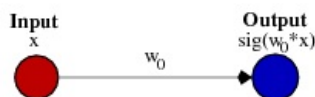Role of Bias in Neural Networks

I think that biases are almost always helpful. In effect, a bias value allows you to shift the activation function to the left or right, which may be critical for successful learning.

It might help to look at a simple example. Consider this 1-input, 1-output network that has no bias:



The output of the network is computed by multiplying the input (x) by the weight ($w_0$) and passing the result through some kind of activation function (e.g. a sigmoid function.)

Here is the function that this network computes, for various values of $w_0$:
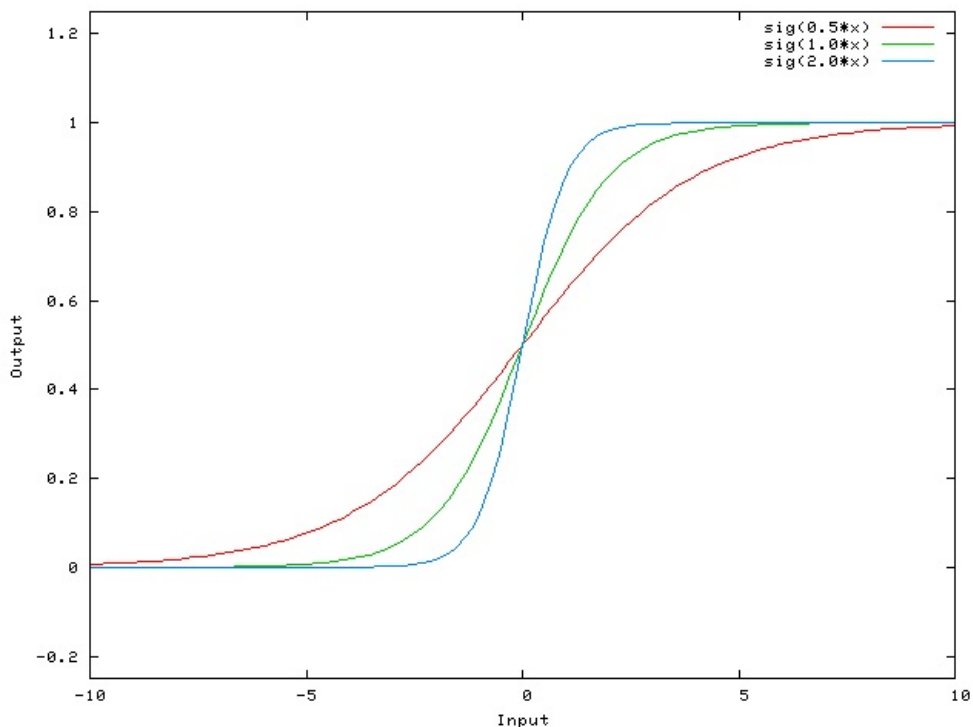


Changing the weight $w_0$ essentially changes the "steepness" of the sigmoid. That's useful, but what if you wanted the network to output 0 when x is 2? Just changing the steepness of the sigmoid won't really work -- you want to be able to shift the entire curve to the right.

That's exactly what the bias allows you to do. If we add a bias to that network, like so:
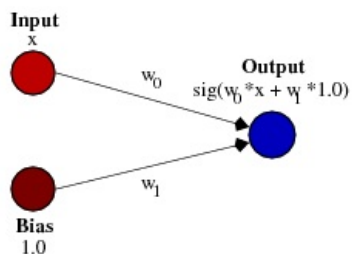


...then the output of the network becomes $sig(w_0 x + w_1 1.0)$. Here is what the output of the network looks like for various values of $w_1$:
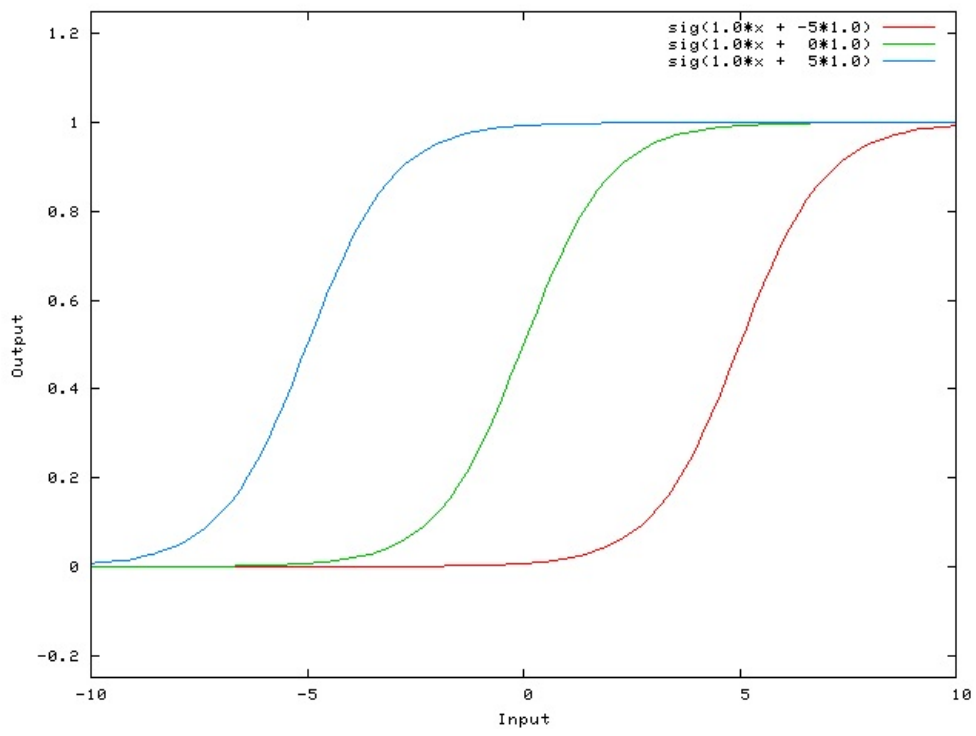
Having a weight of -5 for $w_1$ shifts the curve to the right, which allows us to have a network that outputs 0 when x is 2.