LP1 Assignment AIR A1

8 Puzzle using A* Algorithm

Date - 5th October, 2020.

Assignment Number - AIR A1

Title

8 Puzzle using A* Algorithm

Problem Definition

Solve 8-puzzle problem using A* algorithm. Assume any initial configuration and define goal configuration clearly.

Learning Objectives

- Learn Informed Search Algorithms
- Learn A* Algorithm and its application
- Learn about 8 puzzle problem
- To define Perception, Cognition, Action and Goal clearly

Learning Outcomes

I will be able to design A* algorithm to solve the 8 puzzle problem.

Software Packages and Hardware Apparatus Used

- Operating System : 64-bit Ubuntu 18.04
- Programming Language : Python 3
- Jupyter Notebook Environment : Google Colaboratory

Mathematical Model

S = {s; e; X; Y; Fme; Ff; DD; NDD}

s = start state
* {{1,2,3},{0,4,6},{7,5,8}}

e = end state
* {{1,2,3},{4,5,6},{7,8,0}}

X = {X1}
* X1 = s

Y = {Y1}
* Y1 = e

Fme = {f0}
* f0 = function to perform A* searching

Ff = {f1,f2,f3,f4,f5}
where
* f1 = function to find cost
* f2 = function to find states
* f3 = function to display grid
* f4 = function to generate next possible set of moves
* f4 = function to validate moves

DD = 3x3 Grid of puzzle

NDD = No non deterministic data

Concepts related Theory

8-puzzle Problem

- 8 puzzle is a popular puzzle that consists of 8 tiles and one empty space.
- The puzzle is divided into 3 rows and 3 columns.
- The other 8 tiles have numbers 1 through 8 on it
- The puzzle can be solved by moving the tiles one by one in the single empty space and thus achieving the Goal State.

Start State (Example)

s = {{1,2,3},{0,4,6},{7,5,8}}

1	2	3
	4	6
7	5	8

Perception

- We visualize swapping the empty space with it's neighbours
- The empty tile can have 9 possible locations.
- $\exists$x.(move(x) $\wedge$ valid location(x))
- The empty space can only move in four directions (Movement of empty space)
  $\forall$x.(shuffle(x) $\wedge$ valid(x) $\rightarrow$ open list(x))
    - Up
    - Down
    - Right
    - Left
- The empty space cannot move diagonally and can take only one step at a time.
- $\exists$x.(move(x) $\rightarrow$ ~diagonal(x))

Cognition

f(n) = g(n) + h(n)

Cost of A* Algorithm : f(n) = g(n) + h(n)

- g(n) is the cost of the path traversed from the initial state to node n.
- h(n) is the estimated path-cost or the heuristic function cost from node n to the goal node.

g(n) = Path Cost

- Each step costs 1, so the path cost is the number of steps in the path.

For any 8-puzzle's tile

- Misplaced(i) = { $((x1_i=x2_i)$ & $(y1_i=y2_i))$ $\forall$ $x1_i,y1_i,x2_i,y2_i \in \{0,1,2\}$ }
- Where,
- ($x1_i$, $y1_i$) is the coordinate of the tile with number i in current state
- ($x2_i$, $y2_i$) is the coordinate of the tile with number i in goal state

- $x1_i, y1_i, x2_i, y2_i \in \{0,1,2\}$
- $i \in \{0,1,2,3,4,5,6,7,8\}$
- h(n) = Misplaced(i) for 0<=i<=8

Action

Action = {U, L, D, R}

- Action can represented as a set of 4
- Each Action represents the interchanging of blank tile with the neighbour in one of the 4 directions.
  - Up (U)
  - Down (D)
  - Right (R)
  - Left (L)
- Constraints
  - The neighbour should not be diagonally adjacent
  - The edge positions can interchange in only three directions
  - The corner positions can interchange in only two directions
  - Interchanging takes place one step at a time

fmin = min(f1,f2,...,fm)

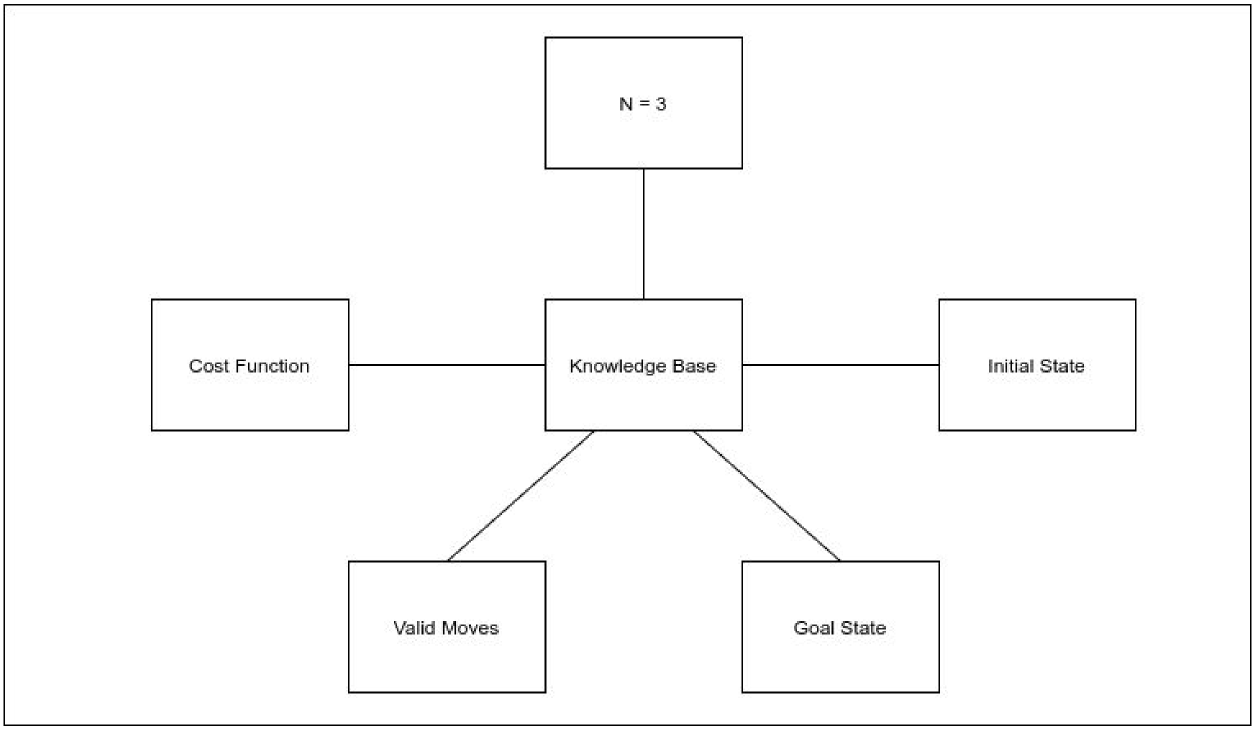
- Choose the heuristic function with the minimum f-value
  - Where m is the number of states

Goal State

e = {{1,2,3},{4,5,6},{7,8,0}}

1	2	3
4	5	6
7	8	

Knowledge Base



Source Code

```
class Node:
   '''A node for A* path finding'''
   def __init__(self, data, level, fval):
       '''Initialize the node with the data, the level of the node and the
calculated fvalue'''
       self.data = data
       self.level = level
       self.fval = fval

   def generate_openList(self):
       '''Generate child nodes from the given node by moving the blank
space either (up, down, left, right)'''
       x, y = self.find(self.data, '_')#in the input data, if blank space
is found, it's coordinates are stored in x and y respectively
```

```
        '''val_list contains the position values for moving the blank space
up,down,left,right resp'''

        '''PERCEPTION'''
        val_list = [[x,y-1], [x, y+1], [x-1, y], [x+1, y]]
        openList = []
        for i in val_list:                                    #provided the
coordinates in val_list are not none,
            child = self.shuffle(self.data, x, y, i[0], i[1]) #exchange the
blank space with the value in the provided coordinates
            #print(child)
            if child is not None:
                child_node = Node(child,self.level + 1, 0)    #child_node
is the value that will be printed as the next matrix
                openList.append(child_node)
        return openList

    def shuffle(self, puz, x1, y1, x2, y2):
        '''Moves the blank space in the given direction and if the position
value is out of limits return None'''
        if x2 >= 0 and x2 < len(self.data) and y2 >= 0 and y2 <
len(self.data):
            temp_puz = []
            temp_puz = self.copy(puz) #creates a new matrix that is the
updated matrix
            temp = temp_puz[x2][y2]
            temp_puz[x2][y2] = temp_puz[x1][y1]
            temp_puz[x1][y1] = temp
            return temp_puz
        else:
            return None

    def copy(self, root):
        '''Copy the function to create a similar matrix of the given
node'''
        temp = []
        for i in root:
```

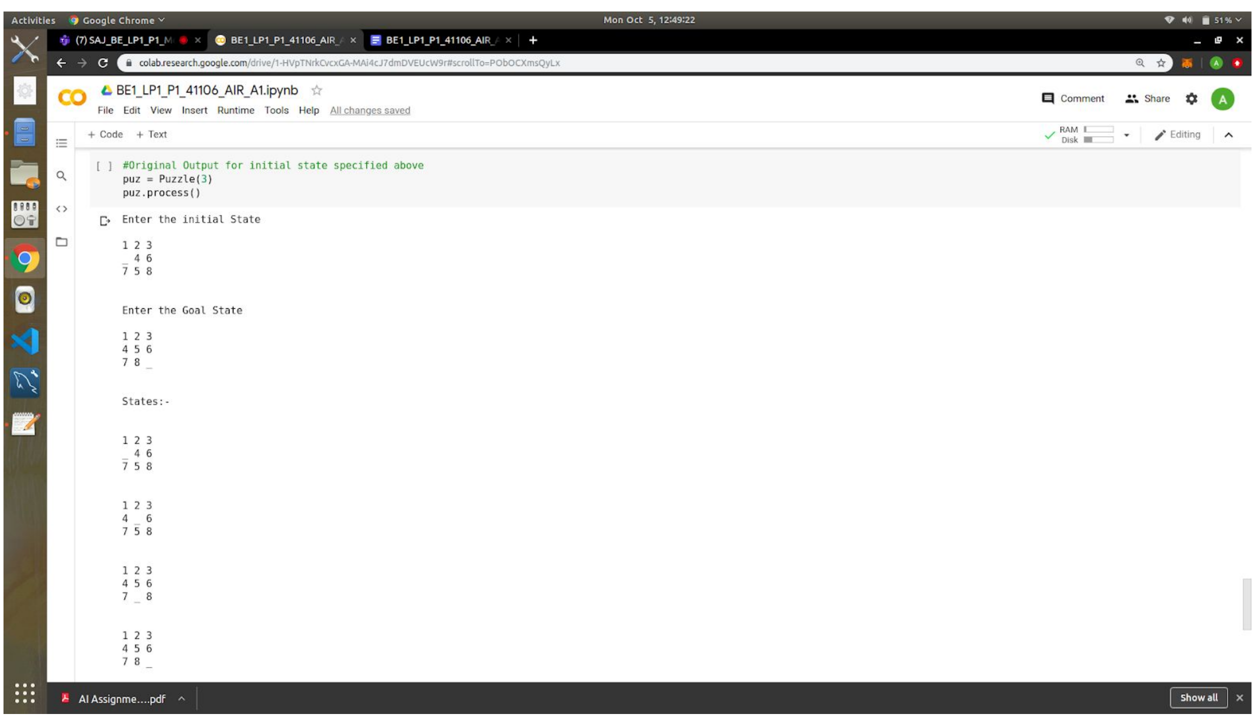
```
            t = []
            for j in i:
                t.append(j)
            temp.append(t)
        return temp

    def find(self, puz, x):
        '''Used to find the position of the blank space'''
        for i in range(len(self.data)):
            for j in range(len(self.data)):
                if puz[i][j] == x:
                    return i,j

class Puzzle:
    def __init__(self,size):
        '''Initialize the size of the puzzle by the specified size, open
and closed lists are empty'''
        self.n = size
        self.open = []
        self.closed = []

    def accept(self):
        '''Accepts input from the user and stores in puz list'''
        puz = []
        for i in range(self.n):
            temp = input().split()
            puz.append(temp)
        return puz

    '''COGNITION'''
    def f(self, state, goal):
        '''Heuristic Function to calculate heuristic value f(x) = h(x) +
g(x)'''
        var = self.h(state.data, goal) + state.level
        return self.h(state.data, goal) + state.level

    def h(self, state, goal):
```

```
        '''Calculates the difference between the given puzzles'''
        temp = 0
        for i in range(self.n):
            for j in range(self.n):
                if state[i][j] != goal[i][j] and state[i][j] != '_':
                    temp += 1
        return temp

    def process(self):
        print('Enter the initial State\n')
        start = self.accept() #input is taken from the user
        print('\n\nEnter the Goal State\n')
        goal = self.accept() #input is taken from the user

        if(start==goal):
          print("Initial State and Goal State are the Same, Exiting the
program...")
          return

        start = Node(start, 0, 0) #input, 0, 0
        start.fval = self.f(start, goal)
        self.open.append(start)
        print('\n\nStates:-')
        while True:
            cur = self.open[0]
            print("\n")
            for i in cur.data:
                for j in i:
                    print(j, end = " ")
                print()
            '''If the difference between current and goal node is 0 we have
reached the goal node'''

            '''GOAL'''
            if(cur.level > 1000):
                printf("Unsolvable")
                break
```

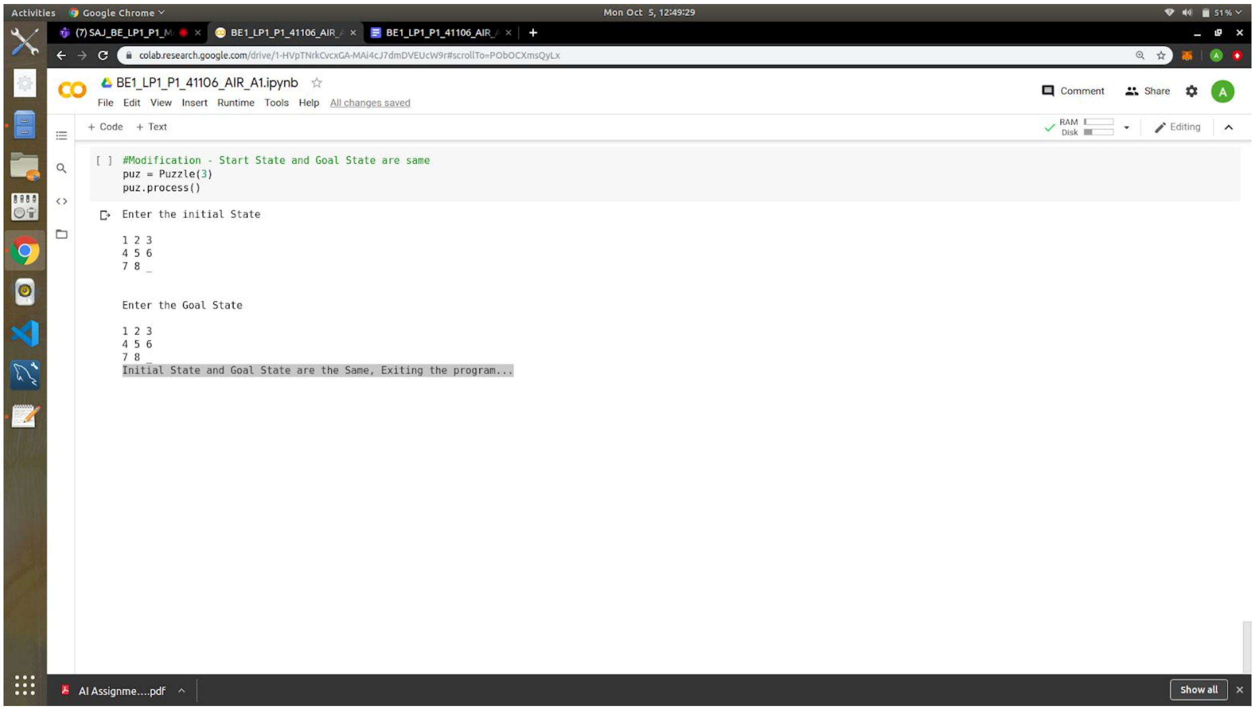
```
        if(self.h(cur.data, goal) == 0):
            break
        for i in cur.generate_openList():
            i.fval = self.f(i, goal)
            self.open.append(i)

        '''ACTION'''
        self.closed.append(cur)
        del self.open[0]
        '''sort the open list according to f value'''
        self.open.sort(key = lambda x:x.fval, reverse = False)

puz = Puzzle(3)
puz.process()
```

Output Screenshots

Original



Modification - Exit if Start State and Goal State are identical



Conclusion

I have successfully designed A* search algorithm for 8 puzzle and defined Perception, Cognition, Action and Goal for the same.