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Exercise 5.3 - Basics of Forward and Backward passes in computational graphs

a) We have:

$$X = [3,\ 1,\ 1], W_1 = [[2,\ 1,\ -2], [-1,\ -3,\ 5]]^T,$$

$$W_2 = [[6,\ -1], [2,\ 8]]^T,$$

$$H = \sigma_{ReLU}(XW_1) = \sigma_{ReLU}([5,\ -1]) = [5,\ 0]$$

$$O = \sigma_{Softmax}(HW_2) = \sigma_{Softmax}([30,\ 10]) = [\frac{e^{30}}{e^{30}+e^{10}},\ \frac{e^{10}}{e^{30}+e^{10}}] =$$

$$[0.99999999793,\ 2.06e-9]$$

The predicted class label is “class 0” with a probability of 99.999999793%.

b) Forward pass:

$$a = 2, b = 1,$$

$$c = a + b = 3,$$

$$d = b + 1 = 2, \text{ and}$$

$$e = c * d = 6$$

Backward pass using reverse-mode differentiation:

$$\frac{\partial e}{\partial a} = \frac{\partial e}{\partial c} * \frac{\partial c}{\partial a} = d * 1 = 2$$

$$\frac{\partial e}{\partial b} = \frac{\partial e}{\partial c} * \frac{\partial c}{\partial b} + \frac{\partial e}{\partial d} * \frac{\partial d}{\partial b} = d * 1 + c * 1 = 2 + 3 = 5$$