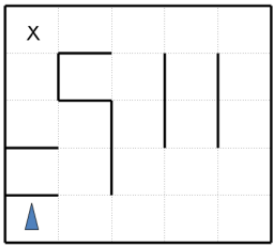
Past Exam Questions: Search

1 Search and Heuristics

Imagine a car-like agent wishes to exit a maze like the one shown below:



The agent is directional and at all times faces some direction $d \in (N, S, E, W)$. With a single action, the agent can *either* move forward at an adjustable velocity v *or* turn. The turning actions are *left* and *right*, which change the agent's direction by 90 degrees. Turning is only permitted when the velocity is zero (and leaves it at zero). The moving actions are *fast* and *slow*. *Fast* increments the velocity by 1 and *slow* decrements the velocity by 1; in both cases the agent then moves a number of squares equal to its NEW adjusted velocity. Any action which would collide with a wall crashes the agent and is illegal. Any action which would reduce v below 0 or above a maximum speed $V_{\max}$ is also illegal. The agent's goal is to find a plan which parks it (stationary) on the exit square using as few actions (time steps) as possible.

As an example: if the agent shown were initially stationary, it might first turn to the east using (*right*), then move one square east using *fast*, then two more squares east using *fast* again. The agent will of course have to *slow* to turn.

1. If the grid is M by N, what is the size of the state space? Justify your answer. You should assume that all configurations are reachable from the start state.

2. What is the maximum branching factor of this problem? You may assume that illegal actions are simply not returned by the successor function. Briefly justify your answer.

3. Is the Manhattan distance from the agent's location to the exit's location admissible? Why or why not?

4. State and justify a non-trivial admissible heuristic for this problem which is not the Manhattan distance to the exit.

5. If we used an inadmissible heuristic in A* tree search, could it change the completeness of the search?

6. If we used an inadmissible heuristic in A* tree search, could it change the optimality of the search?

7. Give a general advantage that an inadmissible heuristic might have over an admissible one.

2 Expanded Nodes

Consider tree search (i.e. no closed set) on an arbitrary search problem with max branching factor b. Each search node n has a backward (cumulative) cost of $g(n)$, an admissible heuristic of $h(n)$, and a depth of $d(n)$. Let c be a minimum-cost goal node, and let s be a shallowest goal node.

For each of the following, you will give an expression that characterizes the set of nodes that are expanded before the search terminates. For instance, if we asked for the set of nodes with positive heuristic value, you could say $h(n) \geq 0$. Don't worry about ties (so you won't need to worry about $>$ versus $\geq$). If there are no nodes for which the expression is true, you must write "none."

1. Give an expression (i.e. an inequality in terms of the above quantities) for which nodes n will be expanded in a breadth-first search.

2. Give an expression for which nodes n will be expanded in a uniform cost search.

3. Give an expression for which nodes n will be expanded in an A* search with heuristic $h(n)$.

4. Let h_1 and h_2 be two admissible heuristics such that $\forall n, h_1(n) \geq h_2(n)$. Give an expression for the nodes which will be expanded in an A* search using h_1 but not when using h_2.

5. Give an expression for the nodes which will be expanded in an A* search using h_2 but not when using h_1.