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Neural Networks

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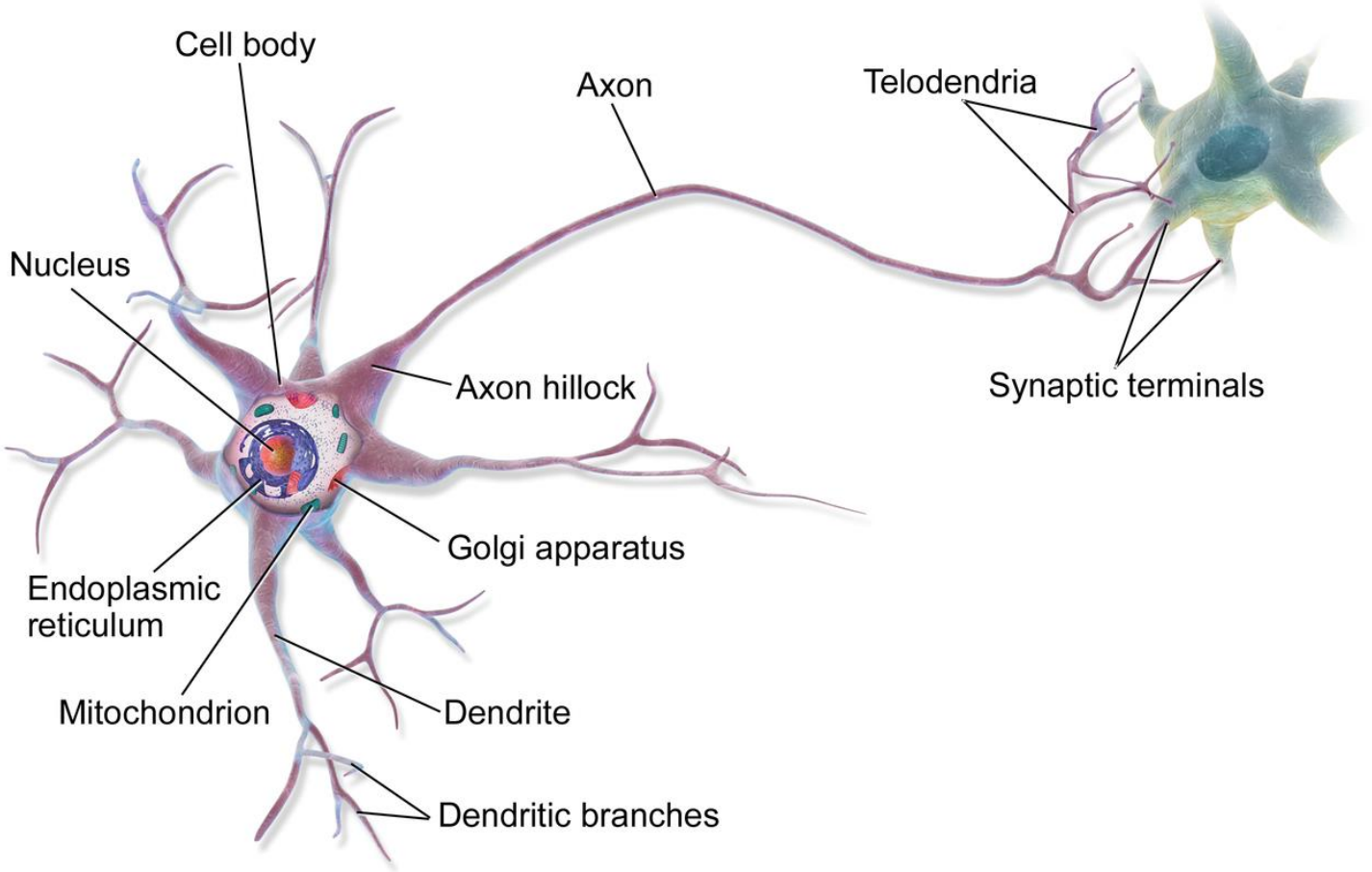
Biological Neuron



Source: https://en.wikipedia.org/wiki/Neuron

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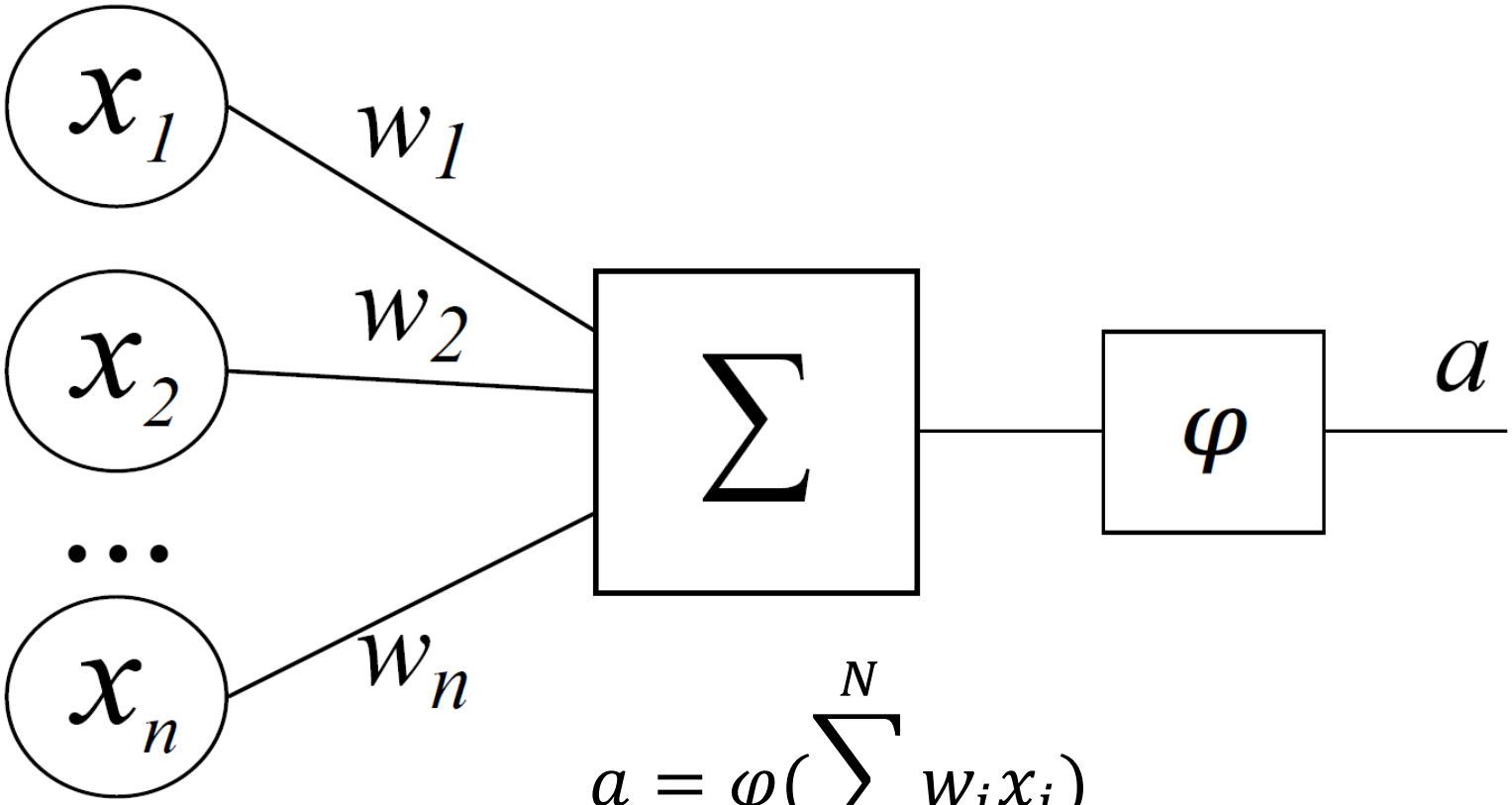
Artificial Neuron



$$a = \varphi\left(\sum_{i=1}^{N} w_i x_i\right)$$

McCulloch and Pitts

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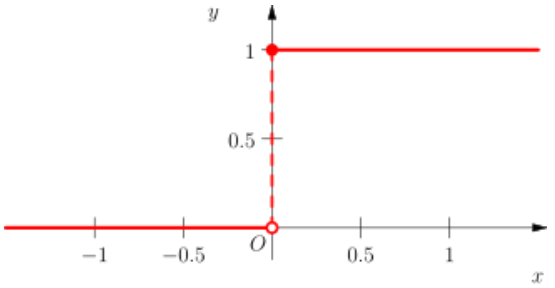
Activation functions

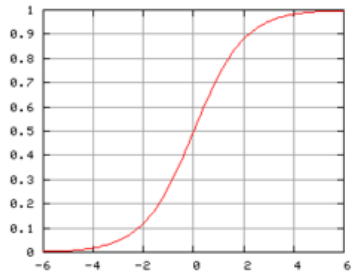
- Heaviside function

$$-\theta(x) = \begin{cases} 0, x < 0 \\ 1, x > 0 \end{cases}$$



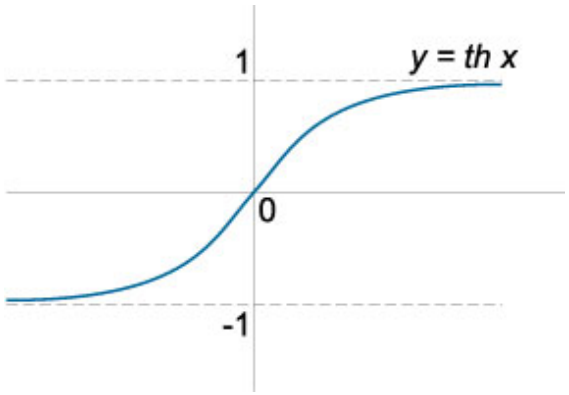
- Sigmoid functions

$$-\sigma(x) = \frac{1}{1+e^{-x}} \text{ (logistics)}$$



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

(hyperbolic tangent)



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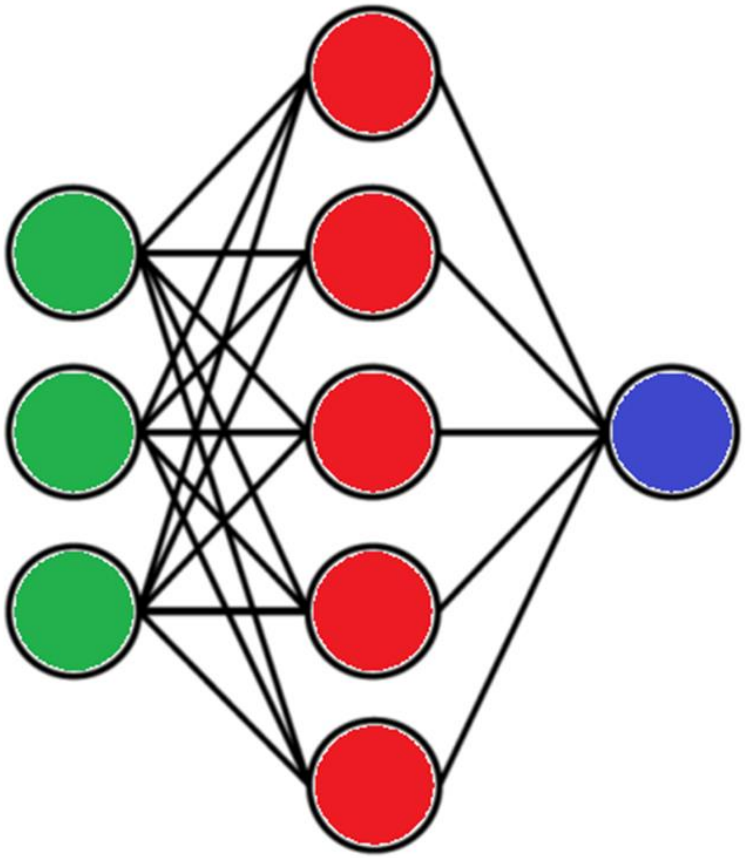
Neural Network



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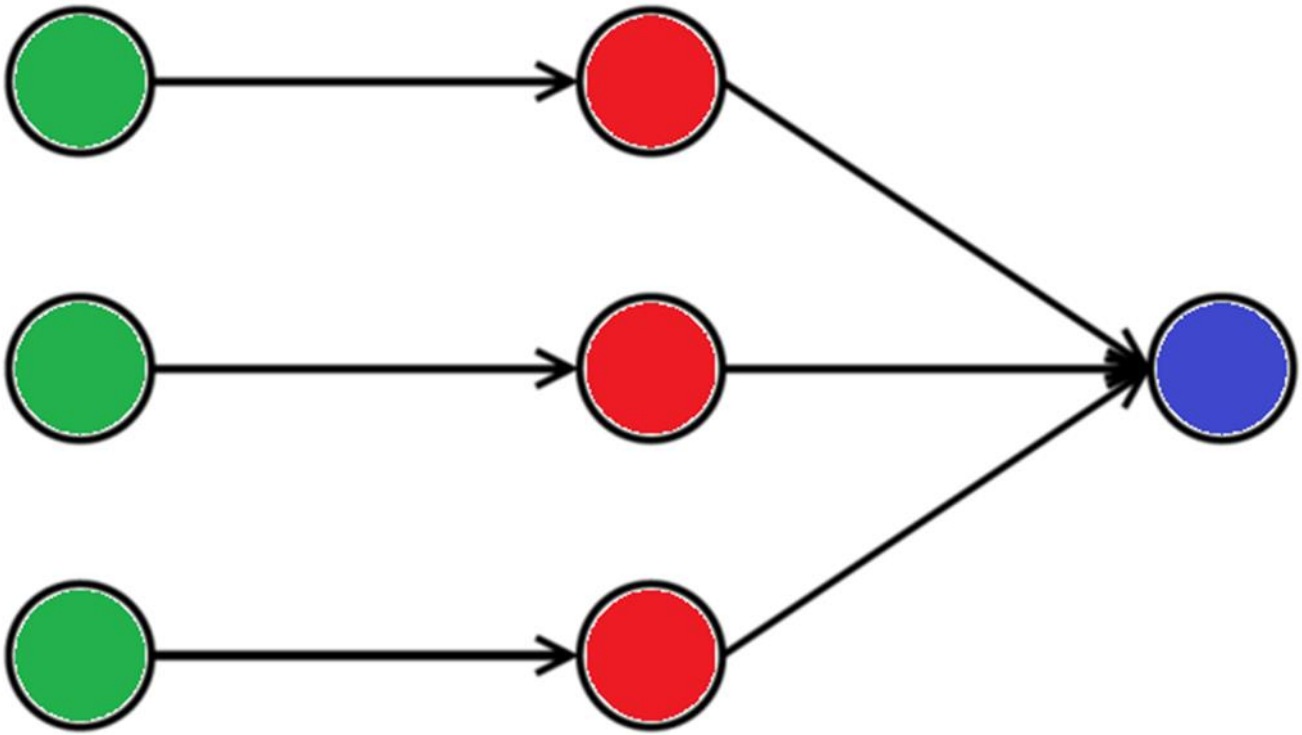
Feed Forward Network



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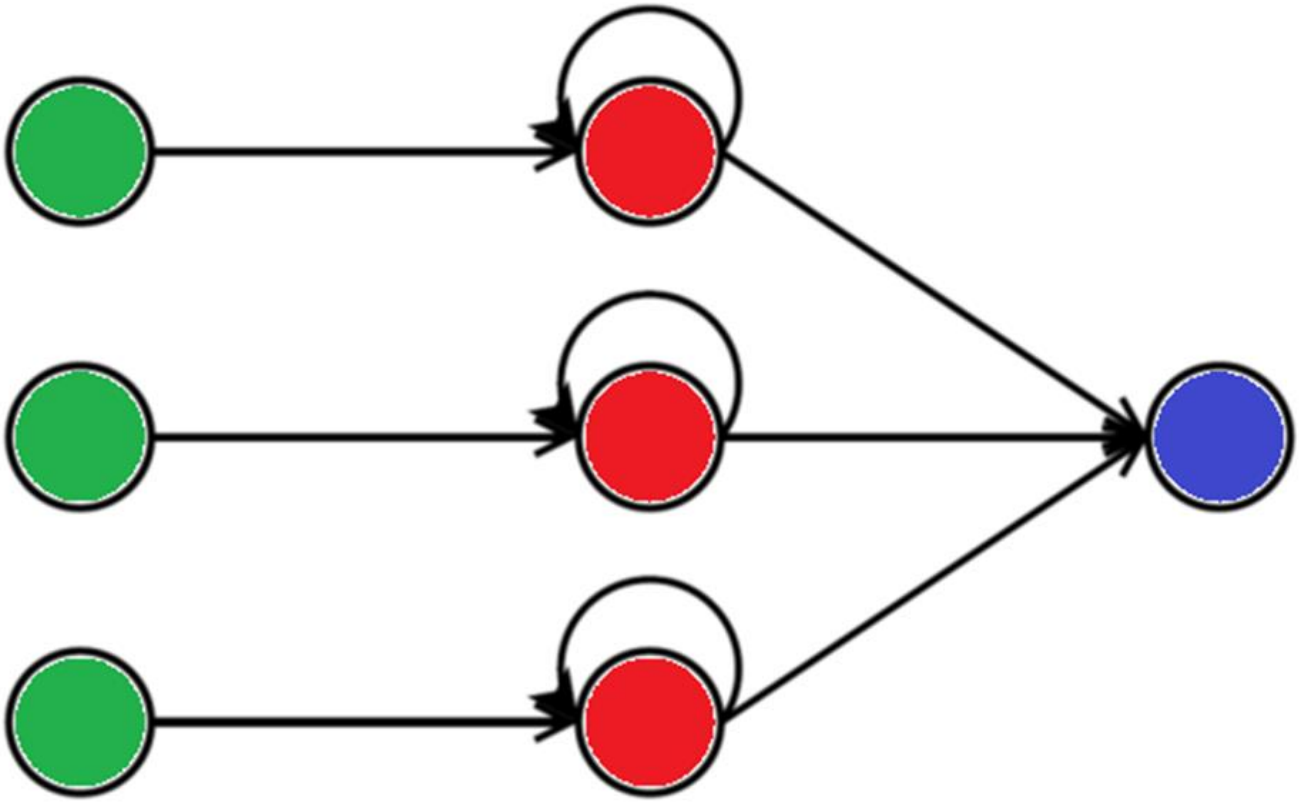
Recurrent Neural Network



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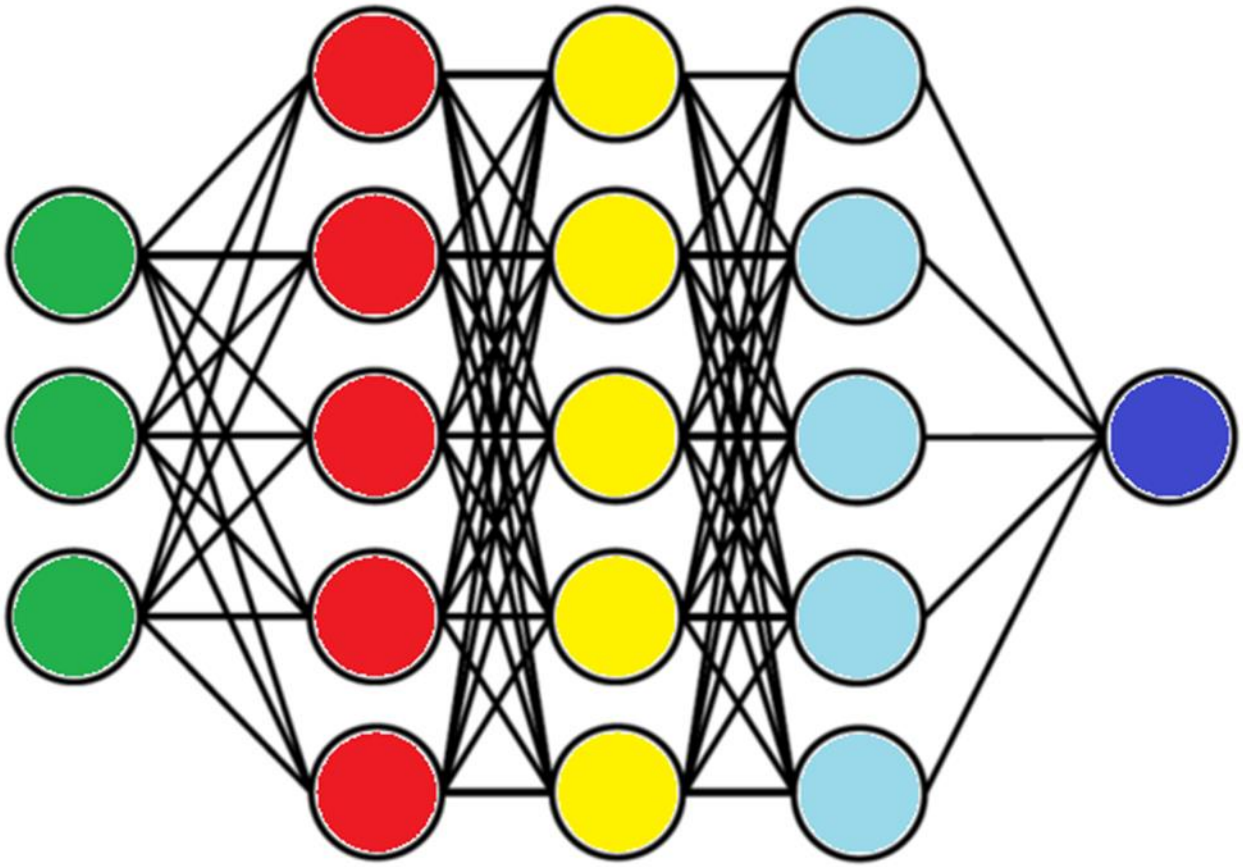
Deep Neural Network



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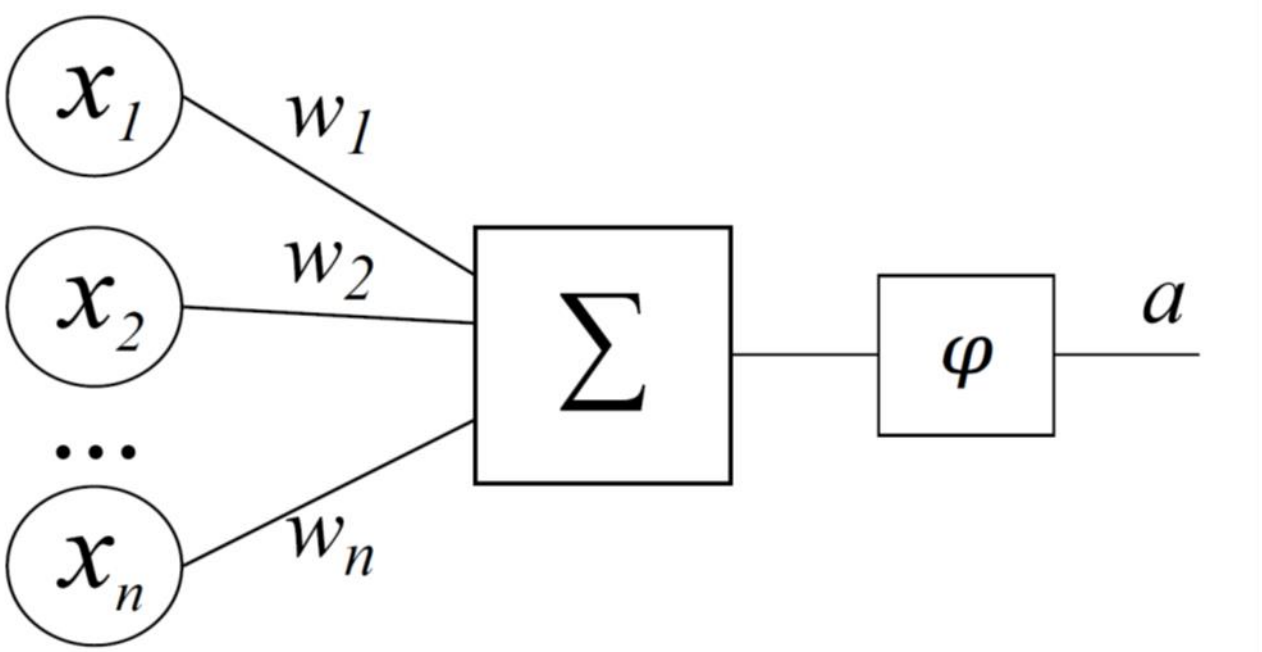
Training Neural Network

Training a model means setting its parameters so that the model best fits the training set.



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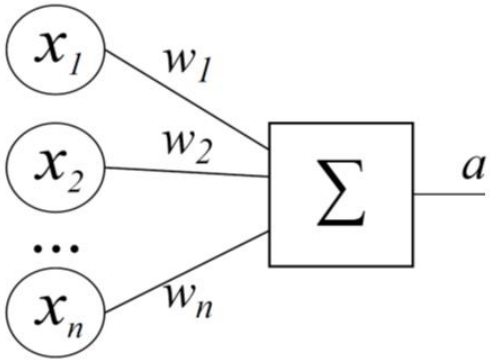
Training Linear Neuron



- Neuron output:

$$a = \sum_{i=1}^{N} w_i x_i$$

- Mean Square Error:

$$\varepsilon = \frac{1}{M} \sum_{j=1}^{M} (a_j - y_j)^2$$

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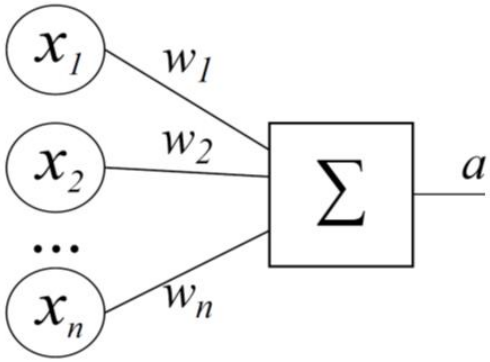
Delta rule



- Changing the weights:

$$w_i = w_i - \eta \frac{2}{M} \sum_{j=1}^{M} x_j^i (a_j - y_j)$$

η – learning rate

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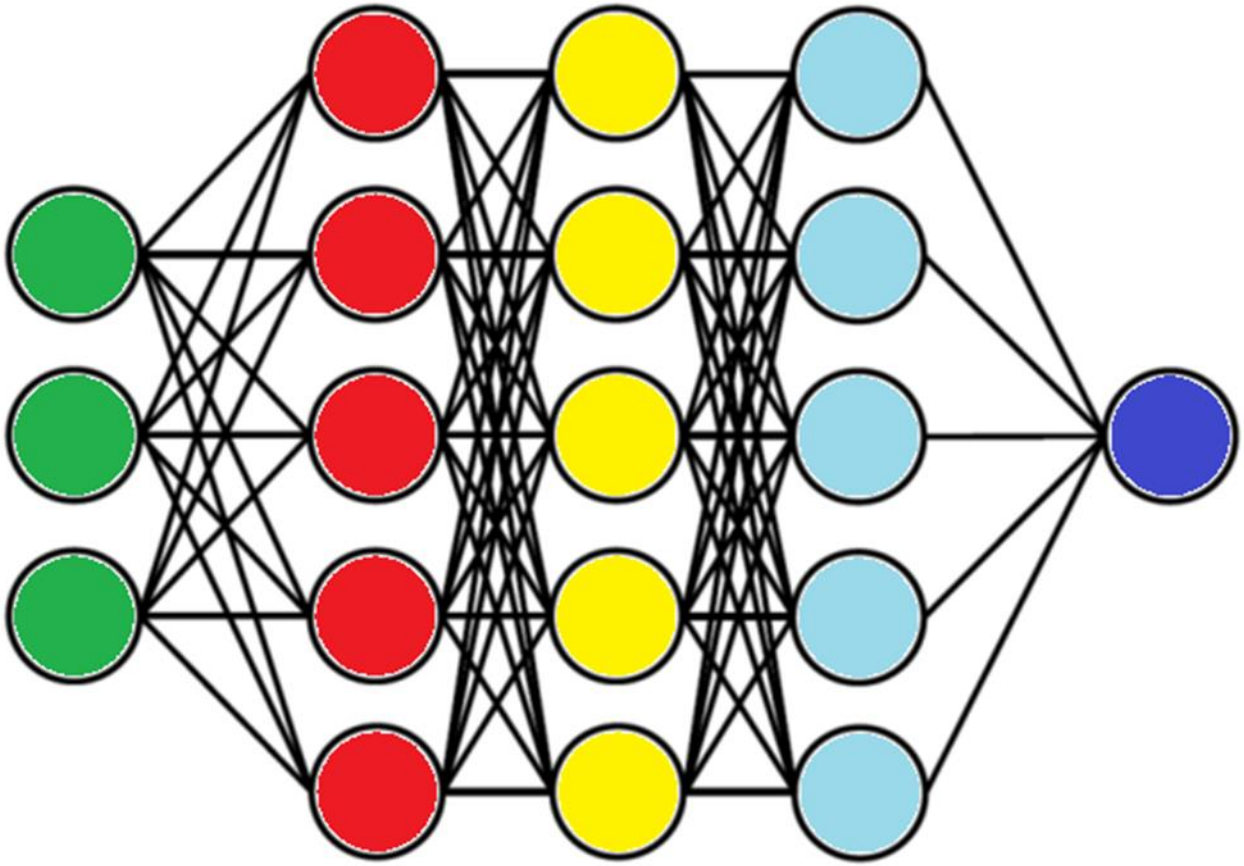
Backpropagation Algorithm



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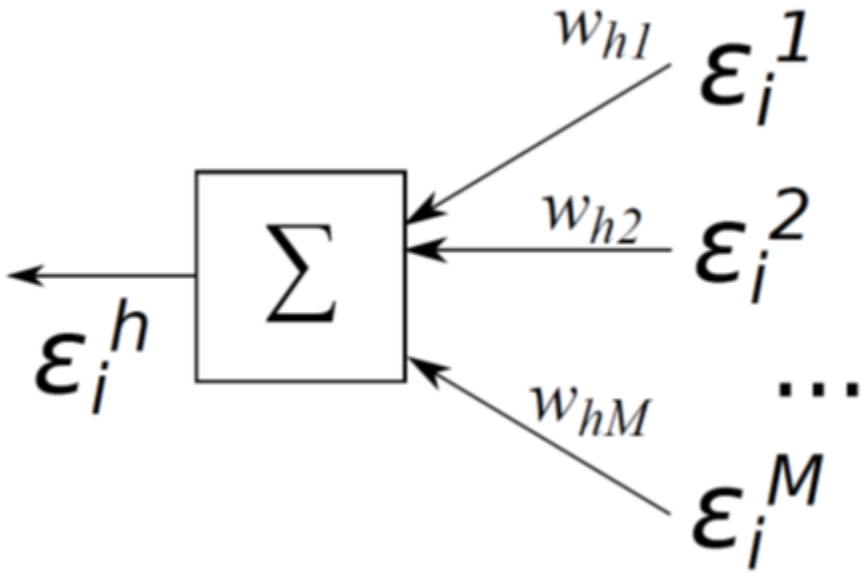
Error Backpropagation



$$\varepsilon_i^h = \sum_{m=1}^{M} \varepsilon_i^m w_{hm}$$

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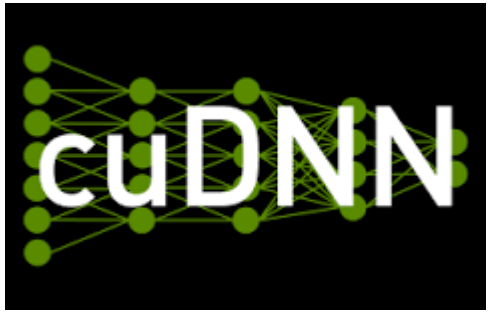
Deep Learning Libraries



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Deep Learning Stack

theano

Microsoft CNTK

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MNIST Dataset

Mixed National Institute of Standards and Technology database

Back-Propagation Applied to Handwritten Zip Code Recognition / *Y. LeCun, B. Boser, J. S. Denker et al*. 1989

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Neural Net for MNIST Recognition

- Input layer:
  - 800 neurons
- Output layer:
  - 10 neurons (the number of classes)
- Examples of the neural network architectures for MNIST
  - https://en.wikipedia.org/wiki/MNIST_database

How to prevent overfitting

- Training dataset
  - Dataset for training the neural network
- Test dataset:
  - Dataset for evaluating the performance and generalization of the neural network after the training

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Parameters and hyperparameters

- Parameters of the neural network (learned during training):
  - Weights of the neuron inputs
- Hyperparameters of the neural network (must be specified by developer):
  - Number of layers in the network
  - Number of neurons in the layers
  - Type of layers (dense, convolutional, recurrent, etc.)
  - Learning rate
  - Number of epoch for training

How to prevent overfitting

- Training dataset
  - Dataset for training the neural network
- Validation dataset
  - Dataset for evaluating the performance and generalization of the neural network **during the training** for tuning **hyperparameters**
- Test dataset:
  - Dataset for evaluating the performance and generalization of the neural network **after the training**

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Thank you!