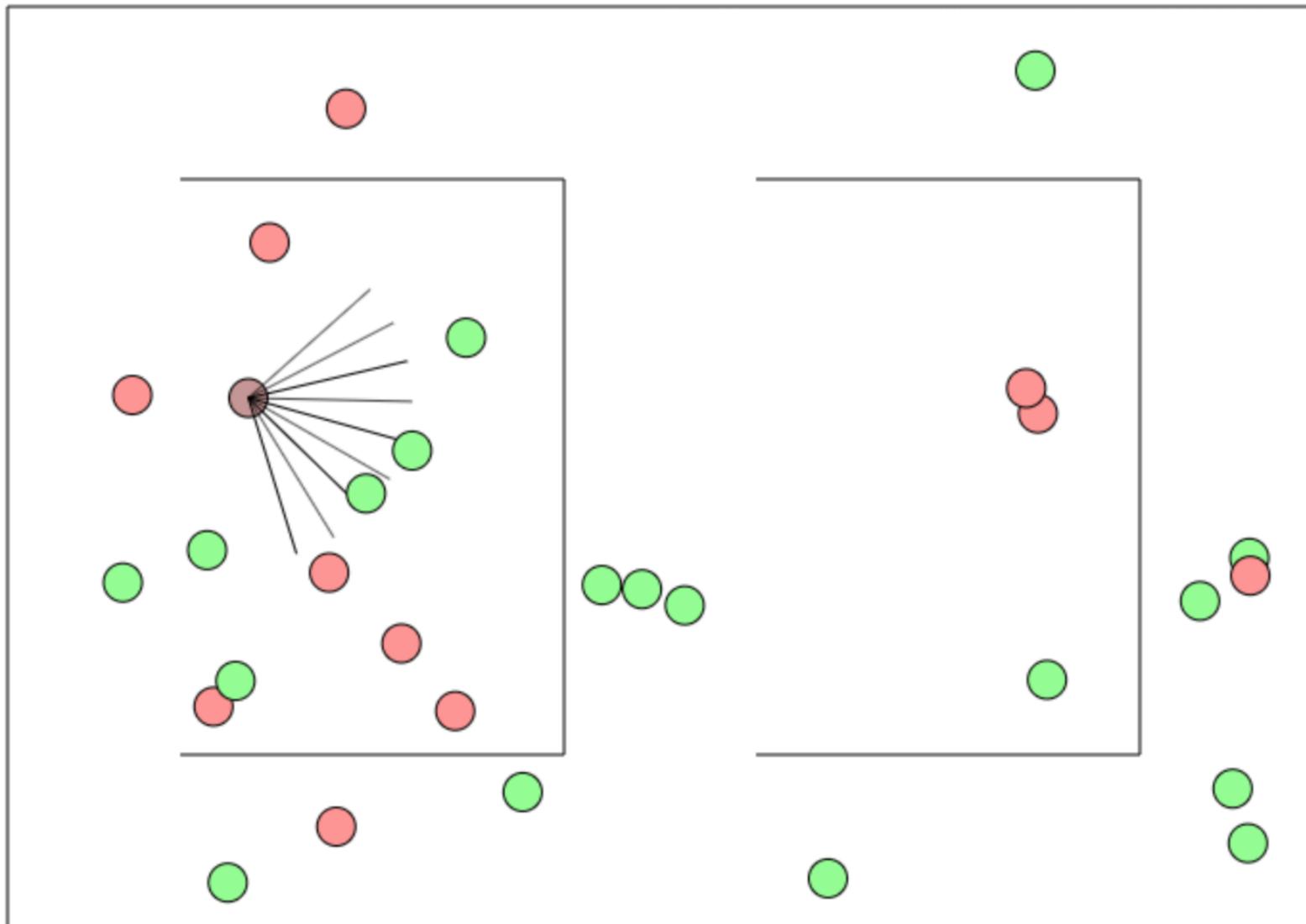




# Artificial Intelligence

Chris Piech  
CSBridge 2020

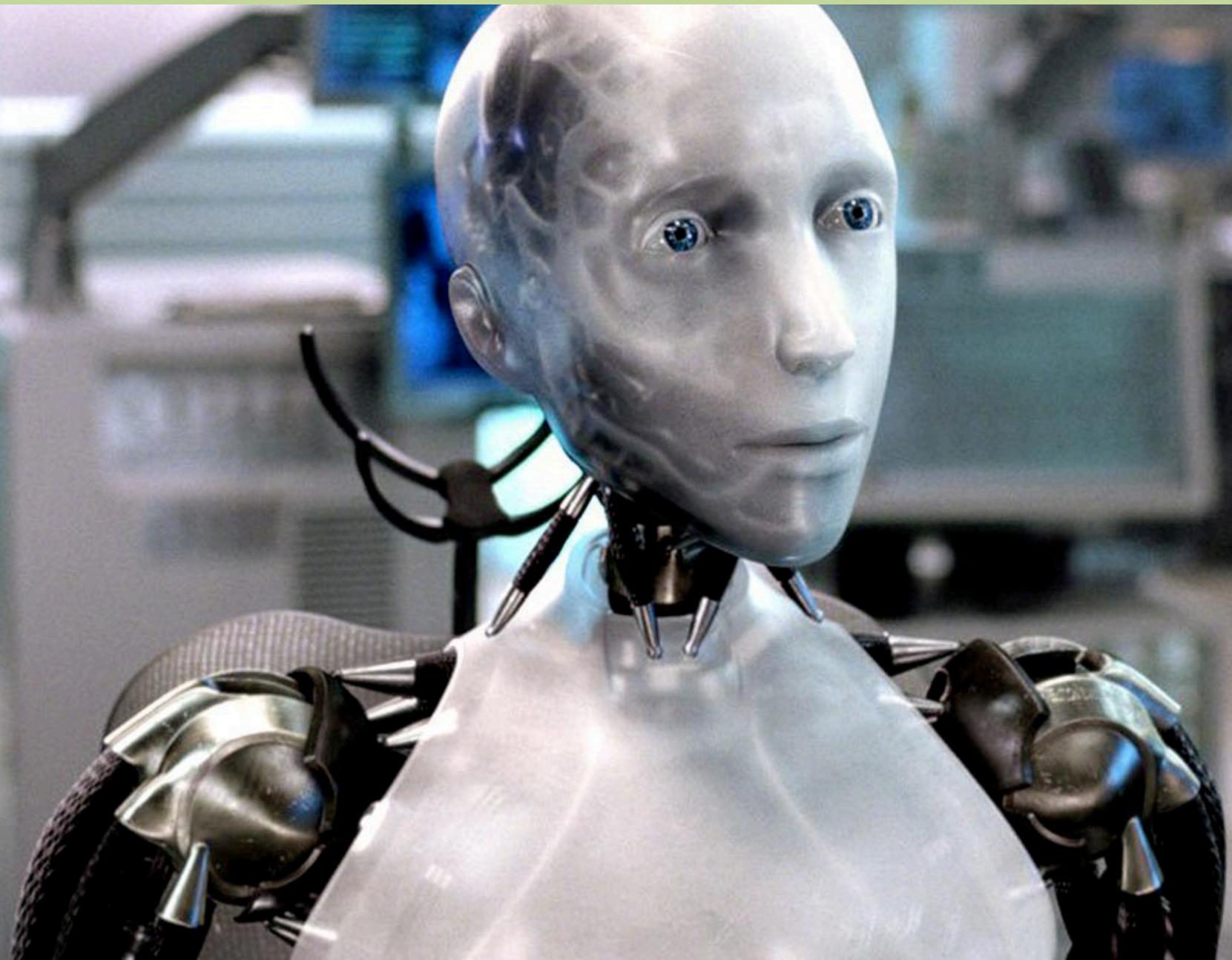
# A Little AI



Something big is happening  
in the world of AI...

Where is my robot?

# Sci-Fi Has Promised Me Robots



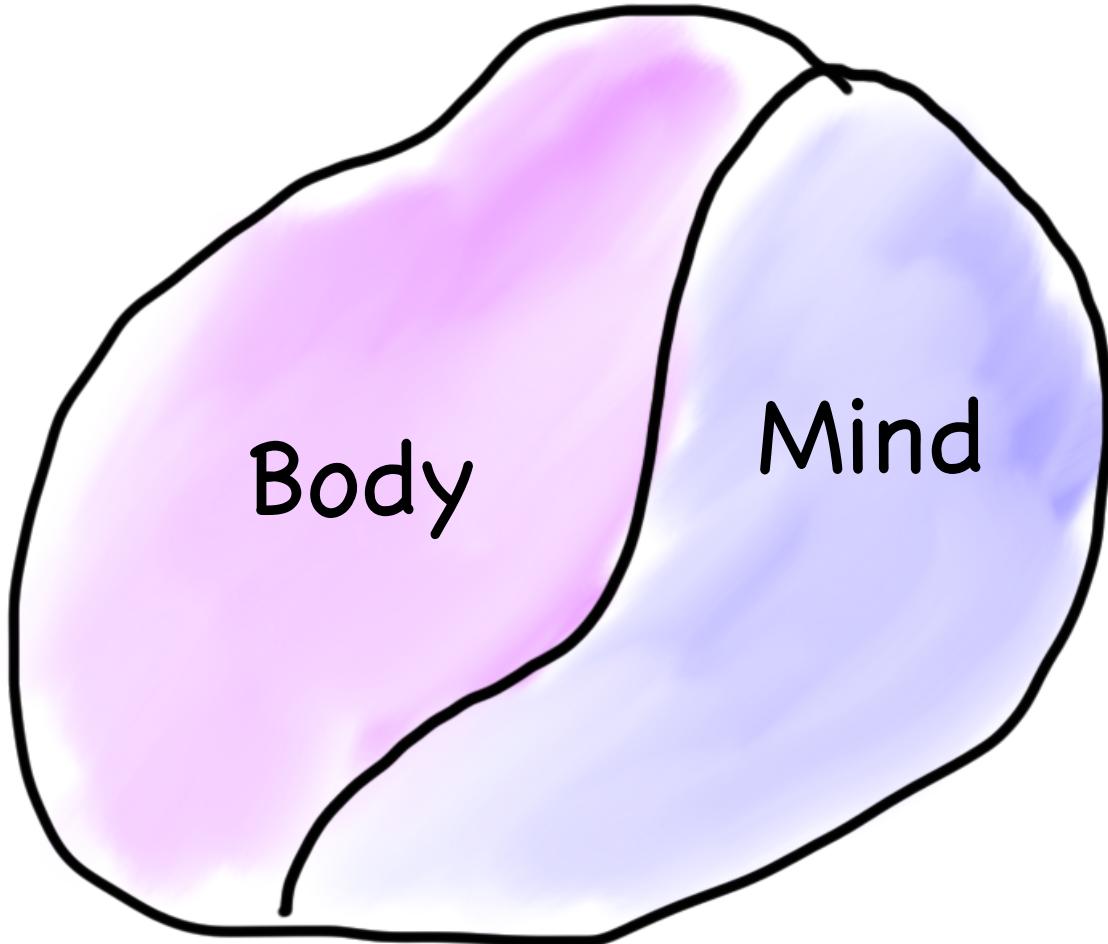
# House Cleaning Robot



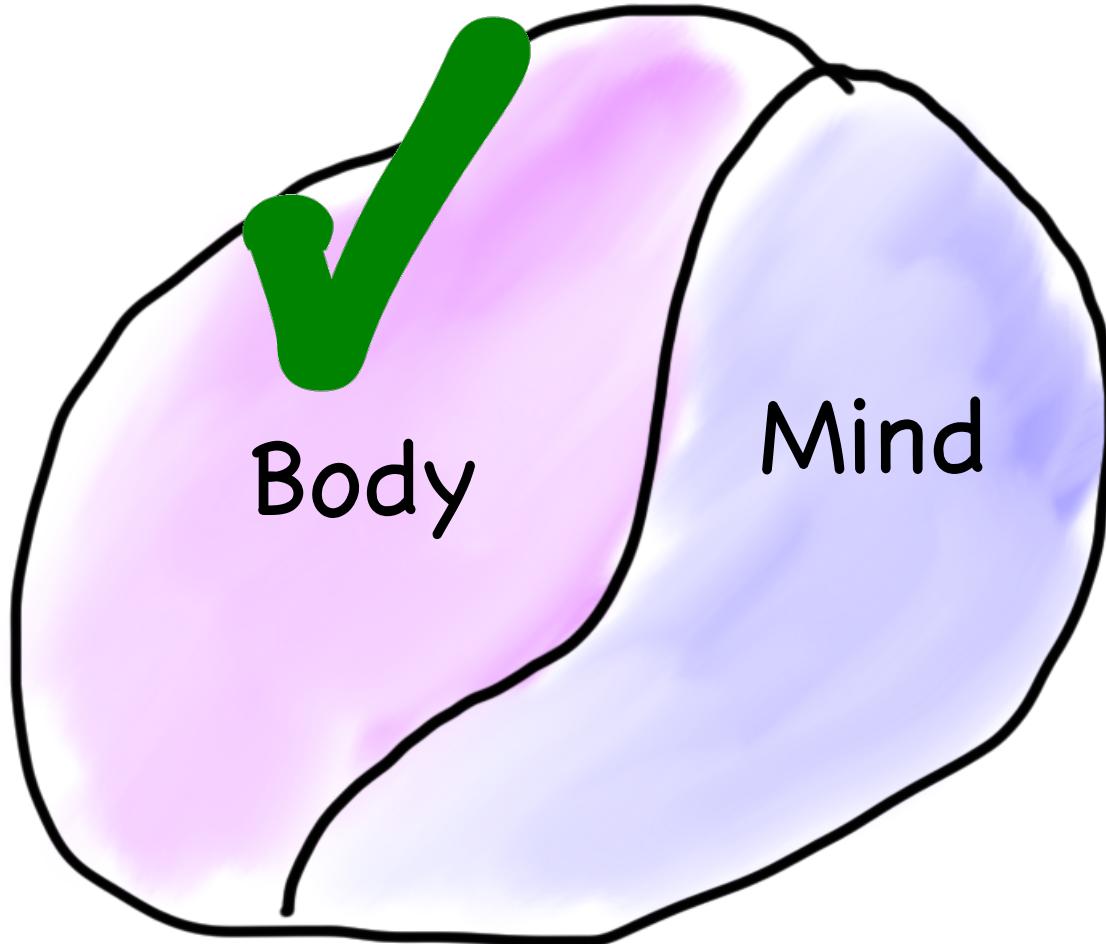
# House Cleaning Robot



# Robots?



# Robots?



# What is AI?

[suspense]

# AI: The study and design of intelligent **agents**



# Volunteer



Computer  
programs

# AI: The study and design of intelligent **agents**

Better than  
chance

As well as  
humans



# Narrow Intelligence

Play Chess

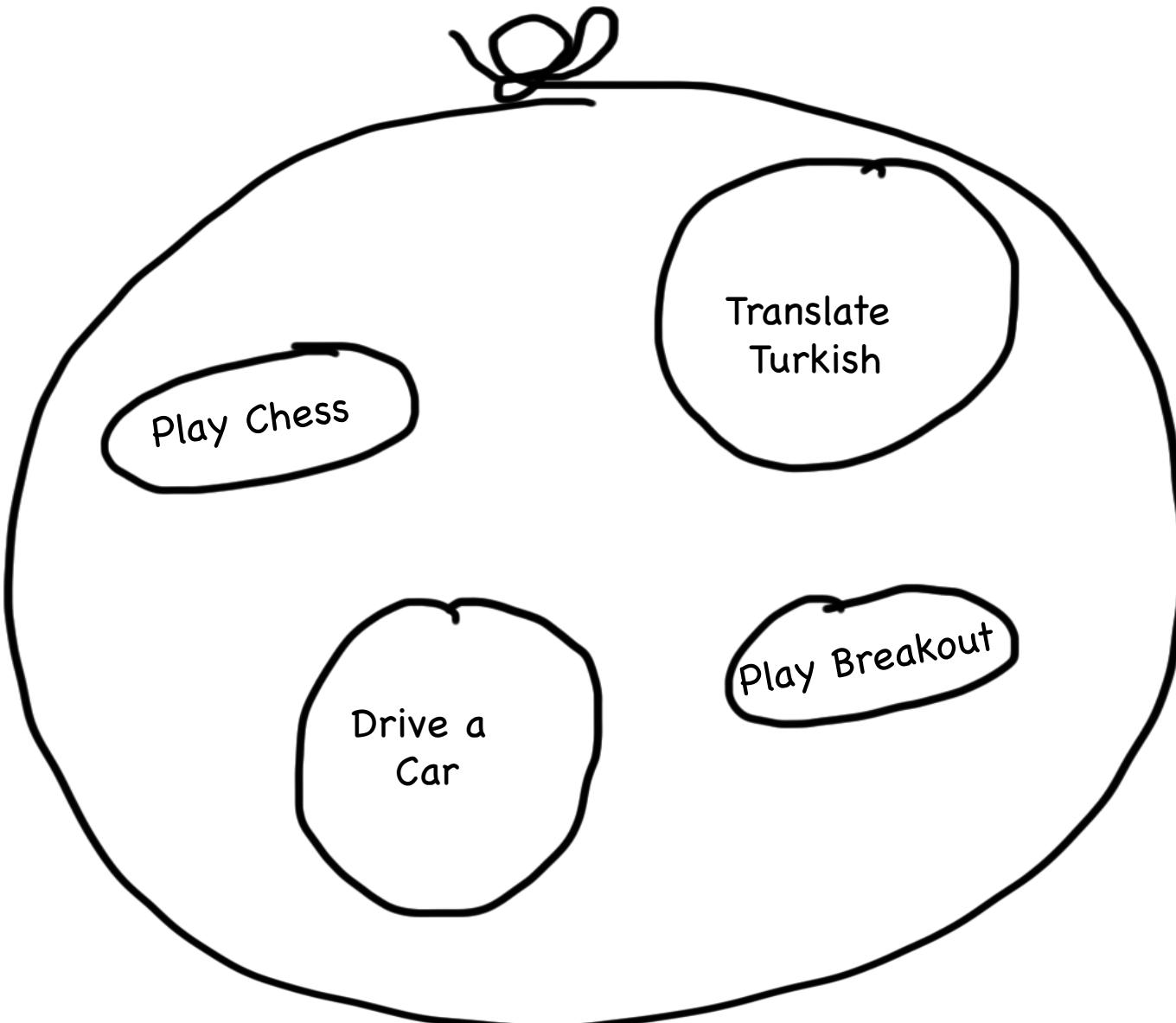
Translate  
Turkish or Czech

Drive a  
Car

Play Breakout



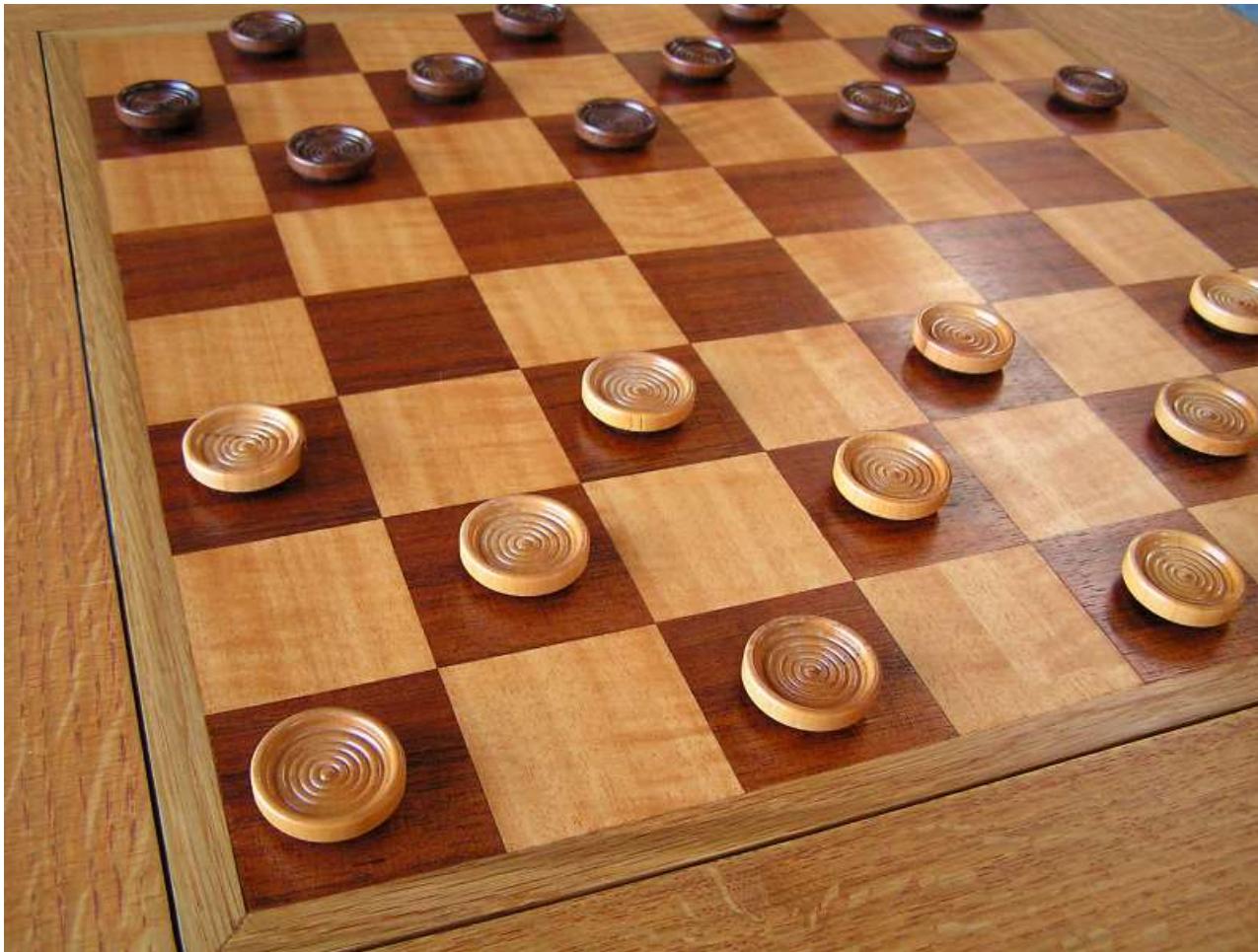
# General Intelligence



# Brief History



# Early Optimism 1950s



1952

CSBridge '20



# Early Optimism 1950s

“Machines will be capable,  
within twenty years, of doing  
any work a man can do.”  
–Herbert Simon, 1952



# Underwhelming Results 1950s to 1980s

*The spirit is willing but the flesh is weak.*



(Russian)



*The vodka is good but the meat is rotten.*

The world is too complex



# BRACE YOURSELVES

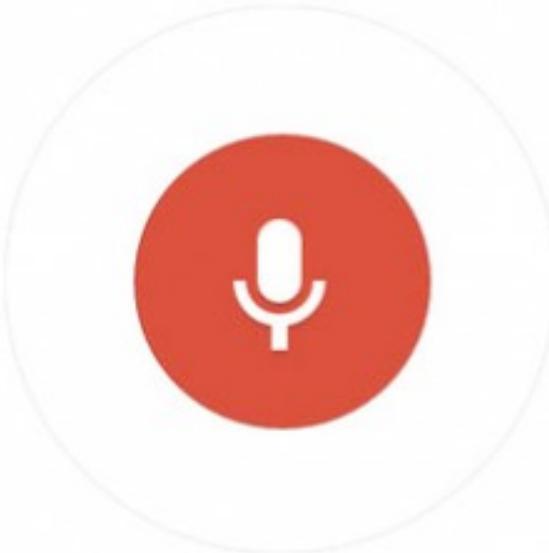


# WINTER IS COMING

# Big Milestones



# Told Speech Was 30 Years Out



Almost perfect...



# The Last Remaining Board Game



# Computers Making Art



# Self Driving Cars



What is going on?

[more suspense]

# Story of Modern AI

Focus on one problem

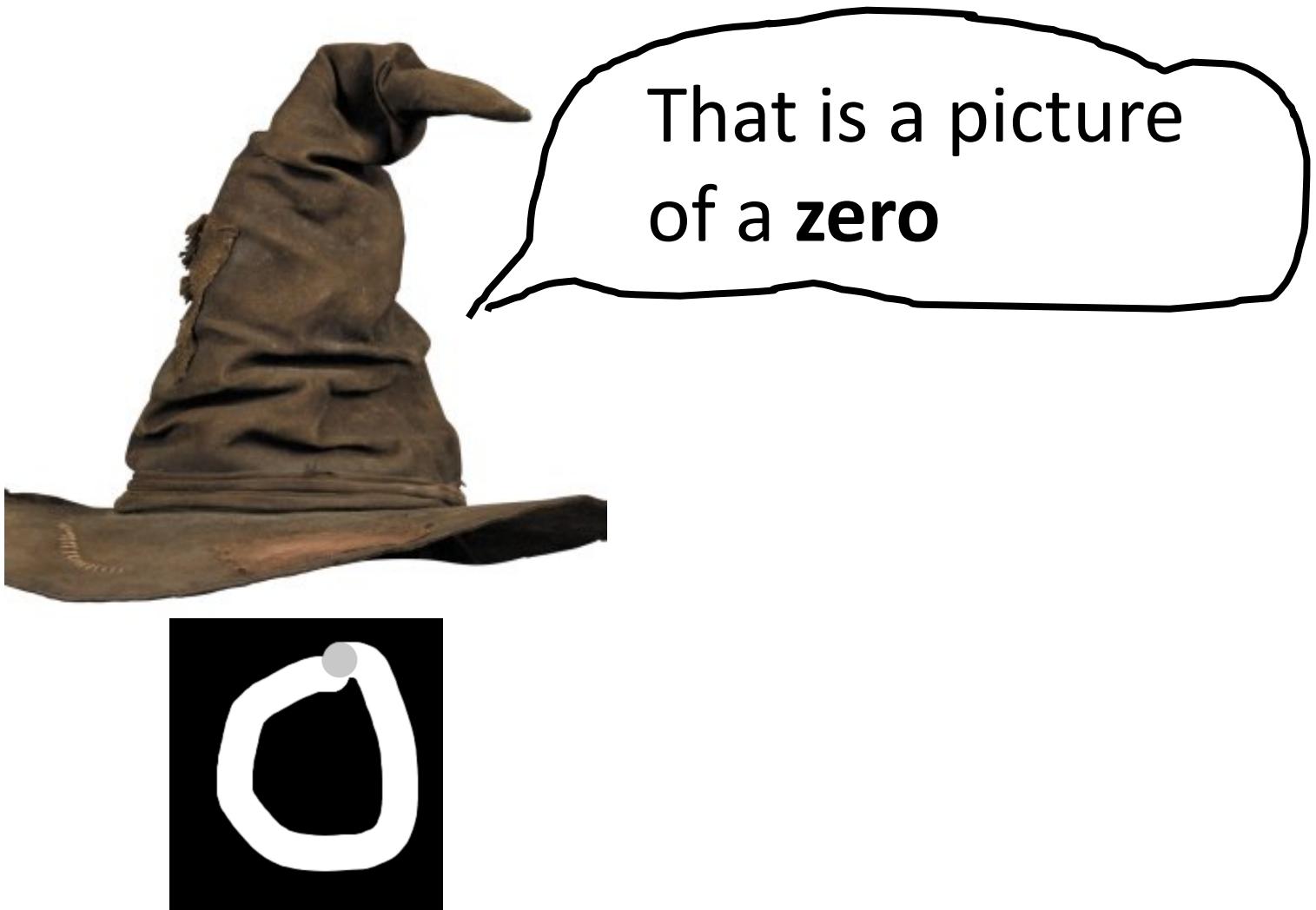
# Make a Harry Potter Sorting Hat



# Classification



# Classification



# Classification



\* It doesn't have to be  
correct all of the time



Can you do it?

1



# How about now?

What a computer sees

0	0	1	0	1	0	1	0	0	0	1	1	1	1	0	1
1	0	0	1	0	1	1	1	0	1	0	0	0	0	0	0
1	1	1	0	1	0	0	1	1	0	0	1	0	1	0	0
1	1	1	1	1	0	0	0	0	0	1	1	0	1	1	1
0	0	0	1	1	0	0	1	0	0	1	1	0	1	1	1
1	0	0	1	1	0	0	0	1	0	0	1	0	1	0	0
1	1	0	1	1	0	0	1	1	0	1	1	0	1	0	0
1	0	1	0	0	1	0	0	1	0	0	1	0	1	0	0
0	0	0	0	1	0	1	0	1	1	1	1	1	1	1	1
0	1	1	0	0	0	0	0	0	1	1	1	1	1	1	1
0	0	1	0	1	1	1	0	0	0	1	1	1	1	1	1
0	1	1	1	0	1	0	0	1	0	0	1	0	1	0	0
1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1
0	0	1	1	1	0	1	0	1	0	1	1	1	1	1	1



What a human sees



# Why is it easy for Humans?



About 30% of your cortex is used for vision  
3% is used to process hearing



# Very hard to Program



```
def main():
    print("Todo: Write program")
```



Perhaps there is an insight?

# Two Great Ideas

1. Artificial Neurons

2. Learn by Example

# Two Great Ideas

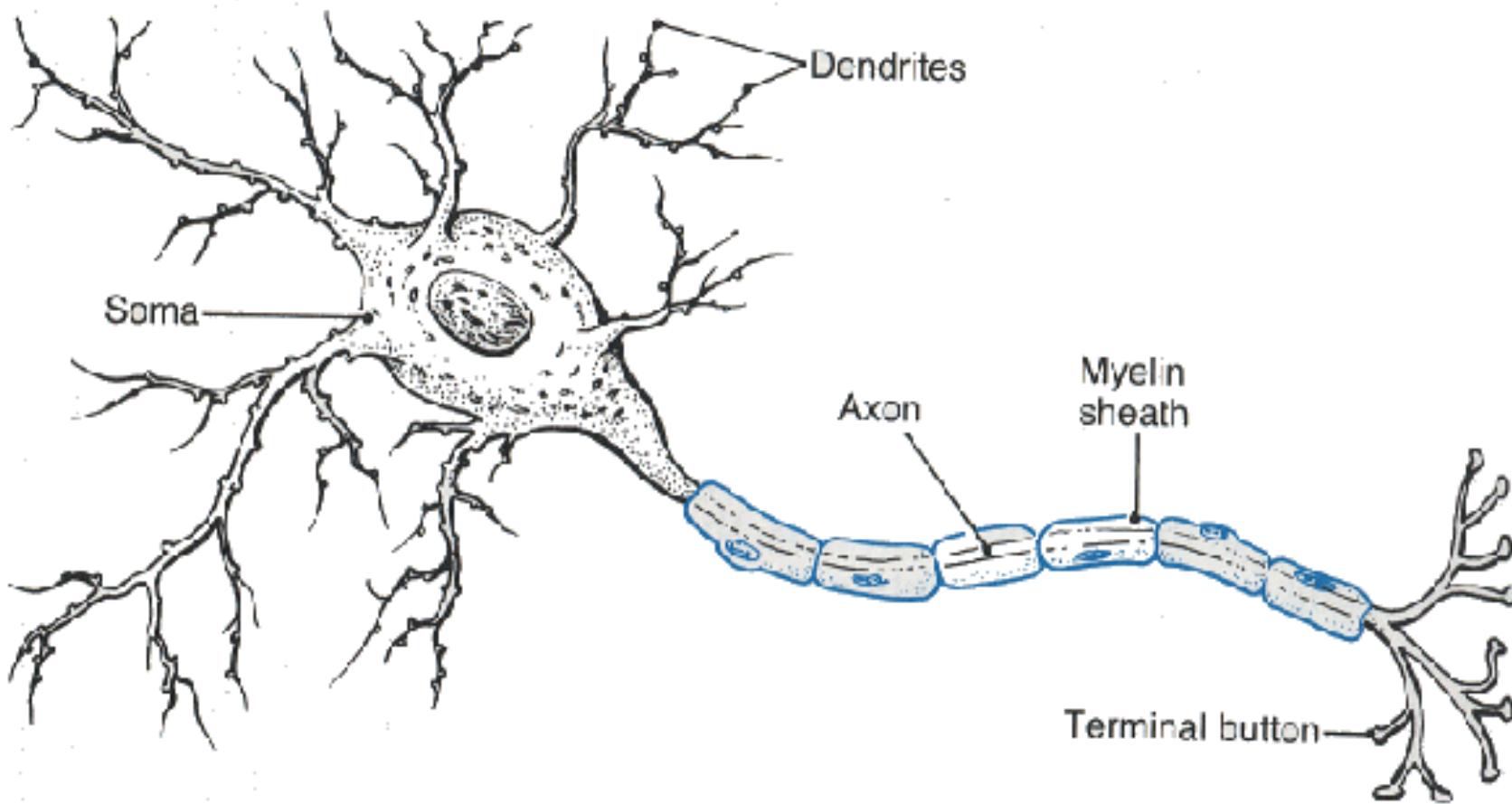
**1. Artificial Neurons**

**2. Learn by Example**

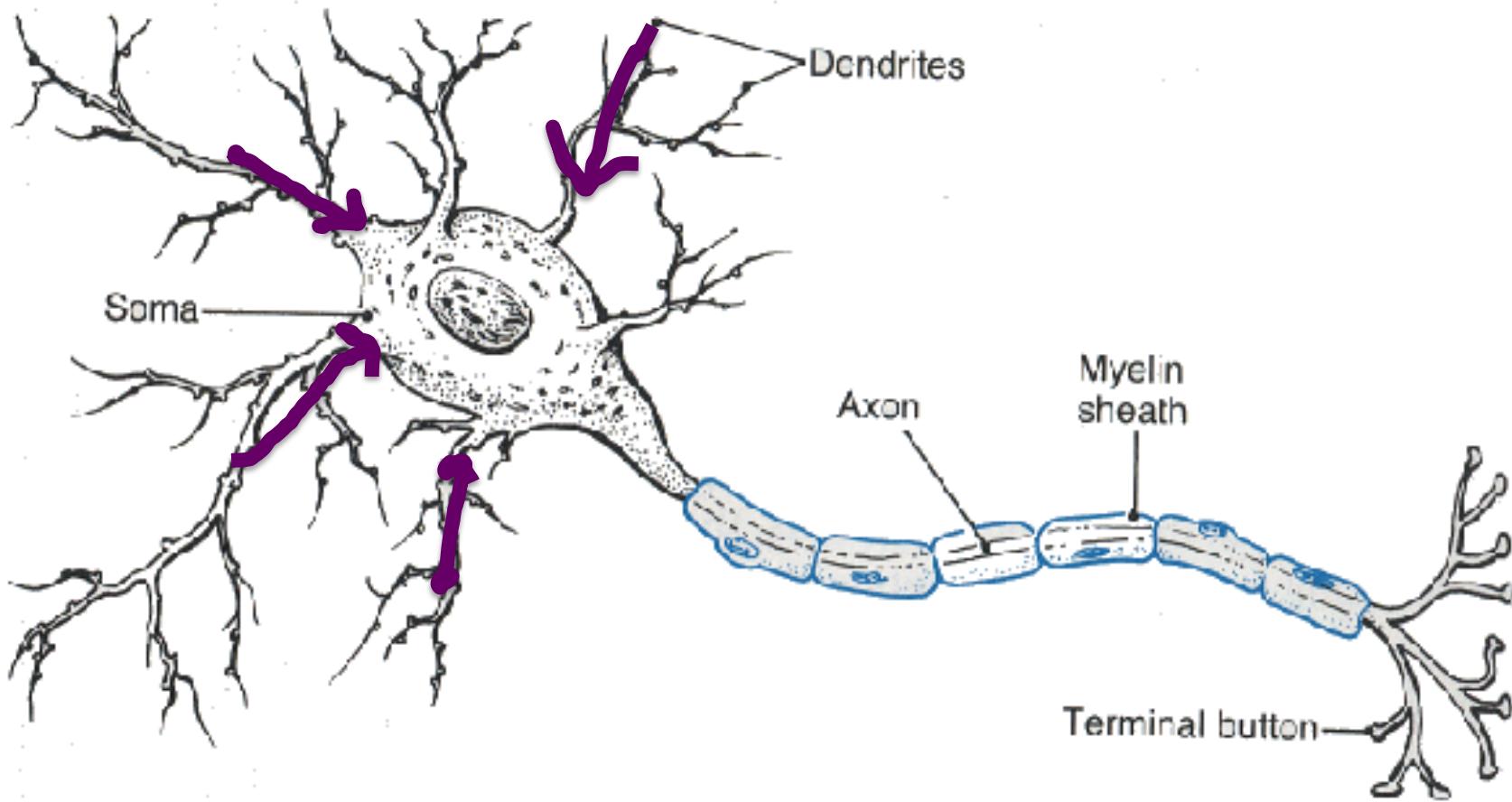
# 1. Artificial Neurons



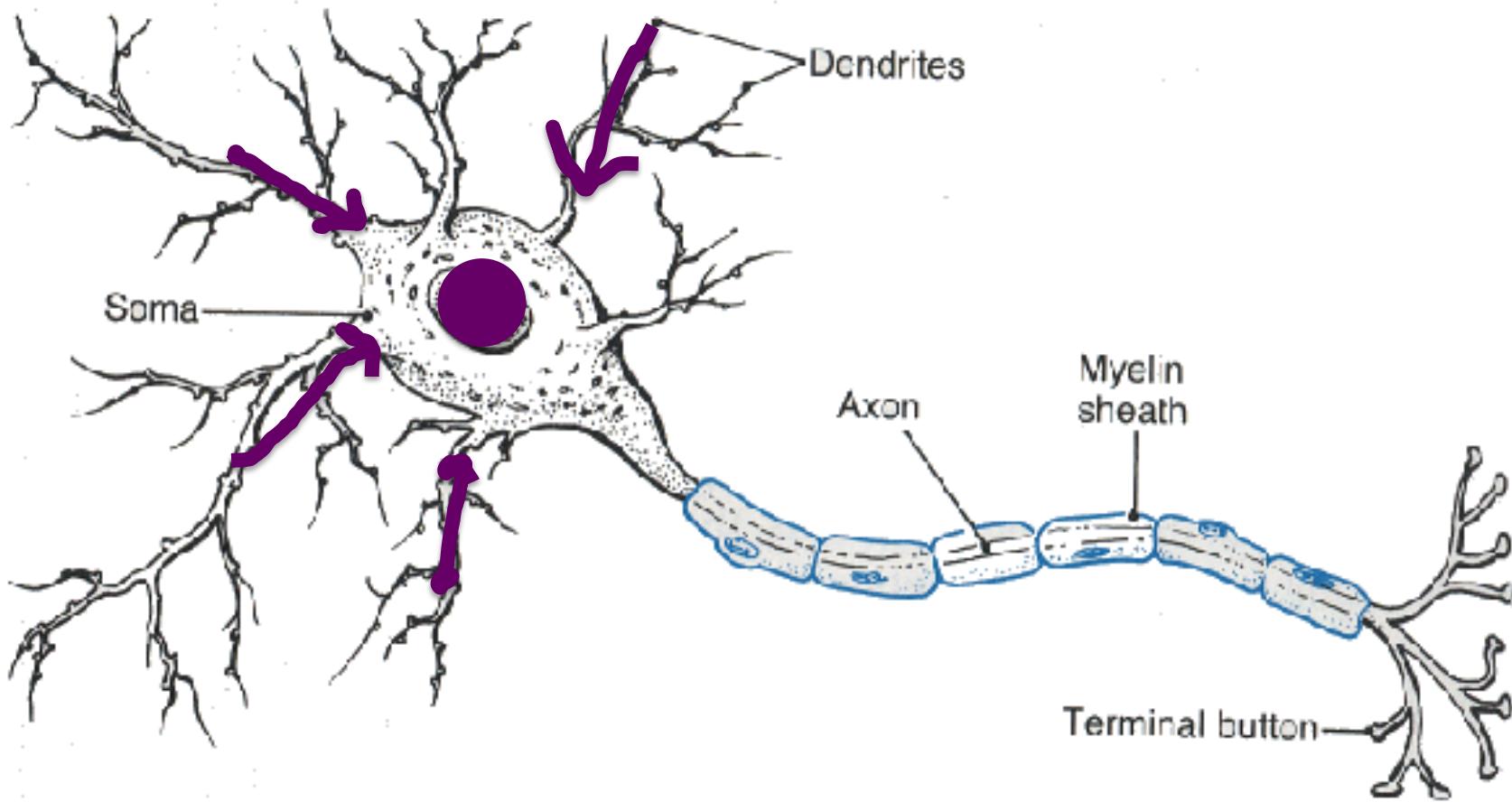
# Neuron



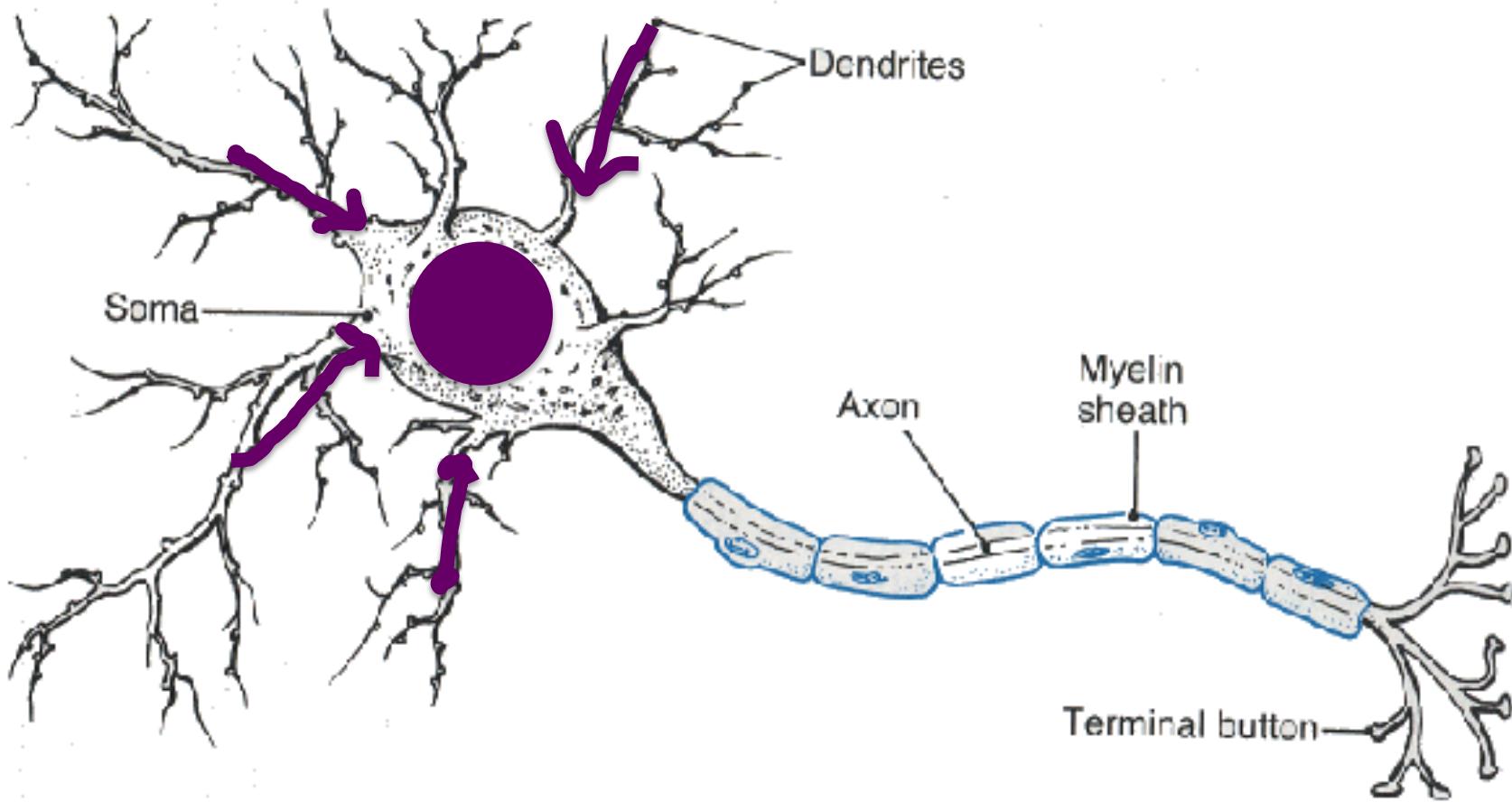
# Neuron



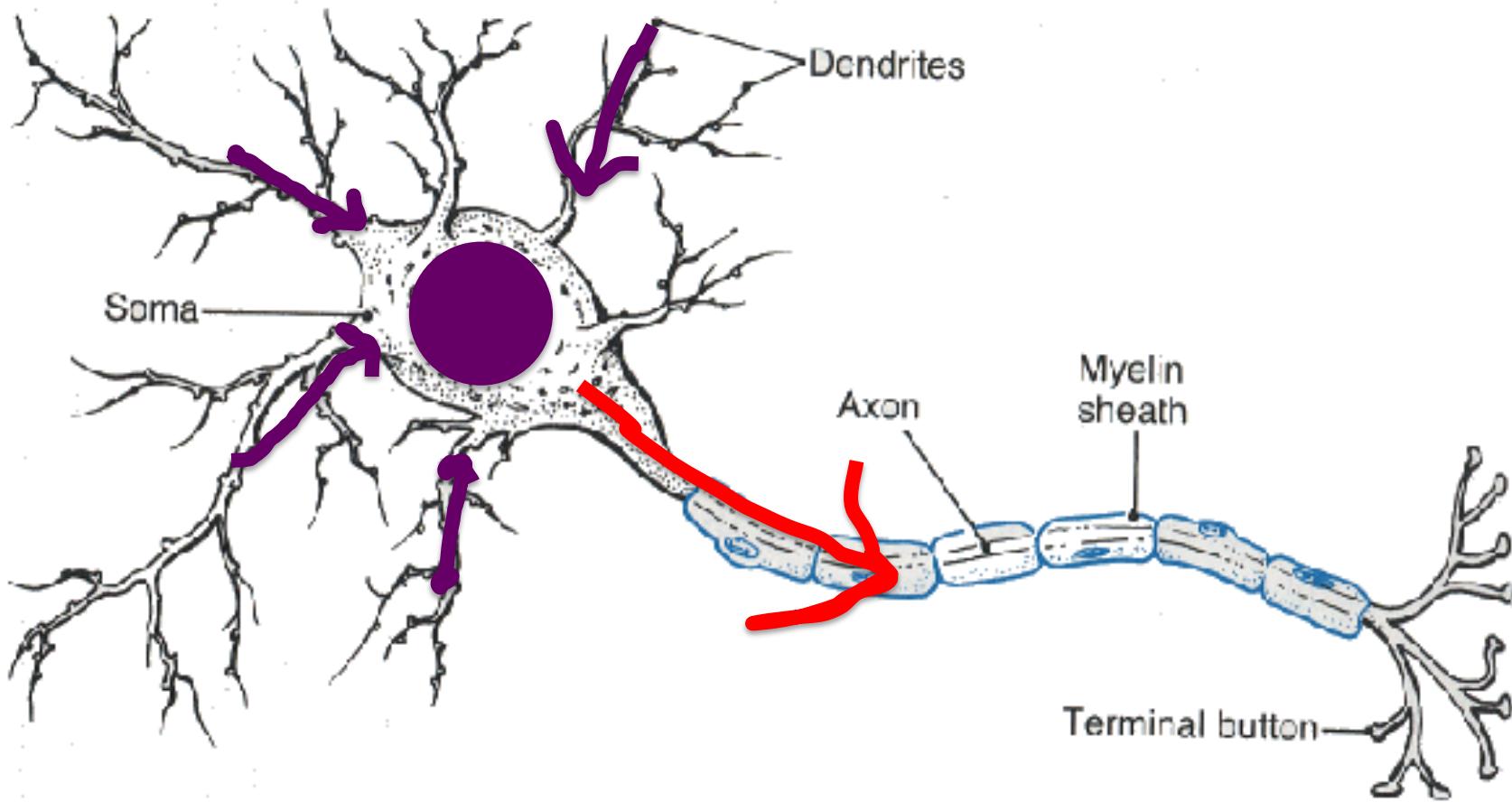
# Neuron



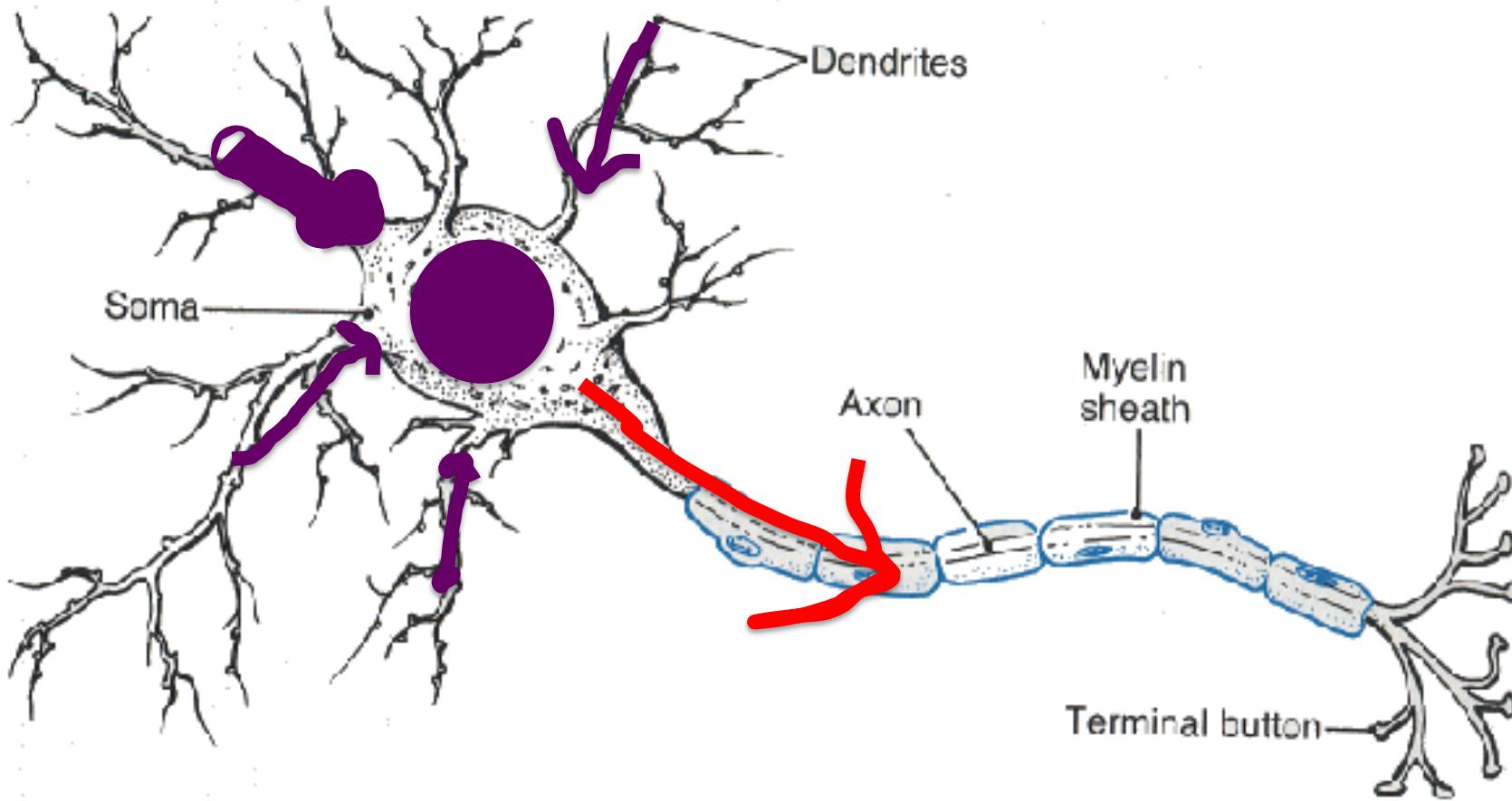
# Neuron



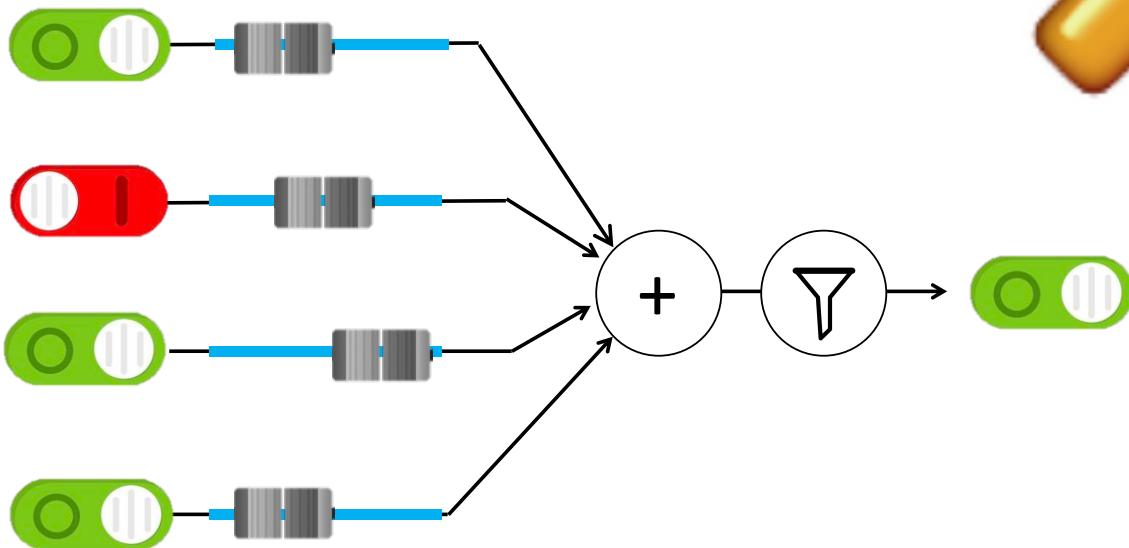
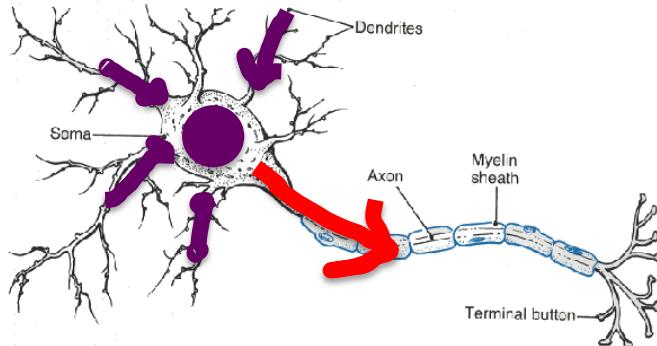
# Neuron



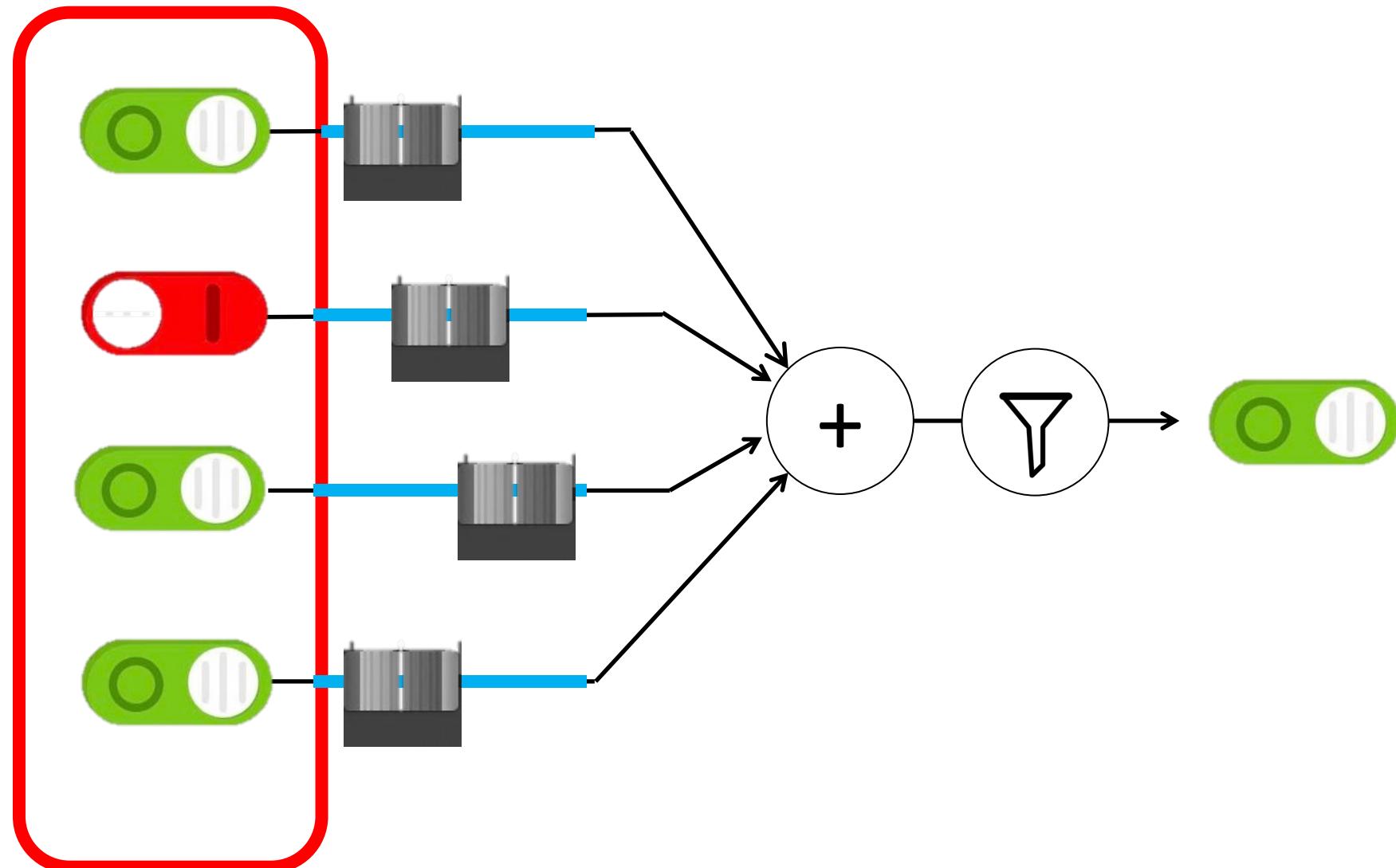
# Some Inputs are More Important



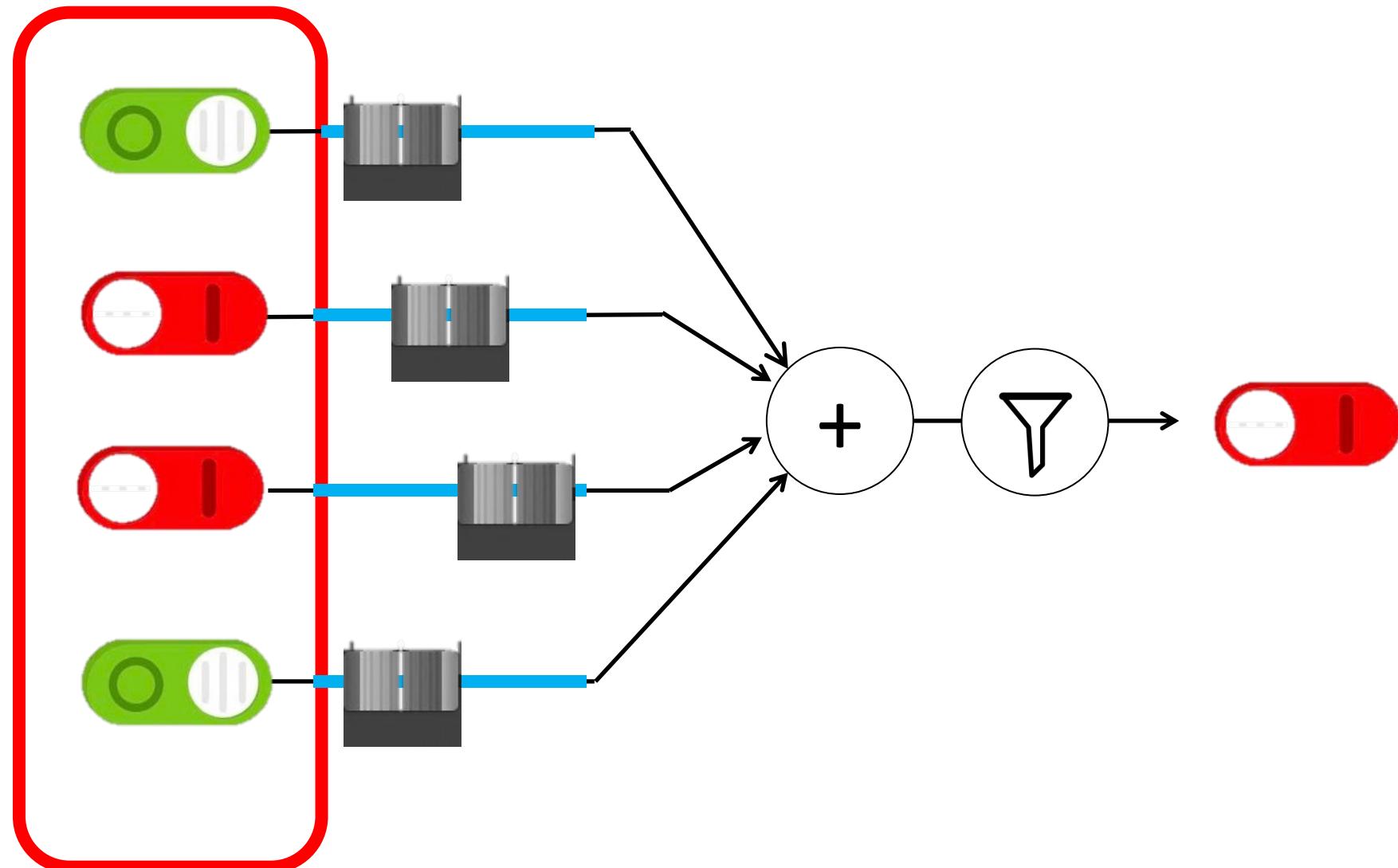
# Artificial Neuron



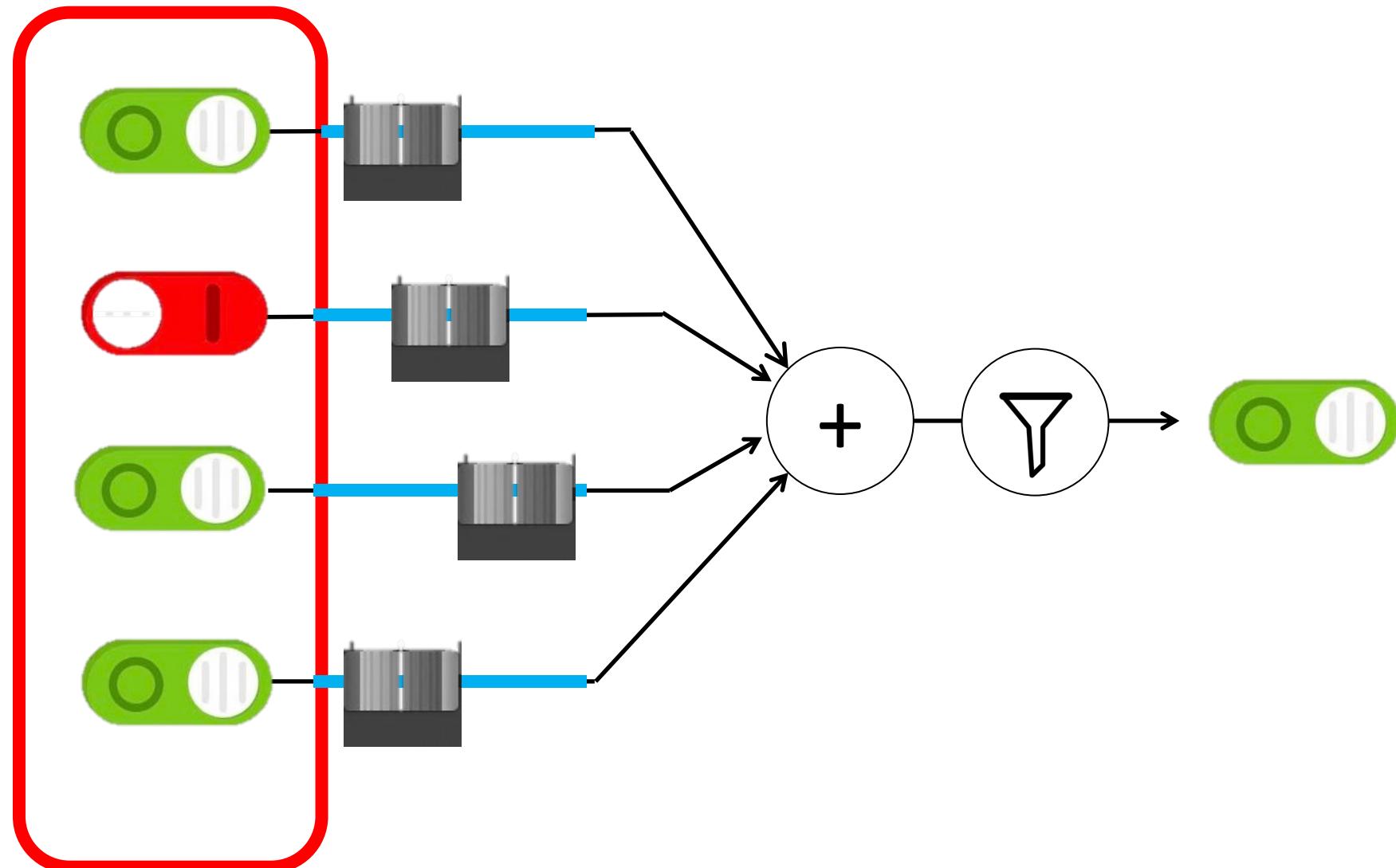
# Inputs



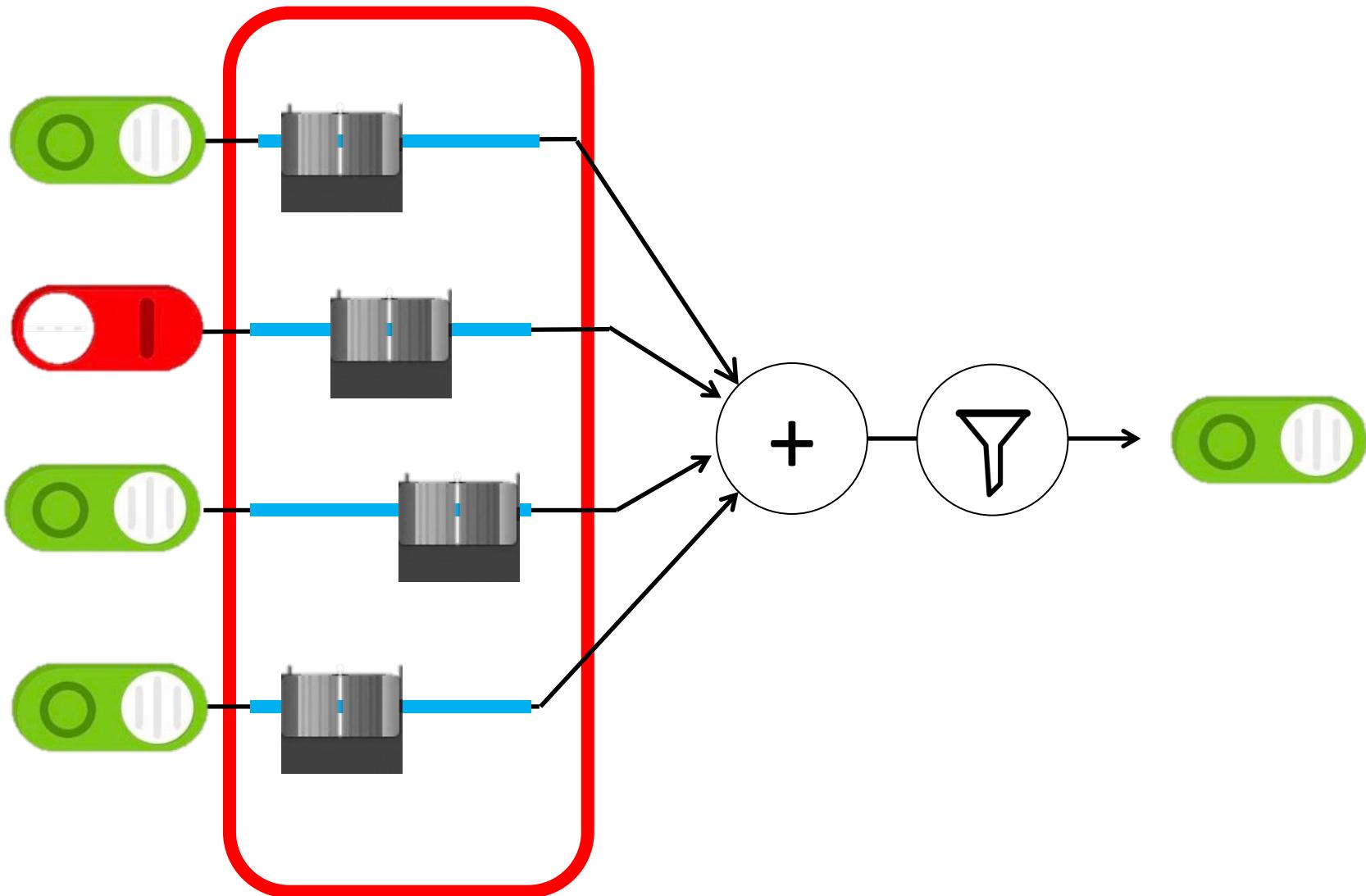
# Inputs



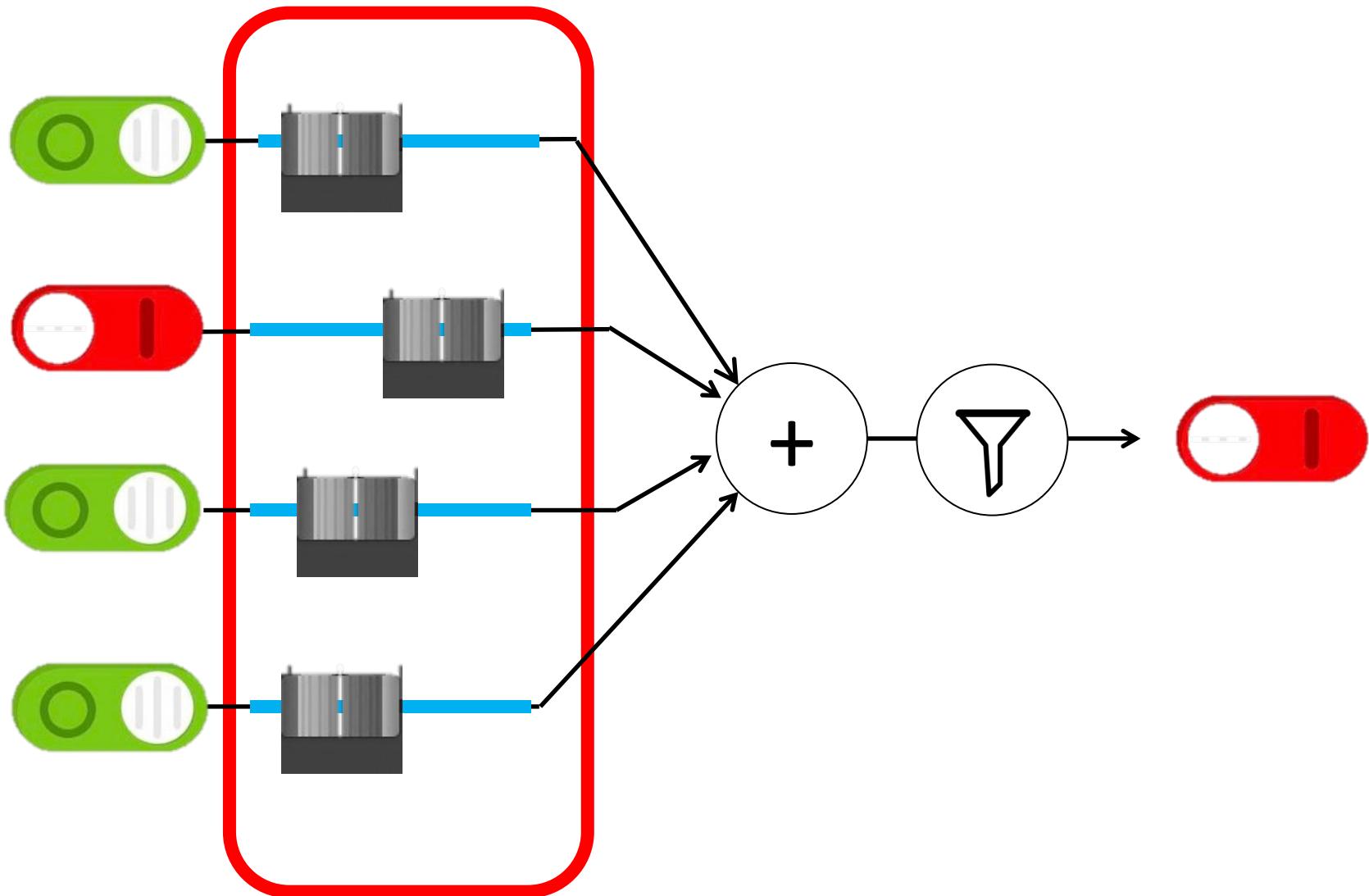
# Inputs



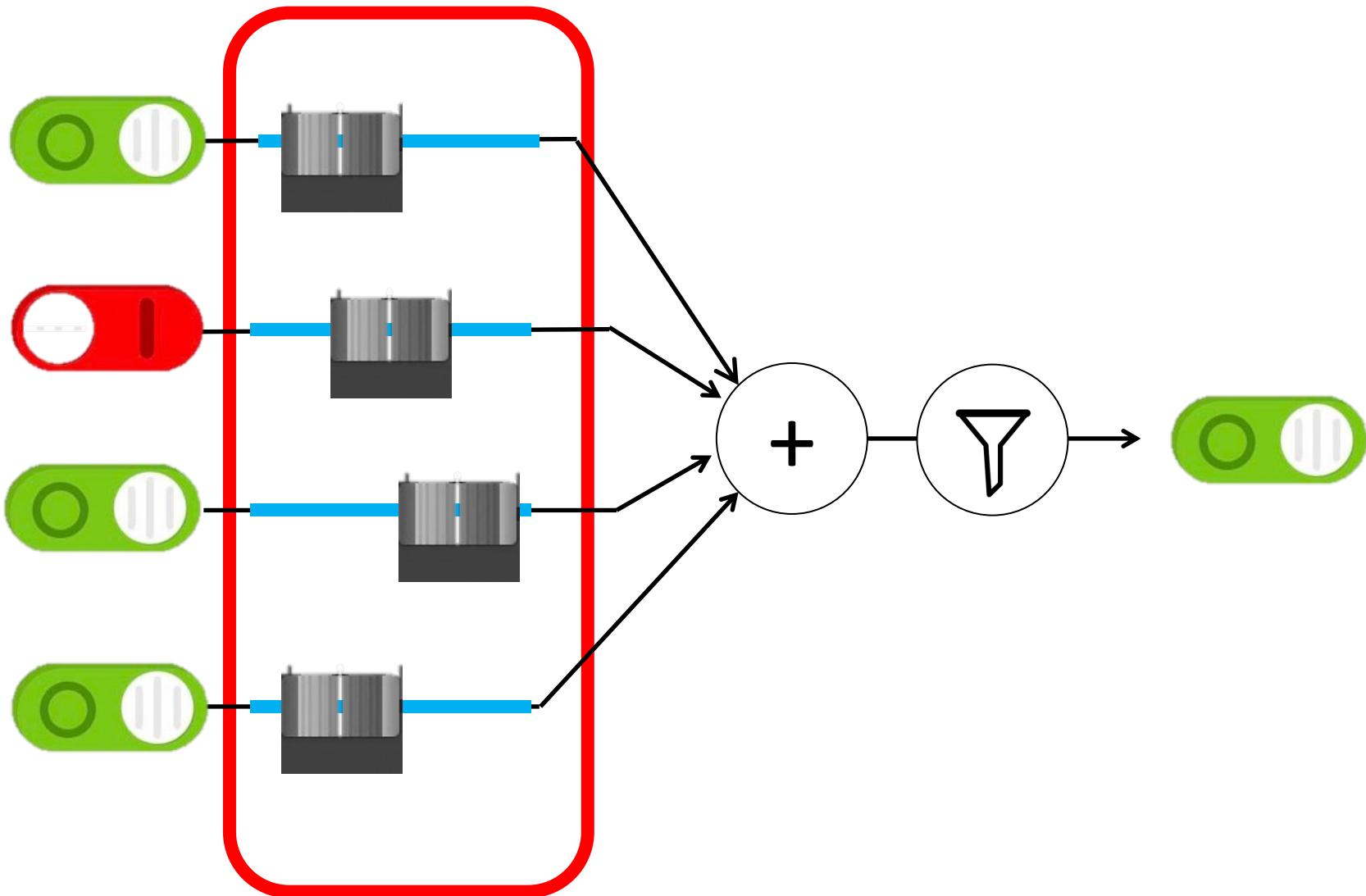
# Weights



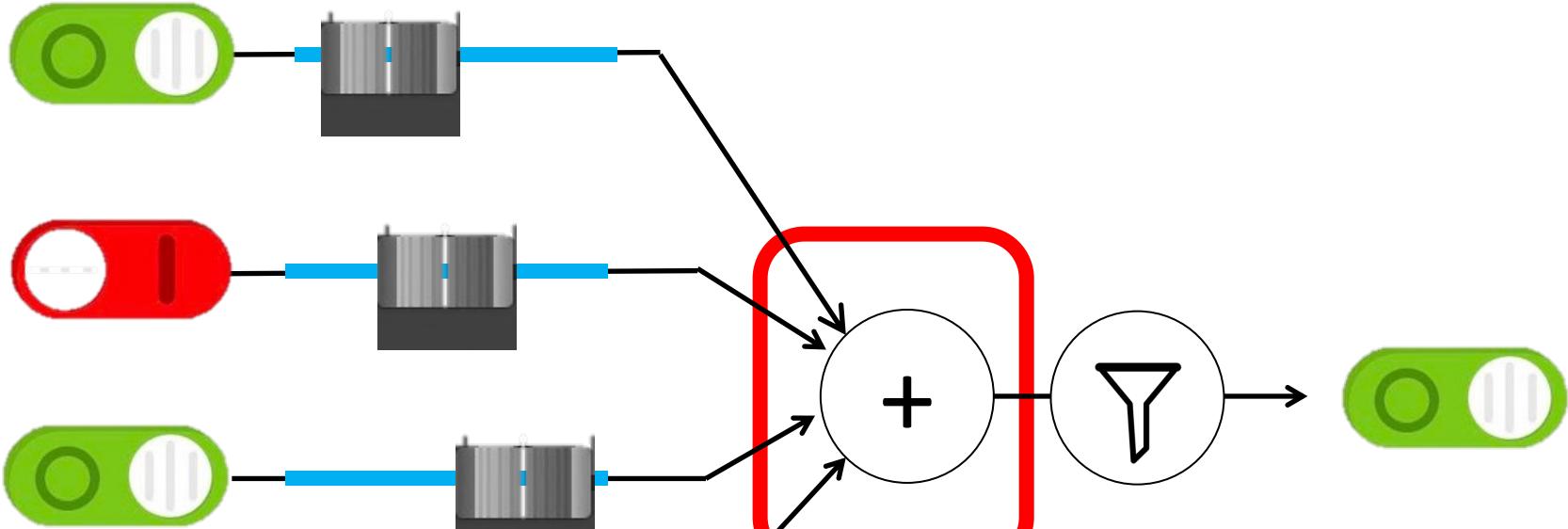
# Weights



# Weights



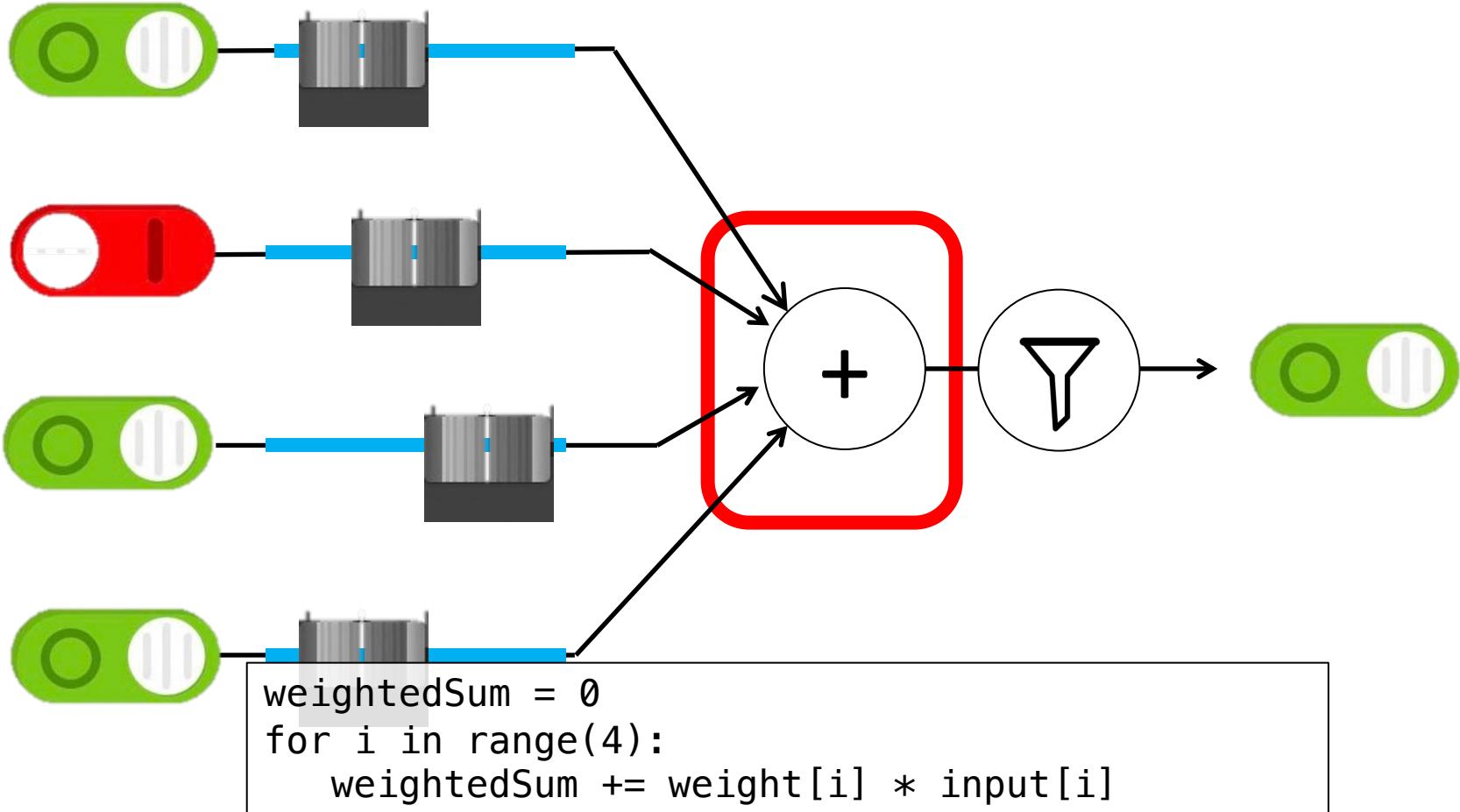
# Weighted Sum



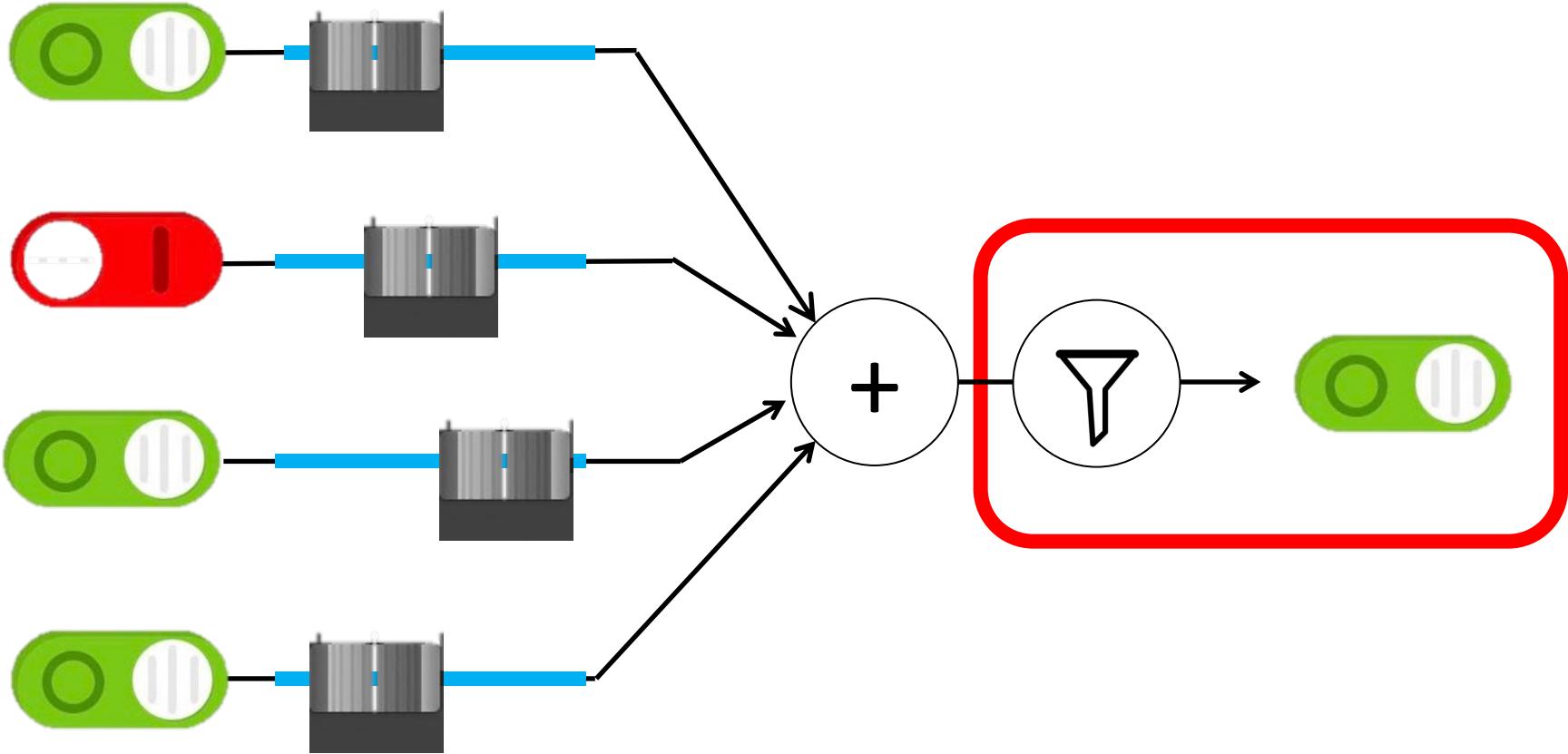
```
weightedSum = 0  
weightedSum = weightedSum + input0 * weight0  
weightedSum = weightedSum + input1 * weight1  
weightedSum = weightedSum + input2 * weight2  
weightedSum = weightedSum + input3 * weight3
```



# Weighted Sum

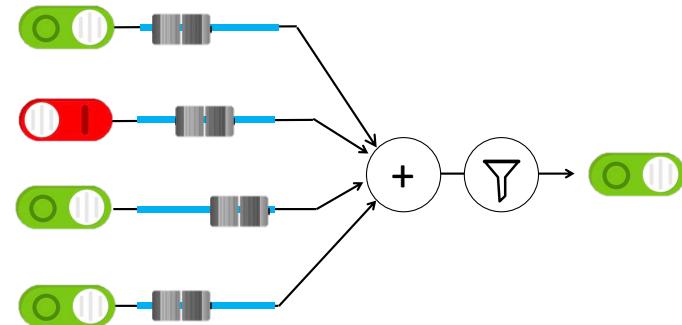
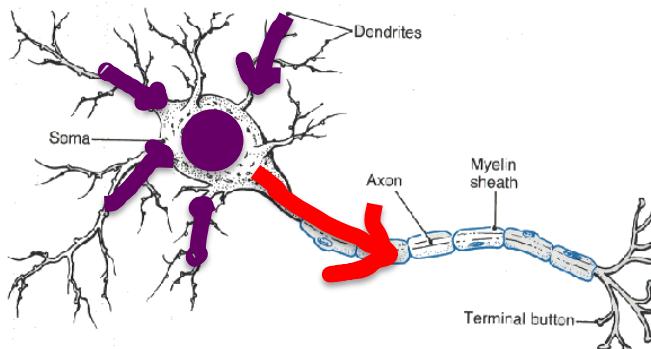


# Filter and Output

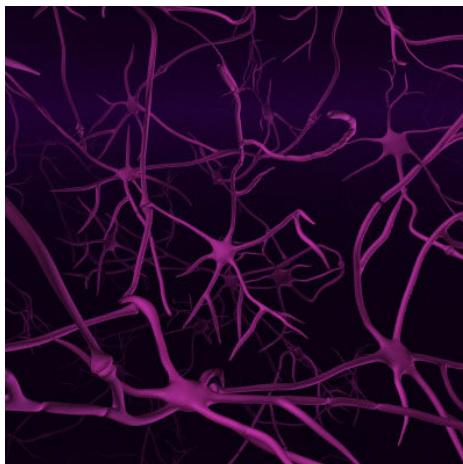


# Biological Basis for Neural Networks

- A neuron



- Your brain

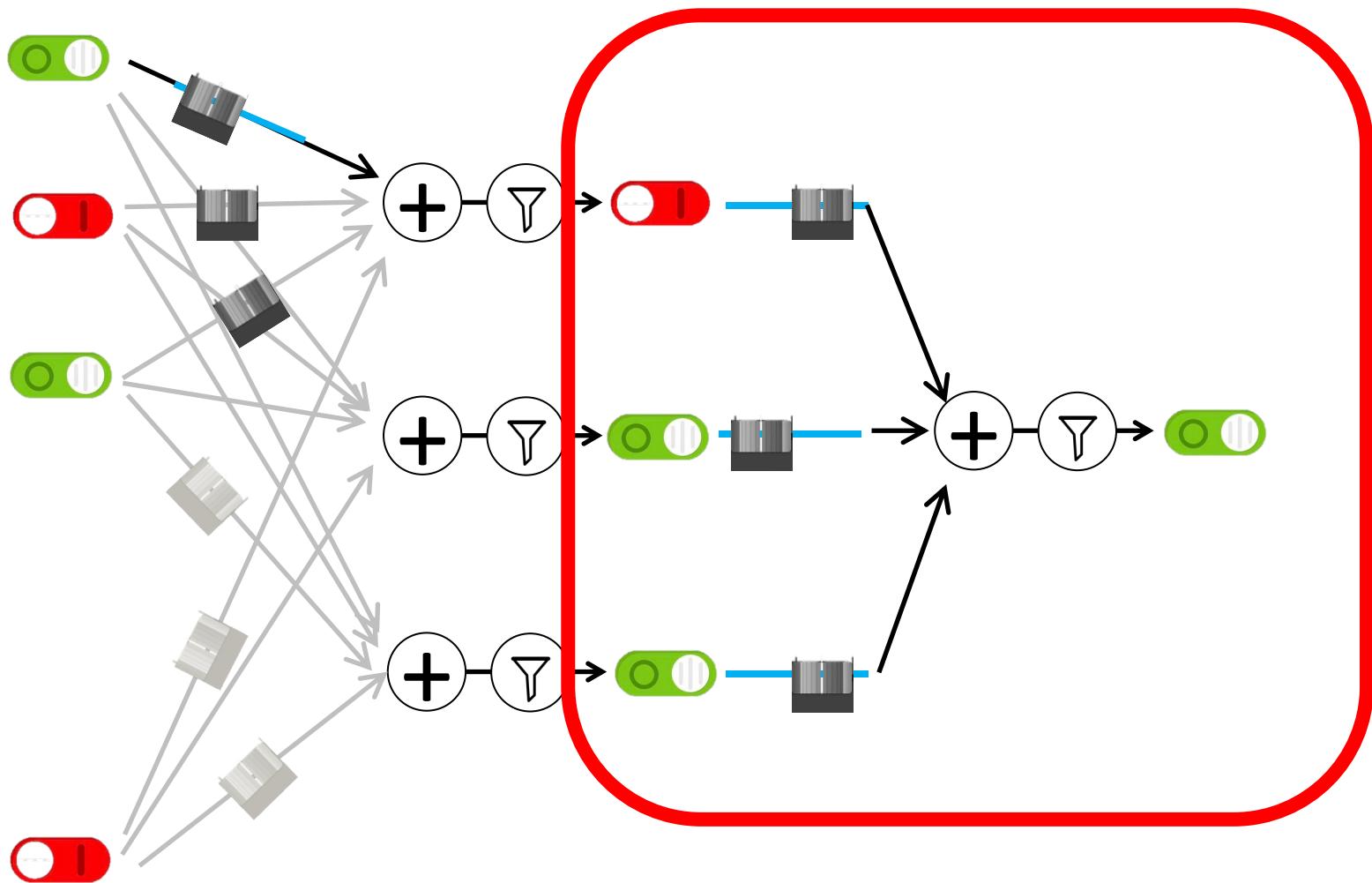


???

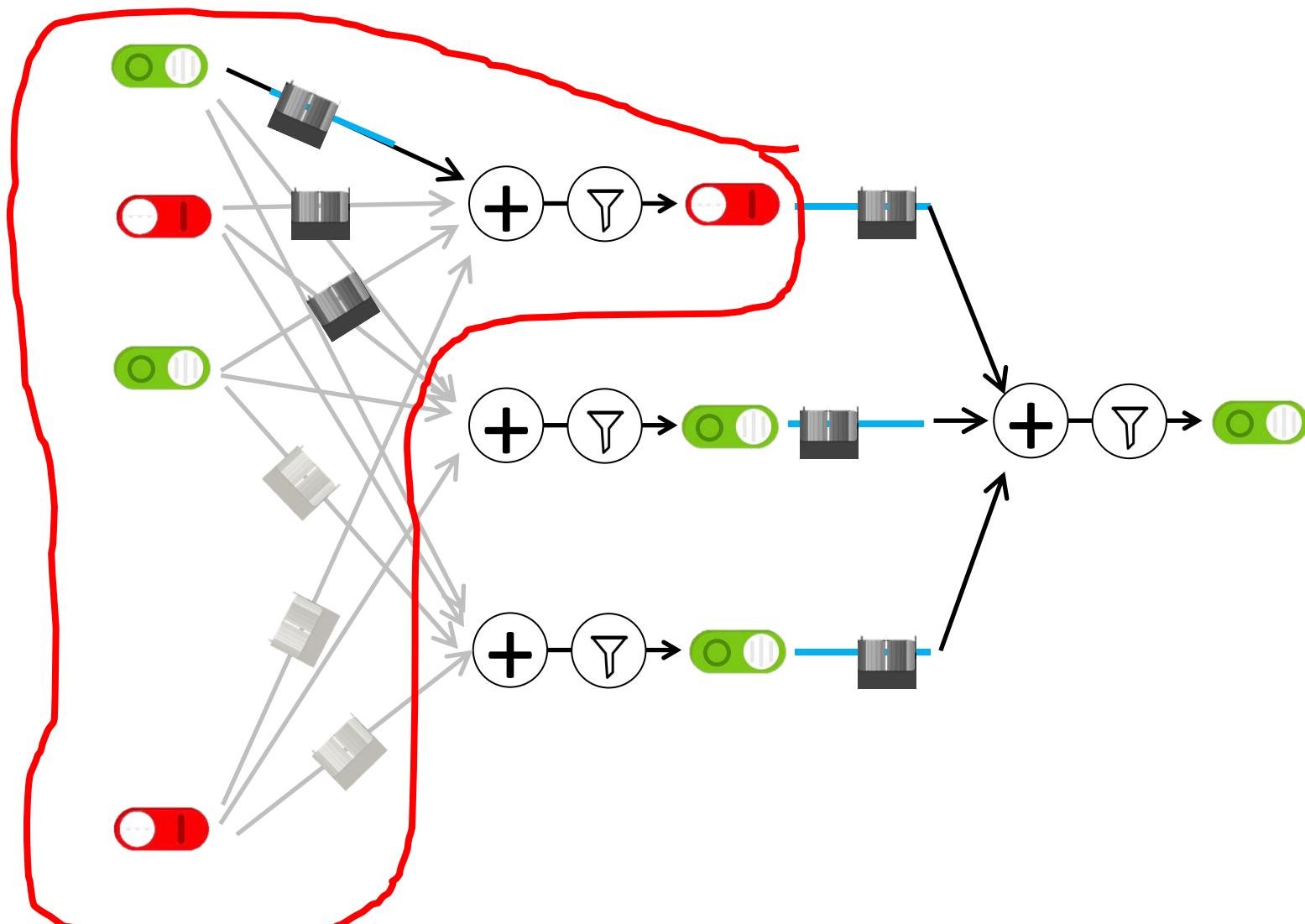
Actually, it's probably someone else's brain



# Put Many Together

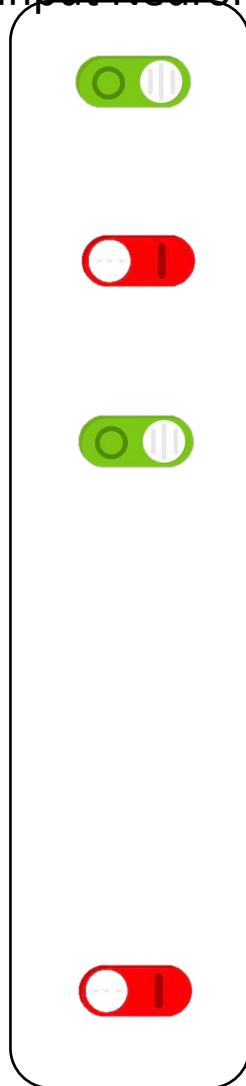


# Put Many Together

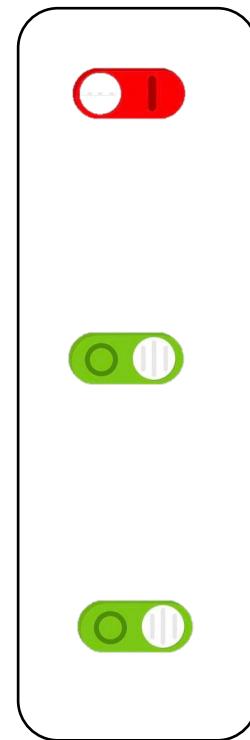


# Put Many Together

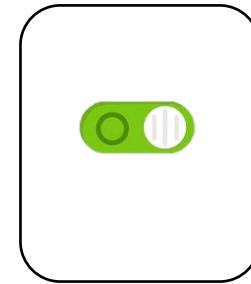
Input Neurons



Hidden Neurons

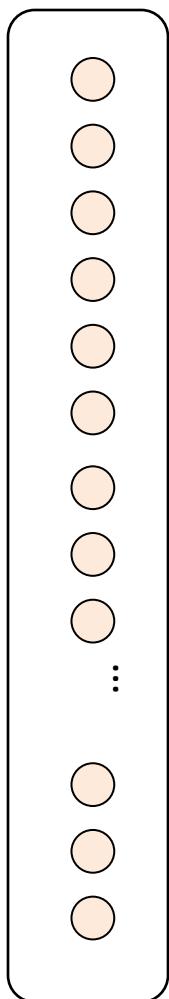


Output Neurons

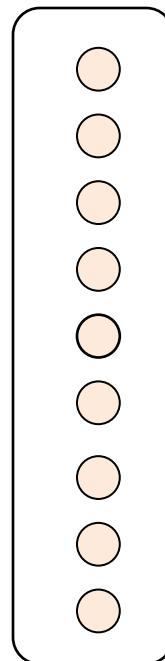


# Making a Prediction

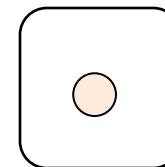
Input Neurons



Hidden Neurons



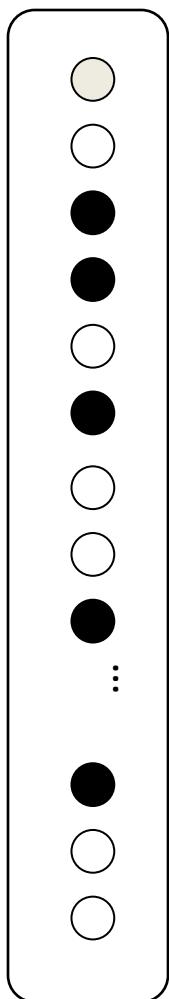
Output Neurons



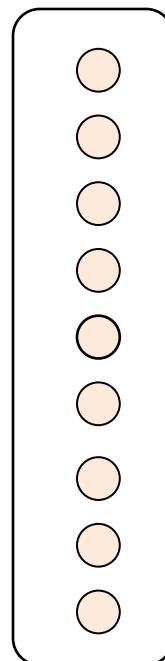
# Making a Prediction



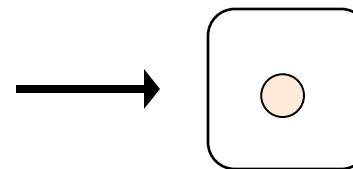
Input Neurons



Hidden Neurons



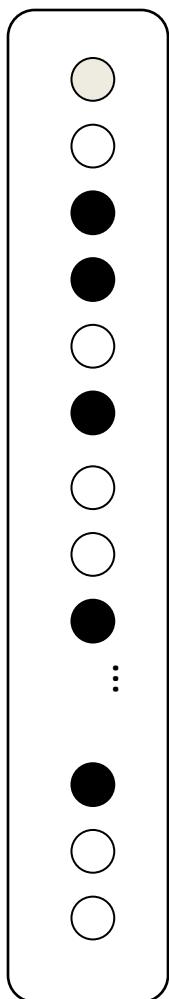
Output Neurons



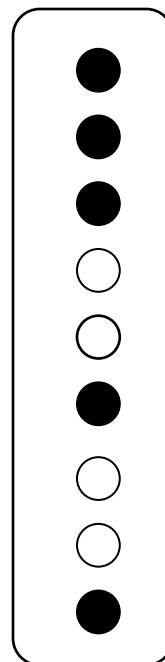
# Making a Prediction



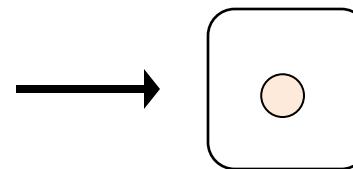
Input Neurons



Hidden Neurons

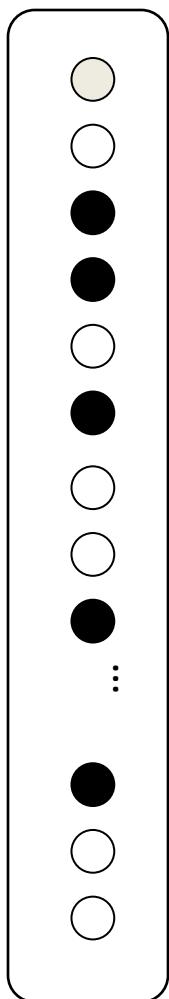


Output Neurons

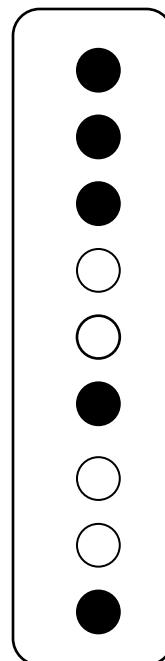


# Making a Prediction

Input Neurons

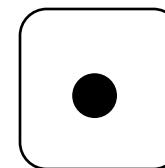


Hidden Neurons



Output Neurons

I think that is  
a picture of a  
one!



# Demonstration

Draw your number here



Downsampled drawing: 0

First guess: 0

Second guess: 8

## Layer visibility

Input layer

Show

Convolution layer 1

Show

Downsampling layer 1

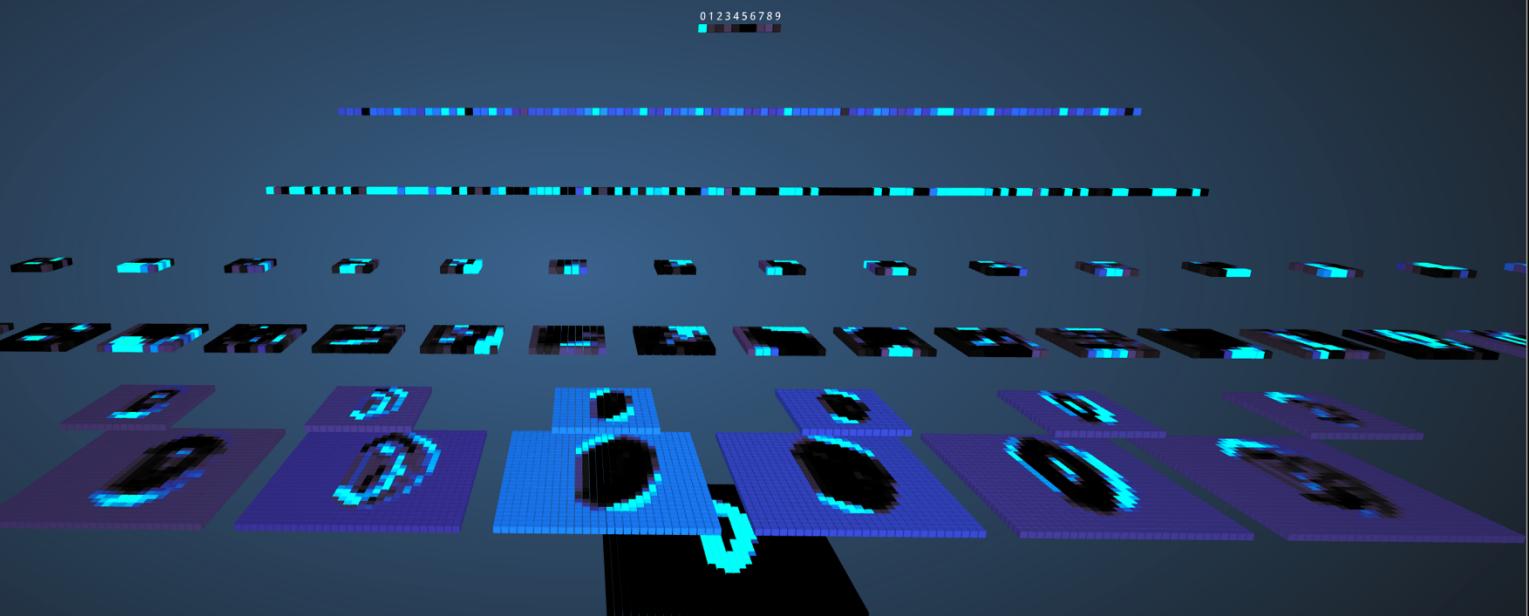
Show

Convolution layer 2

Show

Downsampling layer 2

Show

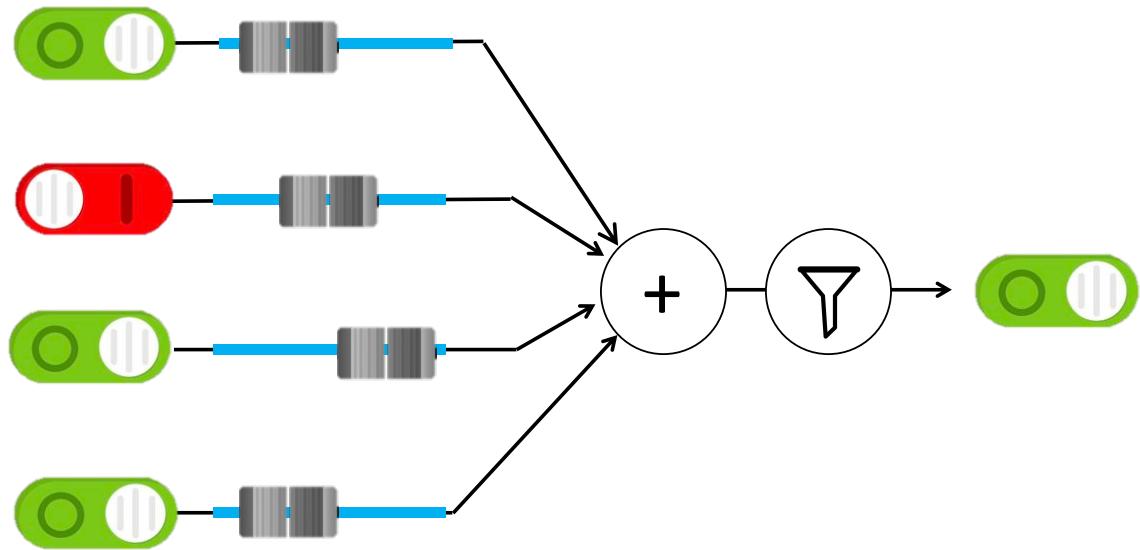
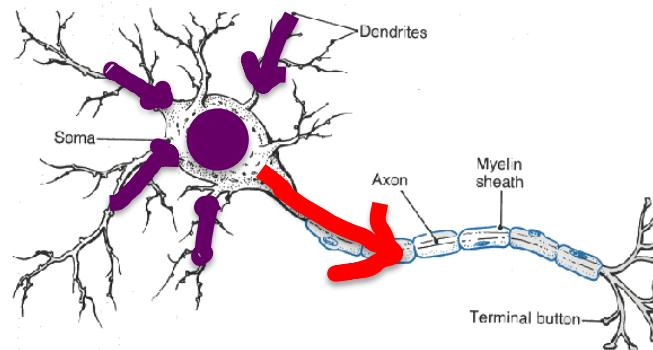


<http://scs.ryerson.ca/~aharley/vis/conv/>

CSBridge '20

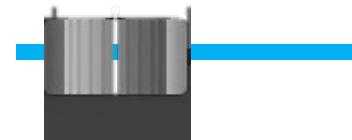


# Great Idea: Artificial Neurons





**Neural Networks** get their intelligence from their sliders (parameters)



# Two Great Ideas

**1. Artificial Neurons**

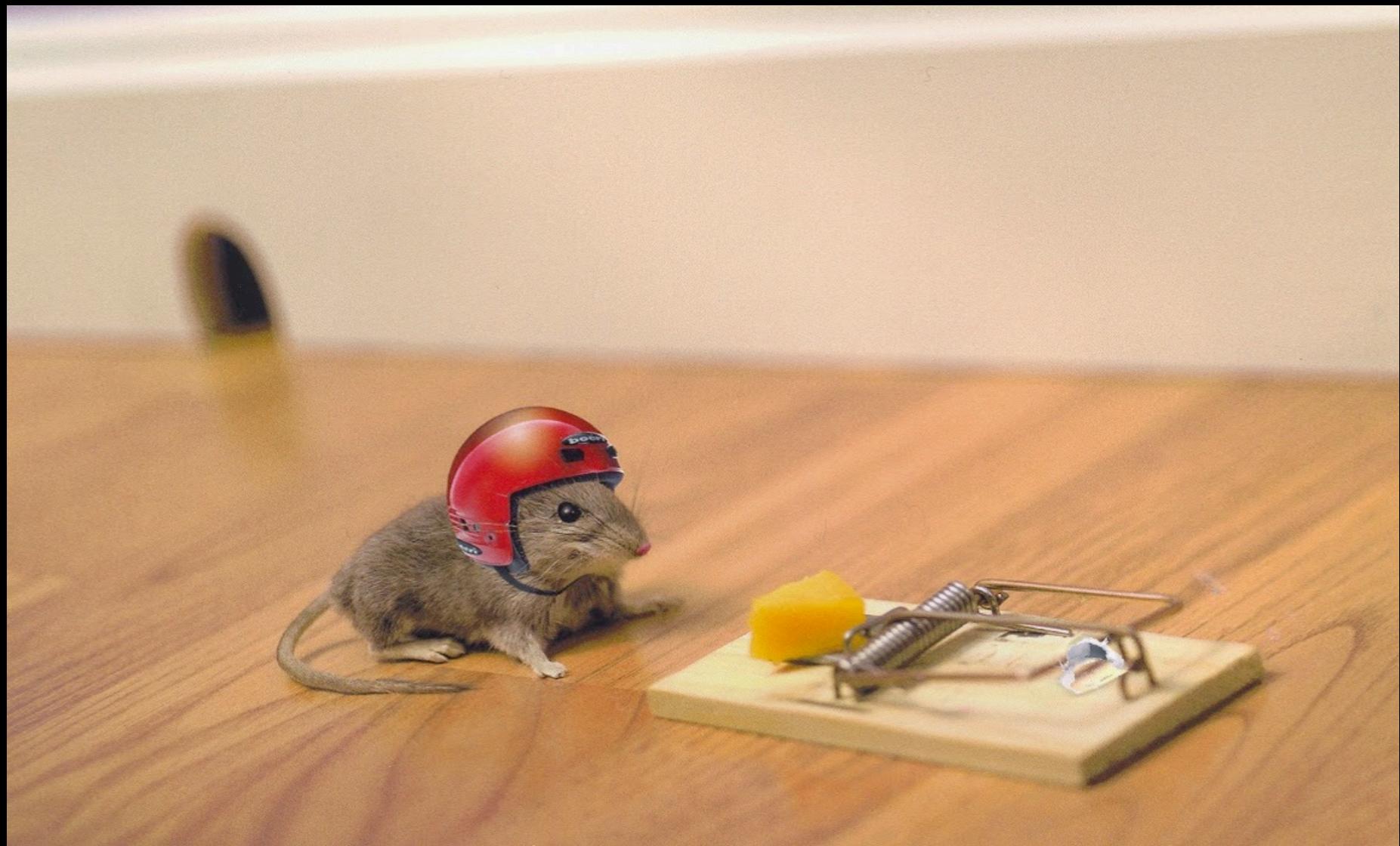
**2. Learn by Example**

# Two Great Ideas

**1. Artificial Neurons**

**2. Learn by Example**

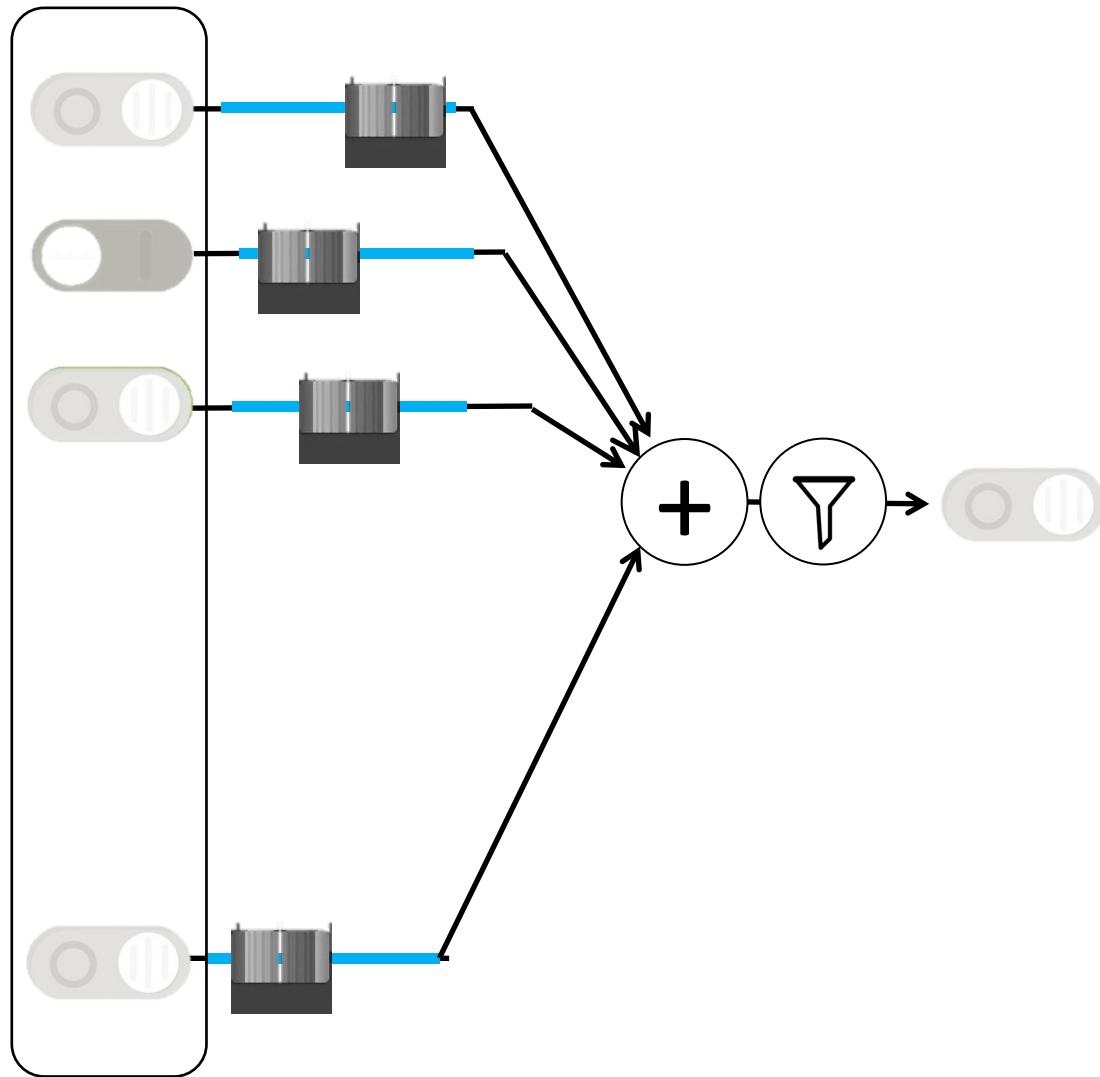
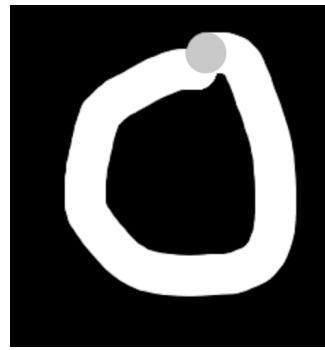
## 2. Learn From Experience

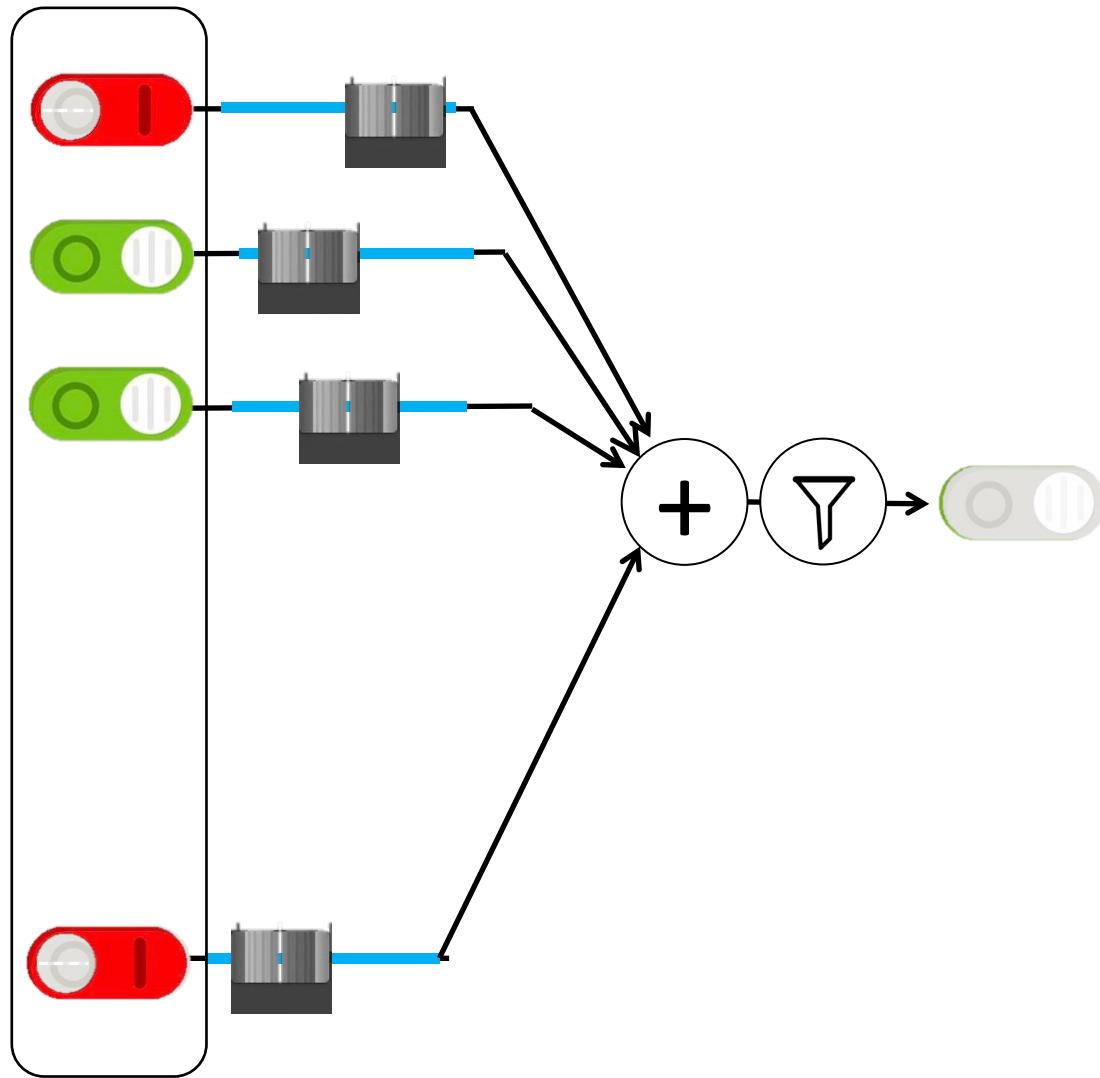
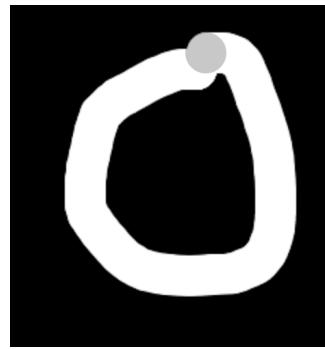


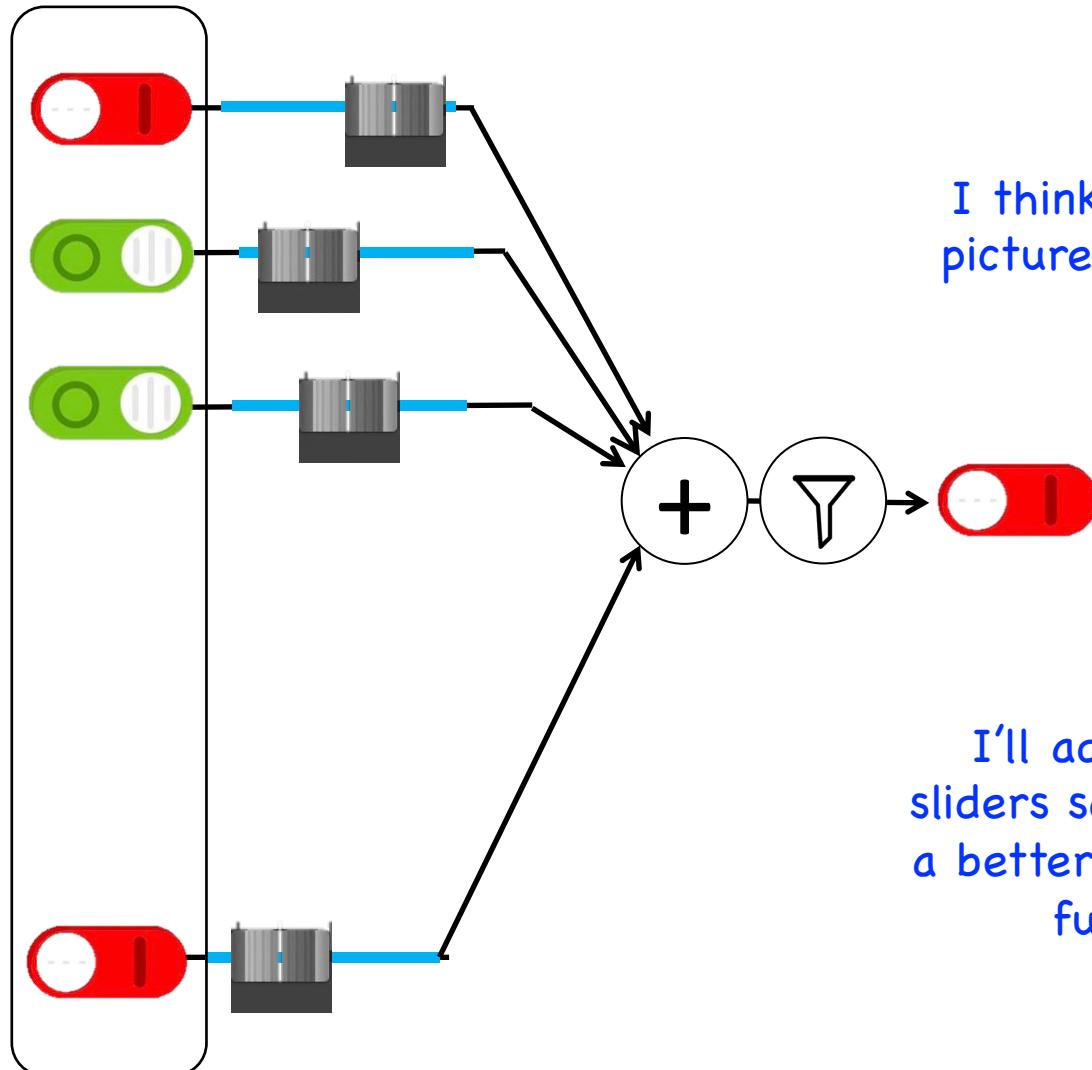
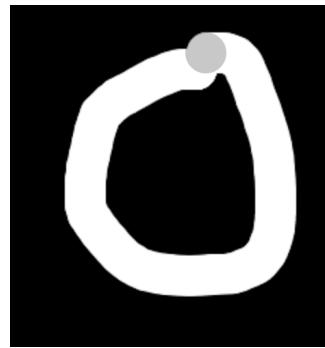
# Learn by Example

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







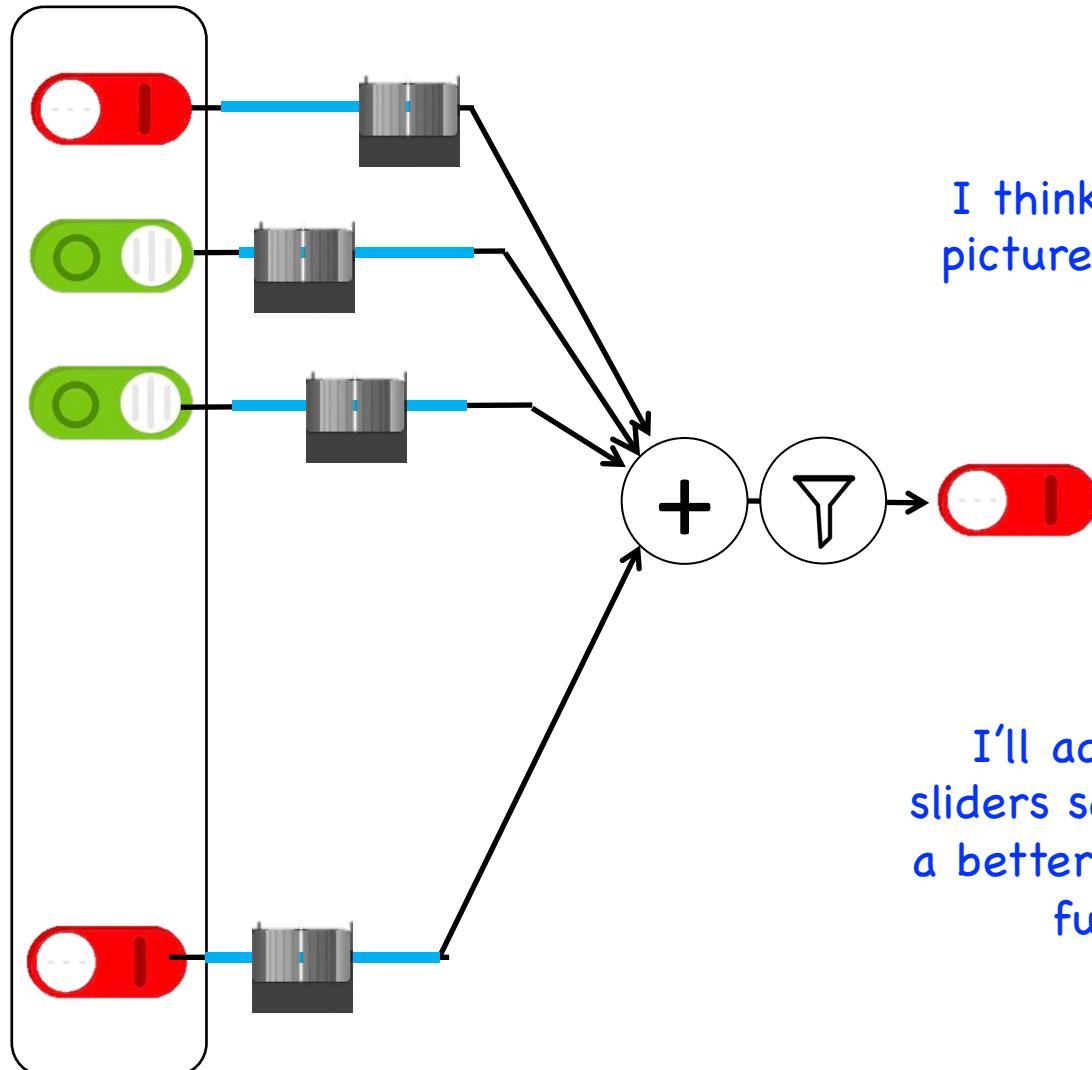
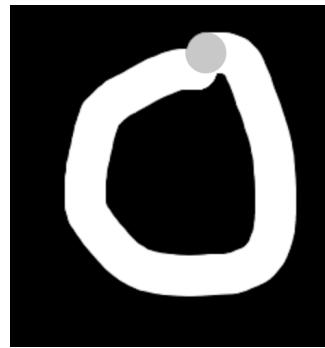


I think that is a picture of a **One!**

What do you mean it's actually a **Zero?**

I'll adjust my sliders so that I do a better job in the future



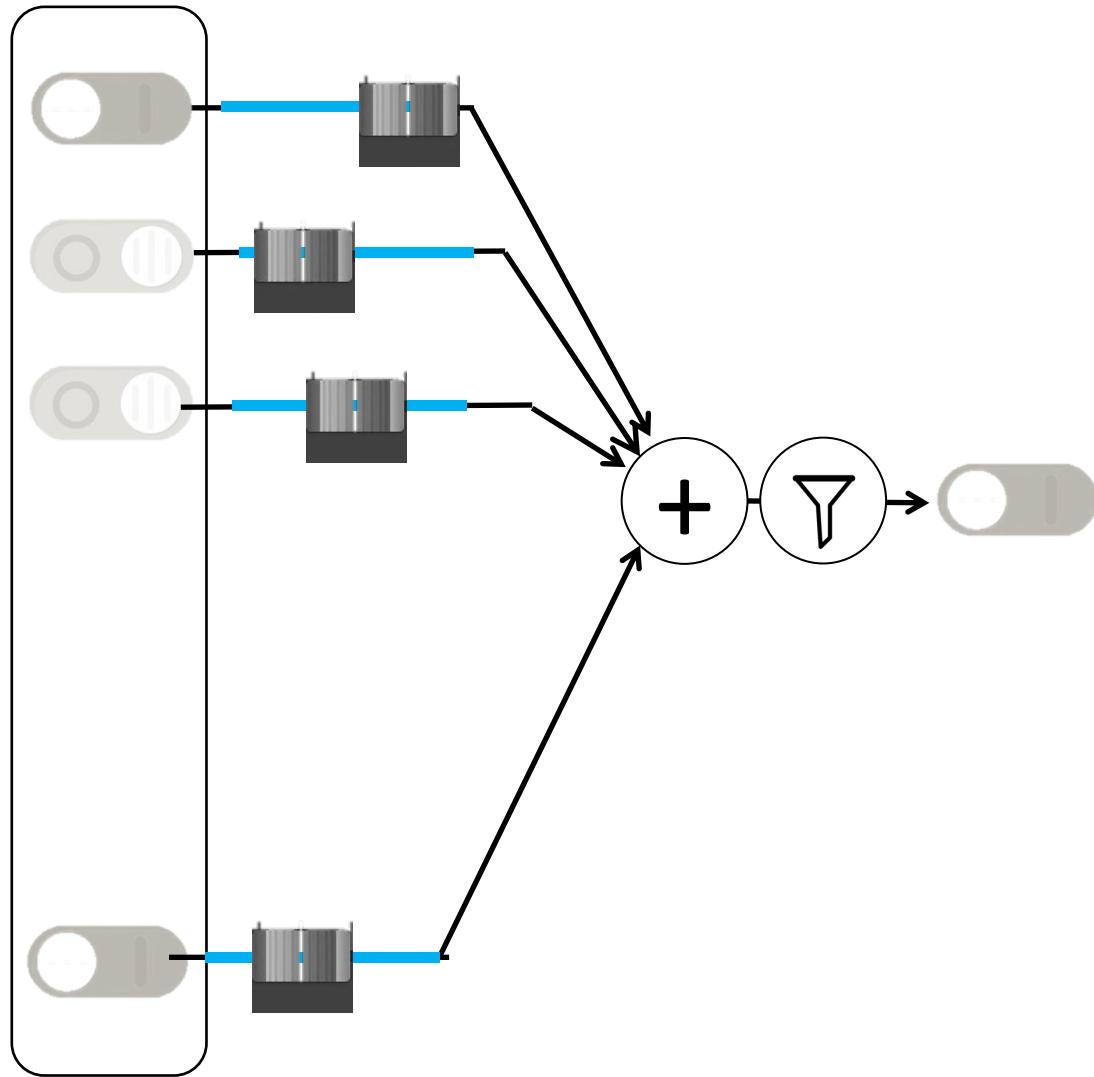


I think that is a picture of a **One!**

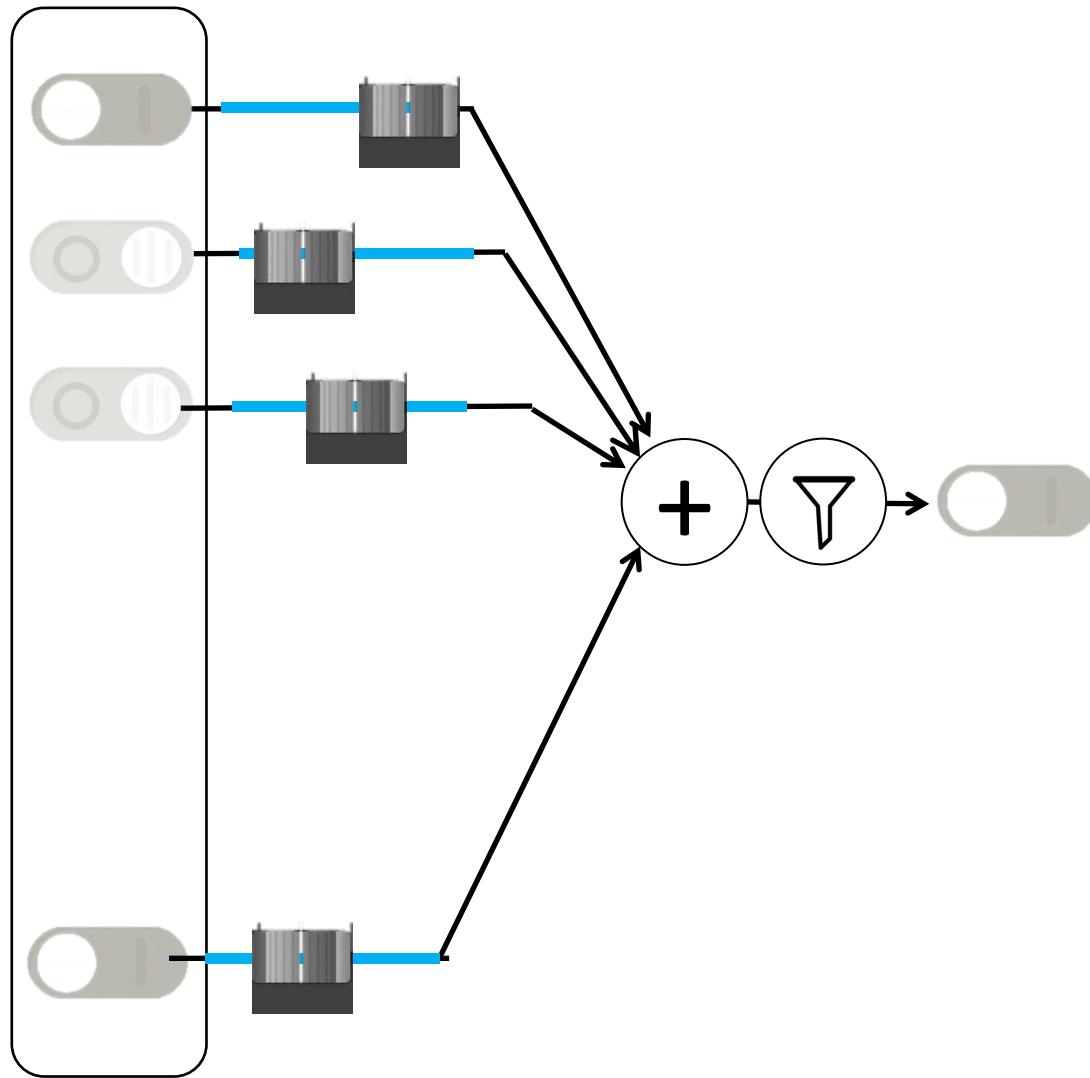
What do you mean it's actually a **Zero?**

I'll adjust my sliders so that I do a better job in the future

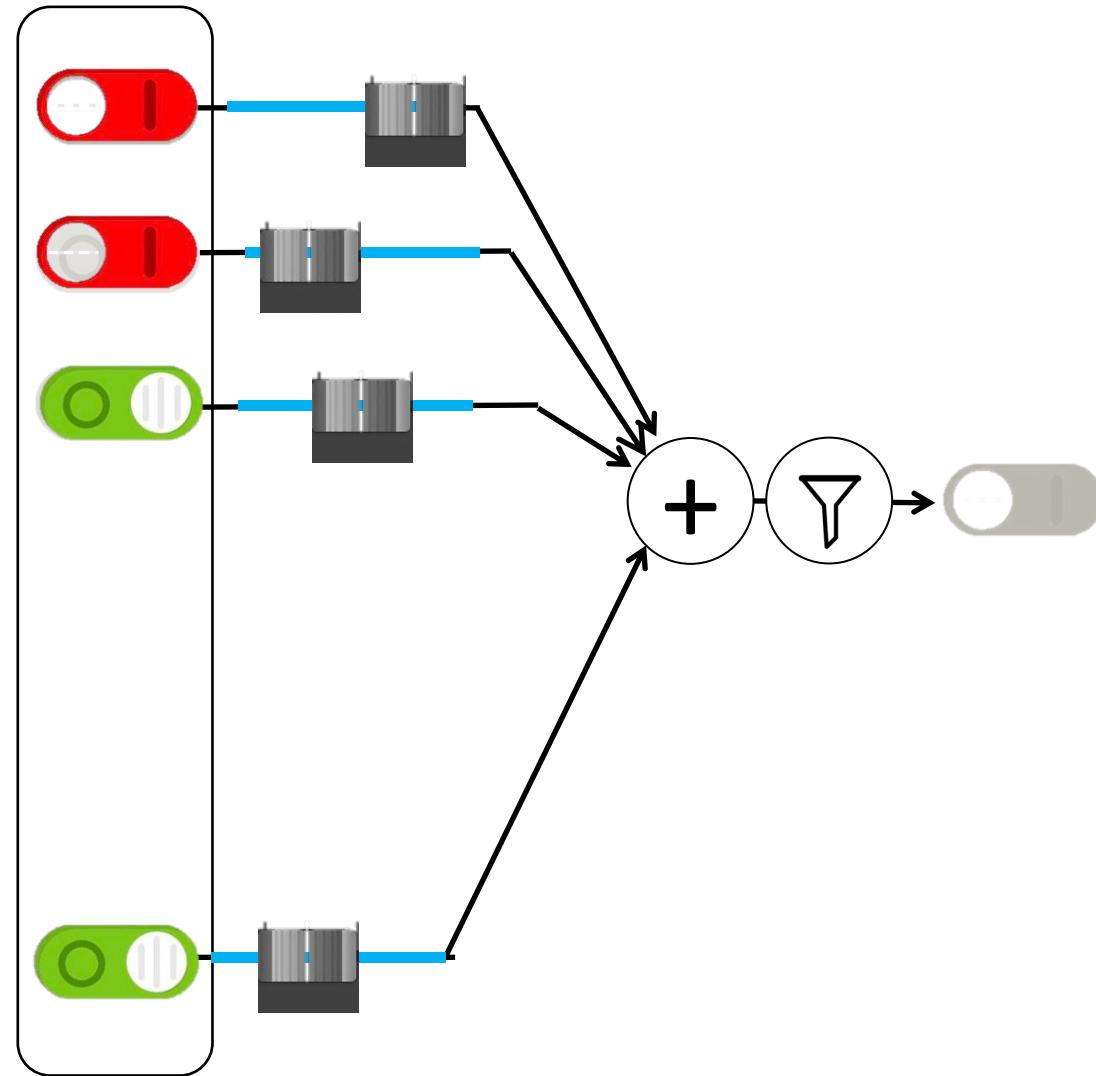


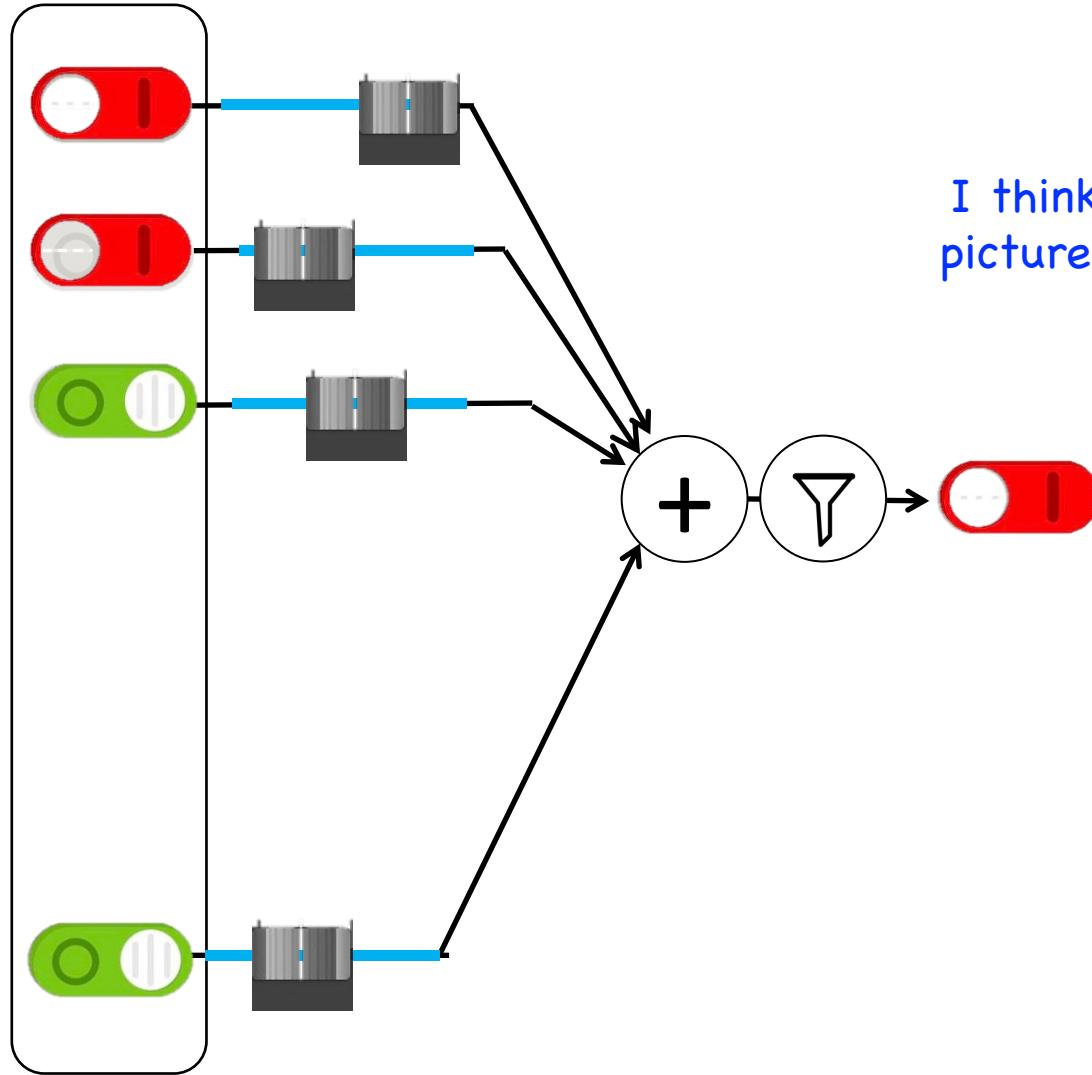


1



1

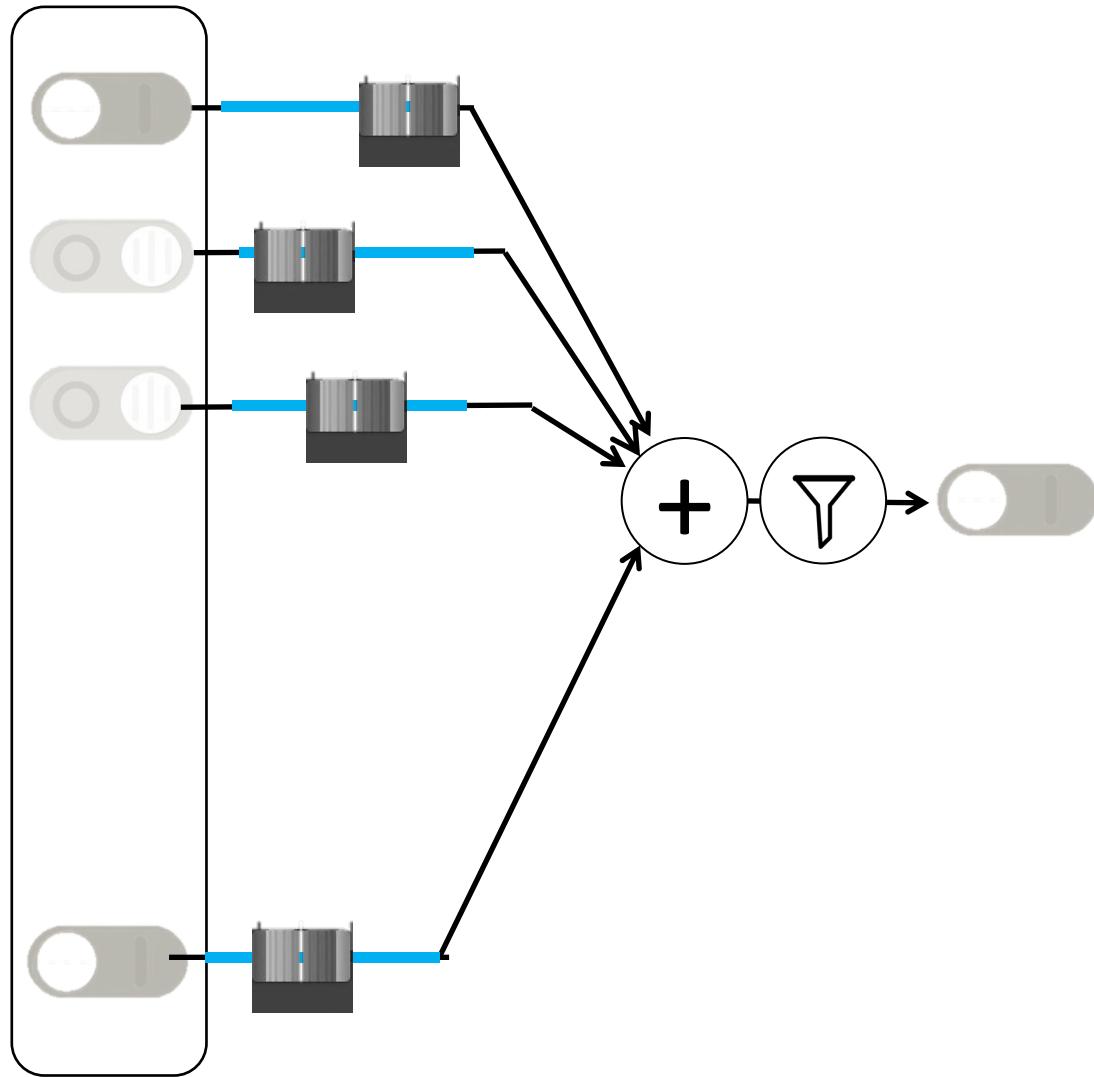




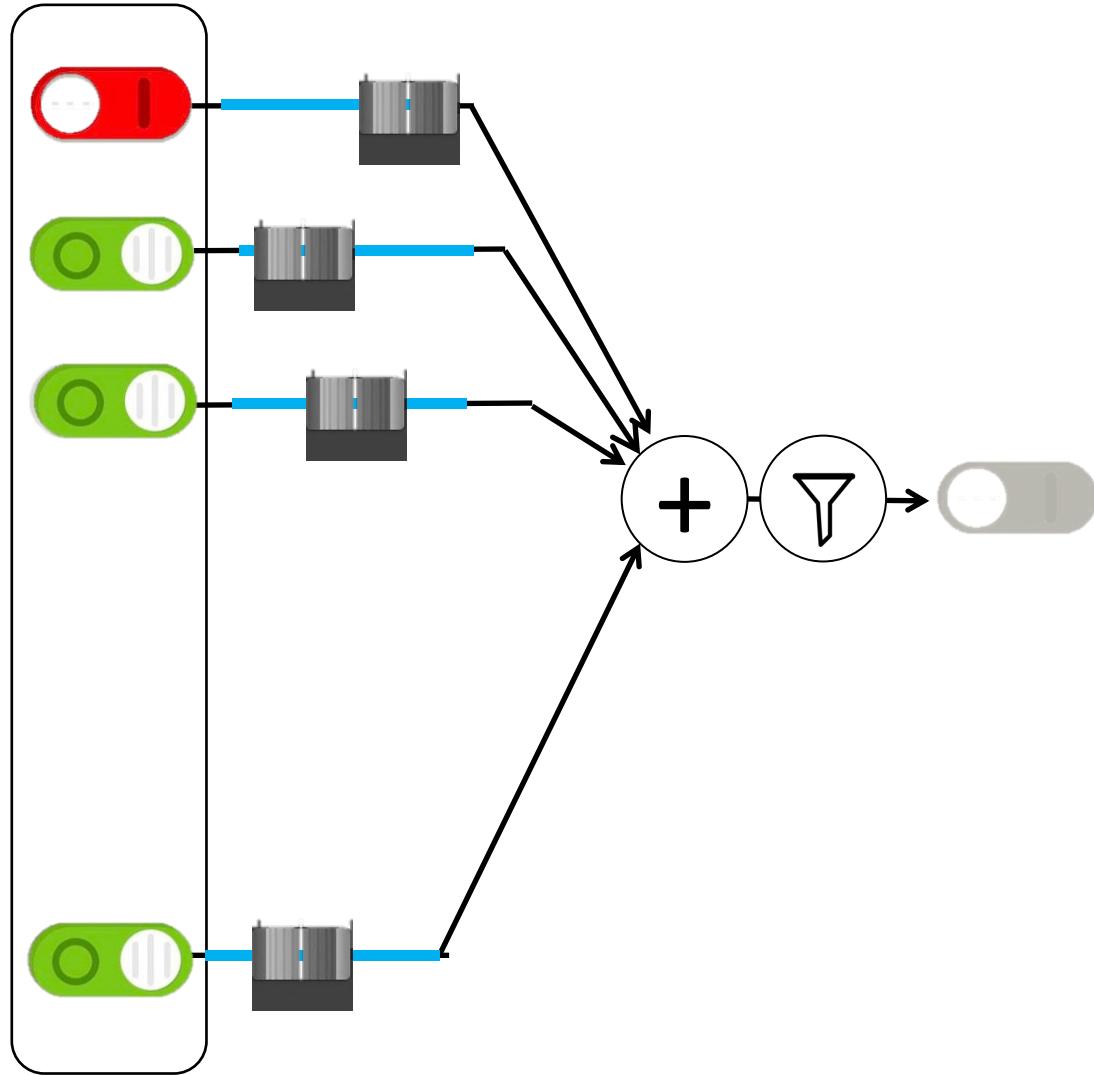
I think that is a picture of a **One!**

Wahoo I got it right!

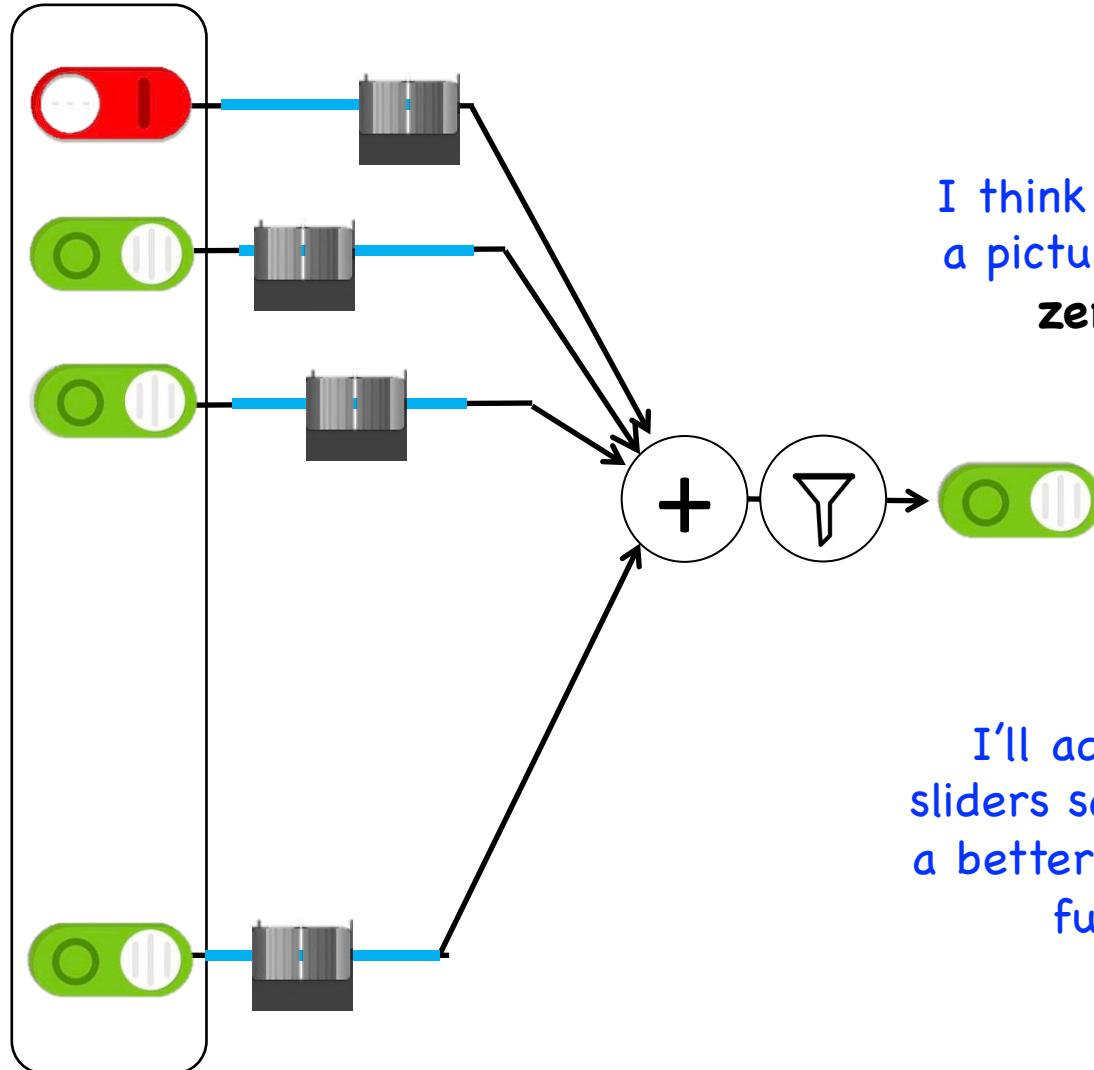




1



1



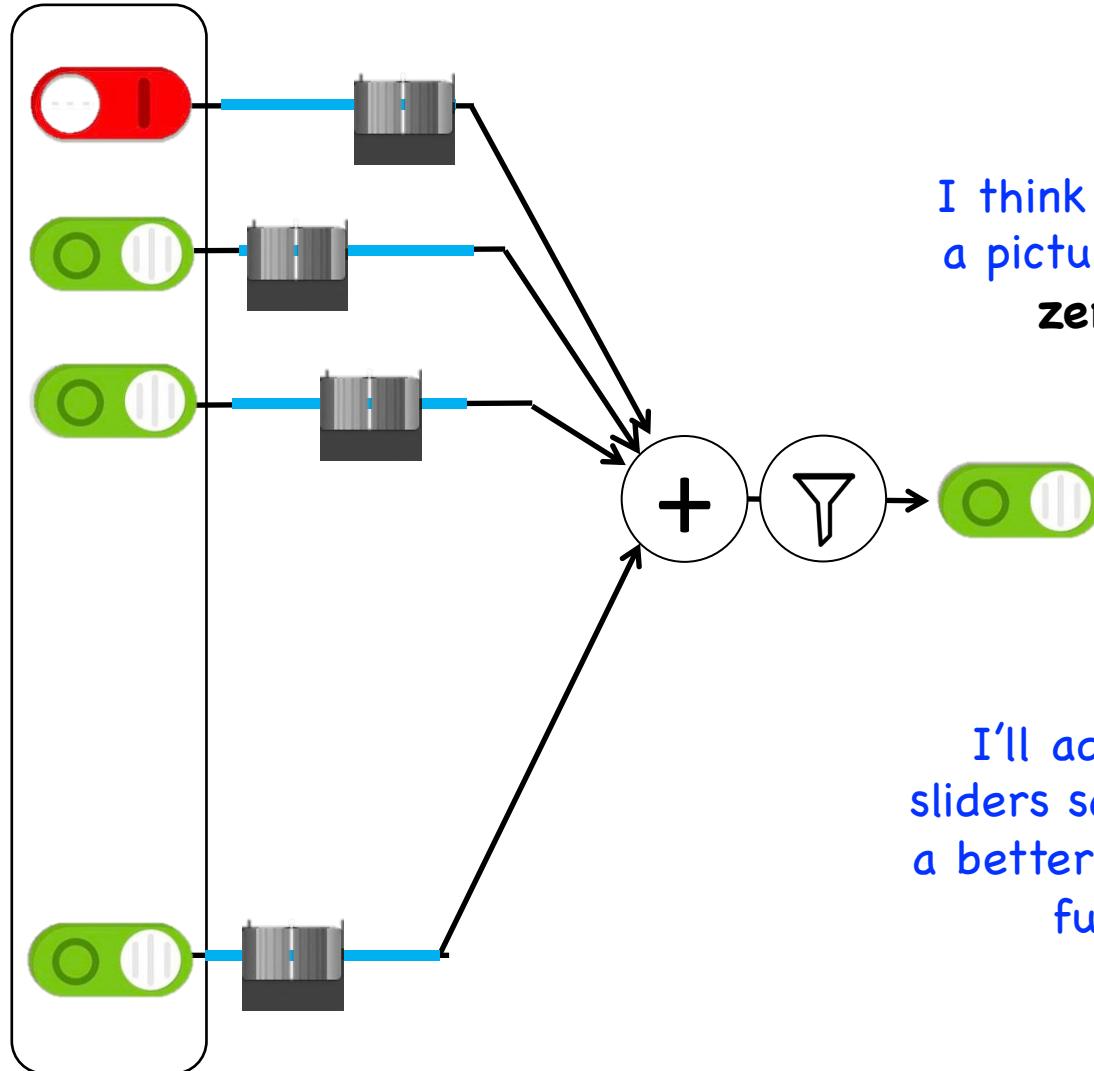
I think that is  
a picture of a  
**zero!**

What do you  
mean it's  
actually a **one?**

I'll adjust my  
sliders so that I do  
a better job in the  
future



1



I think that is  
a picture of a  
**zero!**

What do you  
mean it's  
actually a **one?**

I'll adjust my  
sliders so that I do  
a better job in the  
future

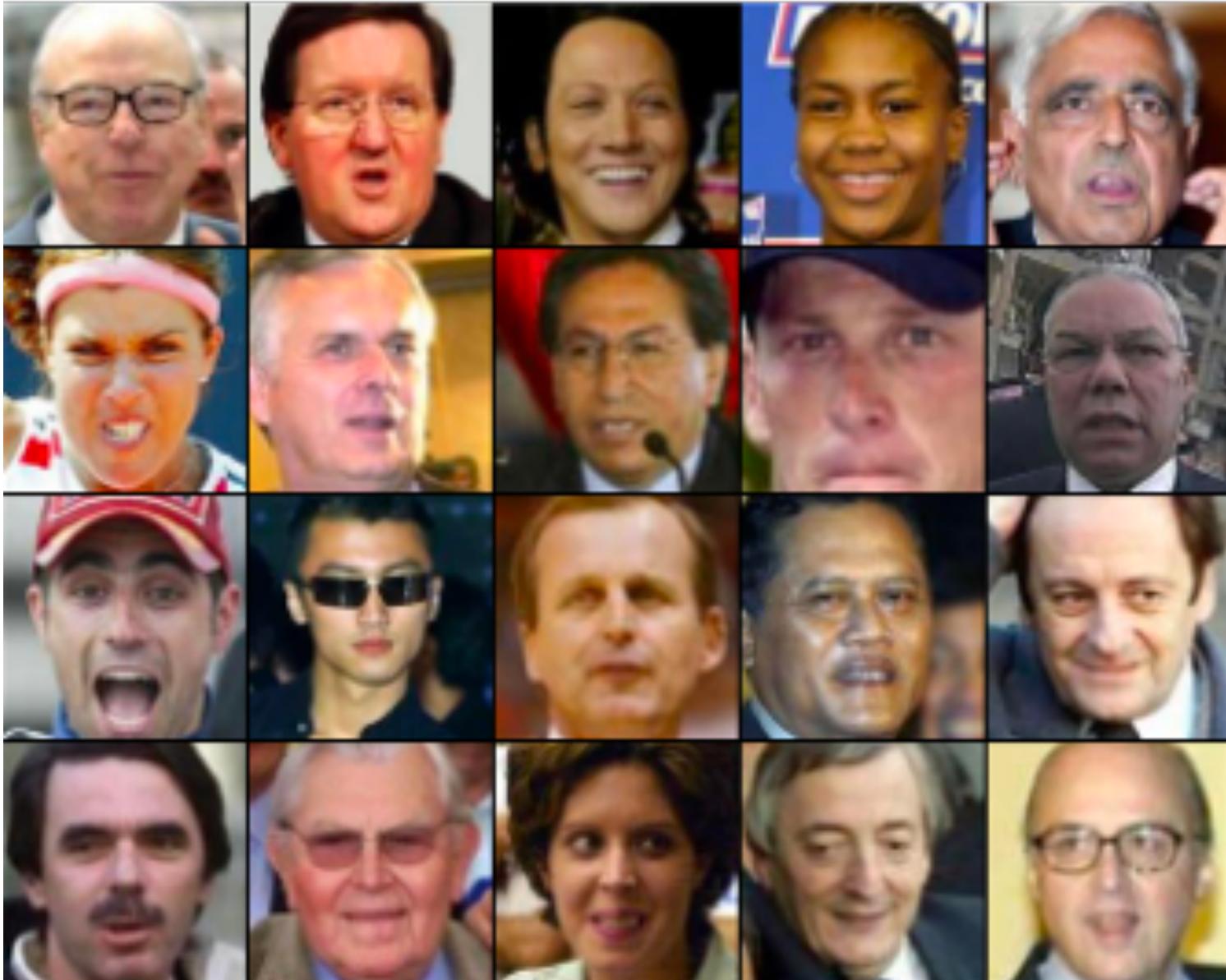


# Study Hard!

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



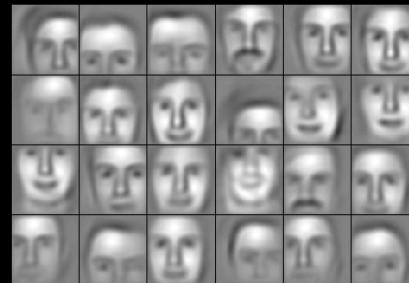
# Train on Faces



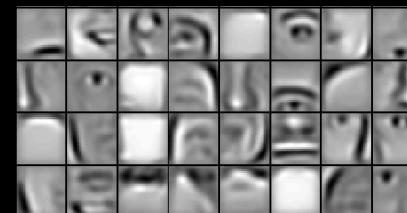
# Visualize the Sliders



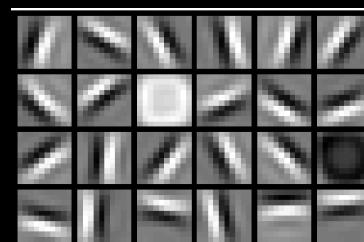
Training set: Aligned  
images of faces.



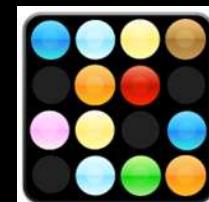
object models



object parts  
(combination  
of edges)



edges



pixels

Woah... that's like a brain...

True.

# Decomposition

Mountain  
Karel

Climb Up  
Mountain

Pick Beeper

Climb Down  
Mountain

Step Up

Step Down



# Image Net Classification

...

smoothhound, smoothhound shark, *Mustelus mustelus*

American smooth dogfish, *Mustelus canis*

Florida smoothhound, *Mustelus norrisi*

whitetip shark, reef whitetip shark, *Triaenodon obesus*

Atlantic spiny dogfish, *Squalus acanthias*

Pacific spiny dogfish, *Squalus suckleyi*

hammerhead, hammerhead shark

smooth hammerhead, *Sphyrna zygaena*

smalleye hammerhead, *Sphyrna tudes*

shovelhead, bonnethead, bonnet shark, *Sphyrna tiburo*

angel shark, angelfish, *Squatina squatina*, monkfish

electric ray, crampfish, numbfish, torpedo

smalltooth sawfish, *Pristis pectinatus*

guitarfish

**roughtail stingray, *Dasyatis centroura***

butterfly ray

eagle ray

spotted eagle ray, spotted ray, *Aetobatus narinari*

cownose ray, cow-nosed ray, *Rhinoptera bonasus*

manta, manta ray, devilfish

**Atlantic manta, *Manta birostris***

devil ray, *Mobula hypostoma*

grey skate, gray skate, *Raja batis*

little skate, *Raja erinacea*

...

**Stingray**



**Mantaray**



0.005%

Random guess

1.5%

Pre Neural Networks

?

GoogLeNet

0.005%

Random guess

1.5%

Pre Neural Networks

43.9%

GoogLeNet

**0.005%**

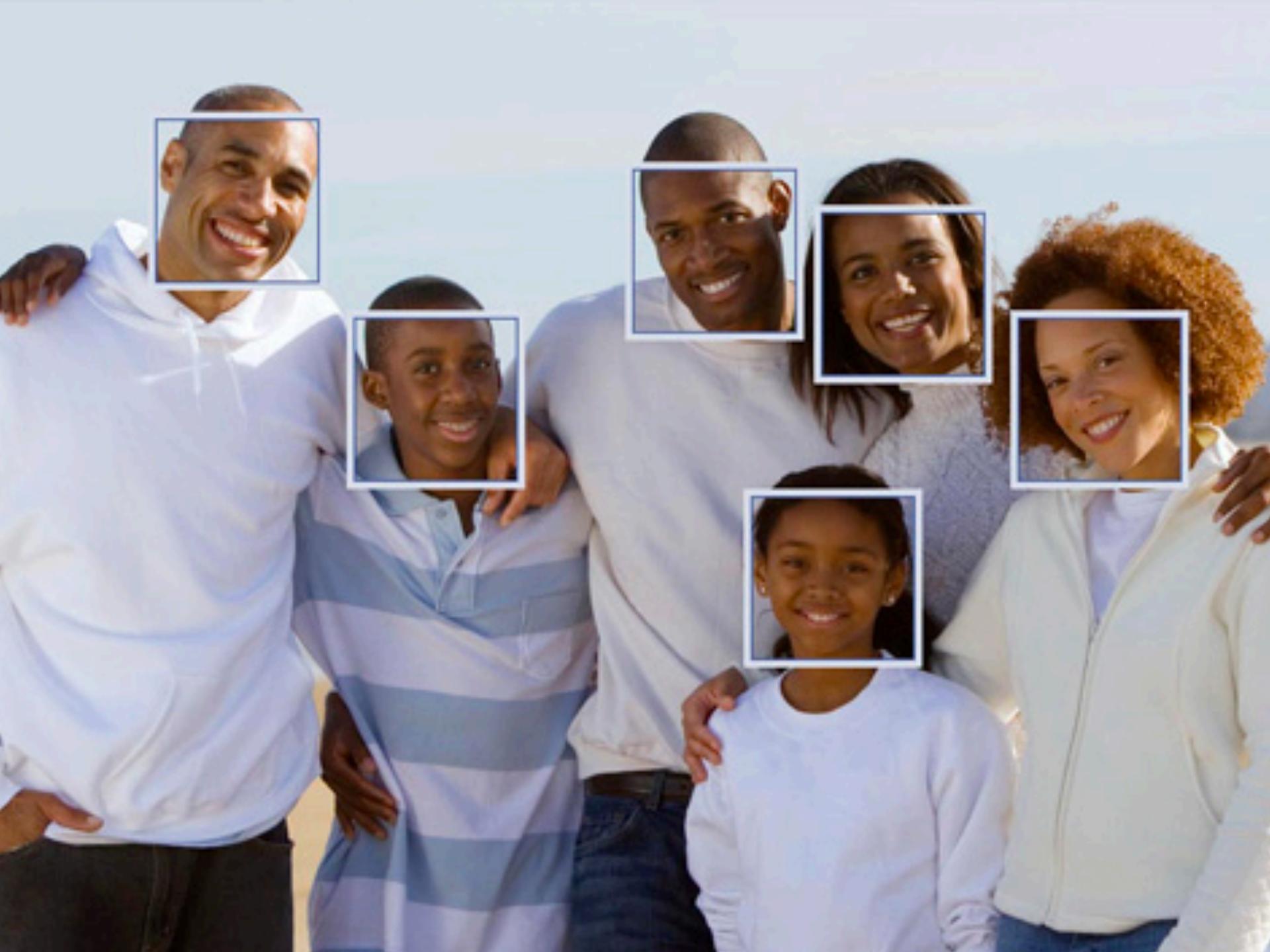
Random guess

**1.5%**

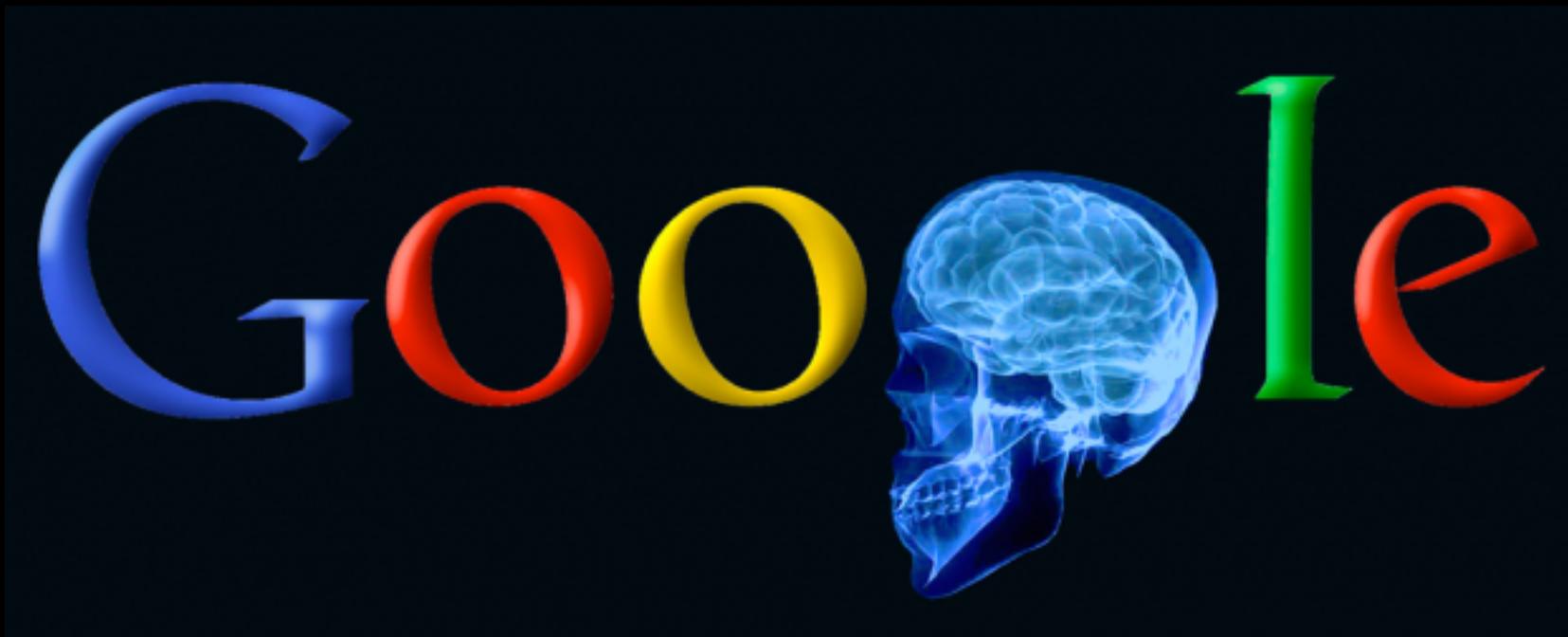
Pre Neural Networks

**66.3%**

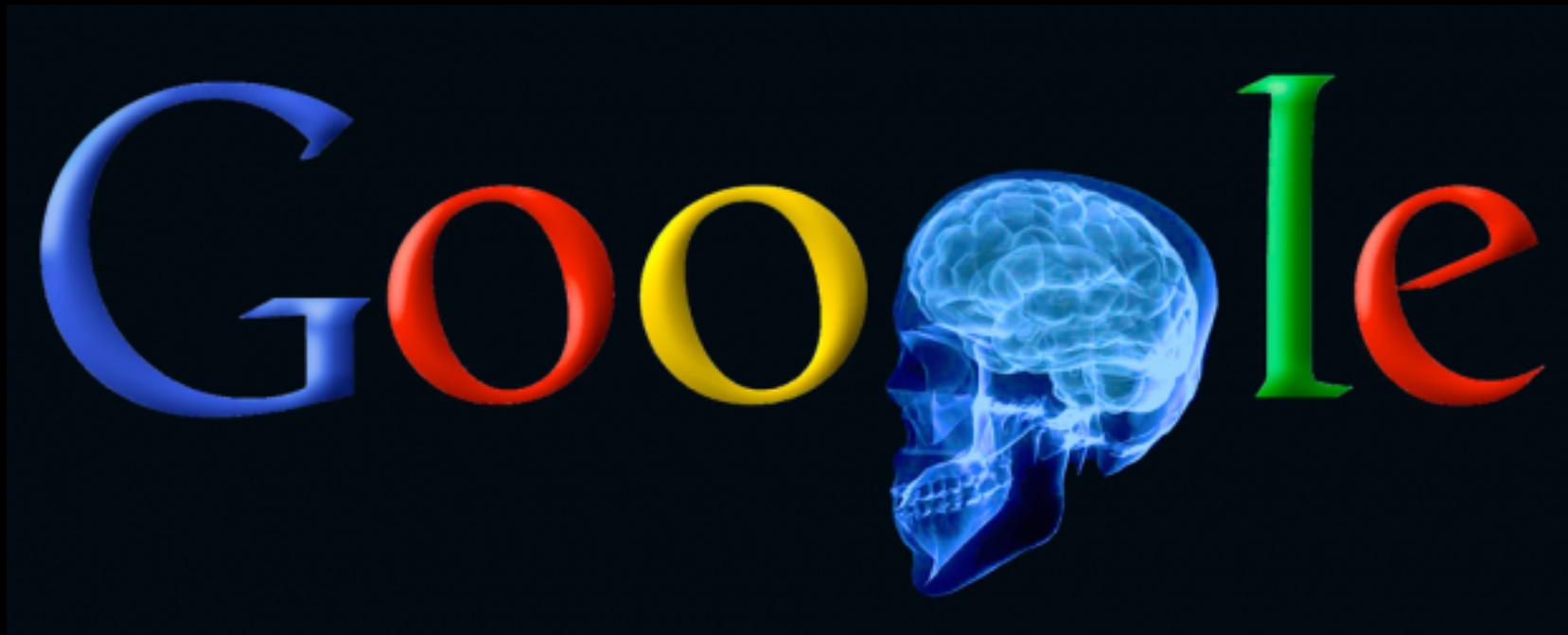
2016



# Google Brain



# Google Brain



1 Trillion Artificial Neurons

# A Neuron That Fires When It Sees Cats

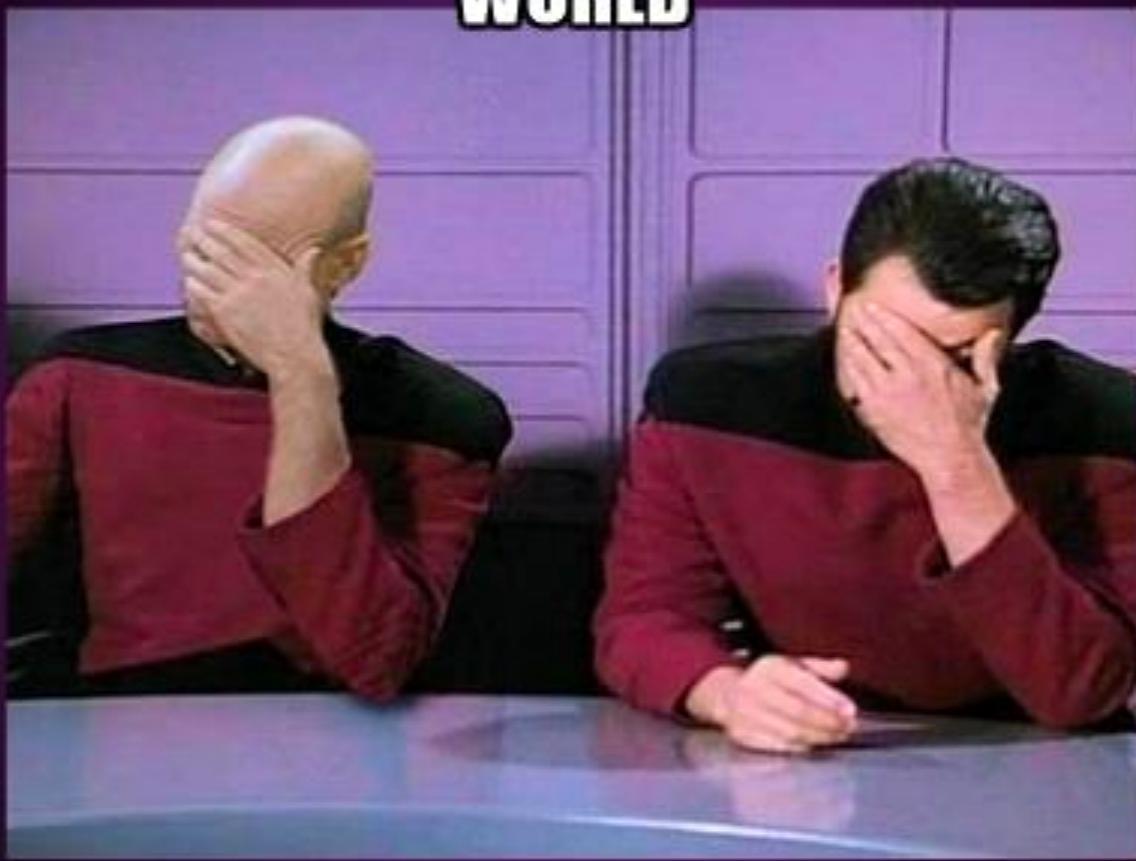


Top stimuli from the test set



Optimal stimulus  
by numerical optimization

**HIRE THE SMARTEST PEOPLE IN THE  
WORLD**



**INVENT CAT DETECTOR**

[inteligentiator.net](http://inteligentiator.net)

# Other Neurons

Neuron 1



Neuron 2



Neuron 3



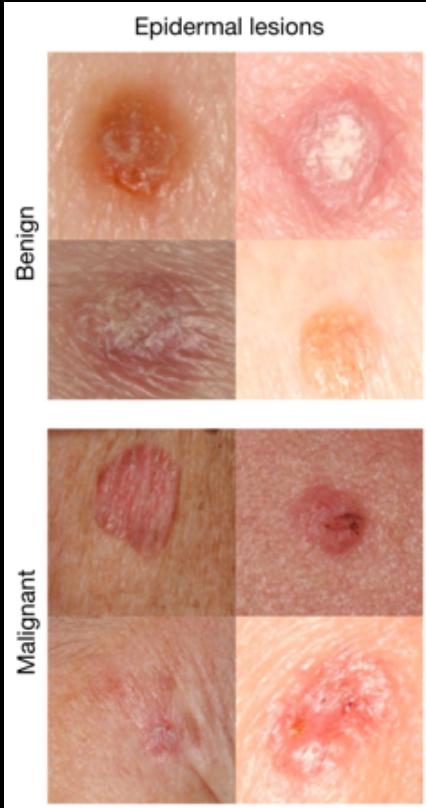
Neuron 4



Neuron 5



# It can be useful



An algorithm learned to detect skin cancer from photo, better than the worlds top expert.

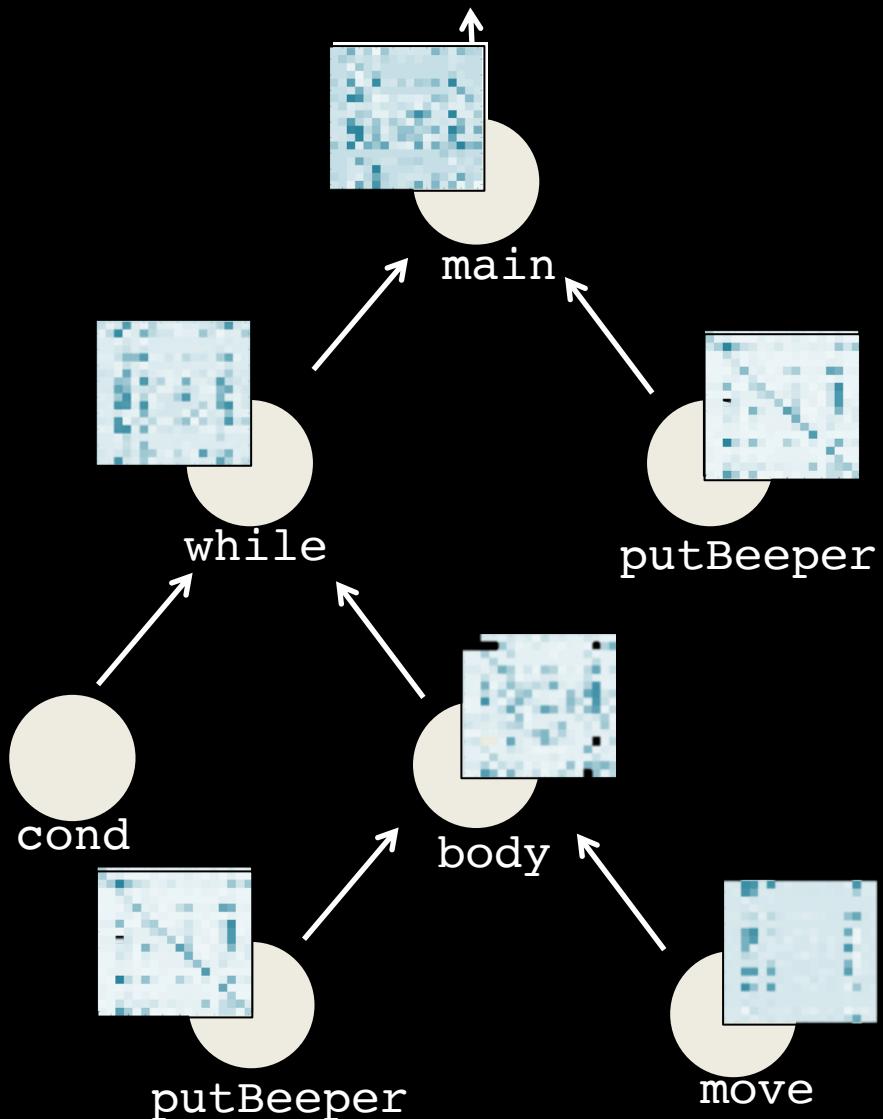
Developed last year

Esteva, Andre, et al. "Dermatologist-level classification of skin cancer with deep neural networks." *Nature* 542.7639 (2017): 115-118.

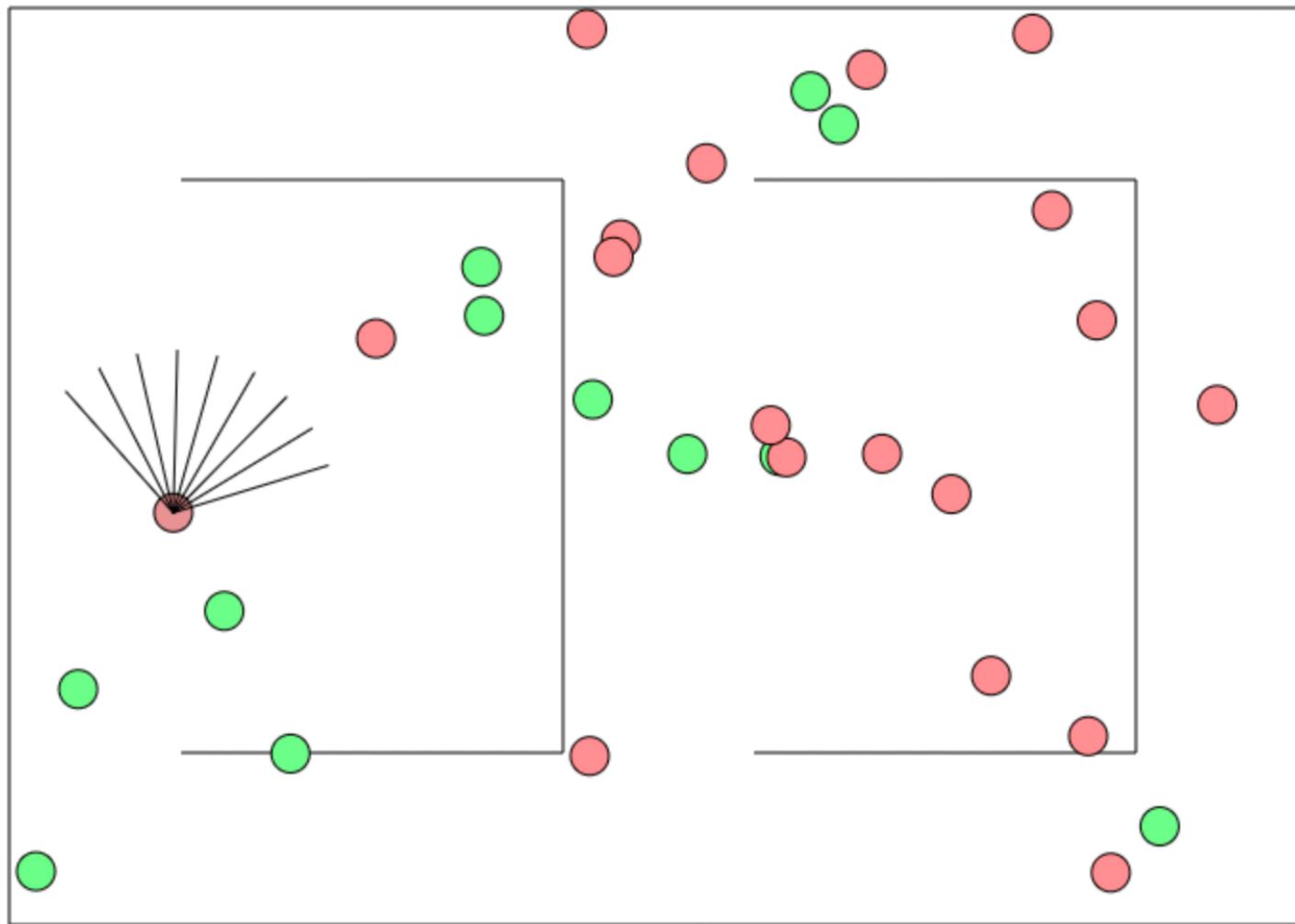
# Helping Students Learn to Program

```
// User defined method
def main():
    while(isClear()):
        put_beeper()
        move()
    put_beeper()
```

It looks like you have a fencepost error!



# Beyond Harry Potter Hats



<http://cs.stanford.edu/people/karpathy/convnetjs/demo/rldemo.html>

CSBridge '20



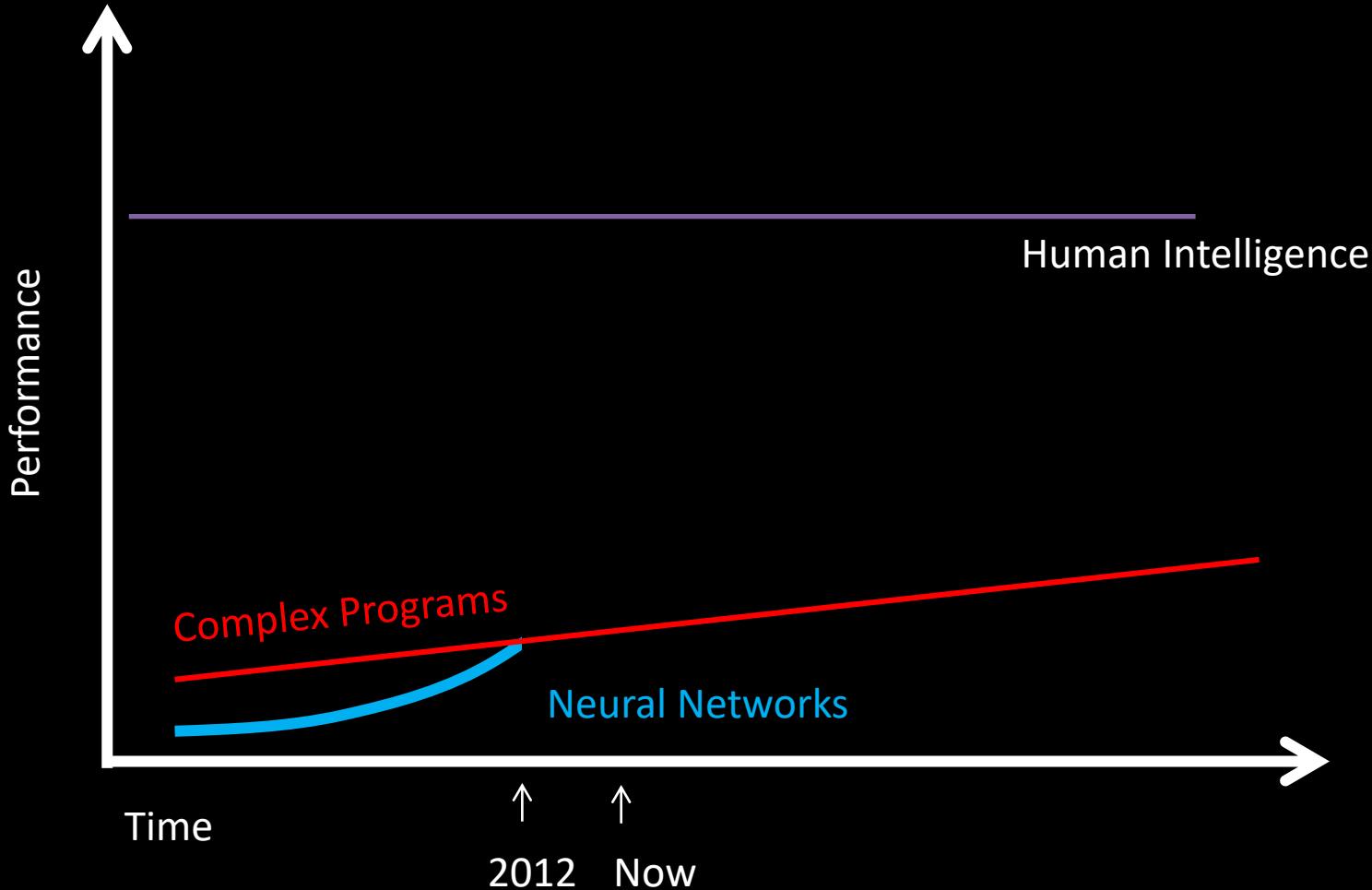
# Beyond Classification

**Starting out - 10 minutes of training**

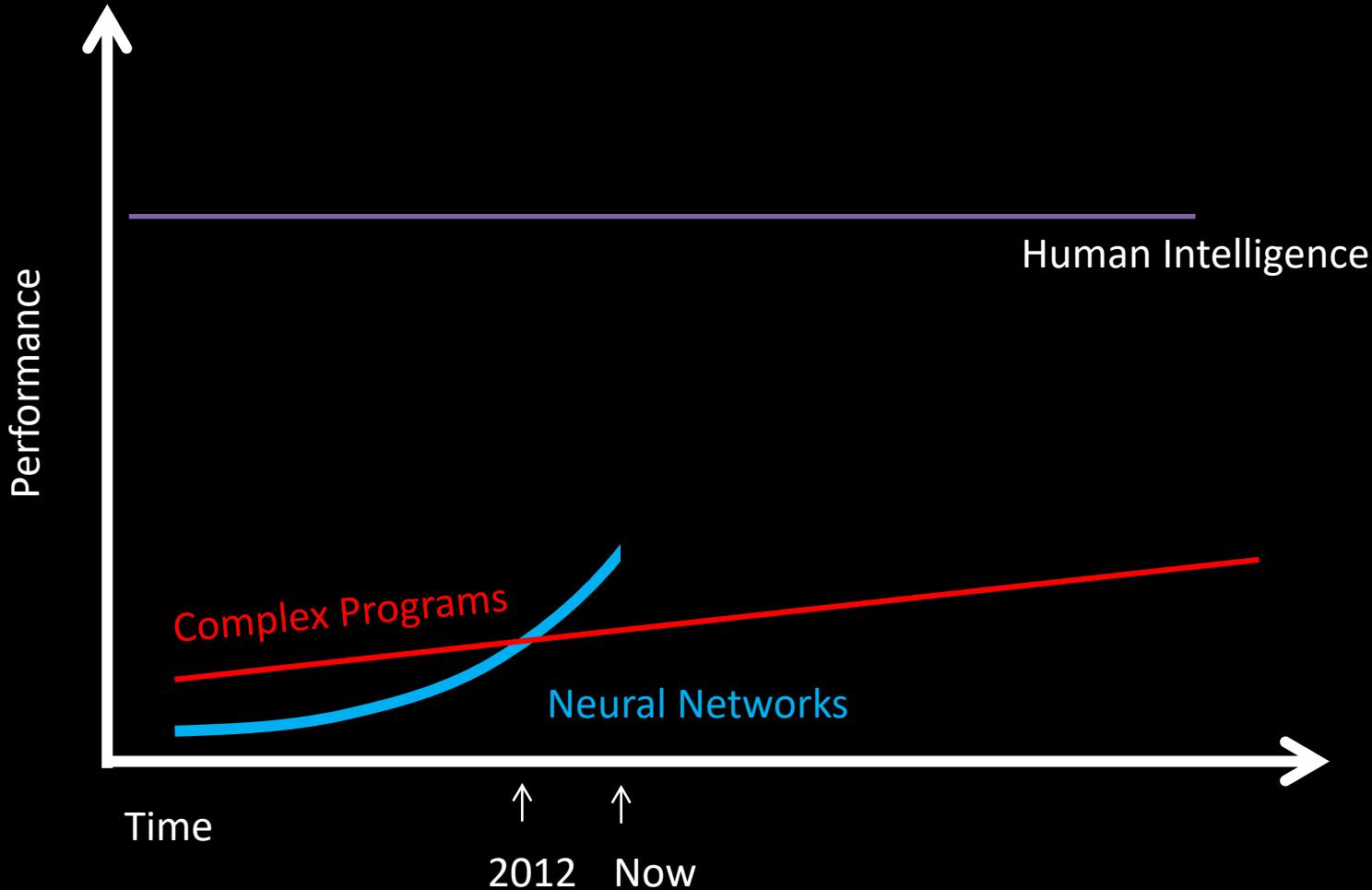
**The algorithm tries to hit the ball back, but  
it is yet too clumsy to manage.**



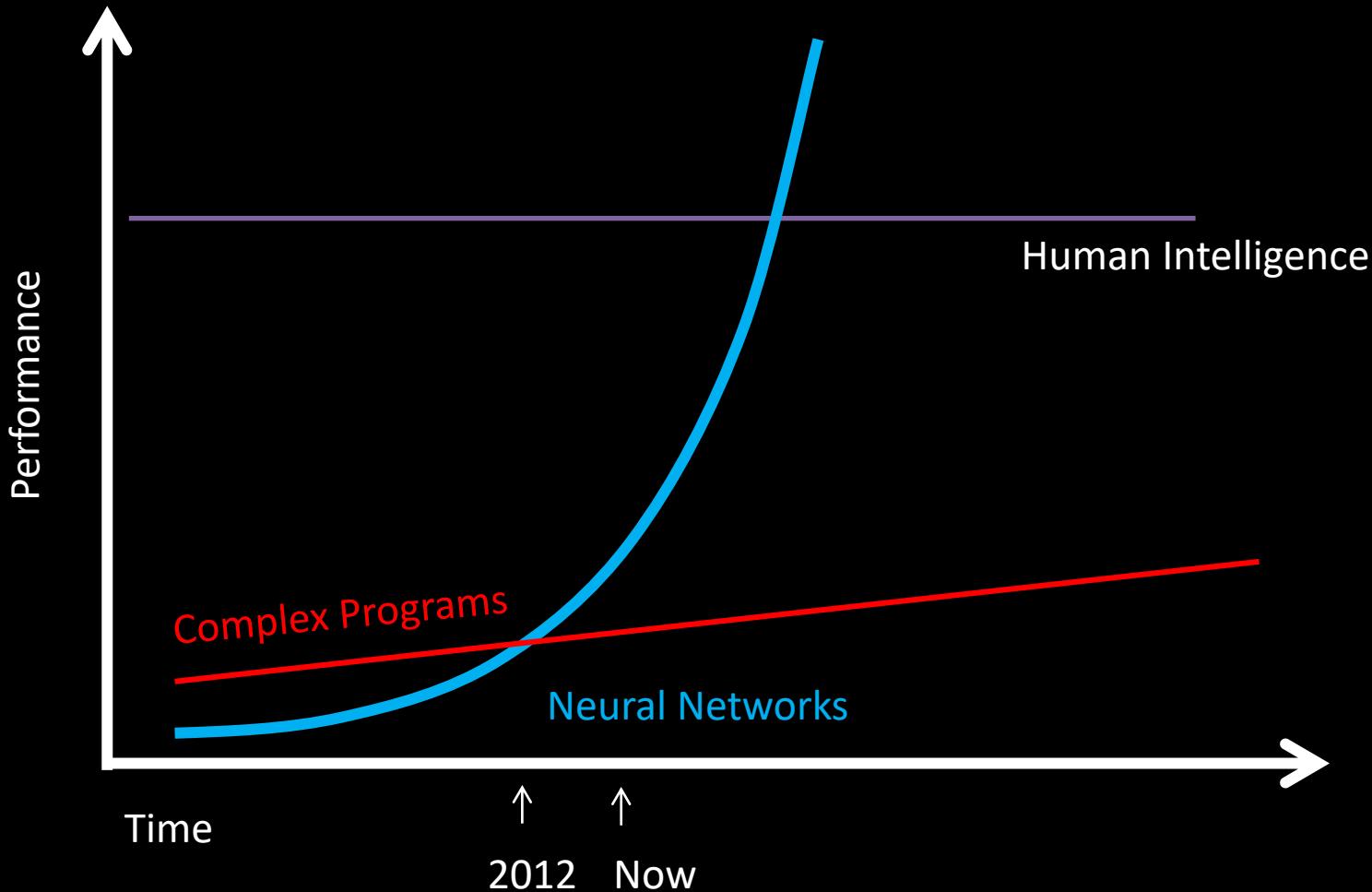
# The Future of AI



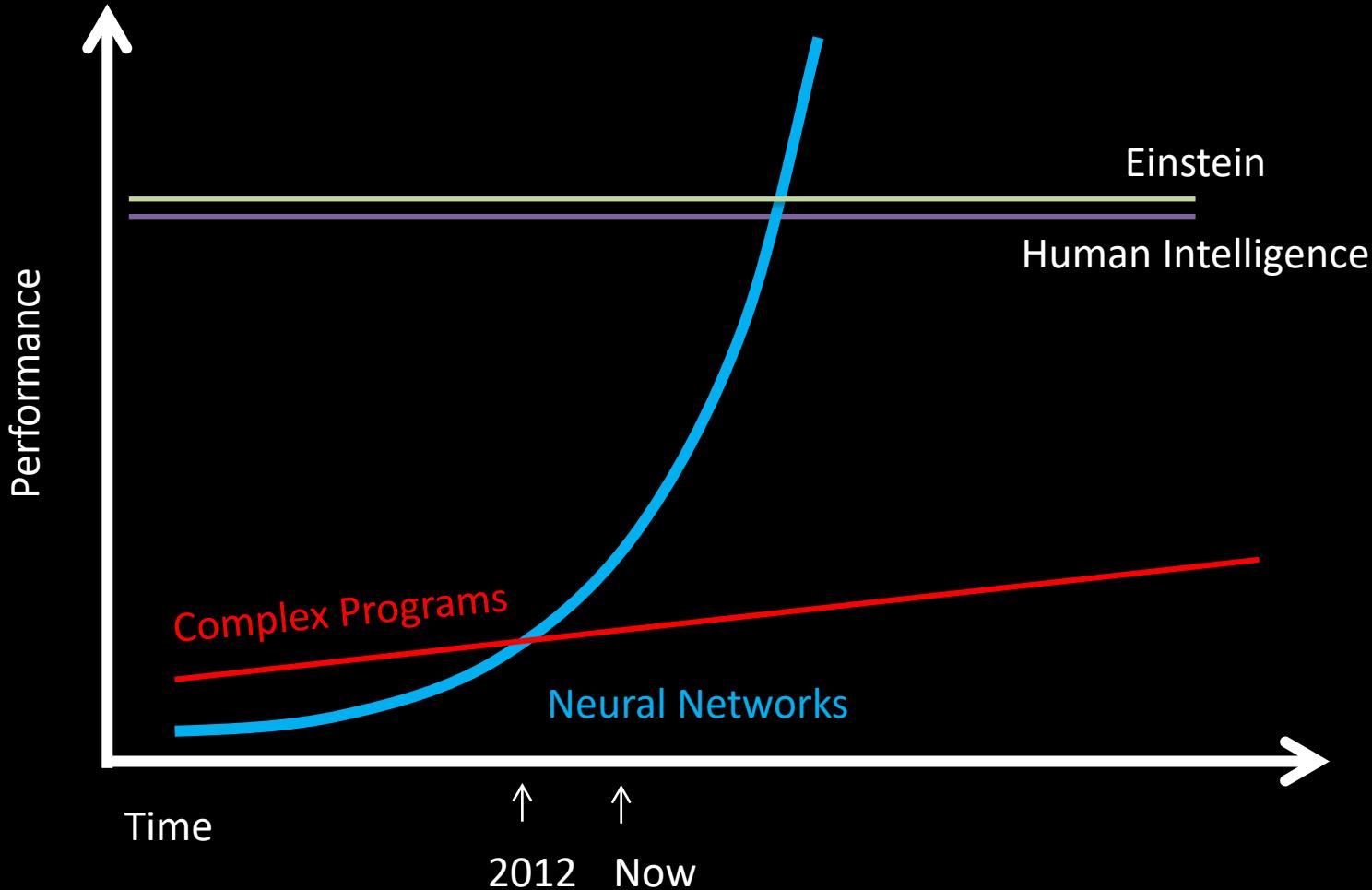
# The Future of AI



# The Future of AI



# The Future of AI



Where is my robot?

... coming soon

Should I study AI?

# Powerful technology



# Now is an amazing time



# Know It So You Can Beat It



Little math



# Todos son bienvenidos

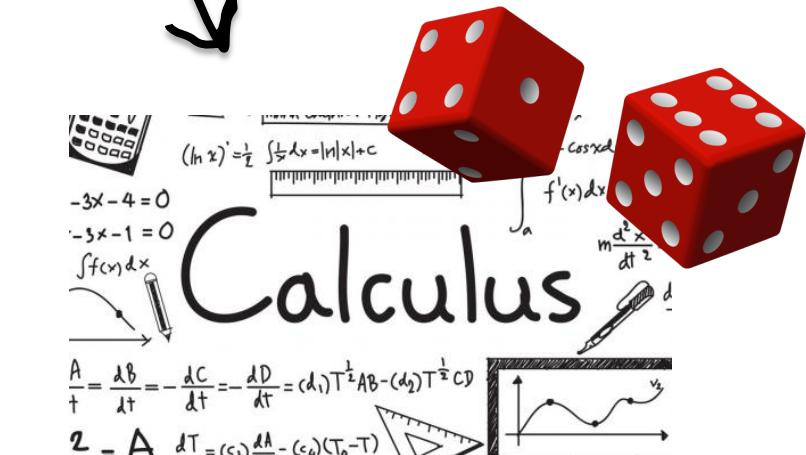


# Road towards AI



**PYTORCH**

Libraries to use AI



Mathematics to invent AI

# Next Step:



Nimm

```
There are 20 stones left
Player 1 would you like to remove 1 or 2 stones? 2

There are 18 stones left
Player 2 would you like to remove 1 or 2 stones? 2

There are 16 stones left
Player 1 would you like to remove 1 or 2 stones? 1

There are 15 stones left
Player 2 would you like to remove 1 or 2 stones? 2

    • • •

Player 1 wins!
```





WALL-E



The End?