8-Puzzle solver

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**8-Puzzle solver**

**Problem Statement:**

8-Puzzle game consists of a board holding 8 distinct movable tiles, plus an empty space. For any such board, the empty space may be legally swapped with any tile horizontally or vertically adjacent to it. Given an initial state of the board, it’s required to use AI algorithms to find a sequence of moves that transitions this state to the goal state.

Shape

Description automatically generatedShape, rectangle

Description automatically generated

**Implemented Algorithms:**

This program depends on 3 algorithms:

1. BFS
2. DFS
3. A\*: Using 2 different heuristic functions (Manhattan distance, Euclidean distance)

**Used Data Structure:**

* **Stack**: used in **DFS** algorithm as a frontier
* **Queue**: used in **BFS** algorithm as a frontier
* **Priority Queue (Heap):** used in **A\*** algorithm as a frontier
* **List**: used to save any details (expanded states, path to goal)
* **Dictionary**: to save each state to its parent in the tree
* **Set**: to save explored states

**Program features**

* This program is designed to solve any shape of the puzzle that will be entered (in case It has a solution)
* The program uses 3 algorithms (BFS, DFS, A\*)
* The Program can find different information during finding the solution:
  + cost of the path from initial state to final state
  + path from initial state to final state
  + run time to find the solution
  + all expanded states
  + depth of the tree

**Implementation (pseudo code):**

Read initial state

Check that input is valid

If not valid: read initial state again

Else:

Choose the algorithm:

if algorithm is BFS: search using BFS ()

If algorithm is DFS: search using DFS ()

If algorithm is A\*: search using A\*()

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BFS (initialState):

Frontier = Queue.new(initialState)

Explored = Set.new()

Parents = hashmap.new(initialState, initialState)

While not frontier.isEmpty():

State = fronter.dequeue()

Explored.add(State)

If State == goalState:

Find cost, depth, run-time  
find path goal state to initial state with backtrace

Return **SUCCESS**(State)

For neighbour in state.neighbors():

If neighbour not in Frontier U Explored:

Parent[neighbour] = State

Frontier.enqueue(neighbour)

Return **FAILURE**

DFS (initialState):

Frontier = Stack.new(initialState)

Explored = Set.new()

Parents = hashmap.new(initialState, initialState)

While not frontier.isEmpty():

State = fronter.pop()

Explored.add(State)

If State == goalState:

Find cost, depth, run-time  
find path goal state to initial state with backtrace

Return **SUCCESS**(State)

For neighbour in state.neighbors():

If neighbour not in Frontier U Explored:

Parent[neighbour] = State

Frontier.push(neighbour)

Return **FAILURE**

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A\* (initialState):

Frontier = PriorityQueue.new(initialState)

Explored = Set.new()

Parents = hashmap.new(initialState, initialState)

Frontier.add(initialState)

While not frontier.isEmpty():

State = fronter.deleteMin()

Explored.add(State)

If State == goalState:

Return **SUCCESS**

For neighbour in state.neighbors():

If (neighbour not in Frontier U Explored)

or (neighbour in frontier) :

neighbour.depth = state.depth + 1

calculate\_cost(neighbour, neighbour.depth)

Parent[neighbour] = State

Frontier.add(neighbour)

Return **FAILURE**

**How to use the program:**

This program uses simple UI:

![Chart, waterfall chart

Description automatically generated](data:image/jpeg;base64,/9j/4AAQSkZJRgABAQEAeAB4AAD/4RDyRXhpZgAATU0AKgAAAAgABAE7AAIAAAANAAAISodpAAQAAAABAAAIWJydAAEAAAAaAAAQ0OocAAcAAAgMAAAAPgAAAAAc6gAAAAgAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAEFobWVkIEhlc2hhbQAAAAWQAwACAAAAFAAAEKaQBAACAAAAFAAAELqSkQACAAAAAzMyAACSkgACAAAAAzMyAADqHAAHAAAIDAAACJoAAAAAHOoAAAAIAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA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Enter button to save the input

Choose any algorithm to try

Solve button to start look for solution

Menu to choose heuristic function

Input Area

1. enter the initial state in the input area
2. press enter to save initial state
3. choose any algorithm to use (in case of A\* choose the heuristic function)
4. start solving by click solve

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Description automatically 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Board representing the puzzle

Length the path form initial to goal

Run time until find the goal

Button to show explored states

Get next state

Show the previous state

Cost to go from initial to goal

Number of expanded states

Maximum depth of search tree

Button to exit this page and return to main page

1. a new window will open showing the path to the goal, with other information:
   1. number of states from initial state to the goal
   2. number of expanded states
   3. depth of the tree
   4. cost of the path
   5. run time
2. we can go through the path state by state by clicking on next or previous
3. on clicking explored a new page will open to see all expanded states
4. to close any pop-up page, click back to main

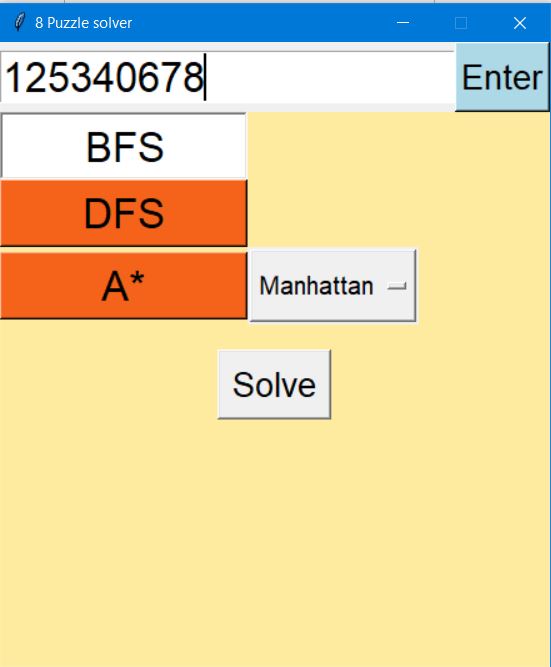
Assumptions

* the program may take many seconds (can reach 100 sec) to find the solution in some cases

Test cases

1. simple test case

* Simple input



* Simple A\* Manhattan

Calendar

Description automatically generated

* Simple A\* Euclidian

Calendar

Description automatically generated with medium confidence

* Simple DFS

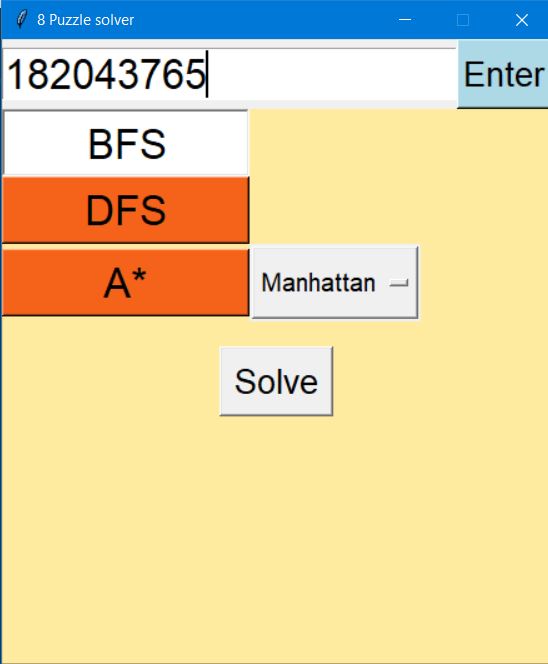


* Simple BFS



1. hard test case

* Hard input



* Hard A\* Manhattan

Calendar

Description automatically generated

* Hard A\* Eculidian

Calendar

Description automatically generated

* Hard DFS



* Hard BFS



Hard teset case 2 :-

Chart

Description automatically generated

BFS :-

Calendar

Description automatically generated with medium confidence

DFS :-

Calendar

Description automatically generated

A\* Manhattan :-

Calendar

Description automatically generated

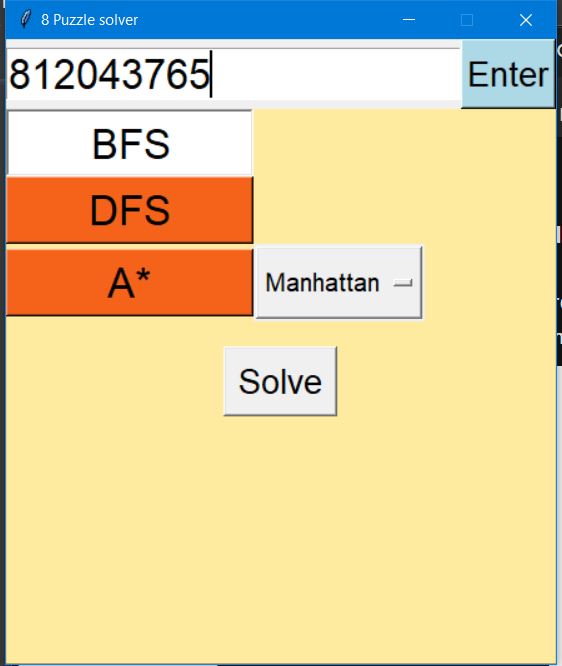
A\* Euclidian :-

Calendar

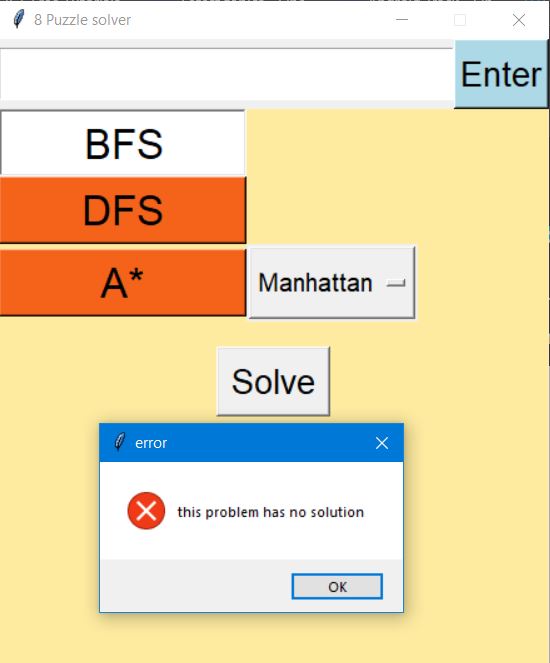
Description automatically generated with medium confidence

1. no solution test case

* No solution input



* No solution output



Corner and hard Test case :-

Zero at start :-

Chart, waterfall chart

Description automatically generated

BFS :-

Calendar

Description automatically generated with medium confidence

DFS :- (FASTER than BFS!)

Calendar

Description automatically generated

A\* Manhattan :-

Calendar

Description automatically generated

A\* Euclidian :-

Calendar

Description automatically generated

Presolved test case :-

Chart

Description automatically generated

BFS :-

Calendar

Description automatically generated

DFS :-

Calendar

Description automatically generated

A\* Manhattan :-

Calendar

Description automatically generated

A\* Euclidian :-

Calendar

Description automatically generated

Example for expanded node view :-

Chart

Description automatically generated

Calendar

Description automatically generated

Calendar

Description automatically generated with medium confidence

Calendar

Description automatically generated with medium confidence

Calendar

Description automatically generated with medium confidence