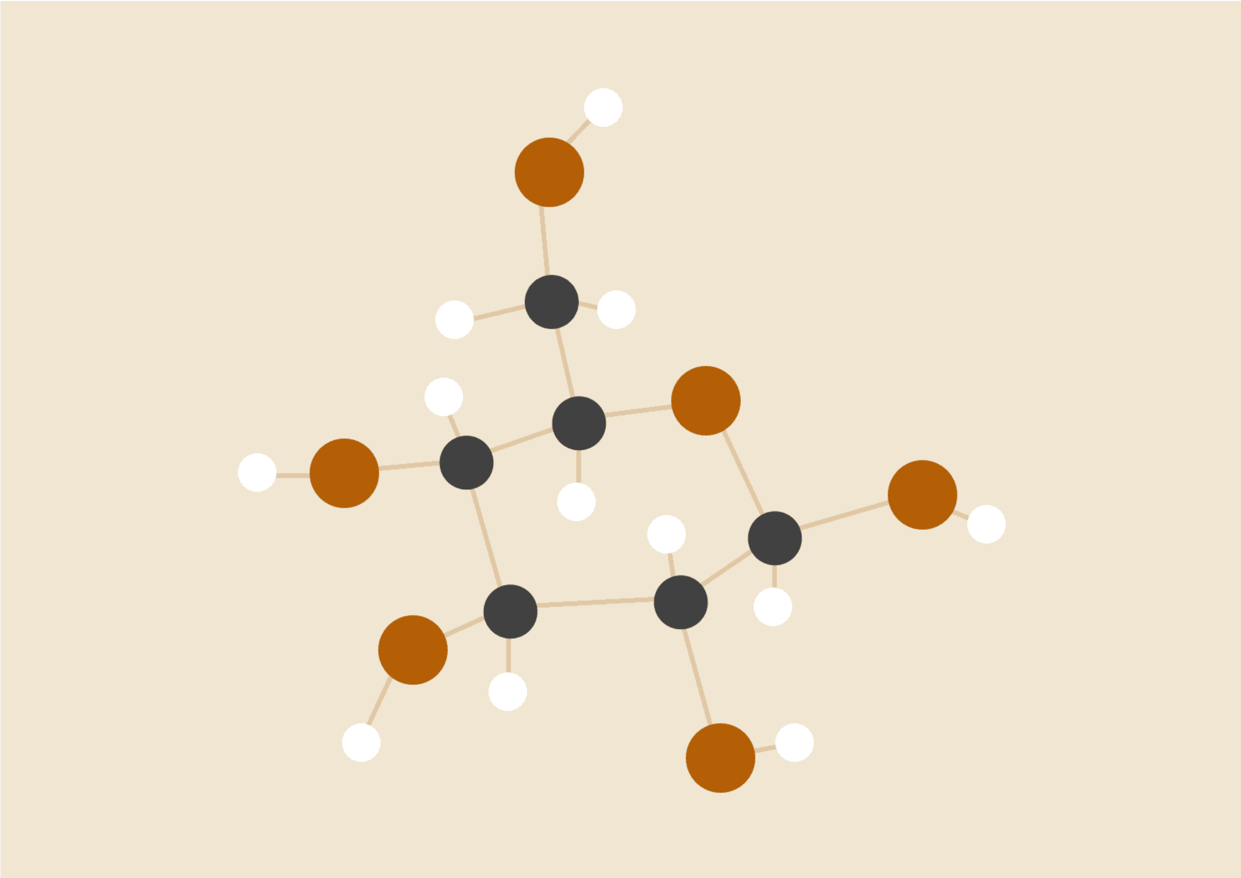
67842 - EX4

Graph Search and PlanGraph



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14TH GRADE COMPUTER SCIENCE (+ARMY)

Q13

Optimality

1. The **max level** heuristic will guarantee optimality because it's consistent (which derives admissibility). Since for every state it returns an answer that is ≤ the optimal cost and for every proceeding state it returns an answer that is ≤ the previous state's answer + cost of moving between them, it is consistent and thus would be optimal. This is because from every state, the minimum level to fulfill all the propositions while ignoring mutex (and even while not) is certainly ≤ the actual level required to fulfill all the propositions.
   The **level sum** heuristic is not even admissible, so it surely does not guarantee optimality. For example, if we can reach our goals A and B on level 2, and we first find A on 1 and B on 2, the level sum heuristic would be 3 despite the optimal cost being 2.

2.

Heuristic	Null	Max	Level Sum
Nodes Expanded	47	28	9
Plan Length	6	6	6
Optimal Plan	Yes	Yes	Yes

3. The practical results are somewhat surprising given that Level Sum does not guarantee optimality. Not only was it optimal, it was significantly more efficient than the rest of the heuristics in nodes expanded. To further push this point, it managed to find a plan for a 7x7 towers of Hanoi problem with just 42 nodes (!!!), a very impressive number of nodes to expand. Zero sum did perform worse than the max heuristic in terms of nodes expanded, which makes sense.

   The results are only somewhat surprising as it is not deterministic that level sum will not yield the optimal result, just not guaranteed. It all depends on how much and in what way it overshoots the "correct" score for each state, and from my tests it seems like it often doesn't do either enough to avoid optimal solutions. Given that we are lucky and it doesn't miss the optimal solution, it makes sense that it would explore less than the max heuristic, since it scores solutions that require expanding more nodes significantly as worse.

Running Time

1. Given two admissible heuristics we can determine that the one who dominates the other will expand ≤ nodes than the other. As we've seen in the recitations, the dominating heuristic is a closer fit and will yield a lesser or equal number of nodes explored in A*.

   In general, if we don't know about the heuristics admissibility and dominance it is hard or impossible to determine which heuristic will expand less nodes deterministically as different situations will yield different results for different heuristics. There are a lot of variables that affect it. The big picture answer is that it really depends on the heuristics being compared.

2. We have shown the number of nodes expanded in the table in Optimality question 2. The most efficient heuristic was level sum, reaching an impressive 9 nodes.

Q14

1. **Set level** is definitely admissible, as it cannot overshoot the optimal solution since the optimal solution requires exactly the condition that set-level seeks - all the goal propositions in the state without mutexes between them. It is also consistent as for every successor of a state the heuristic cost will be at most the cost of movement to the successor and the heuristic cost of the successor. Since it is consistent it is guaranteed an optimal solution, as we saw in class.
2. This heuristic will always expand lesser-or-equal to number of nodes than the max level heuristic, as max-level is set-level with a mutex relaxation, thus a stop condition for set-level will certainly be a stop-condition for max-level but not necessarily vice-versa, and since each step cost in either is 1 we get that it will expand less nodes (at search) as it will mark nodes as more expensive to go to.
3. It is! This heuristic returns the optimal distance to the goal, as it stops at the distance which our optimal solution should be - the shortest path to all goal state propositions without mutexes.