Stephen Chambers

smx227

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Assignment 2 Writeup

**1. Explain each heuristic function you devised and prove that each is admissable.**

*h0:* Return an h value of zero.

Admissability: This is obviously admissable, as the f value will always be less than the optimal solution.

*h1:* Return the number of dirty cells remaining \* 2.

Admissability: This is admissable because the robot needs to move to at least every dirty cell remaining, and needs to vaccum each one. Therefore, the f value will always be less than the optimal solution.

*h2:* Return the manhatten distance of the dirty cell furthest away.

Admissability: The robot always needs to have travel at least to the furthest away dirty cell. Thereofre, the f value will always be less than the optimal solution.

*h3:* Calculate the manhatten distance of the furthest away dirty cell. If the robot has enough charge to get there, return that value. If it does not, return the value of the nearest charging station.

Admissability: The same proof as h2. Additionally, if the robot needs to recharge, and the world is solvable, the closest charging station will be less than the furthest away dirty cell. Therefore, the f value will always be less than the optimal solution.

**2. Describe any implementation choices you made that you felt were important. Mention anything else we should know when evaluationg your program.**

No implmentation details changed drastically between assignment 1 and assignment 2.

**3. What is the time and space complexity of each algorithm you implemented? Which algorithms are admissable?**

|  |  |  |  |
| --- | --- | --- | --- |
| **Algorithm** | **Time Complexity** | **Space Complexity** | **Admissable?** |
| Depth-first | O(bm) | O(b\*m) | No |
| Uniform-Cost | O(bd) | O(bd) | Yes |
| Depth-first iterative deepening | O(bd) | O(b\*d) | Yes |
| A-star | O(bd) | O(bd) | Yes(assuming h is admissable) |
| Greedy Breadth First Search | O(bd) | O(bd) | No(assuming h is admissable) |
| Iterative Deepening A-Star | O(bd) | O(b\*d) | Yes(assuming h is admissable) |

**4. Provide empirical results confirming your answers to the previous question.**

Note: All tests were run with h2, except for the “heuristic domination” section.

*Depth-first Search*

|  |  |  |  |
| --- | --- | --- | --- |
| World | Nodes Expanded | Nodes Generated | Plan length |
| tiny-1.vw | 4 | 10 | 4 |
| tiny-2.vw | 12 | 29 | 11 |
| small-1.vw | 82 | 241 | 77 |
| hard-1.vw | 5383 | 13994 | 525 |
| hard-2.vw | Timed out | Timed out | Timed out |

*Uniform-cost Search*

|  |  |  |  |
| --- | --- | --- | --- |
| World | Nodes Expanded | Nodes Generated | Plan length |
| tiny-1.vw | 11 | 31 | 4 |
| tiny-2.vw | 75 | 197 | 9 |
| small-1.vw | 899 | 2730 | 24 |
| hard-1.vw | 2507 | 7251 | 59 |
| hard-2.vw | 281534 | 796705 | 141 |

*Iterative Deepening Depth-first search*

|  |  |  |  |
| --- | --- | --- | --- |
| World | Nodes Expanded | Nodes Generated | Plan length |
| tiny-1.vw | 41 | 115 | 4 |
| tiny-2.vw | 933 | 2372 | 9 |
| small-1.vw | Timed out | Timed out | Timed out |
| hard-1.vw | Timed out | Timed out | Timed out |
| hard-2.vw | Timed out | Timed out | Timed out |

*Iterative Deepening A-Star*

|  |  |  |  |
| --- | --- | --- | --- |
| World | Nodes Expanded | Nodes Generated | Plan length |
| tiny-1.vw | 4 | 10 | 4 |
| tiny-2.vw | 195 | 476 | 9 |
| small-1.vw | 752480 | 2637663 | 24 |
| hard-1.vw | Timed out | Timed out | Timed out |
| hard-2.vw | Timed out | Timed out | Timed out |

*Greedy Breadth First Search*

|  |  |  |  |
| --- | --- | --- | --- |
| World | Nodes Expanded | Nodes Generated | Plan length |
| tiny-1.vw | 4 | 13 | 4 |
| tiny-2.vw | 24 | 66 | 10 |
| small-1.vw | 181 | 565 | 31 |
| hard-1.vw | 1000 | 2929 | 139 |
| hard-2.vw | 70774 | 200787 | 529 |

*A-Star*

|  |  |  |  |
| --- | --- | --- | --- |
| World | Nodes Expanded | Nodes Generated | Plan length |
| tiny-1.vw | 6 | 18 | 4 |
| tiny-2.vw | 46 | 120 | 9 |
| small-1.vw | 361 | 1171 | 24 |
| hard-1.vw | 974 | 2946 | 59 |
| hard-2.vw | 66851 | 188725 | 141 |

**Hueristic Domination Results:**

*A-Star with h0*

|  |  |  |  |
| --- | --- | --- | --- |
| World | Nodes Expanded | Nodes Generated | Plan length |
| tiny-1.vw | 11 | 31 | 4 |
| tiny-2.vw | 75 | 197 | 9 |
| small-1.vw | 899 | 2730 | 24 |
| hard-1.vw | 2507 | 7251 | 59 |
| hard-2.vw | 281534 | 796705 | 141 |

*A-Star with h1*

|  |  |  |  |
| --- | --- | --- | --- |
| World | Nodes Expanded | Nodes Generated | Plan length |
| tiny-1.vw | 10 | 29 | 4 |
| tiny-2.vw | 46 | 125 | 9 |
| small-1.vw | 706 | 2171 | 24 |
| hard-1.vw | 7067 | 2446 | 59 |
| hard-2.vw | 655835 | 231601 | 141 |

*A-Star with h2*

|  |  |  |  |
| --- | --- | --- | --- |
| World | Nodes Expanded | Nodes Generated | Plan length |
| tiny-1.vw | 6 | 18 | 4 |
| tiny-2.vw | 46 | 120 | 9 |
| small-1.vw | 361 | 1171 | 24 |
| hard-1.vw | 974 | 2946 | 59 |
| hard-2.vw | 66851 | 188725 | 141 |

*Conclusions:*

* h2 dominates h1 which dominates h0. Looking at the results of a-star with the different heuristics, the nodes generated/expanded decrease moving from h0 🡪 h2.
* Although the nodes generated/expanded decreased, the worst case time complexities of the newly added algorithms remain the same as breadth-first search.

**5. What suggestions do you have for improving this assignment in the future?**

I enjoyed this assignment. As long as the framework is in place from assignment 1, it was relatively simple.