NEURAL NETWORKS

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CS159 – Fall 2020

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Admin

Assignment 7

Final project proposal

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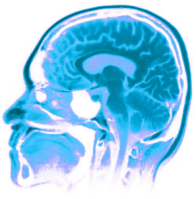
Neural Networks

Neural Networks try to mimic the structure and function of our nervous system

People like biologically motivated approaches



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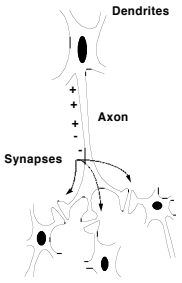
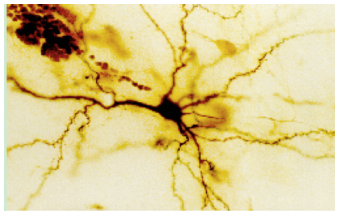
Our Nervous System





Neuron

What do you know?

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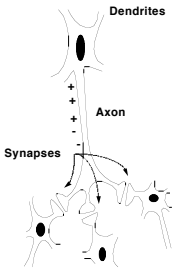
Our nervous system: the computer science view



the human brain is a large collection of interconnected neurons

a NEURON is a brain cell

- they collect, process, and disseminate electrical signals
- they are connected via synapses
- they FIRE depending on the conditions of the neighboring neurons

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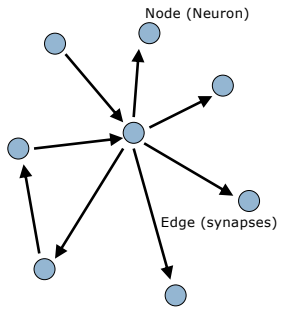
Artificial Neural Networks



our approximation

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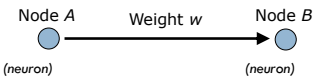

W is the strength of signal sent between A and B.

If *A* fires and *w* is **positive**, then *A* **stimulates** *B*.

If *A fires* and *w* is **negative**, then *A* **inhibits** *B*.

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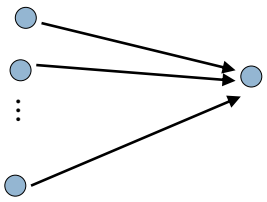

Neurons often have many, many connected input neurons

If a neuron is stimulated enough, then it also fires

How much stimulation is required is determined by its **threshold**

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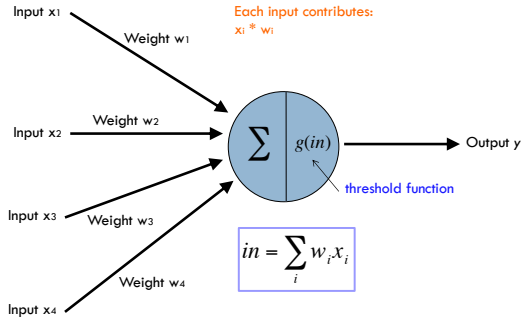
A Single Neuron/Perceptron



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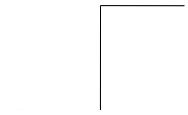
Activation functions

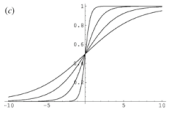
hard threshold:

$$g(in) = \begin{cases} 1 & if\ in \geq T \\ 0 & otherwise \end{cases}$$

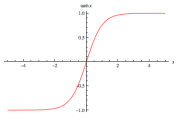


sigmoid

$$g(x) = \frac{1}{1+e^{-ax}}$$



tanh x



why other threshold functions?

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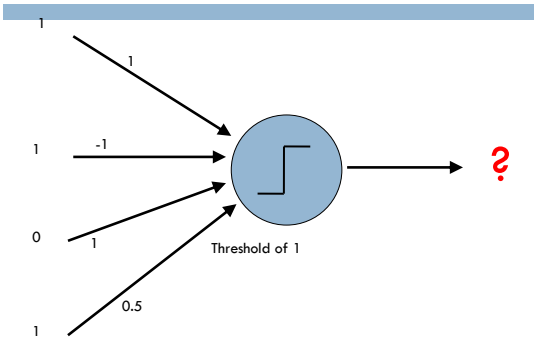
A Single Neuron/Perceptron



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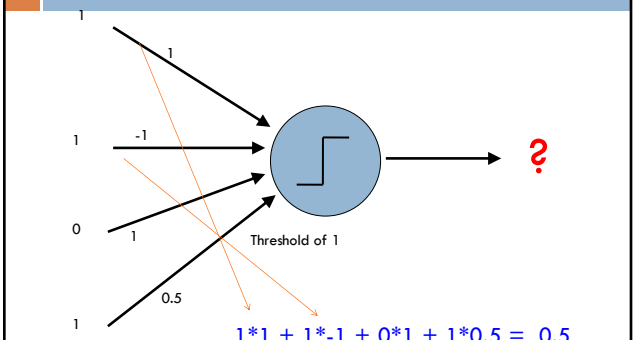
A Single Neuron/Perceptron



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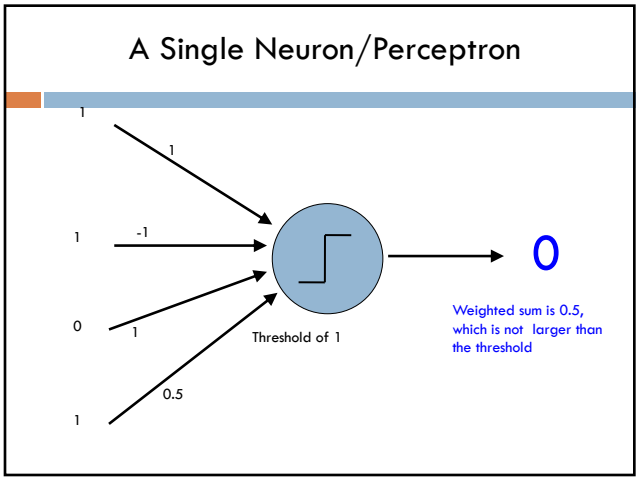
A Single Neuron/Perceptron
1
1
1
-1
0
1
1
0.5
Threshold of 1
0
Weighted sum is 0.5, which is not larger than the threshold

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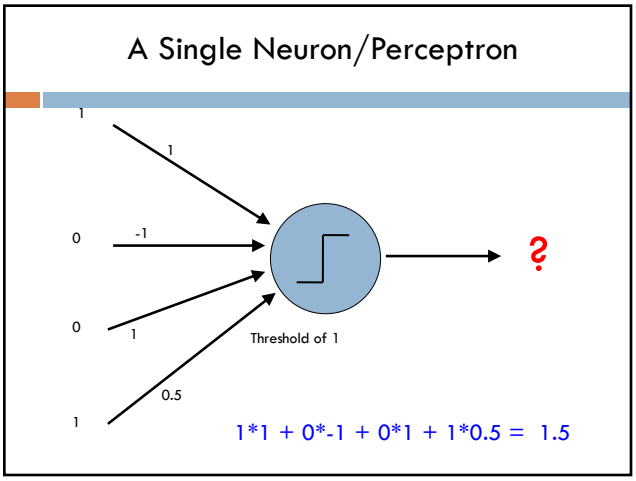
A Single Neuron/Perceptron
1
1
0
-1
0
1
1
0.5
Threshold of 1
?
1*1 + 0*-1 + 0*1 + 1*0.5 = 1.5

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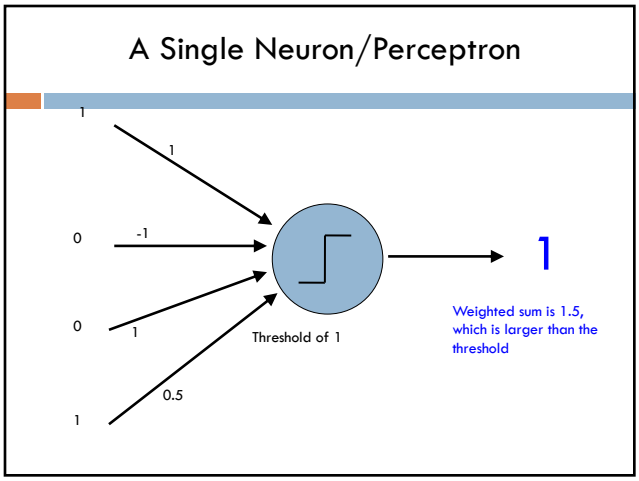
A Single Neuron/Perceptron
1
1
0
-1
0
1
1
0.5
Threshold of 1
1
Weighted sum is 1.5, which is larger than the threshold

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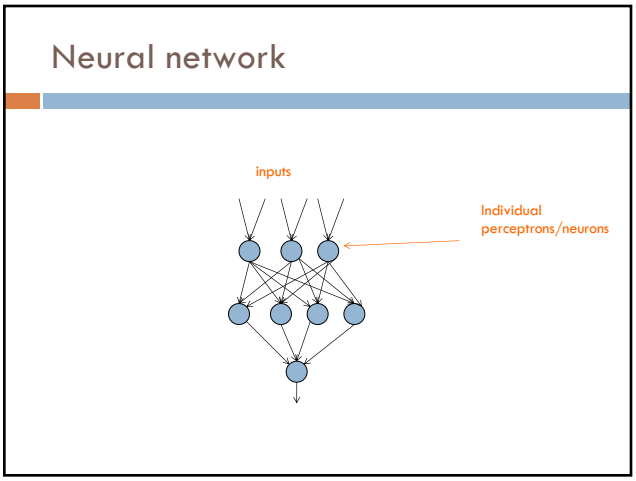
Neural network
inputs
Individual perceptrons/neurons

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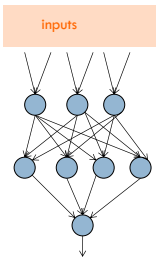
Neural network



some inputs are provided/entered

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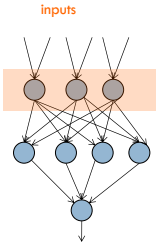
Neural network



each perceptron computes and calculates an answer

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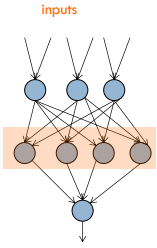
Neural network



those answers become inputs for the next level

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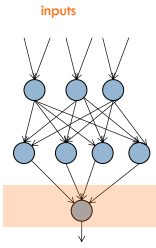
Neural network



finally get the answer after all levels compute

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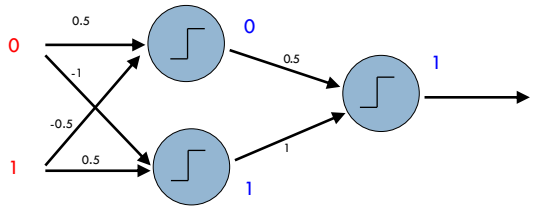
Computation (assume threshold 0)



$$g(in) = \begin{cases} 1 & if\ in \geq T \\ 0 & otherwise \end{cases}$$

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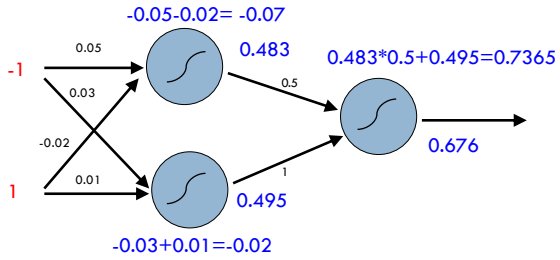
Computation



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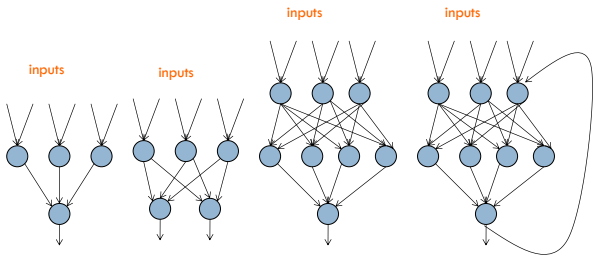
Neural networks

Different kinds/characteristics of networks



How are these different?

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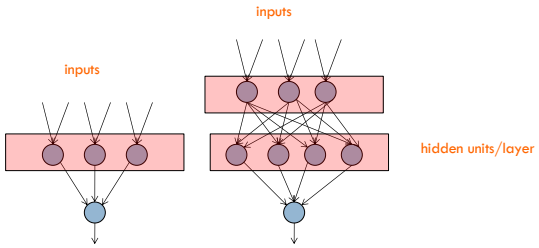
Hidden units/layers



Feed forward networks

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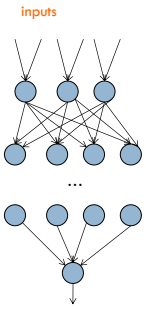
Hidden units/layers



Can have many layers of hidden units of differing sizes

To count the number of layers, you count all but the inputs

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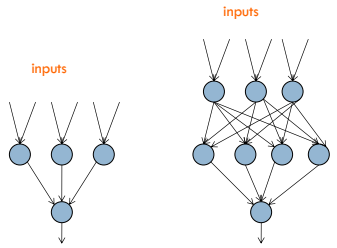
Hidden units/layers



2-layer network

3-layer network

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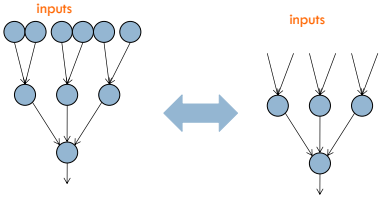
Alternate ways of visualizing

Sometimes the input layer will be drawn with nodes as well



2-layer network

2-layer network

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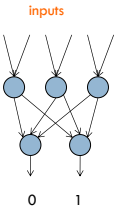
Multiple outputs



Can be used to model multiclass datasets or more interesting predictors, e.g. images

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Multiple outputs

input

output
(edge detection)

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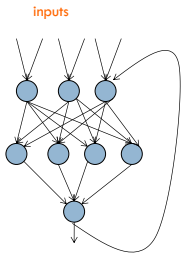
Neural networks



Recurrent network

Output is fed back to input

Can support memory!

Good for temporal data

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History of Neural Networks

McCulloch and Pitts (1943) – introduced model of artificial neurons and suggested they could learn

Hebb (1949) – Simple updating rule for learning

Rosenblatt (1962) - the *perceptron* model

Minsky and Papert (1969) – wrote *Perceptrons*

Bryson and Ho (1969, but largely ignored until 1980s--Rosenblatt) – invented back-propagation learning for multilayer networks

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