National University of Computer and Emerging Sciences

Lahore Campus

Artificial Intelligence (CS/DS 2002) Sessional-II

Date: April 6th 2024 Total Time: 1 Hours Course Instructors Total Marks: 35

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Total Questions: 03
Semester: SP-2024
Campus: Lahore

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Student Name Roll No Section Signature

CLO 1: [Demonstrate understanding of basic AI based search techniques] Problem No 1: [Genetic Algorithms] [2 + 3 + 2 + 2 + 6 Points]

Attempt the following questions using the population of solutions/chromosomes given below. The fitness value of each chromosome is also given. If you need a random number in any part then sequentially select one from the following list starting from 0.86 and moving on.

0.86, 0.59, 0.67, 0.14, 0.34, 0.08, 0.11, 0.29, 0.85, 0.76, 0.43, 0.47, 0.89, 0.98, 0.58, 0.03, 0.57

Fitness	8	1	2	9

Chromosomes 100000001 010101010 010100110 001100111

Part a) Which chromosome will be selected if fitness proportionate selection is used? Show complete working.

Fitness	Proportionate	Count
8	0.4	2
1	0.05	0
2	0.1	0
9	0.45	2

Chromosome 1 AND (OR) 4

Part b) Assume that single point crossover is to be used to compute two new solutions using the first and third chromosome. Show complete working and the resulting chromosomes obtained after the crossover.
HINT: To determine a crossover point you can map the random number R between 0 and 1 to a random number between 1 and N using simple product of R with N i.e. ceiling(R*N).

0.86*9 = 7.74 -> 8

10000000|1
01010011|0

100000000
010100111

Part c) Assume that the chromosome 100101010 has already been selected for mutation using a mutation rate of 0.01. Show the resulting chromosome after mutation.

0.86	0.59	0.67	0.14	0.34	0.08	0.11	0.29	0.85
1	0	0	1	0	1	0	1	0

Since all random numbers generated are less than 0.01 no mutation occur

OR (Using Coin Toss)

0.86	0.59	0.67	0.14	0.34	0.08	0.11	0.29	0.85
1	0	0	1	0	1	0	1	0
0	1	1	1	0	1	0	1	1

Bits having value greater than 0.5 will be flipped

Part d) What is the concept of elitism in the context of genetic algorithm? How would it help in finding a good solution?

In genetic algorithms, elitism ensures the best individuals from each generation are carried over to the next. By keeping good solutions around, elitism avoids getting stuck in suboptimal solutions and makes sure each new generation is more optimal with respect to fitness.

Part e) You are given 10 unique numbers. You have to divide these numbers into 2 sets. Set 1 must have numbers such that their product is as close to 240 as possible. Set 2 must contain numbers such that their sum is as close to 40 as possible. You need to solve this problem using genetic algorithms.

i. Briefly explain how you would represent the solution as a chromosome.

We can represent in binary string of 0s and 1s, one bit for each number. A 0 signifies the number belongs to Set 1, while a 1 indicates Set 2.

Chromosome: 0100110110

Numbers 1, 3, 5, 7, and 9 belong to Set 1 and Numbers 2, 4, 6, 8, and 10 belong to Set 2

OR

Another solution is a unique arrangement (permutation) of the 10 numbers. The first 4 numbers define Set 1, and the remaining 6 belong to Set 2.

Chromosome: (3, 7, 1, 9, 5, 2, 8, 4, 10, 6)

ii. Based on your representation, what is the chromosome for the for the solution in which Set 1 contains 2, 3, 4, 10 and Set 2 has 1, 5, 6, 7, 8, 9.

Chromosome: (2, 3, 4, 10, 1, 5, 6, 7, 8, 9)

OR

Chromosome: (1,0,0,0,1,1,1,1,1,0)

iii. What should be the fitness function for this problem? Provide mathematical representation only.

$(240 - \pi Ci) + (40 - \sum Ci)$

OR

$1/(240 - \pi Ci) + 1/(40 - \sum Ci)$

OR

$(\pi Ci + 1/240) + (\sum Ci + 1/40)$

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CLO 1: [Demonstrate understanding of basic AI based search techniques]

Q. No 2: In this question you are required to attempt exactly one part i.e. either attempt the local search problem or attempt or the game tree question but not both

Part A) [Local Search] [10 Points]

0/1 Knapsack Problem is a classic problem in computer science that can be stated as follows:
Given a set of items and a knapsack with the i^{th} item in the set has a weight w_i and a value v_i and knapsack has a maximum weight capacity W, determine the most valuable combination of items that can be included in the knapsack without exceeding its weight capacity.

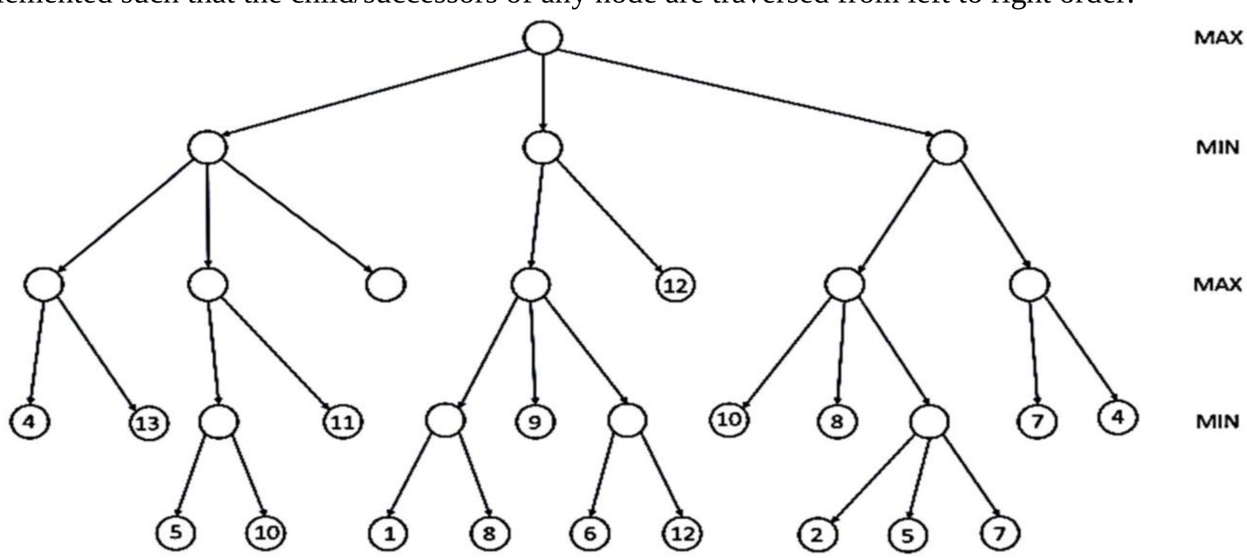
A solution to the knapsack problem for a set of n items can be represented as a binary string of length n with a bit value of 0 means the corresponding item of the set is not included in the knapsack and a bit value of 1 means the item is included. Value of solution is sum of the values of items included in that solution if the total weight of the items do not exceed the capacity W of the sack and the value is 0 if the sum of weights exceed the knapsack capacity.

Item Number	1	2	3	4
Value	7	6	4	1

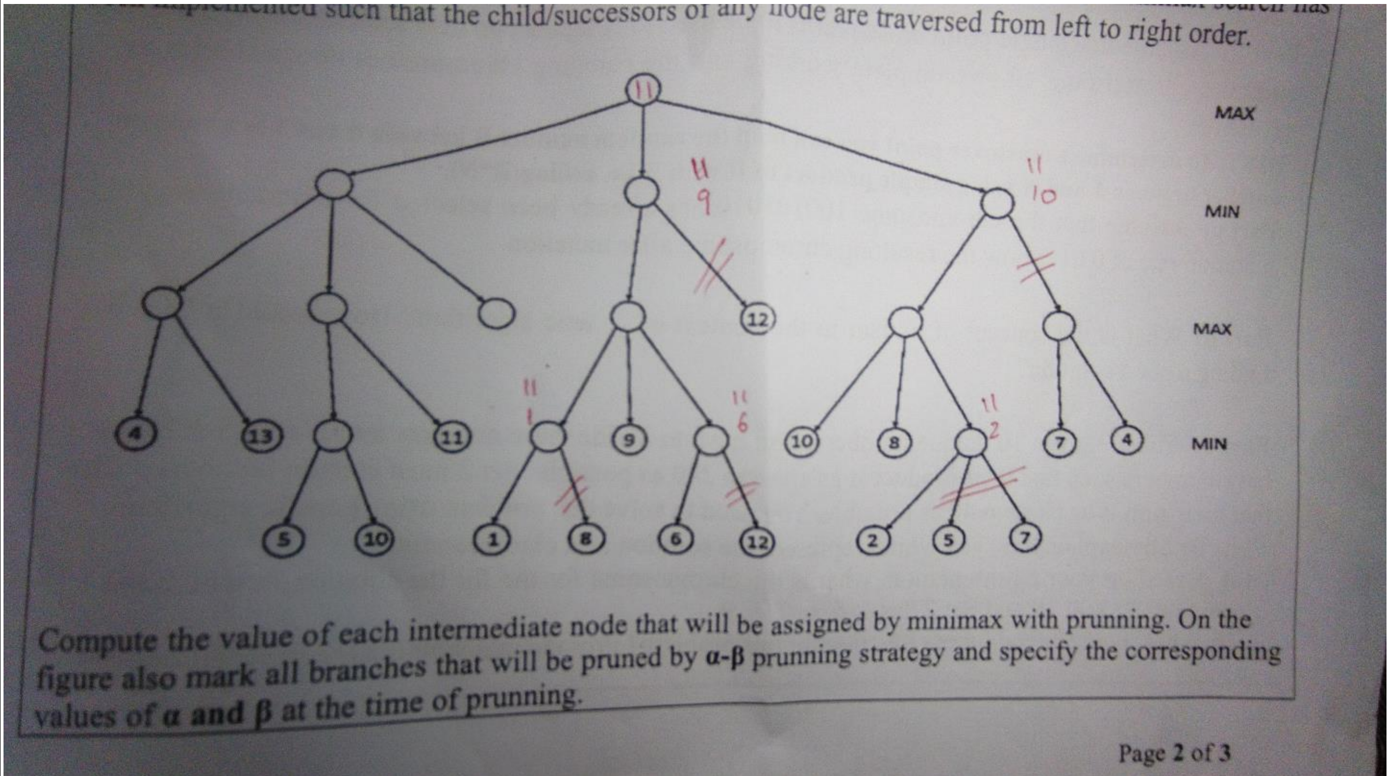
For the set of four items shown above and a knapsack with capacity 10, use the starting solution 0 0 0 0 to find the best solution using the hill-climbing (local search algorithm) You must show all intermediate solutions generated in each iteration. Furthermore, you must assume that the successor/neighbors of a solution are created by setting exactly one of the zero bit to 1 so that the solution 0 0 0 0 has four neighbors.

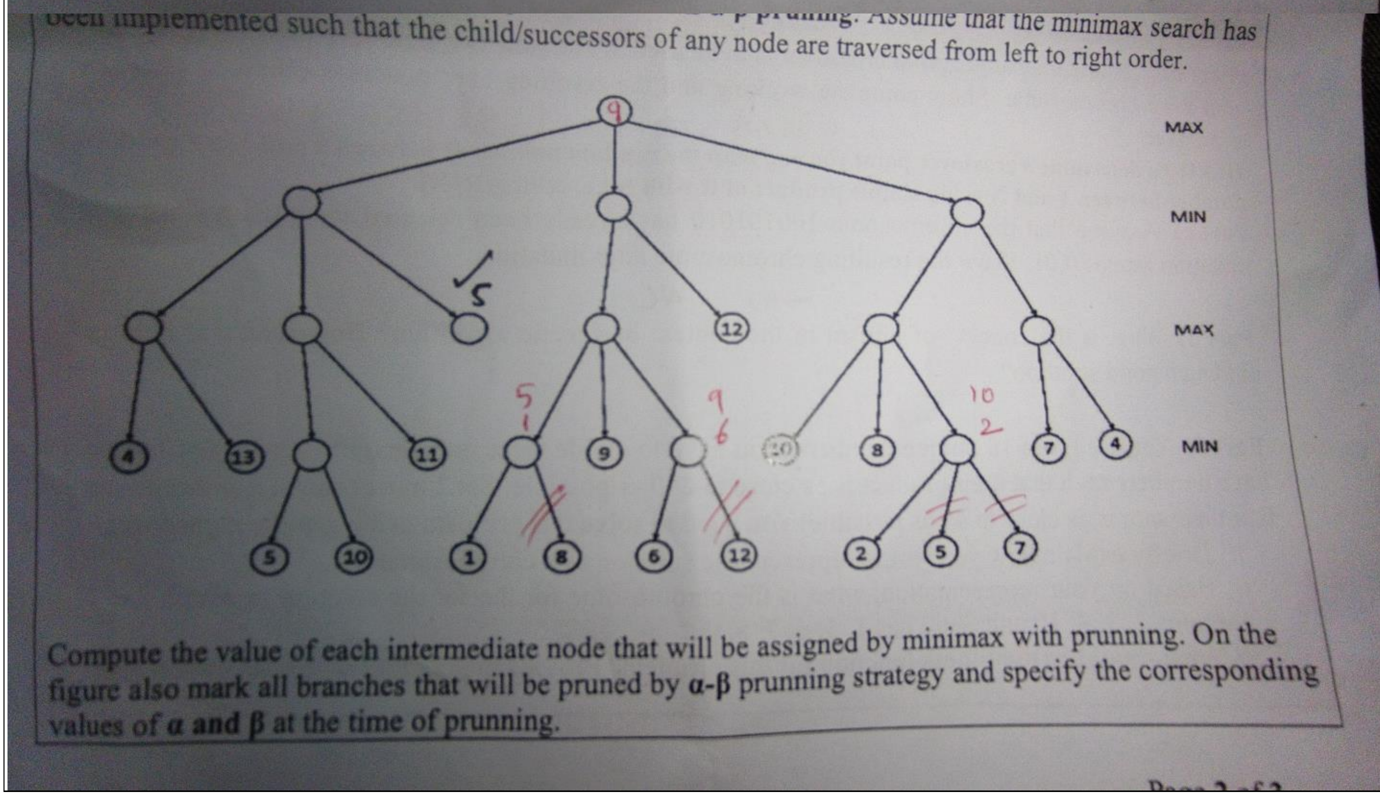
Part A) [Minimax with pruning] [10 Points]

Following figure shows a game tree of a hypothetical game. To find the best move of MAX at the root, this game tree is to be searched using minimax with α-β pruning. Assume that the minimax search has been implemented such that the child/successors of any node are traversed from left to right order.



Compute the value of each intermediate node that will be assigned by minimax with prunning. On the figure also mark all branches that will be pruned by α-β prunning strategy and specify the corresponding values of α and β at the time of prunning.



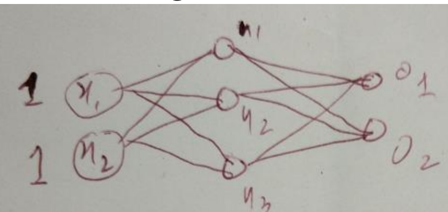


CLO 2: [Use dominant Machine Learning paradigms to design solutions] Question No 3 [Neural Networks]   [5 + 5 Points]

Part a) A multi-layer perceptron, also called the feed-forward neural network, has 2 inputs, a single hidden layer of 3 neurons and an output layer consisting of 2 neurons. The network uses linear activation function in the hidden layer and sigmoid activation at the output layer. Weights of the hidden layer and output layer neurons are given in the following table with the first weight being that of the bias term.

Hidden Layer Weights			Output Layer Weights			
W_0	W_1	W_2	W0	W1	W2	W3
1	0	1	1	1	0	1
0	0	1	-1	1	1	1
1	0	0				

Compute the output of the neural network if the input (1   1) is applied to the network. Assume that input to bias term is +1 and W_0 is weight of the bias term



$h_1 = x_1 w_1 + x_2 w_2 + b = 1\times 0 + 1\times 1 + 1 = 2$

$h_2 = 1\times 0 + 1\times 1 + 0 = 1$

$h_3 = 0\times 1 + 0\times 1 + 1 = 1$

$O_1 = h_1 w_1 + h_2 w_2 + h_3 w_3 + b$
$= 2\times 1 + 1\times 0 + 1\times 1 + 1 = 4$

$O_2 = 2\times 1 + 1\times 1 + 1\times 1 + (-1) = 3$

$g(O_1) = 0.982$, $g(O_2) = 0.952$

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Part b) Consider the dataset consisting of 4 points shown in the following table. Use a single iteration of perceptron learning rule to learn all parameters of the model. Take all initial weight to be zero and take the bias term or weight of the bias term to be zero as well

Inputs	Output
1, 1	+1
1, -1	-1
-1, -1	-1
-1 1	+1

Data point 1:

$w_1 = 0, w_2 = 0, b = 0$

$w_1^{new} = w_1^{old} + \Delta w_1$

$= 0 + (1 \times 1) = 1$

$w_2 = 0 + (1 \times 1) = 1$

$b = 0 + 1 = 1$

Data point 2:

$w_1 = 1 + (-1) = 0$

$w_2 = 1 + 1 = 2$

$b = 1 - 1 = 0$

Data point 3:

$w_1 = 0 + (-1 \times -1) = 1$

$w_2 = 2 + (-1 \times -1) = 3$

$b = 0 - 1 = -1$

Data point 4:

$w_1 = 1 + (-1) = 0$

$w_2 = 3 + 1 = 4$

$b = -1 + 1 = 0$