Deep Learning

Summary

- Overview
- The Neuron
- The Activation Function
- How do Neural Networks work? (example)
- How do Neural Networks learn?
- Gradient Descent
- Stochastic Gradient Descent
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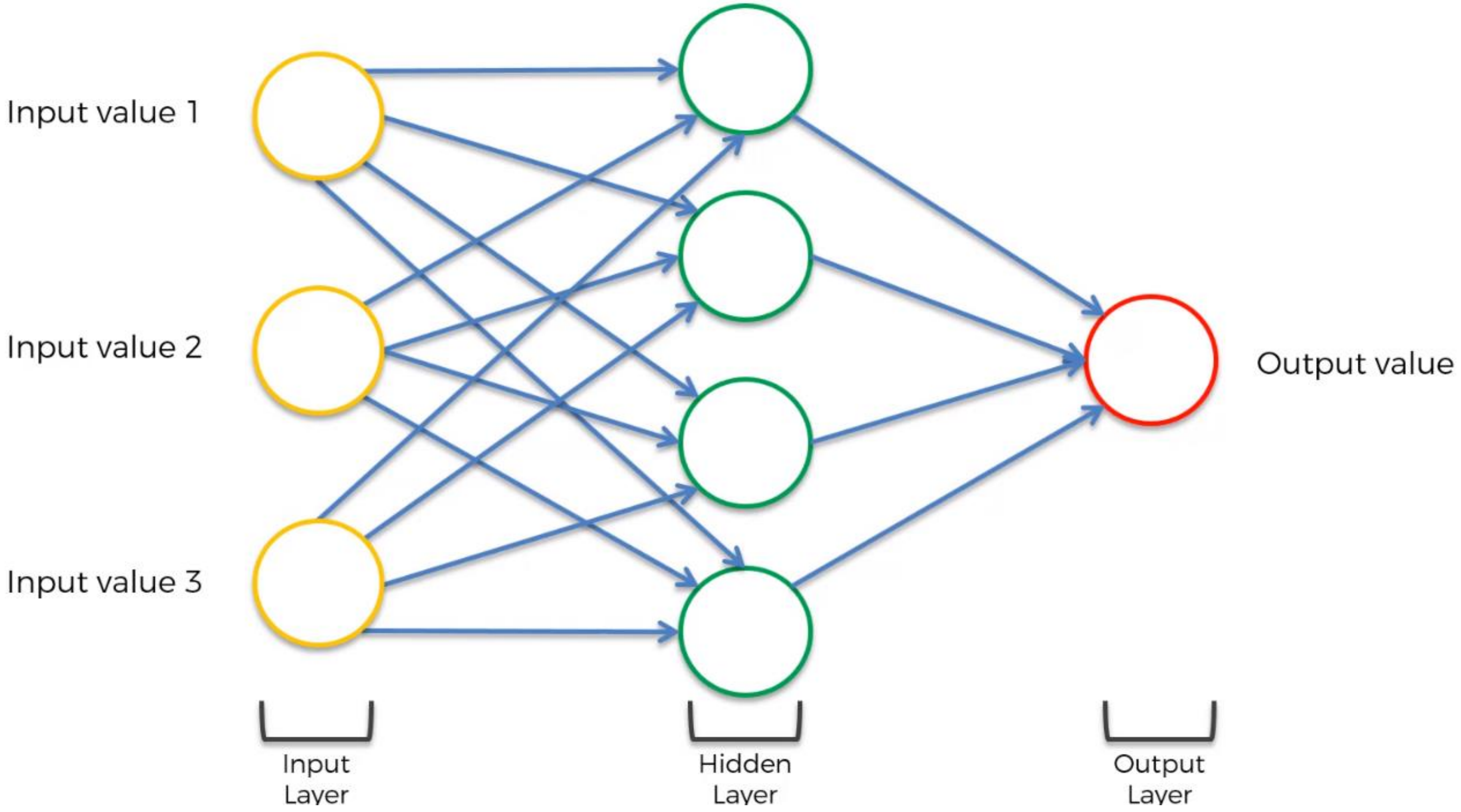
Overview



https://www.udemy.com/course/machinelearning/

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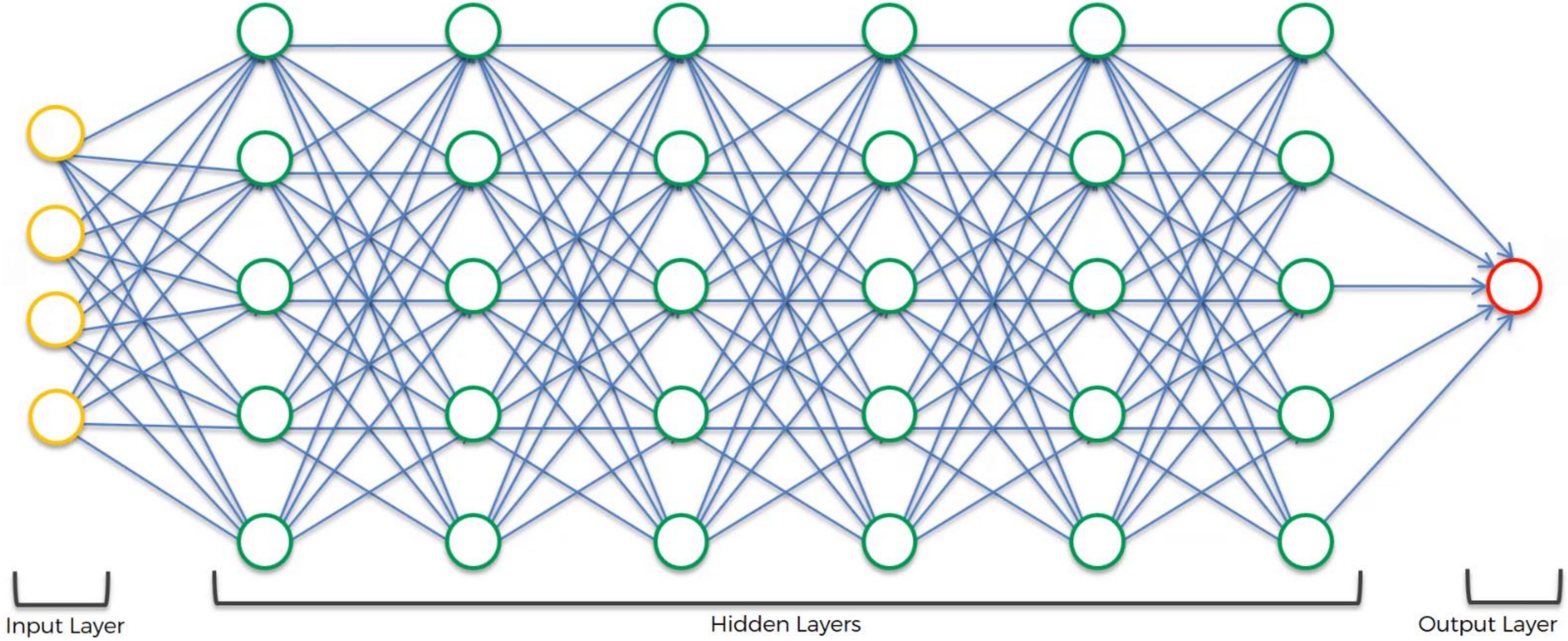

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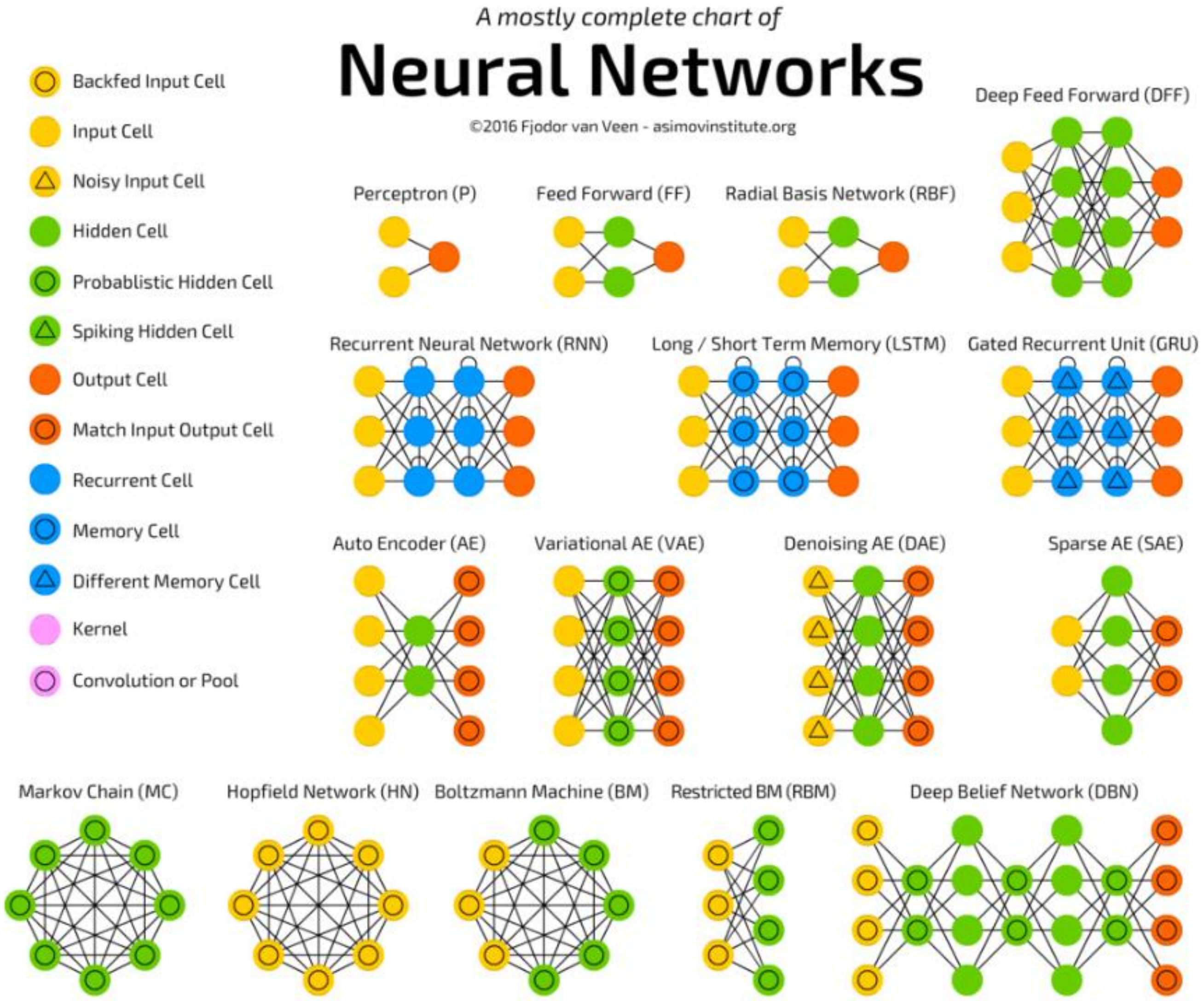

https://towardsdatascience.com/the-mostly-complete-chart-of-neural-networks-explained-3fb6f2367464

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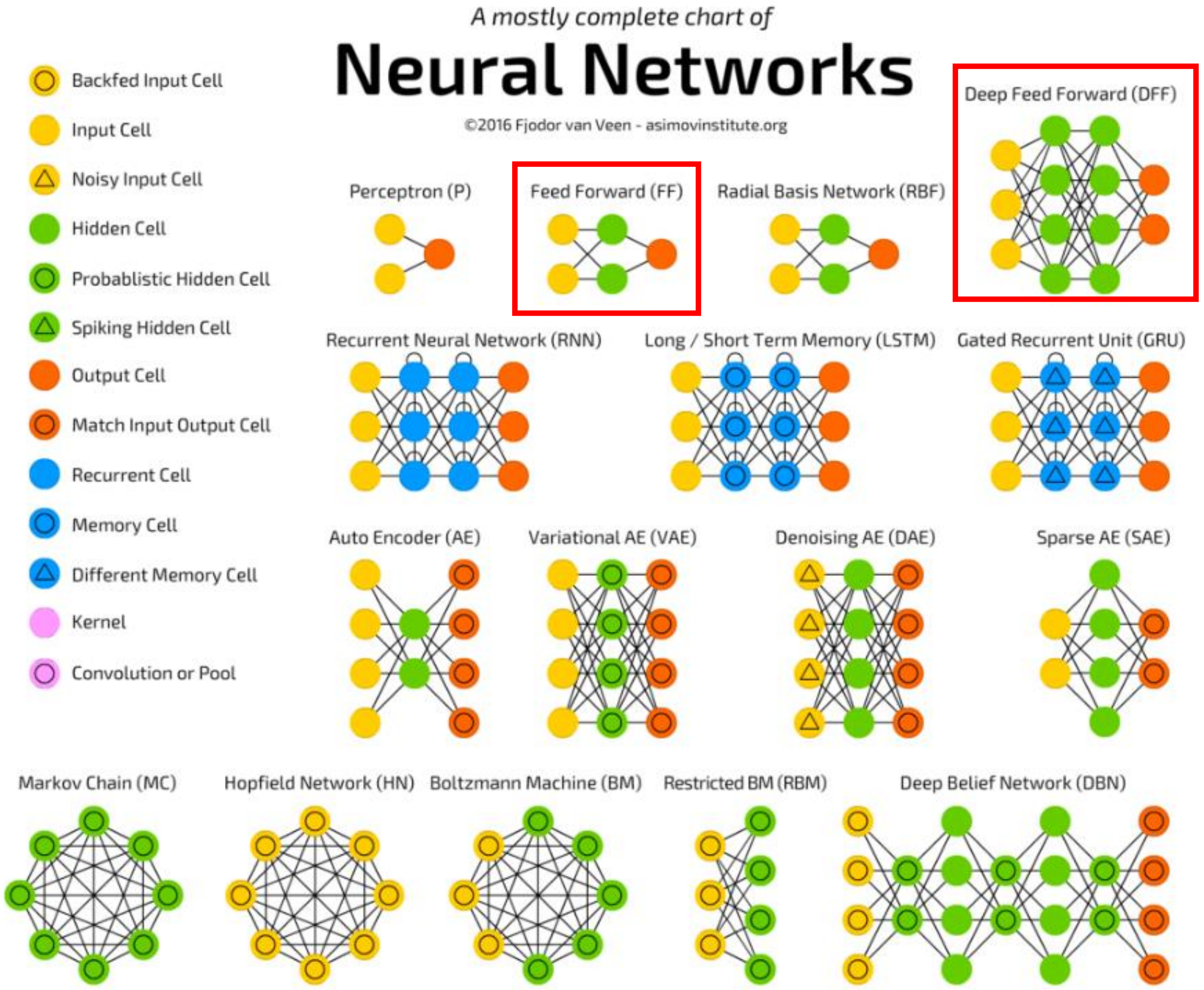

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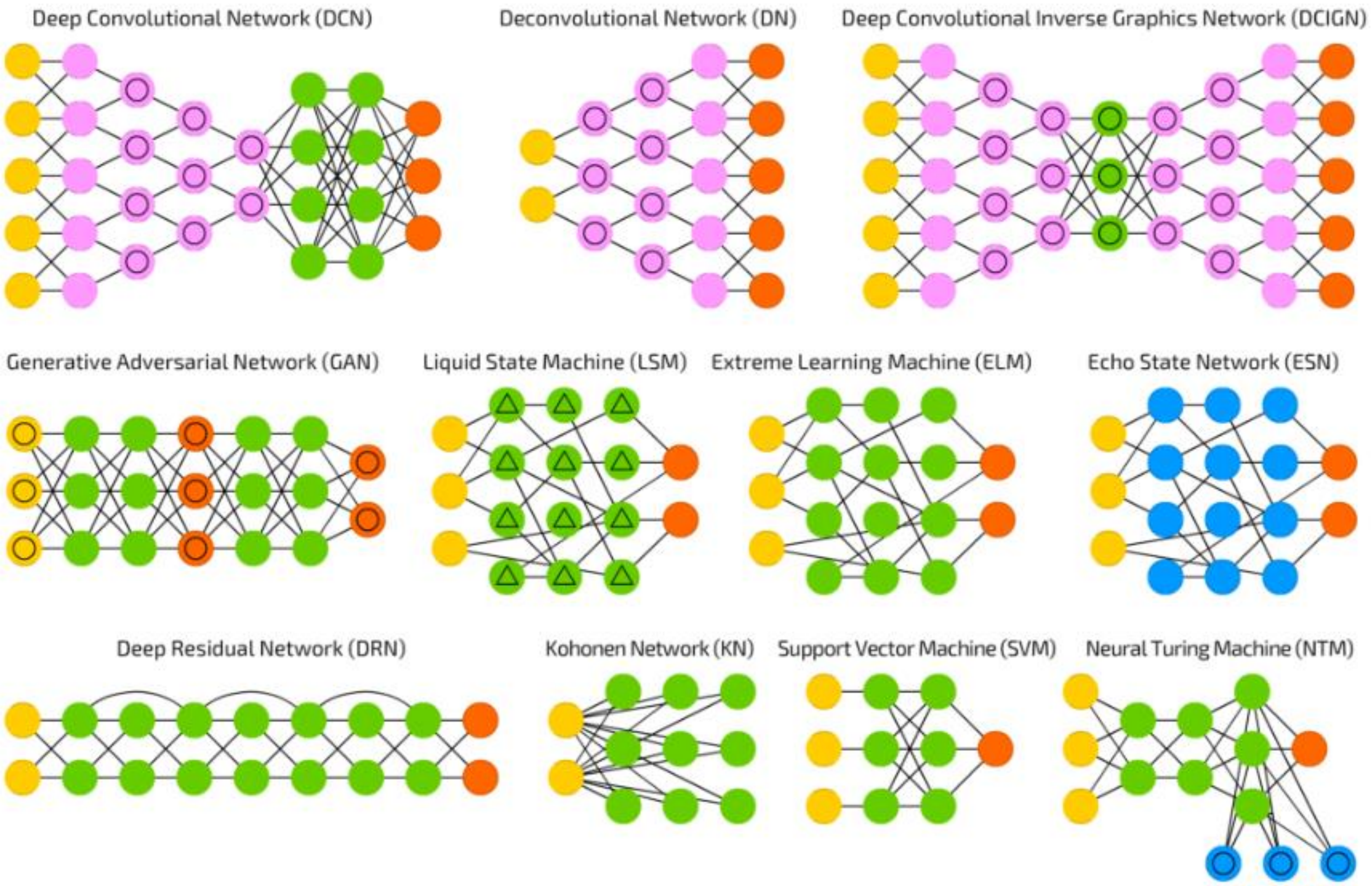
Deep Convolutional Network (DCN)
Deconvolutional Network (DN)
Deep Convolutional Inverse Graphics Network (DCIGN)
Generative Adversarial Network (GAN)
Liquid State Machine (LSM)
Extreme Learning Machine (ELM)
Echo State Network (ESN)
Deep Residual Network (DRN)
Kohonen Network (KN)
Support Vector Machine (SVM)
Neural Turing Machine (NTM)

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Overview

- **Supervised Learning**: CNNs classifying images in imagenet.
- **Unsupervised Learning**: Boltzmann Machines, AutoEncoders, GANs, DC-GANS, VAE, SOMs, etc.
- **Reinforcement**: Deep Convolutional Q-Learning that plays videogames from pixel input, AlphaGO, etc.

Overview

- Artificial Neural Networks for Regression and Classification
- Convolutional Neural Networks for Computer Vision
- Recurrent Neural Networks for Time Series Analysis
- Self Organizing Maps for Feature Extraction
- Deep Boltzmann Machines for Recommendation Systems
- Auto Encoders for Recommendation Systems

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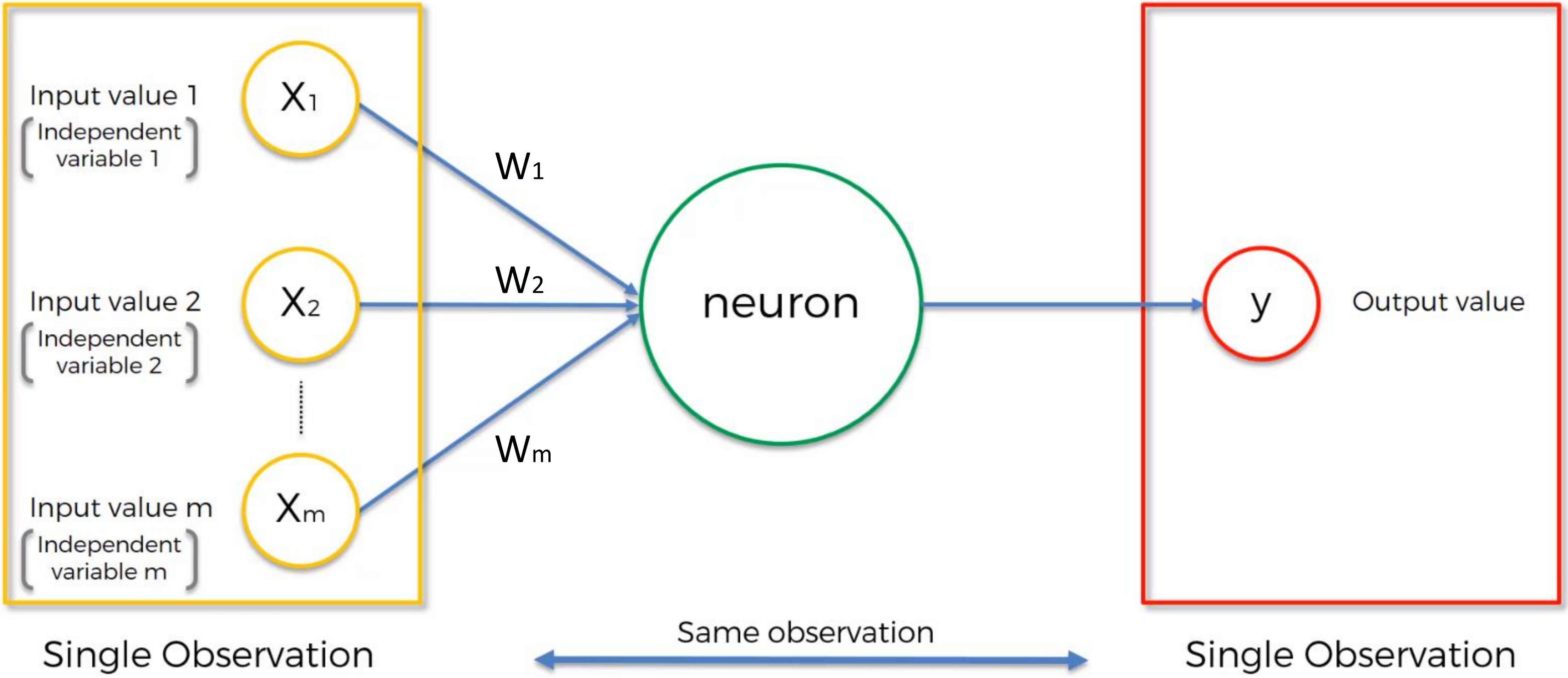
The Neuron



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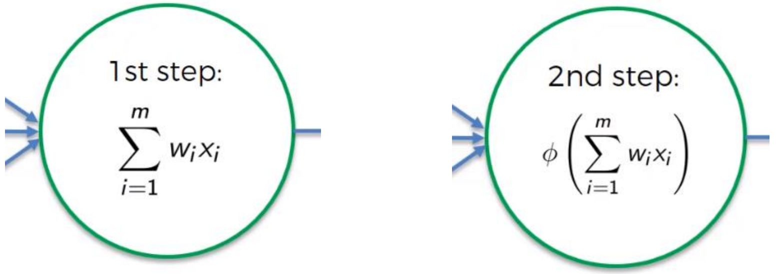

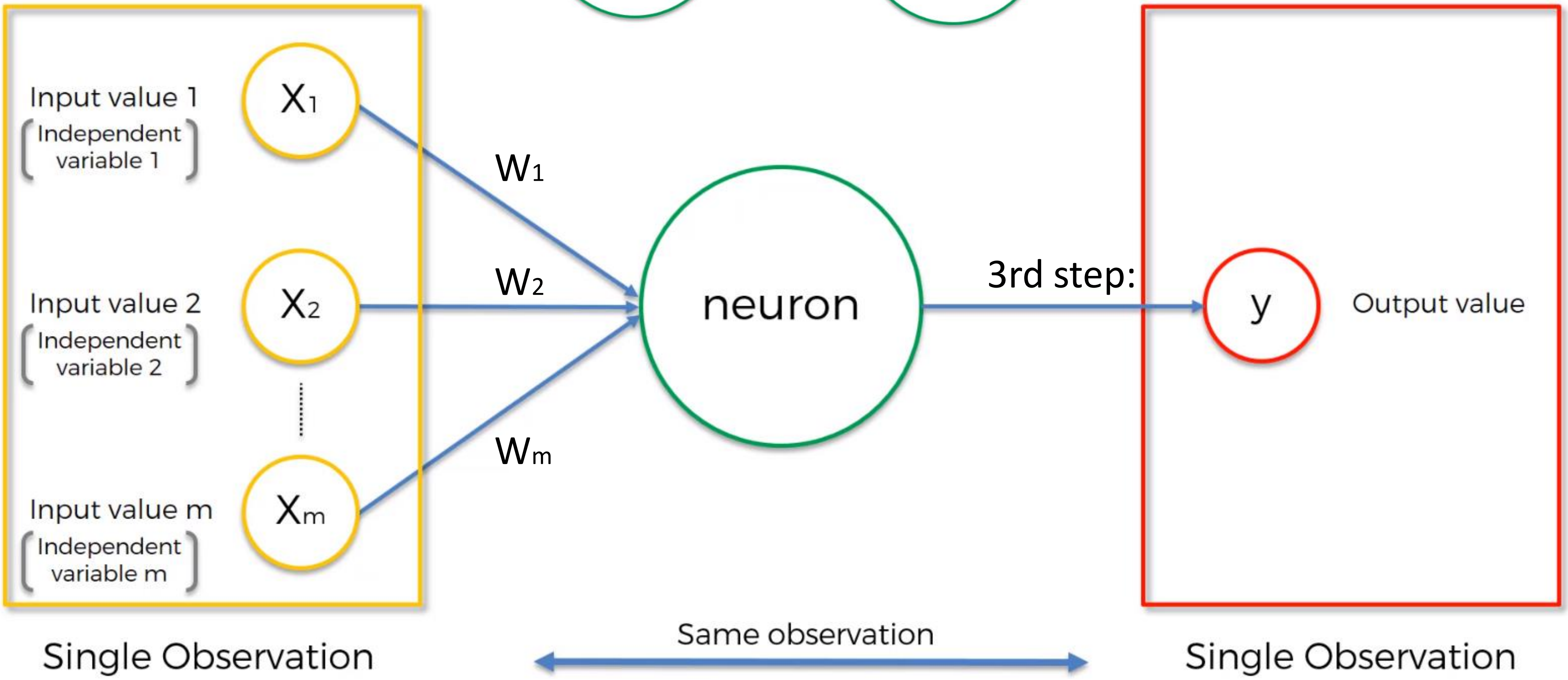

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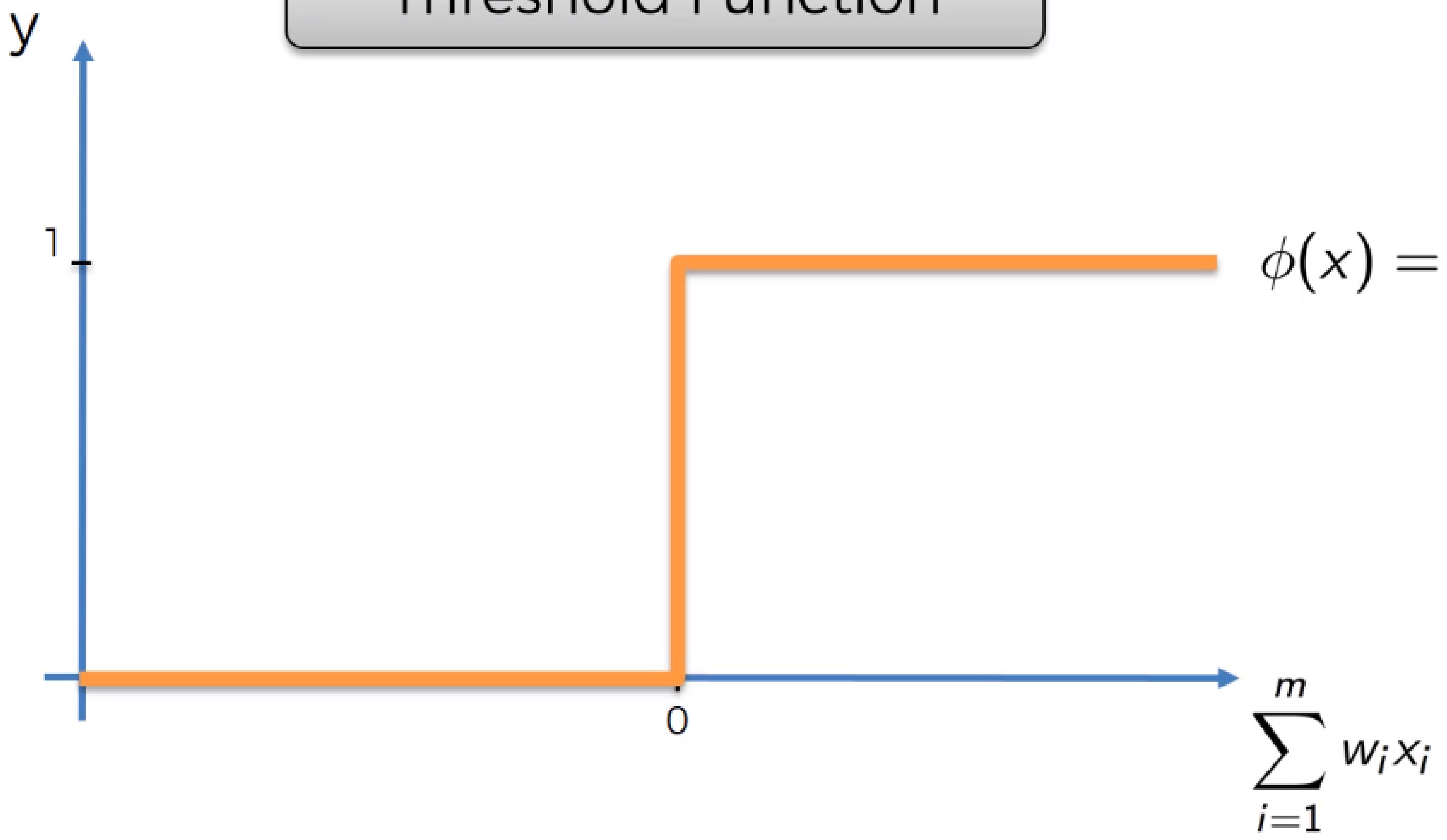
The Activation Function

Threshold Function



$$\phi(x) = \begin{cases} 1 \text{ if } x \geq 0 \\ 0 \text{ if } x < 0 \end{cases}$$

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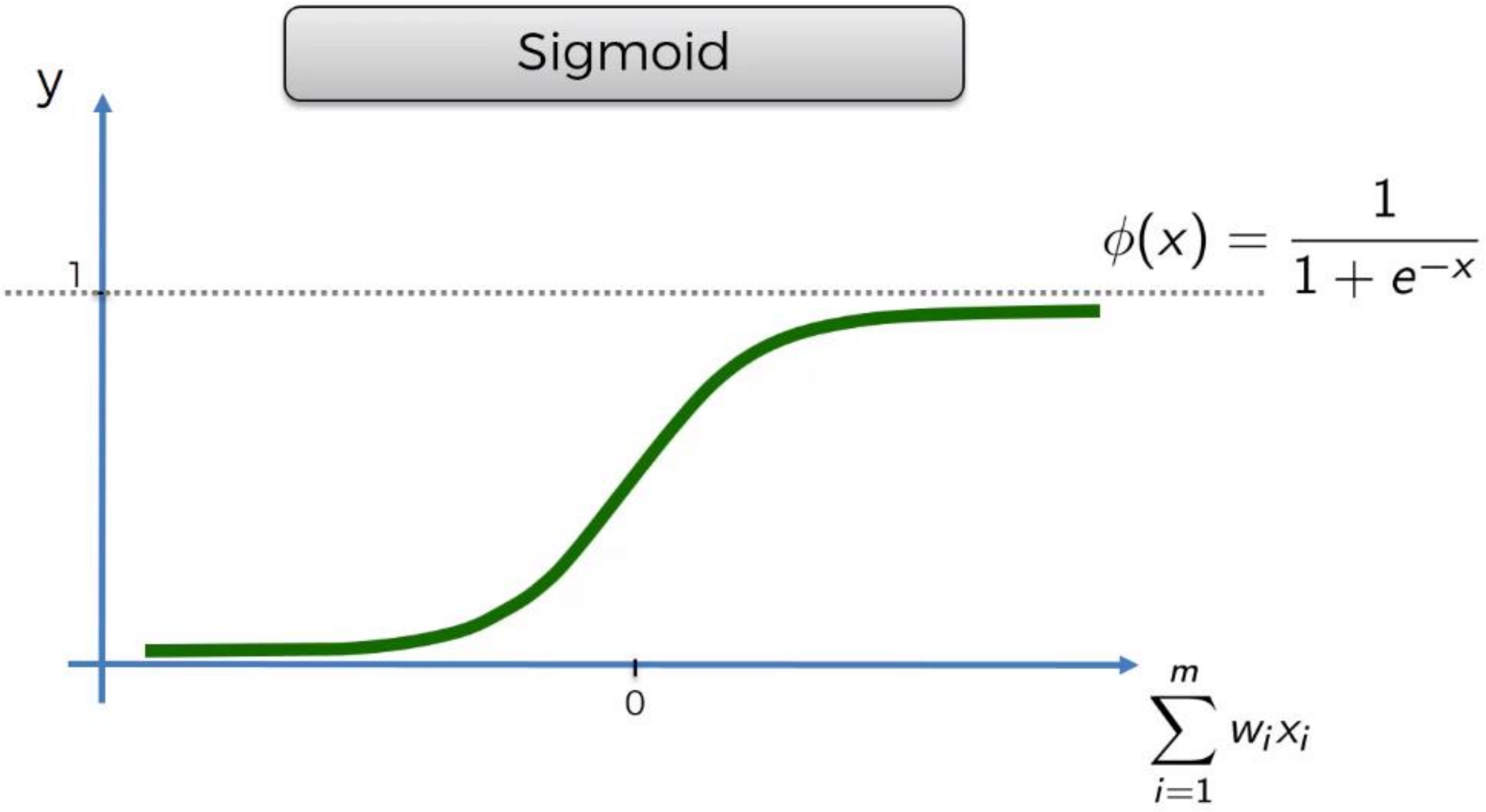
The Activation Function



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

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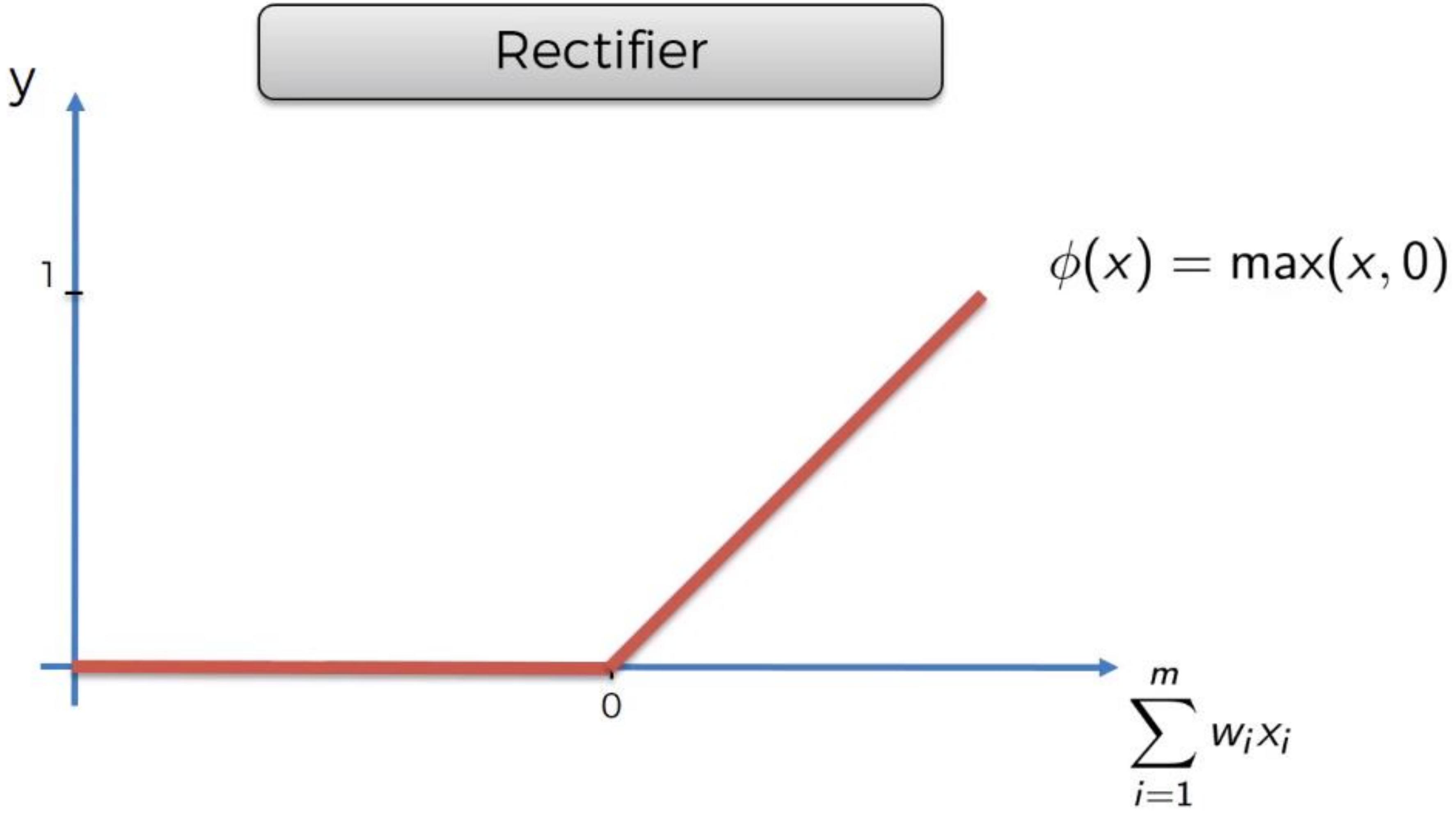
The Activation Function



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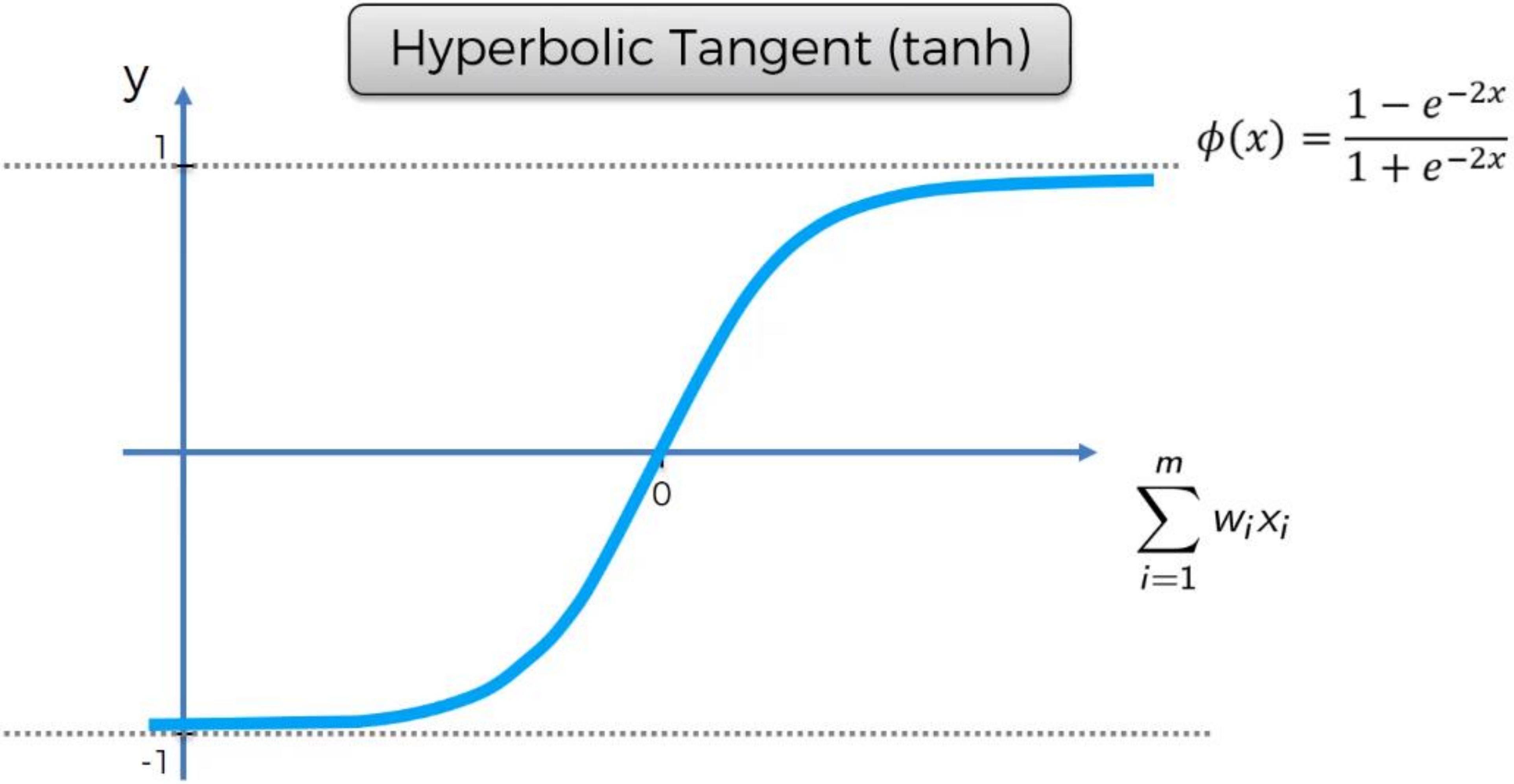
The Activation Function



$$\phi(x) = \frac{1 - e^{-2x}}{1 + e^{-2x}}$$

$$\sum_{i=1}^{m} w_i x_i$$

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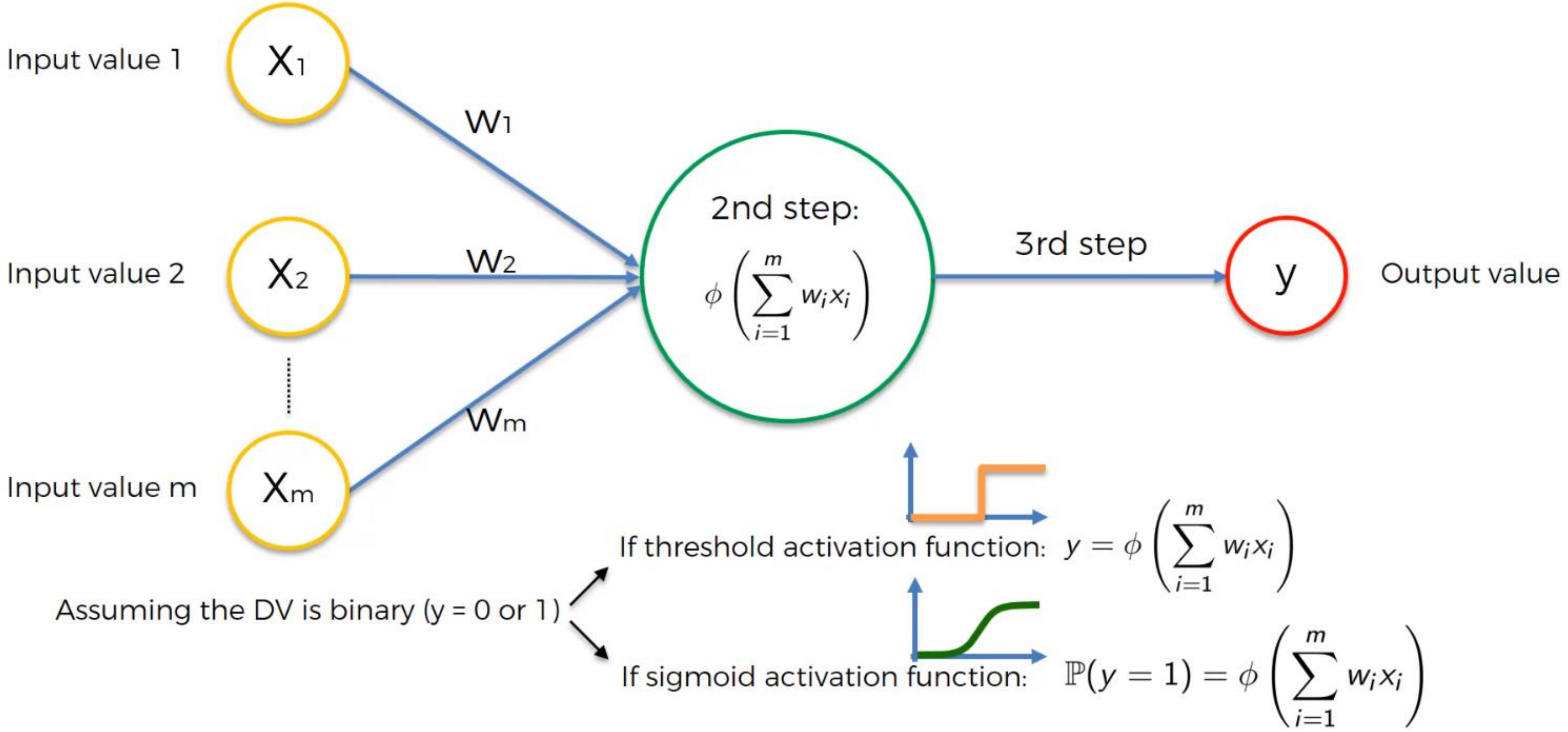
The Activation Function



Assuming the DV is binary (y = 0 or 1)

If threshold activation function: $y = \phi\left(\sum_{i=1}^{m} w_i x_i\right)$

If sigmoid activation function: $\mathbb{P}(y = 1) = \phi\left(\sum_{i=1}^{m} w_i x_i\right)$

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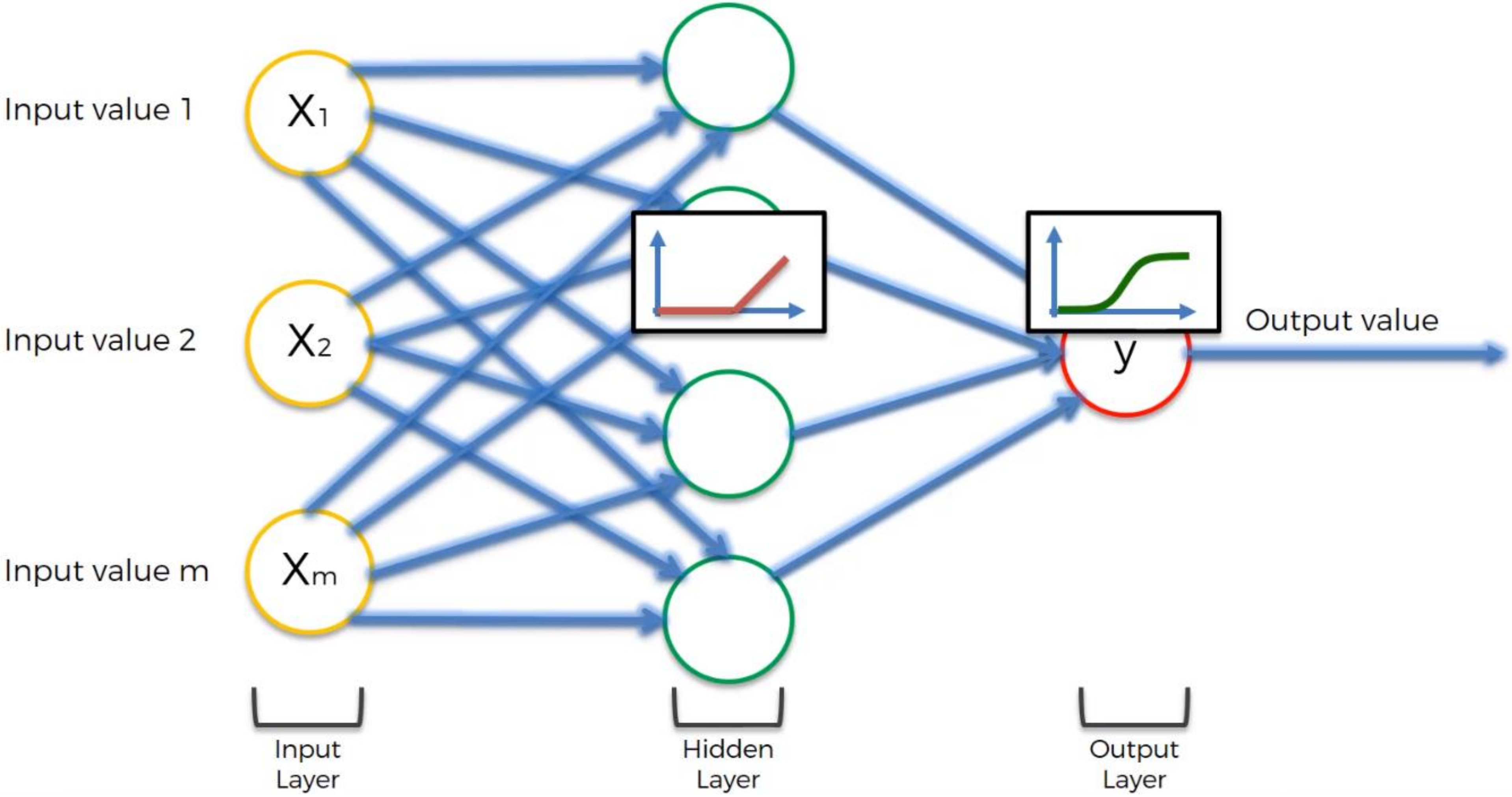
The Activation Function



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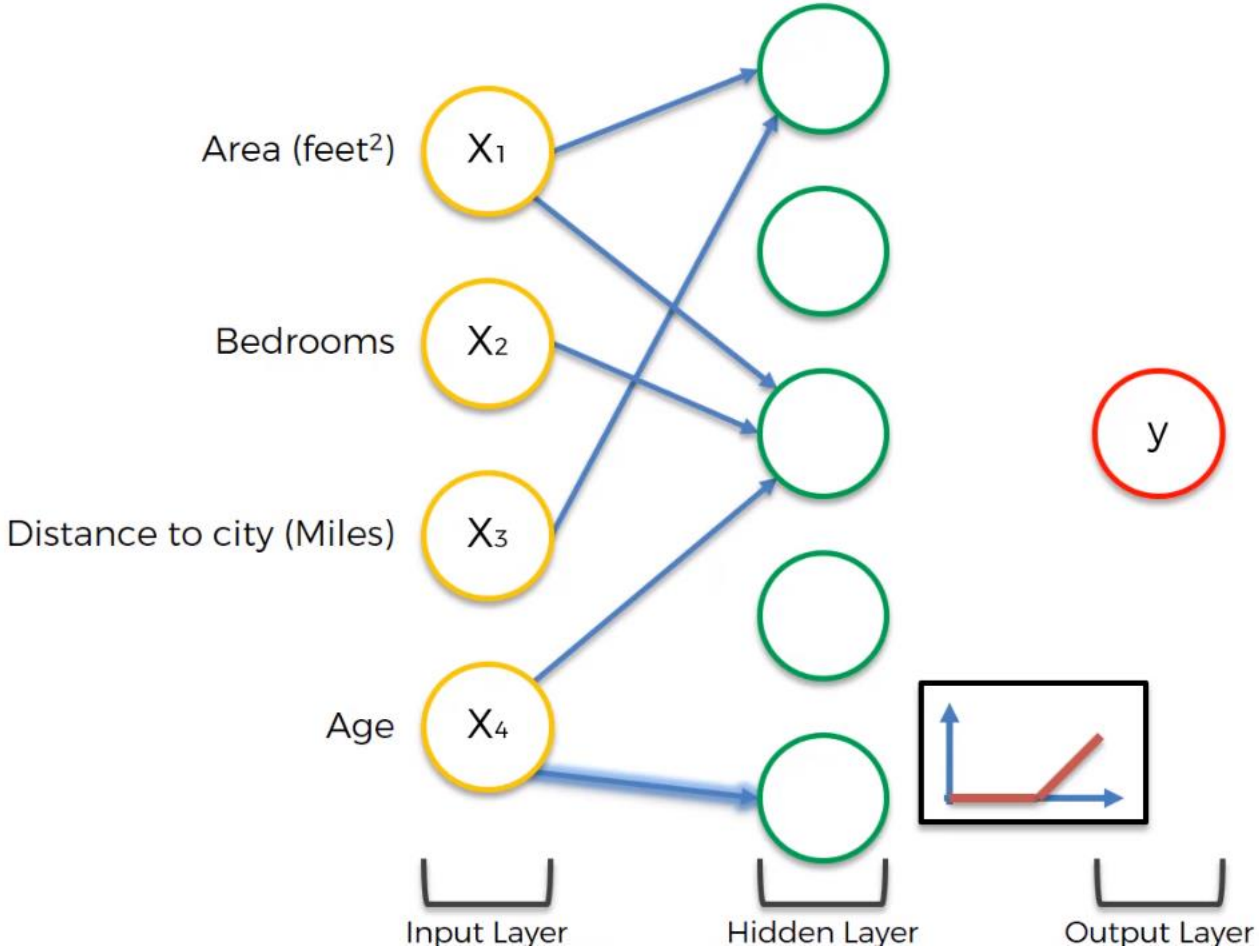
How do Neural Networks work?



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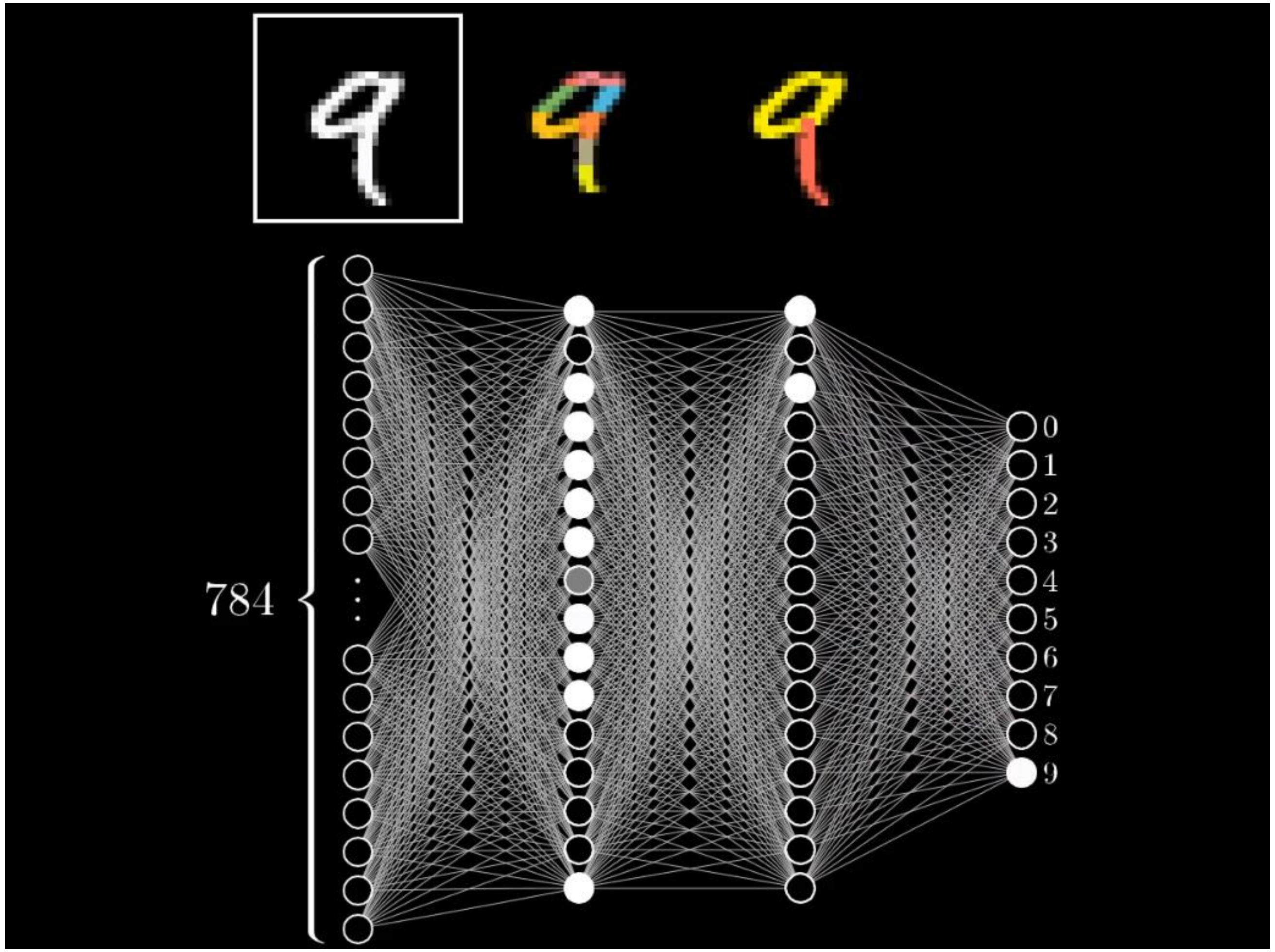
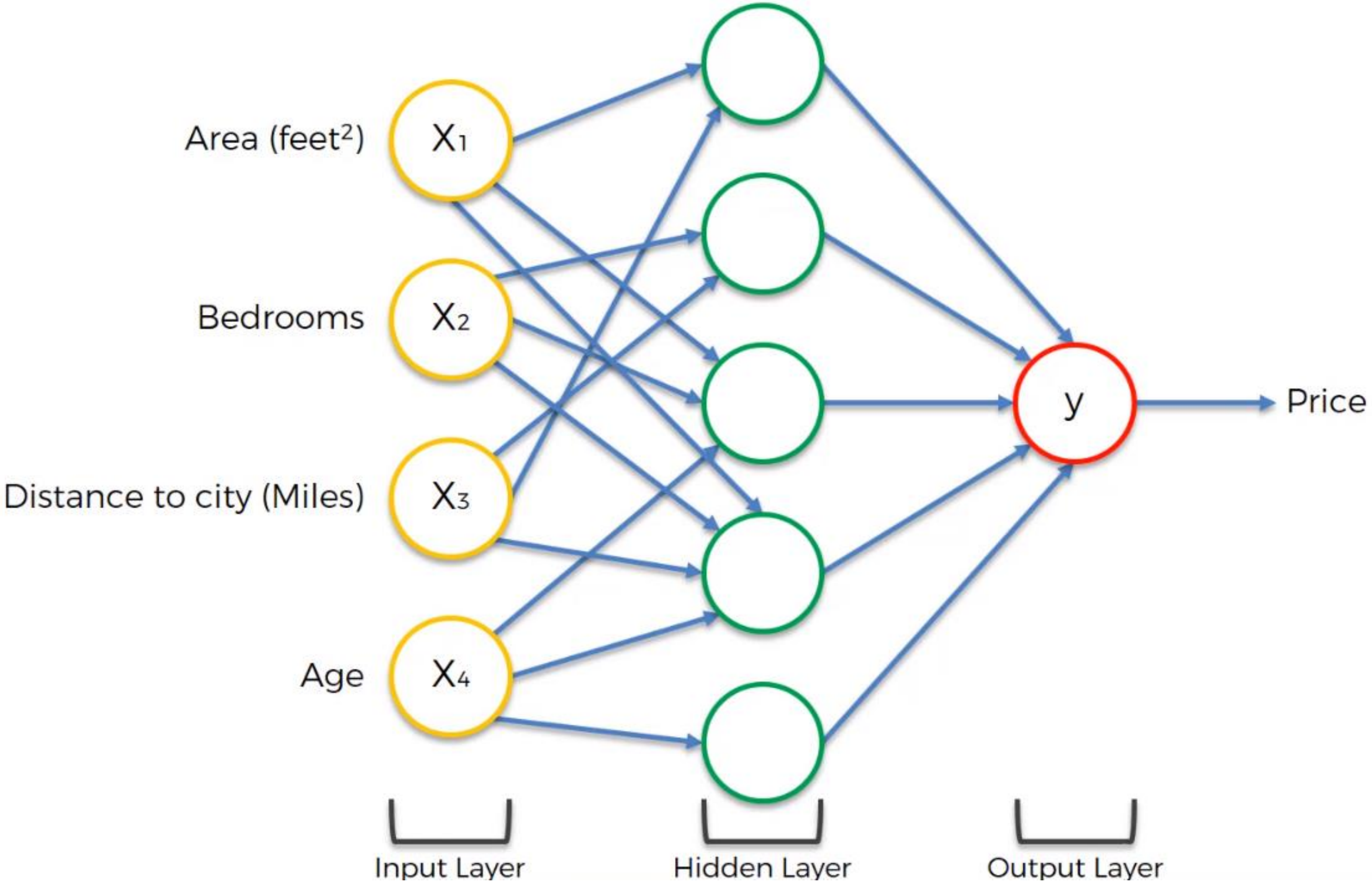


https://youtu.be/aircAruvnKk

How do Neural Networks work?



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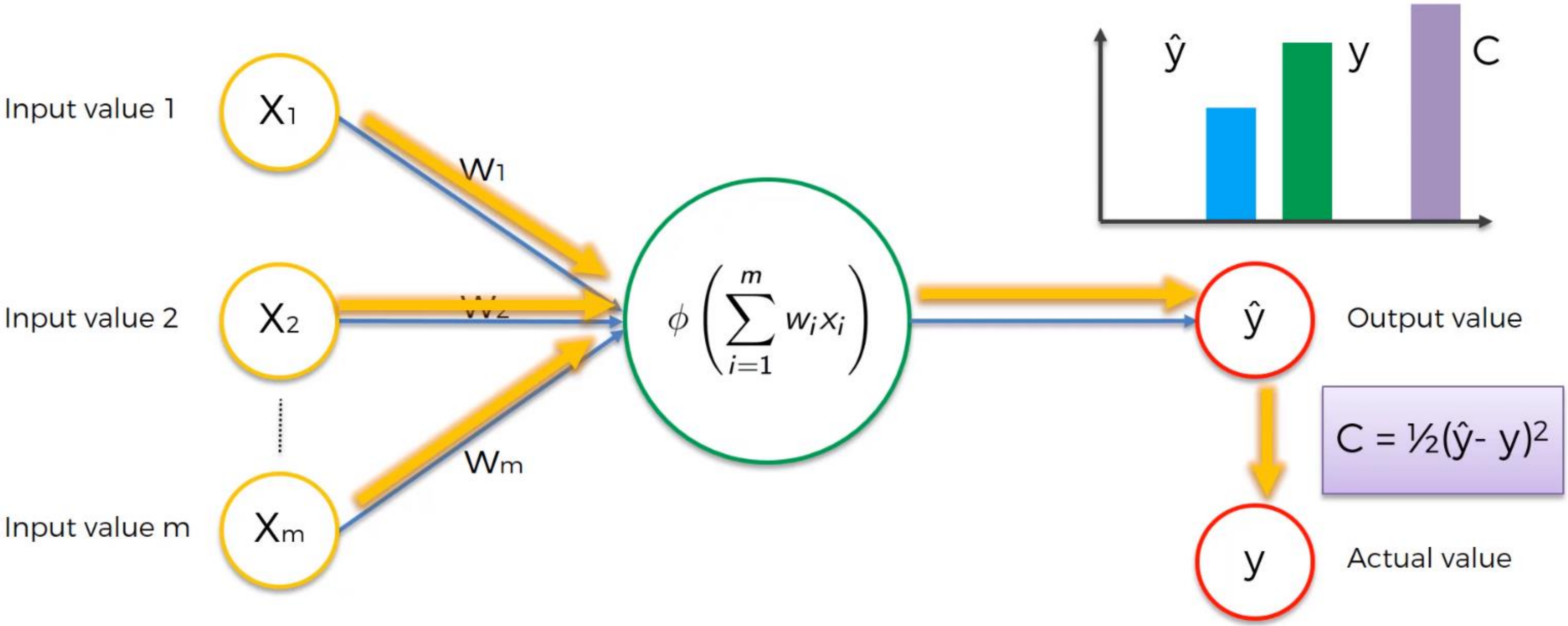
How do Neural Networks learn?



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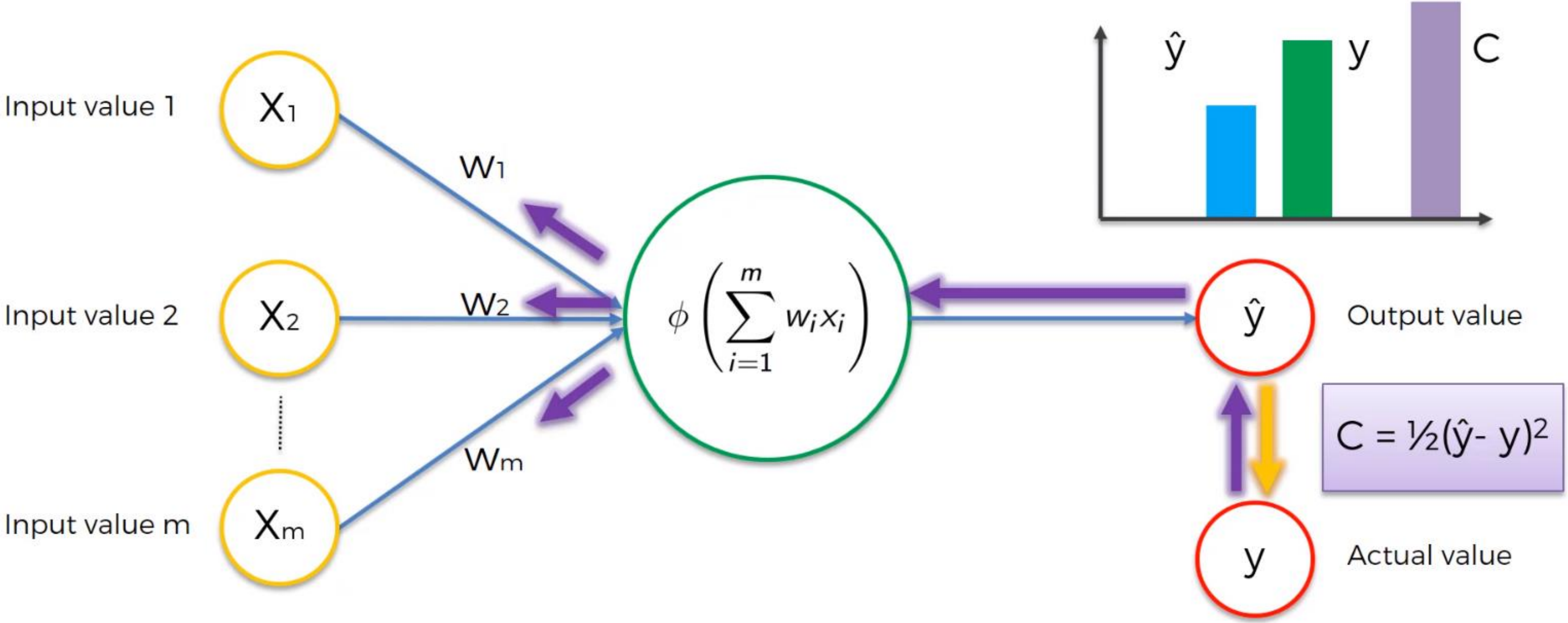
How do Neural Networks learn?



$C = ½(ŷ - y)^2$

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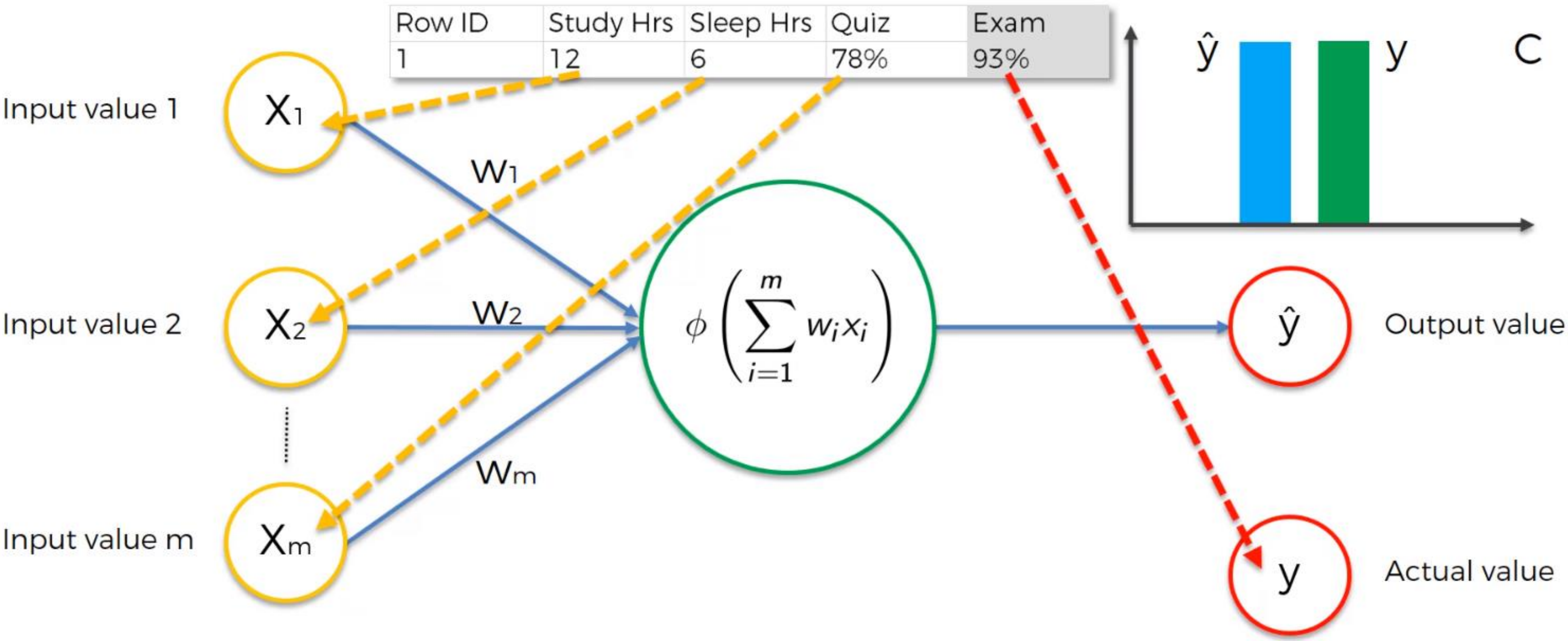
How do Neural Networks learn?



Row ID	Study Hrs	Sleep Hrs	Quiz	Exam
1	12	6	78%	93%

$$\phi\left(\sum_{i=1}^{m} w_i x_i\right)$$

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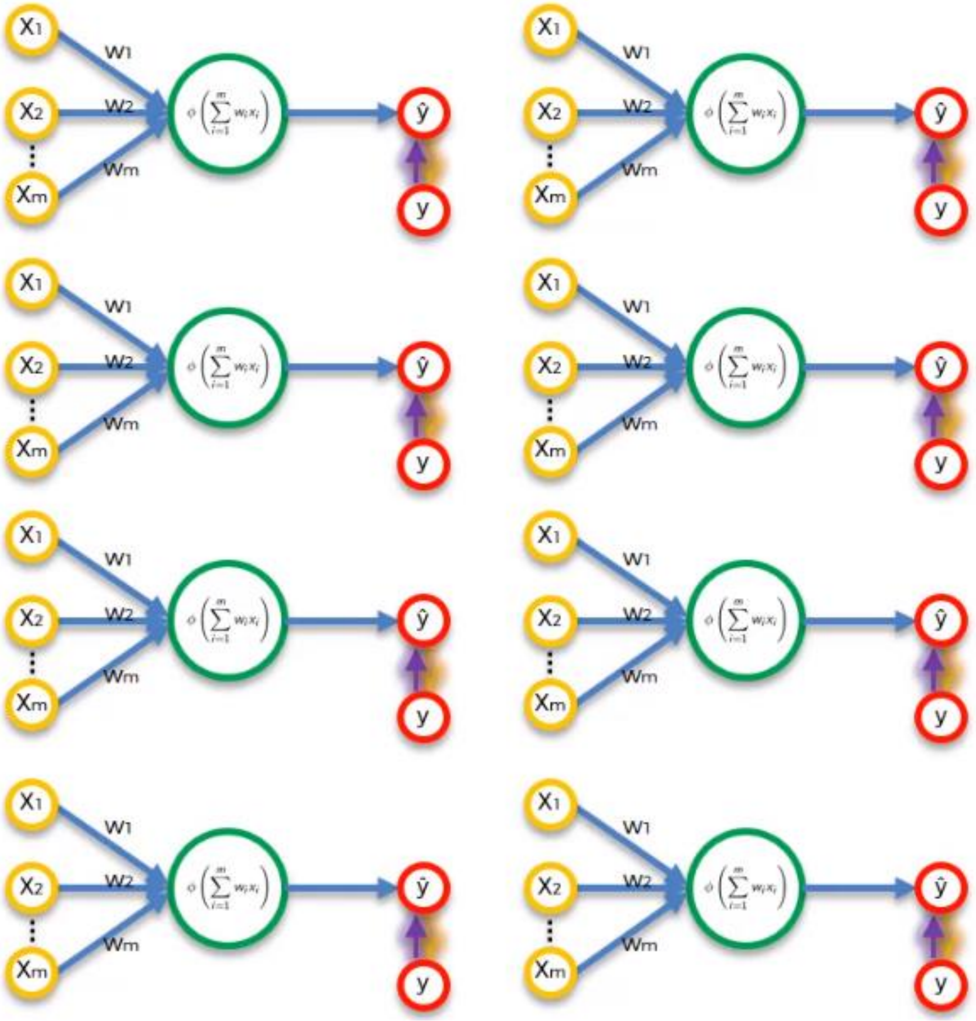
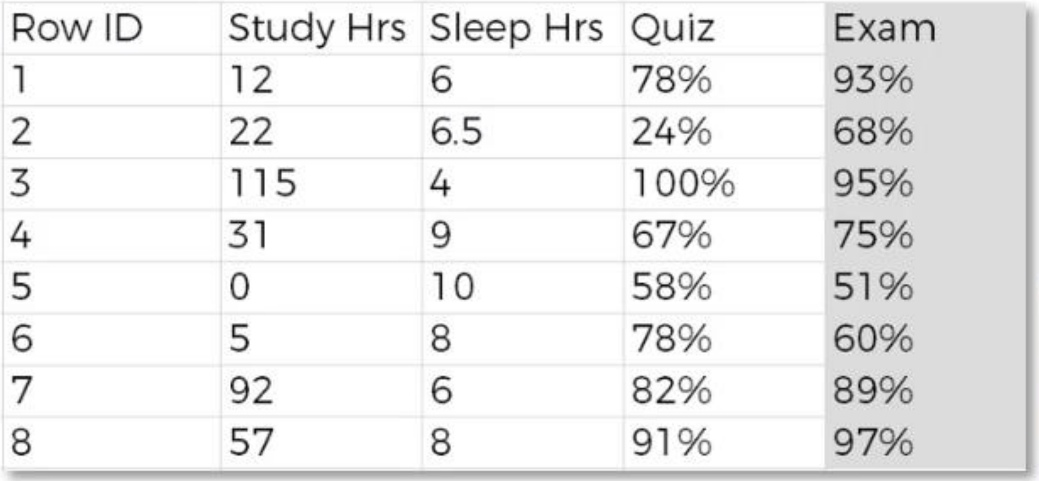
How do Neural Networks learn?





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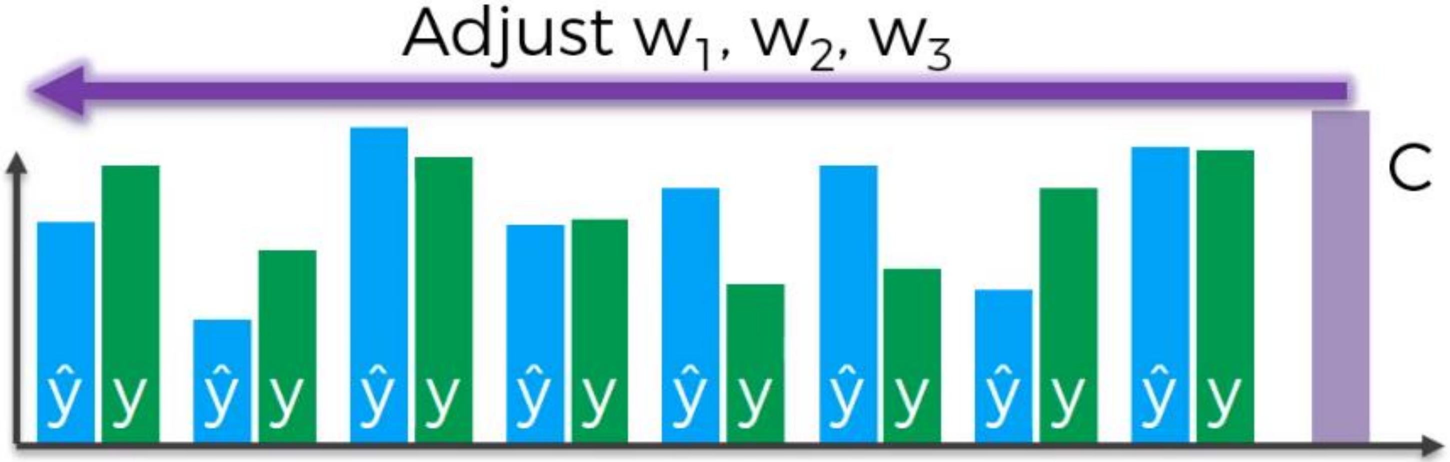
$$C = \sum \tfrac{1}{2}(\hat{y} - y)^2$$



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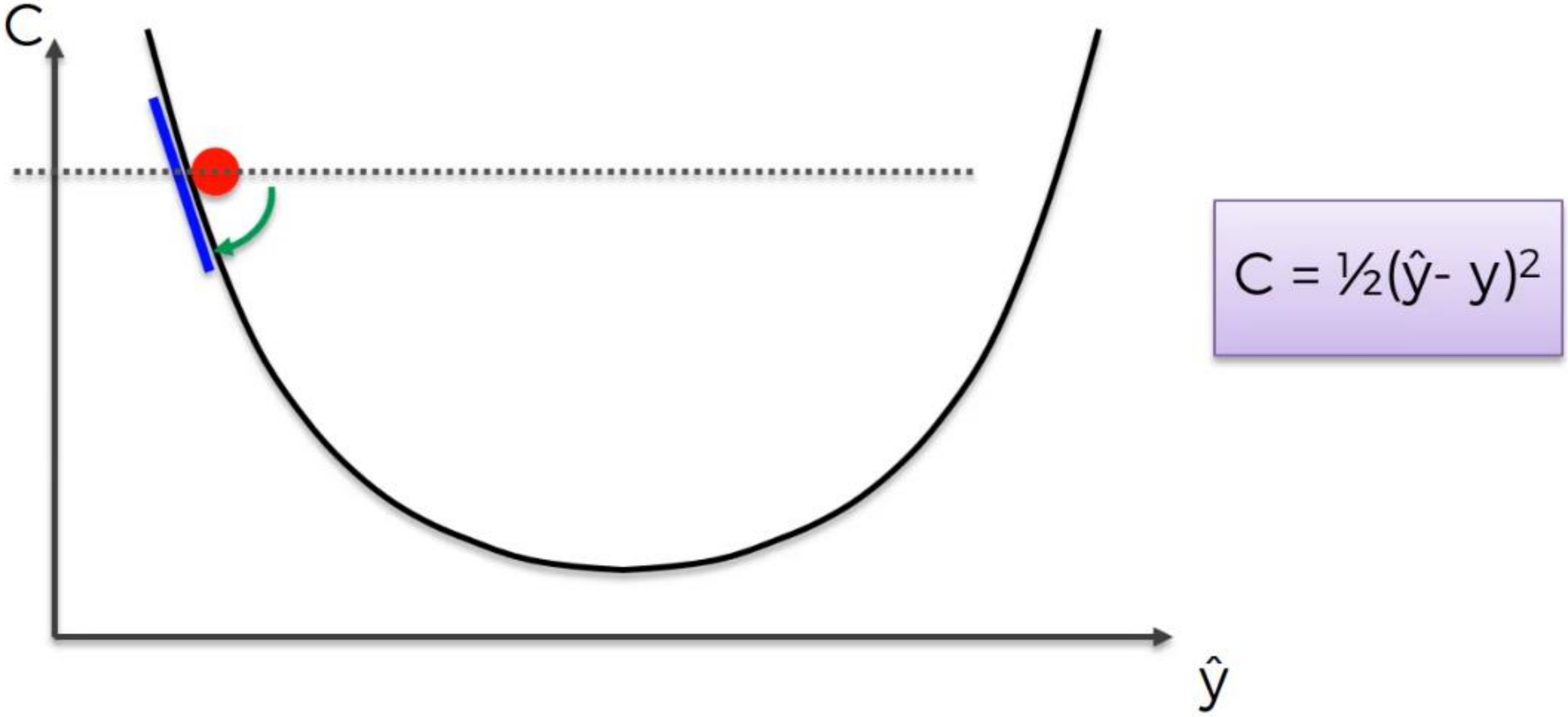
Gradient Descent



$C = ½(\hat{y} - y)^2$

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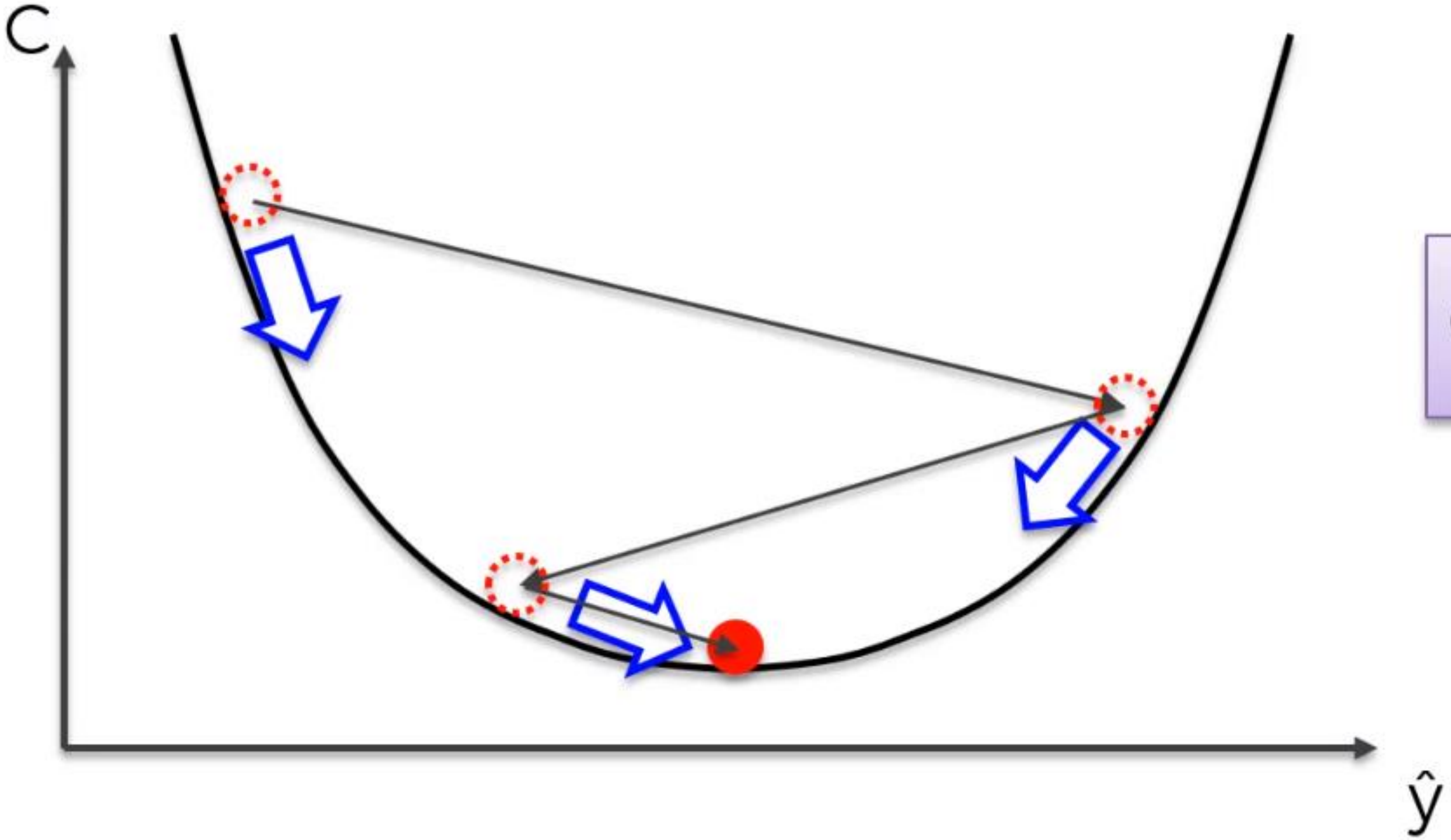
Gradient Descent



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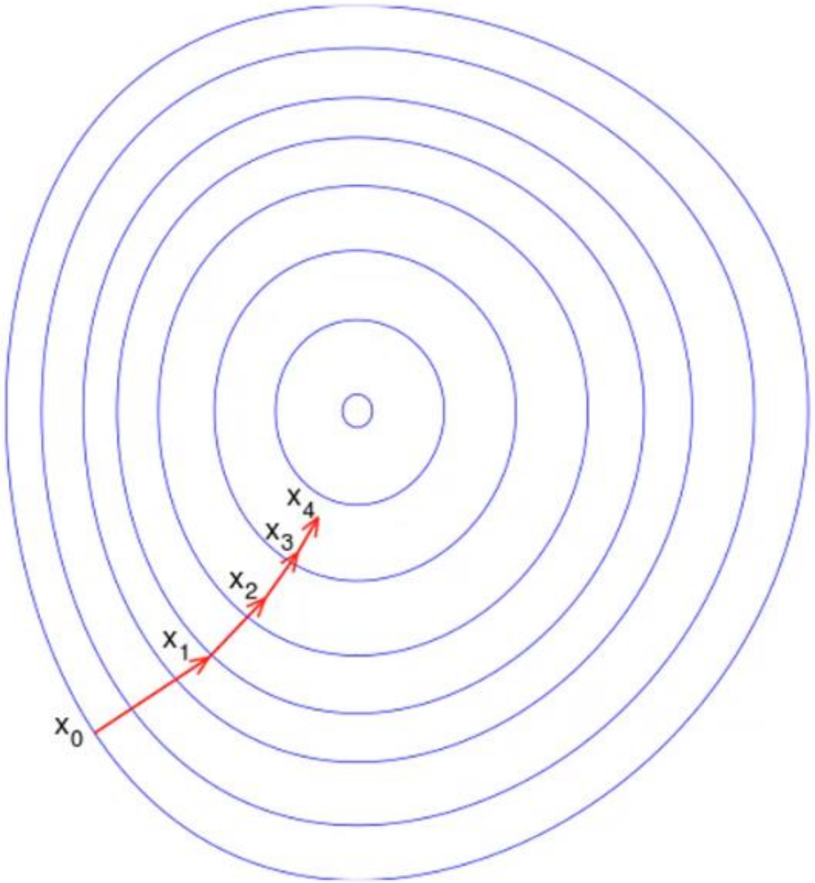

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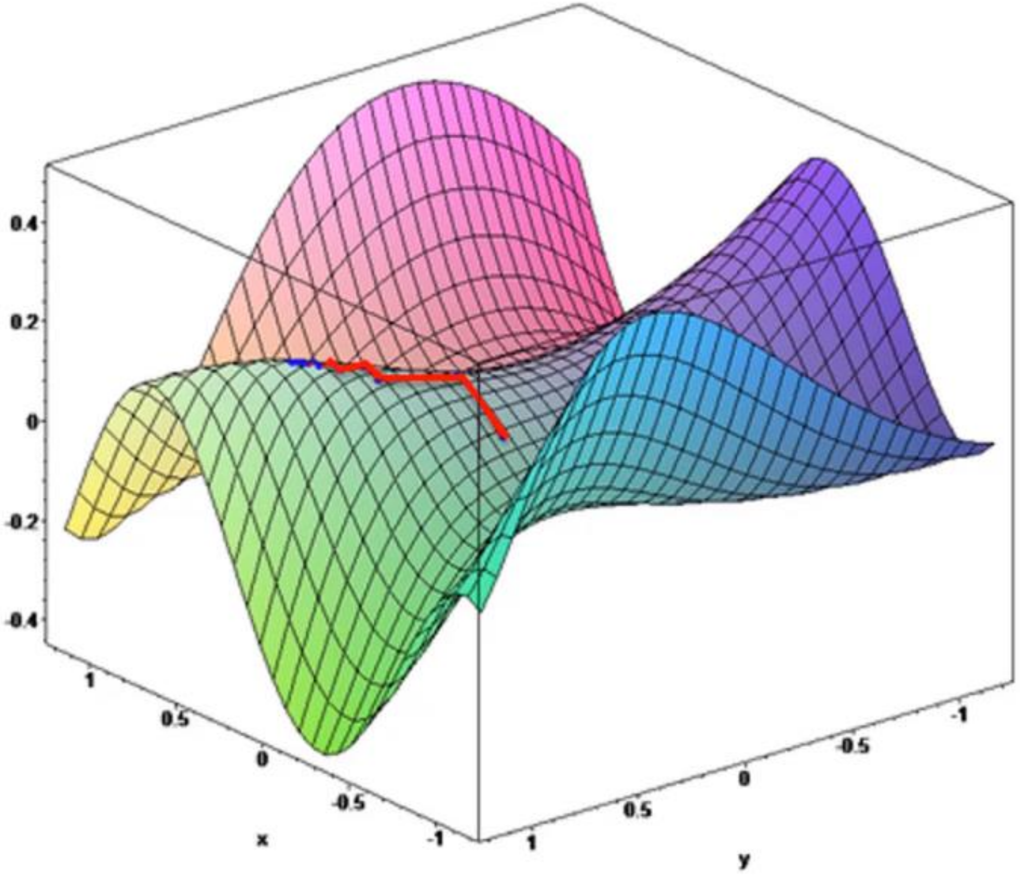

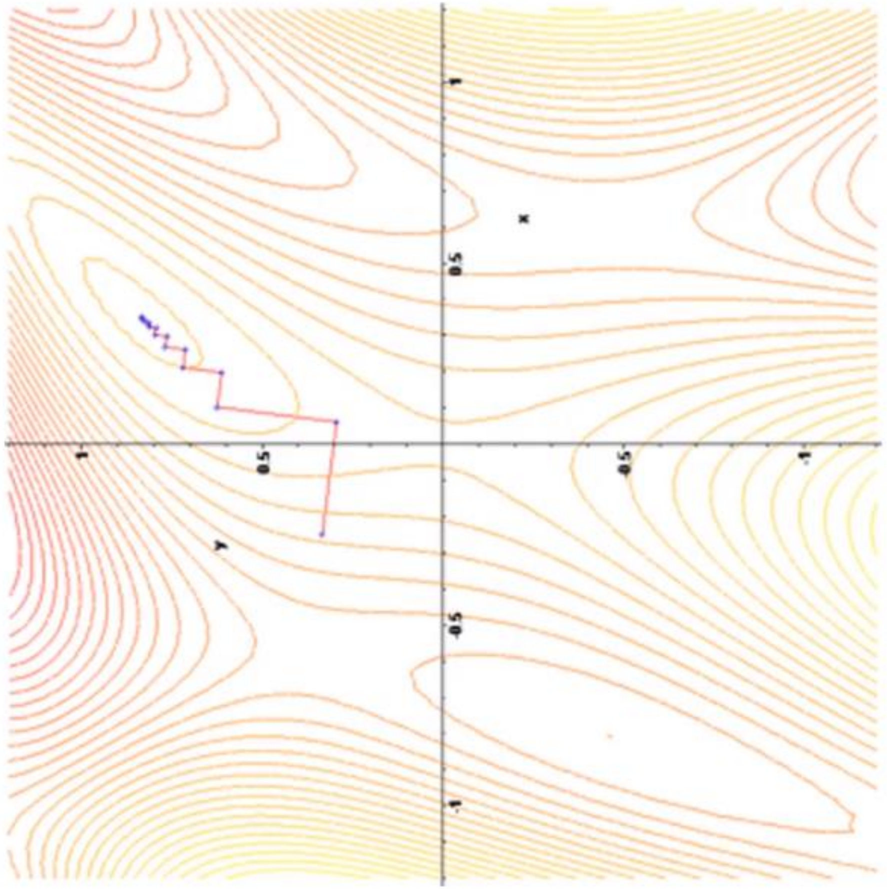

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Gradient Descent

Step 1: Take the derivative of the **Cost Function** for each parameter in it. In fancy Machine Learning lingo, take the **Gradient** of the **Loss Function**.

Step 2: Pick random values for the parameters.

Step 3: Plug the parameter values into the derivatives (**Gradient**).

Step 4: Calculate the Step Sizes: Step Size = **Slope * Learning Rate**

Step 5: Calculate the New Parameters:

New Parameter = Old Parameter – Step Size

Step 6: Go back to **Step 3** and repeat until **Step Size** is very small, or you reach the **Maximum Number of Steps**

https://youtu.be/sDv4f4s2SB8

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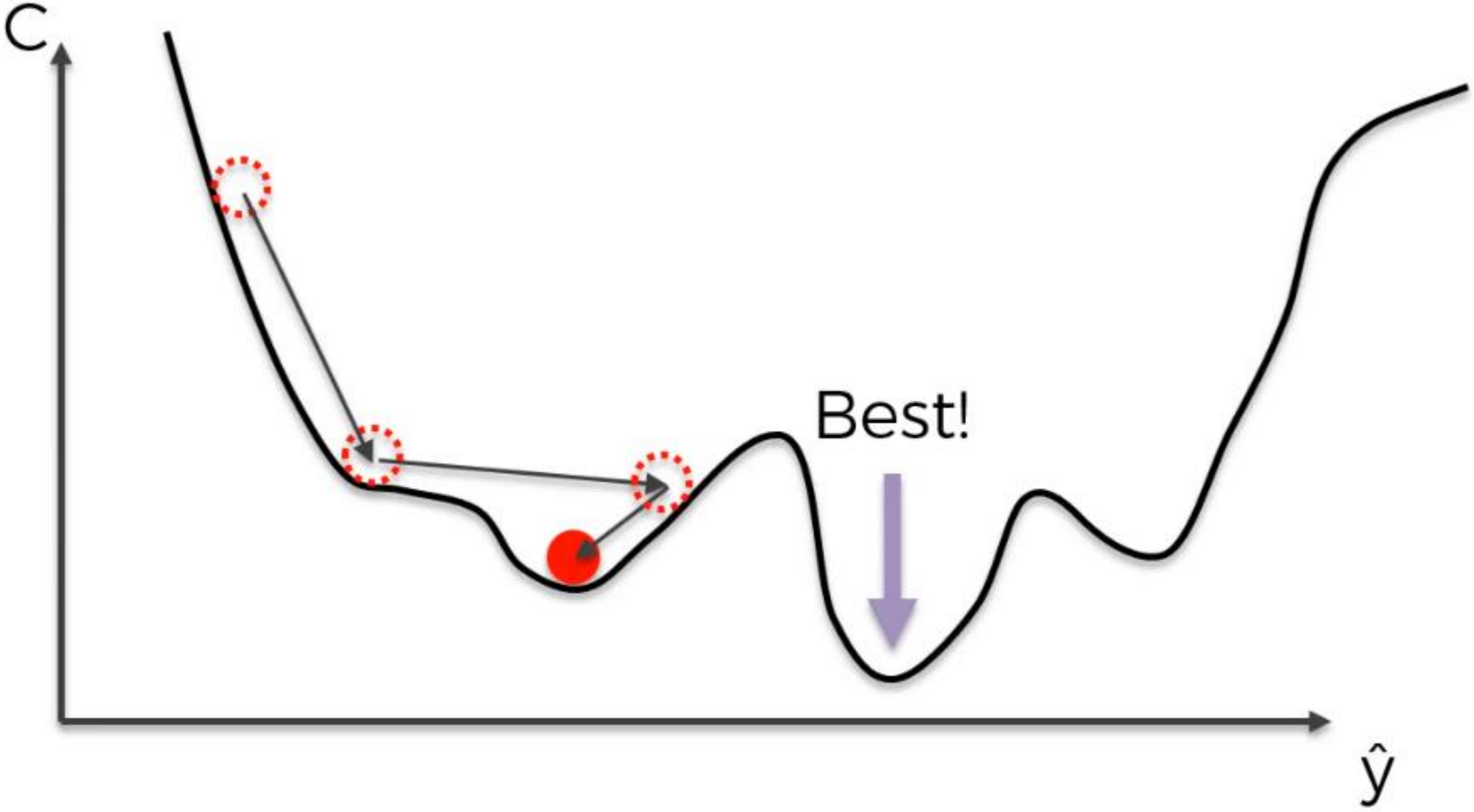
Stochastic Gradient Descent



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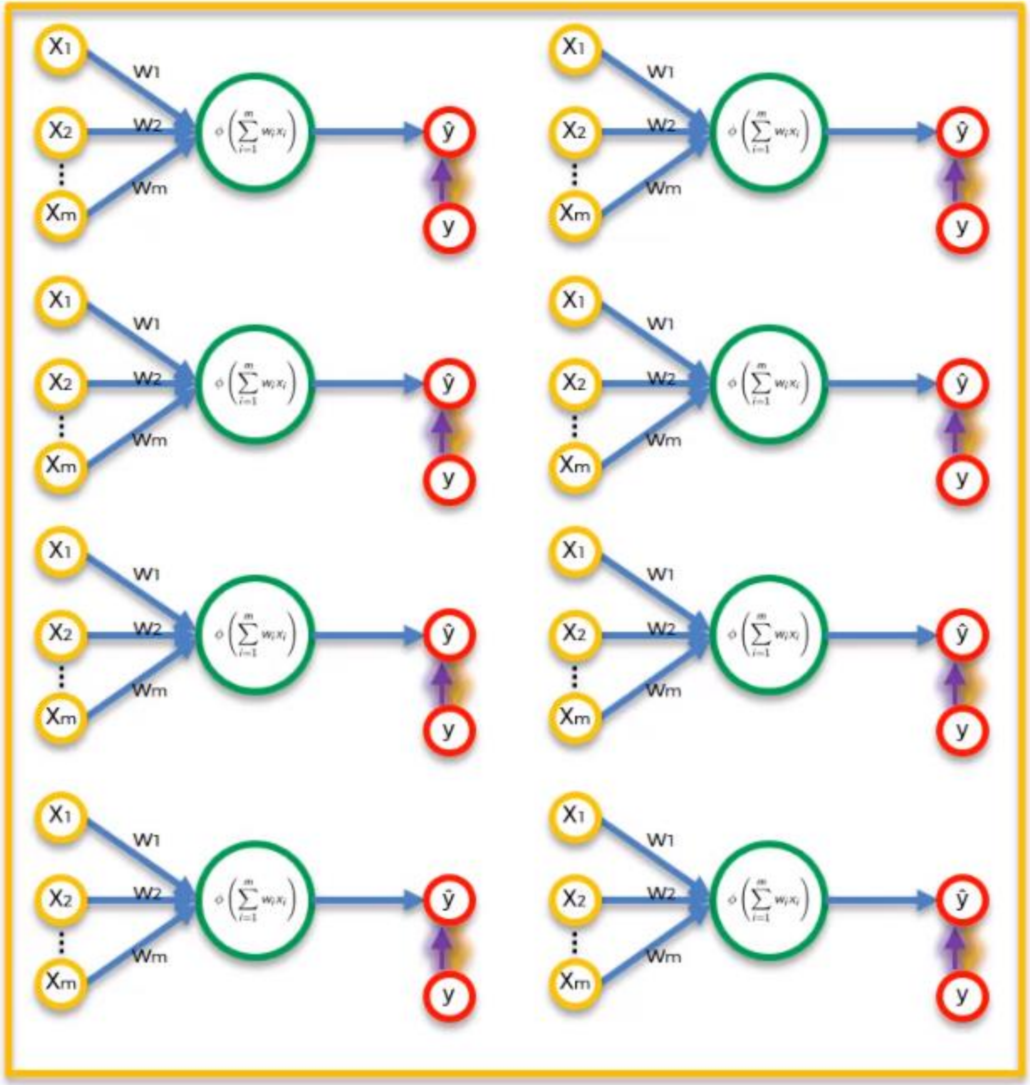
Stochastic Gradient Descent



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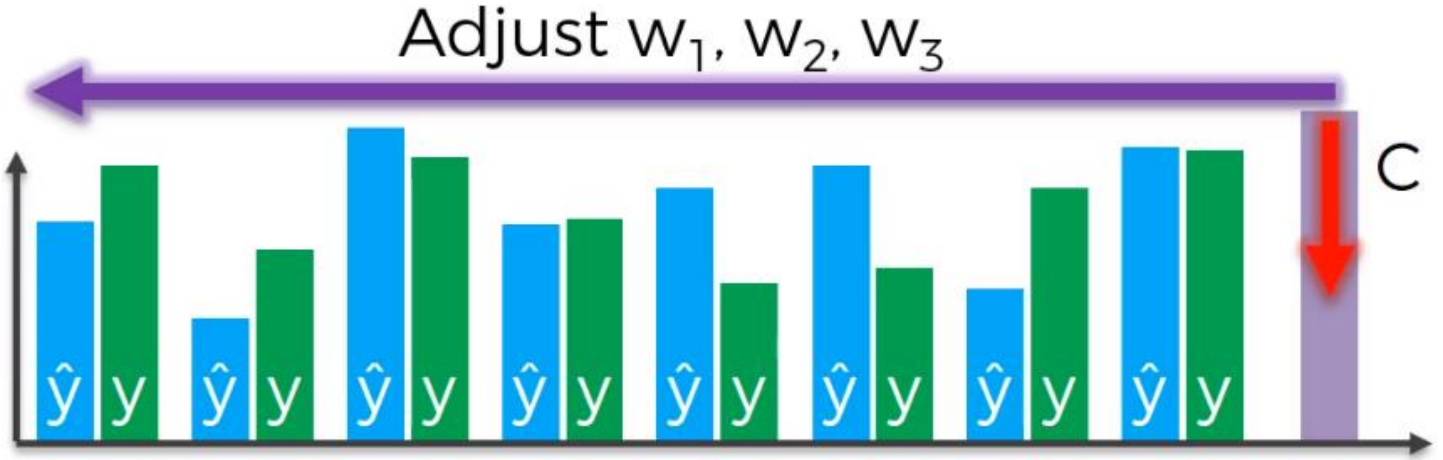
Adjust w_1, w_2, w_3

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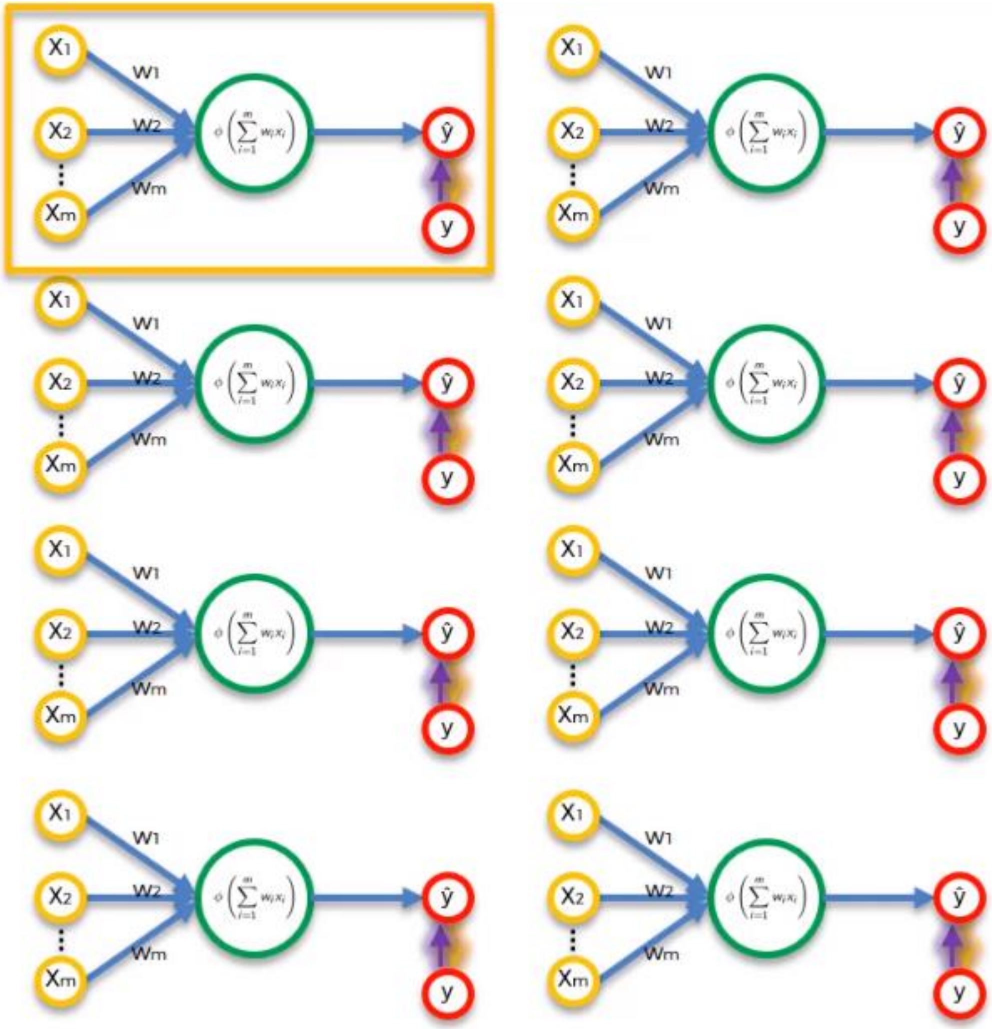
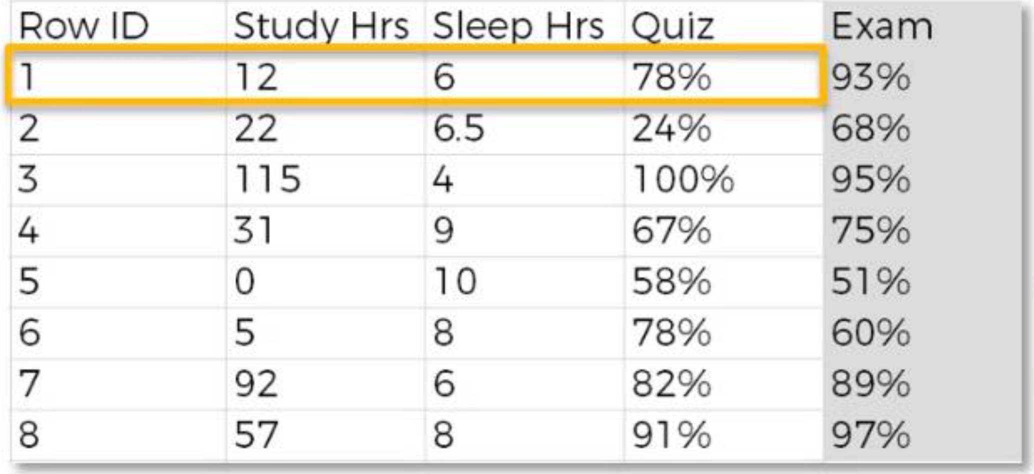
Stochastic Gradient Descent





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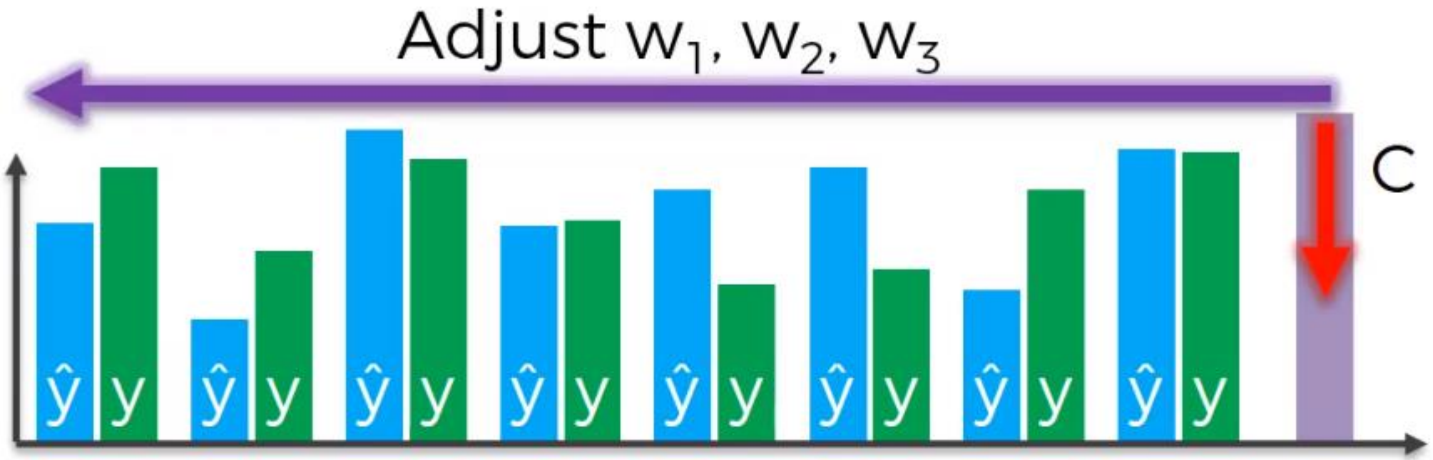

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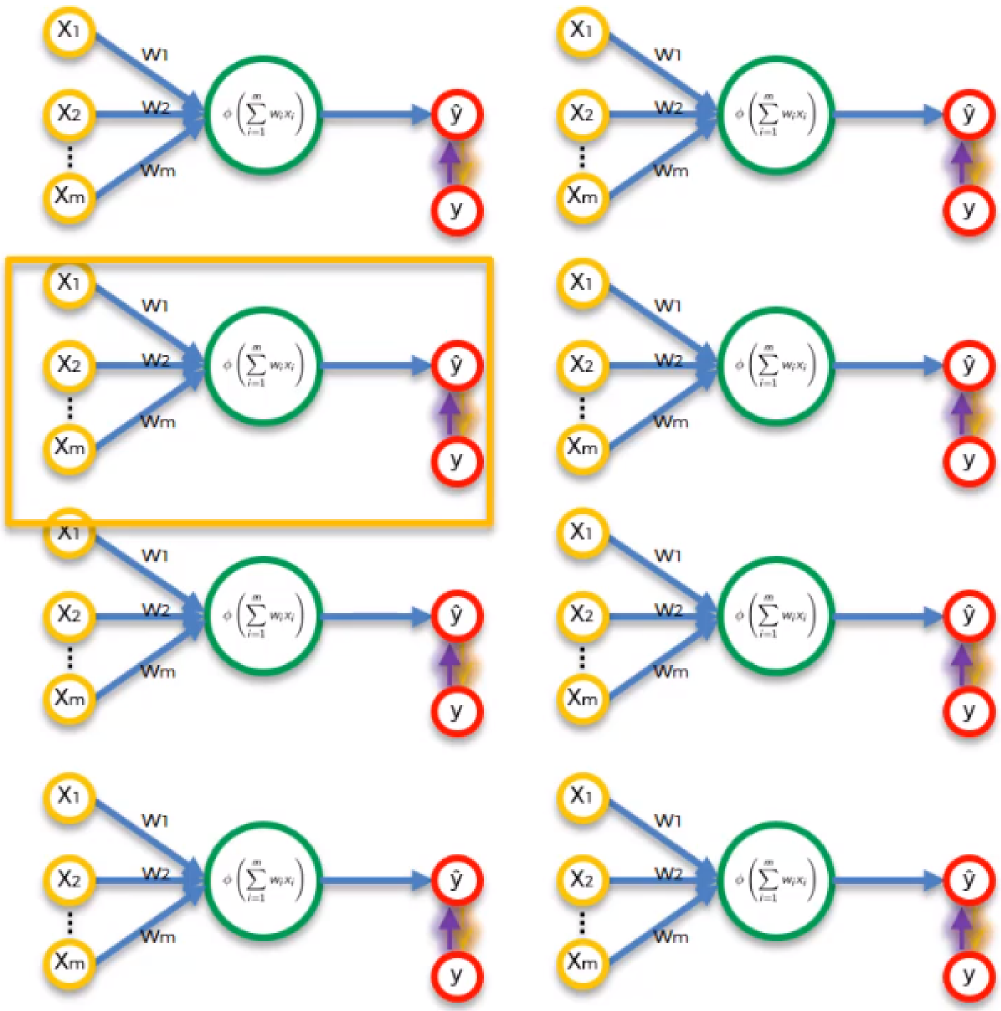

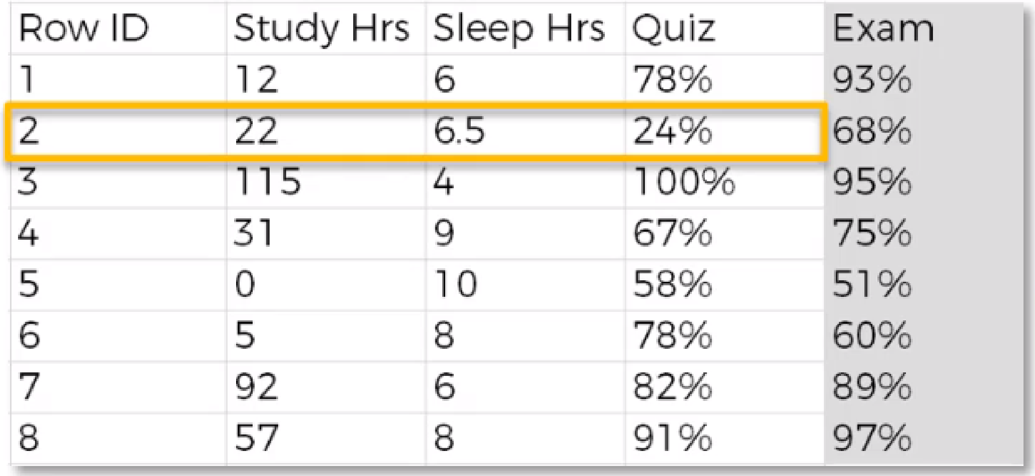

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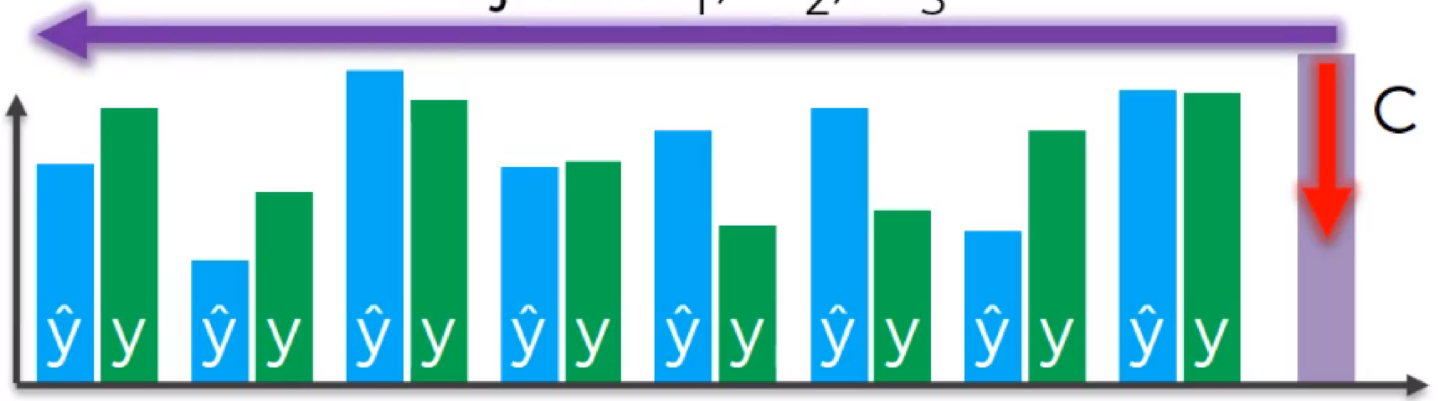

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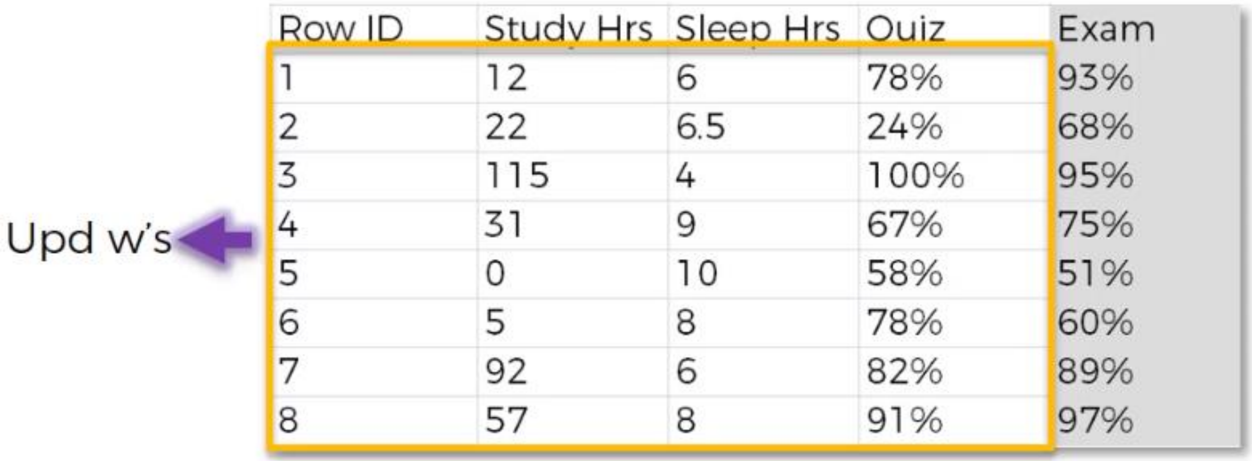

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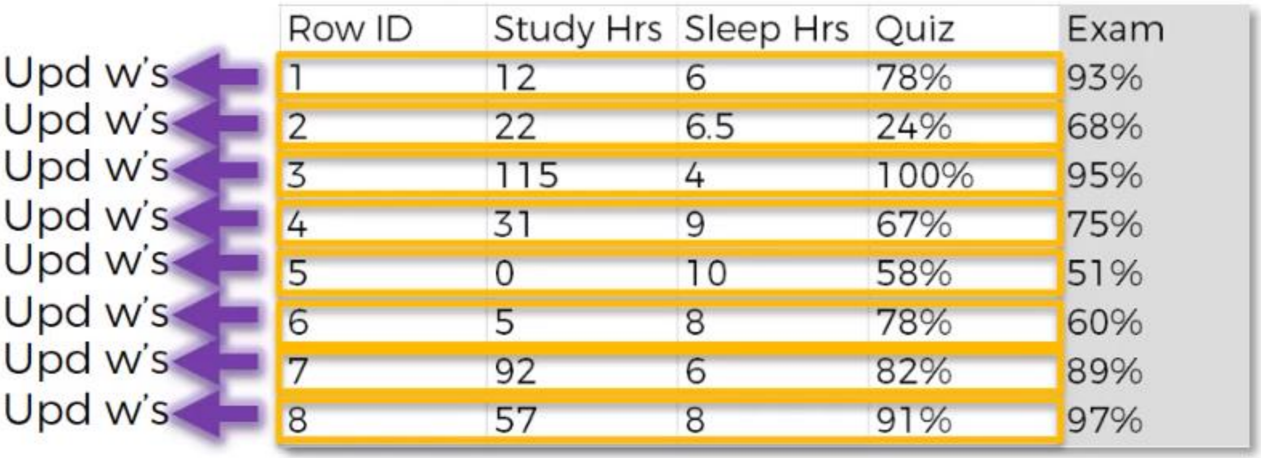
Batch Gradient Descent


Upd w's
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Upd w's

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Stochastic Gradient Descent

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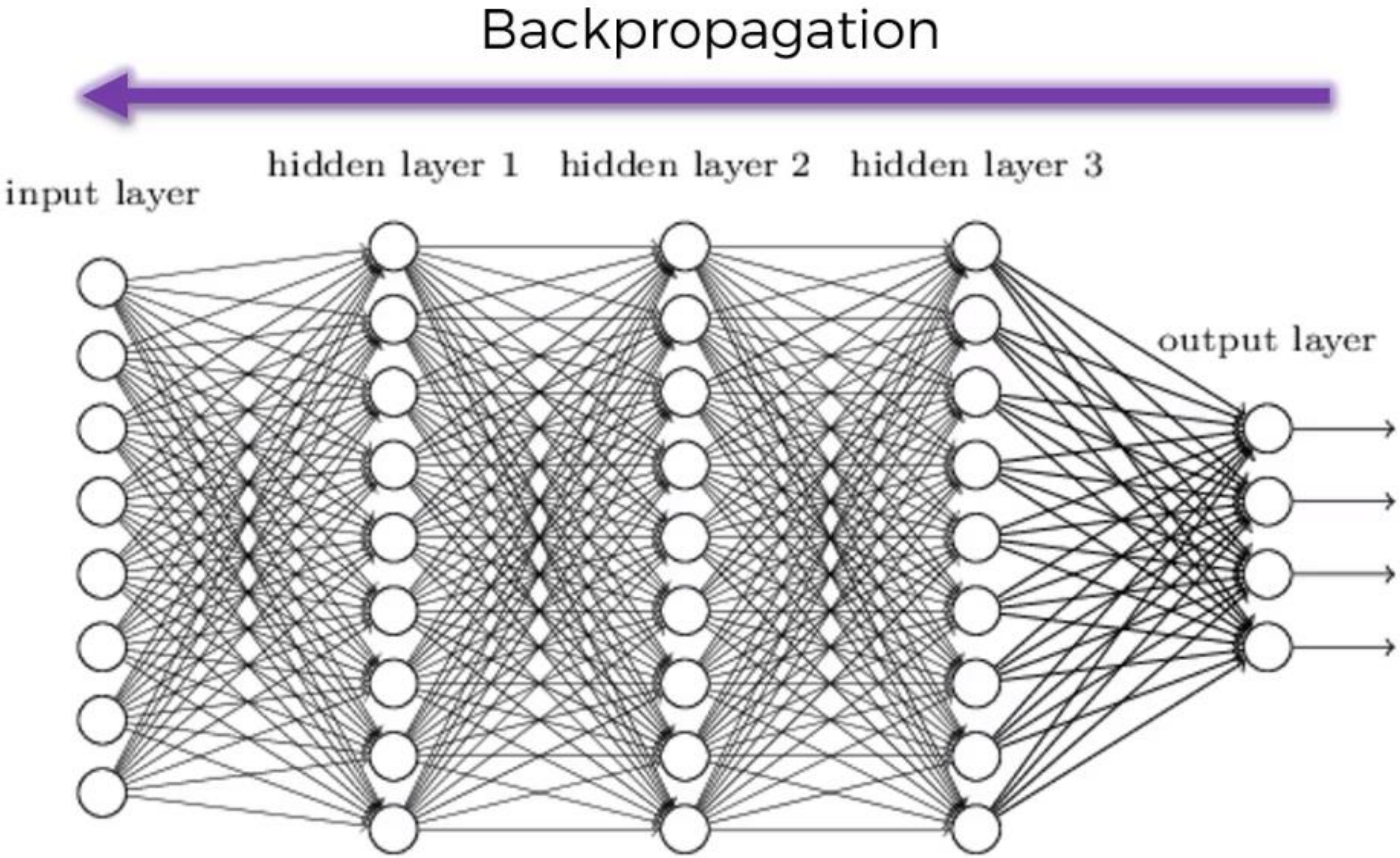
Backpropagation



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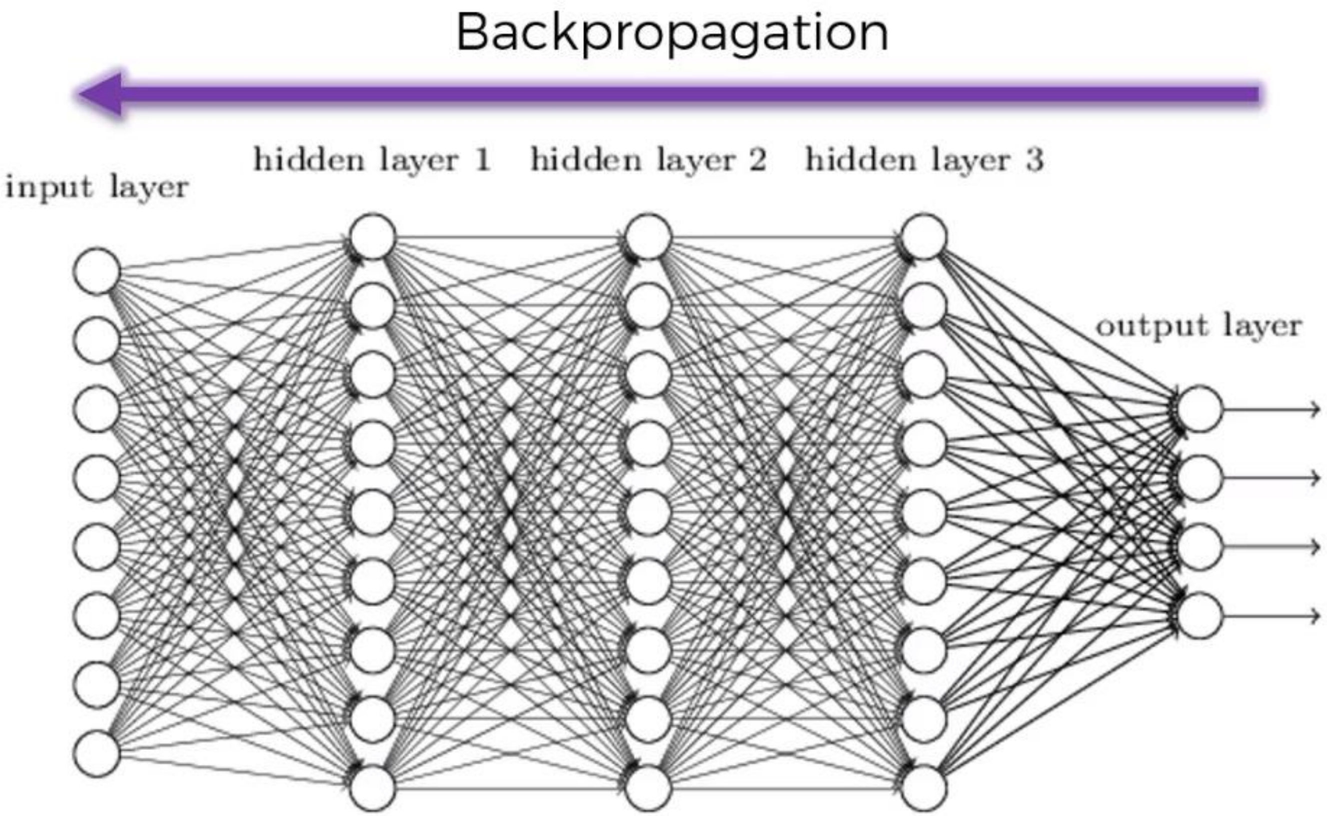
Backpropagation



Gradient of the cost function

Input: 270 weights/biases
Output: 270 weights/biases nudges
Parameters: 1 number (the cost)

Cost function

Input: 270 weights/biases
Output: 1 number (the cost)
Parameters: Many, many, many training example

Neural Network function

Input: 8 numbers (features)
Output: 4 numbers
Parameters: 270 weights/biases

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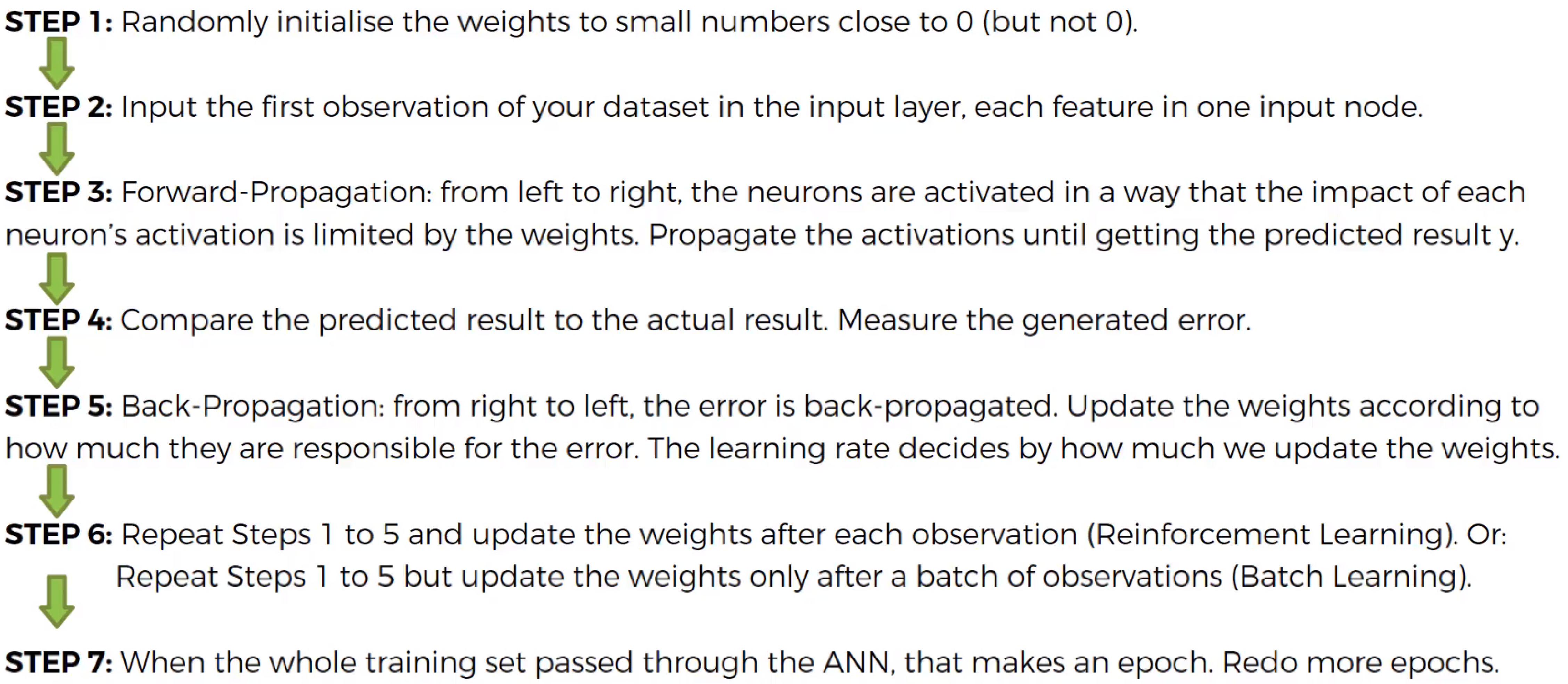

STEP 1: Randomly initialise the weights to small numbers close to 0 (but not 0).

STEP 2: Input the first observation of your dataset in the input layer, each feature in one input node.

STEP 3: Forward-Propagation: from left to right, the neurons are activated in a way that the impact of each neuron's activation is limited by the weights. Propagate the activations until getting the predicted result y.

STEP 4: Compare the predicted result to the actual result. Measure the generated error.

STEP 5: Back-Propagation: from right to left, the error is back-propagated. Update the weights according to how much they are responsible for the error. The learning rate decides by how much we update the weights.

STEP 6: Repeat Steps 1 to 5 and update the weights after each observation (Reinforcement Learning). Or:
Repeat Steps 1 to 5 but update the weights only after a batch of observations (Batch Learning).

STEP 7: When the whole training set passed through the ANN, that makes an epoch. Redo more epochs.

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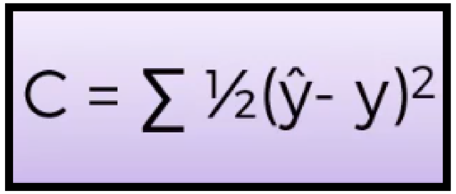
Algorithms used

- Neural Network architecture/topology: **Deep Feed Forward (DFF)**
- Activation function: **Rectifier** and **sigmoid**
- Training method/Optimizer:
  - **Backpropagation** to calculate the derivatives and
  - **Gradient Descent** which descends through the gradient, i.e. adjust the parameters
- Cost/loss function:



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