Q4: Value Functions

Problem 4: Value Functions

Consider a general search problem defined by:

- A set of states, S.
- A start state s_0.
- A set of goal states G, with $G \subset S$.
- A successor function $Succ(s)$ that gives the set of states s' that you can go to from the current state s.
- For each successor s' of s, the cost (weight) $W(s, s')$ of that action.

As usual, the search problem is to find a lowest-cost path from the start state s_0 to a goal $g \in G$. You may assume that each non-goal state has at least one successor, that the weights are all positive, and that all states can reach a goal state in a finite number of steps.

Define $C(s)$ to be the *optimal cost* of the state s; that is, the cost of the lowest-cost path from s to any goal state. For $g \in G$, clearly $C(g) = 0$.

Part 1

4/4 points (ungraded)
Select the Bellman-style (one-step lookahead) equation that expresses $C(s)$ for a non-goal state s in terms of the optimal costs of other states.

- ○ $C(s) = \sum_{s' \in \mathrm{Succ(s)}} W(s, s')$
- ○ $C(s) = \min_{s' \in \mathrm{Succ(s)}} W(s, s')$
- ○ $C(s) = \max_{s' \in \mathrm{Succ(s)}} W(s, s')$
- ○ $C(s) = \sum_{s' \in \mathrm{Succ(s)}} [W(s, s') + C(s')]$
- ◉ $C(s) = \min_{s' \in \mathrm{Succ(s)}} [W(s, s') + C(s')]$ ✔
- ○ $C(s) = \max_{s' \in \mathrm{Succ(s)}} [W(s, s') + C(s')]$

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✔ Correct (4/4 points)

Part 2

2/2 points (ungraded)

Consider a heuristic function $h(s)$ with $h(s) \geq 0$. What relation must hold between $h(s)$ and $C(s)$ for $h(s)$ to be an admissible heuristic?

- ○ $h(s) = C(s), \forall s \in S$
- ◉ $h(s) \leq C(s), \forall s \in S$ ✔
- ○ $h(s) \geq C(s), \forall s \in S$

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✔ Correct (2/2 points)

Part 3

By analogy to value iteration, define $C_k\left(s\right)$ to be the minimum cost of any plan starting from s that is either of length k or reaches a goal state in at most k actions. Define $C_0\left(s\right) = 0$ for all s. $C\left(s\right)$ is defined as before to be the cost of the lowest-cost path from s to any goal state, without any restriction on the number of actions starting from s.

Suppose we use C and C_k as heuristic functions.

Part 3.1

2/2 points (ungraded)

Which of the following statements regarding the admissibility of C and C_k are true? Check all that apply.

- [ ] C_k might be inadmissible for any given value of k.
- [x] C_k is admissible for all k.
- [ ] Let L be the length of the longest path from a state to a goal. C_k is only guaranteed to be admissible if $k \geq L$.
- [x] C is admissible.

✔

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✔ Correct (2/2 points)

Part 3.2

2/2 points (ungraded)

Which of the following statements regarding the consistency of C and C_k are true? Check all that apply.

- [ ] C_k might be inconsistent for any given value of k.
- [x] C_k is consistent for all k.
- [ ] Let L be the length of the longest path from a state to a goal. C_k is only guaranteed to be consistent if $k \geq L$.
- [x] C is consistent.

✔

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✔ Correct (2/2 points)