Neural Networks

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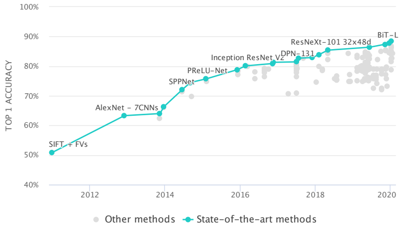
Overview

Preliminaries

- Neural networks/deep learning has gotten a lot of hype in recent years.
- In many areas, they have outperformed many traditional ML methodologies.

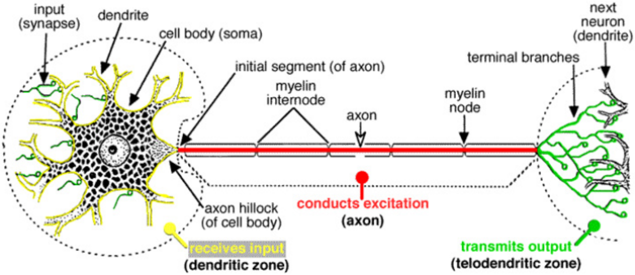


Artificial Neural Network

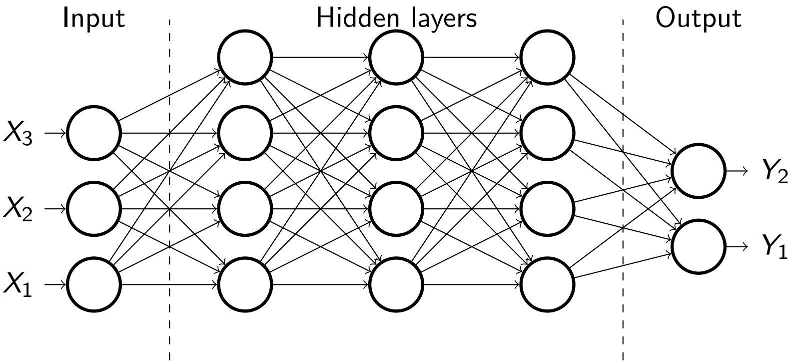
- An artificial neural network (NN) is a learning algorithm that is (very) loosely based on the structure of the brain.

Universal Approximation Theorem[1]

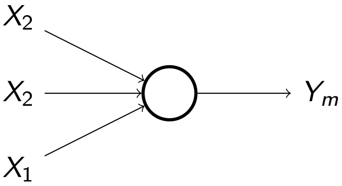
A feed-forward network with a single hidden layer containing a finite number of neurons can approximate continuous functions under mild assumptions on the activation function.



Neural Networks



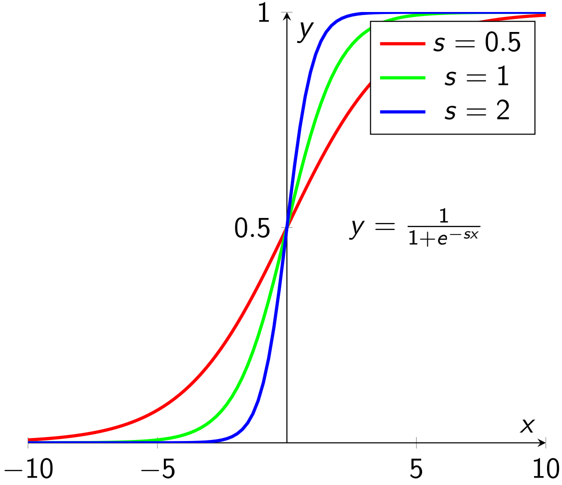
Neuron



$$Y_m = \sigma(\alpha_{0m} + \alpha_m^T \mathbf{X})$$

- Output of each neuron is a linear function of the inputs.
- In hidden layers, the output is passed through an *activation function* σ.

Sigmoid Activation Function



Fitting a Neural Network

- Model *weights* (α in the linear functions) are fitted by *back-propogation*, basically a form of gradient descent.
- Loss functions: squared error for regression, squared error or cross entropy for classification.
- To avoid overfitting, regularization (similar to ridge regression) is typically applied. E.g., *weight decay*:

$$J = \sum \alpha^2$$

Decisions for Neural Networks

- Number of hidden units and layers: generally error on the side of having too many hidden units than too few - flexibility is needed to capture non-linearities in the data.
- Extra weights can be shrunk to zero with appropriate regularization.
- Learning rate is a key parameter in NN as well as other model fitting. The learning rate controls the rate of gradient descent.

Bibliography

Balázs Csanád Csáji.
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PhD thesis.

The End