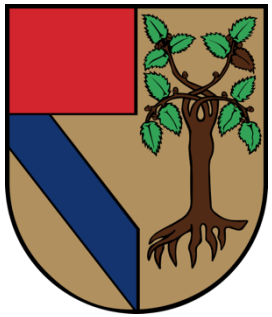

UNIVERSIDAD PANAMERICANA

APRENDIZAJE DE MÁQUINA

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Enrique González N.

Profesor

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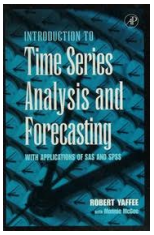
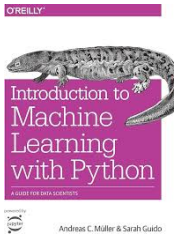
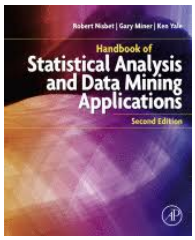
MATERIAL DE CONSULTA



Introduction to Time Series Analysis and Forecasting with applications and SAS and SPSS
Robert Yaffee
Academic Press

Introduction to Machine Learning with Python
Andreas C. Müller & Sarah Guido
O'Reilly



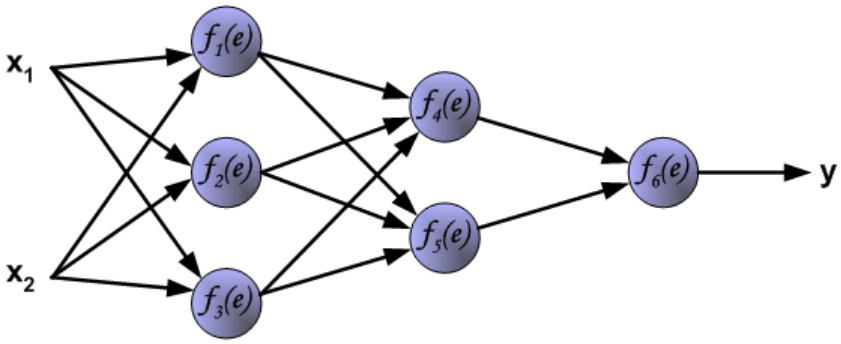


Handbook of Statistical Analysis and Data Mining Applications
Robert Nisbet, Gary Miner & Ken Yale
Academic Press

NEURAL NETWORKS (NN)

- Neural networks (NN), are mathematical structures or computational models inspired by the way biological neural networks in the human brain process information.

- NN are composed of a hierarchical structure of layers:
  - Nodes as neurons with activation functions.
  - Edges or connections with parameters (weights and biases) between the nodes.
  - The flow of the structure goes from input to output.



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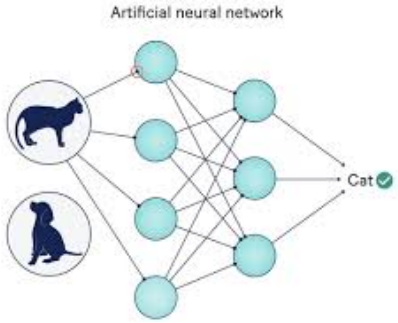
- NN are a spezialed type of graph known as DAG (Directed Acylic Grapht):
  - They have one-way direct connections, the information flows in one direction.
  - No path returns to a previously visited node, so the edges are acylic.
  - The representation of nodes (neurons) and weighted edges (connections) aligns with the fundamental concept of graphs.

- Is mostly used for pattern recognition, data classification, regressions, and predictions, amongst other tasks.



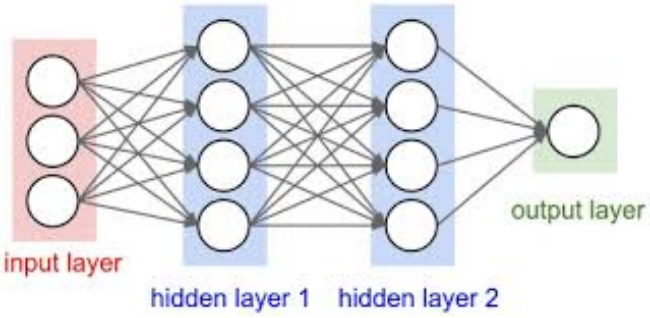
REPRESENTATION

The architecture or hierarchical structure of NN is an arrangement composed by:

- Neurons (Nodes):
  - AKA nodes or units.
  - These are the basic units of NN.
  - Each neuron receives input from the previous layer, processes them, and passes the result to the next layer.

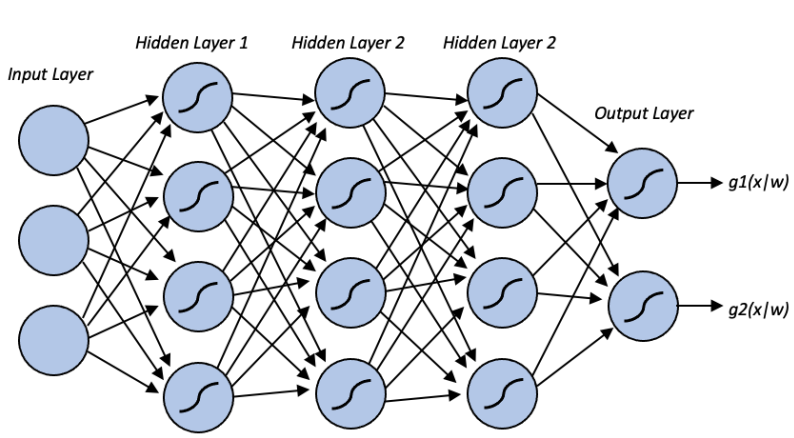
- Layers:
  - Input Layer:
    - The first layer that receives the raw input data.
    - Each neuron in this layer represents a feature of the input data.
  - Hidden Layers:
    - Intermediate layers where computations are performed to transform the input data.
    - At least one hidden layer.
    - There can be multiple hidden layers.
    - Each layer consists of multiple neurons that apply transformations to the input data.
  - Output Layer:

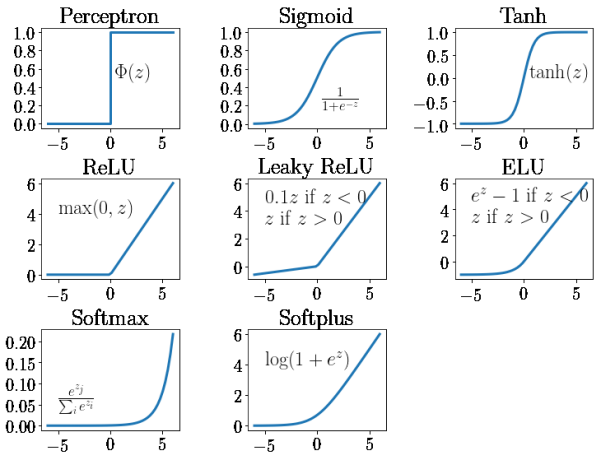
- Is the last layer.
- It produces the final output of the network.
- The number of neurons in this layer depends on the tasks (e.g. number of output variables).



- Weights and Biases:
  - Each edge (connection) between neurons has associated parameter values:
    - Weights: determine (represent) the strength of the connection between neurons.
    - Biases: help adjust the output along with the weighted sum of inputs.
  - These parameter estimates are analogous to the slope and intercept values that we solve when we fit a straight line to data.
  - A NN starts with unknown (random) parameter values:
    - The parameters are learned during the training process.
    - The parameters are estimated when the NN is fitted to the data set.

- Activation Functions:
  - Functions applied to the output of each neuron (in the hidden and output layer) to introduce non-linearity:
    - They bent or curved the lines.
  - Functions allow the network to learn and model complex patterns and relationships:
    - Work as a “building block” for fitting a squiggle to data.
  - Common activation functions include:
    - softplus
    - sigmoid
    - ReLU (Rectified Linear Unit)
    - tanh



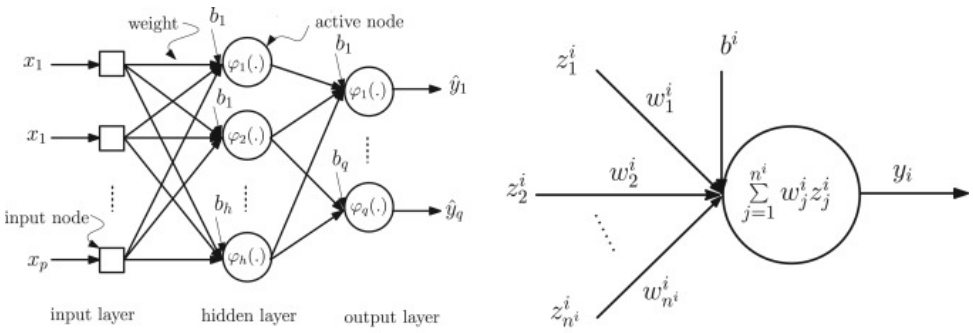


TRAINING PROCESS

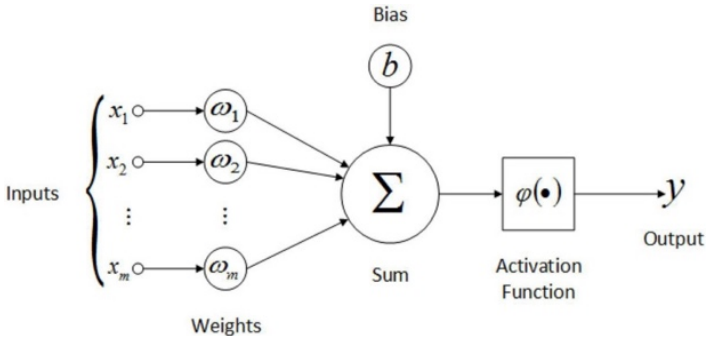
- NN learns from data by adjusting their parameters (weights and biases) through training.

- The training process has two major steps:
  - Feedforward Propagation:
    - The process where input data is passed through the network layer by layer to generate an output.
  - Backpropagation:
    - The learning process in which the parameters are updated to minimize the error.

- Feedforward Propagation:
  - The data is fed into the input layer.
  - The data is passed through each hidden where:
    - The weights are applied-
    - The inputs and bias terms are added.
    - Each neuron (in the hidden and output layer) applies its activation function to produce the output.
  - The transformed data is passed to the output layer to generate the final prediction.



(a) Three-layer feedforward neural network (b) Node of the network



- Backpropagation:
  - The learning process in which the network adjusts its weights and biases based on the error of the output compared to the desired result.
  - The process is done by calculating the gradient of the function being optimized with respect to each parameter.
  - Learning Rate:
    - Is a hyperparameter that controls the step size along the training.
    - It affects the speed and convergence of the training process.
  - Epochs:
    - One complete pass through the entire training process (FF and BP).
    - Multiple epochs are used to iteratively improve the model.