Assignment

A* to solve the modified n-puzzle problem
# CS3612

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Basic Analysis

In this experiment, 100 configurations pairs with varying grid sizes between 5 and 20 were generated. The minimum required steps between the start configuration and end configuration were limited to 50 moves.

After performing A* search on these configuration pairs using both Manhattan heuristic and misplaced tiles heuristic, 100 data point pairs denoting the number of iterations in each case were derived. These data points are attached under annex. Following is a simple summary of the collection of data points.

	Iterations in Manhattan Heuristic A*	Iterations in Misplaced Tiles Heuristic A*
Number of Data Points	100	100
Mean	1220.05	24137.22
Standard Deviation	1976.297709	40866.004537
Min	51	48
25%	275.75	1334.5
50%	602	5959
75%	1397.25	24539
Max	15622	166640

Upon immediate inspection, it seems that misplaced tiles heuristic has taken a larger number of iterations compared to the Manhattan heuristic. If the number of iterations for each heuristic was graphed, it becomes clear that Manhattan distance heuristic took a lesser number of iterations to compute the minimum moves to arrive at the target state compared to the minimum-tiles heuristic. *Note that the values in the following graph were scaled using the logarithmic scale.*
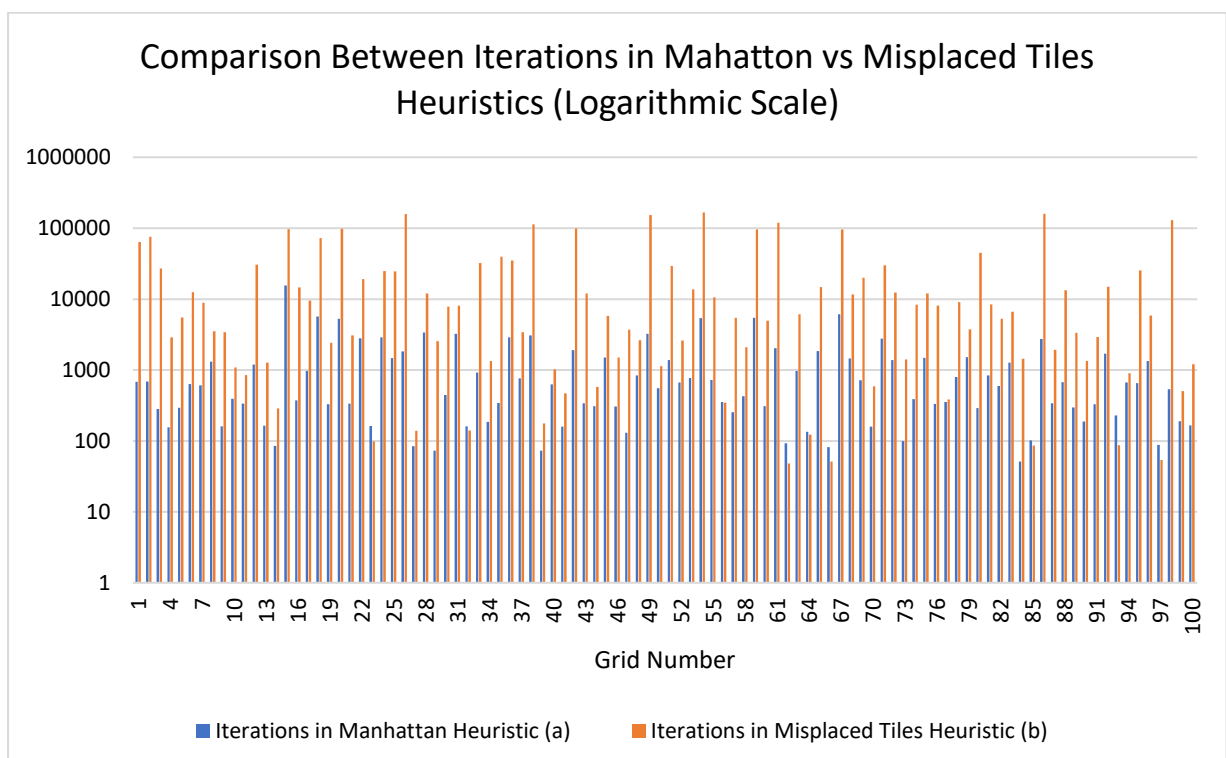
This is even more clear in the below chart. Here, each value is charted regarding grid size and the minimum number of moves it needed. Upon inspection, it can be seen that Manhattan distance heuristic was the better heuristic in most configurations.
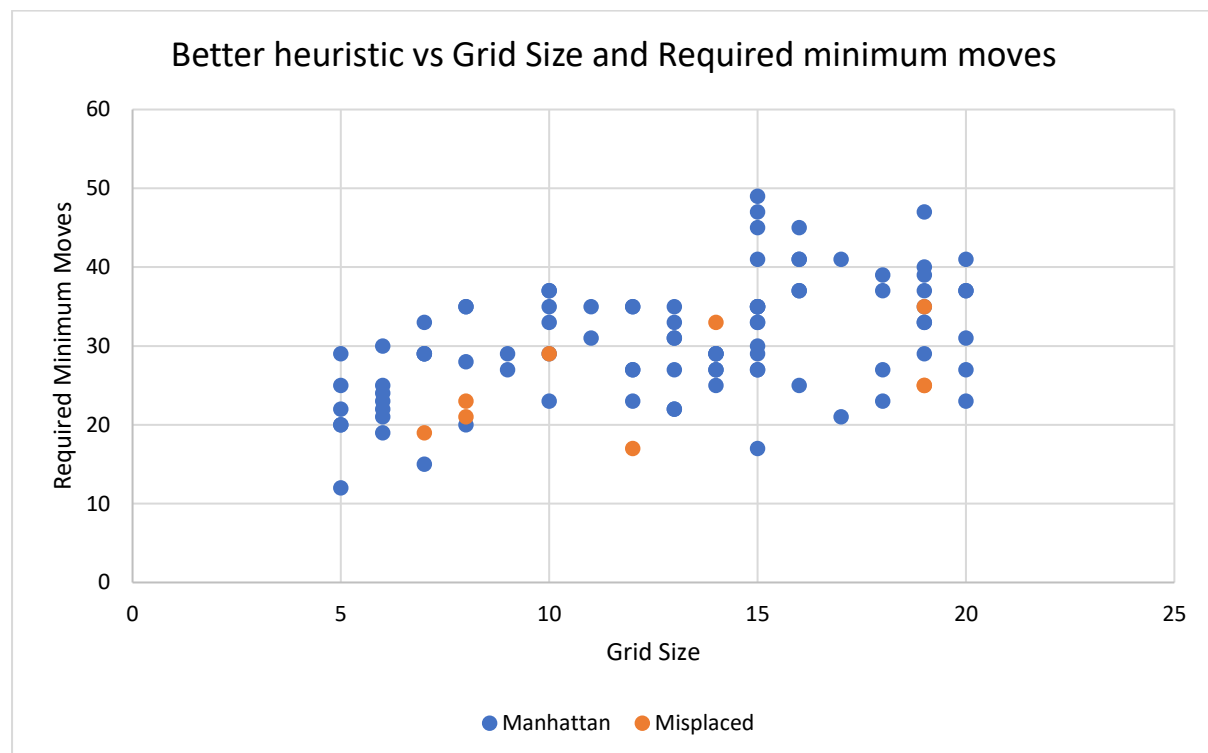
Following is the sums and means of differences in using each heuristic.

	Sum of Differences in iterations count	Mean of Differences in iterations count
When Manhattan is the better heuristic	2292087	25187.769
When misplaced tile count is the better heuristic	370	41.111
Total	2291717	22917.17

So, it is extremely clear that even when misplaced tile count is a better heuristic, the difference between iterations in extremely small compared to the other way around.

Statistical Significance Testing

The statement "Is there any significant difference between the iterations it took to calculate the minimum moves while using Manhattan heuristic and Misplaced Tiles?" can be easily answered using a student's t-test. (two-tailed, paired).

When calculated with the hypothesis that "There is a significant difference between using Manhattan heuristic vs misplaced tiles heuristic", the **power value(p) was 0.0000000948.** This value is significantly less than 0.05. Thus, this proves the hypothesis.

Thus, we can arrive at the conclusion that Manhattan distance is the better heuristic.

Annex: Raw Data

#	Grid Size	Minimum Required Moves	Iterations in Manhattan Heuristic (a)	Iterations in Misplaced Tiles Heuristic (b)	Difference in Iterations (b-a)
1	16	45	681	63827	63146
2	6	30	686	75242	74556
3	13	35	283	27077	26794
4	14	27	156	2879	2723
5	15	45	295	5501	5206
6	13	31	636	12558	11922
7	19	35	606	8908	8302
8	10	23	1310	3533	2223
9	15	27	160	3428	3268
10	16	37	391	1084	693
11	10	37	336	847	511
12	15	35	1200	30518	29318
13	6	23	164	1275	1111
14	13	22	85	286	201
15	19	39	15622	96594	80972
16	11	31	372	14623	14251
17	19	33	970	9538	8568
18	15	30	5655	72354	66699
19	12	35	330	2422	2092
20	6	24	5257	98462	93205
21	6	22	337	3083	2746
22	13	31	2813	19160	16347
23	10	29	163	99	-64
24	5	20	2882	24776	21894
25	14	29	1468	24460	22992
26	17	41	1828	158778	156950
27	13	27	84	139	55
28	10	37	3368	11939	8571
29	6	21	73	2562	2489
30	12	27	445	7861	7416
31	19	33	3253	8066	4813
32	19	35	161	140	-21
33	5	20	922	32147	31225
34	6	19	186	1333	1147
35	15	33	344	39529	39185
36	18	39	2898	34990	32092
37	8	35	763	3422	2659
38	11	35	3061	113222	110161
39	15	17	73	177	104
40	16	25	626	1018	392

41	7	29	159	468	309
42	7	29	1915	99349	97434
43	15	29	339	12008	11669
44	14	29	308	579	271
45	12	27	1508	5773	4265
46	20	37	305	1497	1192
47	9	27	130	3721	3591
48	7	15	840	2635	1795
49	15	35	3253	153622	150369
50	19	47	555	1129	574
51	10	33	1378	29382	28004
52	15	27	668	2602	1934
53	20	41	771	13782	13011
54	14	27	5397	166640	161243
55	13	22	728	10625	9897
56	12	17	354	347	-7
57	18	37	254	5458	5204
58	15	41	425	2096	1671
59	13	33	5457	95701	90244
60	20	23	308	4943	4635
61	6	25	2022	119892	117870
62	8	21	93	48	-45
63	12	35	971	6078	5107
64	19	25	134	123	-11
65	5	25	1842	14820	12978
66	7	19	82	51	-31
67	19	37	6124	96079	89955
68	20	37	1449	11647	10198
69	19	40	715	20032	19317
70	12	23	159	587	428
71	8	28	2779	29901	27122
72	18	23	1380	12325	10945
73	5	12	100	1416	1316
74	5	22	388	8347	7959
75	7	33	1488	11989	10501
76	14	29	334	8060	7726
77	17	21	354	384	30
78	15	35	794	9024	8230
79	20	27	1514	3744	2230
80	15	49	291	44790	44499
81	16	37	839	8427	7588
82	15	47	598	5270	4672
83	19	29	1274	6655	5381
84	8	20	51	1437	1386
85	19	25	102	86	-16

86	16	41	2736	160341	157605
87	10	35	340	1923	1583
88	10	29	676	13295	12619
89	15	35	296	3348	3052
90	18	27	187	1335	1148
91	8	35	328	2932	2604
92	7	29	1701	14936	13235
93	14	33	228	87	-141
94	20	31	666	898	232
95	9	29	654	25314	24660
96	16	41	1340	5840	4500
97	8	23	88	54	-34
98	5	29	537	130286	129749
99	14	25	190	503	313
100	15	33	166	1204	1038