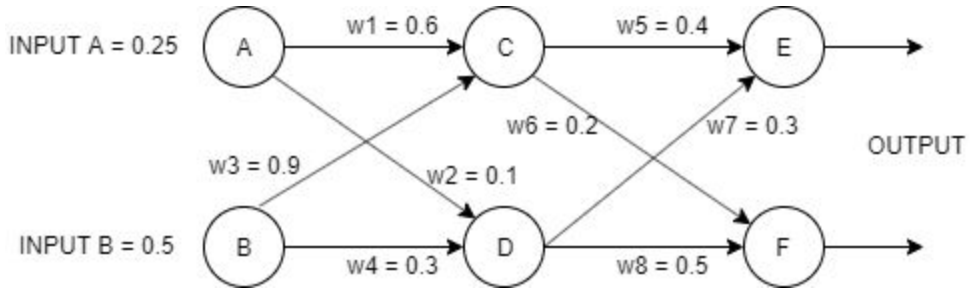
Take-Home Practice on Neural Networks (Non-Graded)

1. Backpropagation example with 2 inputs, 2 hidden units and 2 outputs



Assume that the neurons have sigmoid activation function, learning rate of 1 and answer the following questions:

a) Perform a forward pass on the network and determine the outputs at E and F.
b) Perform back-propagation on the output layer neurons($target_E$=1 and $target_F$=0) and determine the updated weights for w5, w6, w7 and w8.
c) Perform back-propagation on the hidden layer neurons and determine the updated weights for w1, w2, w3, and w4.

Useful sigmoid values:

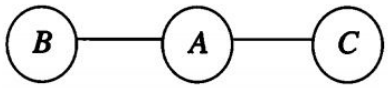
x	0.107	0.175	0.42	0.5	0.6	0.73	0.82
sigmoid(x)	0.526	0.543	0.6	0.622	0.645	0.67	0.694

2. The following matrix represents the weights of a hopfield network with the vectors V_1(0, 1, 0, 1), V_2(1, 0, 0, 1) stored. Use this matrix and answer the following questions.

$$W = \begin{bmatrix} 0 & -2 & 0 & 0 \\ -2 & 0 & 0 & 0 \\ 0 & 0 & 0 & -2 \\ 0 & 0 & -2 & 0 \end{bmatrix}$$

a. What is the weight matrix when a new vector V_3 (0, 1, 1, 0) is added to this network?
b. Use the weight matrix obtained in part a, and assume that the order of node updates is 2, 3, 4, 1. What memory does the network converge to if Vin is (1, 0, 1, 0)? (Show the input vector after each update and the final attractor that the network converges to)

3. Consider the input vectors
$I_1 = (1.1, 1.7, 1.8)$, $I_2 = (0,0,0)$, $I_3 = (0,0.5, 1.5)$, $I_4 = (1,0,0)$, $I_5 = (0.5,0.5,0.5)$, $I_6 = (1, 1, 1)$.
We are using a 3 node Self-Organizing Map network with initial weights W(0) as shown below:



$$W(0) = \begin{pmatrix} w_A: & 0.2 & 0.7 & 0.3 \\ w_B: & 0.1 & 0.1 & 0.9 \\ w_C: & 1 & 1 & 1 \end{pmatrix}$$

Using the above information, answer the following questions:

a. If the neighborhood radius is R = 1 (ie. we consider neighbors at distance 1 of a node when updating weights), learning rate $\eta = 0.5$, and we consider the inputs in order (I_1 to I_6), **what is the weight matrix after the first epoch** (after all inputs are processed once)**?**
b. What clusters (A, B or C) are the inputs assigned to at the end of the first epoch?
c. Assuming a geometric decrease in learning rate of 0.5, what is the learning rate for the second and third epochs?