Using Informed and Uninformed Search Algorithms to Solve 8-Puzzle

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Uninformed Search

Algorithms:

We used in this problem DFS (Depth First Search) and BFS (Breadth first Search)

Data structures:

For both algorithms we used hash table for parent map and set for explored states.

We used stack in DFS for the frontier.

We used queue in BFS for the frontier.

Informed Search

Algorithms:

We used in this problem A* Algorithm with two different heuristics.

Data structures:

For this algorithm we used hash table for parent map and set for explored states.

We used priority Queue (Heap) for the frontier.

Test Cases:

1) Input: 1 2 3 4 5 6 8 7 0 Unsolved test case

Using Breadth First Search:

Depth: 31

Number of expanded nodes: 181440

Running time: 0.6755461692810059

Using Depth First Search:

Depth: 66906

Number of expanded nodes: 181440

Running time: 0.3877389430999756

A* Search with manhattan:

Depth: 34

Number of expanded nodes: 181440

Running time: 1.0670711994171143

A* Search with euclidean:

Depth: 32

Number of expanded nodes: 181440

Running time: 1.3207991123199463

2) Input: 1 2 5 3 4 0 6 7 8

Using Breadth First Search:
---
1 2 5
3 4 0
6 7 8

1 2 0
3 4 5
6 7 8

1 0 2
3 4 5
6 7 8

0 1 2
3 4 5
6 7 8

Cost of the path: 3
Depth: 3
Number of expanded nodes: 10
Running time: 0.0

Using Depth First Search:
---
1 2 5
3 4 0
6 7 8

1 2 5
3 4 8
6 7 0
....
0 1 2
3 4 5
6 7 8

Cost of the path: 157
Depth: 157
Number of expanded nodes: 158
Running time: 0.0

A* Search with manhattan:
---
1 2 5
3 4 0
6 7 8

1 2 0
3 4 5
6 7 8

1 0 2
3 4 5
6 7 8

0 1 2
3 4 5
6 7 8
Cost of the path: 3
Depth: 3
Number of expanded nodes: 4
Running time: 0.0

A* Search with euclidean:
---
1 2 5
3 4 0
6 7 8

1 2 0
3 4 5
6 7 8

1 0 2
3 4 5
6 7 8

0 1 2
3 4 5
6 7 8

Cost of the path: 3
Depth: 3
Number of expanded nodes: 4
Running time: 0.0

3) Input: 1 0 2 7 5 4 8 6 3

Using Breadth First Search:
---
1 0 2
7 5 4
8 6 3

1 2 0
7 5 4
8 6 3

1 2 4
7 5 0
8 6 3

1 2 4
7 0 5
8 6 3

1 2 4
7 6 5
8 0 3

1 2 4
7 6 5
8 3 0

1 2 4
7 6 0
8 3 5

1 2 0
7 6 4
8 3 5
...
0 1 2
3 4 5
6 7 8

Cost of the path: 23
Depth: 24
Number of expanded nodes: 122117
Running time: 0.4406571388244629

Using Depth First Search:
---
1 0 2
7 5 4
8 6 3

1 2 0
7 5 4
8 6 3

1 2 4
7 5 0
8 6 3

1 2 4
7 5 3
8 6 0

1 2 4
7 5 3
8 0 6

1 2 4
7 5 3
0 8 6

1 2 4
0 5 3
7 8 6

1 2 4
5 0 3
7 8 6

1 2 4
5 3 0
7 8 6
...
0 1 2
3 4 5
6 7 8

Cost of the path: 17881
Depth: 17881
Number of expanded nodes: 18601
Running time: 0.03311586380004883

A* Search with manhattan:
---
1 0 2
7 5 4
8 6 3

1 2 0
7 5 4
8 6 3

1 2 4
7 5 0
8 6 3

1 2 4
7 0 5
8 6 3

1 2 4
7 6 5
8 0 3

1 2 4
7 6 5
8 3 0

1 2 4
7 6 0
8 3 5

1 2 4
7 0 6
8 3 5

1 2 4
7 3 6
8 0 5
...
0 1 2
3 4 5
6 7 8

Cost of the path: 23
Depth: 23
Number of expanded nodes: 2714
Running time: 0.016513824462890625

A* Search with euclidean:
---
1 0 2
7 5 4
8 6 3

1 2 0
7 5 4
8 6 3

1 2 4
7 5 0
8 6 3

1 2 4
7 0 5
8 6 3

1 2 4
7 6 5
8 0 3

1 2 4
7 6 5
8 3 0

1 2 4
7 6 0
8 3 5

1 2 0
7 6 4
8 3 5

1 0 2
7 6 4
8 3 5
...
0 1 2
3 4 5
6 7 8

Cost of the path: 23
Depth: 23
Number of expanded nodes: 4306
Running time: 0.033655405044555664

4) Input: 8 0 6 5 4 7 2 3 1

Using Breadth First Search:
---
8 0 6
5 4 7
2 3 1

0 8 6
5 4 7
2 3 1

5 8 6
0 4 7
2 3 1

5 8 6
2 4 7
0 3 1

5 8 6
2 4 7
3 0 1

5 8 6
2 0 7
3 4 1

5 0 6
2 8 7
3 4 1

0 5 6
2 8 7
3 4 1
...
0 1 2
3 4 5
6 7 8

Cost of the path: 31
Depth: 31
Number of expanded nodes: 181439
Running time: 0.6309599876403809

Using Depth First Search:
---
8 0 6
5 4 7
2 3 1

8 6 0
5 4 7
2 3 1

8 6 7
5 4 0
2 3 1

8 6 7
5 4 1
2 3 0

8 6 7
5 4 1
2 0 3

8 6 7
5 4 1
0 2 3

8 6 7
0 4 1
5 2 3

8 6 7
4 0 1
5 2 3

8 6 7
4 1 0
5 2 3
...
0 1 2
3 4 5
6 7 8

Cost of the path: 57329
Depth: 57329
Number of expanded nodes: 67802
Running time: 0.17715668678283691

A* Search with manhattan:
---
8 0 6
5 4 7
2 3 1

0 8 6
5 4 7
2 3 1

5 8 6
0 4 7
2 3 1

5 8 6
4 0 7
2 3 1

5 8 6
4 7 0
2 3 1

5 8 0
4 7 6
2 3 1

5 0 8
4 7 6
2 3 1

0 5 8
4 7 6
2 3 1

4 5 8
0 7 6
2 3 1
...
0 1 2
3 4 5
6 7 8

Cost of the path: 31
Depth: 31
Number of expanded nodes: 16582
Running time: 0.10685253143310547

A* Search with euclidean:
---
8 0 6
5 4 7
2 3 1

0 8 6
5 4 7
2 3 1

5 8 6
0 4 7
2 3 1

5 8 6
2 4 7
0 3 1

5 8 6
2 4 7
3 0 1

5 8 6
2 4 7
3 1 0

5 8 6
2 4 0
3 1 7

5 8 0
2 4 6
3 1 7

5 0 8
2 4 6
3 1 7
...
0 1 2
3 4 5
6 7 8

Cost of the path: 31
Depth: 31
Number of expanded nodes: 35007
Running time: 0.29189133644104004

5) Input: 1 4 2 6 5 8 7 3 0

Using Breadth First Search:
---
1 4 2
6 5 8
7 3 0

1 4 2
6 5 0
7 3 8

1 4 2
6 0 5
7 3 8

1 4 2
6 3 5
7 0 8

1 4 2
6 3 5
0 7 8

1 4 2
0 3 5
6 7 8

1 4 2
3 0 5
6 7 8

1 0 2
3 4 5
6 7 8

0 1 2
3 4 5
6 7 8

Cost of the path: 8
Depth: 9
Number of expanded nodes: 203
Running time: 0.0010001659393310547

Using Depth First Search:
---
1 4 2
6 5 8
7 3 0

1 4 2
6 5 8
7 0 3

1 4 2
6 5 8
0 7 3

1 4 2
0 5 8
6 7 3

1 4 2
5 0 8
6 7 3

1 4 2
5 8 0
6 7 3

1 4 2
5 8 3
6 7 0

1 4 2
5 8 3
6 0 7
...
0 1 2
3 4 5
6 7 8

Cost of the path: 51618
Depth: 51618
Number of expanded nodes: 59137
Running time: 0.11154794692993164

A* Search with manhattan:
---
1 4 2
6 5 8
7 3 0

1 4 2
6 5 0
7 3 8

1 4 2
6 0 5
7 3 8

1 4 2
6 3 5
7 0 8

1 4 2
6 3 5
0 7 8

1 4 2
0 3 5
6 7 8

1 4 2
3 0 5
6 7 8

1 0 2
3 4 5
6 7 8

0 1 2
3 4 5
6 7 8

Cost of the path: 8
Depth: 8
Number of expanded nodes: 13
Running time: 0.0

A* Search with euclidean:
---
1 4 2
6 5 8
7 3 0

1 4 2
6 5 0
7 3 8

1 4 2
6 0 5
7 3 8

1 4 2
6 3 5
7 0 8

1 4 2
6 3 5
0 7 8

1 4 2
0 3 5
6 7 8

1 4 2
3 0 5
6 7 8

1 0 2
3 4 5
6 7 8

0 1 2
3 4 5
6 7 8

Cost of the path: 8
Depth: 8
Number of expanded nodes: 13
Running time: 0.0

Comparisons

Input: 1 2 3 4 5 6 8 7 0 Unsolved test case

	BFS	DFS	A* M	A* E
Cost	----	----	----	----
depth	31	66906	34	32
Ex nodes	181440	181440	181440	181440
time	0.67555	0.38774	1.06707	1.32079

Input: 1 2 5 3 4 0 6 7 8

	BFS	DFS	A* M	A* E
Cost	3	157	3	3
depth	3	157	3	3
Ex nodes	10	158	4	4
time	0.0	0.0	0.0	0.0

Input: 1 0 2 7 5 4 8 6 3

	BFS	DFS	A* M	A* E
Cost	23	17881	23	23
depth	24	17881	23	23
Ex nodes	122117	18601	2714	4306
time	0.42513	0.03459	0.01753	0.03551

Input: 8 0 6 5 4 7 2 3 1

	BFS	DFS	A* M	A* E
Cost	31	57329	31	31
depth	31	57329	31	31
Ex nodes	181439	67802	16582	35007
time	0.77618	0.13396	0.10551	0.28074

Input: 1 4 2 6 5 8 7 3 0

	BFS	DFS	A* M	A* E
Cost	8	51618	8	8
depth	9	51618	8	8
Ex nodes	203	59137	13	13
time	0.001	0.11829	0.0	0.0

<u>Observation</u>

1) DFS has Longest paths and the least time in case of no solution
2) A* Manhattan time is less than time of A* Euclidean
   Reasoning: that Manhattan distance and Euclidean are both admissible but Manhattan distance is larger than Euclidean distance
3) A* Manhattan/Euclidean heuristics decreases the number of expanded nodes so much than in BFS.