Artificial Neural Networks
in
Artificial Intelligence

Artificial Intelligence involves several different approaches, including

- **Symbolic artificial intelligence** is the collection of all methods in artificial intelligence research that are based on high-level "symbolic" (human-readable) representations of problems, logic and search.

- **Bayesian decision networks** are graphical models that represent a set of variables and their dependencies ... ideal for taking an event that occurred and predicting the likelihood that any one of several possible causes was the contributing factor.

- **Evolutionary algorithms** use mechanisms inspired by biological evolution, such as reproduction, mutation, recombination, and selection. Candidate solutions play the role of individuals in a population, and the fitness function determines the quality of the solutions. Evolution of the candidate population then takes place after the repeated application of the mechanisms.

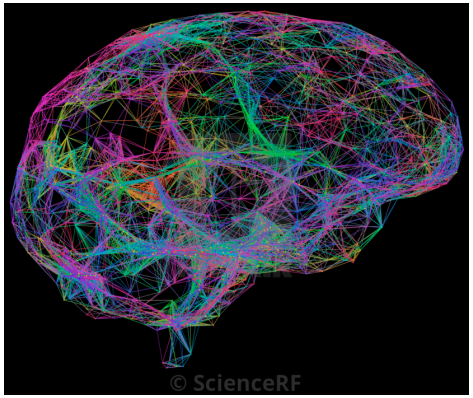
Wikipedia

Here we illustrate

- **Artificial Neural Networks**

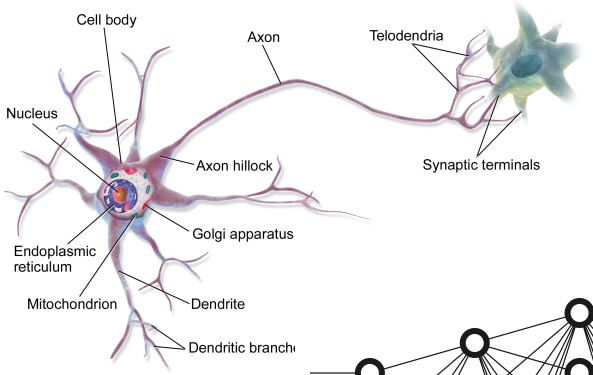
www.braininjuryaustralia.org.au

Our brains sense and think using connected networks of cells called neurons

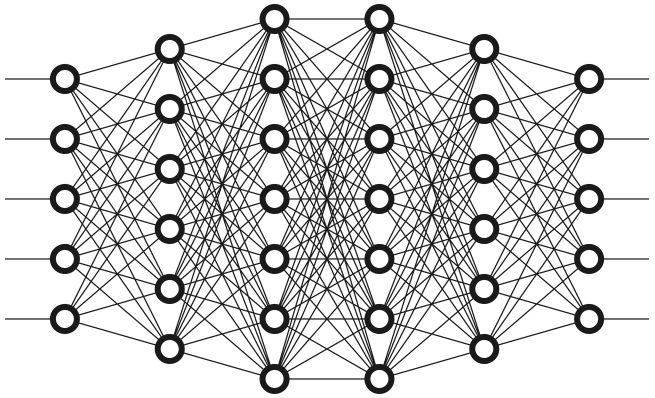


@ScienceRF

Blausen_0657_MultipolarNeuron



These networks are the inspiration for computer simulations of “neural networks,” which can be trained to sense and solve complex problems



neural_network_shutterstock_all_is_magic.jpg

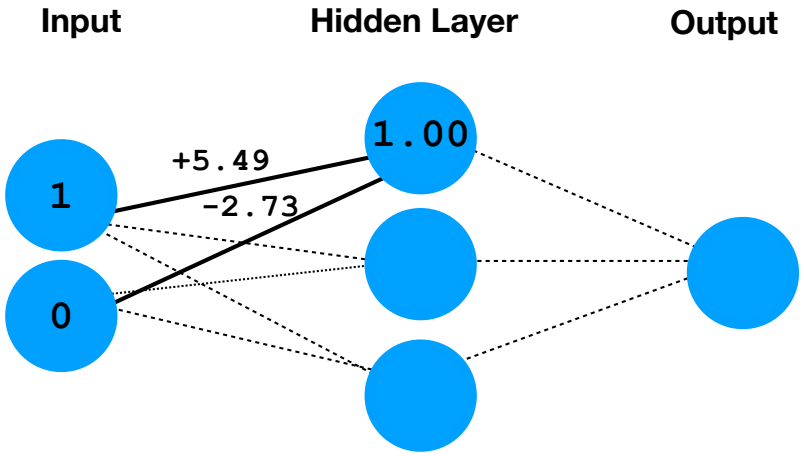
github.com/RichardHerz

Neural Network

Simulates XOR logic - exclusive or

Output is TRUE when one input is TRUE but not both

2 inputs, 1 output,
1 hidden layer
with 3 neurons &
9 synapses



These sums over all nodes in a layer are the product of matrix multiplication. Matrix multiplication is well suited to being accelerated in hardware Graphical Processing Units, since graphic transformations also involve matrix multiplication.

EXAMPLE for input of 1
0

node value = sigmaFunc(sum of (node activation * connection weight))

where sigmaFunc(x) = exp(x) / (1 + exp(x)) >> converts all input x values into range 0 to 1

INPUT > HIDDEN LAYER

sigmaFunc(1 * 5.4868 + 0 * (-2.7276)) = 0.9959 = hidden node 1 activation

The neuron and synapse values are held in memory locations and the CPU executes the math - there are no physical, hardware neurons and synapses.

The connection - synapse - weights for a network are determined as the network is "trained" using combinations of known inputs and outputs.

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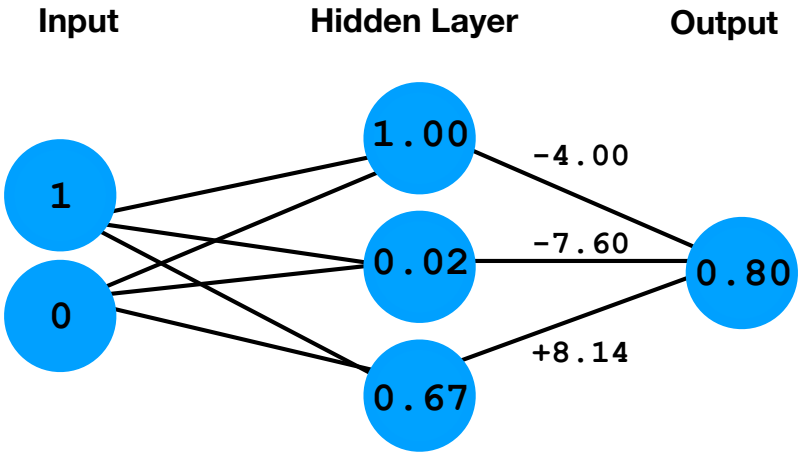

HIDDEN LAYER > OUTPUT

sigmaFunc(0.9959 * (-4.0030) + 0.0153 * (-7.5988) + 0.6719 * 8.1402) = 0.7969 = output node

Output is TRUE when one input is TRUE but not both

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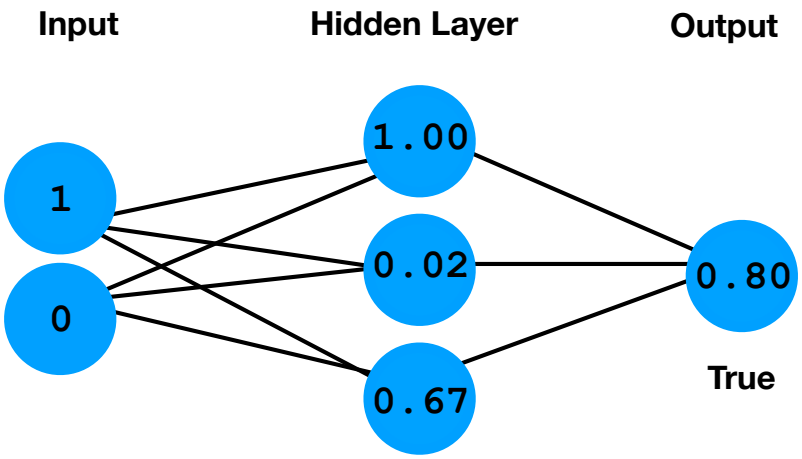

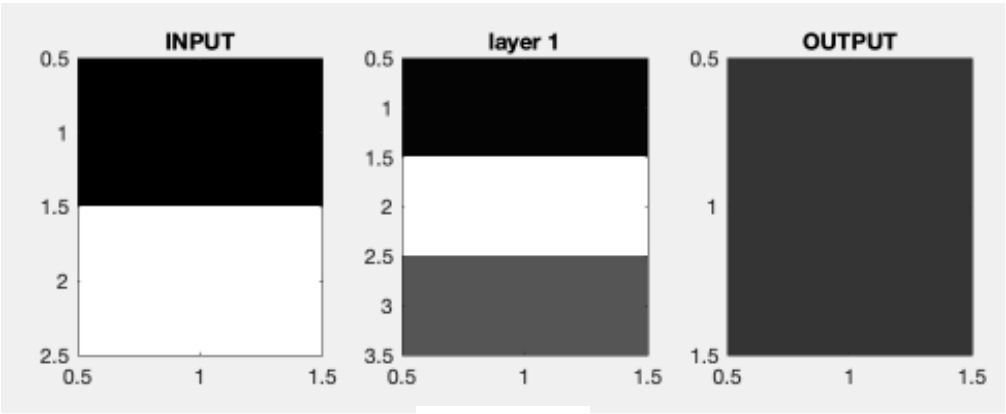


```
1
0
```

```
0.9959
0.0153
0.6719
```

```
0.7969
```

True

github.com/RichardHerz

Neural Network

Simulates XOR logic - exclusive or

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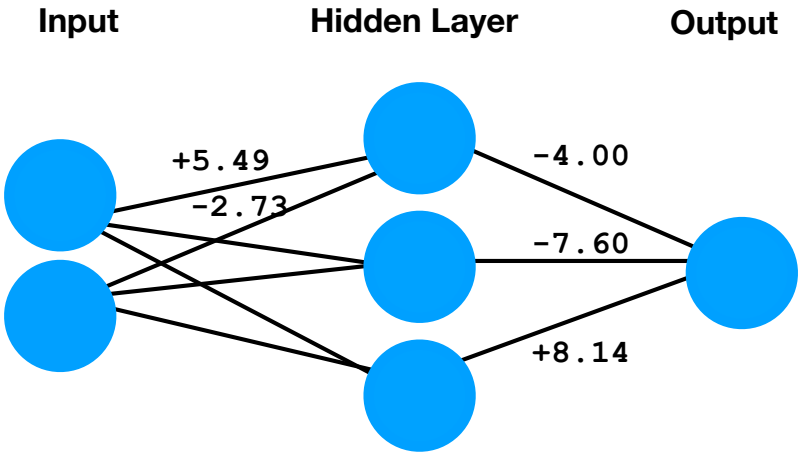
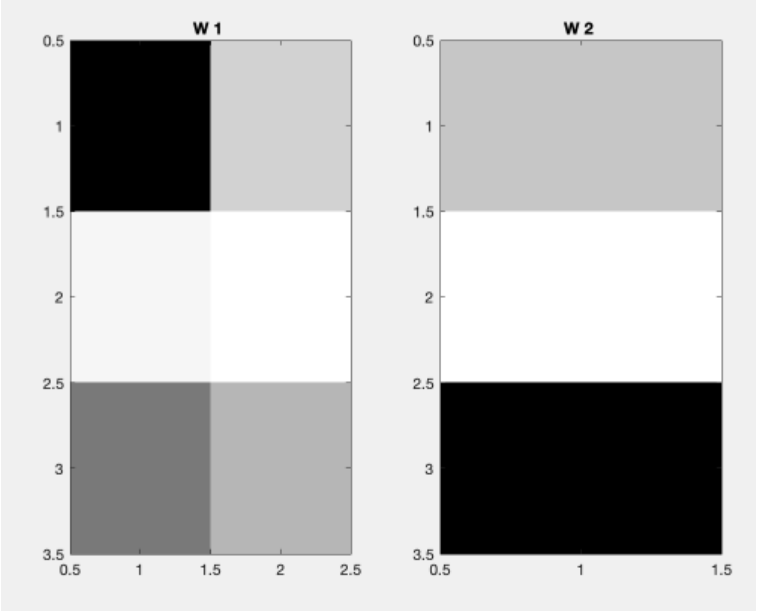


Synapse weights to hidden layer and to output,
min = -7.60 (white), max = +8.14 (black)

```
 5.4868   -2.7276
-4.1663   -4.4991
 0.7169   -1.5748
```




```
-4.0030
-7.5988
 8.1402
```

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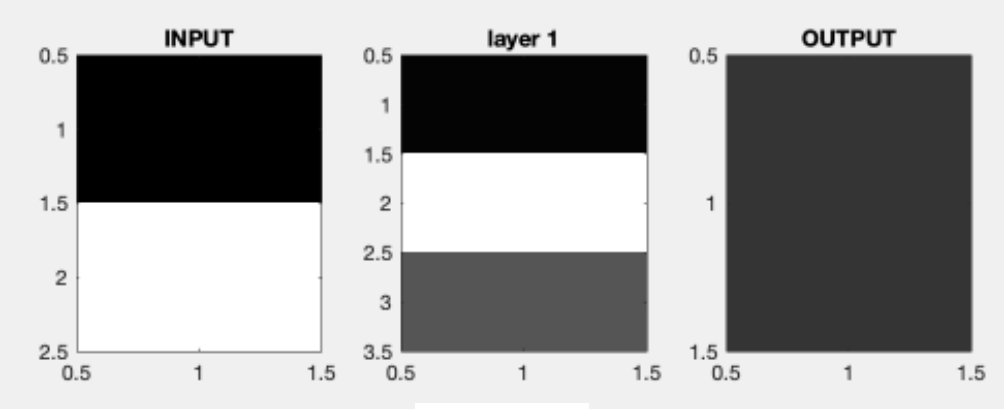
Below are node values: input > hidden layer > output

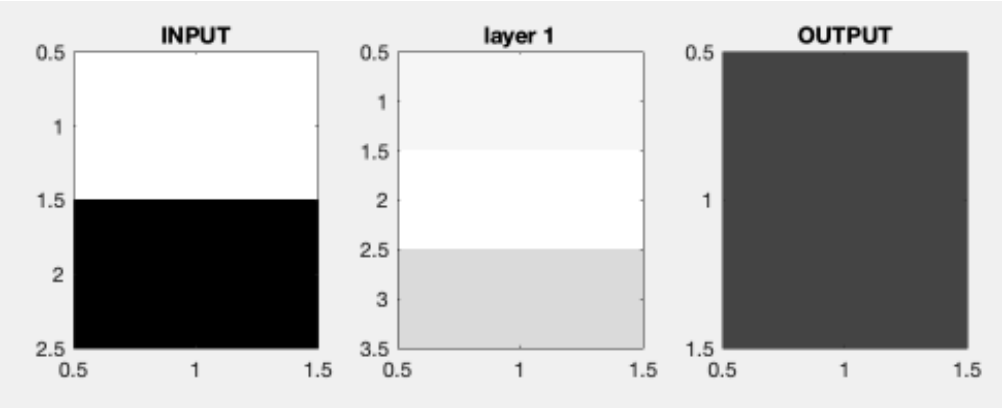


1
0

0.9959
0.0153
0.6719

0.7969

True

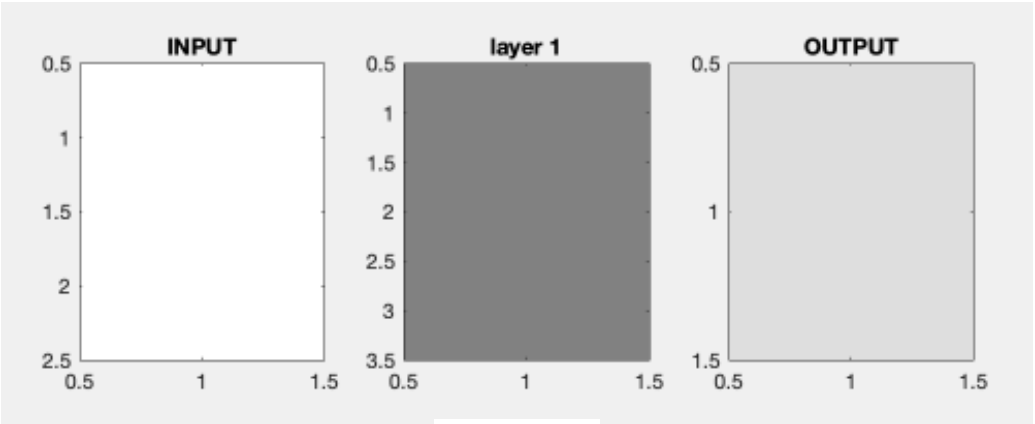


0
1

0.0614
0.0110
0.1715

0.7440

True

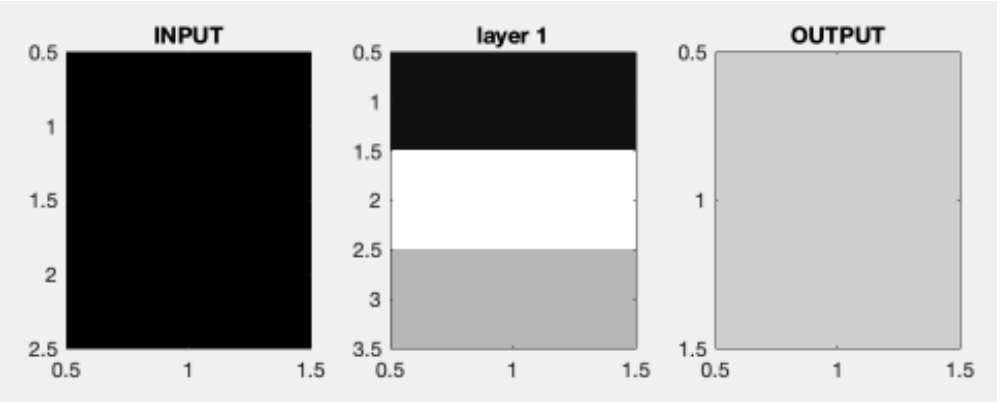


0
0

0.5000
0.5000
0.5000

0.1505

False



1
1

0.9404
0.0002
0.2978

0.2072

False

Output is TRUE when one input is TRUE but not both

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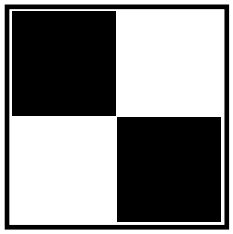
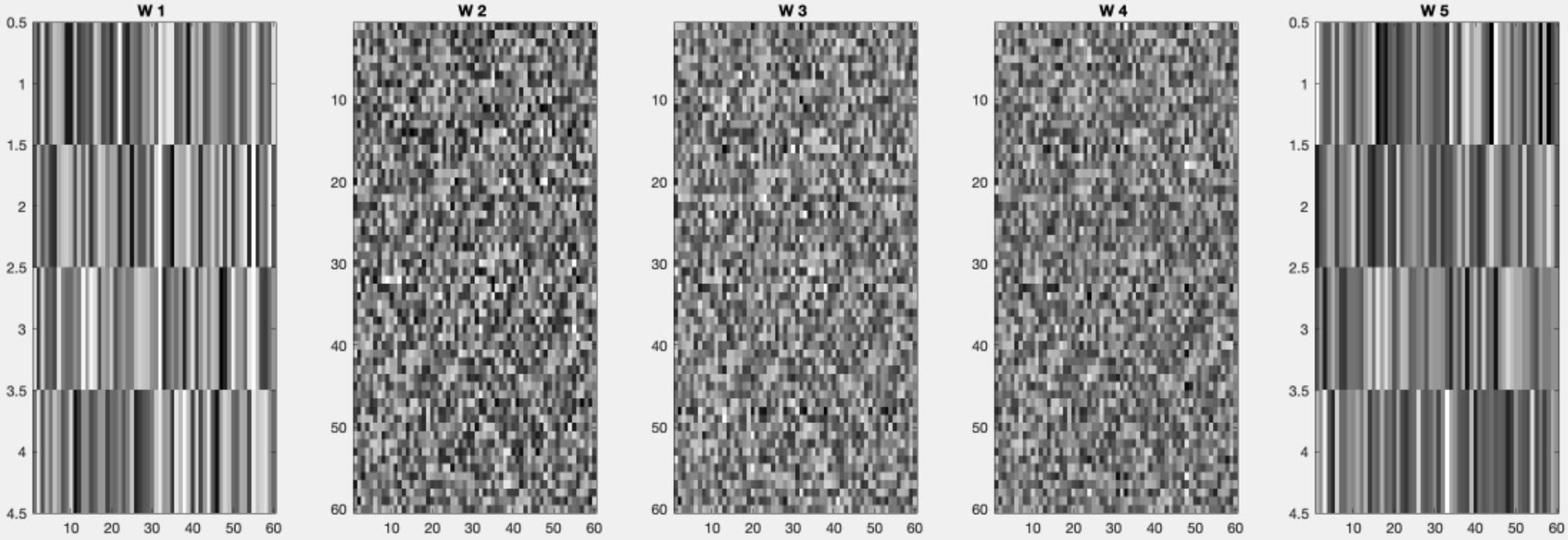
Neural Network

4 inputs, 4 outputs
4 hidden layers, each with 60 neurons = 240 neurons & 11,280 synapses

A little more complex network which detects diagonal, horizontal and vertical inputs to a 2 x 2 "touch screen"

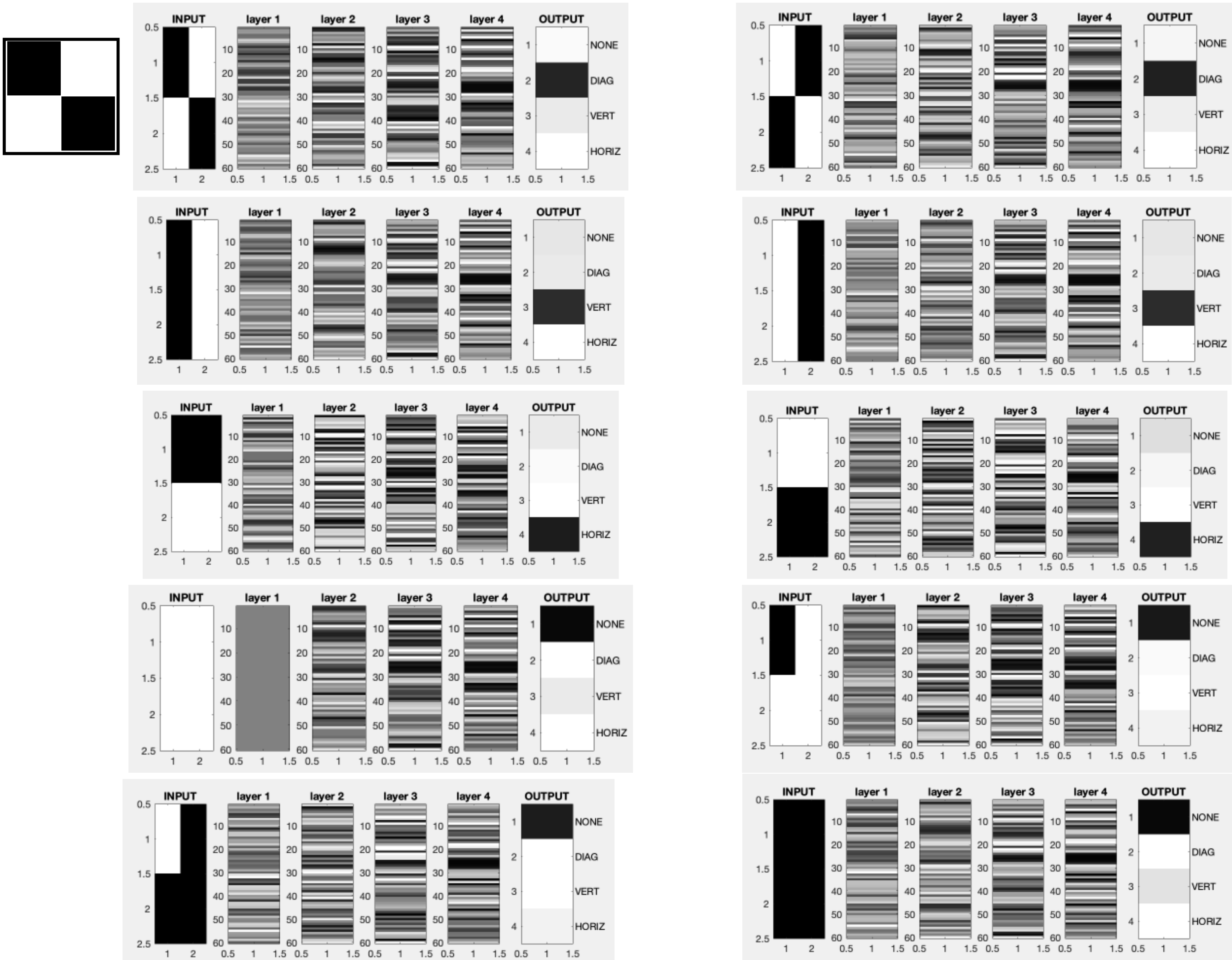


Synapse weights to hidden layers 1-4 and to output, min = -1.23 (white), max = +1.25 (black)



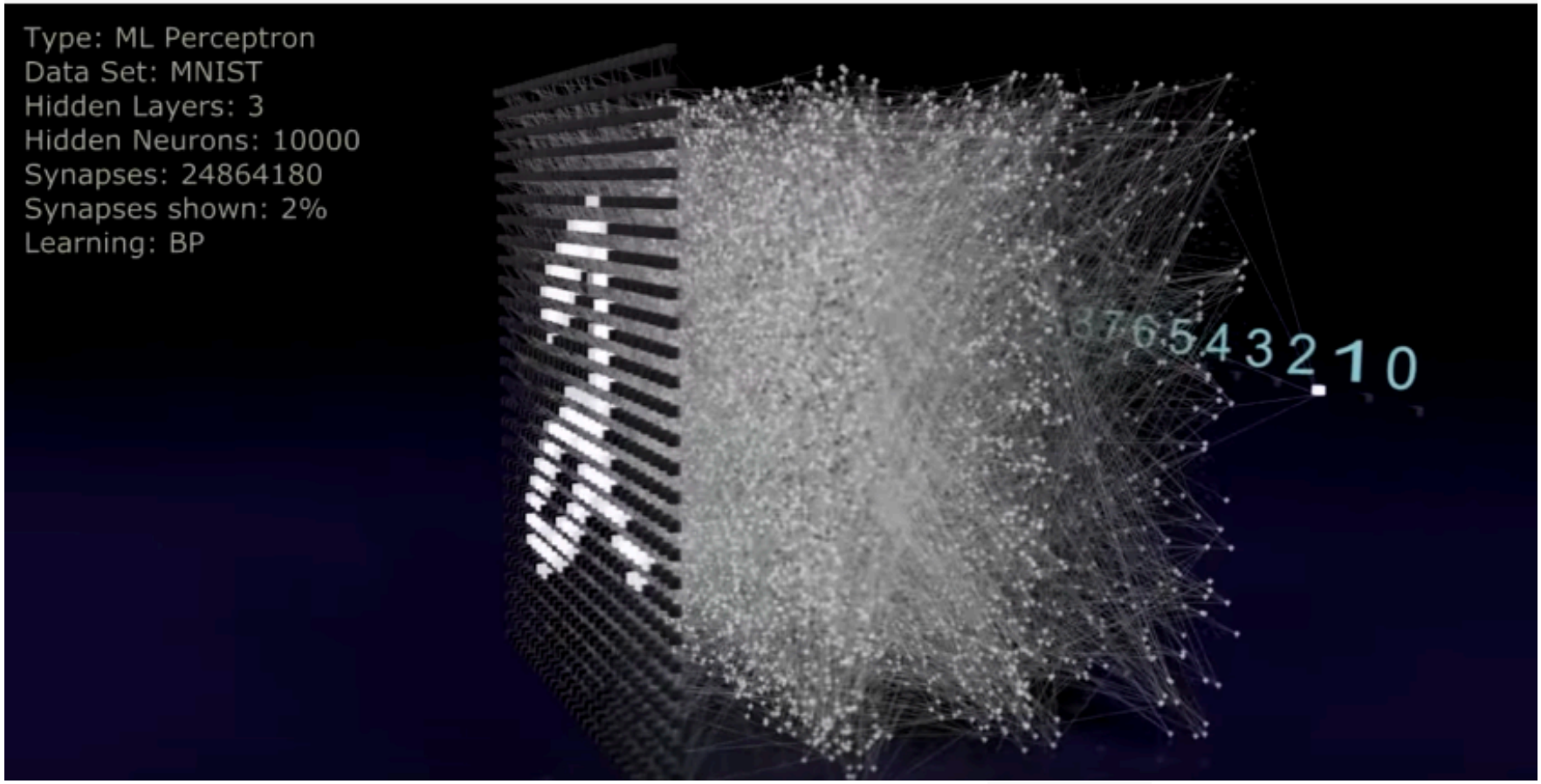
github.com/RichardHerz

Below are node activations: input > 4 hidden layers > output



github.com/RichardHerz

A neural network for a 28 x 28 “touch screen”
note that only 2% of the 24+ million “synapses” are shown



Denis Dmitriev **https://youtu.be/3JQ3hYko51Y**

A neural network represents a large number of coupled equations which, when given a set of input values, can produce a set of desired output values.

The more neurons and synapses - the more equations - and the greater complexity of inputs and outputs which can be "fit" by the system of equations.

"Deep learning" refers to solving complex problems using many hidden layers of neurons and, thus, many equations.