

Neural Networks Problem Set

Due date: 12/18/2019

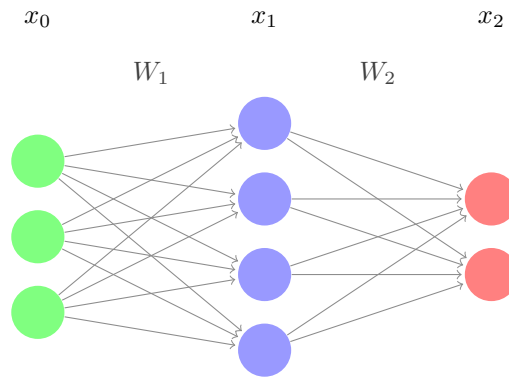
Total Points: 30

If you run out of room for an answer, use scratch paper and staple it to this sheet. You're free to use our lectures, online resources, and a calculator as an aid, but you're not allowed to work with others.

Name and Grade: \_\_\_\_\_

1. (3 points) The sigmoid function is defined as  $\sigma(x) = \frac{1}{1+e^{-x}}$ . Prove that  $\sigma' = \sigma * (1 - \sigma)$ .

Use the following network for all of the other problems:



the weight matrices, bias vectors and input are as follows:

$$W_1 = \begin{bmatrix} 2 & 3 & 4 \\ 2 & 1 & 2 \\ 3 & 5 & 1 \\ 2 & 3 & 4 \end{bmatrix} \quad W_2 = \begin{bmatrix} 3 & 1 & 1 & 1 \\ 1 & 4 & 2 & 2 \end{bmatrix}$$

$$x_0 = \begin{bmatrix} 2 \\ 1 \\ 3 \end{bmatrix} \quad b_1 = \begin{bmatrix} 4 \\ 1 \\ 1 \\ 2 \end{bmatrix} \quad b_2 = \begin{bmatrix} 2 \\ 3 \end{bmatrix}$$

2. (6 points) Instead of using the Sigmoid activation function, use a linear function  $y = x$ , which always has a derivative of 1. Compute the output of one forward pass. Your answer should be a vector that the network would output after passing  $x_0$  into the first layer.

3. (2 points) Find the error using your answer from Question 2. Use the following as the target output:

$$t = \begin{bmatrix} 4 \\ 5 \end{bmatrix}$$

4. (10 points) Compute a backward pass using the following target output and learning rate:

$$t = \begin{bmatrix} 4 \\ 5 \end{bmatrix} \quad \alpha = 0.1$$

Your answer should be a list of the updated weight and bias matrices. Round each value to the nearest tenth. You'll probably need another sheet of paper.

5. (6 points) Use the updated weights and biases you found in the previous question to calculate another forward pass. Your answer should be the output vector from the network.

6. (3 points) Using your answer from the previous question, find what the new error of the network would be. Use the same target output as follows:

$$t = \begin{bmatrix} 4 \\ 5 \end{bmatrix}$$

What do you notice when comparing this answer to what you got for Question 3?