Tyler Evans – Com S 472 Lab 1

Part 2:

**BFS Results:**

\*\*\* S1 \*\*\*

Total Nodes Generated: 259726

Total Nodes Expanded: 97527

Total Time Taken: 350 ms 120400 ns

Path Length: 24.0

Path: DDLUULDRRULLDRRDLLURRULL

\*\*\* S2 \*\*\*

Total Nodes Generated: 77993

Total Nodes Expanded: 29053

Total Time Taken: 62 ms 991100 ns

Path Length: 20.0

Path: DDLLURULDRRDLLURRULL

\*\*\* S3 \*\*\*

The inputted puzzle is not solvable.

7 5 2

6 3 1

4 8 0

\*\*\* S4 \*\*\*

Total Nodes Generated: 483564

Total Nodes Expanded: 181347

Total Time Taken: 379 ms 429700 ns

Path Length: 31.0

Path: DDRUULLDDRURULLDDRURULLDDRRUULL

\*\*\* S5 \*\*\*

Total Nodes Generated: 156

Total Nodes Expanded: 54

Total Time Taken: 222600 ns

Path Length: 6.0

Path: RDLUUL

**IDS Results:**

\*\*\* S1 \*\*\*

Total Nodes Generated: 4073218

Total Nodes Expanded: 1499864

Total Time Taken: 1 sec 1326 ms 27500 ns

Path Length: 24.0

Path: DDLUULDRRULLDRRDLLURRULL

\*\*\* S2 \*\*\*

Total Nodes Generated: 494371

Total Nodes Expanded: 181622

Total Time Taken: 328 ms 937400 ns

Path Length: 20.0

Path: DDLLURULDRRDLLURRULL

\*\*\* S3 \*\*\*

The inputted puzzle is not solvable.

7 5 2

6 3 1

4 8 0

\*\*\* S4 \*\*\*

Total Nodes Generated: 213181709

Total Nodes Expanded: 78532998

Total Time Taken: 57 sec 57588 ms 88500 ns

Path Length: 31.0

Path: DDRUULLDDRURULLDDRURULLDDRRUULL

\*\*\* S5 \*\*\*

Total Nodes Generated: 336

Total Nodes Expanded: 117

Total Time Taken: 146100 ns

Path Length: 6.0

Path: RDLUUL

**A\* Search(h1) Results:**

\*\*\* S1 \*\*\*

Total Nodes Generated: 38264

Total Nodes Expanded: 14121

Total Time Taken: 170 ms 198600 ns

Path Length: 24.0

Path: DDLUULDRRULLDRRDLLURRULL

\*\*\* S2 \*\*\*

Total Nodes Generated: 5903

Total Nodes Expanded: 2183

Total Time Taken: 22 ms 946600 ns

Path Length: 20.0

Path: DDLLURULDRRDLLURRULL

\*\*\* S3 \*\*\*

The inputted puzzle is not solvable.

7 5 2

6 3 1

4 8 0

\*\*\* S4 \*\*\*

Total Nodes Generated: 330413

Total Nodes Expanded: 122894

Total Time Taken: 1 sec 1029 ms 598500 ns

Path Length: 31.0

Path: LDDRURULLDDRRULDRUULLDDRRUULDLU

\*\*\* S5 \*\*\*

Total Nodes Generated: 28

Total Nodes Expanded: 9

Total Time Taken: 170900 ns

Path Length: 6.0

Path: RDLUUL

**A\* Search(h2) Results:**

\*\*\* S1 \*\*\*

Total Nodes Generated: 3815

Total Nodes Expanded: 1433

Total Time Taken: 44 ms 664700 ns

Path Length: 24.0

Path: DDLUULDRRULLDRRDLLURRULL

\*\*\* S2 \*\*\*

Total Nodes Generated: 346

Total Nodes Expanded: 130

Total Time Taken: 1 ms 212100 ns

Path Length: 20.0

Path: DDLLURULDRRDLLURRULL

\*\*\* S3 \*\*\*

The inputted puzzle is not solvable.

7 5 2

6 3 1

4 8 0

\*\*\* S4 \*\*\*

Total Nodes Generated: 21307

Total Nodes Expanded: 8057

Total Time Taken: 70 ms 754200 ns

Path Length: 31.0

Path: LDDRUULDDRURULDRDLUULDDRURULDLU

\*\*\* S5 \*\*\*

Total Nodes Generated: 25

Total Nodes Expanded: 8

Total Time Taken: 177800 ns

Path Length: 6.0

Path: RDLUUL

**A\* Search(h3) Results:**

\*\*\* S1 \*\*\*

Total Nodes Generated: 55557

Total Nodes Expanded: 20437

Total Time Taken: 532 ms 75300 ns

Path Length: 24.0

Path: DDLUULDRRULLDRRDLLURRULL

\*\*\* S2 \*\*\*

Total Nodes Generated: 8654

Total Nodes Expanded: 3183

Total Time Taken: 44 ms 956100 ns

Path Length: 20.0

Path: DDLLURULDRRDLLURRULL

\*\*\* S3 \*\*\*

The inputted puzzle is not solvable.

7 5 2

6 3 1

4 8 0

\*\*\* S4 \*\*\*

Total Nodes Generated: 366812

Total Nodes Expanded: 136869

Total Time Taken: 3 sec 3061 ms 725200 ns

Path Length: 31.0

Path: LDDRRUULDDRUULLDRDRUULLDDRURULL

\*\*\* S5 \*\*\*

Total Nodes Generated: 30

Total Nodes Expanded: 10

Total Time Taken: 148400 ns

Path Length: 6.0

Path: RDLUUL

Part 3:

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Depth | BFS | | IDS | | A\*:h1 | | A\*:h2 | | A\*:h3 | |
| Avg Run Time | Avg # Nodes | Avg Run Time | Avg # Nodes | Avg Run Time | Avg # Nodes | Avg Run Time | Avg # Nodes | Avg Run Time | Avg # Nodes |
| 8 | 2 ms 214170 ns | 376 | 3 ms 68300 ns | 874 | 1 ms 244415 ns | 51 | 1 ms 68565 ns | 32 | 1 ms 855610 ns | 57 |
| 15 | 15 ms 20690 ns | 11663 | 25 ms 242010 ns | 44626 | 4 ms 462740 ns | 999 | 2 ms 313885 ns | 256 | 12 ms 395895 ns | 1181 |
| 24 | 196 ms 158700 ns | 287921 | 1 sec 1430 ms 878170 ns | 5365539 | 107 ms 933730 ns | 44590 | 11 ms 608735 ns | 3113 | 400 ms 425340 ns | 52347 |

Conclusions:

One immediate conclusion that can be drawn from the data is how any heuristic we seemed to choose for the A\* algorithm seemed to be far more efficient than either BFS or IDS, in terms of both time and space complexity. IDS seemed to be the least efficient of the algorithms, which I predicted from the start and validates what we learned in class about such algorithms. One result that was surprising to me was how quickly BFS was able to run, as it even had a lower average run time for a depth of 24 than the A\* search with the h3 heuristic, although it was still lacking in the space complexity department, which as we learned in class is a major drawback of breadth-first search due to the nature of its design.

Regarding my implementation for h3 (Manhattan Distance + Reversal Penalty), while researching various heuristics I was led to believe that it was superior to the heuristics for h1 and h2, and further research seems to validate that. However, my results suggest otherwise, and I believe this may be due to a poor implementation of the heuristic on my part as I had some difficulties with figuring out an efficient way to write the code for it. If I were able to come up with a better way to implement the heuristic I believe that my results would confirm the results from my research into the topic.