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**Using Informed and Uninformed Search Algorithms to Solve 8-Puzzle**

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

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Using Breadth First Search:

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Depth: 31

Number of expanded nodes: 181440

Running time: 0.6755461692810059

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Using Depth First Search:

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Depth: 66906

Number of expanded nodes: 181440

Running time: 0.3877389430999756

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A\* Search with manhattan:

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Depth: 34

Number of expanded nodes: 181440

Running time: 1.0670711994171143

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A\* Search with euclidean:

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Depth: 32

Number of expanded nodes: 181440

Running time: 1.3207991123199463

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

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Using Breadth First Search:

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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

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Using Depth First Search:

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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

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A\* Search with manhattan:

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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

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A\* Search with euclidean:

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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

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

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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

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Using Depth First Search:

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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

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A\* Search with manhattan:

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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

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A\* Search with euclidean:

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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

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

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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

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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

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A\* Search with manhattan:

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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

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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

1. 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

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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

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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

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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 |

Observation

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

1. A\* Manhattan/Euclidean heuristics decreases the number of expanded nodes so much than in BFS.