Assignment 5:
Due Date: 11.59 PM 12/12/2022

1 Question 1 Neural Networks (40 pts)

: Answer the following questions. Use the neural network diagram (Figure 1) for reference wherever applicable. Work out the math for the questions, if you want partial credit.

- 1 a. Consider a neural network that predicts something (out), given a particular input (x). Consider the figure 1 depicting the neural network. What is the dimension of the input and the output? (2 pts)
- 1 b. What is the dimension of the hidden layer? (2 pts)
- 1 c. Let us say, for each dimension 'j' of input x and each dimension 'k' of the hidden layer h, we get $h_k = \sum_j W1_{j,k} * x_j$ (no other additional terms like bias). What is the value of each dimension of the hidden layer in terms of $W1$ and 'x'? (6 pts)
- 1 d. Let us say, the output is calculated from the hidden layer, in the same way $out = \sum_k W2_k * h_k$. What is the output 'out' in terms of the weights (W1 and W2) and the input 'x'? (Do not use hidden layer terms in this expression) (8 pts)
- 1 e. Let us say you have the ground-truth label for this input 'x' as 'y'. You define a loss function 'y' - 'out'. In order to estimate how much you should increase or decrease the weights W1 and W2, you calculate the gradient. i.e, $\frac{\partial loss}{\partial W2_1}$. What will be the gradient for $W2_1$? The derivative should be in terms of $W1_{i,j}$, $W2_i$, and x. (8 pts)
- 1 f. If you use sigmoid activation on the hidden layers, i.e. $h_k = Sigmoid(\sum_j W1_{j,k} * x_j)$. What will be the 'out' value, in terms of $W1_{i,j}$, $W2_i$, and x? (10 pts)
- 1 g. Why do we need activation functions in neural networks? (4 pts)

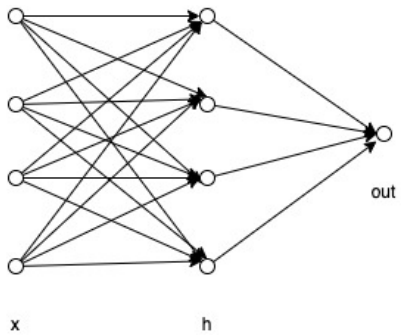

Figure 1:

2 Question 2 Clustering (30 pts)

: In this question, consider an array of numbers [11, 25, 34, 17, 18, 65, 23, 41, 73, 19, 7, 82]. We are going to group these numbers into 2 clusters using k-means. Let us consider the initial centroids of the 2 clusters as 15 and 55.

- 2 a. What will be the cluster assignments (cluster-1 or cluster-2) for each of the numbers in the array for the above-mentioned centroids? Work out the math for this problem. (8 points)
- 2 b. What will be the new centroids of these clusters? (4 pts)
- 2 c. Based on the new centroids, work out the new cluster assignments for each of the numbers in the array. (8 pts)
- 2 d. Mention 3 drawbacks of k-means clustering. (6 pts)
- How would you use k-means clustering in a semi-supervised algorithm? (4 pts)

3 Question 3 Minimax Tree (30 pts)

Consider the minimax game tree shown below. Decisions by MAX are represented as upward-pointing triangles; decisions by MIN are represented as downward-pointing triangles; small letters denote outcomes of the game

- 3 a. Consider Figure 2. What are the values of the two MAX nodes? (4 pts)
- 3 b. Consider Figure 2. Of the eight outcomes, which one(s) would be pruned by an alpha-beta search? (7 pts)

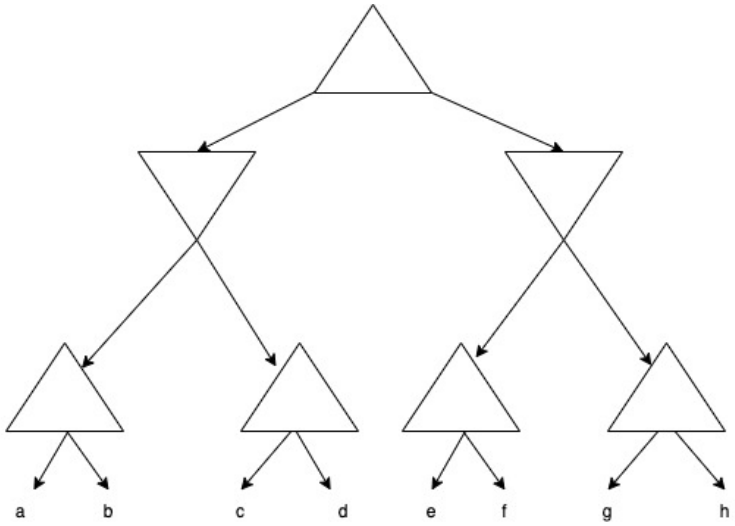

Figure 2: The outcome to the MAX player is as follows [a:8, b:3, c:1, d:7, e:2, f:5, g:6, h:4]

- 3 c. Consider Figure 3. Write down the minimax value of every non-terminal node next to that node. (4 pts)
- 3 d. Consider Figure 3. Cross out the branches that do not need to be examined by alpha-beta search in order to find the minimax value of the top node, assuming that moves are considered in the non-optimal order shown. (7 pts)
- 3 e. Return the final path for Figure 3 (4 pts)
- 3 f. Return the final path for Figure 2 (4 pts)

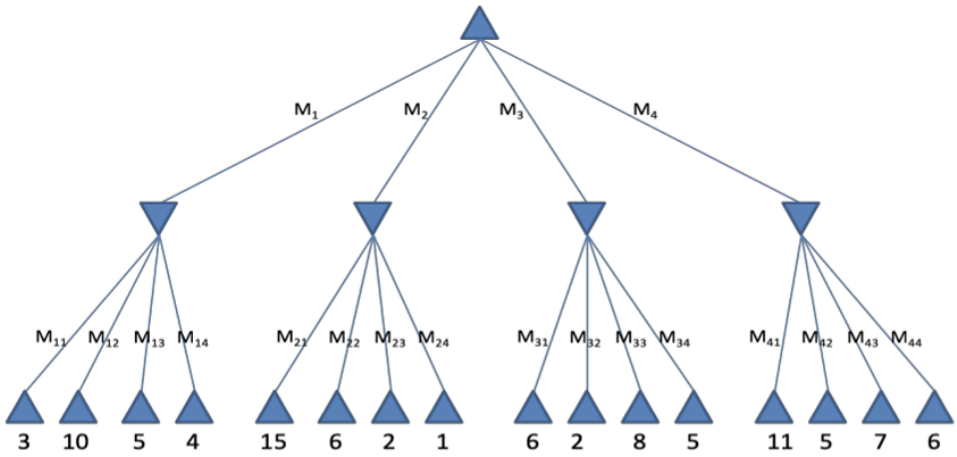

Figure 3: