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Machine Learning

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Lesson 5.1

Neural Network

Contents

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What is Neural Network

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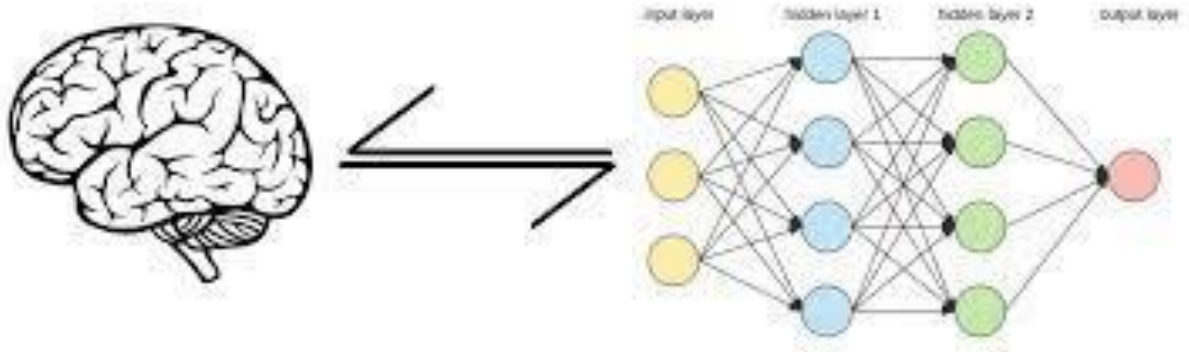
- Artificial neural networks are forecasting methods that are based on simple mathematical models of the brain.

- They allow complex nonlinear relationships between the response variable and its predictors.

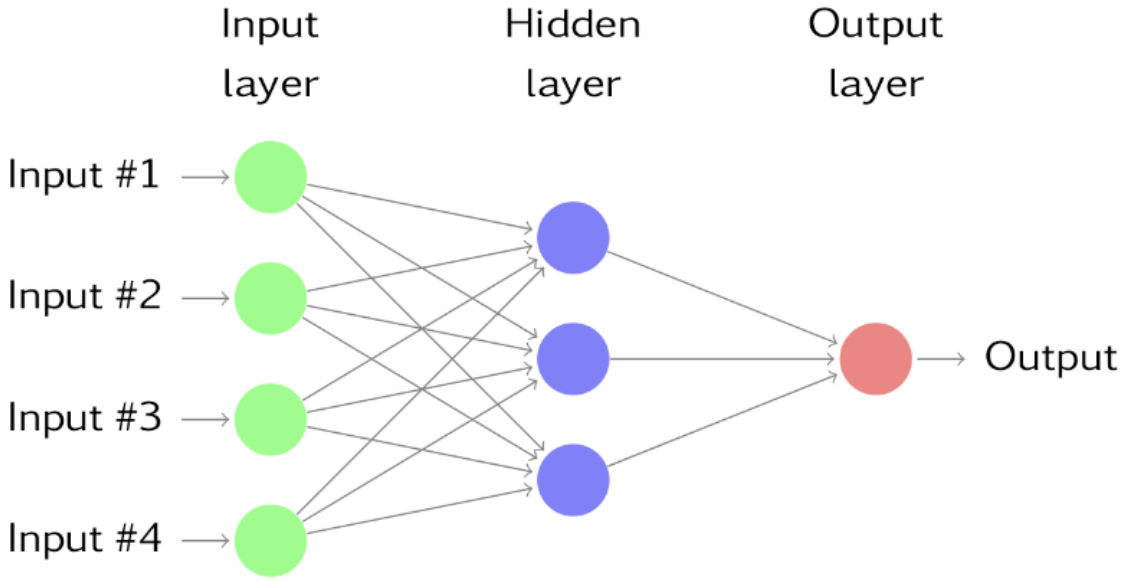


Human Brain

Neural Network

What is Neural Network

- A neural network can be thought of as a network of “neurons” which are organised in layers.
- The predictors (or inputs) form the bottom layer, and the forecasts (or outputs) form the top layer.
- There may also be intermediate layers containing “hidden neurons”.



Simplest Neural Network

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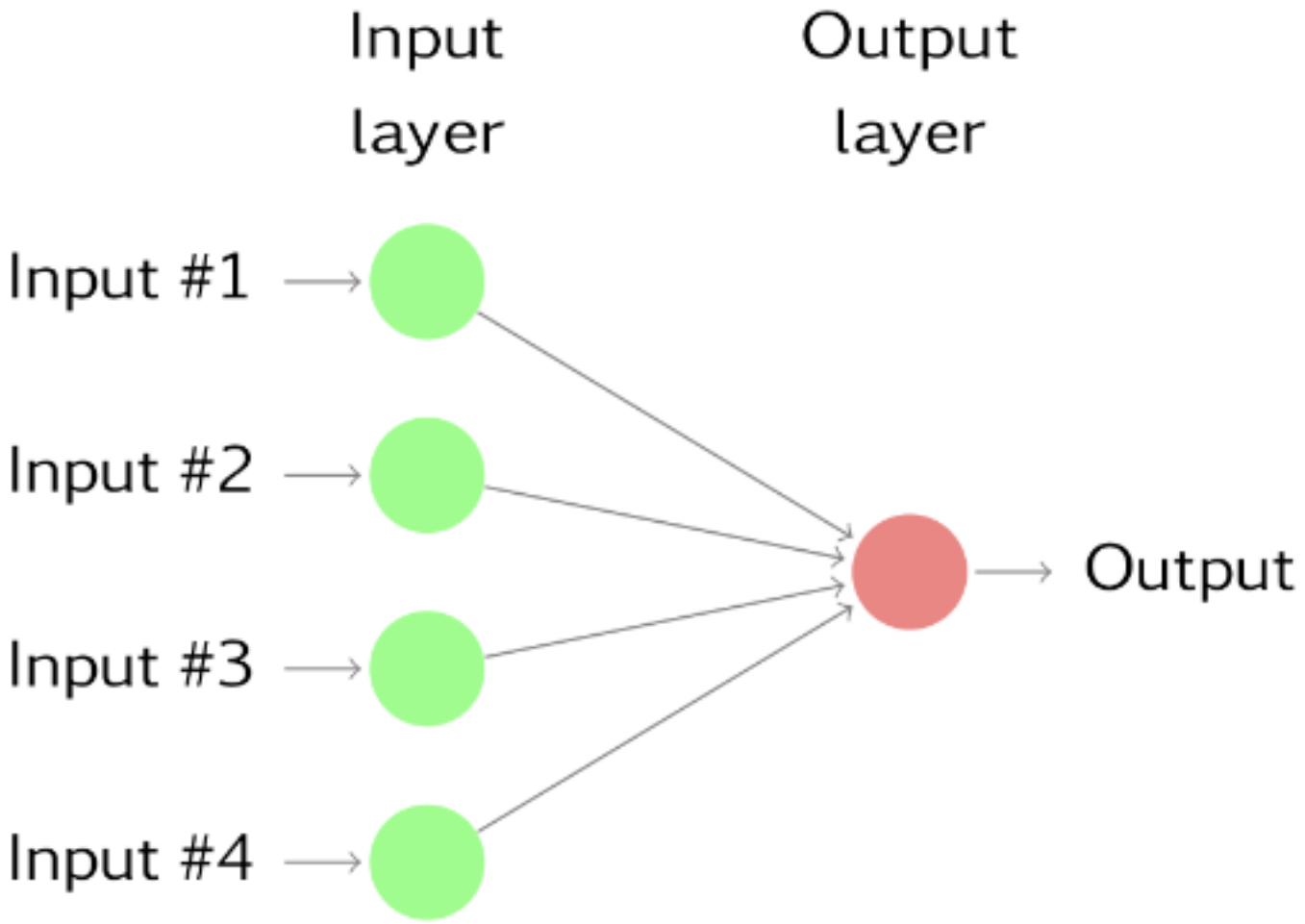
- The simplest networks contain no hidden layers and are equivalent to linear regressions.
- The figure shows the neural network version of a linear regression with four predictors.



Simplest Neural Network

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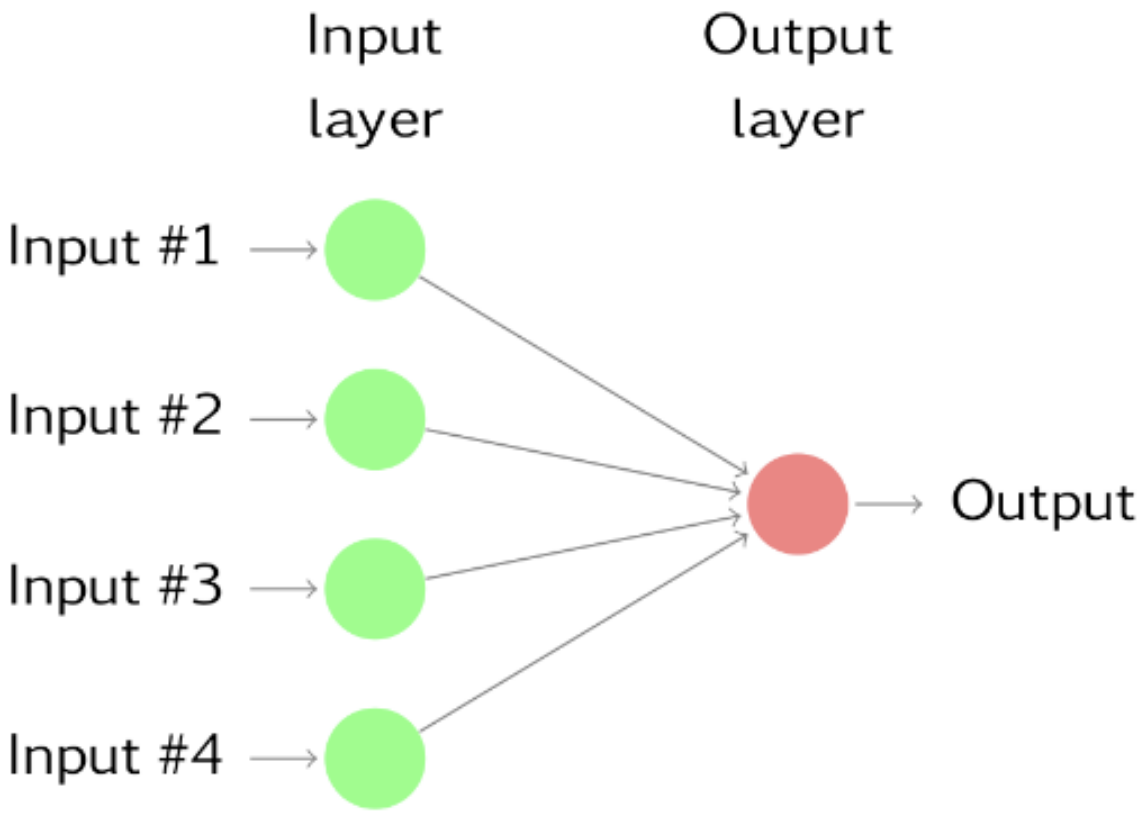
- The coefficients attached to these predictors are called “weights”.
- The weights are selected in the neural network framework using a “learning algorithm” that minimises a “cost function” such as the MSE.



Simplest Neural Network

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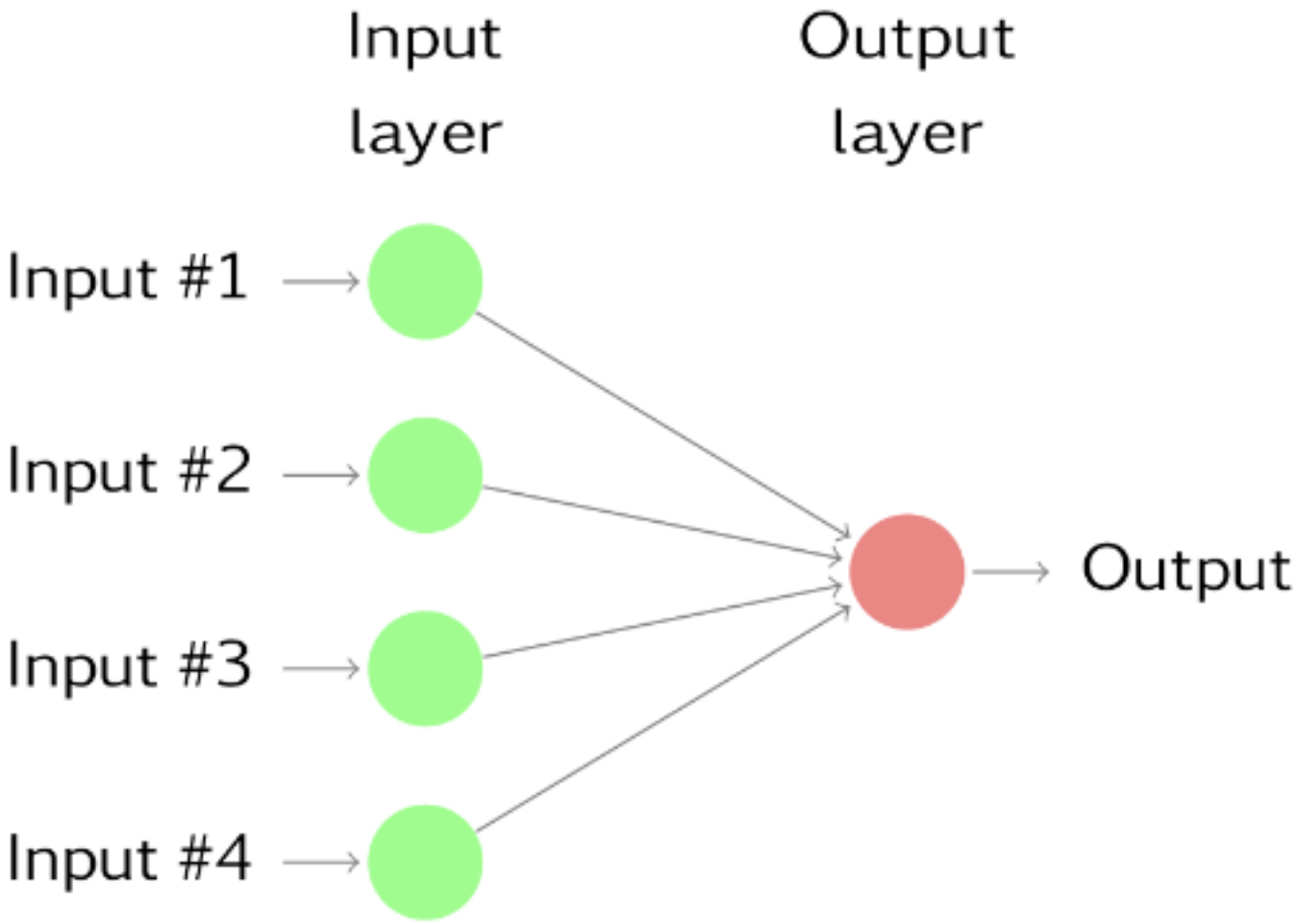
- The forecasts are obtained by a linear combination of the inputs.
- Of course, in this simple example, we can use linear regression which is a much more efficient method of training the model.



Multilayer Neural Network

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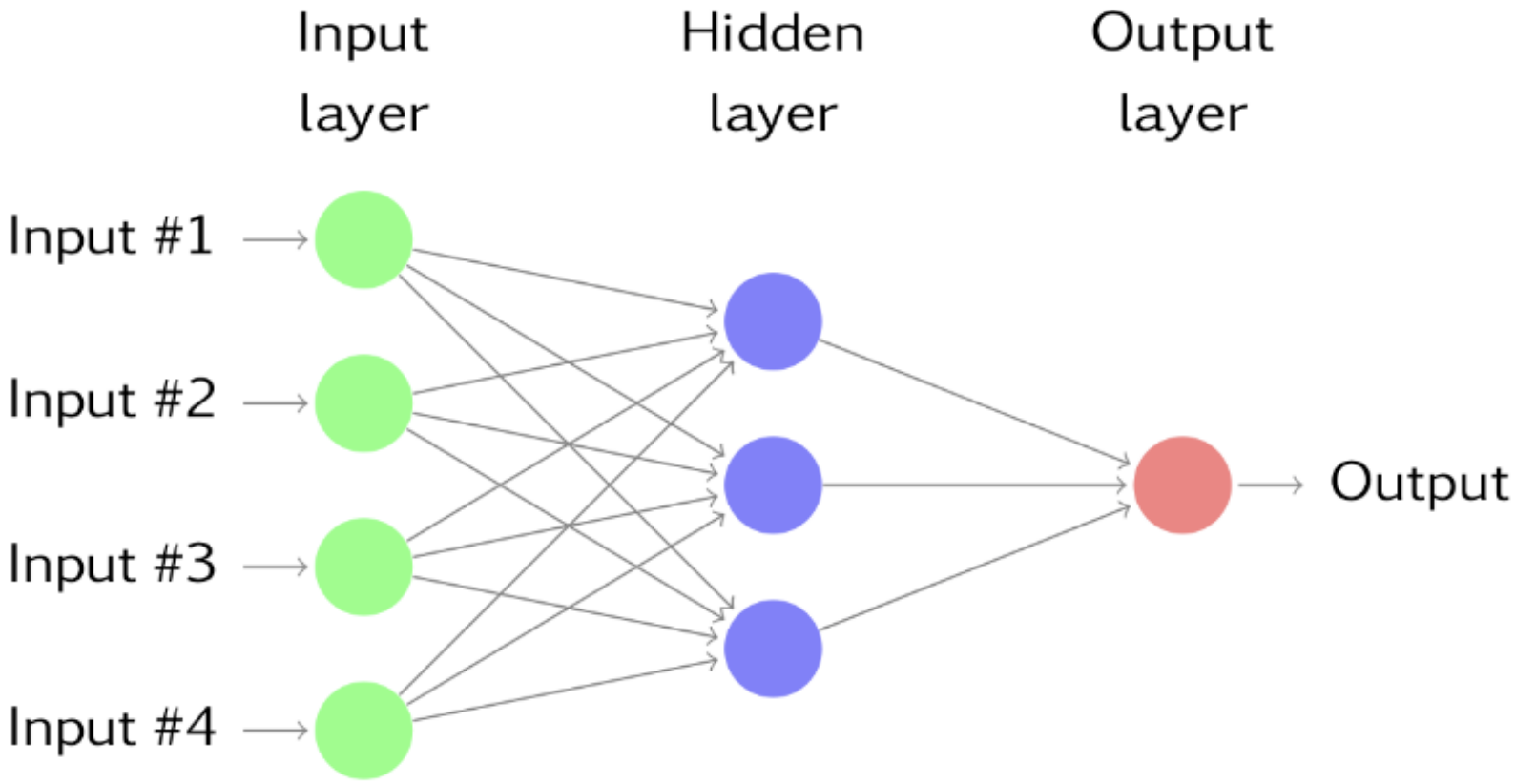
- Once we add an intermediate layer with hidden neurons, the neural network becomes non-linear.
- A simple example is shown in Figure.



Multilayer Neural Network

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- This is known as a *multilayer feed-forward network*, where each layer of nodes receives inputs from the previous layers.
- The outputs of the nodes in one layer are inputs to the next layer.
- The inputs to each node are combined using a weighted linear combination.
- The result is then modified by a nonlinear function before being output.

Multilayer Neural Network

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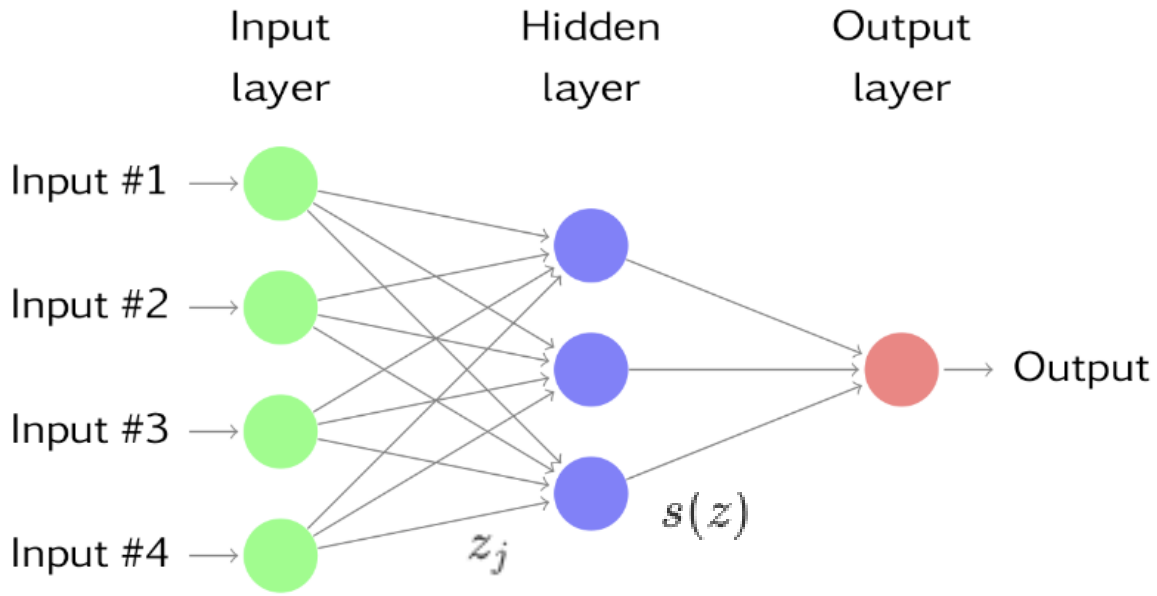
- For example, the inputs into hidden neuron in Figure are combined linearly to give:

$$z_j = b_j + \sum_{i=1}^{4} w_{i,j} x_i$$

- In the hidden layer, this is then modified using a nonlinear function such as a sigmoid, to give the input for the next layer.

$$s(z) = \frac{1}{1 + e^{-z}}$$



This tends to reduce the effect of extreme input values, thus making the network somewhat robust to outliers

Training of Neural Network

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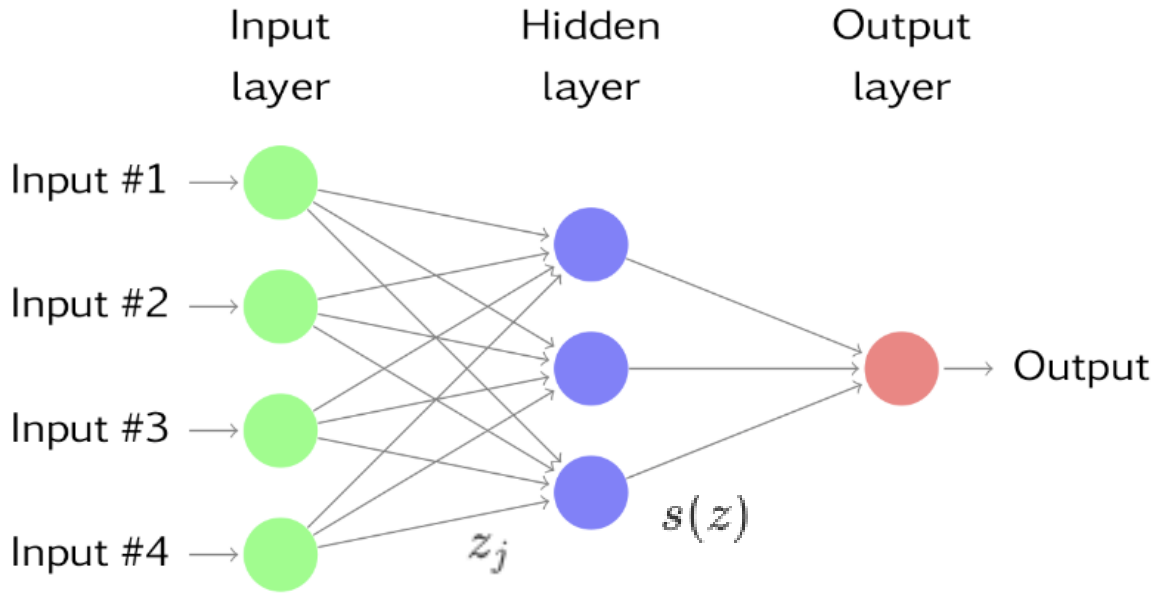
- The parameters $b_1, b_2, b_3 \quad w_{1,1}, \ldots, w_{4,3}$ are "learned" from the data.
- The values of the weights are often restricted to prevent them from becoming too large.
- The parameter that restricts the weights is known as the "decay parameter", and is often set to be equal to 0.1.



$$z_j = b_j + \sum_{i=1}^{4} w_{i,j} x_i$$

Training of Neural Network

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- The weights take random values to begin with, and these are then updated using the observed data.
- Consequently, there is an element of randomness in the predictions produced by a neural network.
- Therefore, the network is usually trained several times using different random starting points, and the results are averaged.
- The number of hidden layers, and the number of nodes in each hidden layer, must be specified in advance.

Training of Neural Network

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- This figure shows an example of forecasts from a neural network with ten lagged inputs and one hidden layer containing six neurons.

- In seminar and lab session, we will learn how to train a neural network using Python