CS-E4800 AI Exercises 2: Search January 17, 2017

Instructions for weekly exercise sessions: *Attend one session on Tuesday, either 12:15-14:00 or 16:15-18:00. The sessions consist of exercises, and sometimes demonstrations by the assistant to more deeply illustrate topics covered in the lecture. Try to solve the exercises before the session (alone, no groupwork allowed!), and mark in the assistant's paper which solutions you are ready to present in the session. If you are chosen to present the solutions, you will get full bonus points from correct solutions as well as from reasonable attempts. If you have marked problems solved, but don't seem to have a clue about how it is solved (indicating dishonesty on your part about marking exercises as solved, or not solving them yourself), we will grant you negative points as a discouragement. Students not chosen to present will get full bonus points.*

Demonstrations

Redundant paths in search algorithms: Sometimes there are multiple paths that end up in the same state. This may cause A* and other search algorithms a performance penalty or other difficulties, if this types of redundant paths are not recognized and handled properly. This demonstration discusses the issue and presents fixes to it in A* and related algorithms.

Exercises

1. Consider path-planning with graph-like maps, as in the Romania and Germany maps on the lecture, solved with informed search algorithms such as A*.
   - Let $D(i, j)$ be the straight-line distance between cities i and j. Which of the following heuristic functions are admissible? (a) $D(i, j)$; (b) $2 \cdot D(i, j)$; (c) $D(i, j)/2$. Why?
   - The *Manhattan distance* between points $p_1 = (x_1, y_1)$ and $p_2 = (x_2, y_2)$ on the 2-dimensional Euclidean plane is defined as $M(p_1, p_2) = |x_1 - x_2| + |y_1 - y_2|$. Is $M(p_1, p_2)$ an admissible heuristic function for graph-like maps? With what values for c is $c \cdot M(p_1, p_2)$ admissible? (Extra question: Can you come up with restricted subclasses of maps where admissibility is guaranteed?)
   - Consider a transportation problem, in which one or more passengers $p \in P$ are transported from one shared starting location to their respective destinations $T(p)$. The actions are
     (a) dropping off passenger at the passenger's target location, and
     (b) moving the vehicle (and the passengers) from location i to a neighboring location j.

     The *drop-off* actions have a small non-zero cost, and the move actions' cost is $|P| \cdot d(i, j)$, where $d(i, j)$ is the road distance between neighboring locations i and j, and $|P|$ is the number of passengers in the vehicle. Develop an admissible heuristic for this problem, better than the obvious one $D(i, j)$. You can refer to the distance from the current location i of the vehicle to the passengers' target locations $T(p), p \in P$, as well as of course the set of passengers P at the current point of the search.
2. Which of the following are true and which are false? Explain your answers.
   - Depth-first search always expands at least as many nodes as A* search with an admissible heuristic.
   - $h(n) = 0$ is an admissible heuristic.
   - A* is of no use in robotics because percepts, states, and actions are continuous.
   - Assume that a rook can move on a chessboard any number of squares in a straight line, vertically or horizontally, but cannot jump over other pieces. Manhattan distance is an admissible heuristic for the problem of moving the rook from square A to square B in the smallest number of moves.
3. Consider a state space where the start state is number 1 and each state k has two successors: numbers $2k$ and $2k + 1$.
   - Draw the portion of the state space for states 1 to 15. (Clearly, the state space is infinite).
   - Suppose the goal state is 11. List the order in which nodes will be visited for breadth-first search, depth-limited search with limit 3, and iterative deepening search.
   - How well would bidirectional search work on this problem? What is the branching factor in each direction of the bidirectional search?