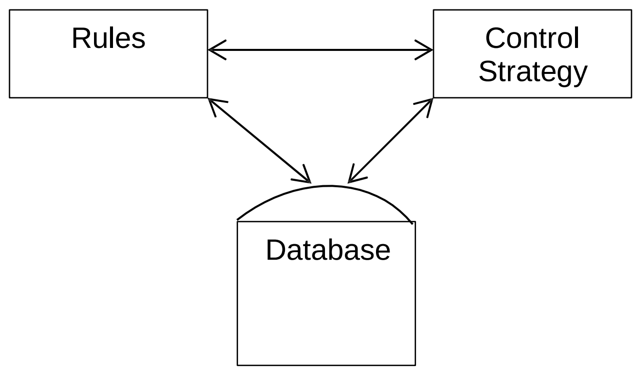
ECE 479/579 **Name (please print in block letters):**

Midterm Examination Spring 2022

1. (5 points) What is an AI Production System. Define its elements and explain how it works.

Answer:



Database: Captures the possible states of the system

Rules: Operators that transform the database via state changes

Control Strategy: Method to apply rules

AIPS is a mechanism to solve problems using the above mentioned elements.

2. (10 points) Does the Branch and Bound search, when applied to the Traveling Salesman Problem guarantee the optimality of the solution found. Assume that nodes are expanded using the following heuristic

$$f(n) = g(n) + h(n)$$

Where f(n) is the merit value of the node n, g(n) is the actual path distance from the start node to the node n, and h(n) is an underestimate of the distance from node n to the goal node (i.e., one that completes the full route for the traveling salesman).

You must justify your answer.

Answer:

Yes, it does. Should a complete route be found whose f(G) is less than or equal to all the f(n)'s of any remaining open paths, there is no point in expanding those open paths. Underestimates guarantee that the distance from the ends of the open paths cannot be lower than what we already have in f(G).

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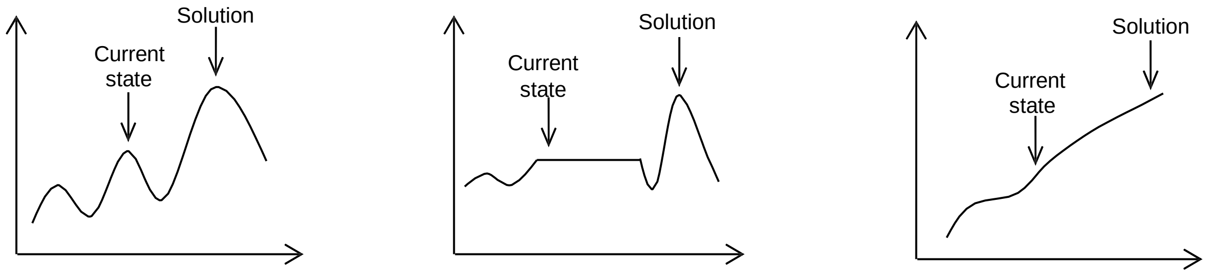
3. (7 points) Explain the Hill Climbing search algorithm. For the illustrations below will Hill Climbing be an efficient algorithm to choose, Yes or No? JUSTIFY your answer!



(a) **(b)** **(c)**

Answer:

Efficient for only illustration (c). The direction towards the goal leads to increasing values of the function (monotonically increasing). So, in this case, hill climbing will find the solution!

Inefficient by (b) and (a) because the value returned by the target function is decreasing or indistinguishable from the nearby regions. There is purely no uphill path. So, in these cases hill climbing will not be able to determine in which direction to step in and assume it is the solution!

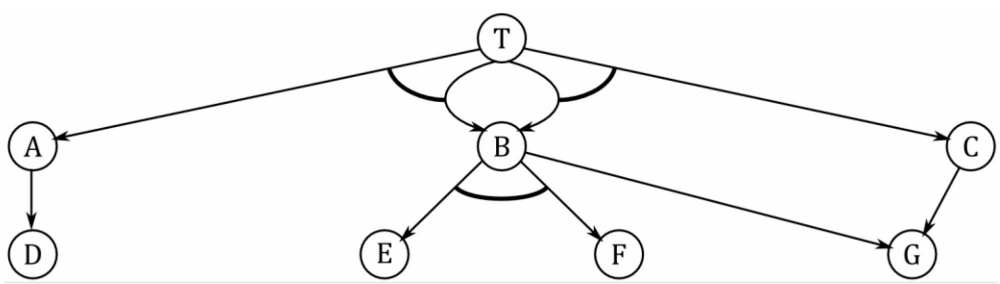
4. (5 points) Suppose we have a production system based on the following rewrite rules:

(A rewrite rule in generative grammar is a rule of the form A → X where A is a label, such as a noun phrase or sentence, and X is a sequence of such labels or a morpheme (smallest linguistic unit) expressing the fact that A can be replaced by X in generating the constituent structure of a sentence.)

R1: T -> A, B
R2: T -> B, C
R3: A -> D
R4: B -> E,F
R5: B -> G
R6 C -> G

Draw an AND/OR graph in which the nodes represent the linguistic labels, and k-connectors reflect the rewrite rules above. Start your AND/OR graph from T.

Answer:



5. (8 points) Define the monotone restriction (MR) on the h(n) function in:

a) A* search
b) AO* search

Answer:

a)

Allow n_j to follow from n_i, h(n) to be the heuristic estimate, and $c(n_i, n_j)$ to be the cost to go from n_i to n_j.

The MR says that: $h(n_j) \geq h(n_i) - c(n_i, n_j)$

b)

Then for all paths/branches radiating from a node n:

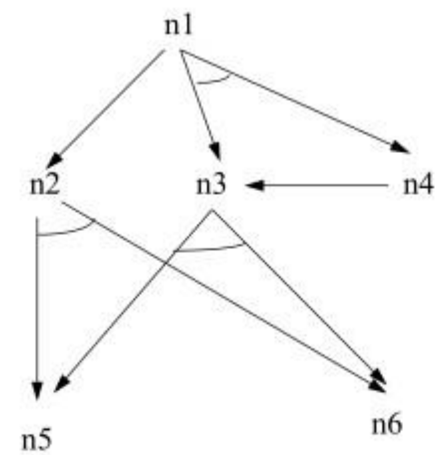
$$h(n) \leq k + \sum_{1}^{k} h(n_i),$$

where k is the number of connectors (or sum of costs of all the connecting edges) in a particular path/branch. This can be expressed without the summation sign as well:

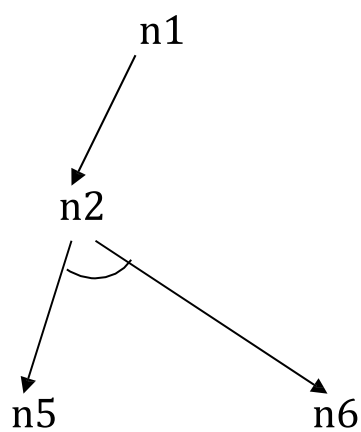
$$h(n) \leq k + h(n_1) + h(n_2) + \cdots + h(n_k),$$

Alternatively this could be stated in words. Essentially, the $h(n)$ function must satisfy the constraint that the heuristic cost plus cumulative cost never decreases for subsequent nodes (hence the name monotone restriction).

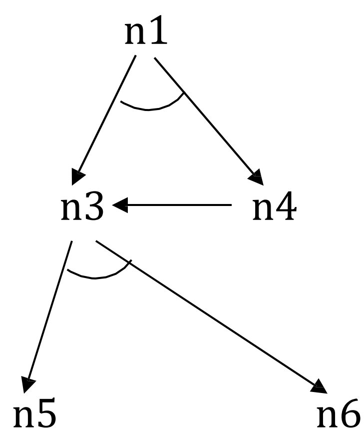
6. (7 points) Given the AND/OR graph below, draw the solution subgraphs. For each subgraph, calculate its cost. Assume arc costs are equal to 1.



Answer:



Cost = 3 i.e. (1 + (1*2))



Cost = 7 i.e. ((1*2) + (1*2) + 1 + (1*2))

Purposefully left blank for answers

7. (7 points) Assume that you conspire with your opponent to fix a game (play it dishonestly). You agree to some secret signals that allow you to tell him exactly how to move. The objective is to beat the opponent as badly as possible (i.e., to get the highest possible number of points). How effective is the alpha-beta procedure under these conditions? JUSTIFY your answer!

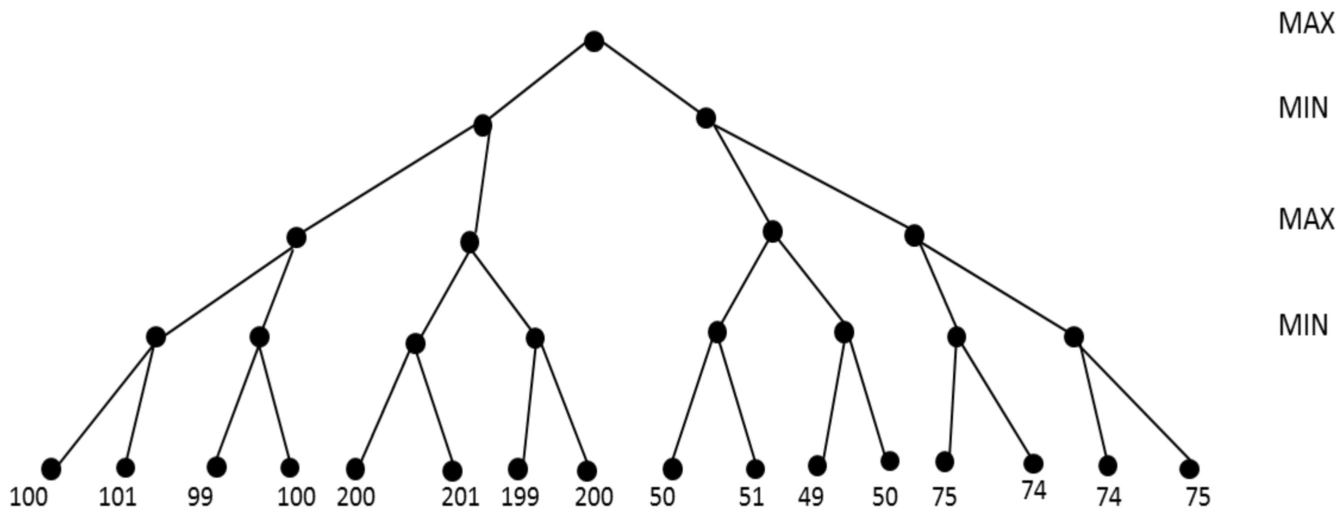
Answer:

The alpha-beta is not effective at all. The reason is that there is no longer an adversary component to the game. To find the worst (best) position at the bottom of the tree, each node must be examined.

8. (8 points) Explore the following game tree using the alpha-beta pruning procedure.

a) Cross out all the nodes where static evaluations need not occur. **Indicate if these are alpha or beta cutoffs.**

b) Show the winning path (starting at the root of the tree)



Answer: