Artificial Intelligence

T-622-ARTI

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Reykjavik university

PROGRAMMING ASSIGNMENT 1 - SEARCH

Report

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Answers to questions 3 and 4

3) Estimate the size of the state space assuming the environment has width W, length L and D dirty spots.

$$W * L * 4 * 2^D$$

The agent can face four different directions for each cell in the grid, and for each possible state each dirty spot can be either clean or dirty.

4) Assess the following blind search algorithms wrt. their completeness, optimality, space and time complexity in the given environment: Depth-First Search, Breadth-First Search, Uniform-Cost Search. If one of the algorithms is not complete, how could you fix it? Note: Do this step before you implement the algorithms, so you know what to expect when you run the algorithms. Otherwise you might be very surprised.

DFS: Not great. It is incomplete without a check for duplicate visited states, and not optimal. Its time complexity of $O(b^m)$ is massively worse than BFS in the worst case, but its space complexity of $O(bm)$ is significantly better than that of BFS.

BFS: Some good, some bad. It's complete, but not optimal. Its time complexity of $O(b^d)$ is better than DFS, and its space complexity of $O(b^d)$ is significantly worse than DFS.

Uniform Search: Both complete and optimal. Its time and space complexity are $O(b^{(1+C/\epsilon)})$.

Where b is the branching factor, m is the maximal depth of a leaf node, d is the depth of the depth of the shallowest goal node, C is the cost of the optimal solution, and ϵ is the minimum cost of an action.

Short description of your heuristics and why you think it is admissible

In our solution we based our heuristics on given formula:

((number of dirt - 1)*Min distance between dirt)
+ Manhattan distance from Home to furthest dirt
+ Manhattan distance from agent to furthest dirt

Where by multiplying the number of dirt -1 times minimum distance between dirt, we can ensure that it will form a minimal spanning tree, where we diced the furthest node is the root of that tree and we add the distances from the starting position to the root and as well the agent's position to the root. This way we can predict a feasible heuristic which is admissible but not consistent where we switch to a Manhattan distance back to starting point when we finished cleaning all dirt.

The results of the experiments and the conclusions you draw from those results (tasks 5 and 7)

DFS results:

world 1:
- Maximum frontier size: 110
- Expansion count: 383
- Elapsed time: 0.005
- Solution cost: 109

world 2:
- Maximum frontier size: 88
- Expansion count: 323
- Elapsed time: 0.006
- Solution cost: 87

world 3:
- Maximum frontier size: 1350
- Expansion count: 6210
- Elapsed time: 0.039
- Solution cost: 1349

world 4:
Maximum frontier size: 2894
Expansion count: 16736
Elapsed time: 0.078
Solution cost: 2893
world 5:
Maximum frontier size: 2318
Expansion count: 16418
Elapsed time: 0.083
Solution cost: 2317
world 6:
Maximum frontier size: 1
Expansion count: 2073473
Elapsed time: 3.583
Solution cost: 0
world 7:
Maximum frontier size: 1276
Expansion count: 5982
Elapsed time: 0.034
Solution cost: 1275
world 8:
Maximum frontier size: 1309
Expansion count: 6089
Elapsed time: 0.045
Solution cost: 1308
world 9:
Maximum frontier size: 1334
Expansion count: 6157
Elapsed time: 0.035
Solution cost: 1333
world 10:
Maximum frontier size: 1347
Expansion count: 6174
Elapsed time: 0.034
Solution cost: 1346

BFS results:

world 1:
Maximum frontier size: 42
Expansion count: 3884
Elapsed time: 0.023
Solution cost: 41

world 2:
    Maximum frontier size: 46
    Expansion count: 3571
    Elapsed time: 0.022
    Solution cost: 45
world 3:
    Maximum frontier size: 286
    Expansion count: 5569476
    Elapsed time: 21.298
    Solution cost: 285
world 4:
    Maximum frontier size: 202
    Expansion count: 4168270
    Elapsed time: 12.77
    Solution cost: 201
world 5:
    Maximum frontier size: 170
    Expansion count: 5565363
    Elapsed time: 14.96
    Solution cost: 169
world 6:
    Maximum frontier size: 1
    Expansion count: 2073473
    Elapsed time: 4.008
    Solution cost: 0
world 7:
    Maximum frontier size: 222
    Expansion count: 349022
    Elapsed time: 0.515
    Solution cost: 221
world 8:
    Maximum frontier size: 259
    Expansion count: 697566
    Elapsed time: 0.9
    Solution cost: 258
world 9:
    Maximum frontier size: 270
    Expansion count: 1394394
    Elapsed time: 1.971
    Solution cost: 269

world 10:
Maximum frontier size: 271
Expansion count: 2786756
Elapsed time: 6.587
Solution cost: 270

UCS results:

world 1:
Maximum frontier size: 74
Expansion count: 453
Elapsed time: 0.006
Solution cost: 73
world 2:
Maximum frontier size: 71
Expansion count: 418
Elapsed time: 0.006
Solution cost: 70
world 3:
Maximum frontier size: 1585
Expansion count: 22794
Elapsed time: 0.076
Solution cost: 1584
world 4:
Maximum frontier size: 1923
Expansion count: 23864
Elapsed time: 0.088
Solution cost: 1922
world 5:
Maximum frontier size: 1200
Expansion count: 20935
Elapsed time: 0.074
Solution cost: 1199
world 6:
Maximum frontier size: 1
Expansion count: 2073473
Elapsed time: 3.629
Solution cost: 0
world 7:
Maximum frontier size: 1165
Expansion count: 16464
Elapsed time: 0.072
Solution cost: 1164

world 8:
    Maximum frontier size: 1202
    Expansion count: 16603
    Elapsed time: 0.071
    Solution cost: 1201
world 9:
    Maximum frontier size: 1473
    Expansion count: 21581
    Elapsed time: 0.078
    Solution cost: 1472
world 10:
    Maximum frontier size: 1580
    Expansion count: 22738
    Elapsed time: 0.085
    Solution cost: 1579

A* results:

world 1:
    Maximum frontier size: 42
    Expansion count: 2316
    Elapsed time: 0.022
    Solution cost: 41
world 2:
    Maximum frontier size: 46
    Expansion count: 2243
    Elapsed time: 0.02
    Solution cost: 45
world 3:
    Maximum frontier size: 286
    Expansion count: 4719619
    Elapsed time: 14.084
    Solution cost: 285
world 4:
    Maximum frontier size: 202
    Expansion count: 1883454
    Elapsed time: 4.368
    Solution cost: 201
world 5:
    Maximum frontier size: 170
    Expansion count: 3310135
    Elapsed time: 11.066
    Solution cost: 169

world 6:
    Maximum frontier size: 1
    Expansion count: 2073473
    Elapsed time: 6.252
    Solution cost: 0
world 7:
    Maximum frontier size: 222
    Expansion count: 237804
    Elapsed time: 0.446
    Solution cost: 221
world 8:
    Maximum frontier size: 259
    Expansion count: 540578
    Elapsed time: 0.893
    Solution cost: 258
world 9:
    Maximum frontier size: 270
    Expansion count: 1129794
    Elapsed time: 2.101
    Solution cost: 269
world 10:
    Maximum frontier size: 271
    Expansion count: 2256226
    Elapsed time: 4.926
    Solution cost: 270

Conclusion: A* is leaps and bounds better than any of the other search algorithms. It searches the biggest state space in the shortest time, and returns an optimal solution. Given that none of the algorithms find a solution to world 6 we can infer that no solution exists. Going by the measured maximum frontier size, BFS appears to actually be among the more spatially efficient algorithms.