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from copy import deepcopy
import numpy as np
import time

def bestsolution(state):
    bestsol = np.array([], int).reshape(-1, 9)
    count = len(state) - 1
    while count != -1:
        bestsol = np.insert(bestsol, 0, state[count]['puzzle'], 0)
        count = (state[count]['parent'])
    return bestsol.reshape(-1, 3, 3)

# checks for the uniqueness of the iteration(it).
def all(checkarray):
    set=[]
    for it in set:
        for checkarray in it:
            return 1
    else:
        return 0

# number of misplaced tiles
def misplaced_tiles(puzzle,goal):
    mscost = np.sum(puzzle != goal) - 1
    return mscost if mscost > 0 else 0

def coordinates(puzzle):
    pos = np.array(range(9))
    for p, q in enumerate(puzzle):
        pos[q] = p
    return pos

# start of 8 puzzle evaluvation, using Misplaced tiles heuristics
def evaluate_misplaced(puzzle, goal):
    steps = np.array([('up', [0, 1, 2], -3),('down', [6, 7, 8], 3),('left', [0, 3, 6], -1),('right', [2, 5, 8], 1)],
        dtype = [('move', str, 1),('position', list),('head', int)])

    dtstate = [('puzzle', list),('parent', int),('gn', int),('hn', int)]

    costg = coordinates(goal)

    # initializing the parent, gn and hn, where hn is misplaced_tiles function call
    parent = -1
    gn = 0
    hn = misplaced_tiles(coordinates(puzzle), costg)
    state = np.array([(puzzle, parent, gn, hn)], dtstate)

    #priority queues with position as keys and fn as value.
    dtpriority = [('position', int),('fn', int)]

    priority = np.array([(0, hn)], dtpriority)

    while 1:
        priority = np.sort(priority, kind='mergesort', order=['fn', 'position'])
        position, fn = priority[0]
        # sort priority queue using merge sort,the first element is picked for exploring.
        priority = np.delete(priority, 0, 0)
        puzzle, parent, gn, hn = state[position]
        puzzle = np.array(puzzle)

        blank = int(np.where(puzzle == 0)[0])

        gn = gn + 1
        c = 1
        start_time = time.time()
        for s in steps:
            c = c + 1
            if blank not in s['position']:
                openstates = deepcopy(puzzle)
                openstates[blank], openstates[blank + s['head']] = openstates[blank + s['head']], openstates[blank]

            if ~(np.all(list(state['puzzle']) == openstates, 1)).any():
                end_time = time.time()
                if ((end_time - start_time) > 2):
                    print(" The 8 puzzle is unsolvable \n")
                    break

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    hn = misplaced_tiles(coordinates(openstates), costg)
    # generate and add new state in the list
    q = np.array([(openstates, position, gn, hn)], dtstate)
    state = np.append(state, q, 0)
    # f(n) is the sum of cost to reach node
    fn = gn + hn

    q = np.array([(len(state) - 1, fn)], dtpriority)
    priority = np.append(priority, q, 0)

    if np.array_equal(openstates, goal):
        print(' The 8 puzzle is solvable \n')
        return state, len(priority)

return state, len(priority)

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# initial state
puzzle = []

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puzzle.append(2)
puzzle.append(8)
puzzle.append(3)
puzzle.append(7)
puzzle.append(1)
puzzle.append(4)
puzzle.append(0)
puzzle.append(6)
puzzle.append(5)

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#goal state
goal = []

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goal.append(1)
goal.append(2)
goal.append(3)
goal.append(8)
goal.append(0)
goal.append(4)
goal.append(7)
goal.append(6)
goal.append(5)

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state, visited = evaluvate_misplaced(puzzle, goal)
bestpath = bestsolution(state)
print(str(bestpath).replace('[', ' ').replace(']', ''))
totalmoves = len(bestpath) - 1
print('\nSteps to reach goal:',totalmoves)
visit = len(state) - visited
print('Total nodes visited: ',visit, "\n")

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 The 8 puzzle is solvable

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2 8 3
7 1 4
0 6 5

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2 8 3
0 1 4
7 6 5

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2 8 3
1 0 4
7 6 5

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2 0 3
1 8 4
7 6 5

```

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0 2 3
1 8 4
7 6 5

```

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1 2 3
0 8 4
7 6 5

```

```

1 2 3
8 0 4
7 6 5

```

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Steps to reach goal: 6
Total nodes visited: 11

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