AI Academy: Introduction to Data Mining
Week 9 Workshop

Workshop 9 contains 1 question.

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1 ANN+Backpropagation

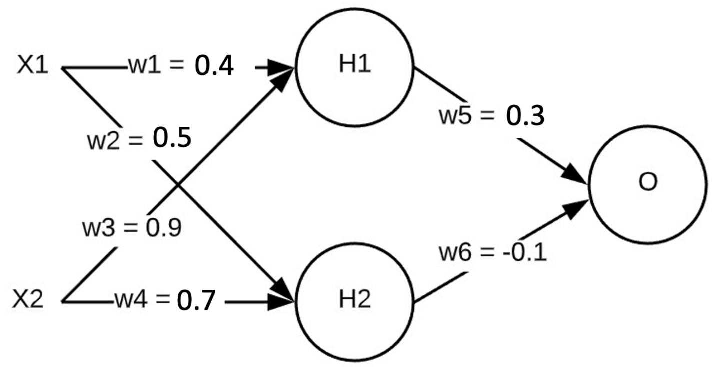

Figure 1: Neural Network Structure with initial weights

Table 1: Initial weights for given neural network in (a)

Weight	From	To	Initial Value
w1	X1	H1	0.4
w2	X1	H2	0.5
w3	X2	H1	0.9
w4	X2	H2	0.7
w5	H1	O	0.3
w6	H2	O	-0.1

You are given the above (Figure 1) neural network with continuous input attributes $X1$ and $X2$ and continuous output variable Y. For clarity, the relationship between weights and activations is also shown in Table 1. All three activations $H1$, $H2$ and O use the linear activation function $f(z) = Mz$, with constant $M = 1$. Initial weights are as given in Figure 1 and repeated in Table 1. There is **no bias** (w_0) added to any of the units. Answer the following:

1. **Forward Pass**: If you are given one training data point: $X1_i = 1$, $X2_i = -1$, and $Y_i = 1$. Compute the activations of the neurons $H1$, $H2$ and O.

2. **Backward Pass**: At the end of forward pass, using the current training instance i: $X1_i = 1$, $X2_i = -1$, and $Y_i = 1$, calculate the updated value of each of the following weights after one iteration of backpropagation: $w1$, $w5$ and $w6$.

   Use 0.1 as your learning rate and MSE (mean squared error) as your cost function. Show your work on the following steps for each weight, w ($w1$, $w5$, $w6$):

   (a) Consider only the training instance i. Let a_N be the activation at neuron N, $X1_i$ be the value of the attribute $X1$ for instance i, and Y_i be the actual class of the instance i. Write equations to define the following:

i. The cost function C in terms of Y_i and a_O (Since we are considering a single instance, you do not have to sum over instances.)

ii. The activation of the final layer a_O in terms of second layer weights w_5, w_6 and the activation of the first layer a_{H1} and a_{H2}

iii. The activation of the node a_{H1} in terms of inputs $X1_i$, $X2_i$ and weights w_1 and w_3

(b) For layer-2 weights (w_5 and w_6), what is the *sign* of $\frac{\delta C}{\delta w_i}$. Here C is the cost function and w is the given weight. You do not need to calculate the actual gradients - only state if they are positive, negative, or zero. To phrase it another way, as the weight goes up, how does the cost change (increase/decrease/stay)?

(c) For the layer-1 weight w_1, what is the *sign* of $\frac{\delta C}{\delta w_1}$. You do not need to calculate the actual gradients - only state if they are positive, negative, or zero. To phrase it another way, as the weight goes up, how does the cost change (increase/decrease/stay)? **Hint**: It may be helpful to first calculate the sign of $\frac{\delta C}{\delta a_{H1}}$ – as the activation value at H_1 goes up, how does the cost function change? Then think about the relationship between that activation and w_1.