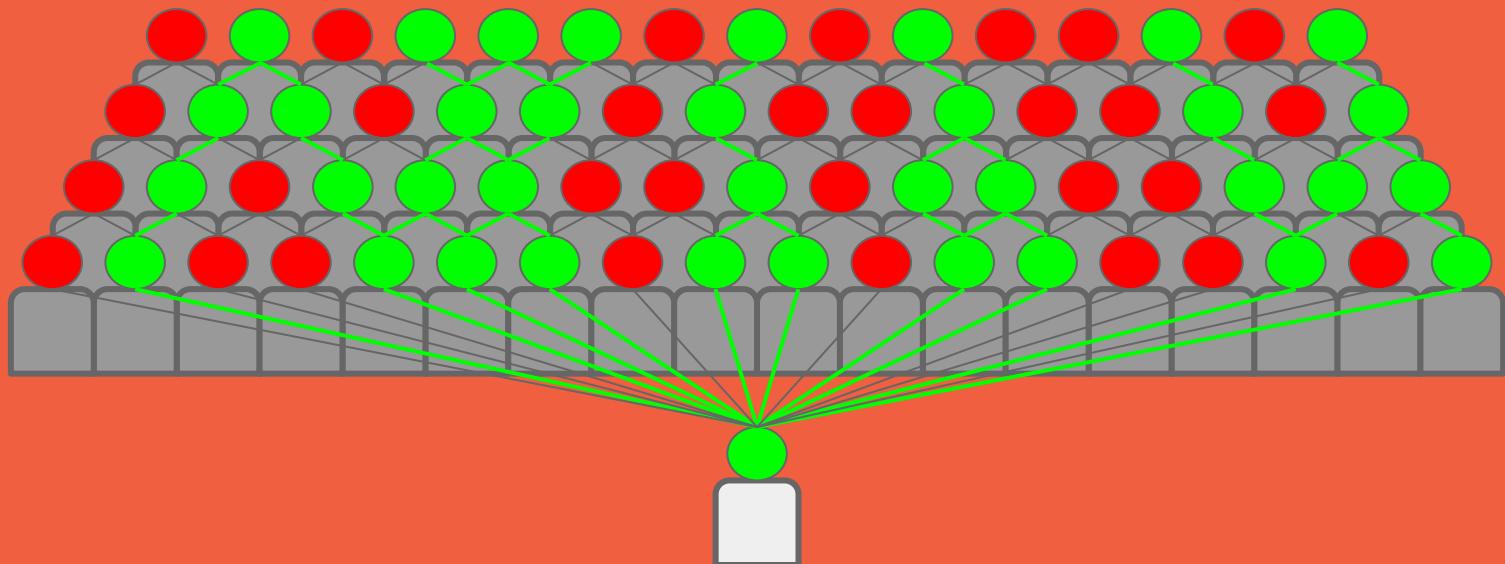


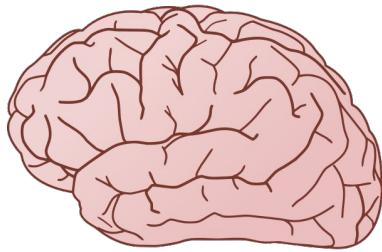
Human Neural Network



STAGE ONE EDUCATION
Hands-on Engineering Workshops

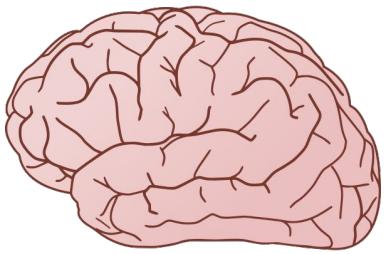
What is a Neural Network?

What is a Neural Network?

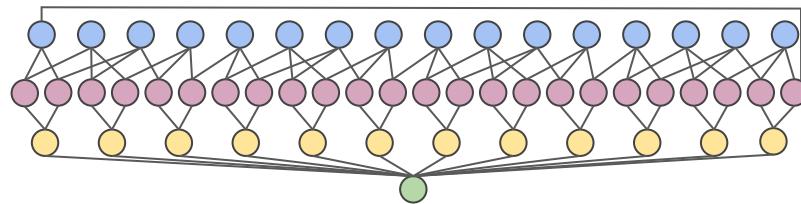


Natural

What is a Neural Network?



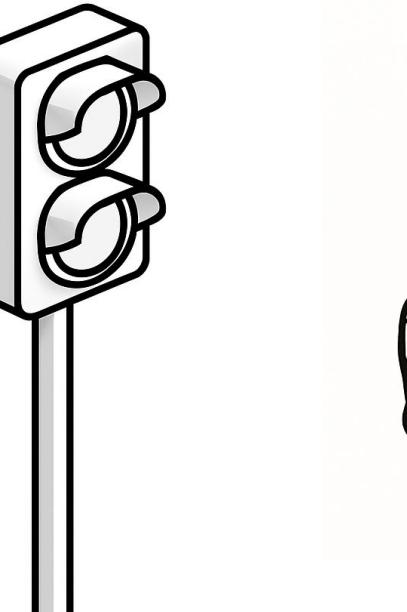
Natural



Artificial

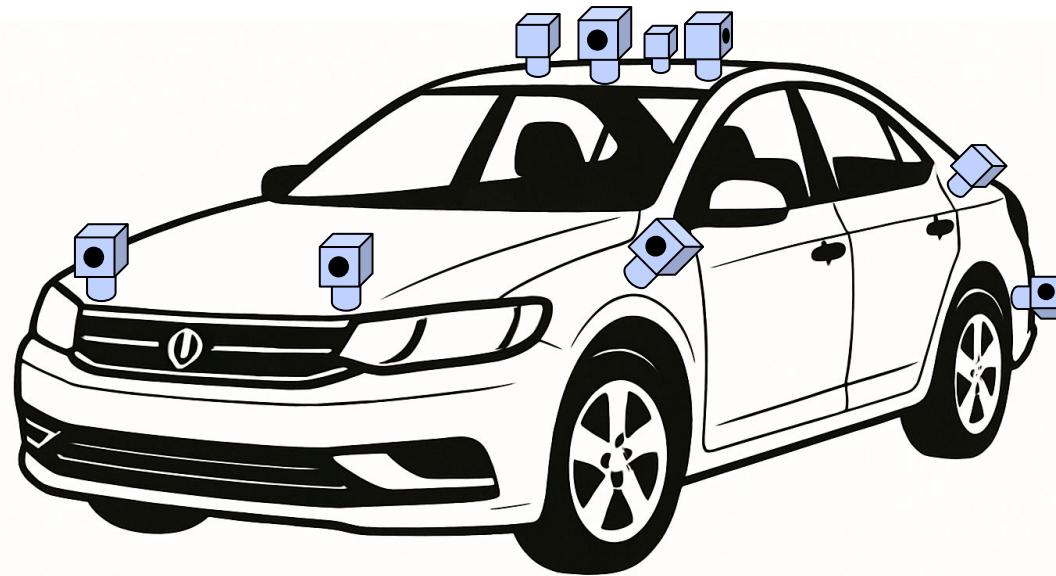
Self-Driving Car

What sensors do we need?



Self-Driving Car

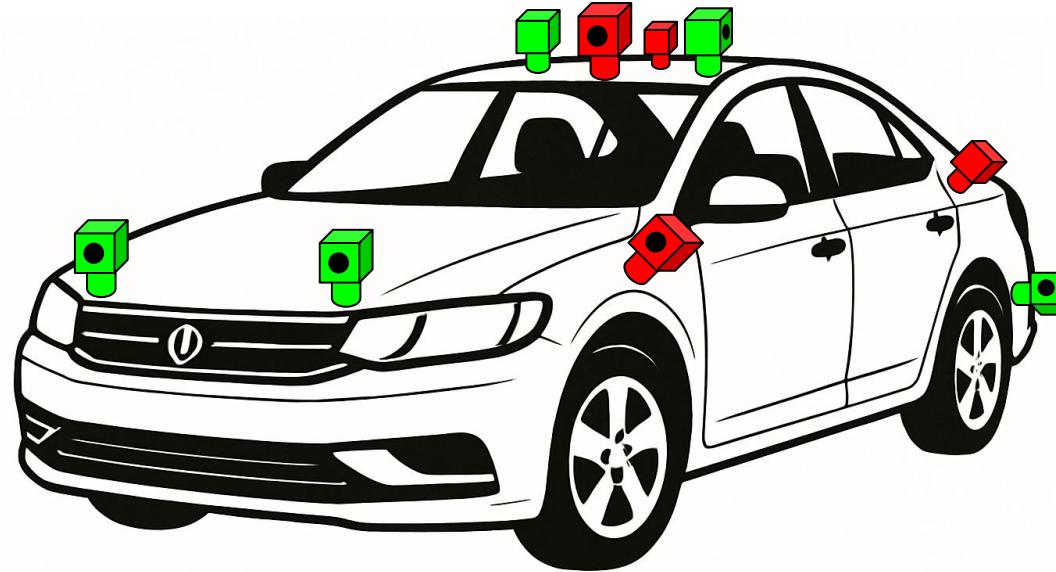
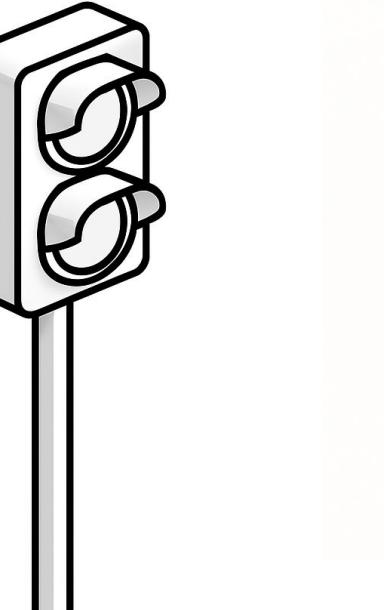
Camera Sensors



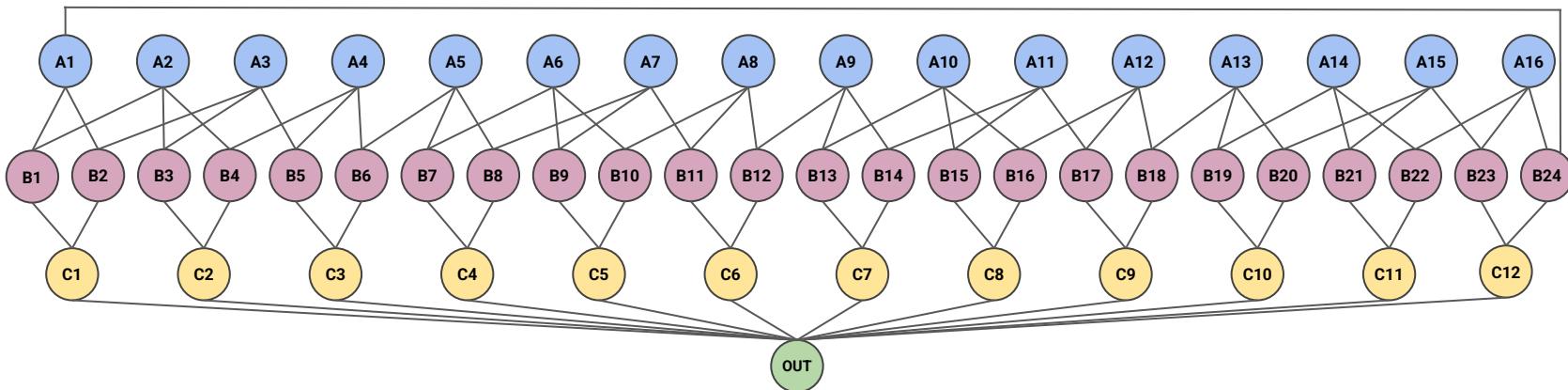
Self-Driving Car

Camera Sensors are not reliable

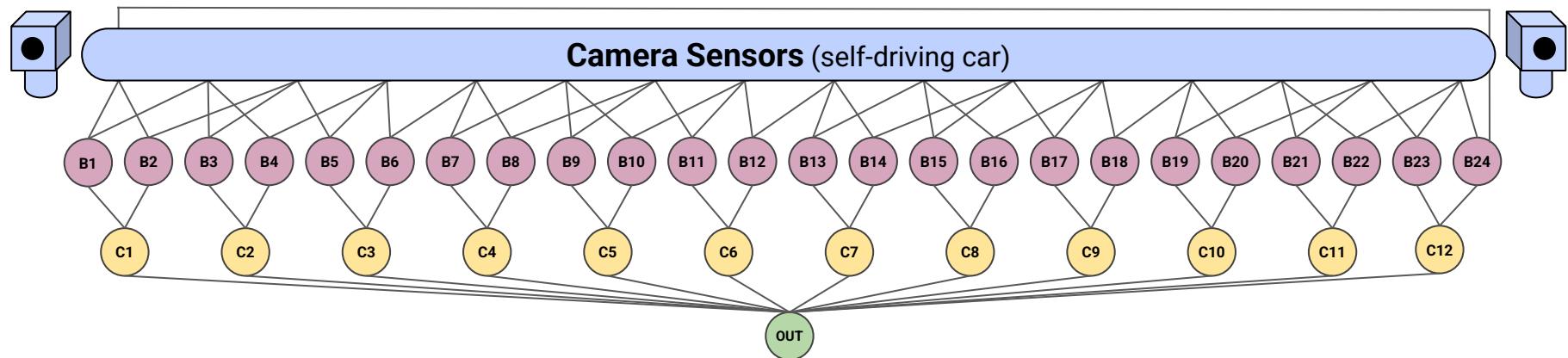
Our *neural network* will learn when to **GO** and when to **STOP**



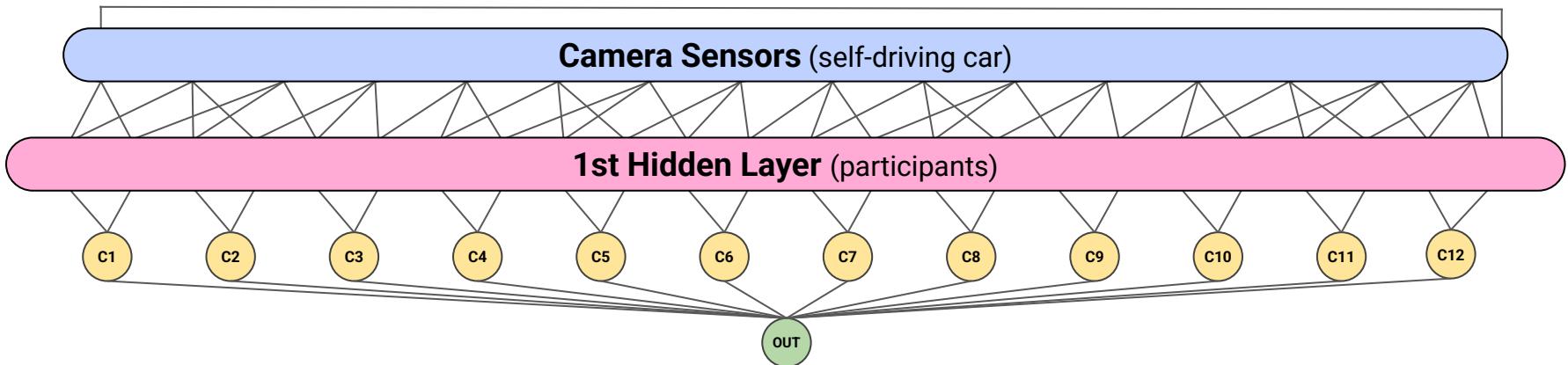
“Human Neural Network”



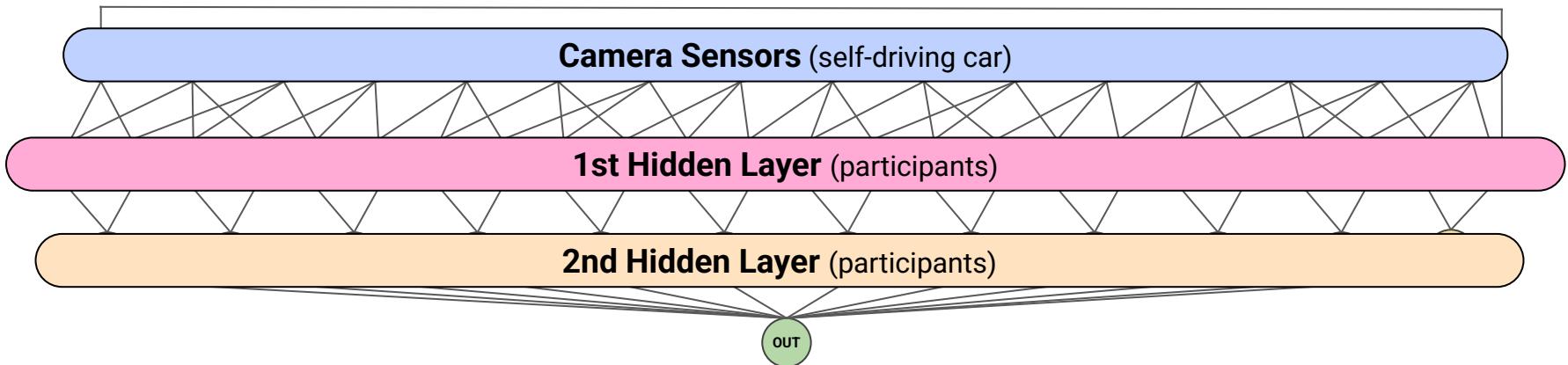
“Human Neural Network”



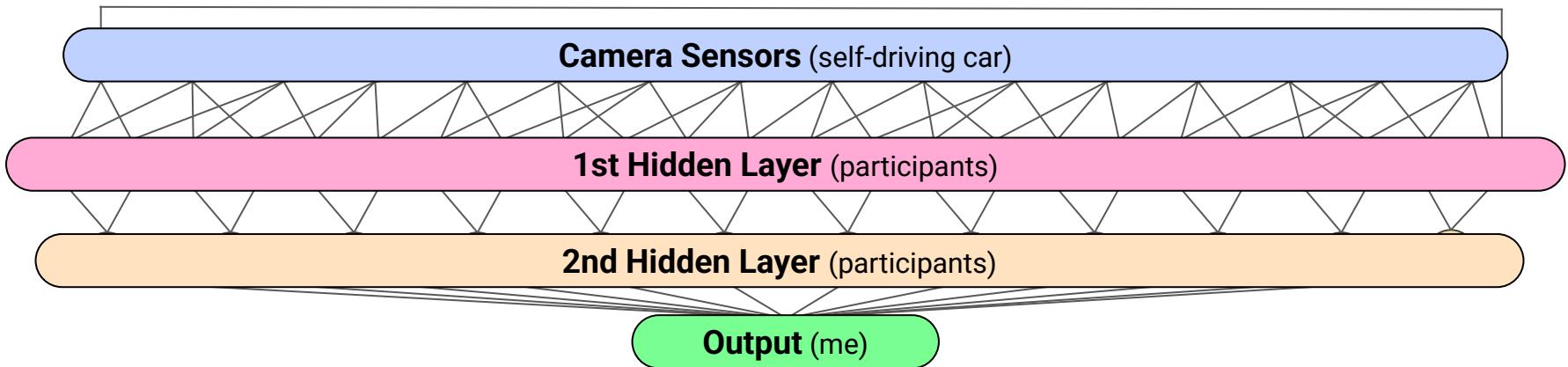
“Human Neural Network”



“Human Neural Network”

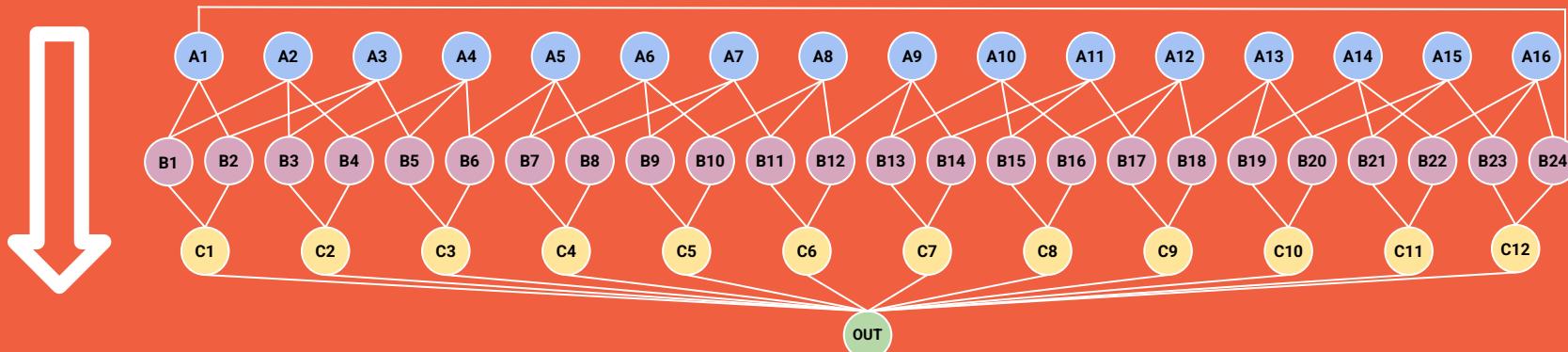


“Human Neural Network”



Forwards Pass

(firing neurons)

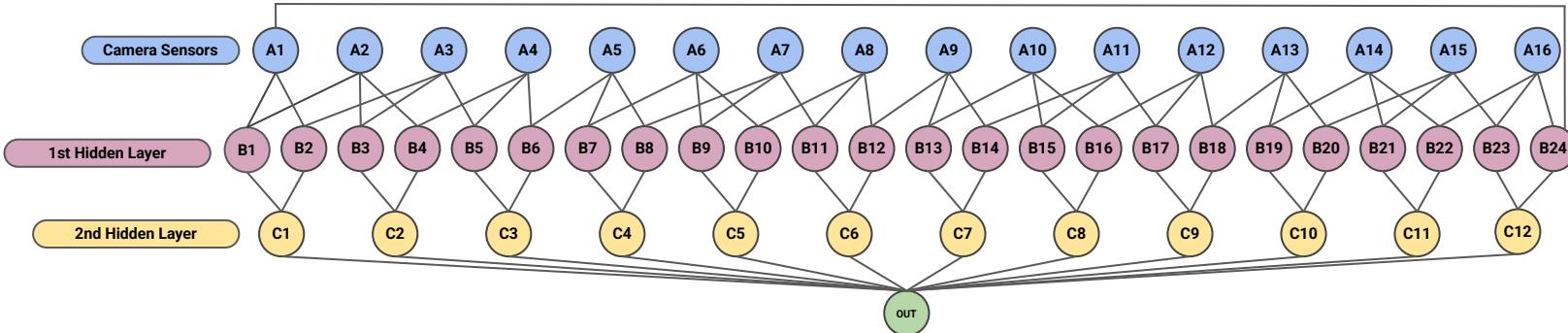


Node

B1

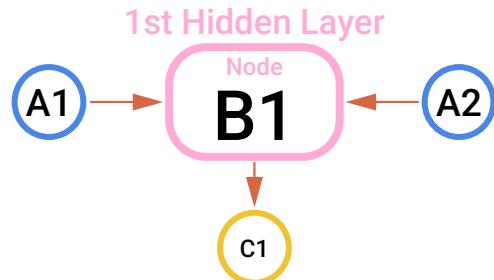
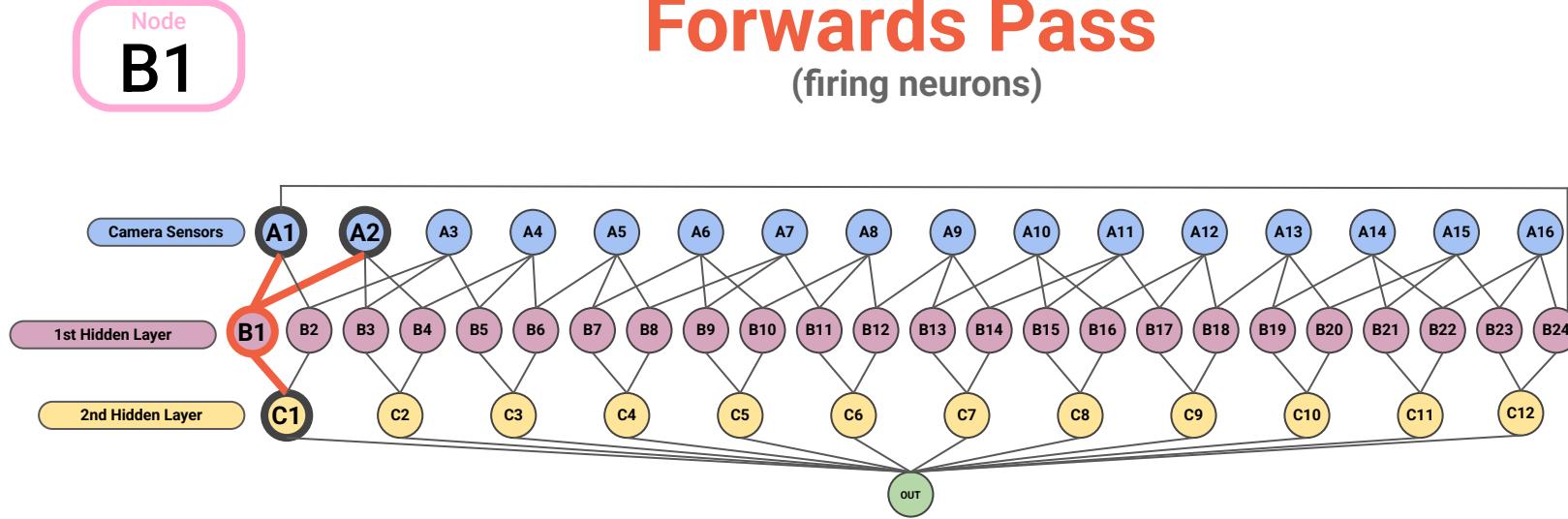
Forwards Pass

(firing neurons)



Forwards Pass

(firing neurons)

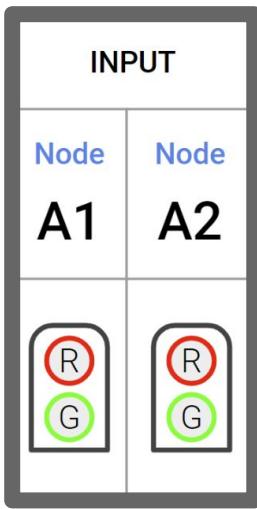


Node

B1

Forwards Pass

(firing neurons)



Node

B1

Forwards Pass

(firing neurons)

Bubble in the input nodes
(Red or Green)

Inputs displayed on the screen

INPUT	
Node	Node
A1	A2
R G	R G

Node

B1

Forwards Pass

(firing neurons)

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

INPUT	
Node	Node
A1	A2
	

Node

B1

Forwards Pass

(firing neurons)

Bubble in the input nodes
(Red or Green)

Inputs displayed on the screen

INPUT	
Node	Node
A1	A2
	

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
		<p>Node: <u>A1</u> <u>A1</u> <u>A1</u> <u>A2</u> <u>A2</u> <u>A2</u></p> <p>Rolled:      </p>

Node

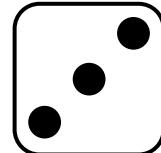
B1

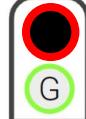
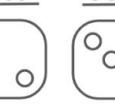
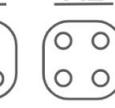
Forwards Pass

(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
 A traffic light node with a red light at the top labeled 'R' and a green light at the bottom labeled 'G'. The red light is illuminated.	 A traffic light node with a red light at the top labeled 'R' and a green light at the bottom labeled 'G'. The green light is illuminated.	Node:      Rolled:     

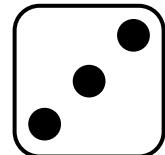
Node

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
 R	 G	Node: Rolled: A1 A1 A1 A2 A2 A2

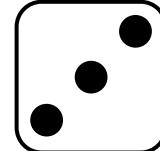
Node

B1

Forwards Pass

(firing neurons)

We rolled a 3:



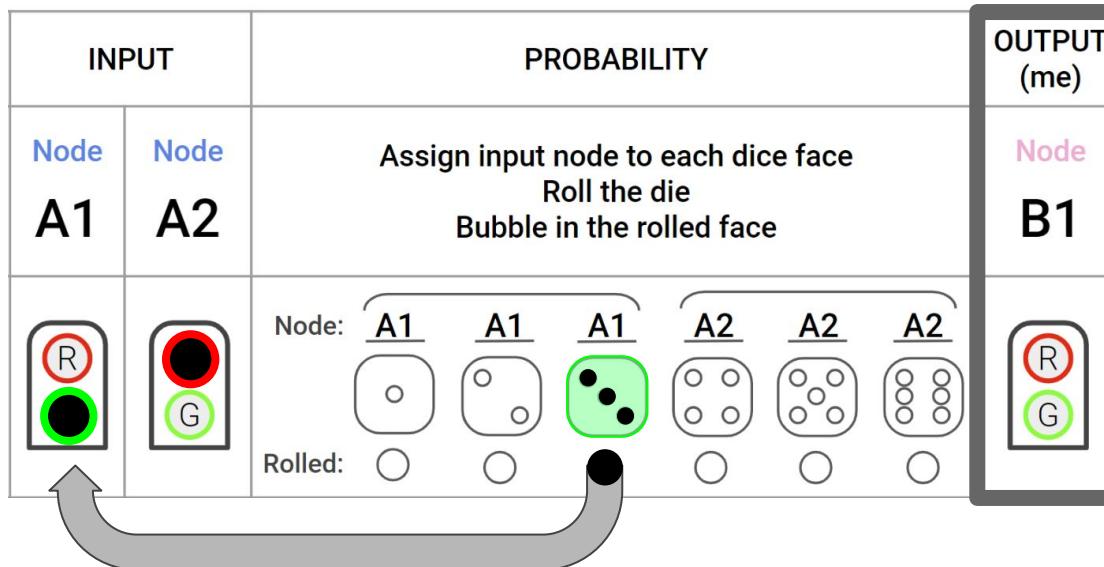
INPUT		PROBABILITY
Node A1	Node A2	Assign input node to each dice face Roll the die Bubble in the rolled face
 R G		<p>Node: <u>A1</u> <u>A1</u> <u>A1</u> <u>A2</u> <u>A2</u> <u>A2</u></p> <p>Rolled: </p> <p>A green curved arrow points from the bottom of the first column to the third die face (labeled A1).</p>

Node

B1

Forwards Pass

(firing neurons)



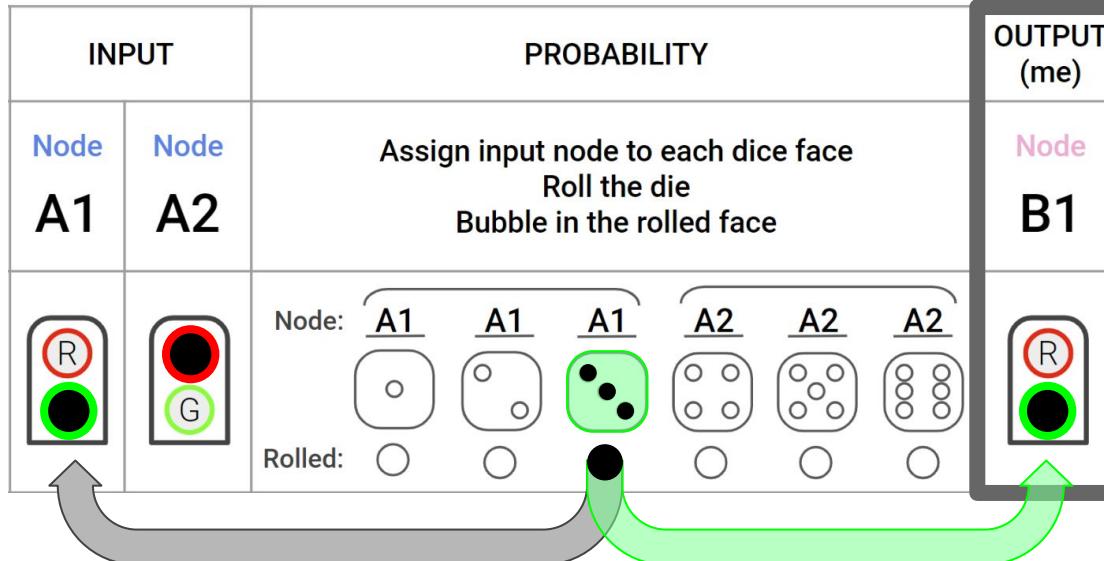
Forwards Pass

(firing neurons)

Node

B1

Bubble in the output
based on the
corresponding die roll



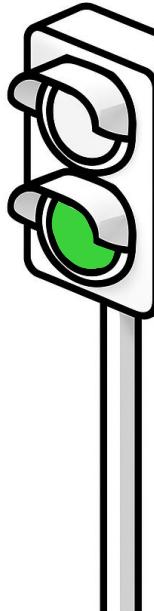
Node

B1

Forwards Pass - Verification

(firing neurons)

VERIFICATION	
Traffic Light	Is my node correct?
	<input type="radio"/> Yes <input type="radio"/> No



Node

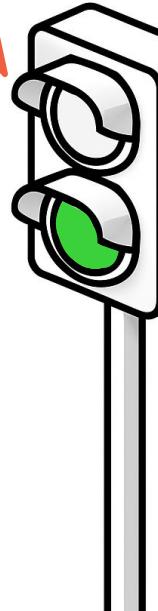
B1

Forwards Pass - Verification

(firing neurons)

Bubble in the state of
the traffic light

VERIFICATION	
Traffic Light	Is my node correct?
	<input type="radio"/> Yes <input type="radio"/> No



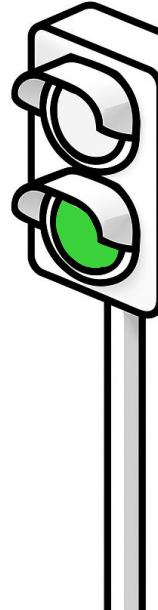
Node

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?
		Node: Rolled: 			<input type="radio"/> Yes <input type="radio"/> No		



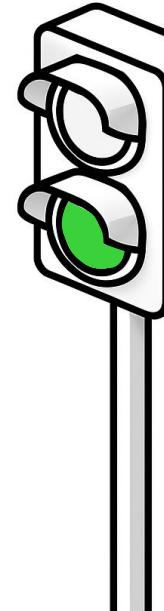
Node

B1

Forwards Pass - Verification

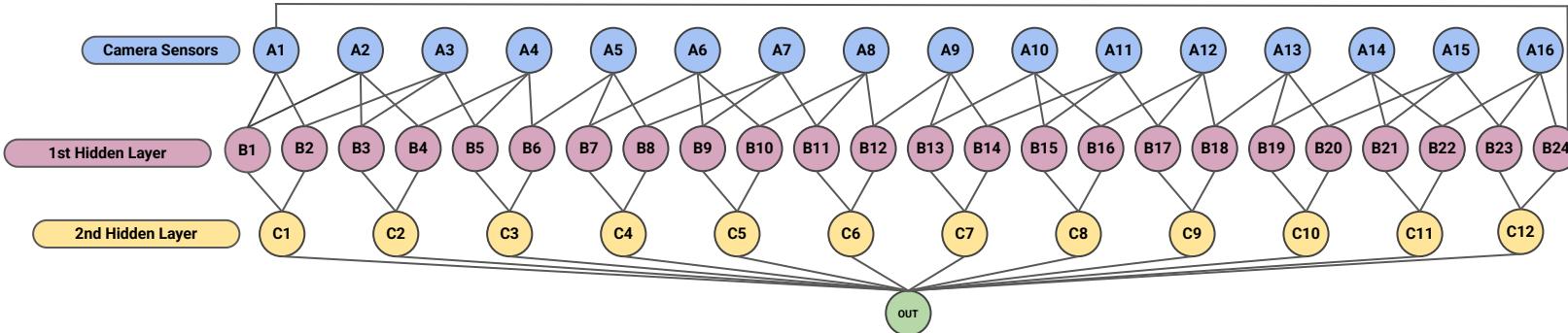
(firing neurons)

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?
		Node: Rolled: 					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

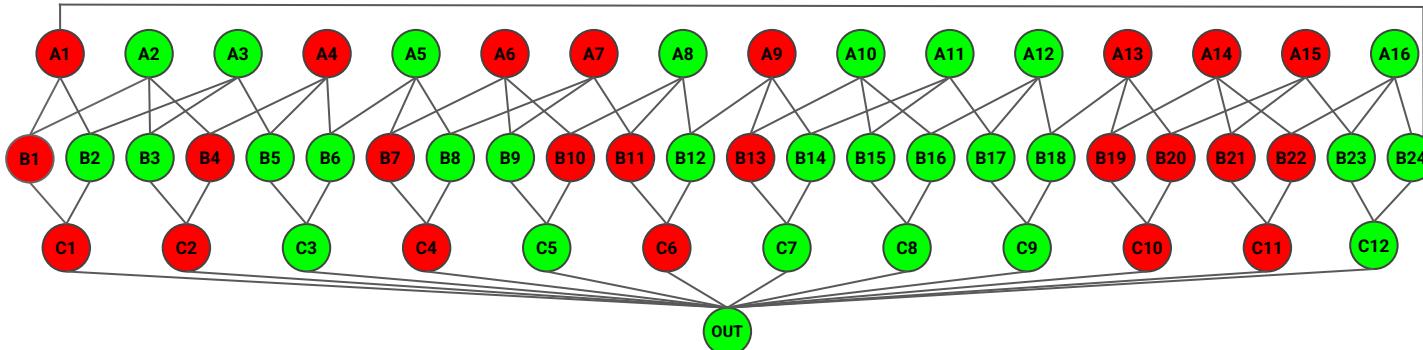
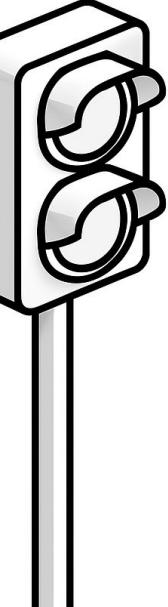
Output

Return to your seat

the instructor will compute the output

Forwards Pass - Completed

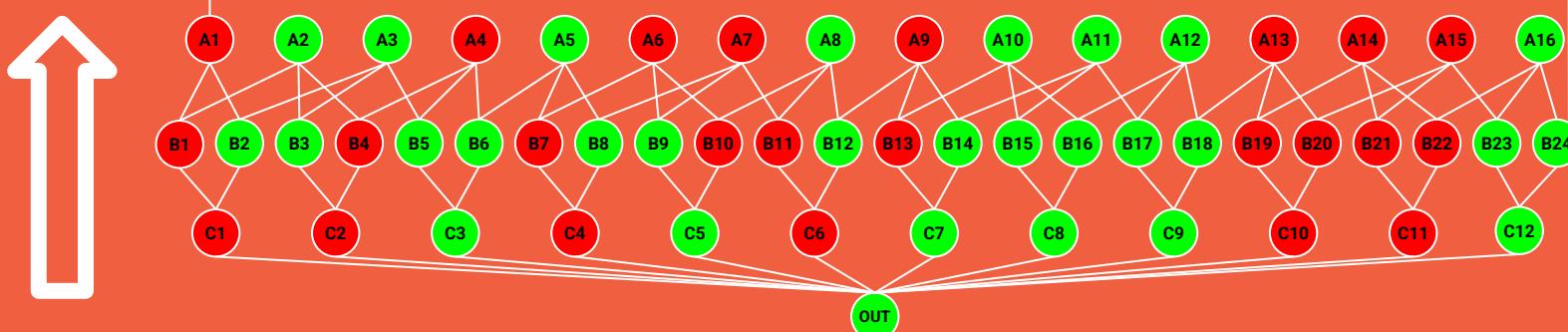
(firing neurons)



Network is Random

Backwards Pass

(learning update)



Correct nodes are trusted more

Backwards Pass

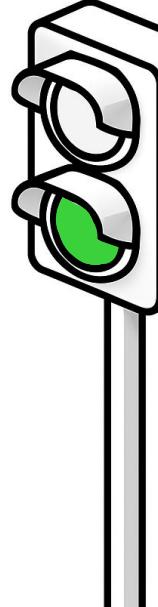
(firing neurons)

Node

B1

ITERATION		INPUT		PROBABILITY		OUTPUT (me)	VERIFICATION		
#		Node	Node	Assign input node to each dice face Roll the die Bubble in the rolled face		Node	Traffic Light	Is my node correct?	
1		A1	A2			B1			
				Node:	     	Rolled:	 		
2				Node:	     	Rolled:	 		

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



Backwards Pass

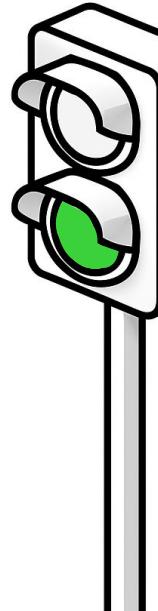
(firing neurons)

Node

B1

ITERATION		INPUT		PROBABILITY		OUTPUT (me)		VERIFICATION	
#		Node	Node	Assign input node to each dice face Roll the die Bubble in the rolled face		Node	B1	Traffic Light	Is my node correct?
1		A1	A2	Node: A1 A1 A1 A2 A2	Rolled: 1 2 3 4 5				Yes No
2				Node: A1 A1 A1 A2 A2	Rolled: 1 2 3 4 5				Yes No

Identify which input node matched the traffic light



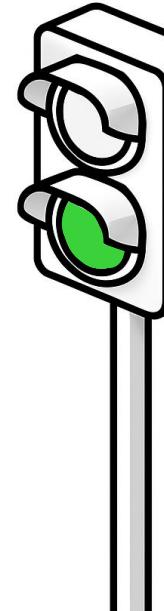
Backwards Pass

(firing neurons)

Node

B1

ITERATION #	INPUT		PROBABILITY Assign input node to each dice face Roll the die Bubble in the rolled face	OUTPUT (me)	VERIFICATION
	Node A1	Node A2			
1	 		Node: <u>A1</u> <u>A1</u> <u>A1</u> <u>A2</u> <u>A2</u> <u>A2</u> Rolled: ○ ○ ● ○ ○ ○		Traffic Light Is my node correct?  Yes 
2	 		Node: <u> </u> <u> </u> <u> </u> <u> </u> <u> </u> <u> </u> Rolled: ○ ○ ○ ○ ○ ○		 Yes 

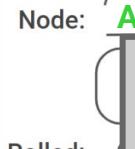
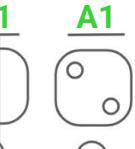
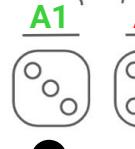
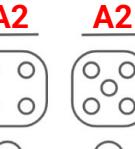
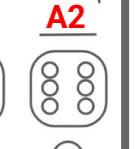
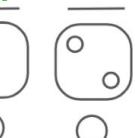
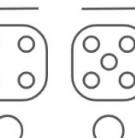
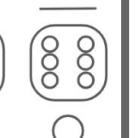


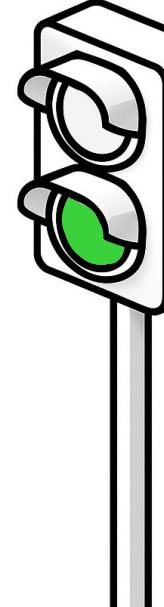
Backwards Pass

(firing neurons)

Node

B1

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

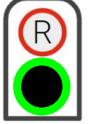
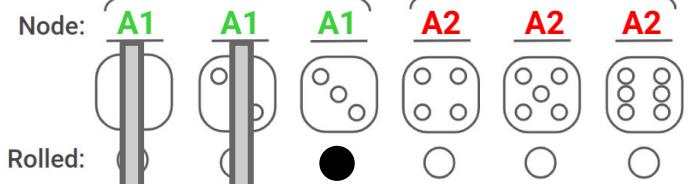
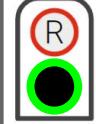


Backwards Pass

(firing neurons)

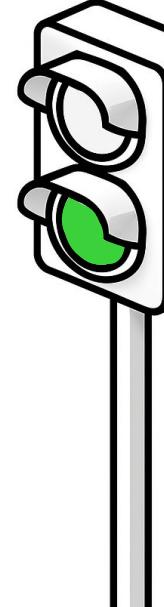
Node

B1

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
1				Node: 	Rolled: 				
2				Node: 	Rolled: 				

Yes No

Yes No

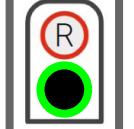
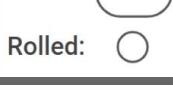


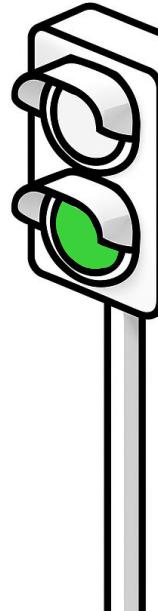
Backwards Pass

(firing neurons)

Node

B1

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
1				Node:      	Rolled:      			Is my node correct?  Yes  No	
2				Node:      	Rolled:      			Is my node correct?  Yes  No	

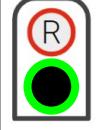
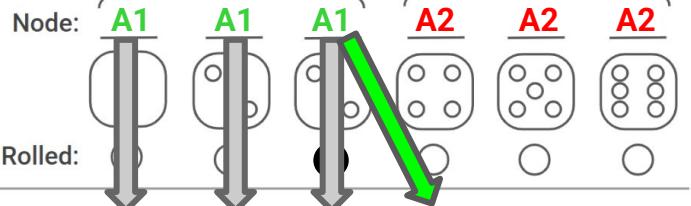
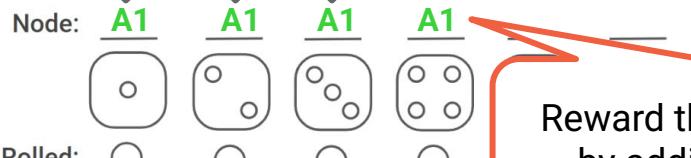
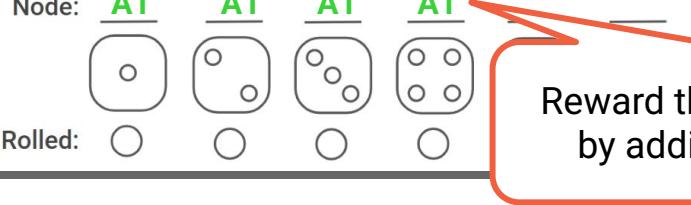


Backwards Pass

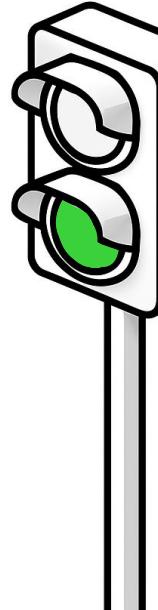
(firing neurons)

Node

B1

ITERATION		INPUT		PROBABILITY		OUTPUT (me)		VERIFICATION	
#		Node	Node			Node			
	A1	A2				B1		Traffic Light	Is my node correct?
1				Assign input node to each dice face Roll the die Bubble in the rolled face					Is my node correct?
				Node:  Rolled: 					
2				Node:  Rolled: 					

Reward the correct node
by adding a die face

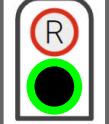
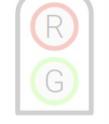


Backwards Pass

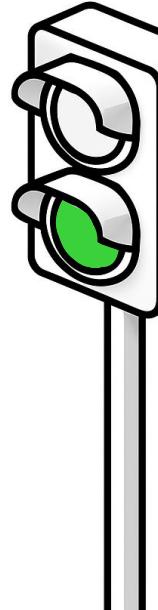
(firing neurons)

Node

B1

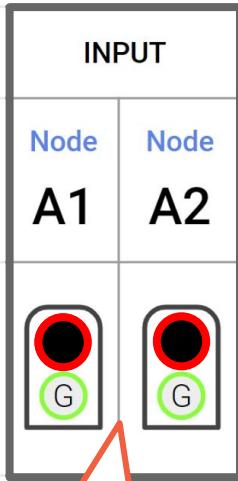
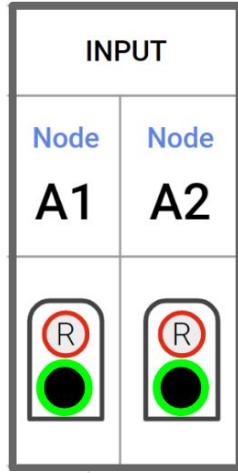
ITERATION		INPUT		PROBABILITY		OUTPUT (me)		VERIFICATION						
#		Node	Node					Node						
		A1	A2	Assign input node to each dice face		Roll the die		Is my node correct?						
1				Node:	 A1	 A1	 A1	 A2	 A2	 A2			Yes	No
2				Rolled:	 A1	 A1	 A1	 A1	 A2	 A2			Yes	No

Fill in the remaining die faces
with the incorrect node



Backwards Pass

(firing neurons)



1

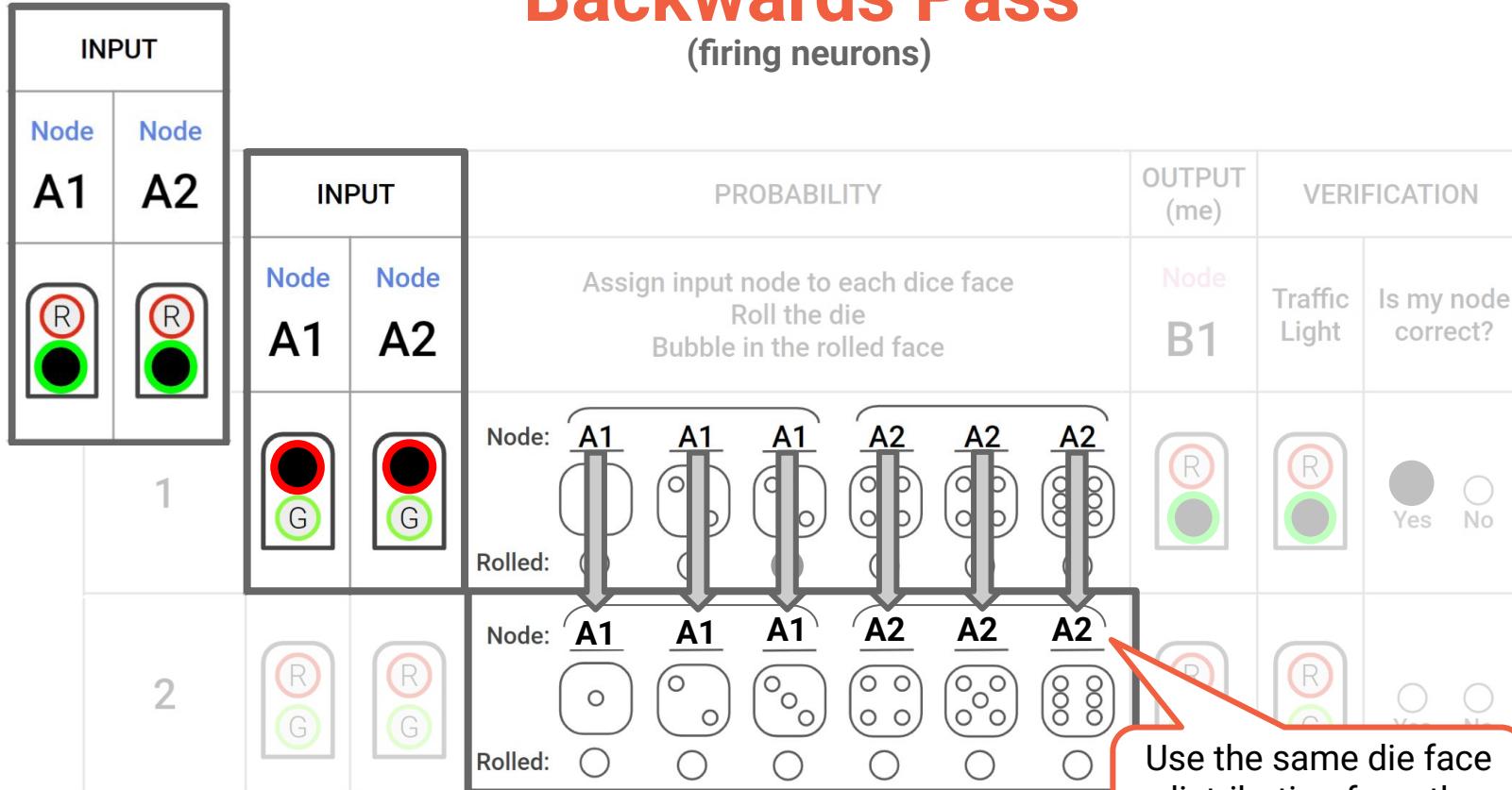
2

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

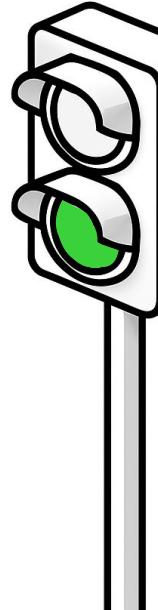
		PROBABILITY	OUTPUT (me)	VERIFICATION	
		Assign input node to each dice face Roll the die Bubble in the rolled face	Node B1	Traffic Light	Is my node correct?
Node:	<u>A1</u>				<input checked="" type="radio"/> Yes <input type="radio"/> No
Node:	<u>A1</u>				<input checked="" type="radio"/> Yes <input type="radio"/> No
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Backwards Pass

(firing neurons)



Use the same die face distribution from the previous round

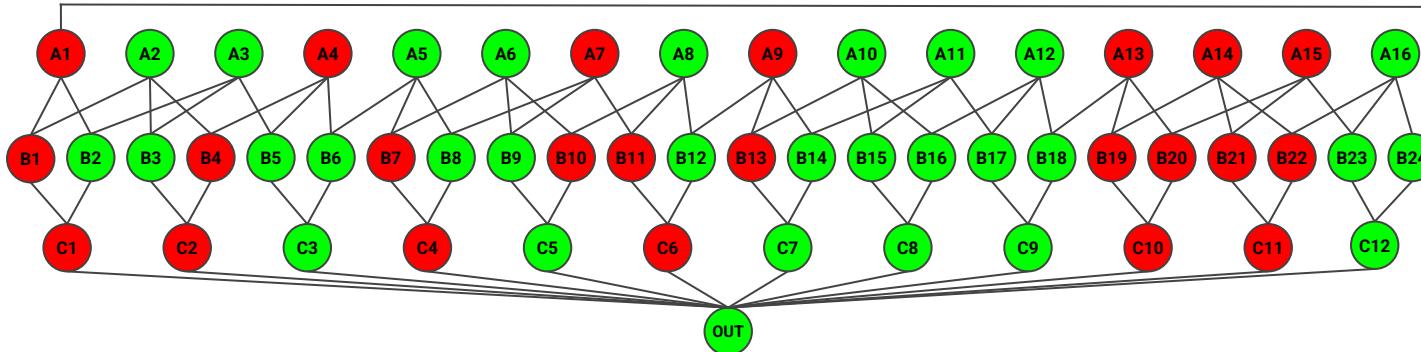


Everyone update your weights

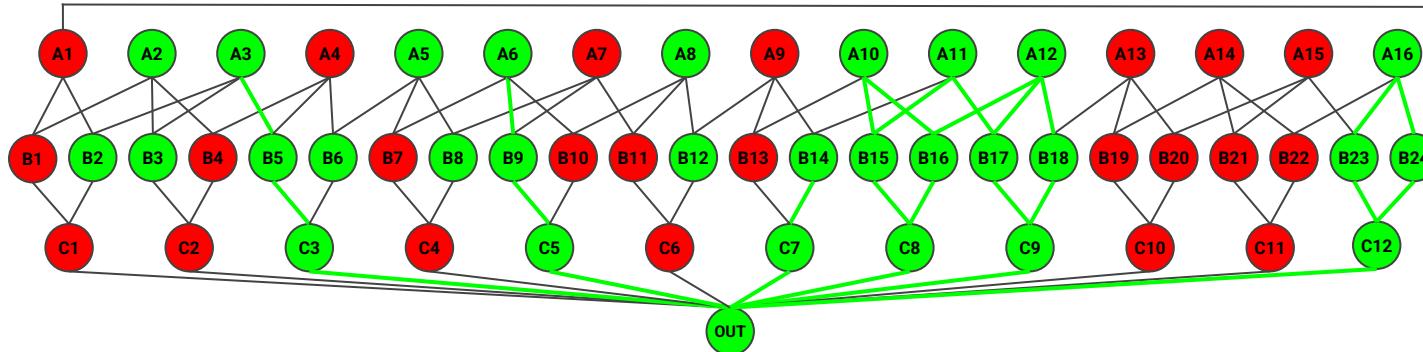
Let's Start Iteration # 2

Repeat

What will happen as we keep learning?



What will happen as we keep learning?

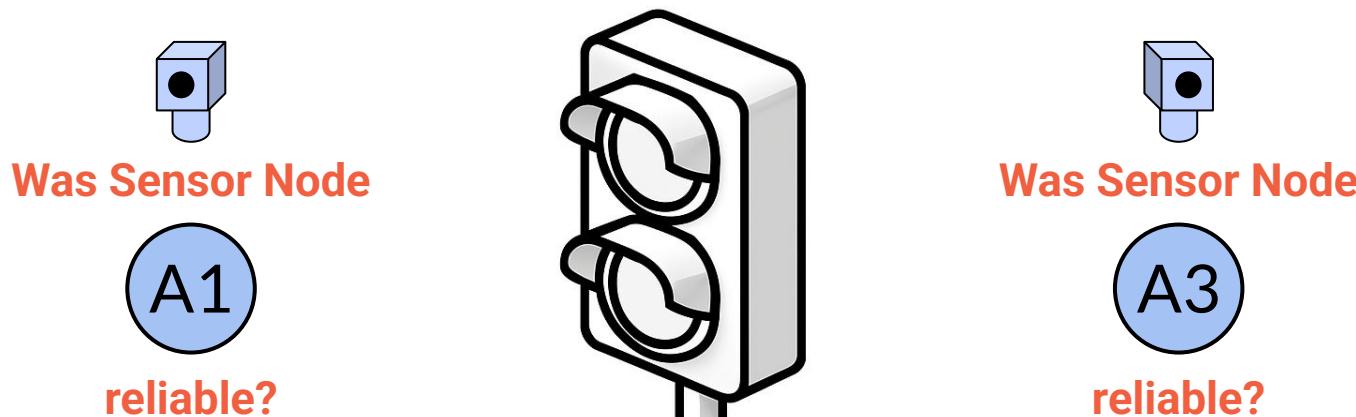


Correct nodes ***weight/influence*** increases

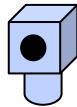
Inspect the network weights

Did we learn which sensors are
reliable?

Reviewing the Network

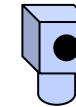
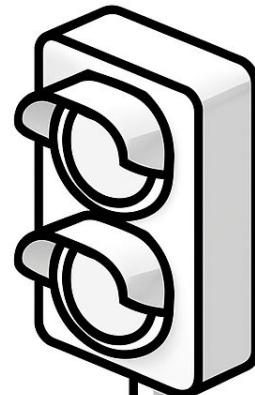


Reviewing the Network



A1

Correct 83.3% of the time



A3

Correct 16.6% of the time