Notes

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The Essence of Neural Networks

Let's consider that we want to predict (y) if you're going to fail (0) and exam, or approve it (1). The inputs (a.k.a. features) are those things that can influence the prediction, and even those that don't, like for instance:

How much did you study? $\rightarrow x_1$

How smart are you? $\rightarrow x_2$

You previous knowledge $\rightarrow x_3$

Your name $\rightarrow x_4$

In this case, we can think that x_1 has an important influence on the prediction. x_2 and x_3 can help you in the exam, but are not decisive. Finally, x_4 is not important for the prediction. This last observation give us the notion of the importance level or weight of each variable.

Now, we have to model an equation in order to get our probability, we can do as follow:

$$z = x_1(w_1) + x_2(w_2) + x_3(w_3) + x_4(w_4)$$

where each w_i is the weight that we will assign to each variable:

$w_1 = 1$ because is decisive for the prediction.

$w_1 = 0.5$ can probably help.

$w_1 = 0.2$ can help if you had a similar course.

$w_4 = 0$ because in fact is not important.

$$z = x_1(1) + x_2(0.5) + x_3(0.2) + x_4(0)$$

Once we get z, we need a function for modeling that z to our final result (y). Like for instance: maybe our z ends with a value of 2.8 but we need a value in between $0 - 1$. These kind of functions are called Activation Functions ($f(x)$) and we can model all this system as follow:

We call it a Neuron, and we can express it more formally as follow:

$$y = f(\sum_{i=1}^{n} x_i w_i)$$

Or, adding a bias term (w_0) we can express as follow:

$$y = f(w_0 + \sum_{i=1}^{n} x_i w_i)$$

Finally, a little bit more convenient way of expressing this is using linear algebra:

$$y = f(w_0 + \mathbf{X}^T\mathbf{W})\mathbf{X} = \begin{bmatrix} x_1 \\ \vdots \\ x_n \end{bmatrix} \quad \text{and} \quad \mathbf{W} = \begin{bmatrix} w_1 \\ \vdots \\ w_n \end{bmatrix}$$

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