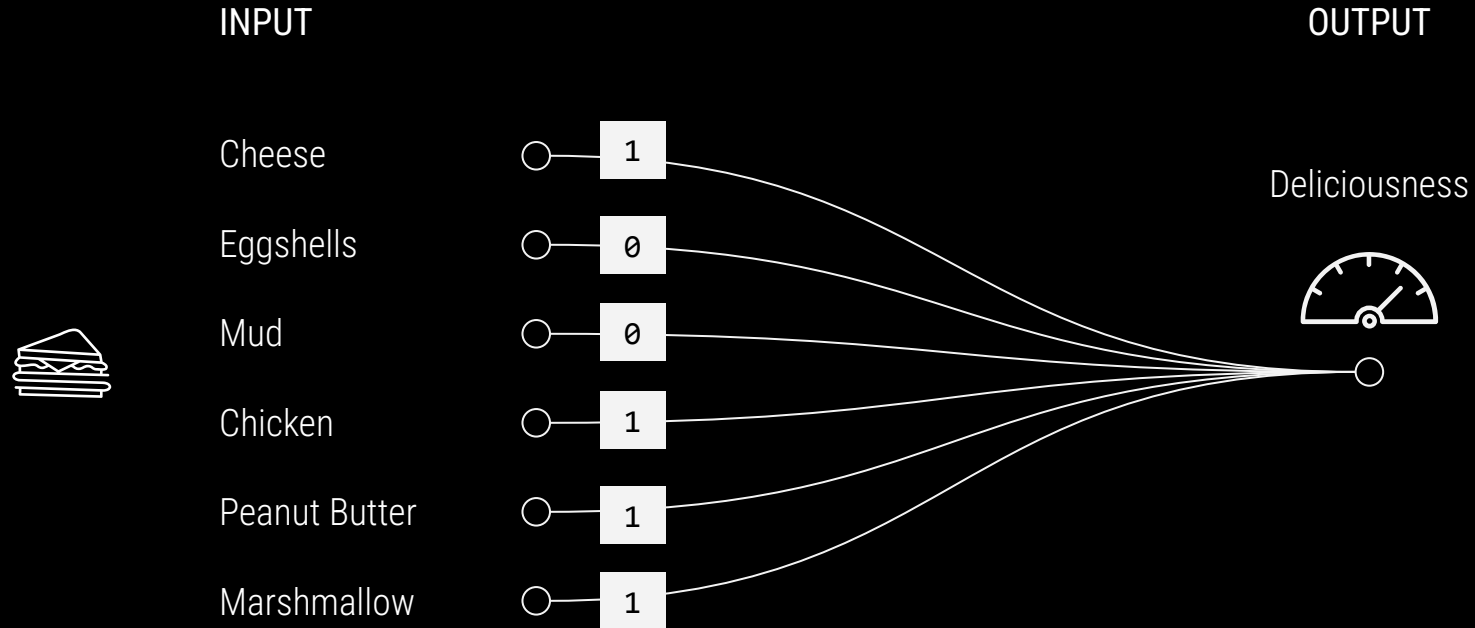
- Cheese
- Eggshells
- Mud
- Chicken
- Peanut Butter
- Marshmallow

Only 1 in 1000 is actually good - but really, really good.

We want to train a neural network to identify the delicious ones!







HOW NEURAL NETWORKS WORK

EGGSHELLS AND MUD?

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INPUT

Cheese

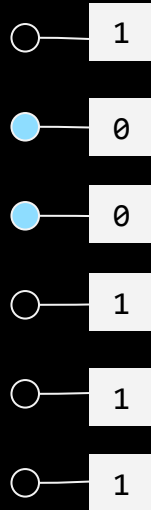
Eggshells

Mud

Chicken

Peanut Butter

Marshmallow



OUTPUT

Deliciousness



= 0

Great :-)

HOW NEURAL NETWORKS WORK

PEANUT BUTTER AND
MARSHMALLOW?

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INPUT

Cheese

Eggshells

Mud

Chicken

Peanut Butter

Marshmallow

○ 1

○ 0

○ 0

○ 1

● 1

● 1

OUTPUT

Deliciousness



= 2

Great :-)

HOW NEURAL NETWORKS WORK

CHEESE AND MARSHMALLOW?

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INPUT

Cheese

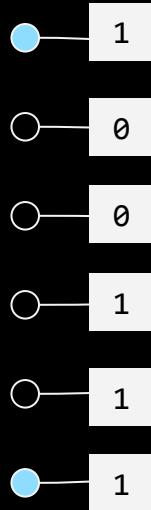
Eggshells

Mud

Chicken

Peanut Butter

Marshmallow



OUTPUT

Deliciousness



= 2

Really :-)



INPUT

Cheese



Eggshells



Mud



Chicken



Peanut Butter



Marshmallow



OUTPUT

Deliciousness



= 4

Really ???



INPUT

Cheese

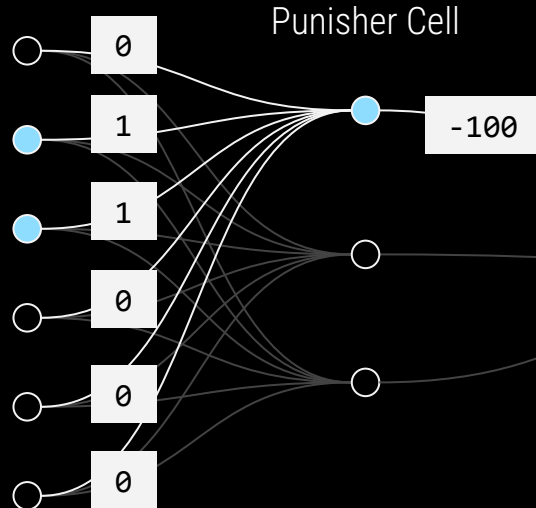
Eggshells

Mud

Chicken

Peanut Butter

Marshmallow



OUTPUT

Deliciousness



$$(1 + 1) * -100 = -200$$

Better :-)

HOW NEURAL NETWORKS WORK

THE DELI SANDWICH CELL

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INPUT

Cheese

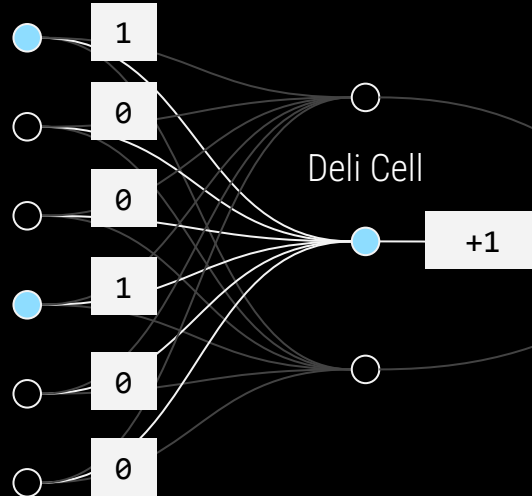
Eggshells

Mud

Chicken

Peanut Butter

Marshmallow



OUTPUT

Deliciousness

$$(1 + 1) * 1 = 2$$

HOW NEURAL NETWORKS WORK

PUNISH CERTAIN COMBOS

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INPUT

Cheese

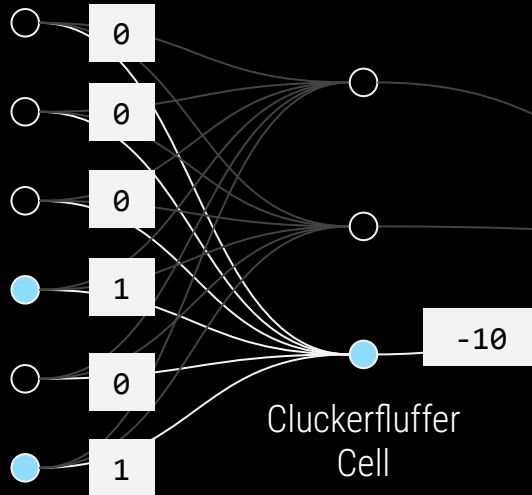
Eggshells

Mud

Chicken

Peanut Butter

Marshmallow



OUTPUT

Deliciousness

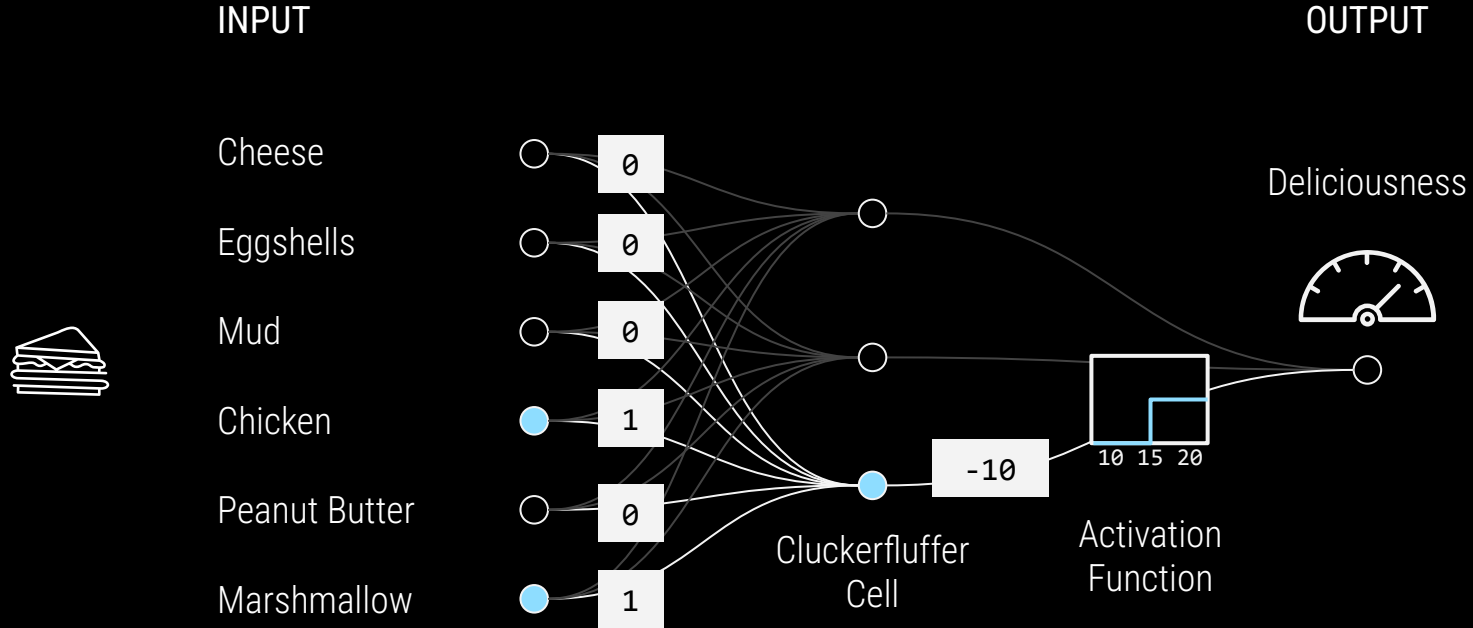


$$(1 + 1) * -10 = -20$$

HOW NEURAL NETWORKS WORK

THE ACTIVATION FUNCTION

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HOW NEURAL NETWORKS WORK

TRAINING THE NEURAL NETWORK

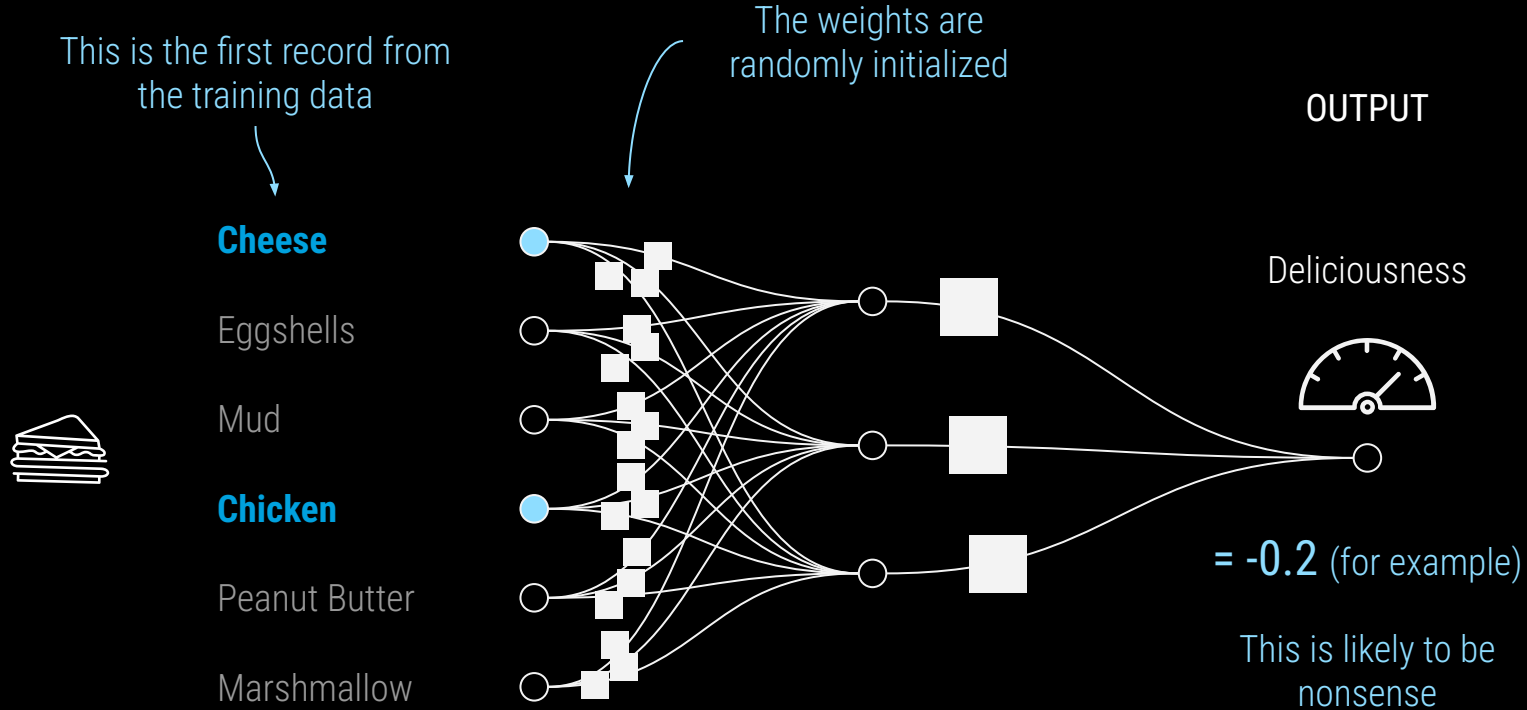
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Cheese	Eggshells	Mud	Chicken	Peanut Butter	Marshmallow	Delicious
1	0	0	1	0	0	9.5
0	1	1	0	0	0	0.0
1	0	1	0	1	0	0.5
1	0	0	0	0	0	6
0	0	0	0	1	1	8.9

HOW NEURAL NETWORKS WORK

TRAINING THE NEURAL NETWORK

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HOW NEURAL NETWORKS WORK

TRAINING THE NEURAL NETWORK

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The weights are adjusted gradually, so the network is more likely to predict the correct score next time



Cheese

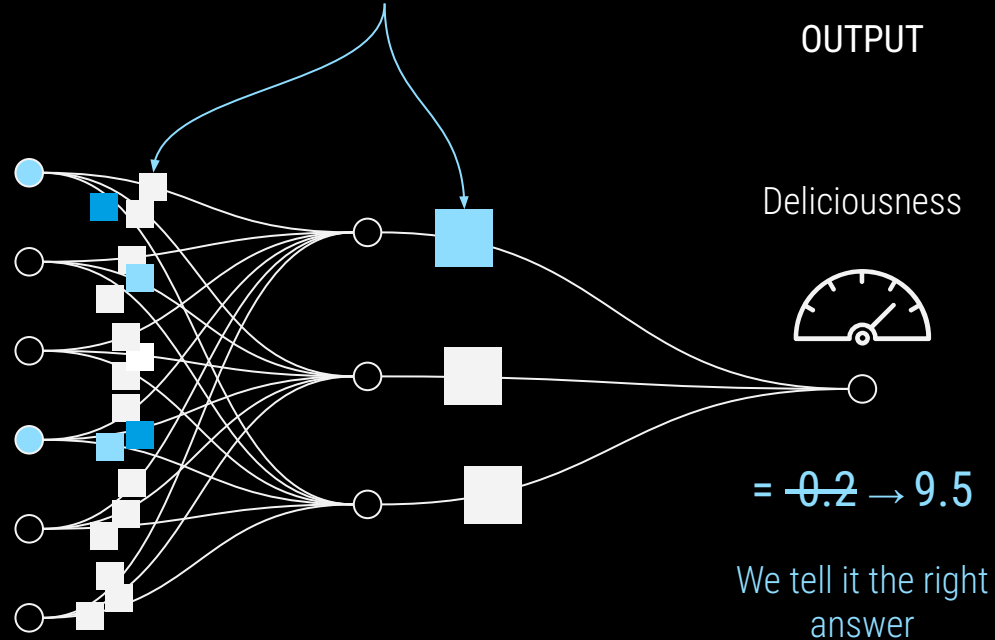
Eggshells

Mud

Chicken

Peanut Butter

Marshmallow

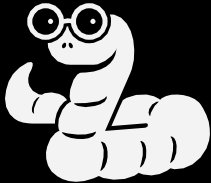


~~Researchers estimate ANNs could have as many neurons as a human brain by 2050 (~80 billion)~~

UPDATE: The GPT-3 neural network, released in May 2020, has **~170 billion** neurons.

UPDATE: GPT-4, released in March 2023, has ~1.2 trillion neurons.

UPDATE: GPT-5, released in August 2025, is estimated to have 2-5 trillion neurons.



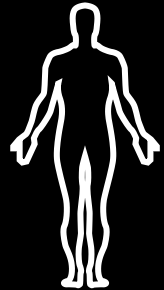
Modest sized ANNs have as many neurons as a worm's brain (~300)



Large ANNs come close to the number of neurons a bee's brain has (~170.000)



The largest ANNs have about the size of a frog's brain (16 million neurons)



A human brain has about 86 billion neurons

Neural Networks

