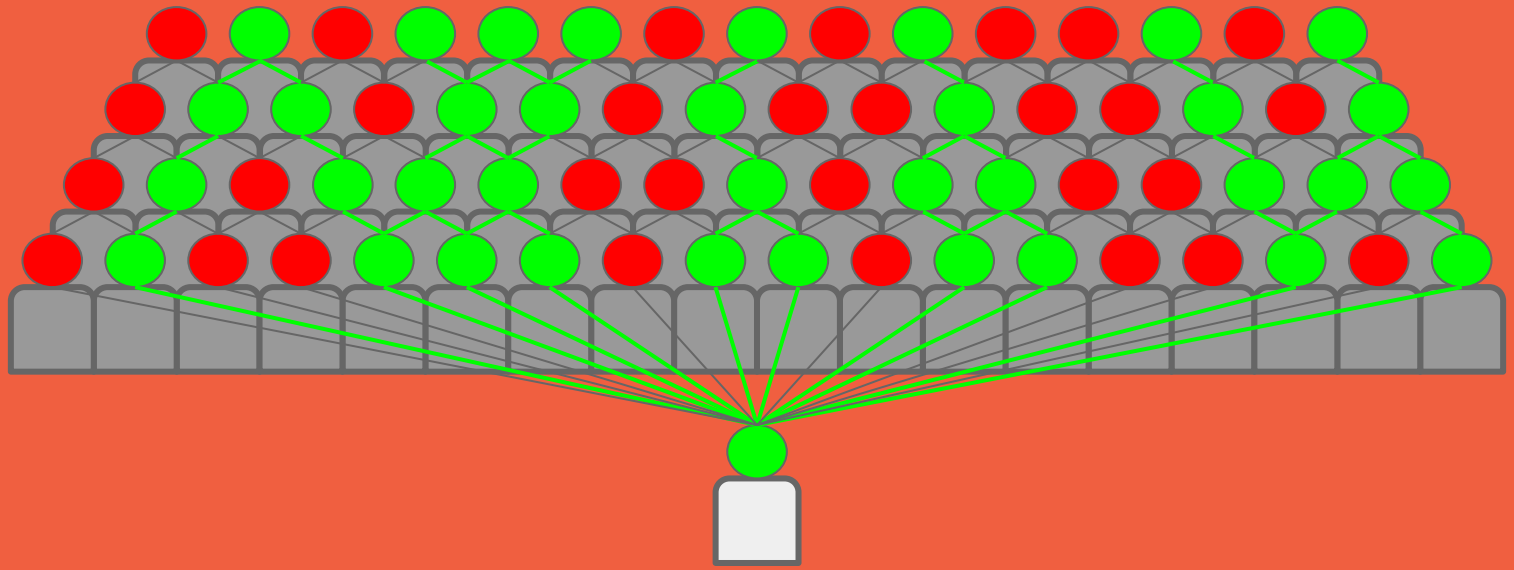
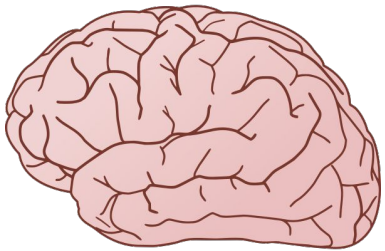
Human Neural Network



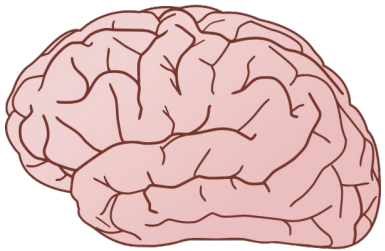
What is a Neural Network?

What is a Neural Network?

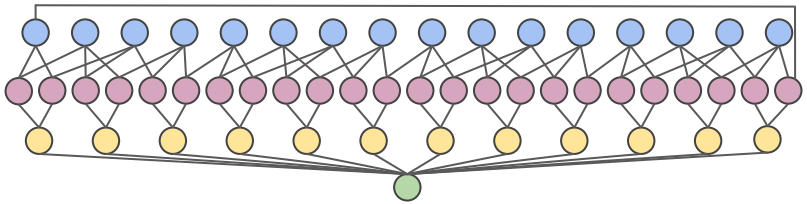


Natural

What is a Neural Network?



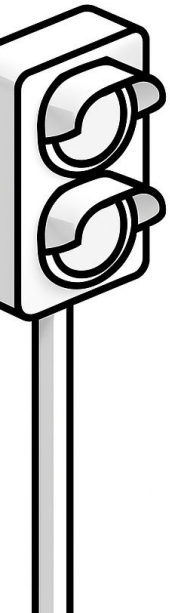
Natural



Artificial

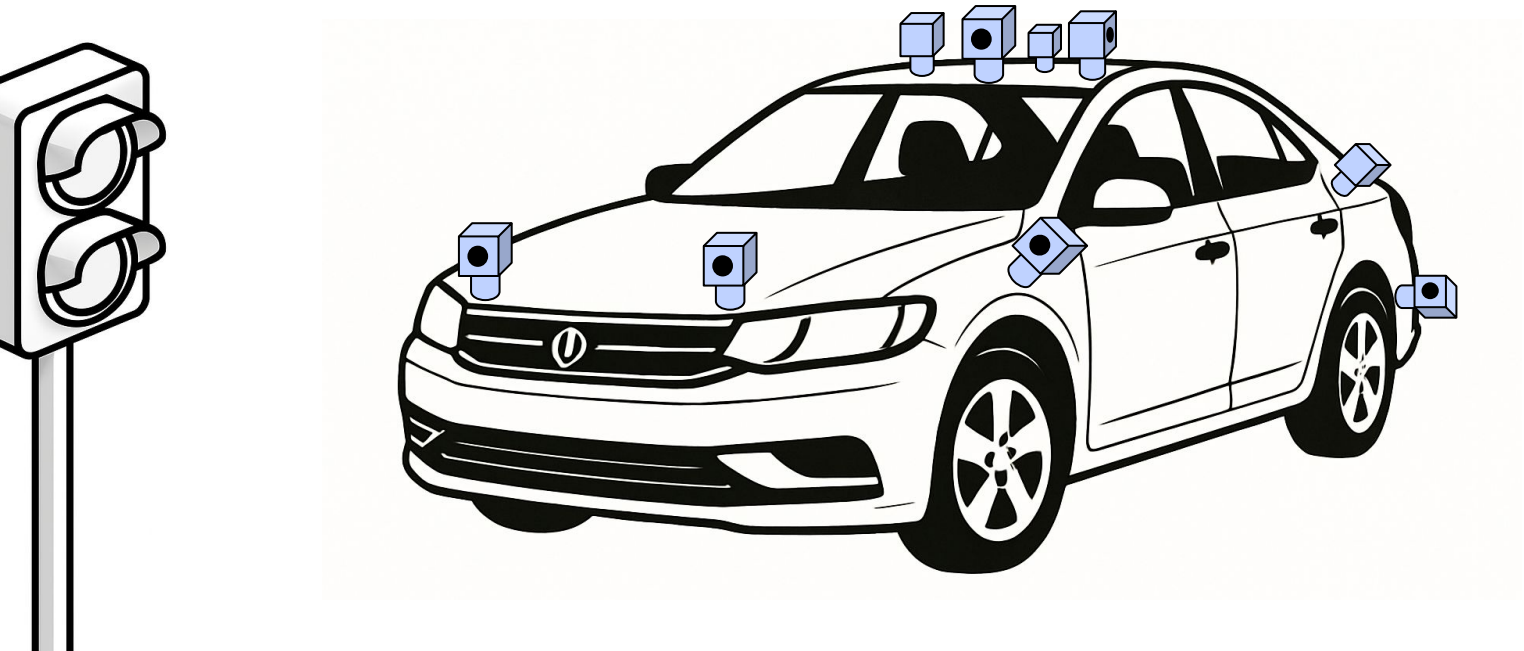
Self-Driving Car

What sensors do we need?



Self-Driving Car

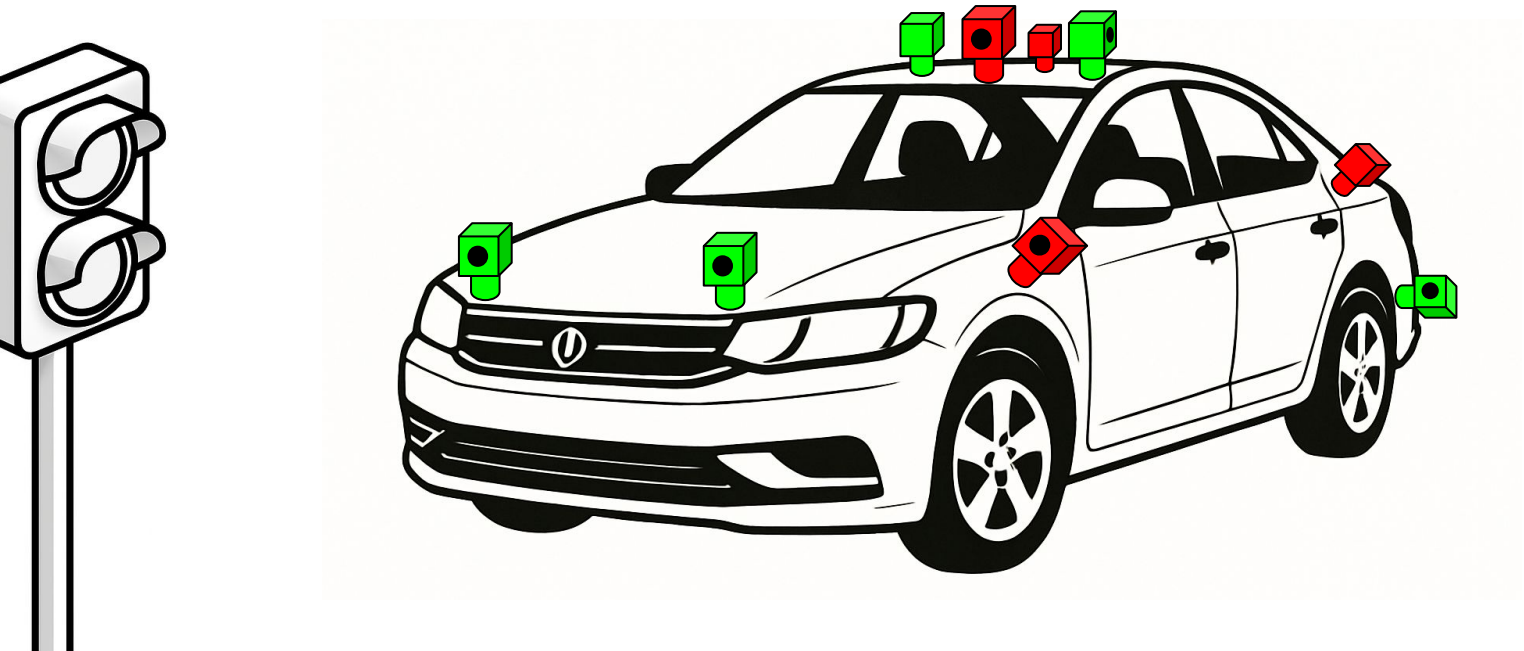
Camera Sensors



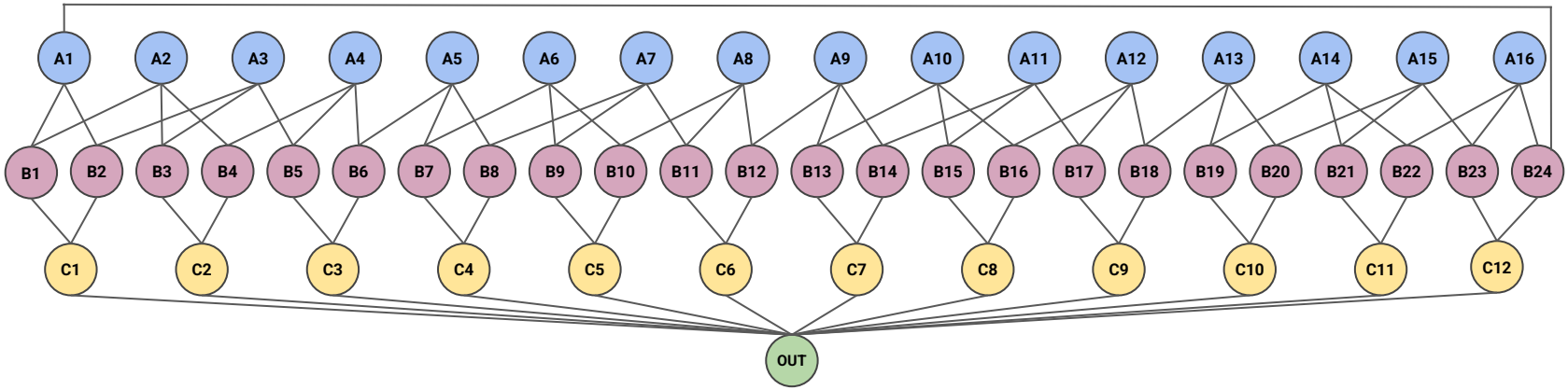
Self-Driving Car

Camera Sensors are not reliable

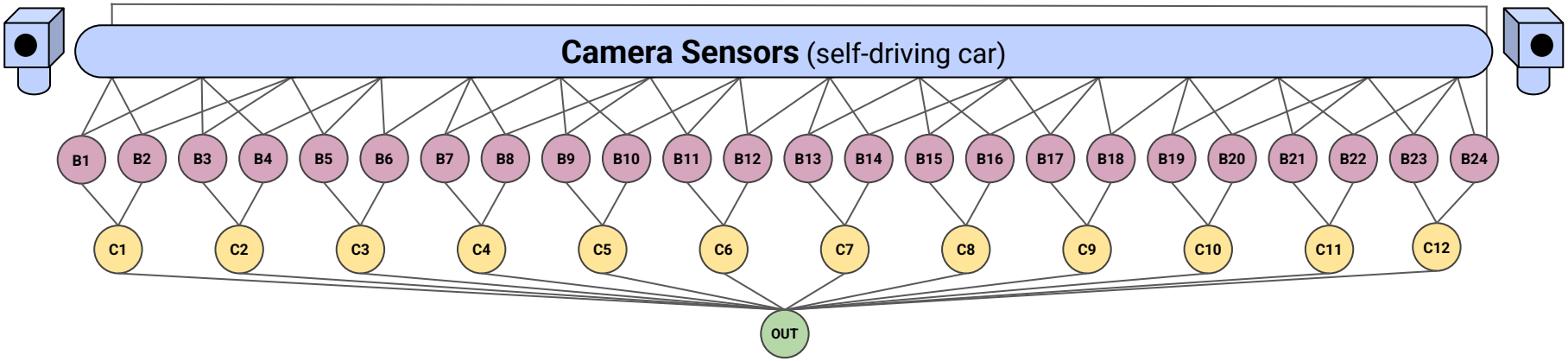
Our ***neural network*** will learn when to **GO** and when to **STOP**



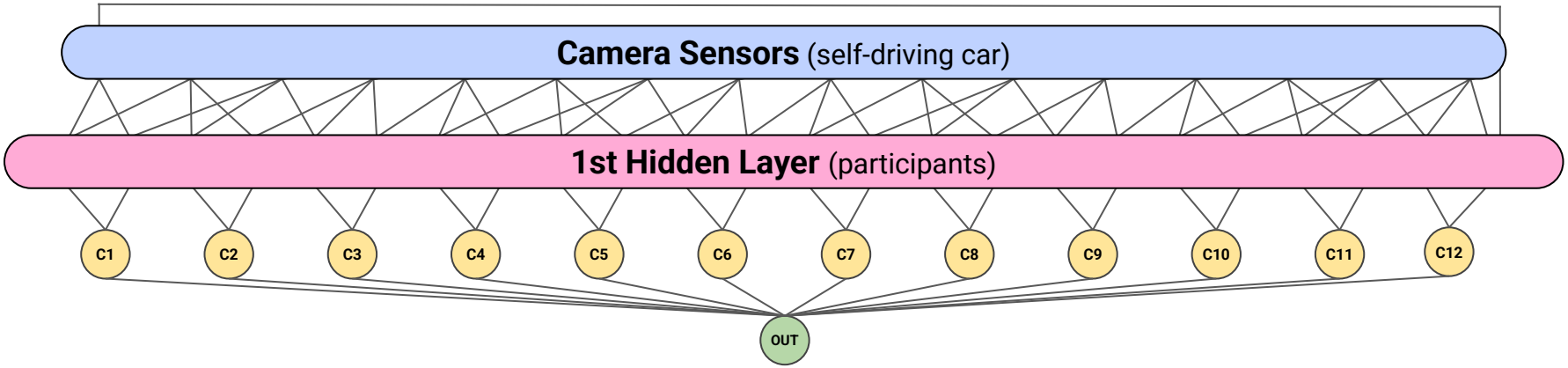
“Human Neural Network”



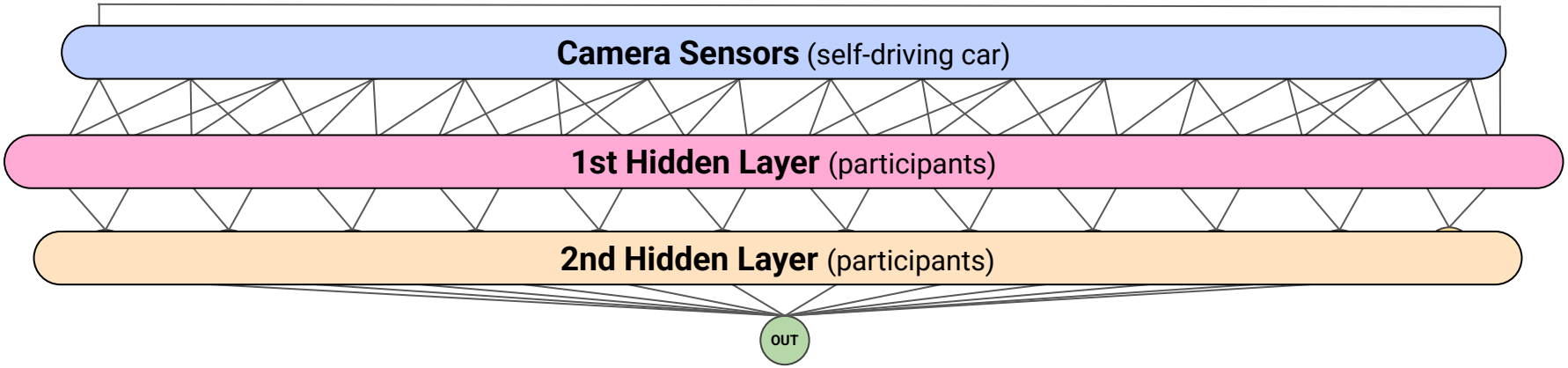
“Human Neural Network”



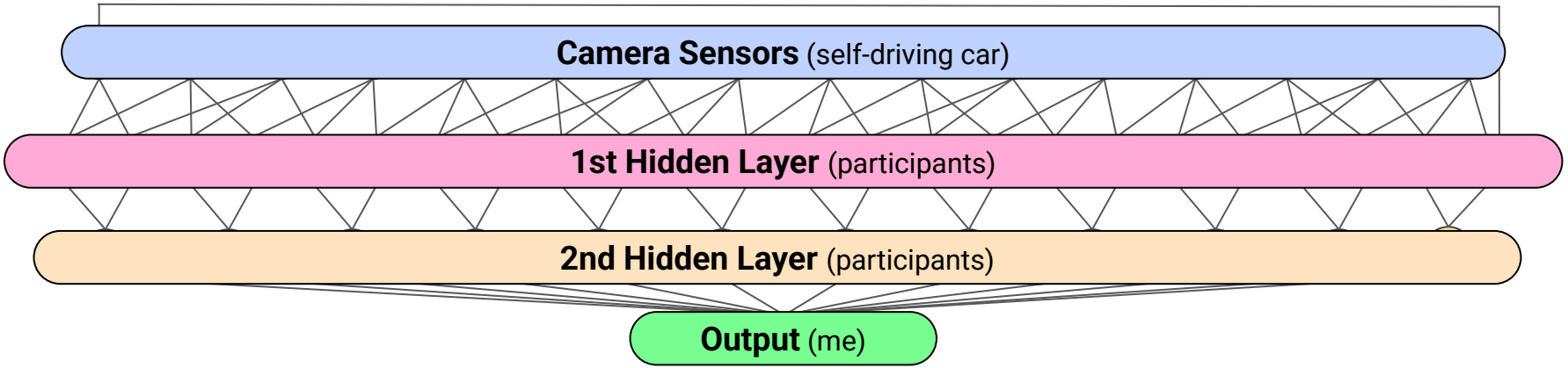
“Human Neural Network”



“Human Neural Network”

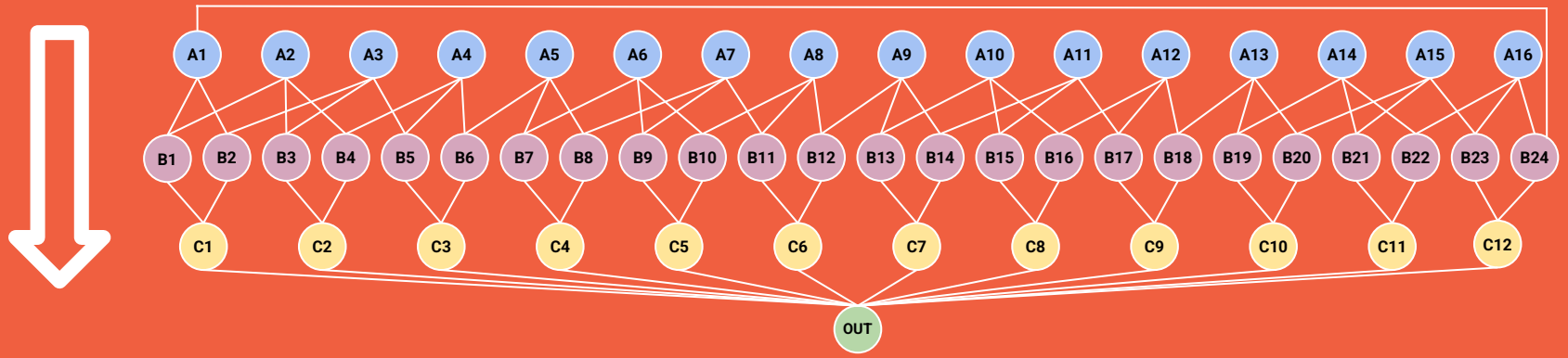


“Human Neural Network”



Forwards Pass

(firing neurons)

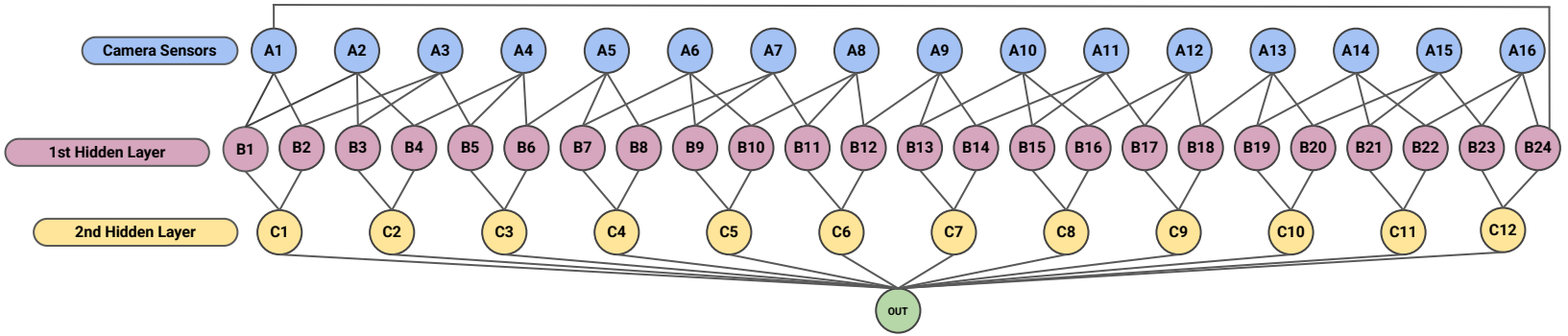


Node

B1

Forwards Pass

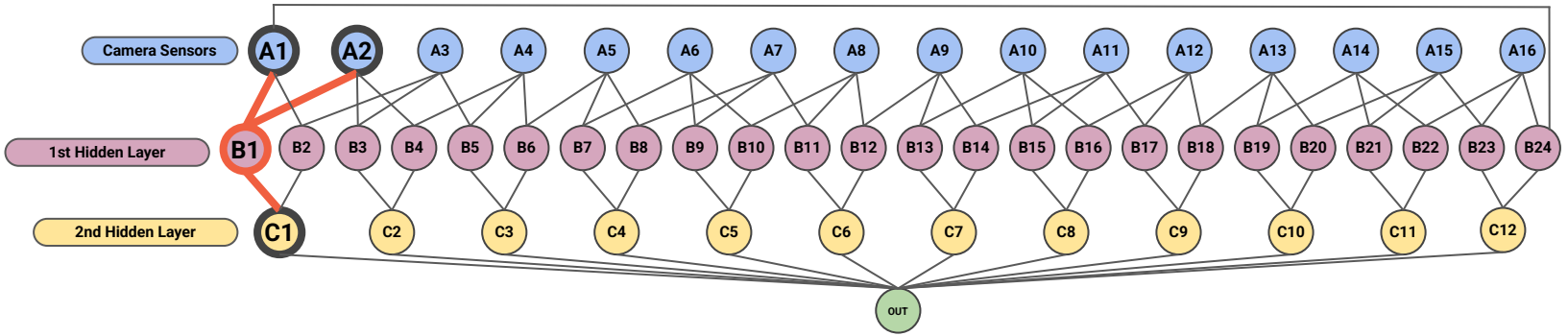
(firing neurons)



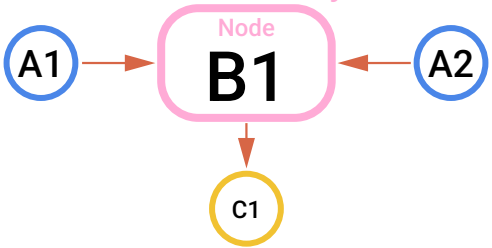
Node
B1

Forwards Pass

(firing neurons)



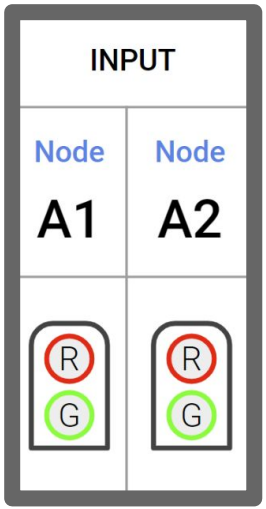
1st Hidden Layer



Node
B1

Forwards Pass

(firing neurons)

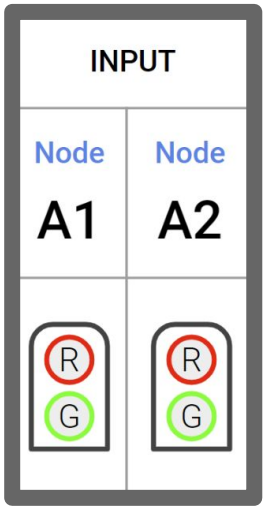


Node
B1

Forwards Pass

(firing neurons)

Bubble in the input nodes
(Red or Green)
Inputs displayed on the screen

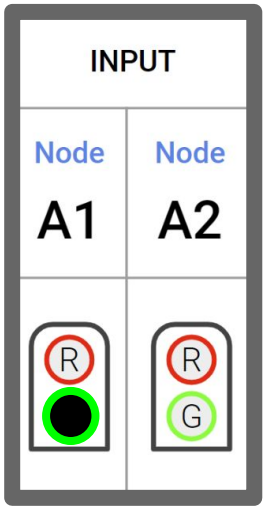


Node
B1

Forwards Pass

(firing neurons)

Bubble in the input nodes
(Red or Green)
Inputs displayed on the screen

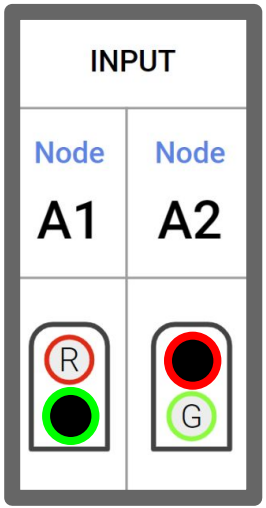


Node
B1

Forwards Pass

(firing neurons)

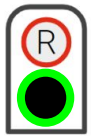
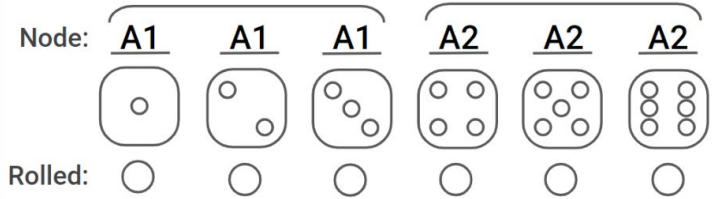
Bubble in the input nodes
(Red or Green)
Inputs displayed on the screen



Node
B1

Forwards Pass

(firing neurons)

INPUT		PROBABILITY
Node A1	Node A2	Assign input node to each dice face Roll the die Bubble in the rolled face
		

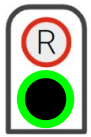
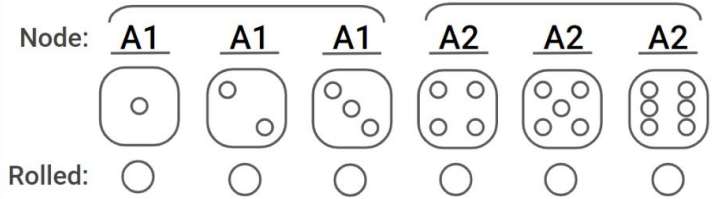
Node
B1

Forwards Pass

(firing neurons)

Roll the die

We rolled a 3:

INPUT		PROBABILITY
Node A1	Node A2	Assign input node to each dice face Roll the die Bubble in the rolled face
		

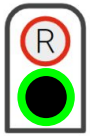
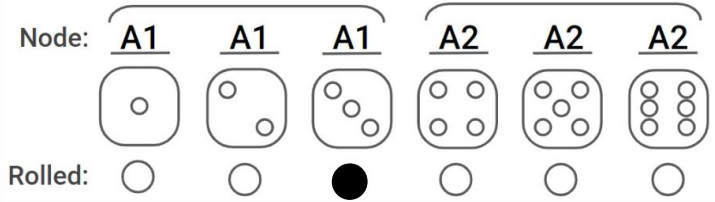
Node
B1

Forwards Pass

(firing neurons)

We rolled a 3:

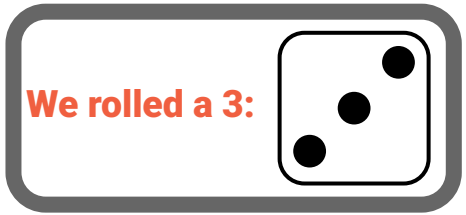
Bubble in the rolled die face

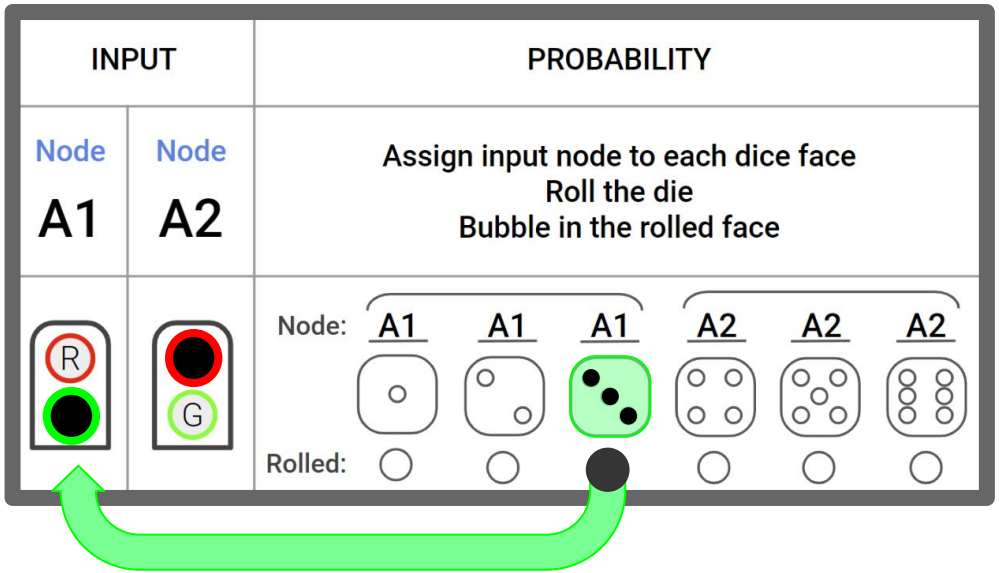
INPUT		PROBABILITY
Node A1	Node A2	Assign input node to each dice face Roll the die Bubble in the rolled face
		

Node
B1

Forwards Pass

(firing neurons)

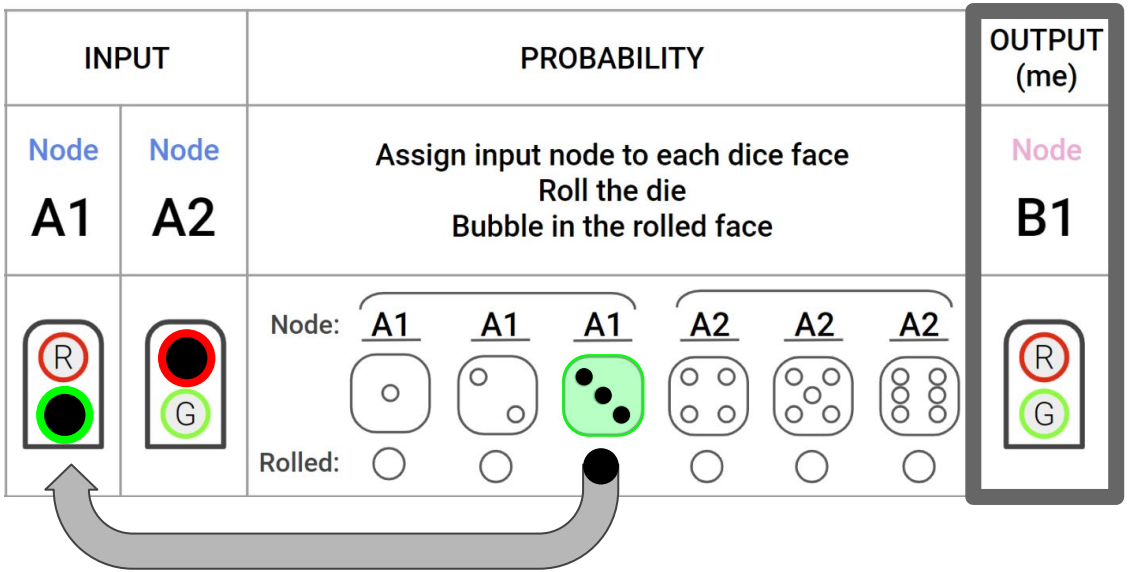




Node
B1

Forwards Pass

(firing neurons)

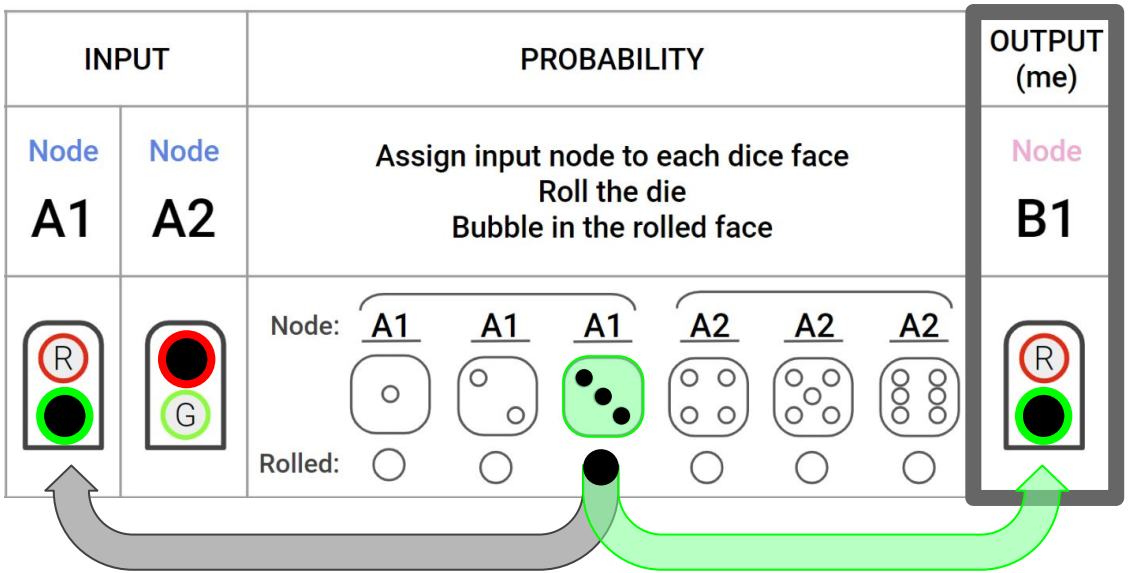


Node
B1

Forwards Pass

(firing neurons)

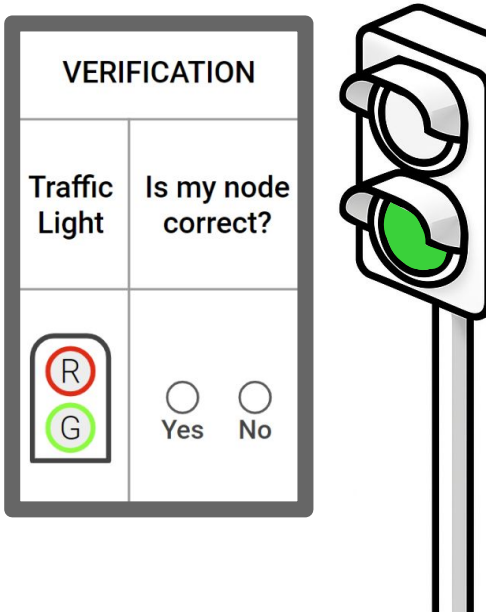
Bubble in the output based on the corresponding die roll



Node
B1

Forwards Pass - Verification

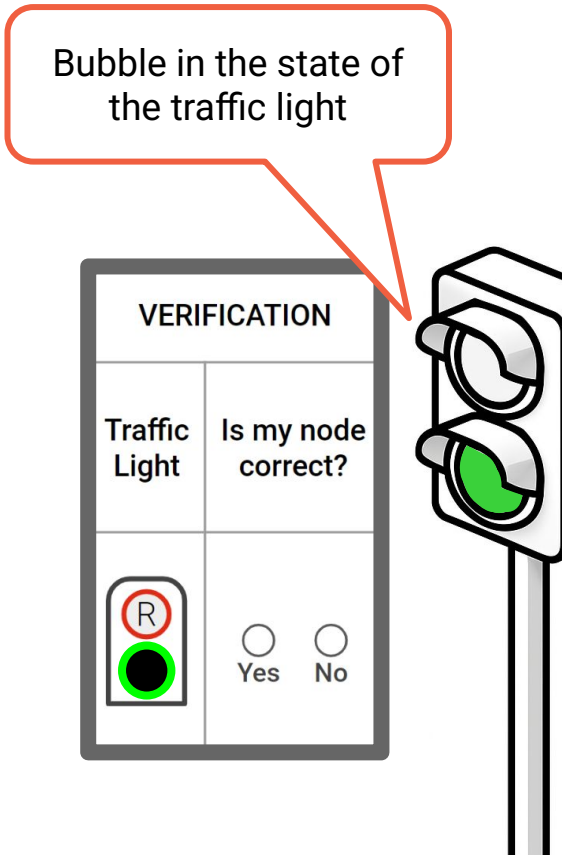
(firing neurons)



Node
B1

Forwards Pass - Verification

(firing neurons)

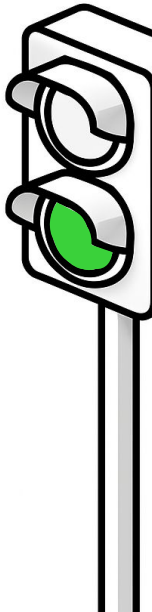


Node
B1

Forwards Pass - Verification

(firing neurons)

INPUT		PROBABILITY	OUTPUT (me)	VERIFICATION	
Node A1	Node A2	Assign input node to each dice face Roll the die Bubble in the rolled face	Node B1	Traffic Light	Is my node correct?
R	G	Node: A1 A1 A1 A2 A2 A2 Rolled:	R	R	Yes No

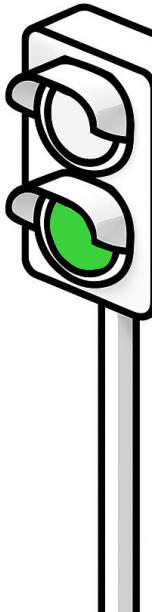


Node
B1

Forwards Pass - Verification

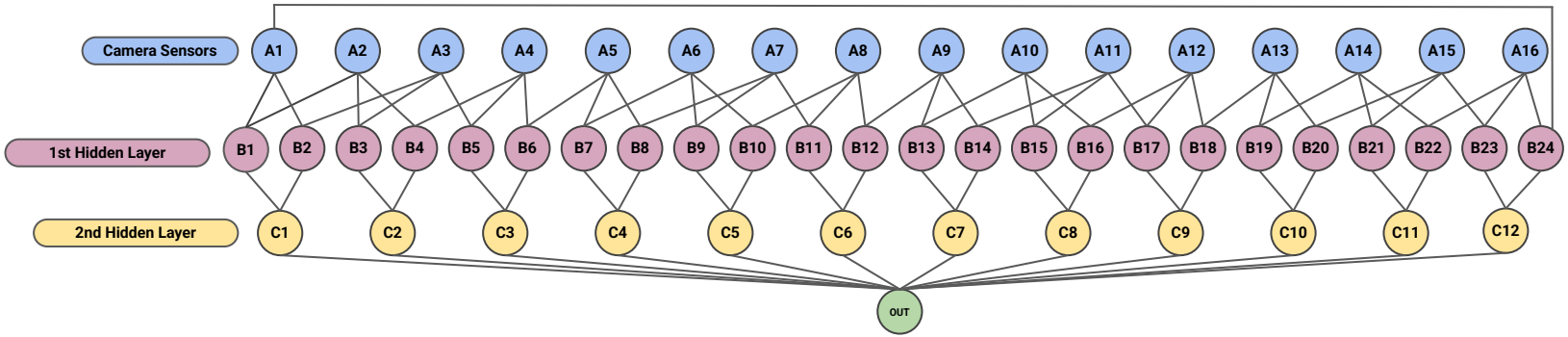
(firing neurons)

INPUT		PROBABILITY	OUTPUT (me)	VERIFICATION	
Node A1	Node A2	Assign input node to each dice face Roll the die Bubble in the rolled face	Node B1	Traffic Light	Is my node correct?
R	G	Node: A1 A1 A1 A2 A2 A2 Rolled: ○ ○ ● ○ ○ ○	R	R	● Yes ○ No



Forwards Pass

(firing neurons)



Everyone get up!

Find your connections

(C) nodes

1. Bubble in (B) node inputs
2. roll the 
3. Bubble in your output

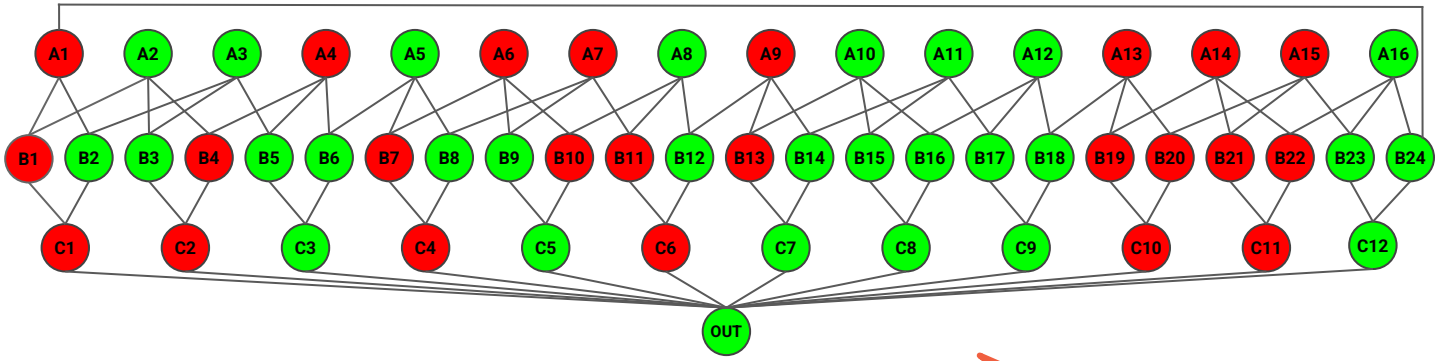
Output

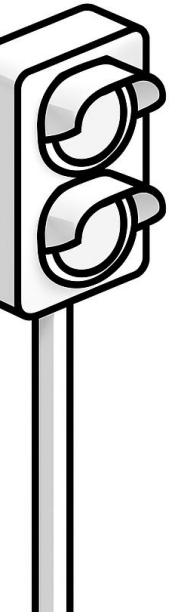
Return to your seat

the instructor will compute the output

Forwards Pass - Completed

(firing neurons)

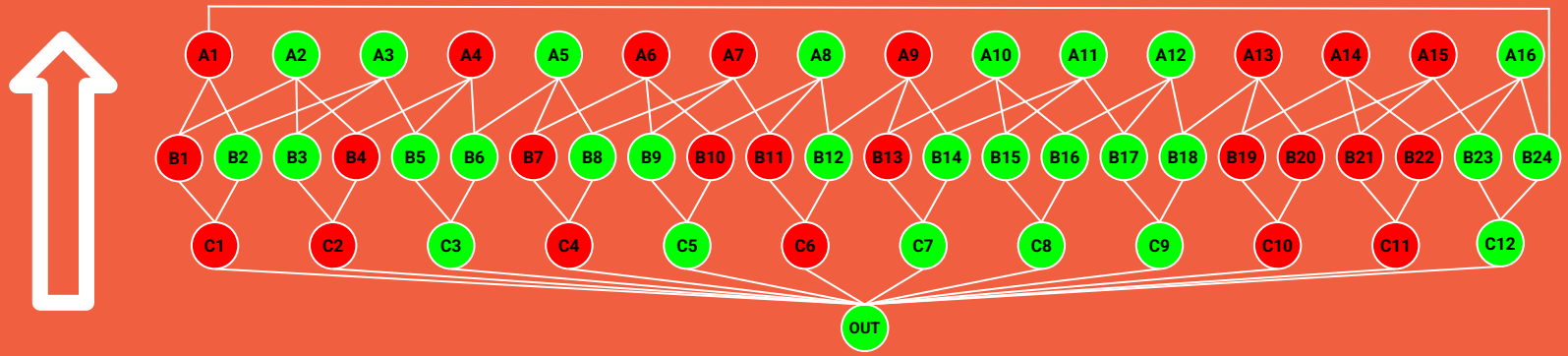




Network is Random

Backwards Pass

(learning update)



Correct nodes are trusted more

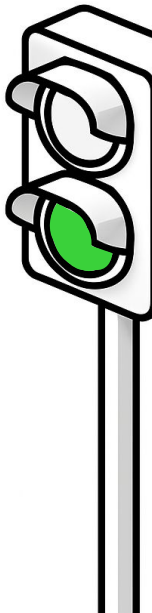
Node
B1

Backwards Pass

(firing neurons)

ITERATION	INPUT		PROBABILITY	OUTPUT (me)	VERIFICATION	
#	Node A1	Node A2	Assign input node to each dice face Roll the die Bubble in the rolled face	Node B1	Traffic Light	Is my node correct?
1	R	G	Node: A1 A1 A1 A2 A2 A2 Rolled: ○ ○ ● ○ ○ ○	R G	R G	Yes ● No ○
2	R	R	Node: Rolled: ○ ○ ○ ○ ○ ○	R G	R G	Yes ○ No ○

In the previous round are your **input nodes different**



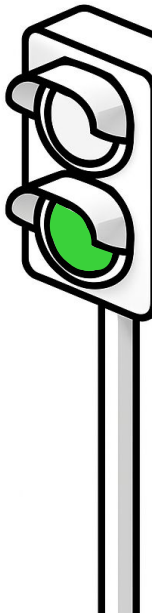
Node
B1

Backwards Pass

(firing neurons)

ITERATION	INPUT		PROBABILITY	OUTPUT (me)	VERIFICATION	
#	Node A1	Node A2	Assign input node to each dice face Roll the die Bubble in the rolled face	Node B1	Traffic Light	Is my node correct?
1	R / G	R / G	Node: A1 A1 A1 A2 A2 A2 Rolled:	R / G	R / G	Yes No
2	R / G	R / G	Node: Rolled:	R / G	R / G	Yes No

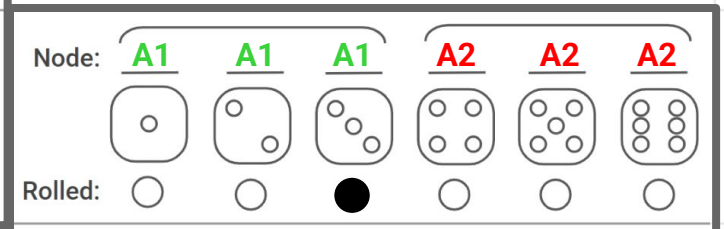
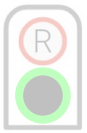
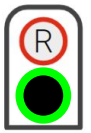
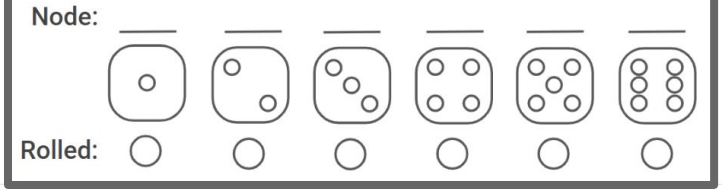
Identify which input node matched the traffic light

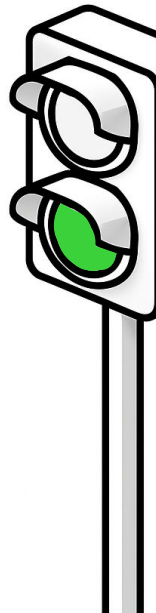


Node
B1

Backwards Pass

(firing neurons)

ITERATION	INPUT		PROBABILITY	OUTPUT (me)	VERIFICATION	
#	Node A1	Node A2	Assign input node to each dice face Roll the die Bubble in the rolled face	Node B1	Traffic Light	Is my node correct?
1						Yes No
2						Yes No

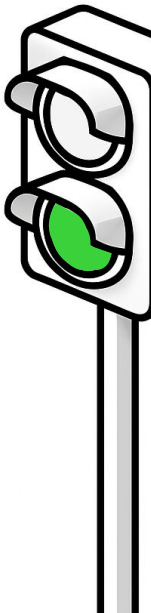


Node
B1

Backwards Pass

(firing neurons)

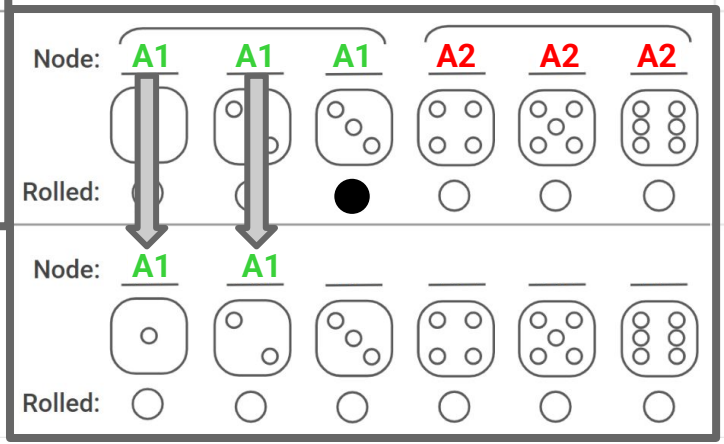
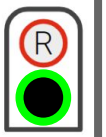
ITERATION	INPUT		PROBABILITY	OUTPUT (me)	VERIFICATION	
#	Node A1	Node A2	Assign input node to each dice face Roll the die Bubble in the rolled face	Node B1	Traffic Light	Is my node correct?
1	R / G	R / G	Node: A1 A1 A1 A2 A2 A2 Rolled:	R / G	R / G	Yes / No
2	R / G	R / G	Node: A1 Rolled:	R / G	R / G	Yes / No

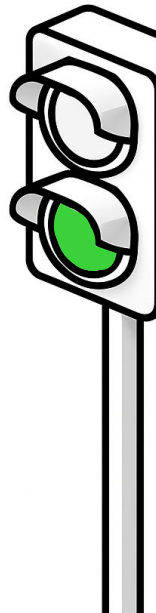


Node
B1

Backwards Pass

(firing neurons)

ITERATION	INPUT		PROBABILITY	OUTPUT (me)	VERIFICATION	
#	Node A1	Node A2	Assign input node to each dice face Roll the die Bubble in the rolled face	Node B1	Traffic Light	Is my node correct?
1						Yes No
2						Yes No

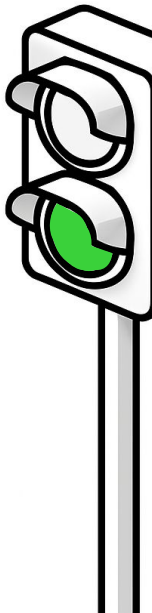


Node
B1

Backwards Pass

(firing neurons)

ITERATION	INPUT		PROBABILITY	OUTPUT (me)	VERIFICATION	
#	Node A1	Node A2	Assign input node to each dice face Roll the die Bubble in the rolled face	Node B1	Traffic Light	Is my node correct?
1	R / G	R / G	Node: A1 A1 A1 A2 A2 A2 Rolled:	R / G	R / G	Yes / No
2	R / G	R / G	Node: A1 A1 A1 ___ ___ ___ Rolled:	R / G	R / G	Yes / No



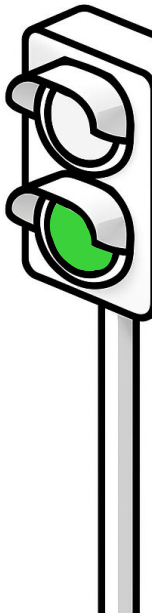
Node
B1

Backwards Pass

(firing neurons)

ITERATION	INPUT		PROBABILITY	OUTPUT (me)	VERIFICATION	
#	Node A1	Node A2	Assign input node to each dice face Roll the die Bubble in the rolled face	Node B1	Traffic Light	Is my node correct?
1	R	G	Node: A1 A1 A1 A2 A2 A2 Rolled:	R	R	Yes / No
2	R / G	R / G	Node: A1 A1 A1 A1 Rolled:			Yes / No

Reward the correct node by adding a die face



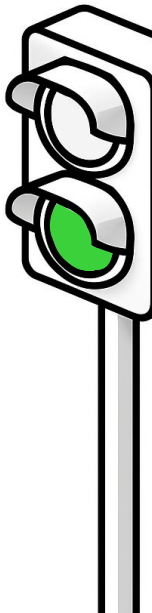
Node
B1

Backwards Pass

(firing neurons)

ITERATION	INPUT		PROBABILITY	OUTPUT (me)	VERIFICATION	
#	Node A1	Node A2	Assign input node to each dice face Roll the die Bubble in the rolled face	Node B1	Traffic Light	Is my node correct?
1	R	G	Node: A1 A1 A1 A2 A2 A2 Rolled:	R	R	Yes No
2	R G	R G	Node: A1 A1 A1 A1 A2 A2	R G	R G	Yes No

Fill in the remaining die faces with the incorrect node



Backwards Pass

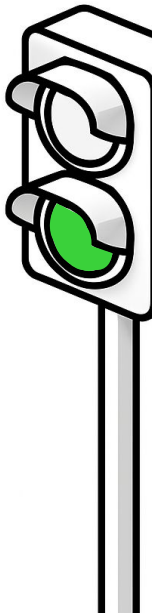
(firing neurons)

INPUT		PROBABILITY	OUTPUT (me)	VERIFICATION	
Node A1	Node A2	Assign input node to each dice face Roll the die Bubble in the rolled face	Node B1	Traffic Light	Is my node correct?
R	R	Node: A1 A1 A1 A2 A2 A2 Rolled:	R	R	Yes / No
G	G	Node: Rolled:	R G	R G	Yes / No

1

2

In the previous round are your **input nodes the same**



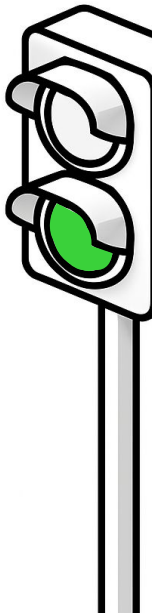
Backwards Pass

(firing neurons)

INPUT	
Node A1	Node A2
R	R

	INPUT		PROBABILITY	OUTPUT (me)	VERIFICATION	
	Node A1	Node A2	Assign input node to each dice face Roll the die Bubble in the rolled face	Node B1	Traffic Light	Is my node correct?
1	G	G	Node: A1 A1 A1 A2 A2 A2 Rolled:	R	R	Yes / No
2	R G	R G	Node: A1 A1 A1 A2 A2 A2 Rolled:	R	R	

Use the same die face distribution from the previous round

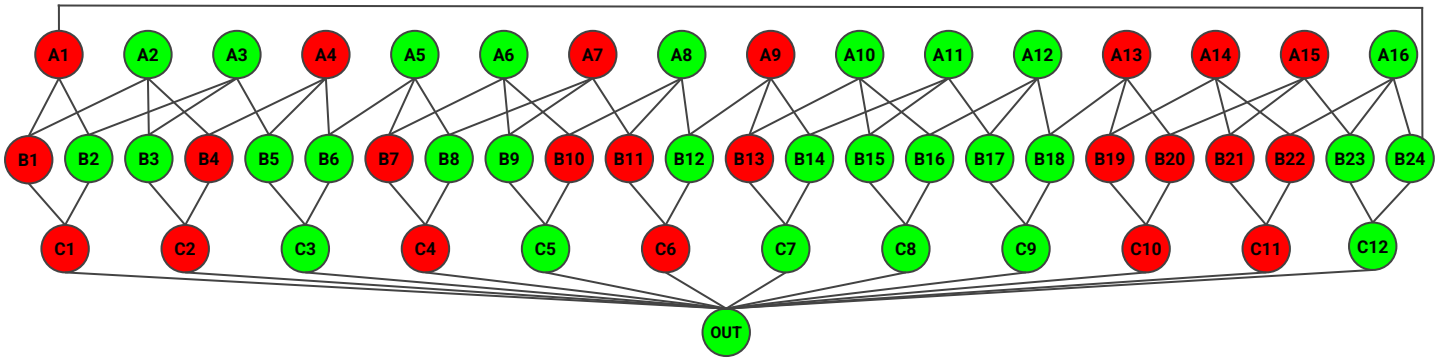


Everyone update your weights

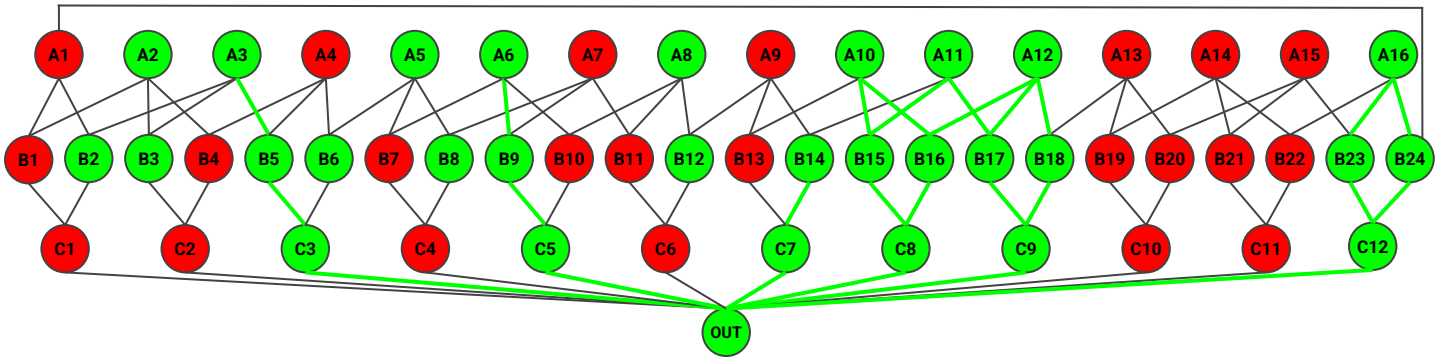
Let’s Start Iteration # 2

Repeat

What will happen as we keep learning?



What will happen as we keep learning?

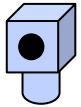


Correct nodes ***weight/influence*** increases

Inspect the network weights

Did we learn which sensors are reliable?

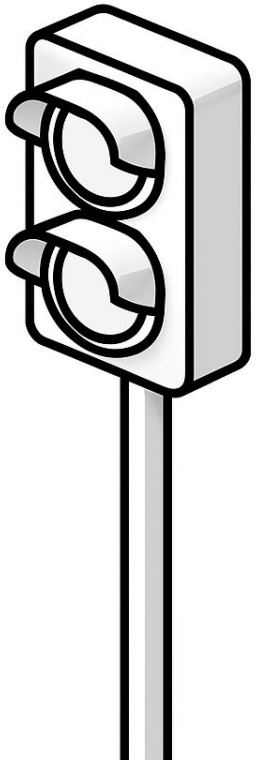
Reviewing the Network

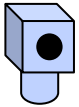


Was Sensor Node

A1

reliable?



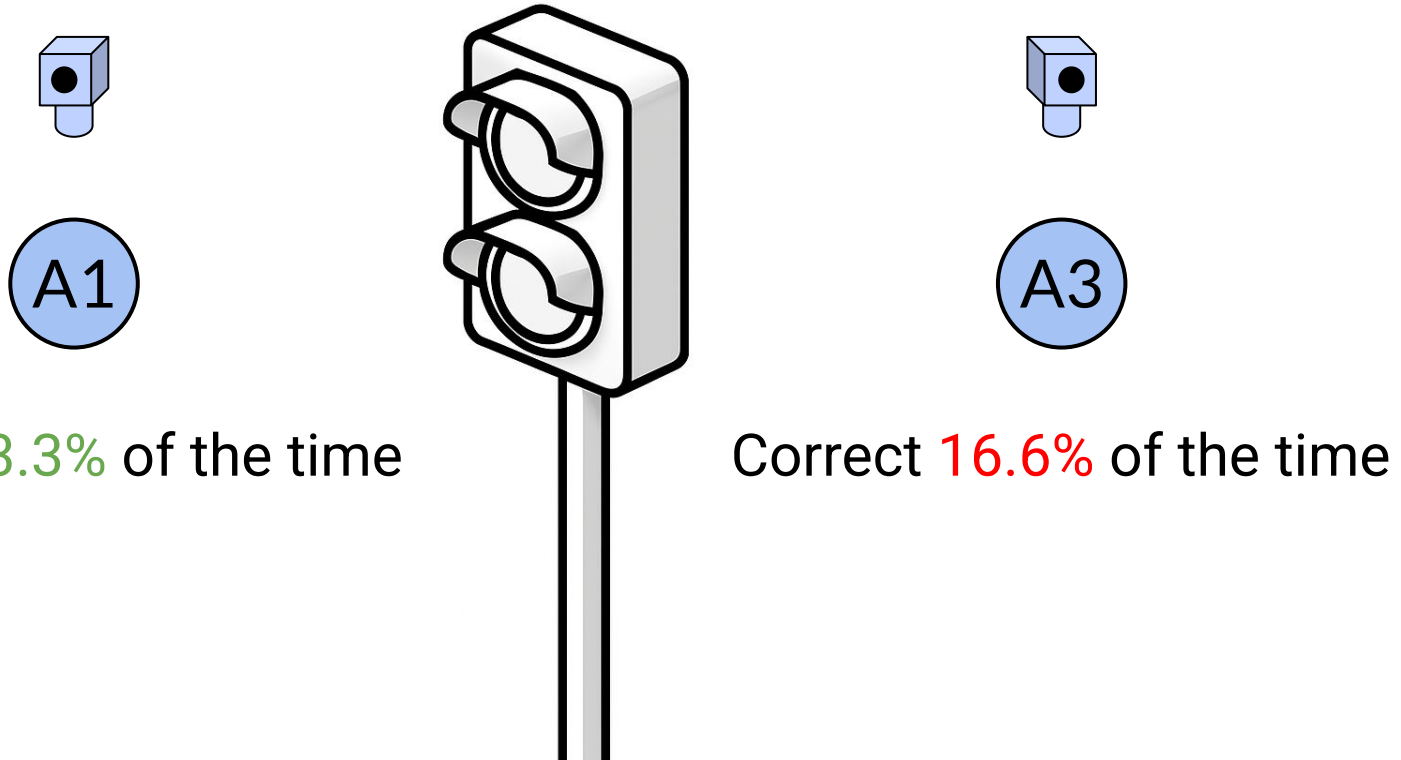


Was Sensor Node

A3

reliable?

Reviewing the Network



Correct 83.3% of the time

Correct 16.6% of the time