CSPB Artificial Intelligence 2020 Spring

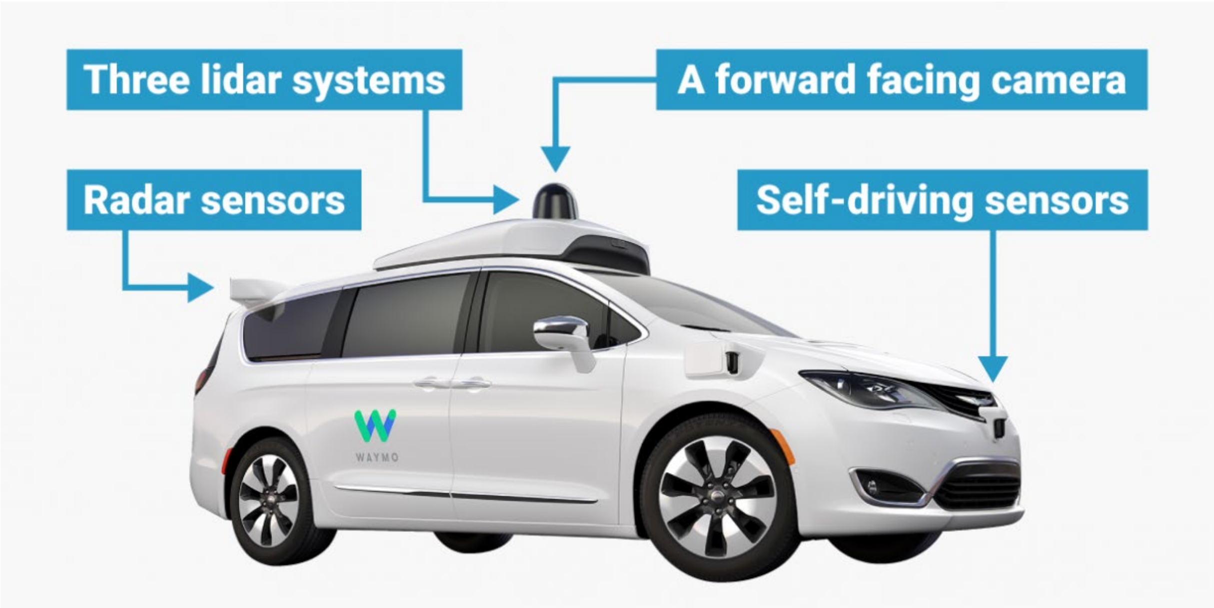
Intro to Deep Learning

Geena Kim

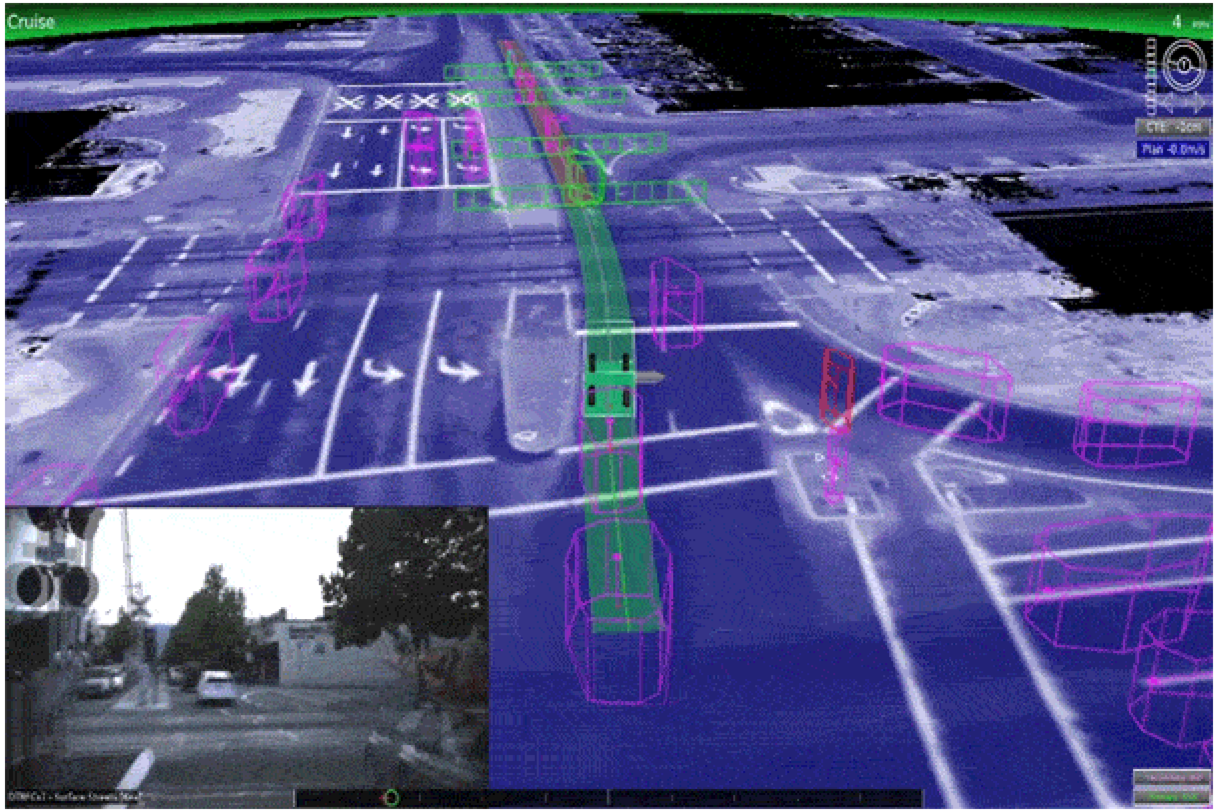
*Some of the slide/diagram adopted from CMU deep learning course

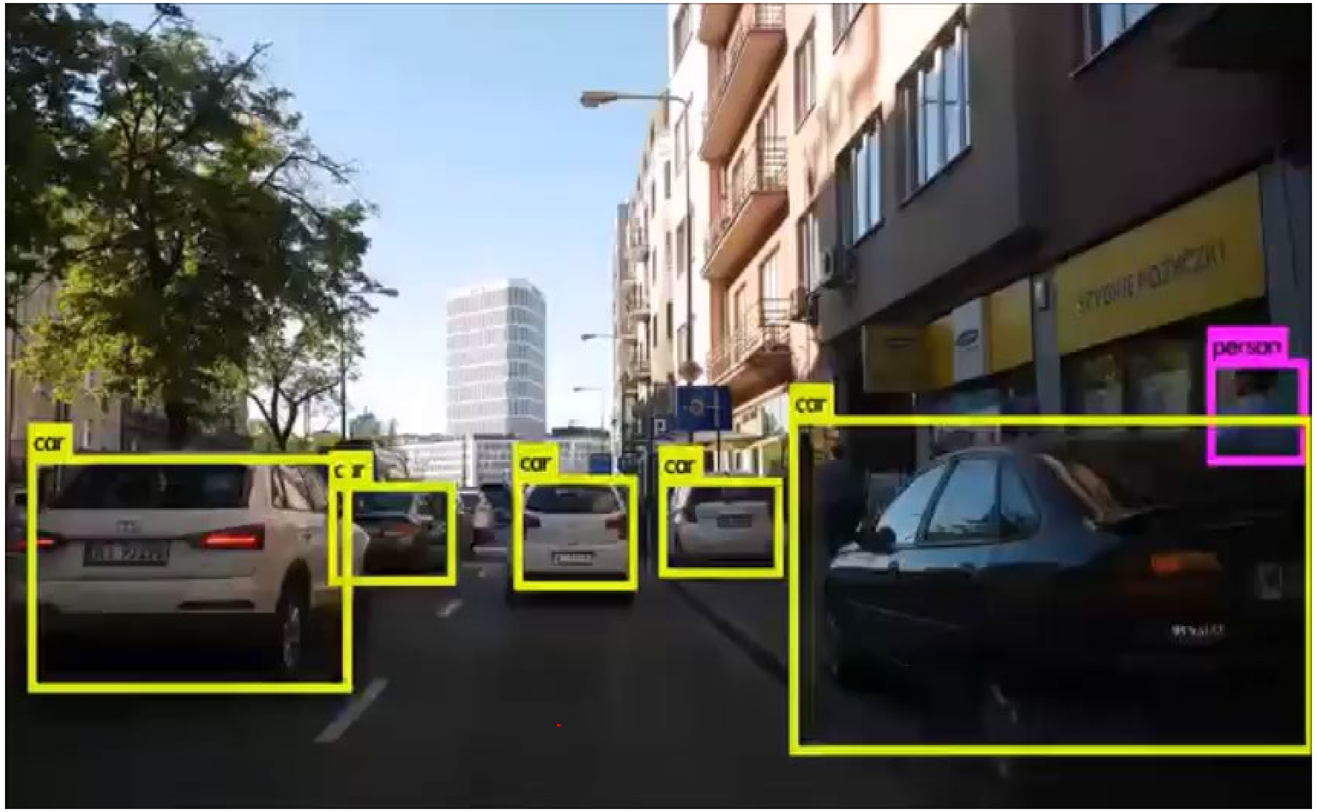
Why Deep Learning?

Self-driving Cars



Why Deep Learning?

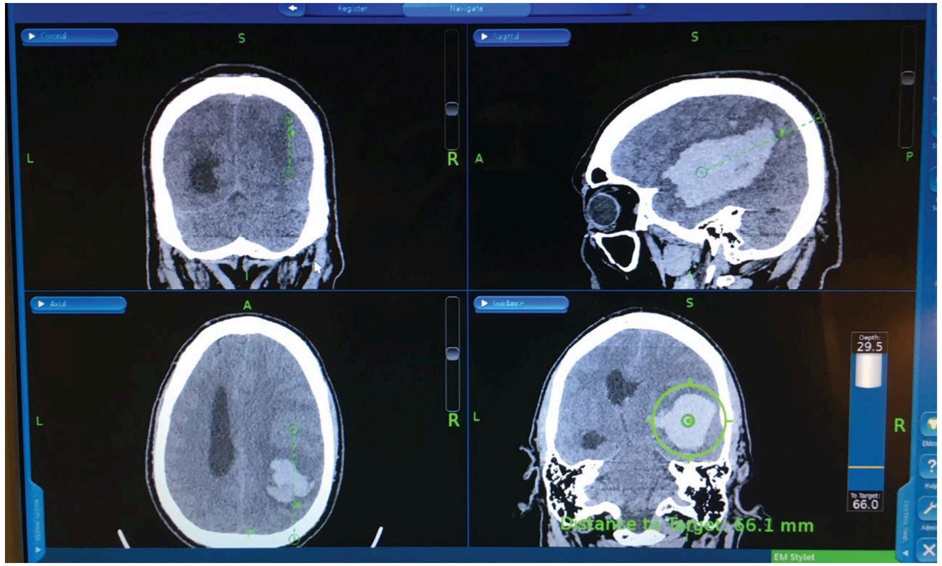


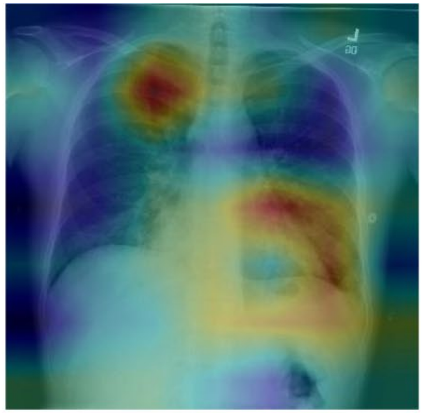


https://www.youtube.com/watch?v=EhcpGpFHCrw

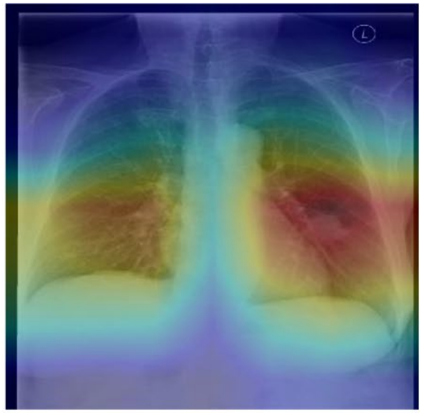
Why Deep Learning?

Medical Imaging, AI in Medicine

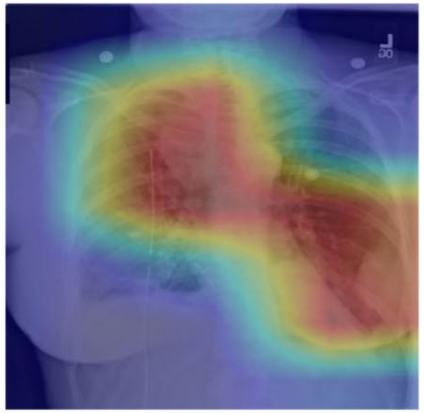




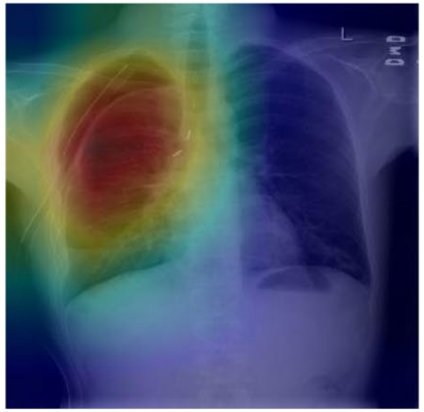
(a) Patient with multifocal community acquired pneumonia. The model correctly detects the airspace disease in the left lower and right upper lobes to arrive at the pneumonia diagnosis.



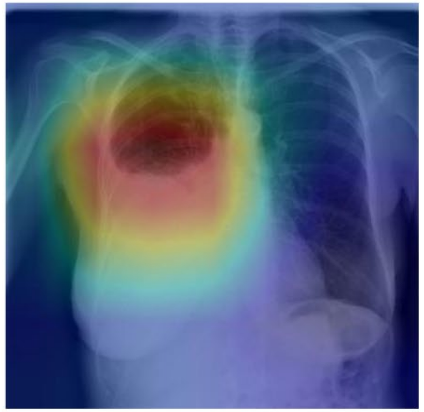
(b) Patient with a left lung nodule. The model identifies the left lower lobe lung nodule and correctly classifies the pathology.



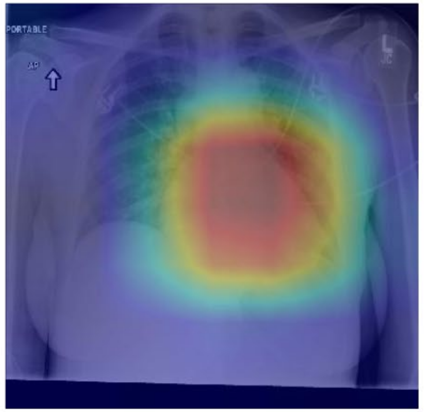
(c) Patient with primary lung malignancy and two large masses, one in the left lower lobe and one in the right upper lobe adjacent to the mediastinum. The model correctly identifies both masses in the X-ray.



(d) Patient with a right-sided pneumothroax and chest tube. The model detects the abnormal lung to correctly predict the presence of pneumothorax (collapsed lung).



(e) Patient with a large right pleural effusion (fluid in the pleural space). The model correctly labels the effusion and focuses on the right lower chest.



(f) Patient with congestive heart failure and cardiomegaly (enlarged heart). The model correctly identifies the enlarged cardiac silhouette.

P. Rajpurkar et el., arXiv:1711.05225v3

Why Deep Learning?

News Startups Mobile Gadgets Enterprise Social Europe   Trending Amazon Tesla Microsoft

- eBay
- shopping
- Search
- eCommerce
- eCommerce

Popular Posts

Shopping, e-commerce

eBay launches visual search tools that let you shop using photos from your phone or web

Posted Oct 26, 2017 by Sarah Perez (@sarahintampa)

Next Story

Crunchbase

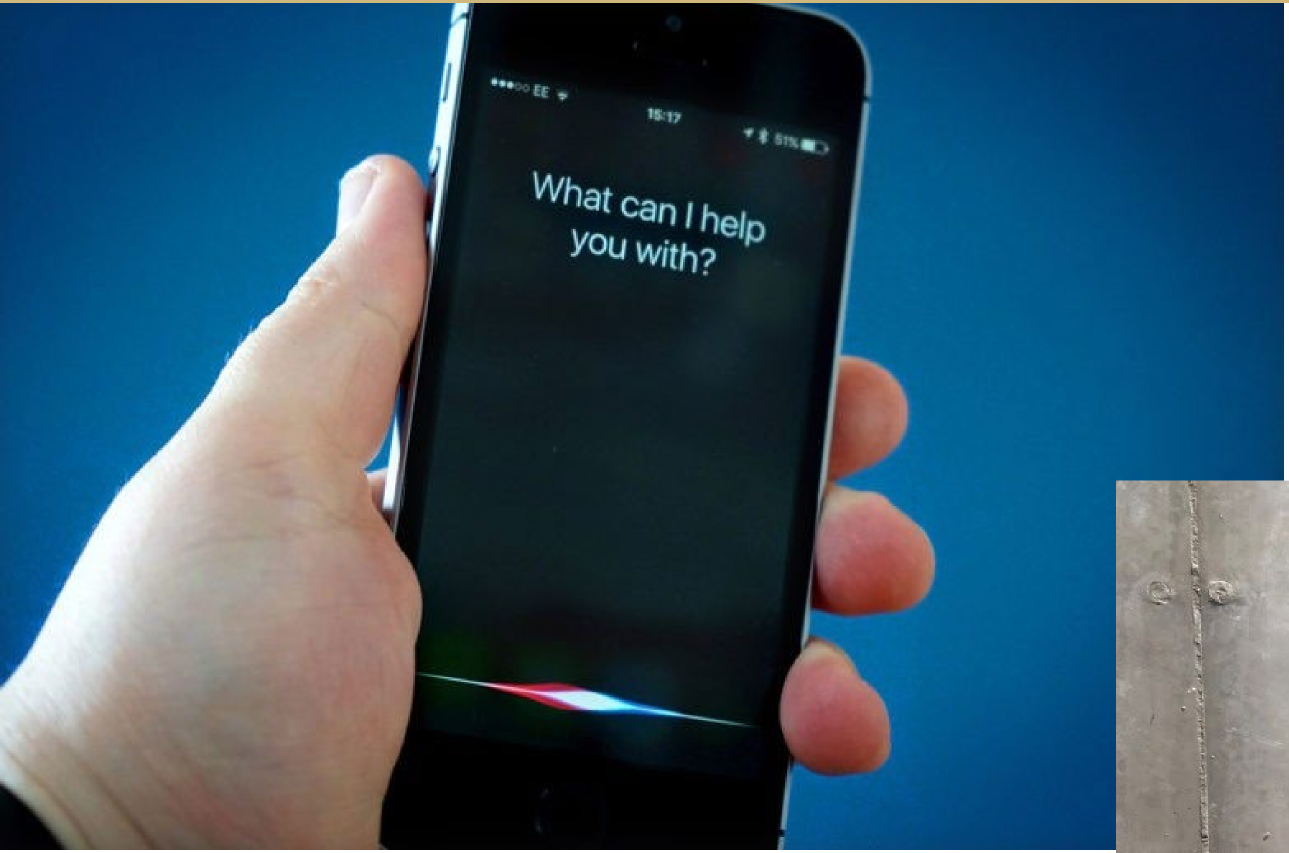
eBay

FOUNDED
1995

OVERVIEW
eBay is an online marketplace. The platform connects millions of buyers with sellers globally utilizing PayPal to ensure secure transactions. eBay products can be sold either via a silent auction in which users are able to input the maximum price they are willing to pay and for which the site will automatically increase bids as necessary up to that maximum, or via the Buy It

Computer vision in Robotics

Why Deep Learning?



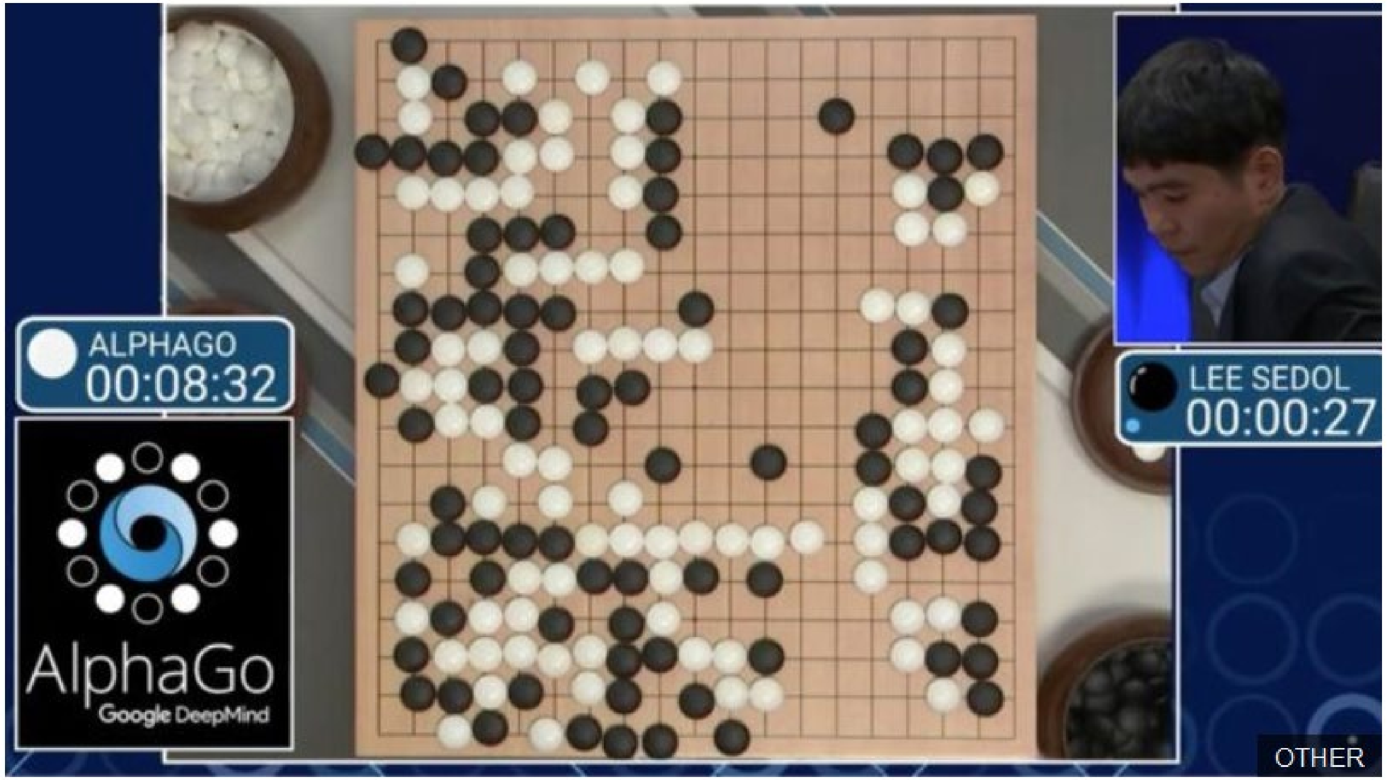
Voice Recognition,
Smart Devices

Deep learning in game playing

Artificial intelligence: Google's AlphaGo beats Go master Lee Se-dol

12 March 2016

Share



A computer program has beaten a master Go player 3-0 in a best-of-five competition, in what is seen as a landmark moment for artificial intelligence.

Deep learning face generation

A few sample faces — all completely fake — created by ThisPersonDoesNotExist.com

Deep learning sound generation

The embedding can also transfer fine time-aligned prosody from one phrase to a slightly different phrase, though this technique works best when the reference and target phrases are similar in length and structure.

Reference Text: For the first time in her life she had been danced tired.

Synthesized Text: For the last time in his life he had been handily embarrassed.

Reference prosody (American)

Synthesized without prosody embedding (American)

Synthesized with prosody embedding (American)

Excitingly, we observe prosody transfer even when the reference audio comes from a speaker whose voice is not in Tacotron's training data.

https://ai.googleblog.com/2018/03/expressive-speech-synthesis-with.html

Deep learning explaining pictures

Multimodal Recurrent Neural Network

https://cs.stanford.edu/people/karpathy/deepimagesent/

Our Multimodal Recurrent Neural Architecture generates sentence descriptions from images. Below are a few examples of generated sentences:

"man in black shirt is playing guitar."

"construction worker in orange safety vest is working on road."

"two young girls are playing with lego toy."

"boy is doing backflip on wakeboard."

"girl in pink dress is jumping in air."

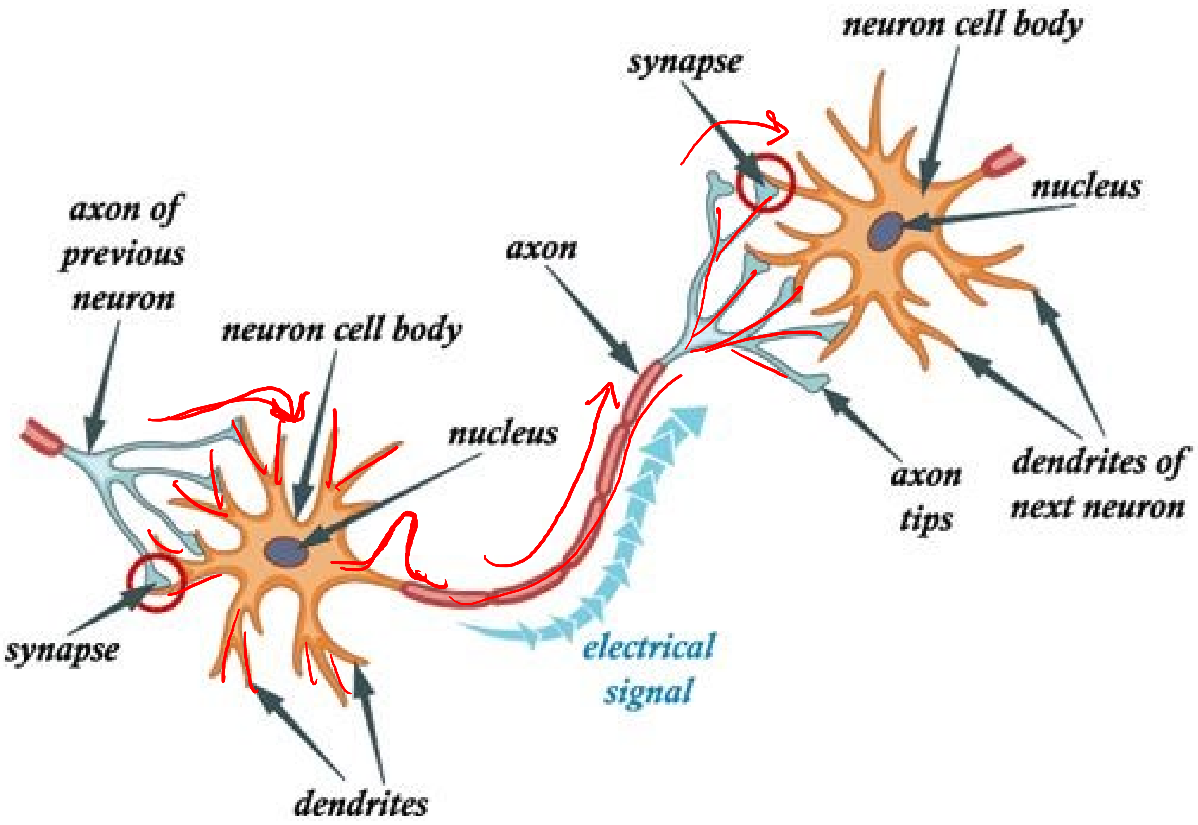
"black and white dog jumps over bar."

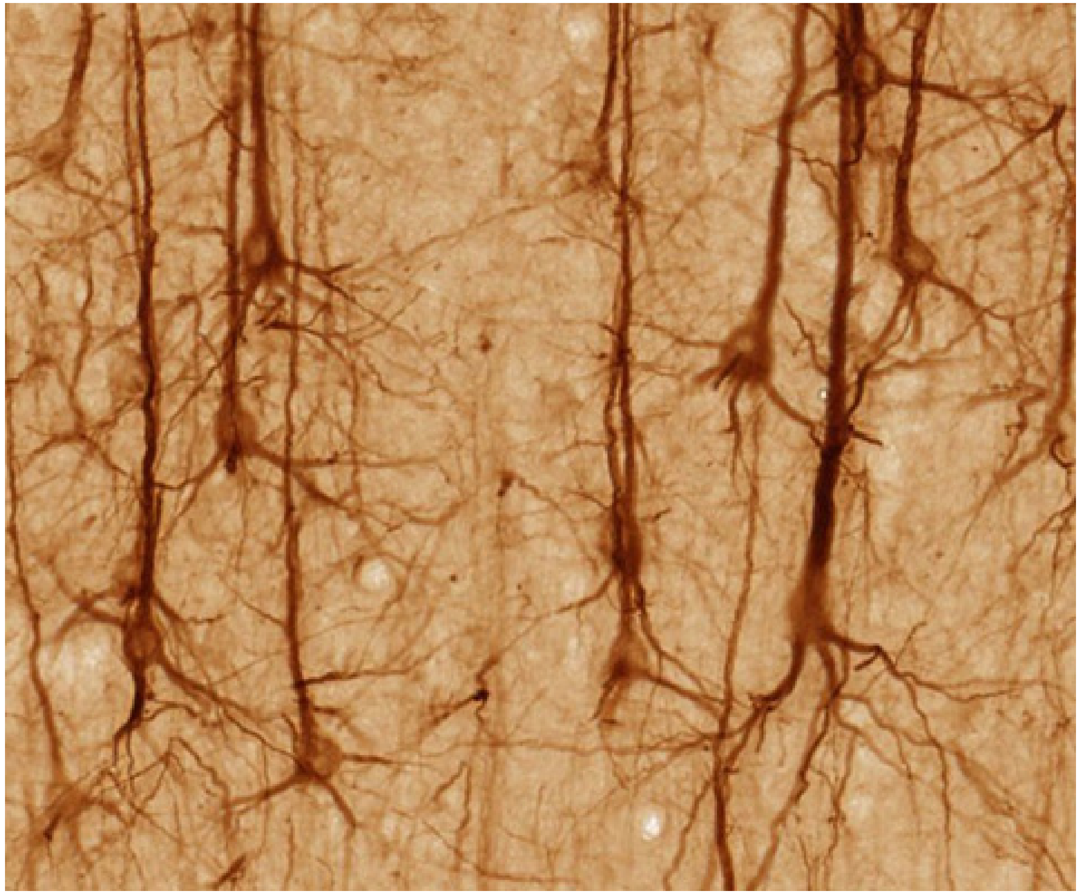
"young girl in pink shirt is swinging on swing."

"man in blue wetsuit is surfing on wave."

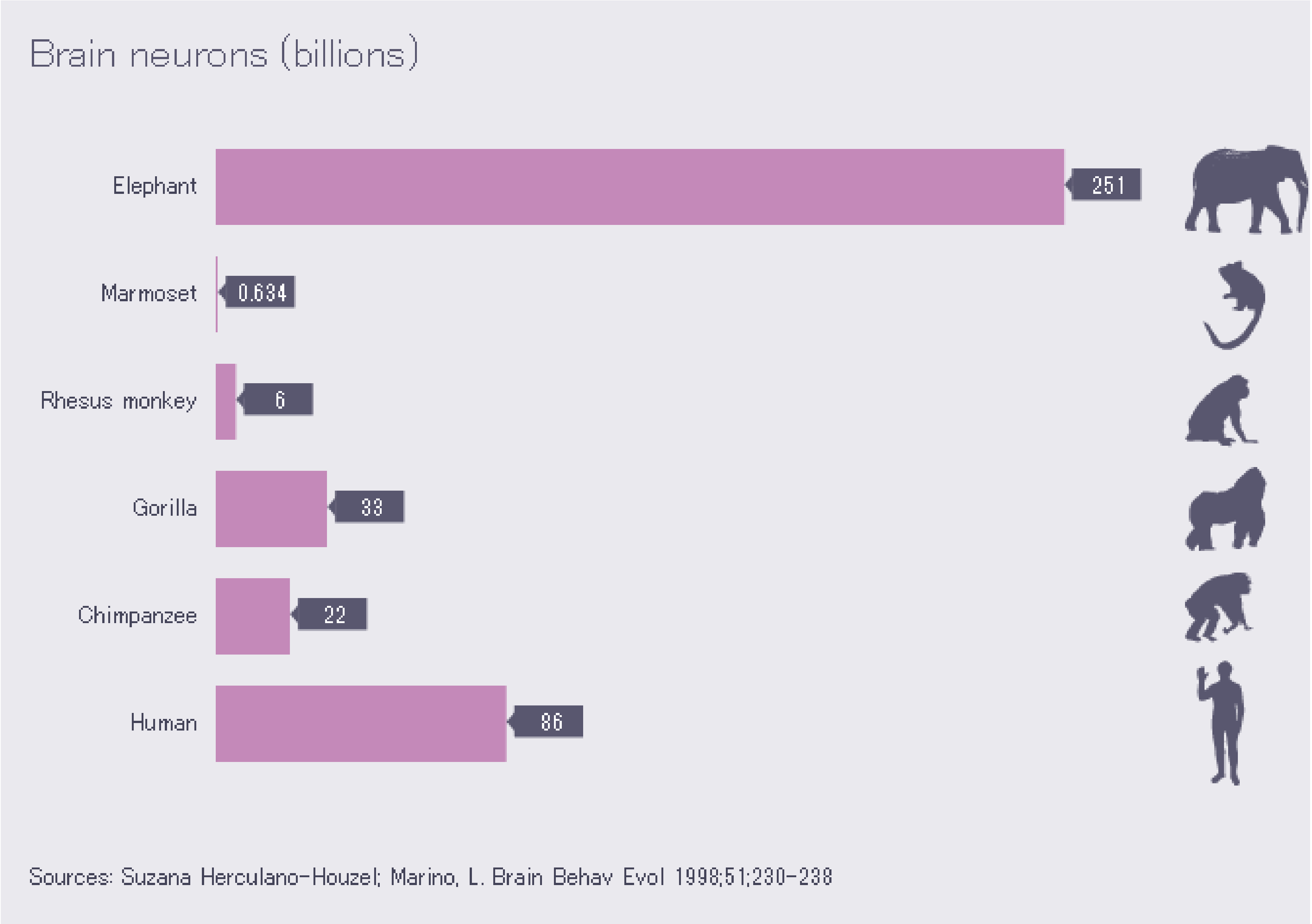
The Deep Learning Age

Neurons in Biological Systems

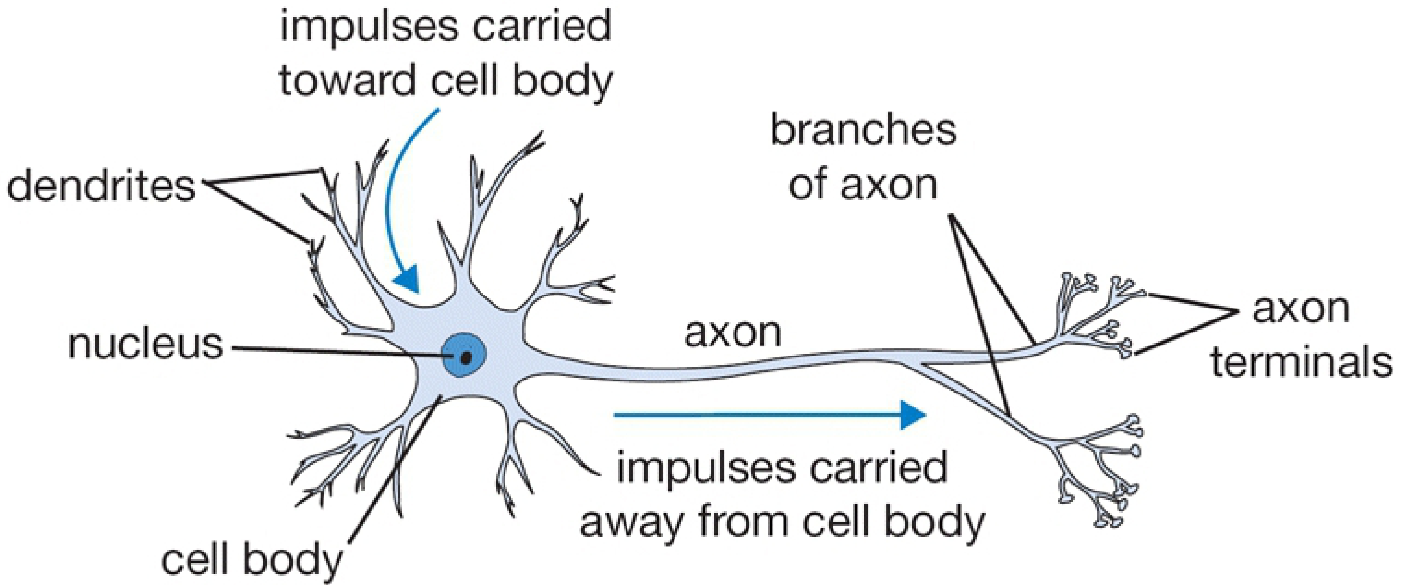


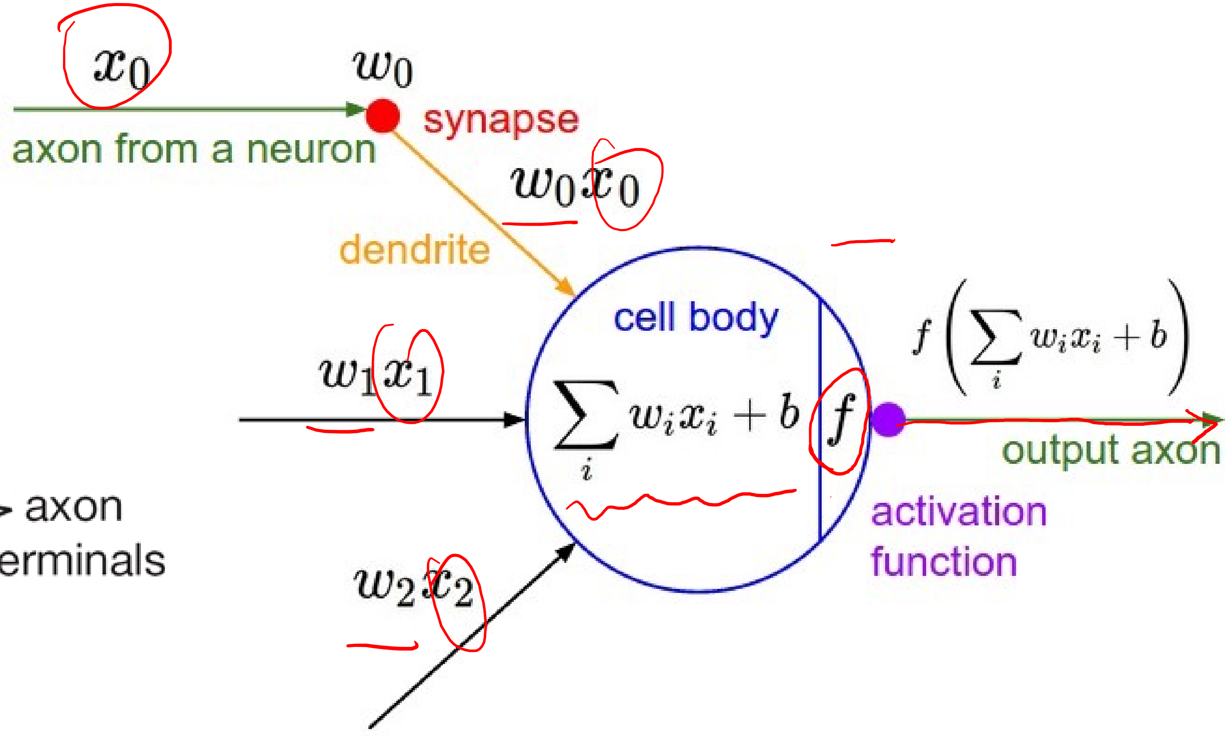


Neurons in Biological Systems



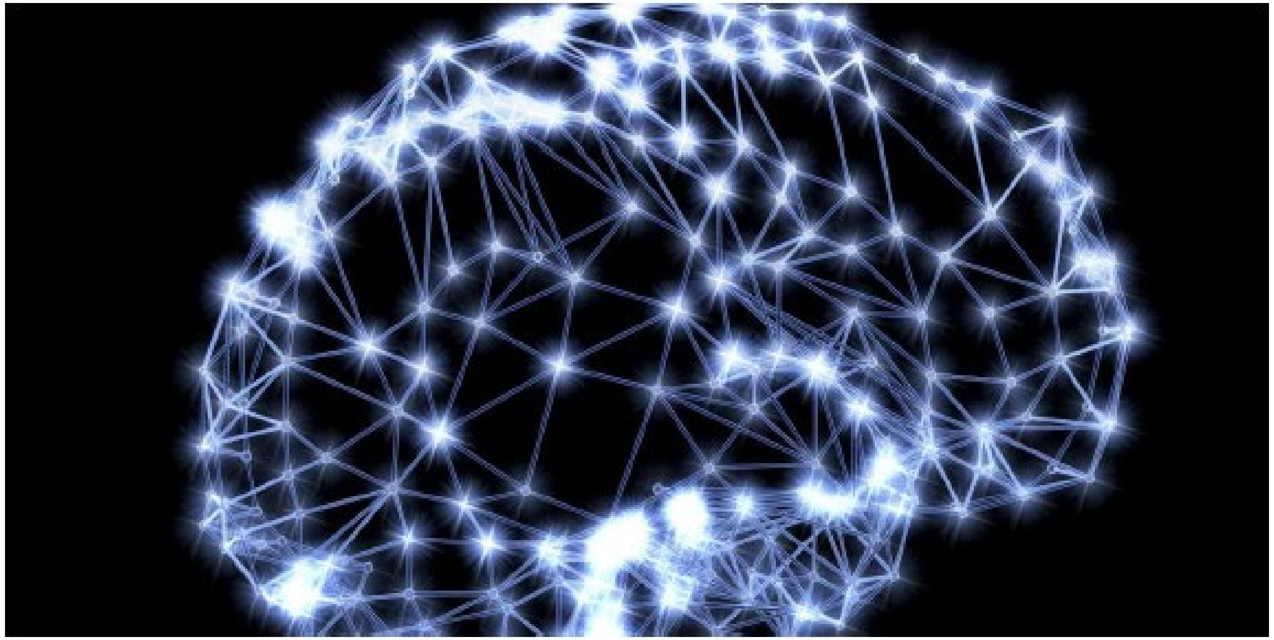
What is Artificial Neuron (Perceptron)





Perceptron

History of neural networks



- Mid 1800s: The brain is a mass of interconnected neurons

History of neural networks

"Connectionism"

- Alexander Bain, philosopher, psychologist, mathematician, logician, linguist, professor
- 1873: The information is in the ***connections***
  - *Mind and body* (1873)

History of neural networks

"Perceptron"

- Frank Rosenblatt
  - Psychologist, Logician
  - Inventor of the solution to everything, aka the Perceptron (1958)

History of neural networks

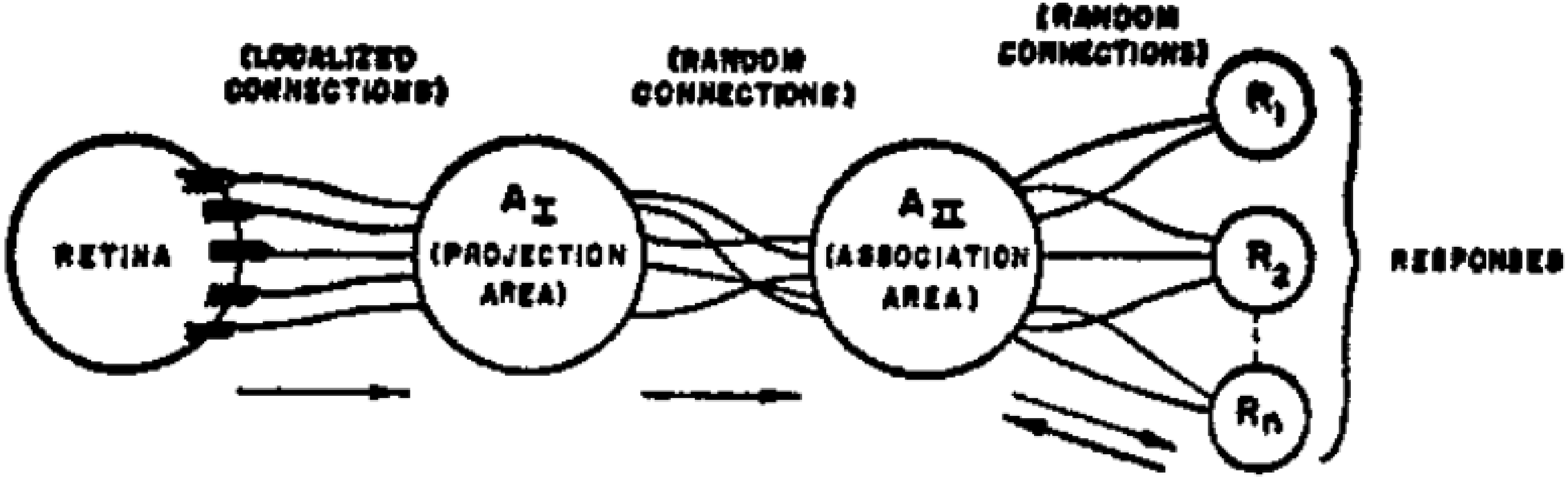
"Perceptron"

Psychological Review
Vol. 65, No. 6, 1958

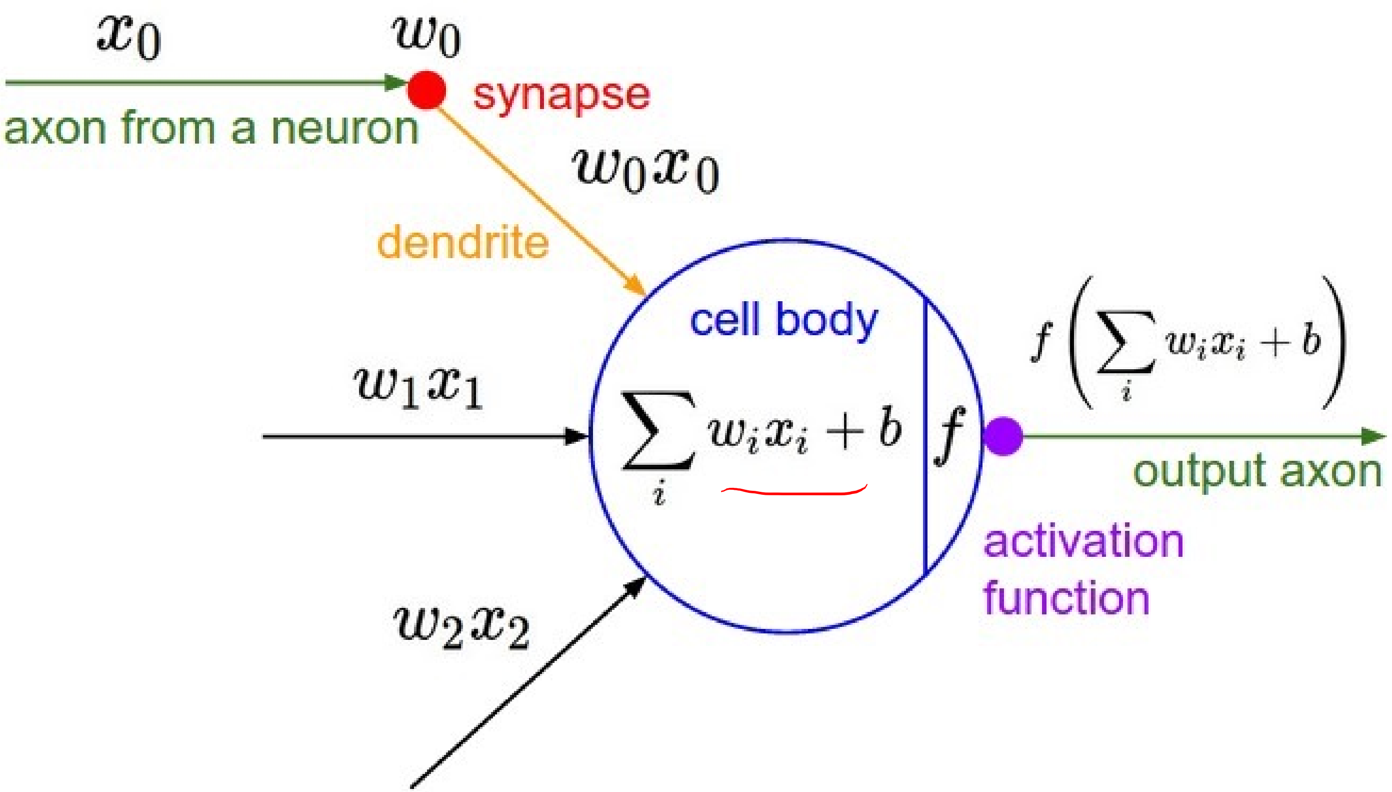
THE PERCEPTRON: A PROBABILISTIC MODEL FOR INFORMATION STORAGE AND ORGANIZATION IN THE BRAIN[1]

F. ROSENBLATT

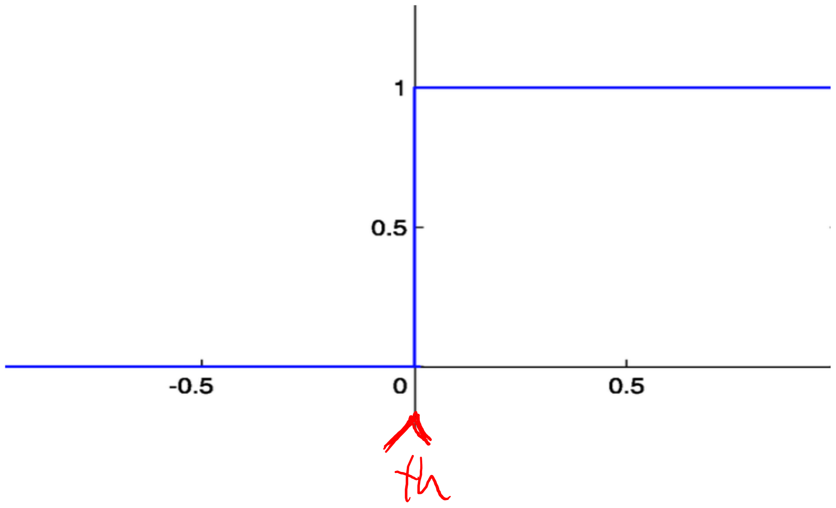
Cornell Aeronautical Laboratory



Perceptron

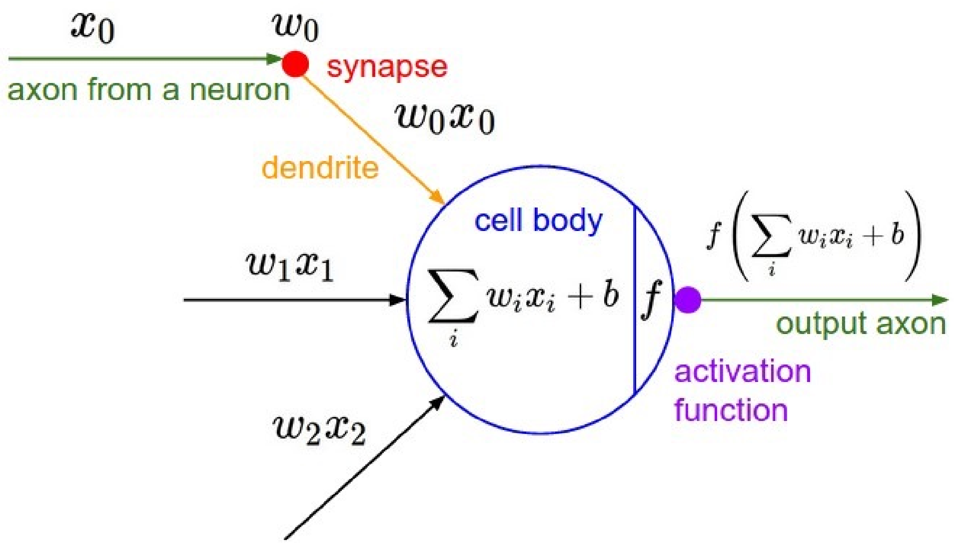


- Binary Threshold (Step function)

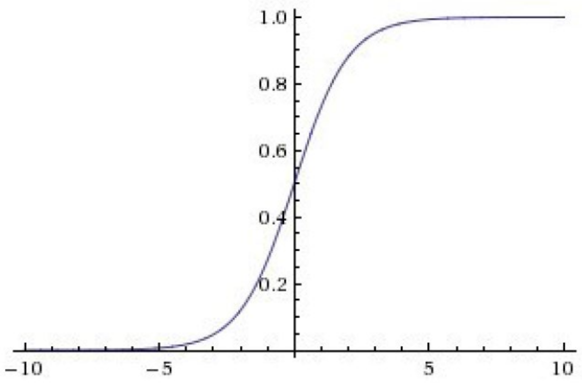


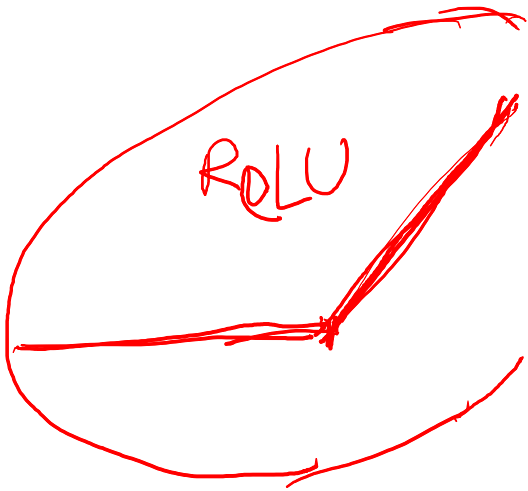
$$f(x) = \begin{cases} 1 & \text{if } w \cdot x + b > 0 \\ 0 & \text{otherwise} \end{cases}$$

Activation functions

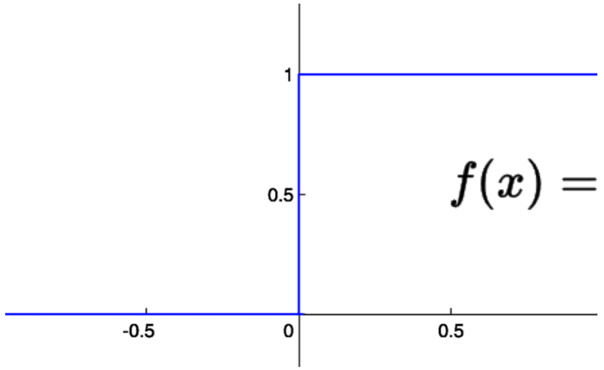


- Sigmoid 0 – 1



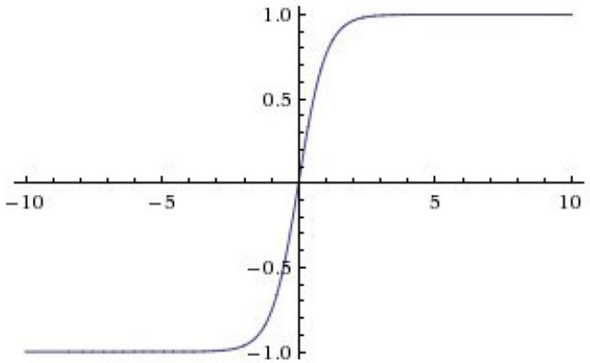


- Binary Threshold (Step function)



$$f(x) = \begin{cases} 1 & \text{if } w \cdot x + b > 0 \\ 0 & \text{otherwise} \end{cases}$$

- Tanh −1 ~ 1



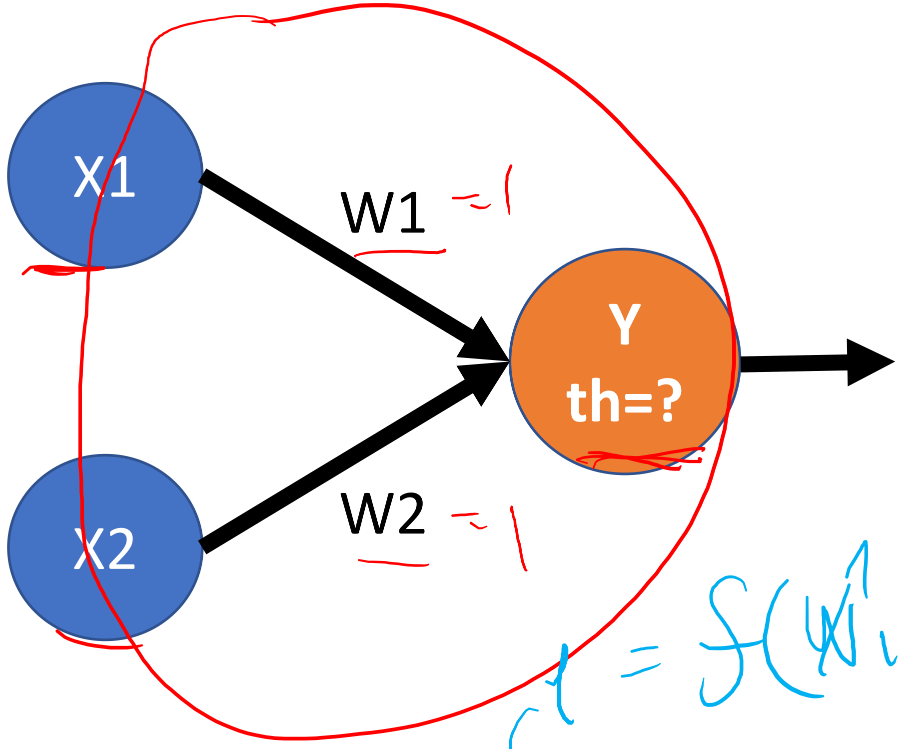
Perceptron

What can a perceptron do?

- Boolean tasks
- Update the weights whenever the perceptron output is wrong
- Proved convergence for linearly separable classes

Perceptron- quiz

A perceptron does not need to have binary input,
but let's consider a perceptron as a Boolean logic gate



X1 and X2 are binary inputs (either 0 or 1)
W1 and W2 are weights set to 1
What should the step activation function threshold "th" in order to have AND gate output?

$$y = f(W_1 x_1 + W_2 x_2) \begin{cases} 1 \\ 0 \end{cases}$$

x_1		x_2	th	Y
1	+	1	2	1
0		1		0
1		0		0
0		0		0

Perceptron- quiz

A perceptron does not need to have binary input,
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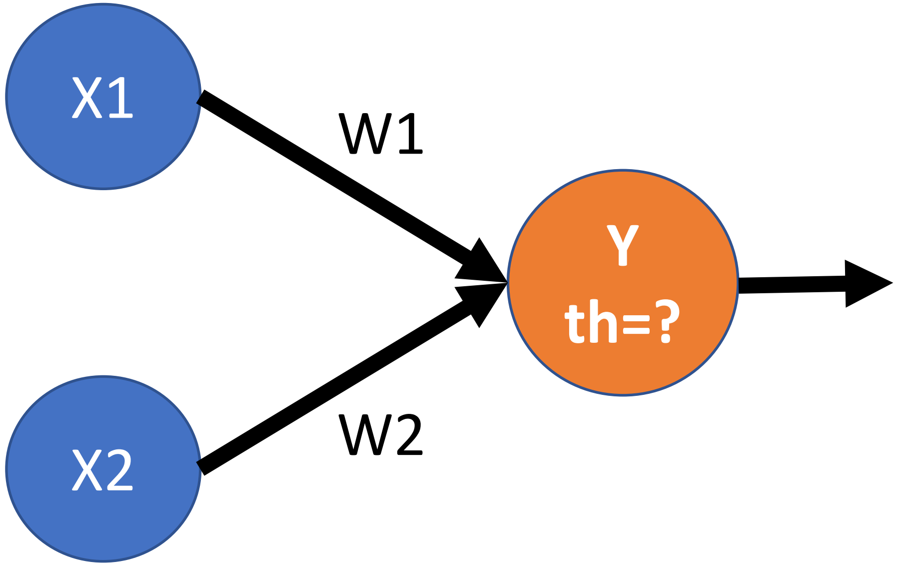


X1 and X2 are binary inputs (either 0 or 1)
W1 and W2 are weights set to 1
What should the step activation function threshold "th" in order to have OR gate output?

X_1		X_2	th	Y
1	+	0	1	1
0	+	1	1	1
1	+	1	2	1
0	+	0	0	0

Perceptron

A perceptron can do more than just a binary logic gate.
It can also do classification or regression tasks.

Learning in perceptron

- Perceptron rule
- Delta rule (Gradient Descent)

Perceptron

Perceptron rule

$$\omega_j \leftarrow \omega_j^{\text{old}} \underbrace{- \alpha(\hat{y}_i^{\text{pred}} - y_i^{\text{target}})X_{ij}}_{+\Delta W_j}$$

i

Key: Red -1, Blue = +1

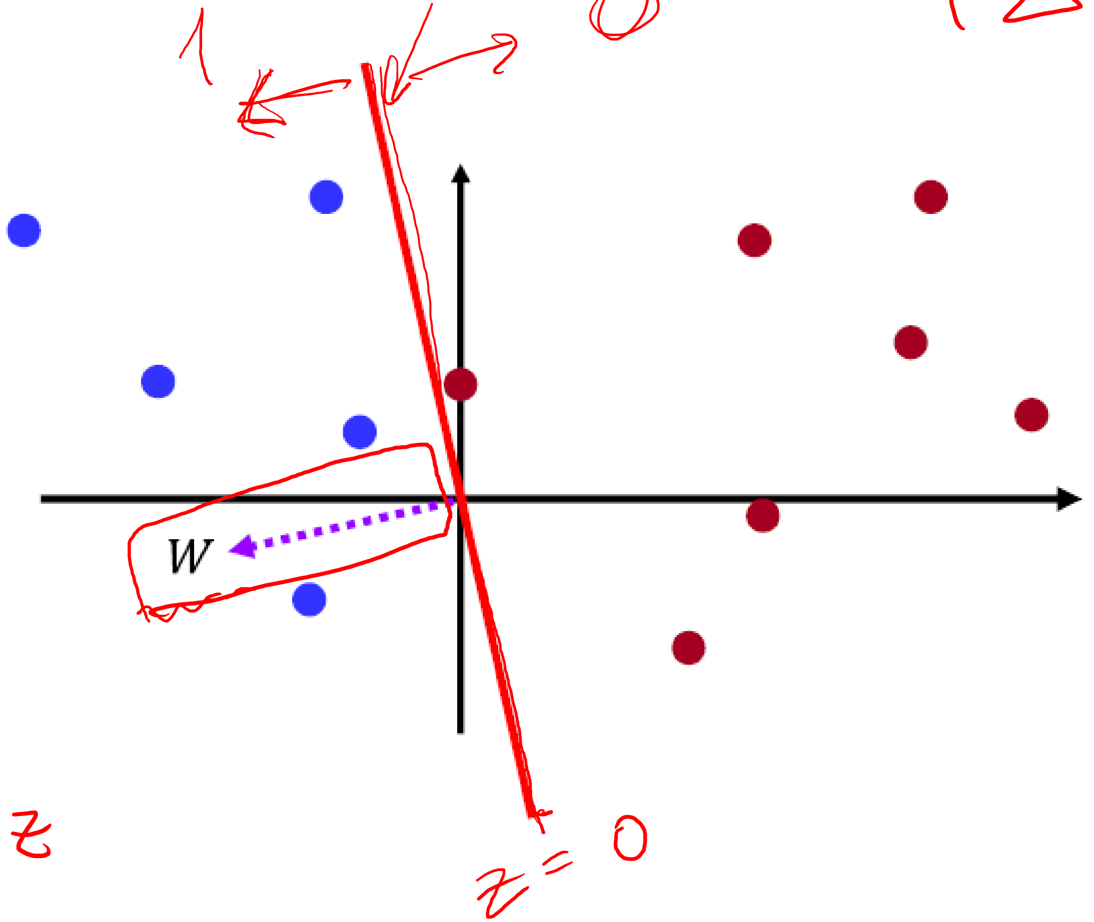
0.0x

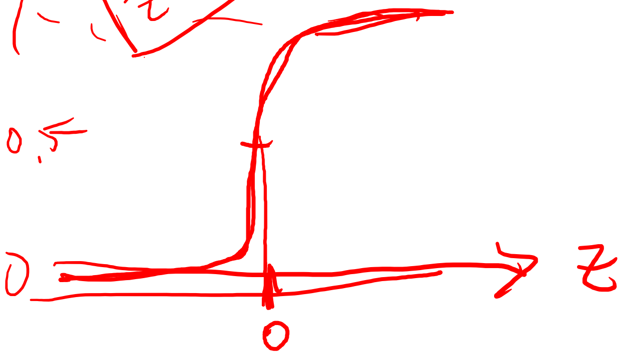
1 →
2
3
⋮
n

$f\left(\sum W_j x_j + b\right)$

$\sigma(z)$

$z = \sum w \cdot x = 0$





Perceptron

Perceptron algorithm

- Cycle through the training instances
- Only update W on "misclassified" instances
- If instance misclassified:
  - If instance is positive class (positive misclassified as negative) $y=1$

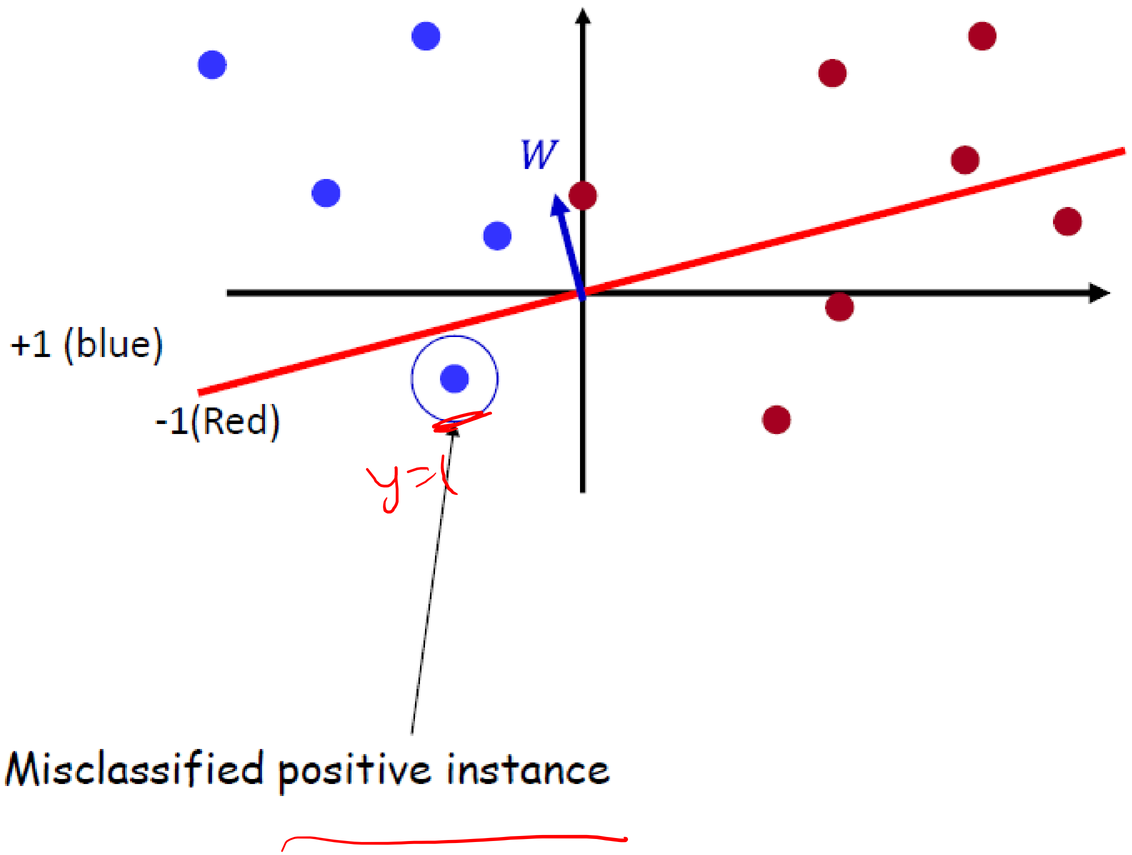
$$W = W + X_i$$

  - If instance is negative class (negative misclassified as positive) $y=0$

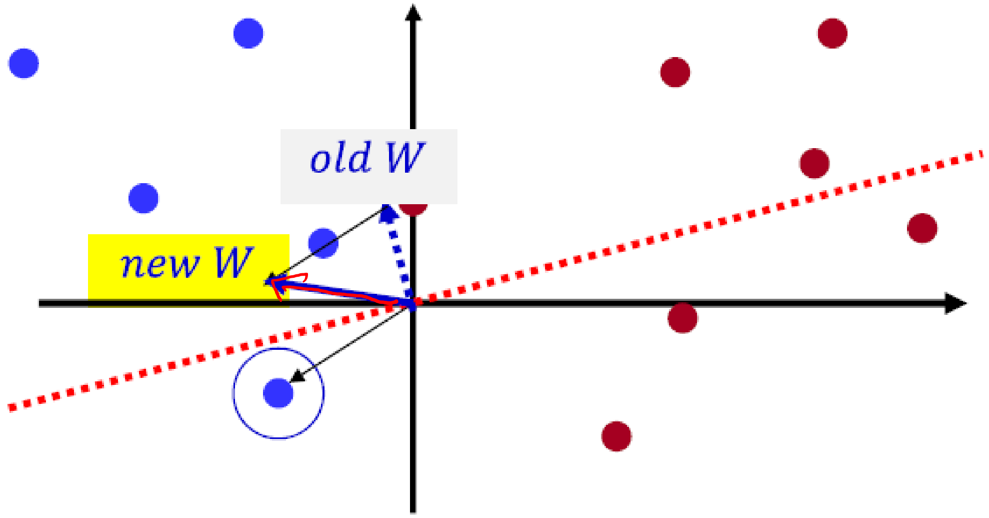
$$W = W - X_i$$

Perceptron

Perceptron algorithm



Perceptron algorithm

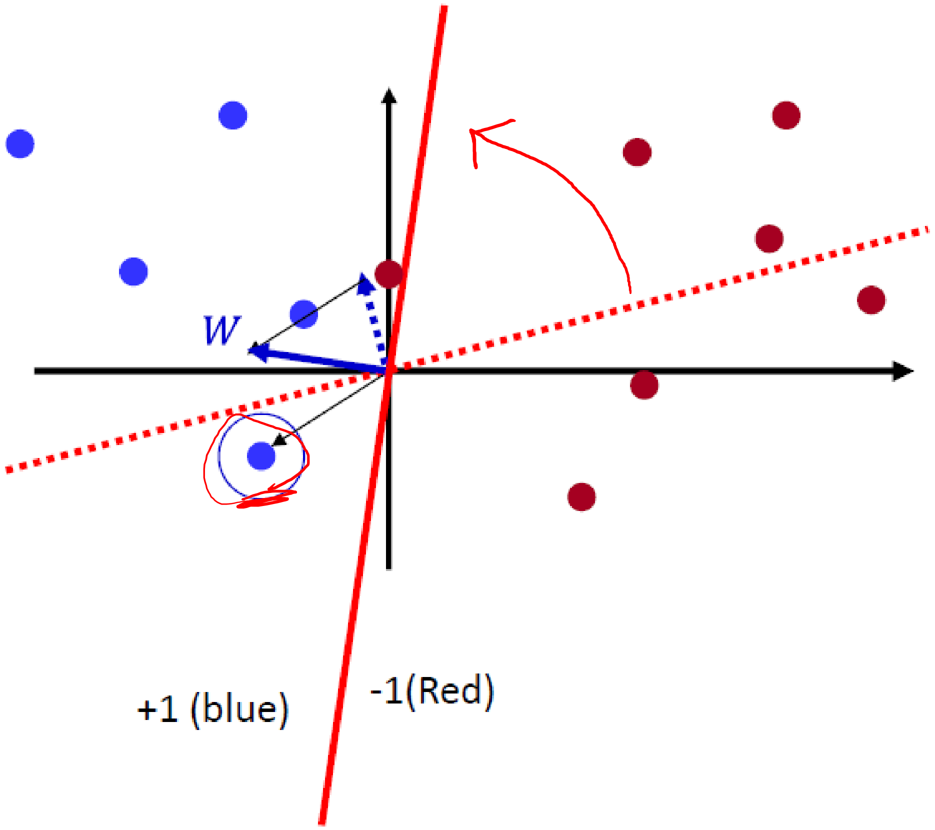


Updated weight vector

Misclassified *positive* instance, *add* it to W

Perceptron

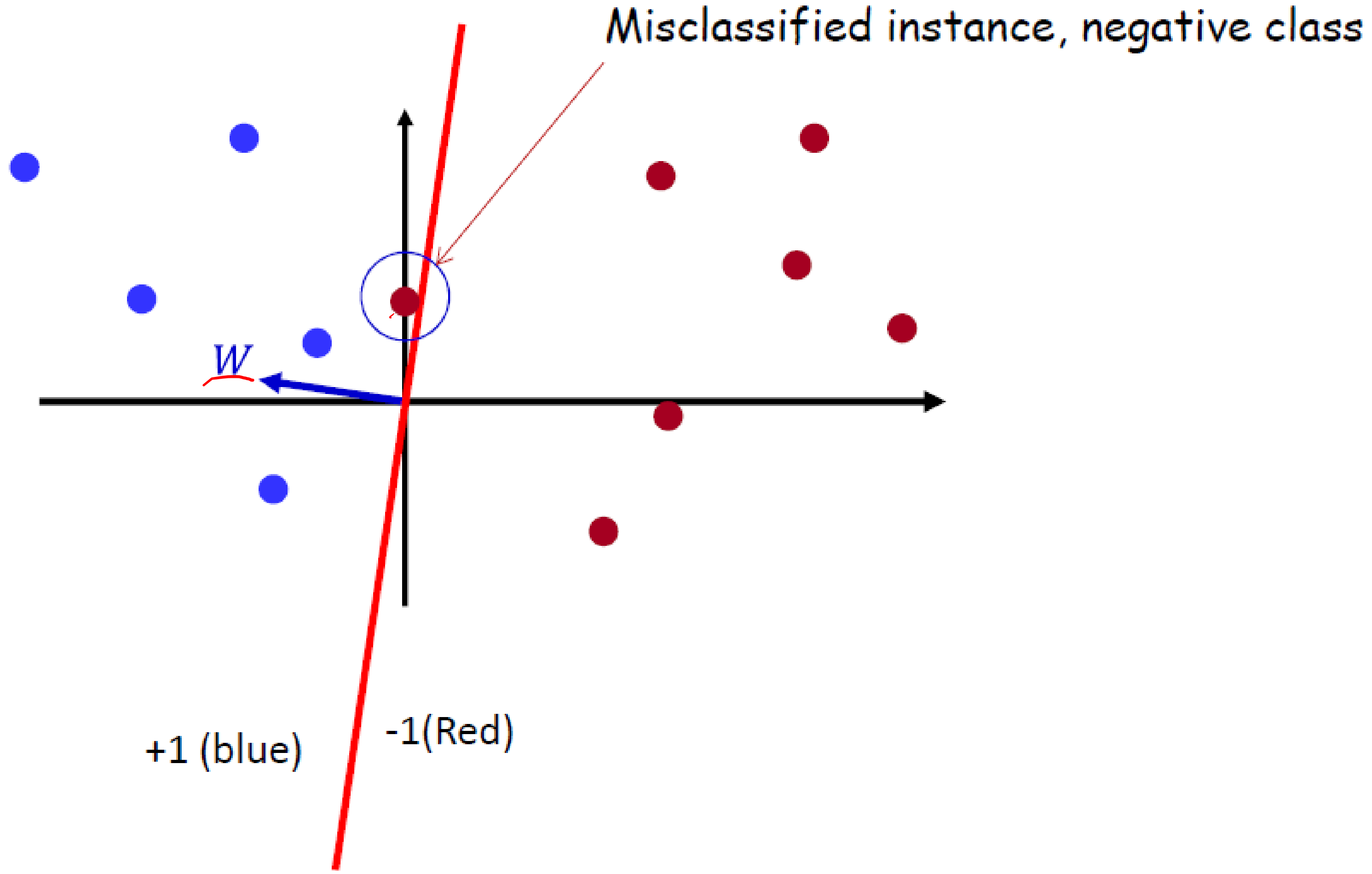
Perceptron algorithm



Updated hyperplane

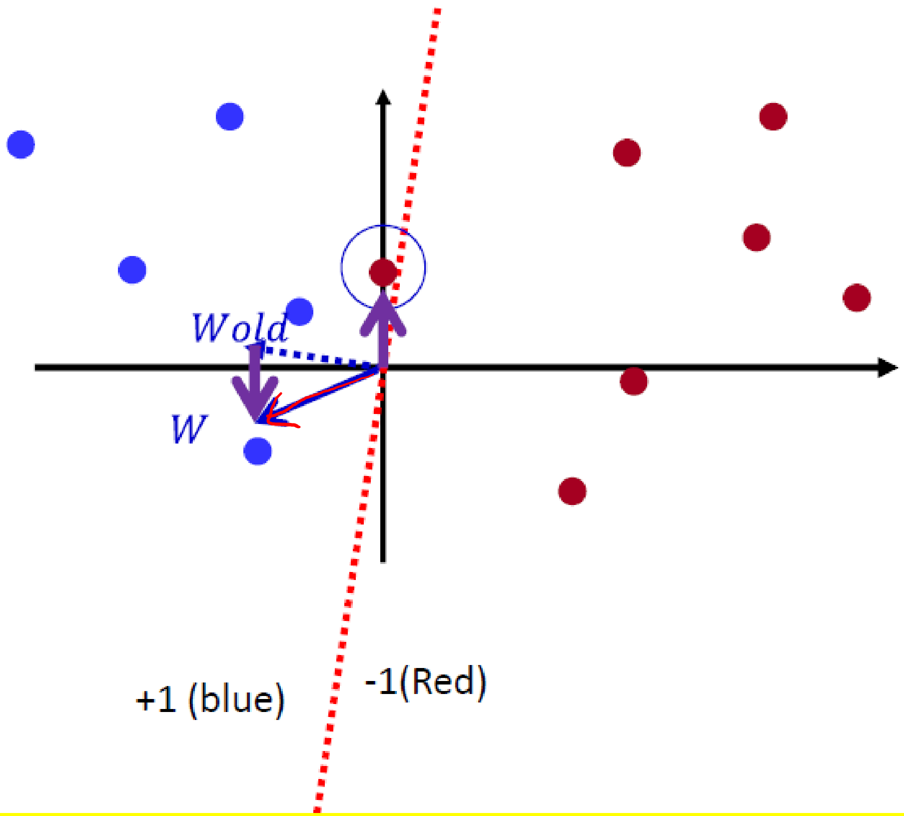
Perceptron

Perceptron algorithm



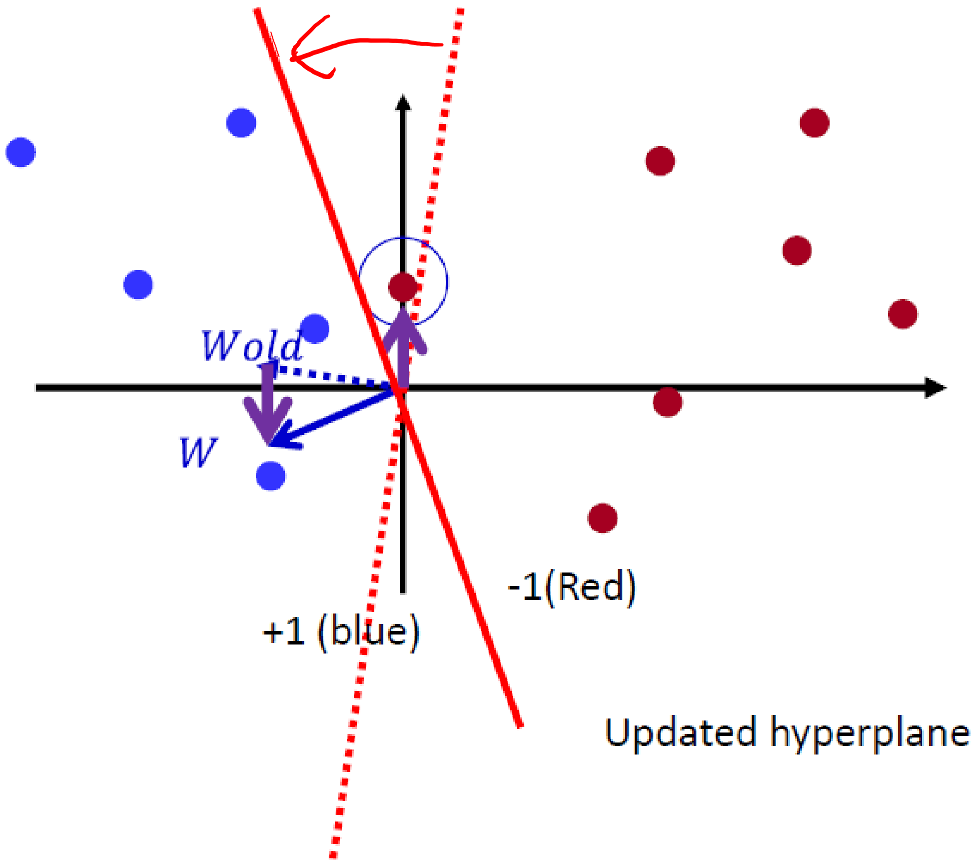
Perceptron

Perceptron algorithm



Misclassified *negative* instance, *subtract* it from W

Perceptron algorithm



Perceptron

Delta rule (Gradient Descent)

$w_j \leftarrow w_j + \Delta w_j$

$$\omega_j \leftarrow \omega_j - \alpha \frac{\partial \mathcal{L}}{\partial \omega_j}$$

$$\mathcal{L} = \frac{1}{2}(\hat{y}_i - y_i)^2$$

MSE

prediction

$$\hat{y}_i = f\left(\sum_j \omega_j X_{ij}\right)$$

$$\omega_j \leftarrow \omega_j - \alpha(\hat{y}_i - y_i)X_{ij}$$

Perceptron

Learning in perceptron- conclusion

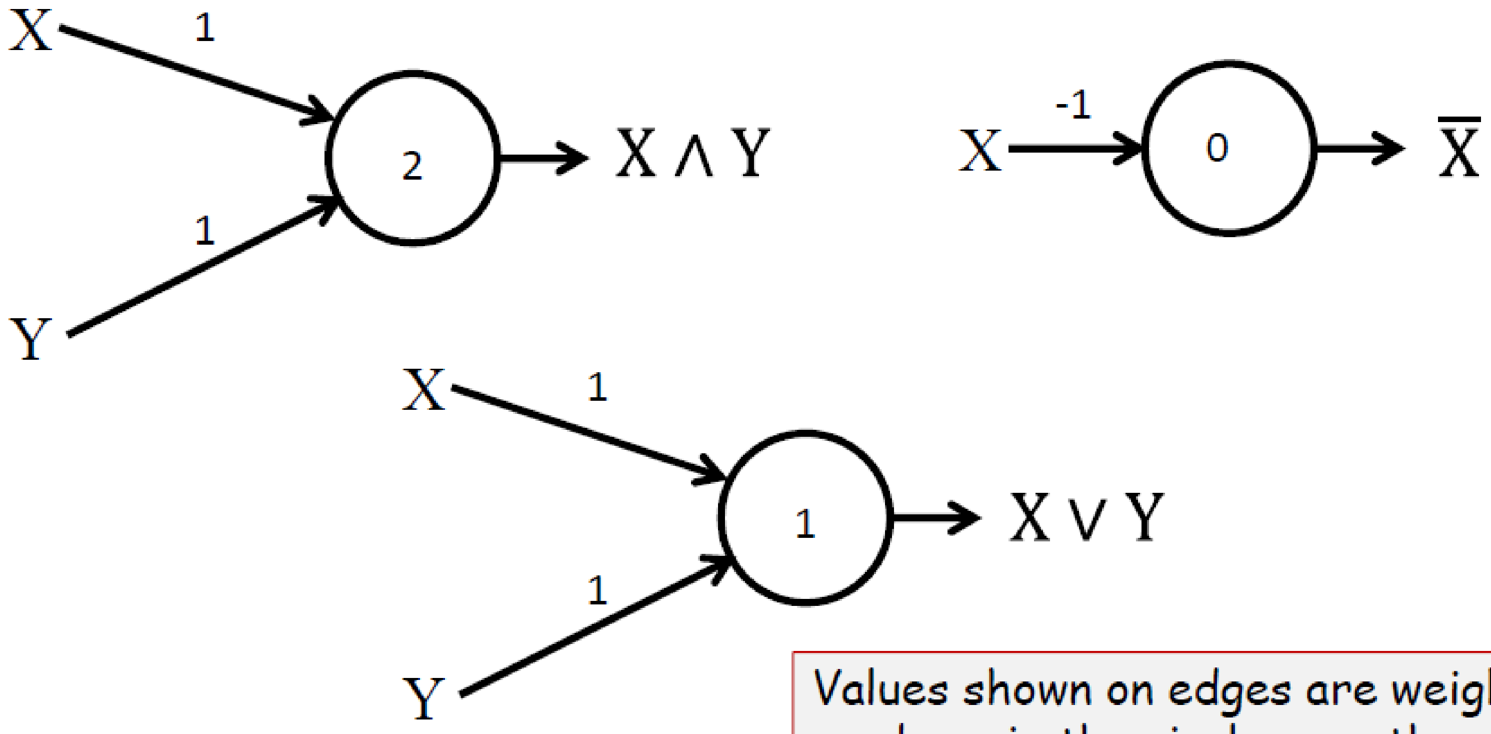
- Perceptron rule $$\omega_j \leftarrow \omega_j - \alpha(\hat{y}_i - y_i)X_{ij}$$
- Delta rule (Gradient Descent) $$\omega_j \leftarrow \omega_j - \alpha(\hat{y}_i - y_i)X_{ij}$$

learning rate

stepsize

$0 < \quad < 1$

Perceptron

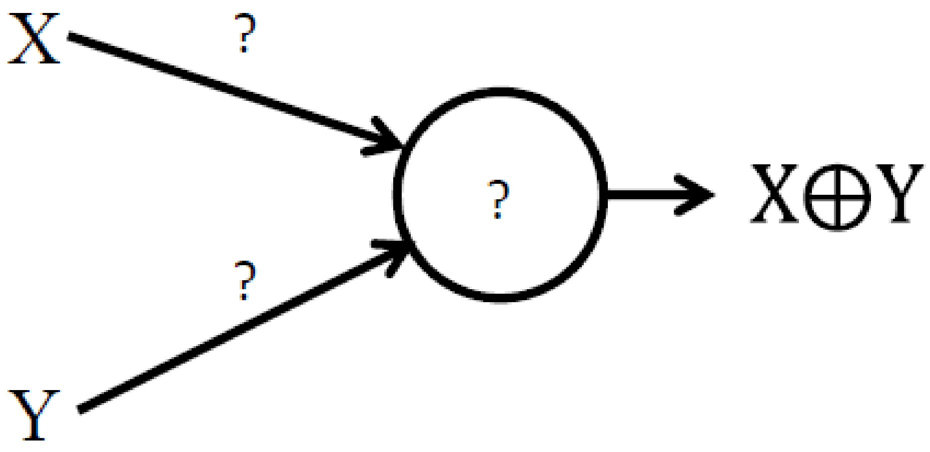


Values shown on edges are weights, numbers in the circles are thresholds

- Easily shown to mimic any Boolean gate
- But…

Perceptron

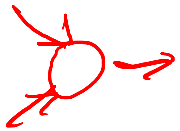
No solution for XOR!
Not universal!



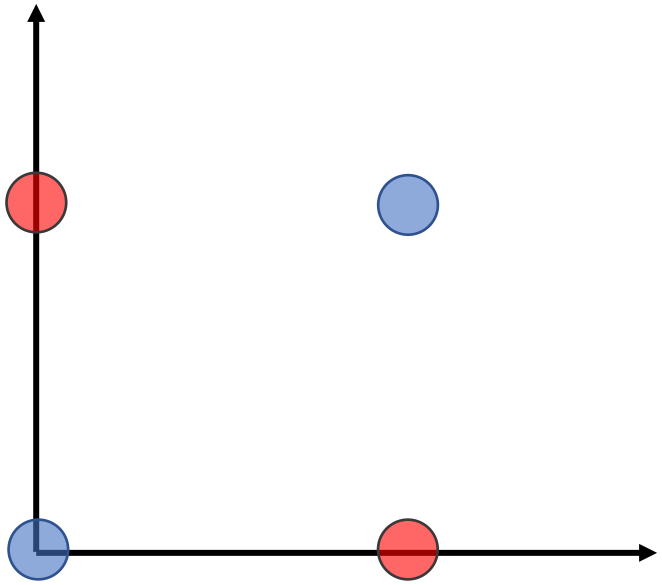
- Minsky and Papert, 1968

Perceptron

What’s special about XOR operation?



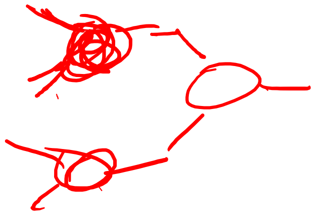
INPUT		OUTPUT
A	B	A XOR B
0	0	0
0	1	1
1	0	1
1	1	0

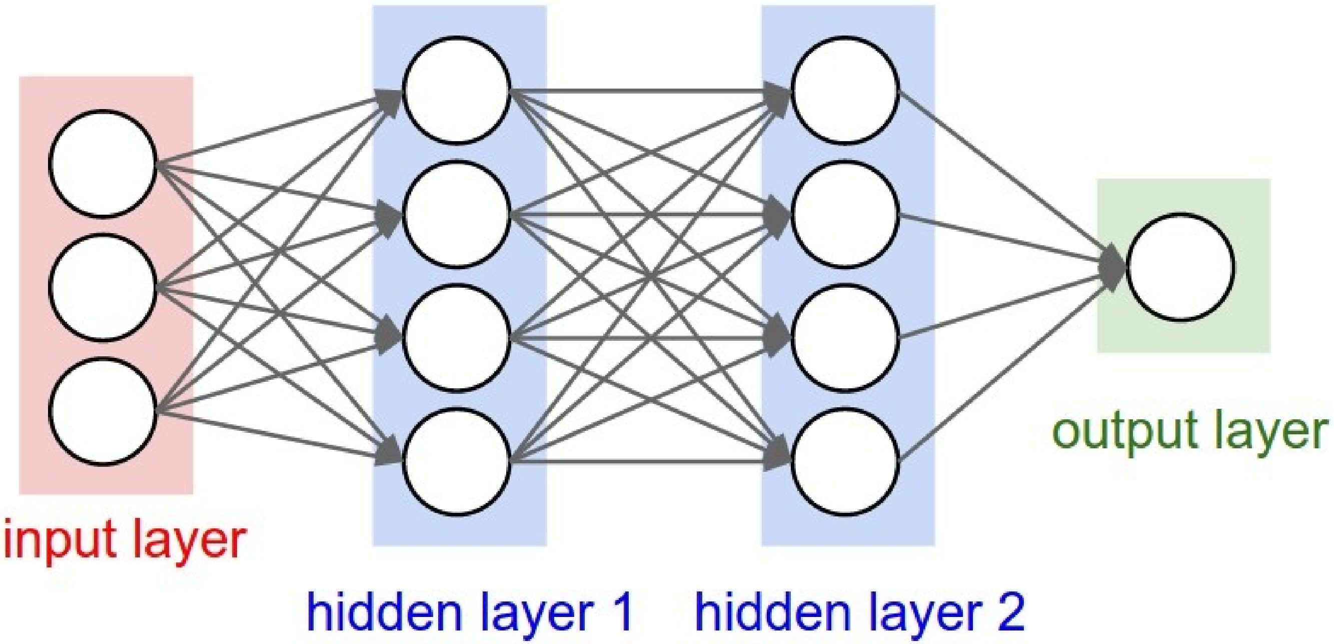


How do we handle linearly inseparable cases?

MLP

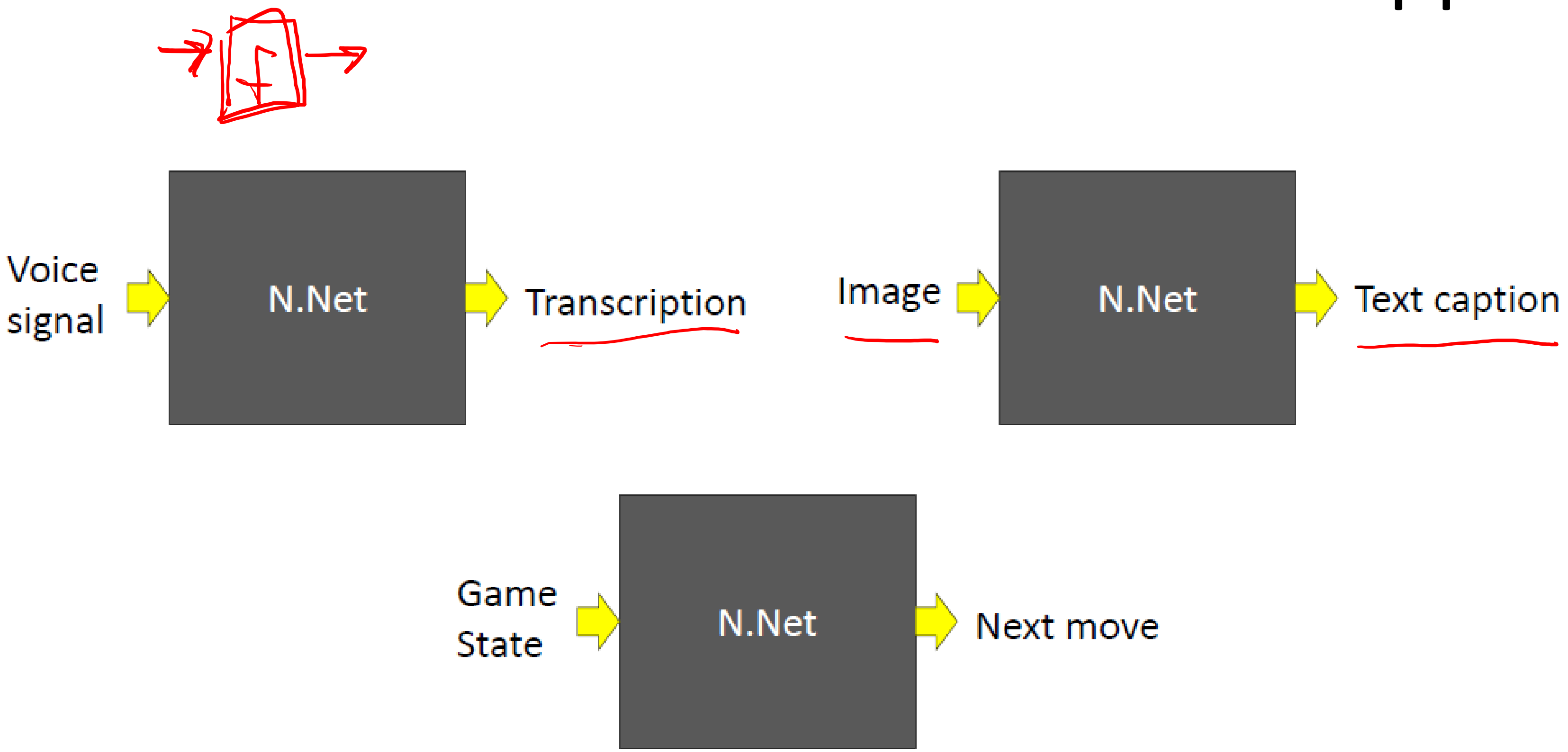
How do we handle linearly inseparable cases?





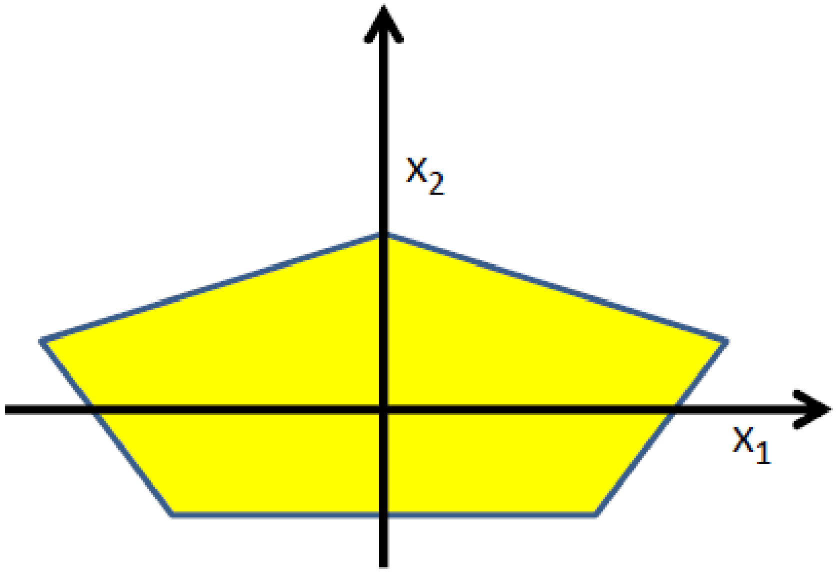
MLP

Neural networks are universal function approximator



MLP

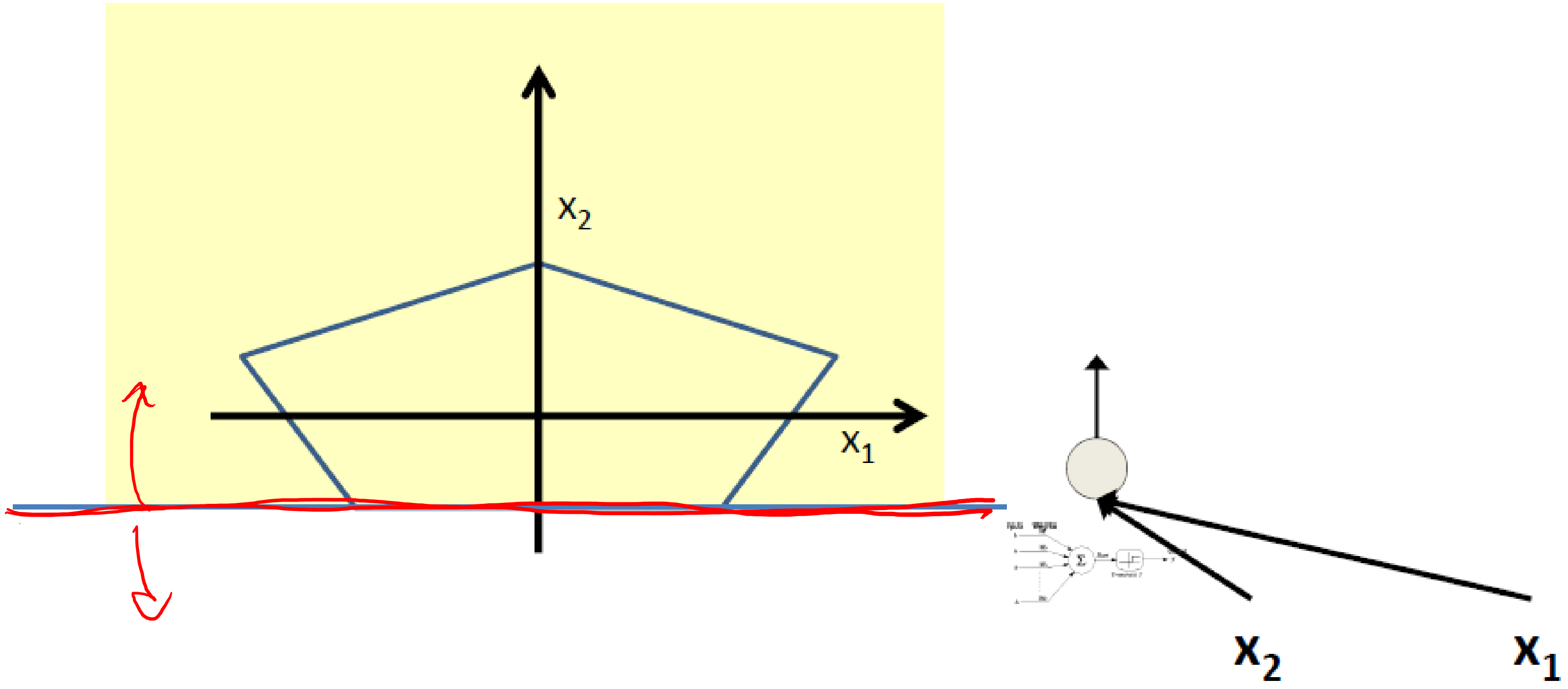
We can make an arbitrary shape decision boundary



Can now be composed into "networks" to compute arbitrary classification "boundaries"

MLP

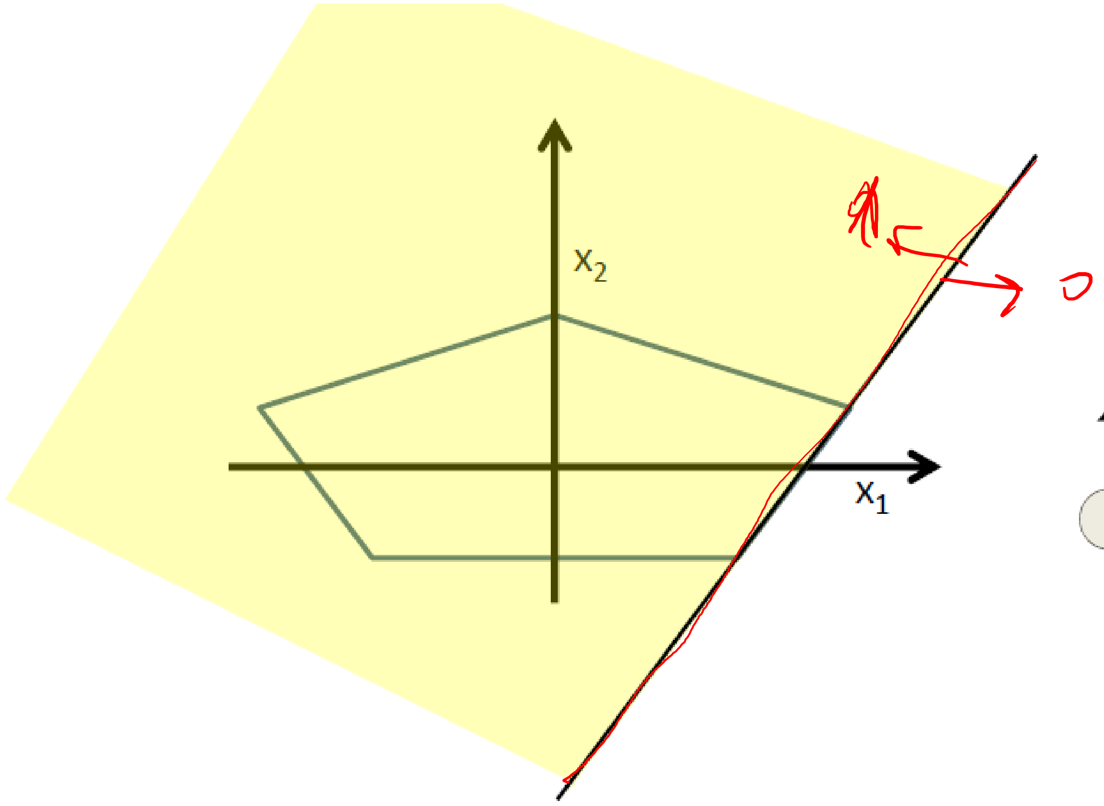
Boolean over real numbers

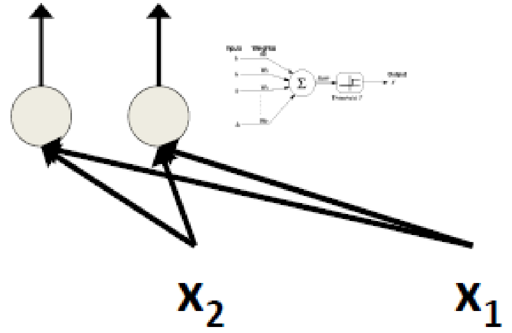


The network must fire if the input is in the coloured area

MLP

Boolean over real numbers





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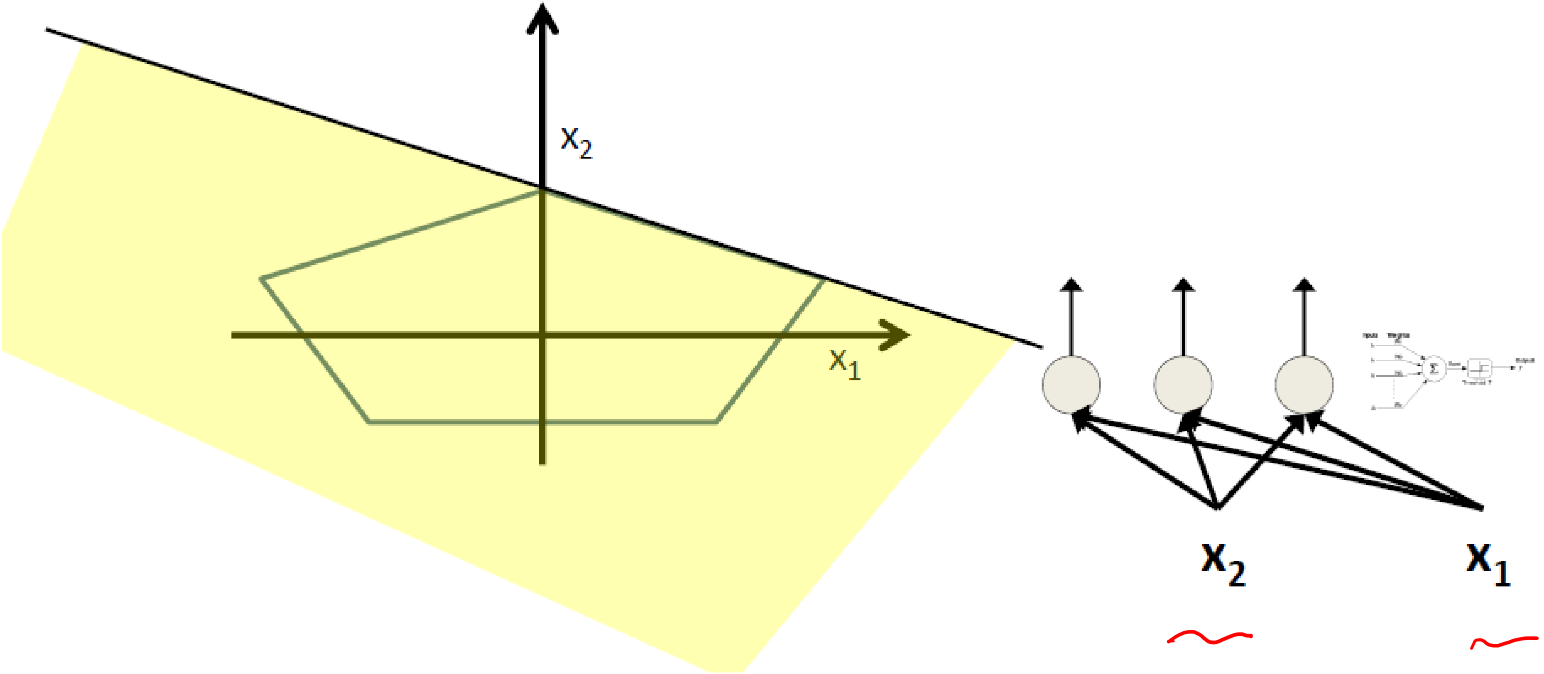
MLP

Boolean over real numbers



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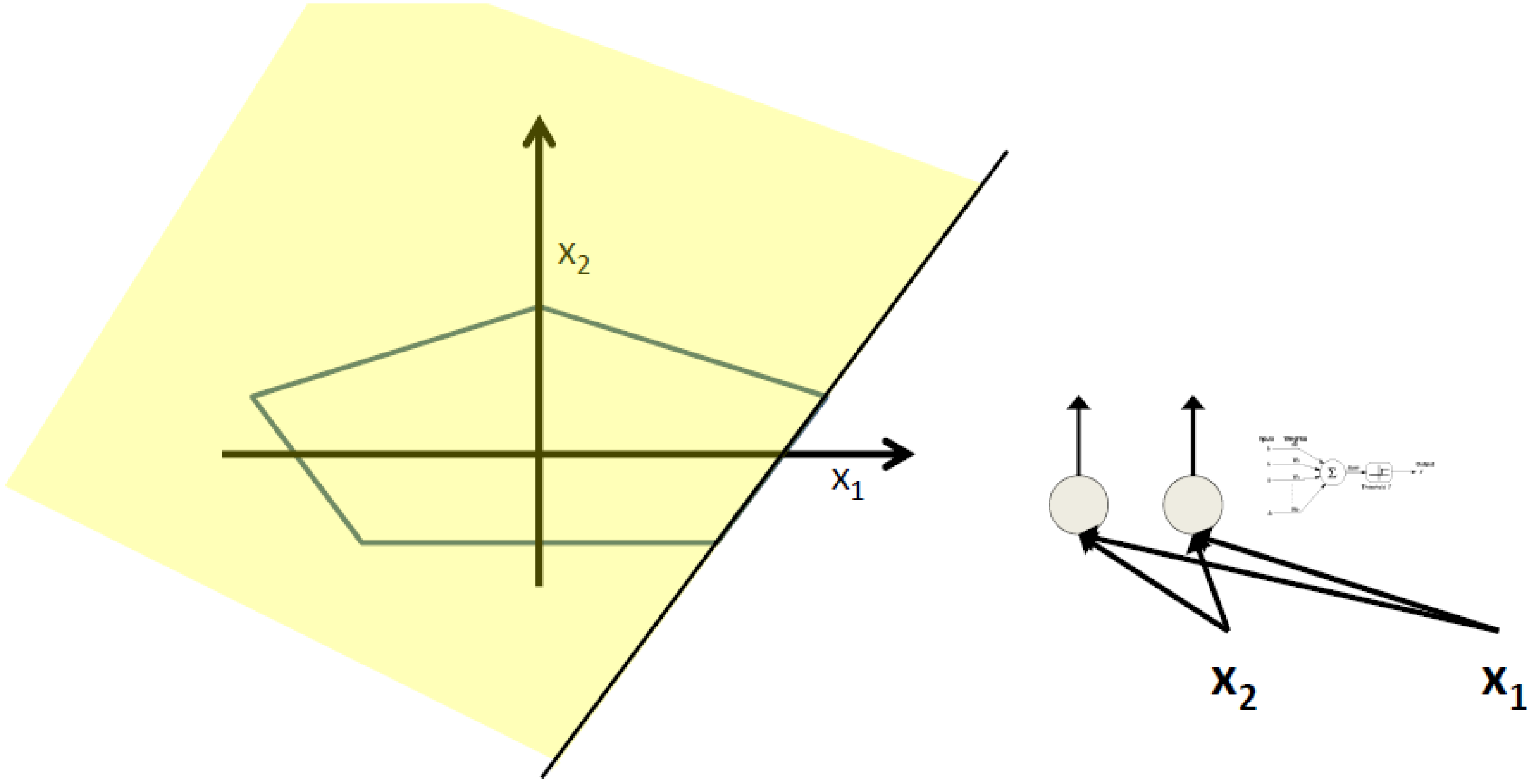
Boolean over real numbers



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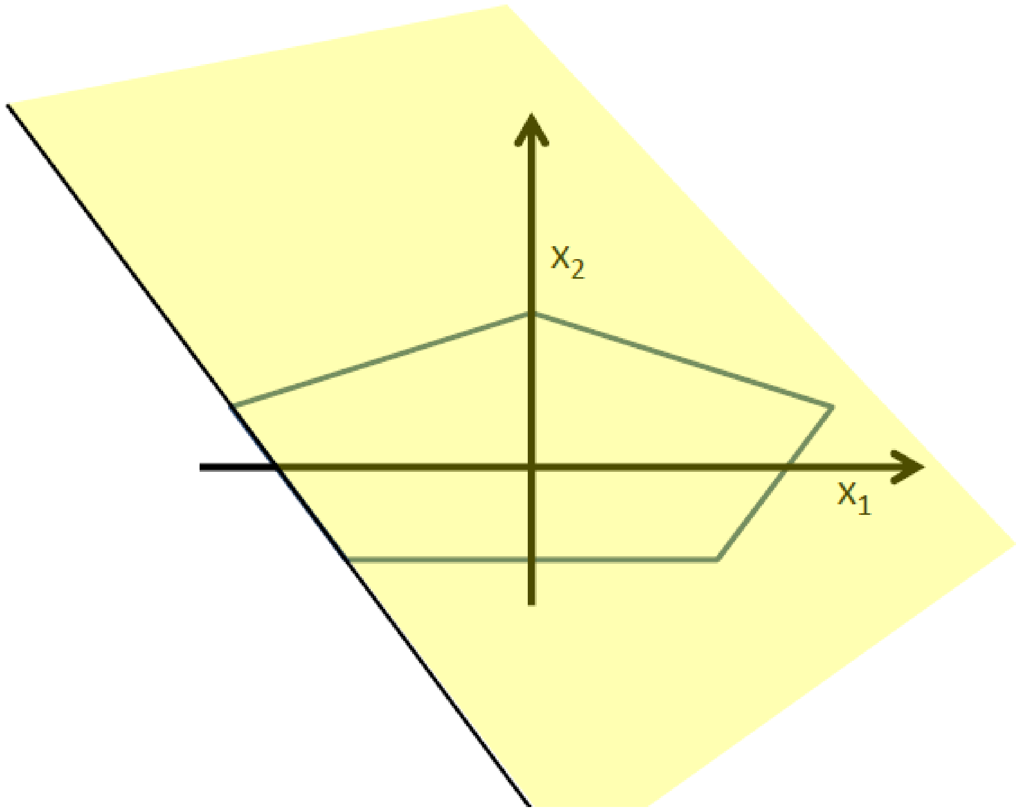
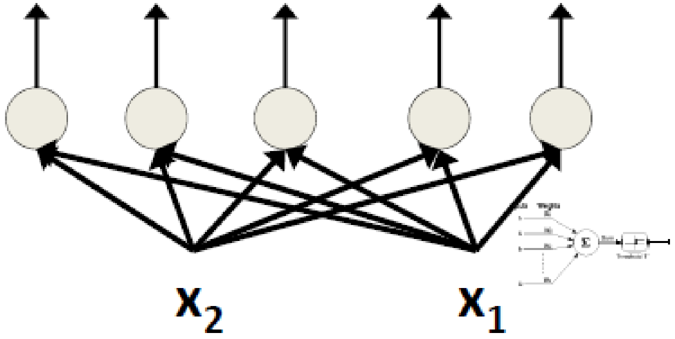
Boolean over real numbers





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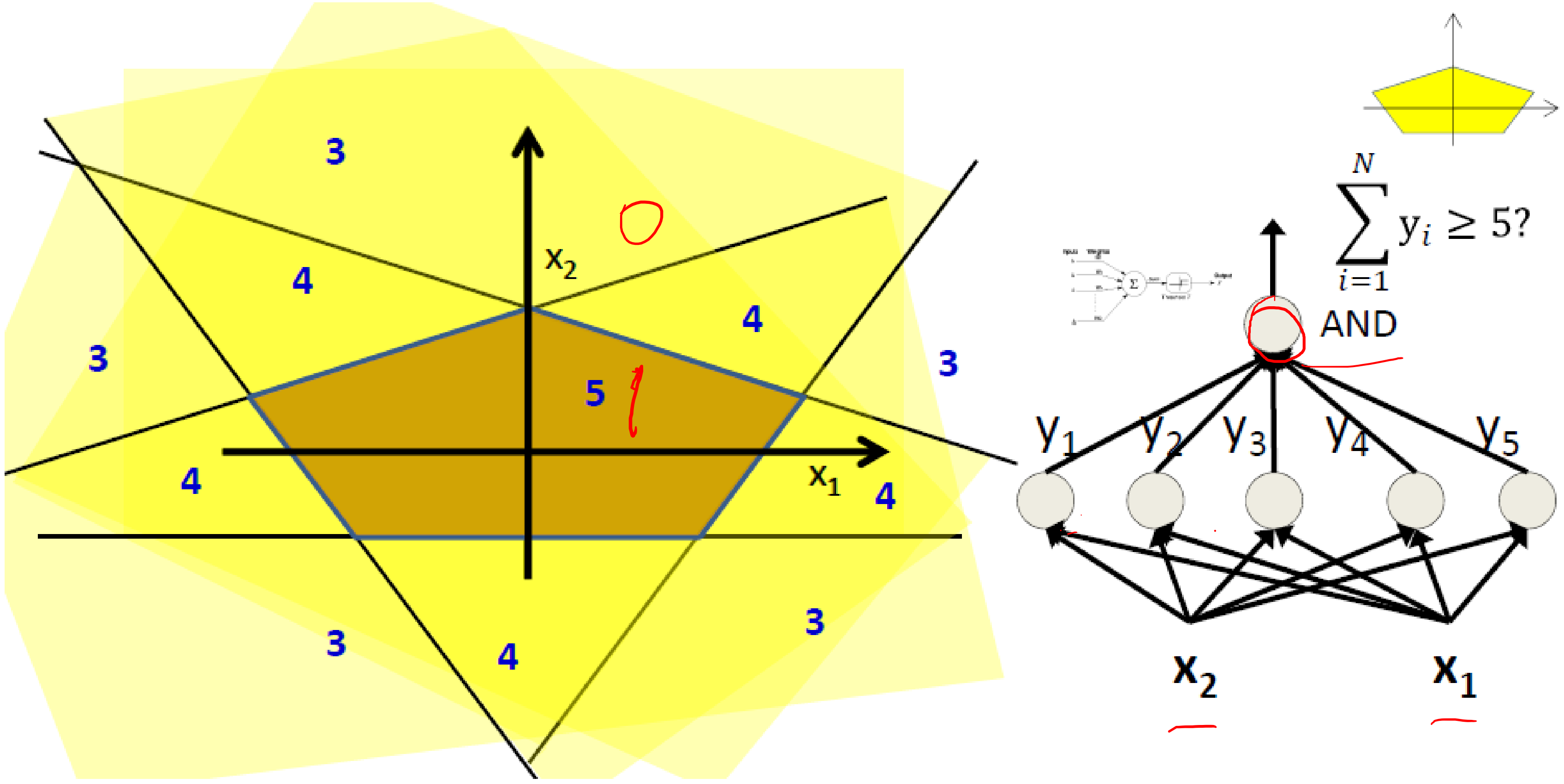
MLP

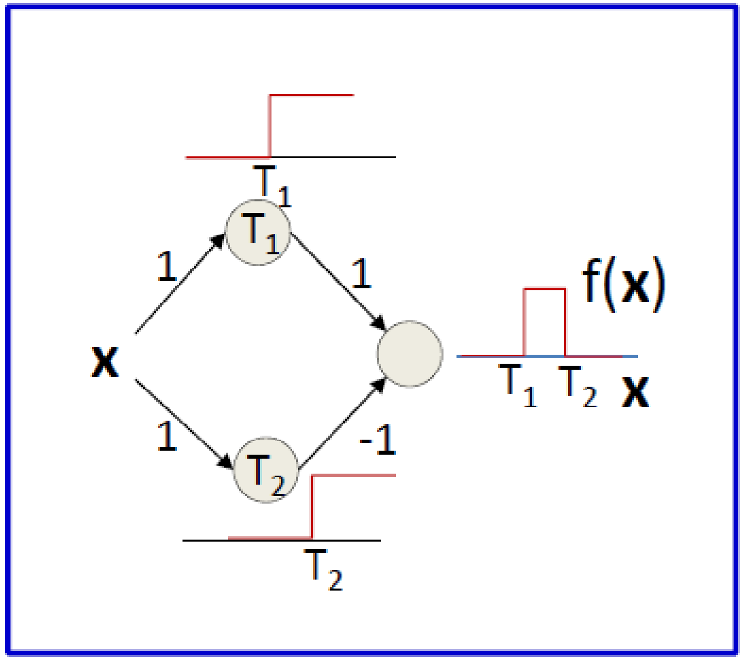
Boolean over real numbers

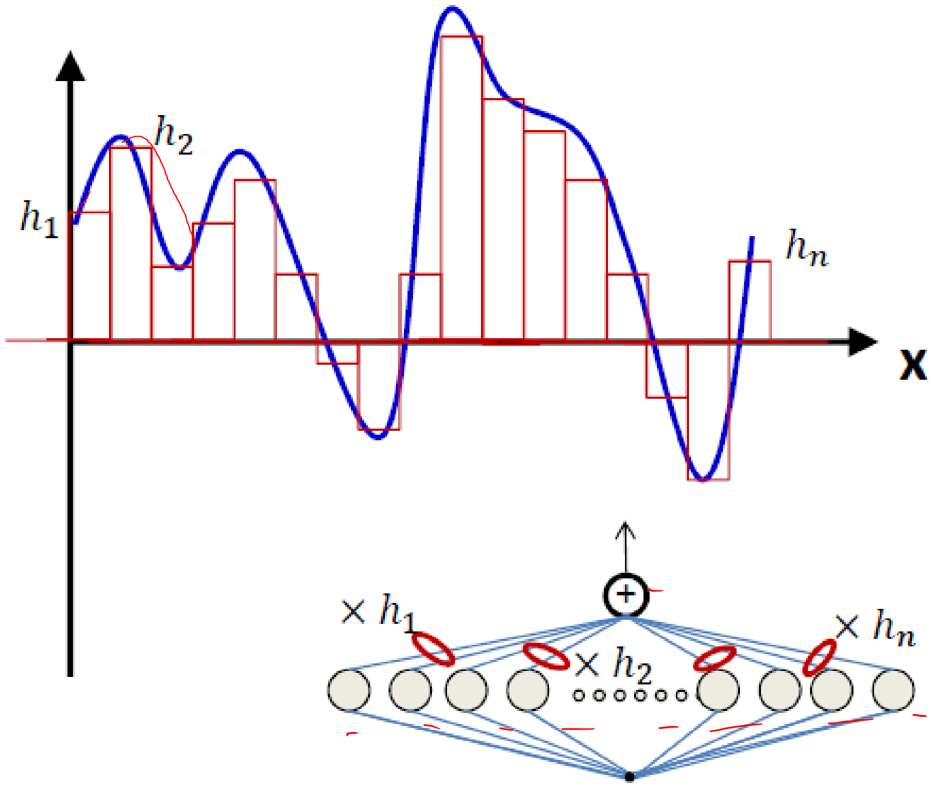


The network must fire if the input is in the coloured area

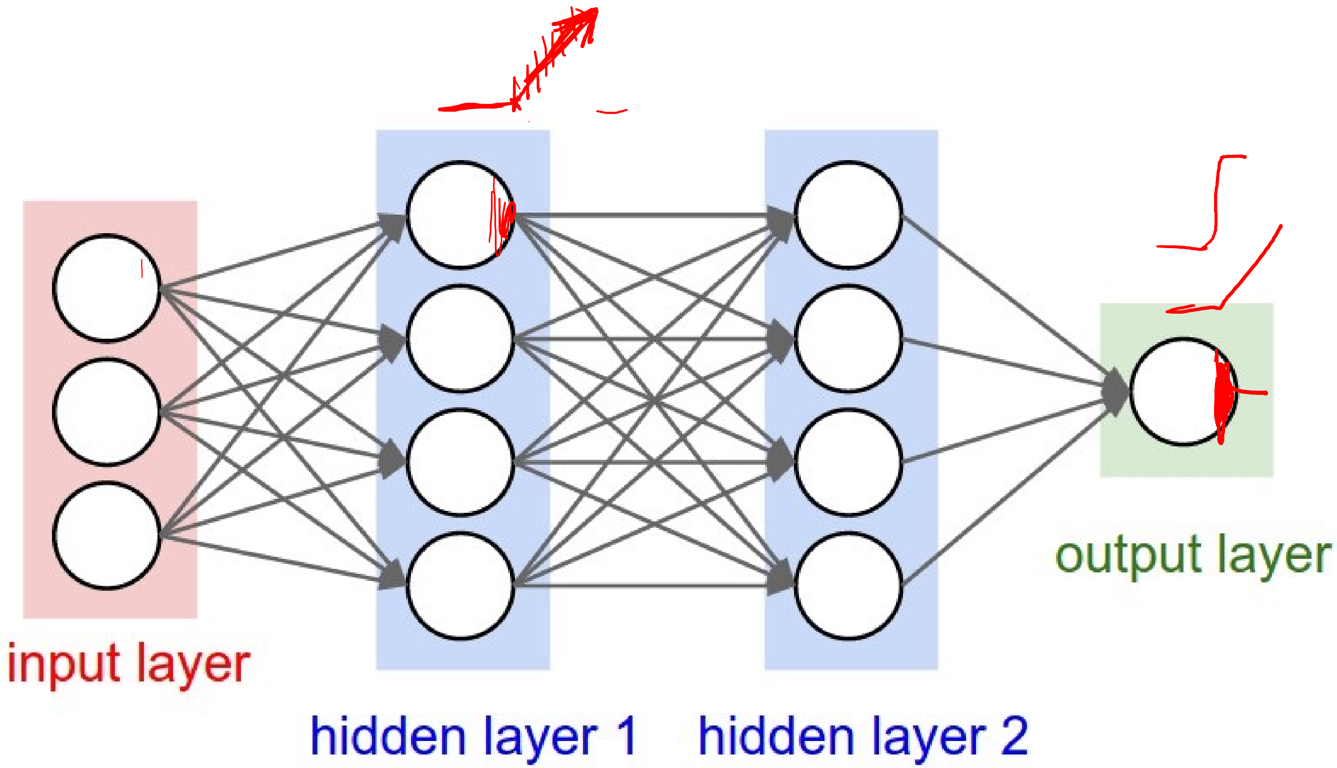
MLP

Neural networks can be used for regression tasks





Multi-layer Perceptron (Neural network)



Design Parameters

- Architecture
- Number of layers
- Number of neurons in a layer
- Activation functions

Artificial Neural Network facts

= MLP

Can approximate any non-linear function
-> Nonlinearity comes from nonlinear activation function

Deeper layer and larger number of neurons in a layer
-> more model capacity

MLP: fully-connected neural network
Weights for every connection

FC layer
= Dense layer

Weights = parameters #
(cf) Hyperparameters = design parameters

Next time: How Neural Network Training Works