



Artificial Intelligence

8 PUZZLE GAME

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- **Data structures used:**

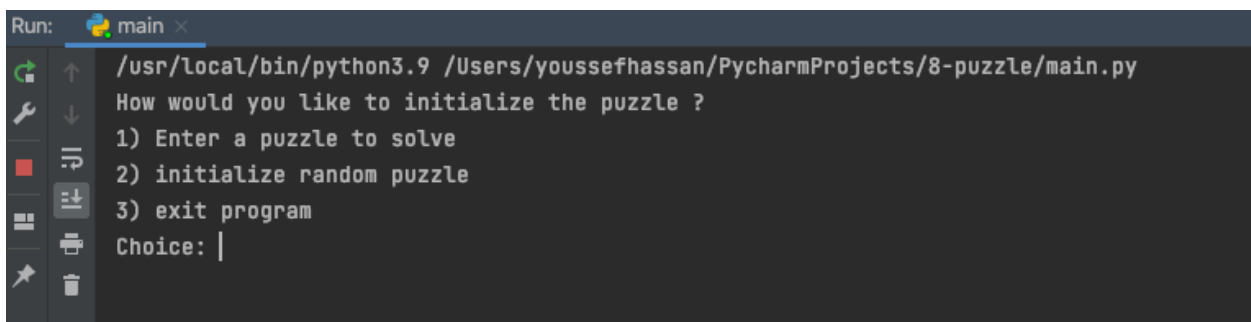
1. We used set to make a copy of points in frontier list to search faster as it occurs in order of (1) which is faster than searching in a list.
2. BFS: Queue
3. DFS: Stack
4. A*: Heap

- **Heuristics**

Manhattan heuristic is more admissible as it's closer to the output.

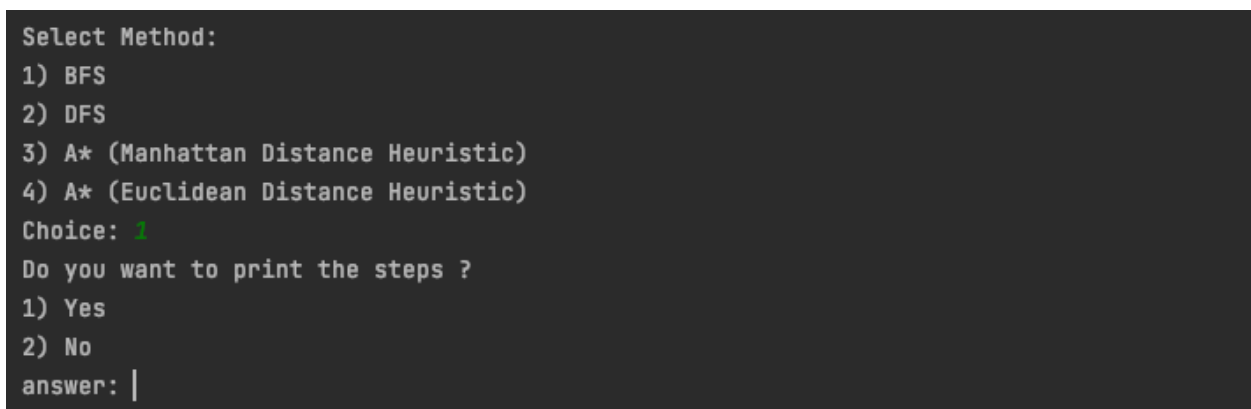
- **On start:**

1. Programmer ask the user to enter a puzzle to solve or to start with random puzzle.

A screenshot of a terminal window titled 'main'. The prompt is '/usr/local/bin/python3.9 /Users/youssefhassan/PycharmProjects/8-puzzle/main.py'. The program asks 'How would you like to initialize the puzzle ?' and lists three options: '1) Enter a puzzle to solve', '2) initialize random puzzle', and '3) exit program'. The prompt 'Choice: |' is shown at the bottom.

```
Run: main x
/usr/local/bin/python3.9 /Users/youssefhassan/PycharmProjects/8-puzzle/main.py
How would you like to initialize the puzzle ?
1) Enter a puzzle to solve
2) initialize random puzzle
3) exit program
Choice: |
```

2. Then you choose which algorithm to solve the puzzle and if you want to print the path.

A screenshot of a terminal window showing the 'Select Method:' menu. It lists four options: '1) BFS', '2) DFS', '3) A* (Manhattan Distance Heuristic)', and '4) A* (Euclidean Distance Heuristic)'. The prompt 'Choice: |' is shown with the number '1' entered. Below this, it asks 'Do you want to print the steps ?' with options '1) Yes' and '2) No'. The prompt 'answer: |' is shown at the bottom.

```
Select Method:
1) BFS
2) DFS
3) A* (Manhattan Distance Heuristic)
4) A* (Euclidean Distance Heuristic)
Choice: 1
Do you want to print the steps ?
1) Yes
2) No
answer: |
```

- **Test Cases:**

BFS

- Starting Board State:

```
-----  
| 6   | 1   |     |  
-----  
| 5   | 3   | 8   |  
-----  
| 4   | 7   | 2   |
```

Cost of Path = 20

Number of Nodes Expanded = 51903

Depth of Search = 20

BFS Running time = 0.47003 sec

- Path:

Step Number: 1

```
-----  
| 6   | 1   |     |  
-----  
| 5   | 3   | 8   |  
-----  
| 4   | 7   | 2   |
```

Step Number: 2

```
-----  
| 6   |     | 1   |  
-----  
| 5   | 3   | 8   |  
-----  
| 4   | 7   | 2   |
```

Step Number: 3

```
-----  
| 6   | 3   | 1   |  
-----  
| 5   |     | 8   |  
-----  
| 4   | 7   | 2   |  
-----
```

Step Number: 4

6	3	1	
	5	8	
4	7	2	

Step Number: 5

6	3	1	
4	5	8	
	7	2	

Step Number: 6

6	3	1	
4	5	8	
7		2	

Step Number: 7

6	3	1	
4		8	
7	5	2	

Step Number: 8

6	3	1	
4	8		
7	5	2	

Step Number: 9

6	3	1	
4	8	2	
7	5		

Step Number: 10

6	3	1	
4	8	2	
7		5	

Step Number: 11

6	3	1	
4		2	
7	8	5	

Step Number: 12

6	3	1	
	4	2	
7	8	5	

Step Number: 13

	3	1	
6	4	2	
7	8	5	

Step Number: 14

3		1	
6	4	2	
7	8	5	

Step Number: 15

3	1		
6	4	2	
7	8	5	

Step Number: 16

3	1	2	
6	4		
7	8	5	

Step Number: 17

3	1	2	
6	4	5	
7	8		

Step Number: 18

3	1	2	
6	4	5	
7		8	

Step Number: 19

3	1	2	
6	4	5	
	7	8	

Step Number: 20

3	1	2	
	4	5	
6	7	8	

Step Number: 21

	1	2	
3	4	5	
6	7	8	

DFS:

Starting Board State:

| 6 | | 3 |

| 1 | 8 | 4 |

| 2 | 5 | 7 |

Cost of Path = 8145

Number of Nodes Expanded = 174874

Depth of Search = 66124

DFS Running time = 0.960892915725708 sec

A* Manhattan heuristics:

Cost of Path = 20

Number of Nodes Expanded = 489

Depth of Search = 20

A* Running time = 0.0255317 sec

Path:

Step Number: 1

```
-----  
| 4   | 1   | 2   |  
-----  
| 5   | 3   | 7   |  
-----  
| 8   | 6   |     |  
-----
```

Step Number: 2

```
-----  
| 4   | 1   | 2   |  
-----  
| 5   | 3   |     |  
-----  
| 8   | 6   | 7   |  
-----
```

Step Number: 3

```
-----  
| 4   | 1   |     |  
-----  
| 5   | 3   | 2   |  
-----  
| 8   | 6   | 7   |  
-----
```

Step Number: 4

```
-----  
| 4   |     | 1   |  
-----  
| 5   | 3   | 2   |  
-----  
| 8   | 6   | 7   |  
-----
```


Step Number: 5

4	3	1	
5		2	
8	6	7	

Step Number: 6

4	3	1	
	5	2	
8	6	7	

Step Number: 7

4	3	1	
8	5	2	
	6	7	

Step Number: 8

4	3	1	
8	5	2	
6		7	

Step Number: 9

4	3	1	
8		2	
6	5	7	

Step Number: 10

4	3	1	
	8	2	
6	5	7	

Step Number: 11

	3	1	
4	8	2	
6	5	7	

Step Number: 12

3		1	
4	8	2	
6	5	7	

Step Number: 13

3	1		
4	8	2	
6	5	7	

Step Number: 14

3	1	2	
4	8		
6	5	7	

Step Number: 15

3	1	2	
4		8	
6	5	7	

Step Number: 16

3	1	2	
4	5	8	
6		7	

Step Number: 17

3	1	2	
4	5	8	
6	7		

Step Number: 18

3	1	2	
4	5		
6	7	8	

Step Number: 19

3	1	2	
4		5	
6	7	8	

Step Number: 20

3	1	2	
	4	5	
6	7	8	

Step Number: 21

	1	2	
3	4	5	
6	7	8	

A* Euclidean heuristic:

Cost of Path = 22

Number of Nodes Expanded = 1010

Depth of Search = 22

A* Running time = 0.09825992584228516 sec

Starting Board State:

```
-----  
| 5 | 1 | 7 |  
-----  
| 3 | 4 | 8 |  
-----  
|   | 2 | 6 |
```

Path:

Step Number: 1

```
-----  
| 5 | 1 | 7 |  
-----  
| 3 | 4 | 8 |  
-----  
|   | 2 | 6 |
```

Step Number: 2

```
-----  
| 5 | 1 | 7 |  
-----  
|   | 4 | 8 |  
-----  
| 3 | 2 | 6 |
```

Step Number: 3

```
-----  
| 5 | 1 | 7 |  
-----  
| 4 |   | 8 |  
-----  
| 3 | 2 | 6 |
```

Step Number: 4

5		7	
4	1	8	
3	2	6	

Step Number: 5

	5	7	
4	1	8	
3	2	6	

Step Number: 6

4	5	7	
	1	8	
3	2	6	

Step Number: 7

4	5	7	
1		8	
3	2	6	

Step Number: 8

4	5	7	
1	2	8	
3		6	

Step Number: 9

4	5	7	
1	2	8	
3	6		

Step Number: 10

4	5	7	
1	2		
3	6	8	

Step Number: 11

4	5		
1	2	7	
3	6	8	

Step Number: 12

4		5	
1	2	7	
3	6	8	

Step Number: 13

4	2	5	
1		7	
3	6	8	

Step Number: 14

4	2	5	
1	7		
3	6	8	

Step Number: 15

| 4 | 2 | | |

| 1 | 7 | 5 | |

| 3 | 6 | 8 | |

Step Number: 16

| 4 | | 2 | |

| 1 | 7 | 5 | |

| 3 | 6 | 8 | |

Step Number: 17

| | 4 | 2 | |

| 1 | 7 | 5 | |

| 3 | 6 | 8 | |

Step Number: 18

| 1 | 4 | 2 | |

| | 7 | 5 | |

| 3 | 6 | 8 | |

Step Number: 19

| 1 | 4 | 2 | |

| 3 | 7 | 5 | |

| | 6 | 8 | |

Step Number: 20

| 1 | 4 | 2 | |

| 3 | 7 | 5 | |

| 6 | | 8 | |

Step Number: 21

1	4	2	
3		5	
6	7	8	

Step Number: 22

1		2	
3	4	5	
6	7	8	

Step Number: 23

	1	2	
3	4	5	
6	7	8	