The Feedforward Process- Finding h⃗

In this section we will look closely at the math behind the **feedforward** process. With the use of basic Linear Algebra tools, these calculations are pretty simple!

Assuming that we have a single hidden layer, we will need two steps in our calculations. The first will be calculating the value of the hidden states and the latter will be calculating the value of the outputs.
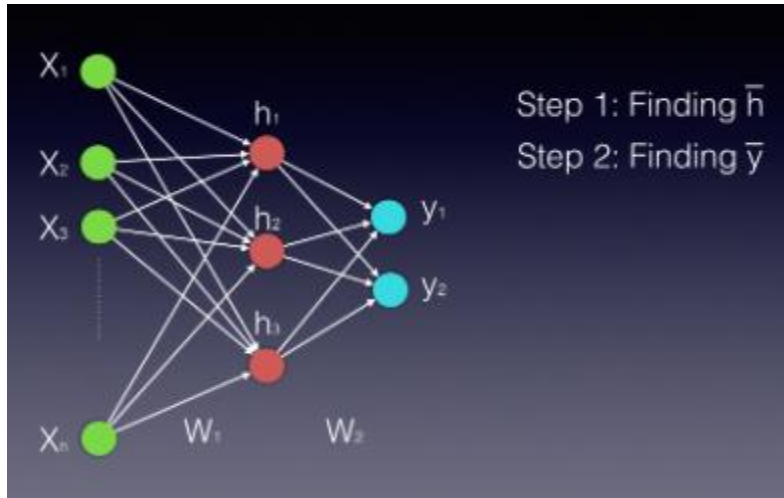
Notice that both the hidden layer and the output layer are displayed as vectors, as they are both represented by more than a single neuron.

Our first video will help you understand the first step- **Calculating the value of the hidden states**.

As you saw in the video above, vector $h'^{\rightarrow}$ of the hidden layer will be calculated by multiplying the input vector with the weight matrix W^1 the following way:

$$\overrightarrow{h'} = (\vec{x}\, W^1)$$

Using vector by matrix multiplication, we can look at this computation the following way:

$$
\begin{bmatrix} h'_1 & h'_2 & h'_3 \end{bmatrix} = \begin{bmatrix} x_1 & x_2 & x_3 & \text{.......} & x_n \end{bmatrix} \cdot \begin{bmatrix} W_{11} & W_{12} & W_{13} \\ W_{21} & W_{22} & W_{23} \\ \vdots & & \\ W_{n1} & W_{n2} & W_{n3} \end{bmatrix}
$$

Equation 17

After finding $h'^{\rightarrow}$ we need an activation function.

The symbol we use for the activation function is the Greek letter phi: ϕ.

This activation function finalizes the computation of the hidden layer's values.

We can use the following two equations to express the final hidden vector $h'^{\rightarrow}$:

$h^{\rightarrow} = \phi(\vec{x}\, W^1)$

or

$h^{\rightarrow} = \phi(\overrightarrow{h'})$

Since W_{ij} represents the weight component in the weight matrix, connecting neuron *i* from the input to neuron *j* in the hidden layer, we can also write these calculations using a **linear combination**: (notice that in this example we have *n* inputs and only 3 hidden neurons)

$$h_1 = \Phi(x_1 W_{11} + x_2 W_{21} + ... + x_n W_{n1})$$

$$h_2 = \Phi(x_1 W_{12} + x_2 W_{22} + ... + x_n W_{n2})$$

$$h_3 = \Phi(x_1 W_{13} + x_2 W_{23} + ... + x_n W_{n3})$$

Equation 18

More information on the activation functions and how to use them will be found in the next lesson (Introduction to Neural Networks).