



# Comp 472 Assignment 2

Team : Unlimited

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# Explanation of Heuristics

Heuristic 1 : Manhattan distance between node and 2 goal states.

Heuristic 2 : Count number of out of place values.



# Generate file with 50 random puzzles

See random\_50\_puzzles.txt

```
1 7 1 5 6 0 4 3 2
2 2 7 4 5 1 3 6 0
3 4 1 0 7 6 3 2 5
4 7 4 5 6 2 3 0 1
5 0 1 4 2 3 7 5 6
6 2 0 6 3 1 5 7 4
7 3 4 2 5 6 7 1 0
8 6 0 5 1 2 4 7 3
9 3 4 2 0 1 5 6 7
10 6 2 3 4 5 1 0 7
11 5 0 7 3 6 4 2 1
12 7 1 6 4 2 3 0 5
13 0 1 2 4 7 5 6 3
14 0 6 4 7 3 2 5 1
15 6 4 1 5 0 7 2 3
16 3 4 0 6 2 7 1 5
17 7 6 1 4 2 0 5 3
18 1 4 6 0 5 3 2 7
19 1 5 0 4 6 2 7 3
20 6 4 1 7 5 3 0 2
21 5 3 0 4 7 6 1 2
22 3 2 1 5 4 0 7 6
23 2 6 4 0 7 5 1 3
24 0 2 7 3 5 1 6 4
25 4 6 0 1 2 3 5 7
26 0 1 2 5 7 6 4 3
27 3 6 1 5 7 2 4 0
28 4 5 0 2 7 6 3 1
29 7 6 3 4 5 1 0 2
30 5 7 1 4 3 6 2 0
31 2 4 6 7 0 3 1 5
32 0 6 4 1 2 5 3 7
33 6 5 0 3 2 7 1 4
34 1 3 2 4 7 5 0 6
35 6 1 0 4 3 2 7 5
36 6 5 4 1 3 0 7 2
37 3 0 4 5 1 6 7 2
38 1 5 0 7 2 4 6 3
39 3 0 6 4 1 2 5 7
40 5 6 3 2 1 0 7 4
41 0 7 3 5 1 2 4 6
42 4 0 6 7 3 2 1 5
43 5 2 0 6 1 4 7 3
44 0 7 3 6 5 1 4 2
45 4 7 0 1 3 2 5 6
46 4 7 0 1 5 6 3 2
47 2 0 5 1 4 6 7 3
48 5 7 0 2 3 6 4 1
49 6 7 1 3 5 4 0 2
50 1 6 3 4 5 2 7 0
```



## Analysis of the 50 random puzzles using UCS

```
----- ANALYSIS -----  
Algo name: ucs  
1.  
Total Length of Solution Path:      37  
Average Length of Solution Path:    0.74  
  
Total Length of Search Path:        5743  
Average Length of Search Path:      114.86  
  
2.  
Total number of "no solution":      45  
Average number of "no solution":    0.9  
  
3.  
Total Cost:                          44  
Average Total Cost:                  0.88  
Total Execution Time:               10.917  
Average Execution Time:              0.21834
```

# Analysis of the 50 random puzzles ran on GBFS using our first Heuristic

```
----- ANALYSIS -----  
Algo name: gbfs-h1  
1.  
Total Length of Solution Path:      16  
Average Length of Solution Path:    0.32  
  
Total Length of Search Path:        77  
Average Length of Search Path:      1.54  
  
2.  
Total number of "no solution":      48  
Average number of "no solution":    0.96  
  
3.  
Total Cost:                          20  
Average Total Cost:                  0.4  
Total Execution Time:               0.131  
Average Execution Time:             0.00262
```

# Analysis of the 50 random puzzles ran on GBFS using our second Heuristic

```
----- ANALYSIS -----  
Algo name: gbfs-h2  
1.  
Total Length of Solution Path:      61  
Average Length of Solution Path:    1.22  
  
Total Length of Search Path:        225  
Average Length of Search Path:      4.5  
  
2.  
Total number of "no solution":      45  
Average number of "no solution":    0.9  
  
3.  
Total Cost:                         85  
Average Total Cost:                 1.7  
Total Execution Time:               0.30400000000000005  
Average Execution Time:             0.0060800000000000001
```



## Analysis of the 50 random puzzles ran on A\* using our first Heuristic

```
----- ANALYSIS -----  
Algo name: astar-h1  
1.  
Total Length of Solution Path:      255  
Average Length of Solution Path:    5.1  
  
Total Length of Search Path:        3065  
Average Length of Search Path:      61.3  
  
2.  
Total number of "no solution":      26  
Average number of "no solution":    0.52  
  
3.  
Total Cost:                          287  
Average Total Cost:                  5.74  
Total Execution Time:                73.27000000000001  
Average Execution Time:              1.4654000000000003
```



## Analysis of the 50 random puzzles ran on A\* using our second Heuristic

```
----- ANALYSIS -----  
Algo name: astar-h2  
1.  
Total Length of Solution Path:      203  
Average Length of Solution Path:    4.06  
  
Total Length of Search Path:        4588  
Average Length of Search Path:      91.76  
  
2.  
Total number of "no solution":      29  
Average number of "no solution":    0.58  
  
3.  
Total Cost:                         234  
Average Total Cost:                 4.68  
Total Execution Time:               45.039  
Average Execution Time:             0.90078
```





# Scaling up

We tried these sizes for scaling up:

2x4, 3x4, 4x4

We generated 3 random puzzles for each size.

Most of the time, the 3 generated 2x4 puzzles have a solution in less than 5 seconds.

For the other sizes, we never found a solution even after 500 seconds per puzzle.

We tried with a 3x4 puzzle that is very close to the goal states and it works.

But with a random 3x4 puzzle, the goals are very far in the search path, so the algorithm takes a very long time.

One solution would be to improve our implementation of the internal data structures and parallelize some operations. We could also make use of the GPU.