Neural Networks

A Very Basic Introduction

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Neural Networks

- A "neural network" is a machine learning technique that tries to mathematically emulate the way the brain learns.
- It is based on the idea of an "artificial neuron".

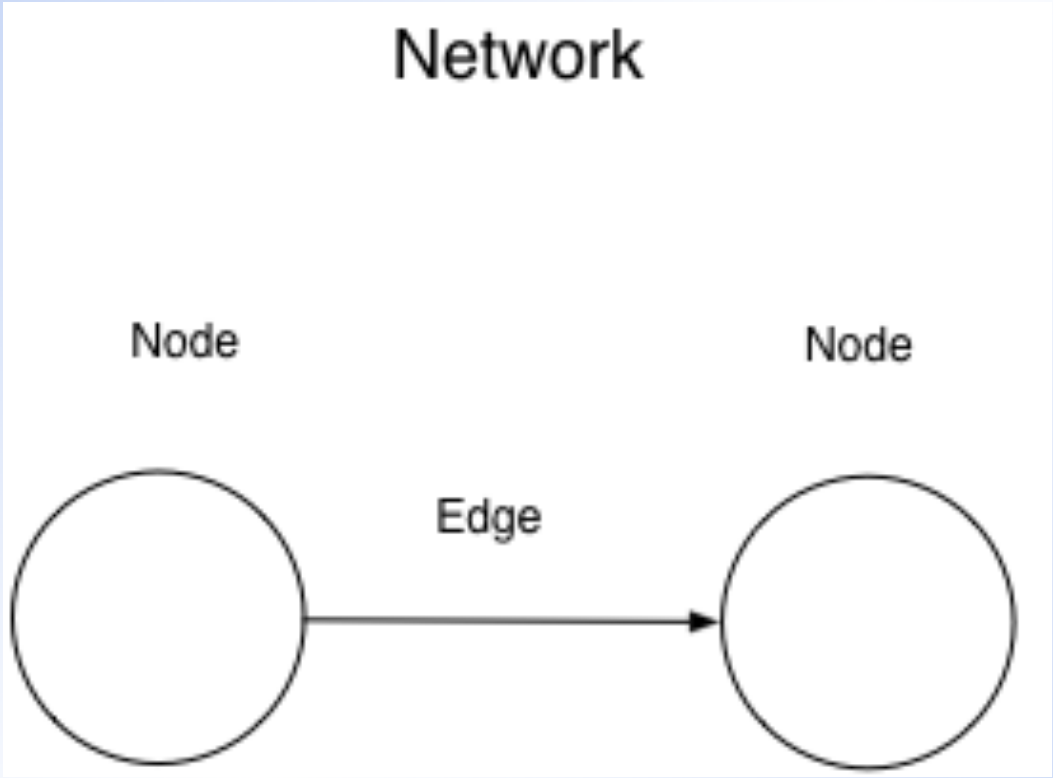
Neural Networks

- The neural network is "trained" to look at a set of input values and "predict" an associated output.
- Conceptually and mathematically relatively simple, they can produce remarkable results.

Neural Networks

- A network is a set of "nodes" connected by a set of "edges".

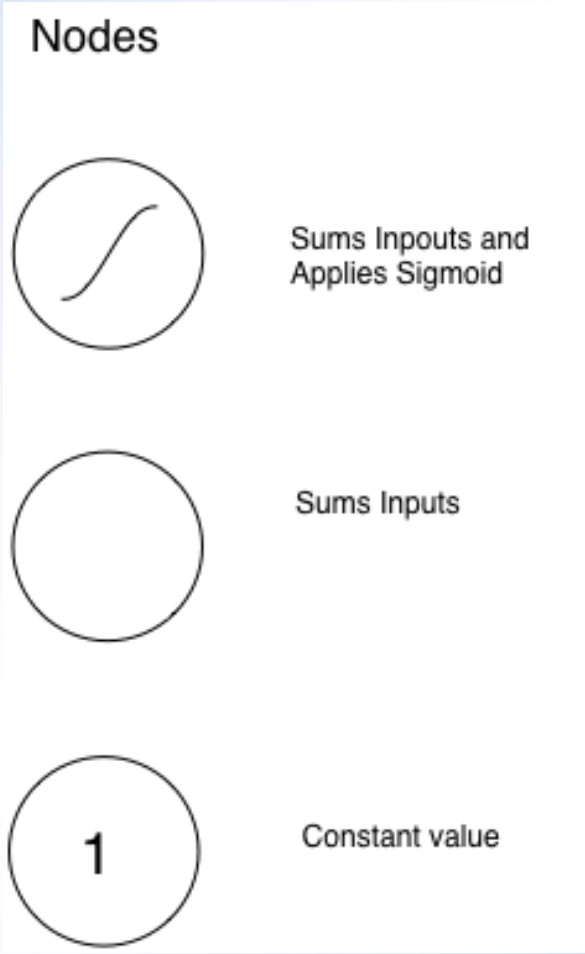
Network



Nodes

- There are three types of nodes:
  - Artificial neurons
    - Sum their inputs
    - Apply an activation function, usually a sigmoid
  - Input and output nodes
    - Sum their inputs
  - Bias nodes
    - Present a constant value of one

Nodes

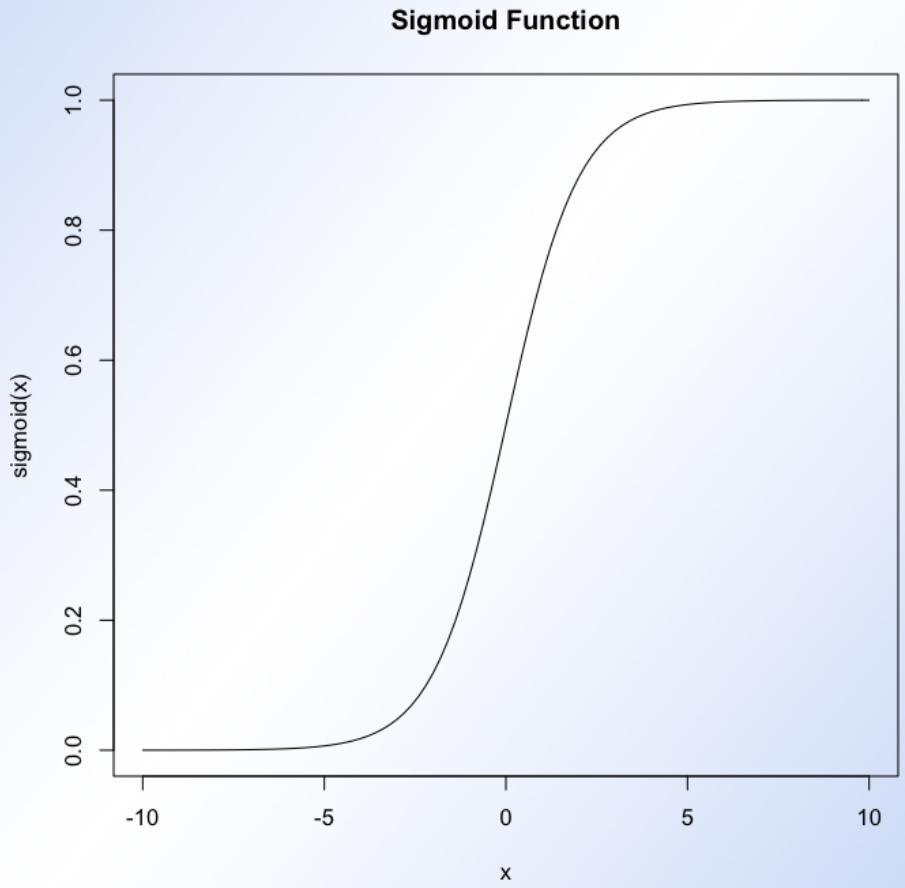


Sigmoid Function

- The "sigmoid" or "logistic" function maps the real numbers from minus infinity to infinity to the range from zero to one.

$$\frac{1}{1+e^{-x}}$$

Sigmoid Function



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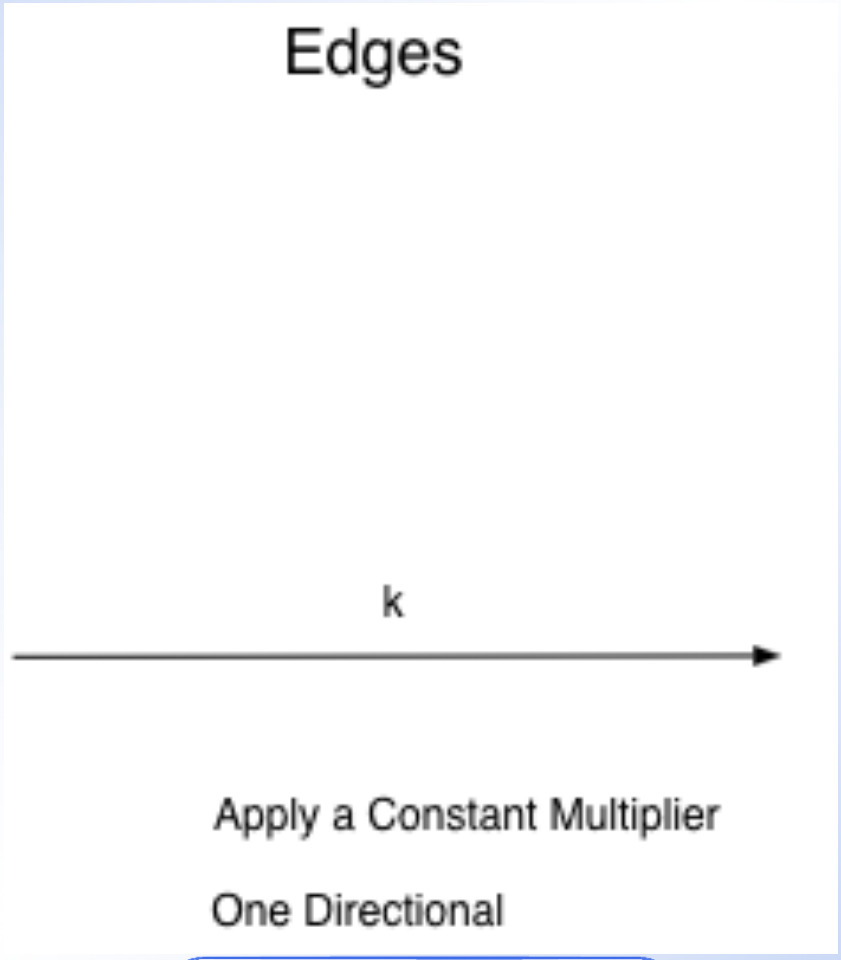
Edges

- Edges apply a constant multiplier to their input and present the result to their output.

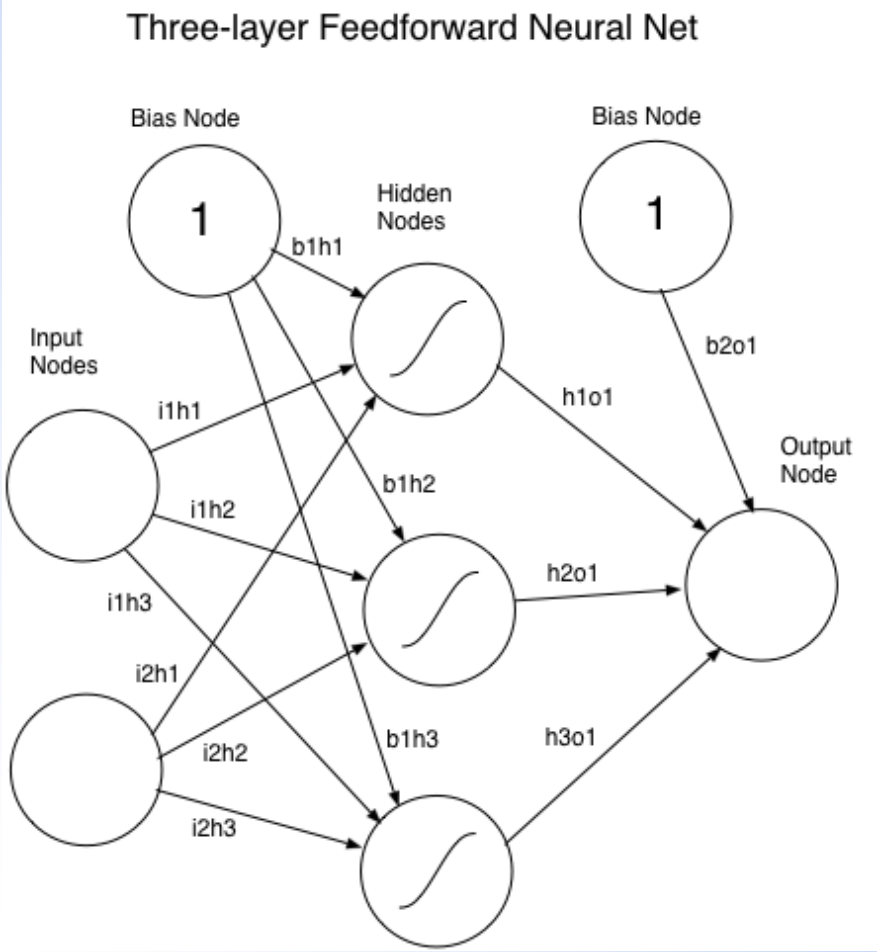
Edges



Neural Networks

- The following diagram represents a neural network with three layers:
  - An input layer with two inputs
  - An output layer with one output
  - A "hidden layer" with three artificial neurons
  - Edges connecting the nodes

Neural Network



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"Training"

- A neural network is "trained" in an iterative process of multiple steps referred to as "epochs".
- It is trained using a set of data with multiple "instances" or "examples". Each example has a value for each input and a value for each associated output.

"Training"

- An initial set of multipliers are randomly chosen, one for each of the edges.
- At each "epoch", each of the training examples are presented to the network in turn and the output compared to the training output. The error values are accumulated.
- At the end of each "epoch", the multipliers are adjusted in a way that will reduce the total error.

"Training"

- This process is repeated until the cumulative error for an epoch is below a threshold, or a certain number of epochs have occurred.
- At this point, the network is "trained".

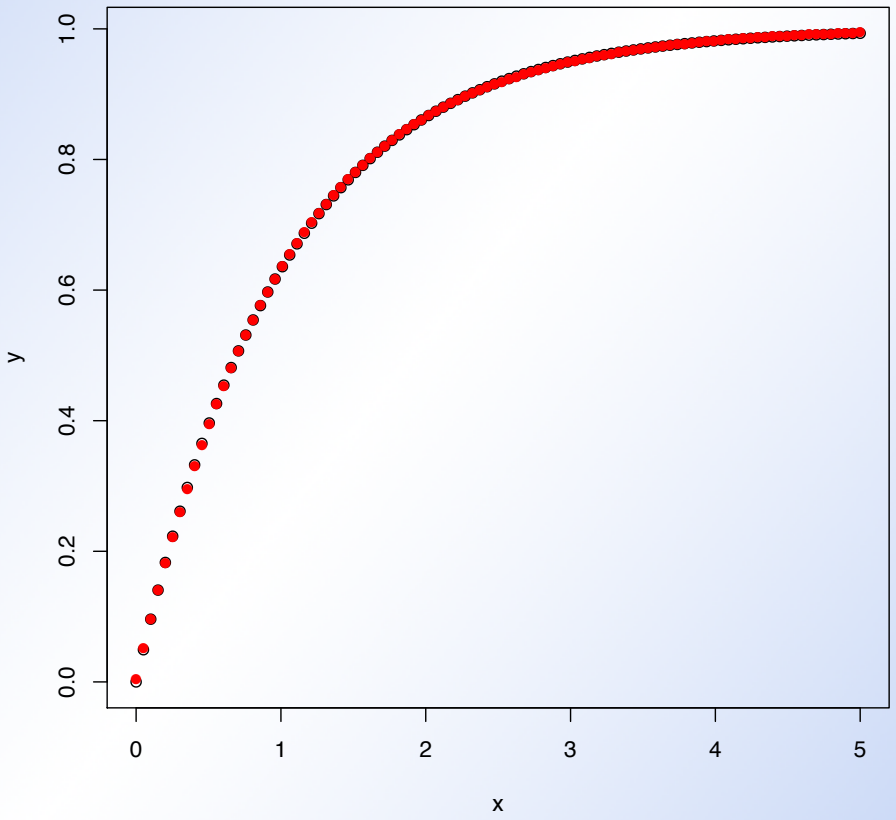
Example

- A neural network with one input, three hidden neurons, and one output was built in R using the nnet package and trained with data representing the equation

$$y = 1 - e^{-x}$$

- The training x data was 100 points evenly spaced on the interval (0,5).

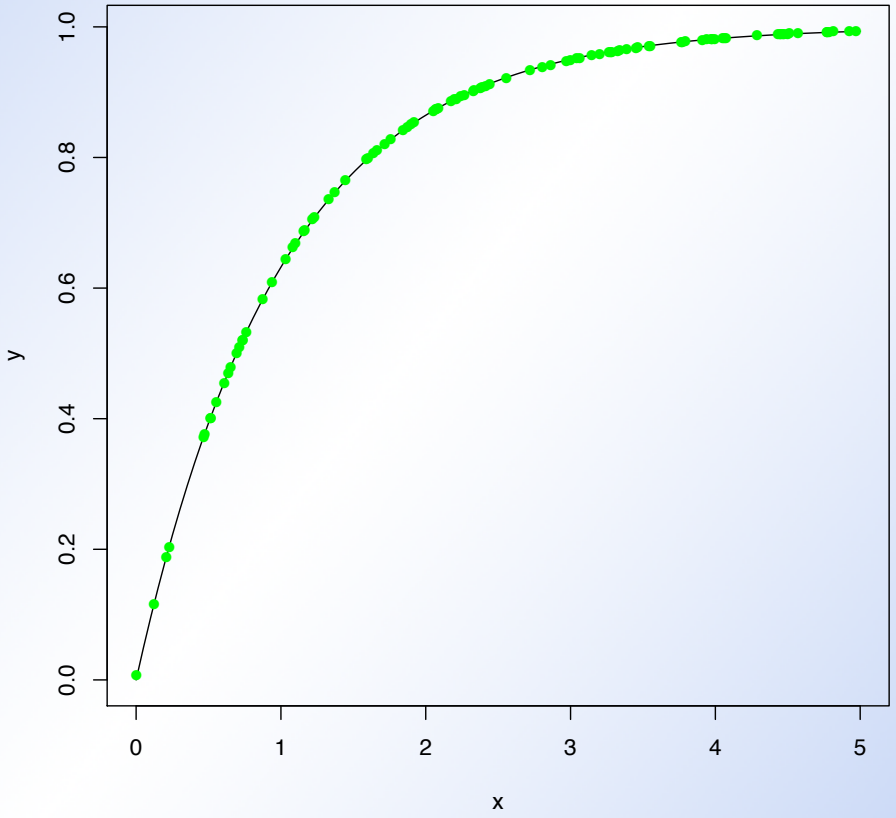
Example – Training Data



Example - Results

- After training, the model was presented with a number of random x values, also in the interval (0,5).
- The resulting x,y pairs are plotted in green superimposed on the line representing the training data.

Example - Results



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Neural Networks

- Neural networks can have multiple outputs.
- Neural networks can also be used to predict categorical values. ("Yes" or "No"; "Red", "Blue" or "Green")
- Neural networks can have more than one hidden layer ("deep learning")