CS 331 **Introduction to Artificial Intelligence** Fall 2024

OREGON STATE UNIVERSITY

School of Electrical Engineering and Computer Science

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Total points: 100 HW 2: **Search** Due date: Oct 26 2024

Instructions: This homework assignment consists of a written portion and a programming portion. Collaboration is not allowed on any part of this assignment. Solutions must be typed (hand written and scanned submissions will not be accepted) and saved as a .pdf file. You will submit a single .zip file that contains the the code base and solutions as a .pdf file.

1. Answer:
   Shortest path: S-1-4-G with a solution cost of 14. Number of nodes expanded= 8 (if you used a list for tracking expanded nodes, since 4 will be expanded twice). Number of nodes expanded= 7 (if you used a set for tracking expanded nodes, since it will count only unique nodes expanded). The time taken to solve will vary but it is a very small value, roughly around 0.0002 seconds.

2. Answer:
   With this less informative heuristic, A* will still find the optimal solution since this is an admissible heuristic. Shortest path: S-1-4-G with a solution cost of 14. Number of nodes expanded= 8 (if you used a list for tracking expanded nodes, since 4 will be expanded twice). Number of nodes expanded= 7 (if you used a set for tracking expanded nodes, since it will count only unique nodes expanded).Since this heuristic is consistent, A* will expand least number of nodes possible, even though the heuristic is less informative than that of Q1. The time taken to solve will vary but it is a very small value.

3. Answer:
   A simple heuristic that is admissible but not consistent is to modify the heuristic value of node 3 in Q1 to be 8. $h(3) = 8$ is admissible because the cost to get to G from node 3 is 9 and $h(3) < 9$. However, this is not consistent because $h(3) > c(3-4) + h(4)$. That is, $8 > 5 + 2$. The solution path with the modified heuristic is S-1-4-G with a solution cost of 14. It finds an optimal solution.

4. (i) Answer:
   (a) $D(i, j)$ and (c) $D(i, j)/2$ are admissible. The straight line distance between two cities will be less than or equal to the actual travel distance between them. Hence (a) is admissible. In the best case, the friends head straight for each other in steps of equal size, reducing their separation by twice the time cost on each step. Hence (c) is admissible.

   (ii) Answer:
   For an informed search algorithm like A*, the solution cost does not vary as long as the heuristic is admissible. If the heuristic is not admissible, then A* is not guaranteed to find an optimal solution, which may result in a different solution cost.

   (iii) Answer:
   Yes: e.g., a map with two nodes connected by one link. The two friends will swap places forever. The same will happen on any chain if they start an odd number of steps apart.

5. (**25 points**) Consider the graph in Figure 1 with blue nodes denoting MAX nodes and red nodes denoting MIN nodes.

   (i) Solve the graph using minimax algorithm. Clearly show your calculations at each step. Identify what strategy A must choose and the corresponding payoff it will receive (value).

   (ii) Solve the graph using alpha-beta pruning. Clearly show your calculations at each step. What strategy should A choose and what is the corresponding payoff?

   (iii) Which nodes are pruned using alpha-beta pruning? Did it change A's strategy? Why or why not?

   Answer:
   The best strategy for A is to choose D. A would receive a payoff of 8 using this strategy. Figure 1 shows the minimax values and Figure 2 shows the alpha-beta pruning result. Alpha beta pruning does not change the strategy, because by definition a node can be pruned only if it is guaranteed to be no better than the best payoff identified so far. Nodes O, Q, I (and thus T and U), and Y are pruned.

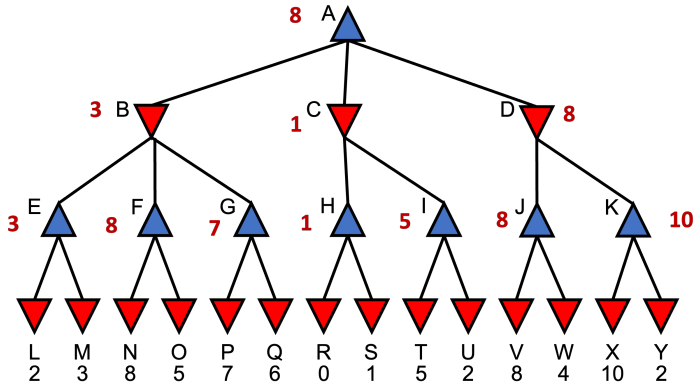

Figure 1: Minimax algorithm

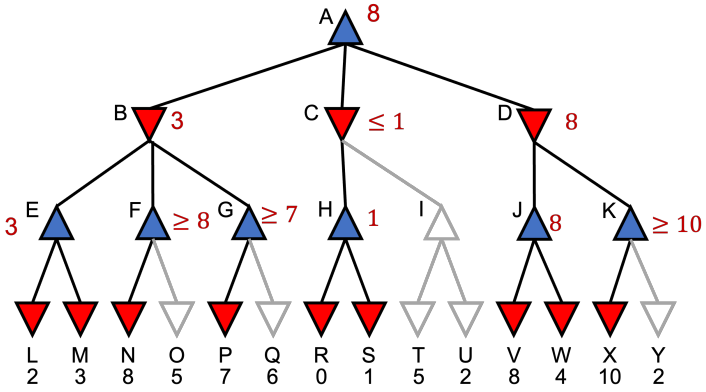

Figure 2: Alpha beta pruning