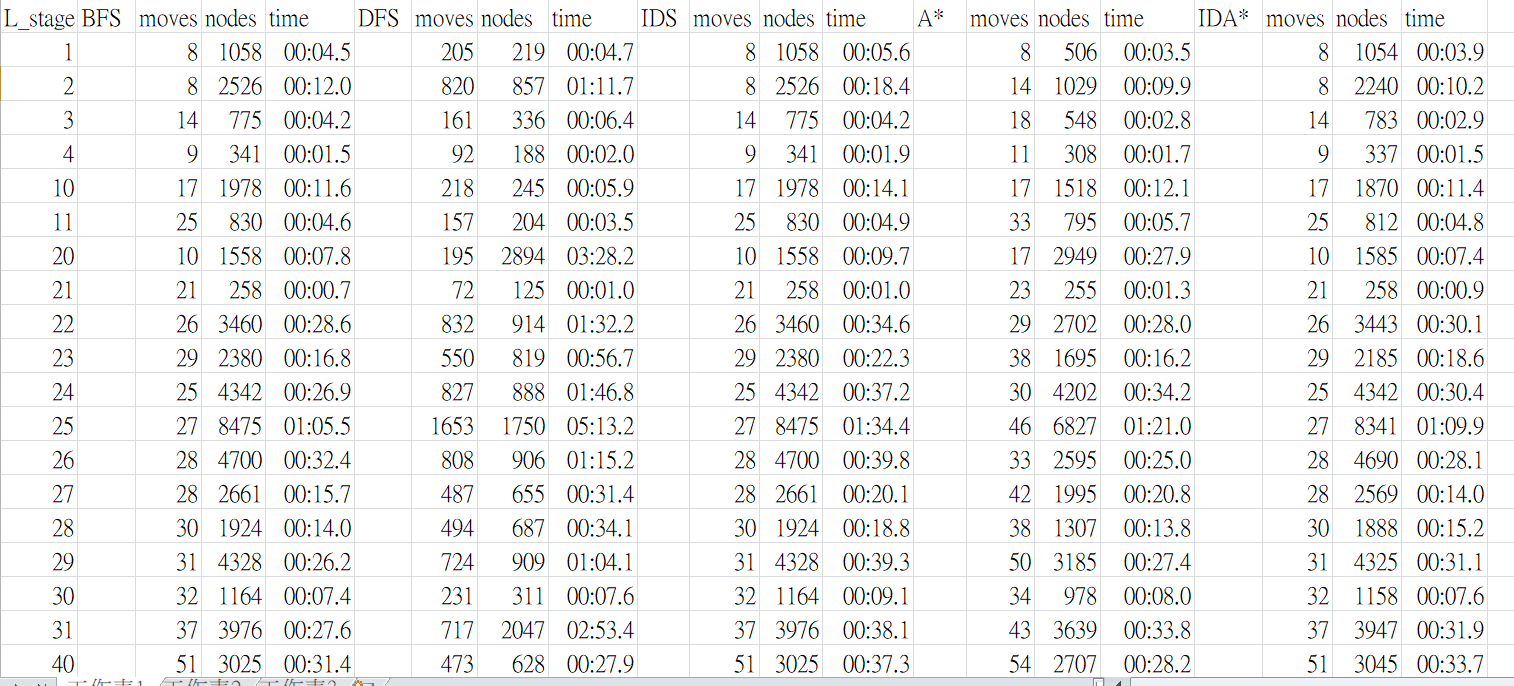
report

這次作業的要求是用五種演算法解rush hour的問題，以下是我針對五種演算法，分別比較其所需移動的步數(深度)及所經過之節點數(空間)。



左邊第一行是關卡(題目)編號Lxx.txt，然後後方是各演算法步數、節點數、時間。

根據觀察，DFS雖然所需之步數會較BFS多，但節點數反而會較少，時間方面，DFS 若在錯誤的路徑下不斷搜索，也可能導致浪費較多時間。

而第三種方法，IDS在此種情況下，表現就和BFS一樣，可能是因為其演算法是固定層數的DFS，最後導致和BFS一樣的行為。

第四種A\*演算法，由於是採用blocking heuristic的方法，搜索時會以blocking value值較小的情況優先搜索，因此在快接近答案時(blocking value很小)，能較快找到答案，所以所需步數類似於BFS，但經過之節點數明顯優於BFS。

最後一種IDA\*的方法，感覺起來表現和BFS差不多，推測是因為每層的深度都固定，所以無法在接近答案時，繼續向下搜索，因此表現會類似於IDS和BFS。

在實作的過程時發現，DFS的答案很容易有步數和節點數很接近之情形，可能是因為在某種情形下，不斷加深的深度都沒有遇到死路，所以一直做多餘的步數，導致深度不斷加深，最後才找到答案。

A\*演算法還滿讓我意外的，本來以為要做很久，沒想到加了一些東西就能有不錯的結果了，也因為每次的下一步都是從可能的步數裡挑blocking value最小的，因而跳過很多會增加blocking value的動作(雖然也可能會跳過答案)，不過這樣的演算法確實有發揮效果。

一開始要做作業時，本來覺得很麻煩，有五種演算法，加上之前學過的BFS、DFS和資料結構都還得差不多了，不過實際做了之後發現好像沒有那麼複雜，也學到了一些python的資料結構用法。另外我有把題目和解法轉換成圖形的形式，以第一題的答案為例，如下所示。

(一開始的puzzle)

1 1 \_ \_ \_ 7

4 \_ \_ 6 \_ 7

4 0 0 6 \_ 7

4 \_ \_ 6 \_ \_

5 \_ \_ \_ 2 2

5 \_ 3 3 3 \_

< 2, 4, 4 > ==> < 2, 4, 1 >(代表該編號的車2，(超過10就用16進位ABC)從左邊的位置移到右邊(4,4🡪4,1))

然後印出下一個puzzle，之後以此類推

1 1 \_ \_ \_ 7

4 \_ \_ 6 \_ 7

4 0 0 6 \_ 7

4 \_ \_ 6 \_ \_

5 2 2 \_ \_ \_

5 \_ 3 3 3 \_

< 7, 0, 5 > ==> < 7, 3, 5 >

1 1 \_ \_ \_ \_

4 \_ \_ 6 \_ \_

4 0 0 6 \_ \_

4 \_ \_ 6 \_ 7

5 2 2 \_ \_ 7

5 \_ 3 3 3 7

< 1, 0, 0 > ==> < 1, 0, 4 >

\_ \_ \_ \_ 1 1

4 \_ \_ 6 \_ \_

4 0 0 6 \_ \_

4 \_ \_ 6 \_ 7

5 2 2 \_ \_ 7

5 \_ 3 3 3 7

< 4, 1, 0 > ==> < 4, 0, 0 >

4 \_ \_ \_ 1 1

4 \_ \_ 6 \_ \_

4 0 0 6 \_ \_

\_ \_ \_ 6 \_ 7

5 2 2 \_ \_ 7

5 \_ 3 3 3 7

< 5, 4, 0 > ==> < 5, 3, 0 >

4 \_ \_ \_ 1 1

4 \_ \_ 6 \_ \_

4 0 0 6 \_ \_

5 \_ \_ 6 \_ 7

5 2 2 \_ \_ 7

\_ \_ 3 3 3 7

< 3, 5, 2 > ==> < 3, 5, 0 >

4 \_ \_ \_ 1 1

4 \_ \_ 6 \_ \_

4 0 0 6 \_ \_

5 \_ \_ 6 \_ 7

5 2 2 \_ \_ 7

3 3 3 \_ \_ 7

< 6, 1, 3 > ==> < 6, 3, 3 >

4 \_ \_ \_ 1 1

4 \_ \_ \_ \_ \_

4 0 0 \_ \_ \_

5 \_ \_ 6 \_ 7

5 2 2 6 \_ 7

3 3 3 6 \_ 7

< 0, 2, 1 > ==> < 0, 2, 4 >

4 \_ \_ \_ 1 1

4 \_ \_ \_ \_ \_

4 \_ \_ \_ 0 0

5 \_ \_ 6 \_ 7

5 2 2 6 \_ 7

3 3 3 6 \_ 7

Algorithm: A\*Puzzle completed in 8 moves.Number of nodes visited in search: 506time: 0:00:03.476703

雖然說把puzzle的圖形印出來在驗證答案時比較清楚也比較能接受，但也花了不少時間，但總體來說還是滿值得的，畢竟感覺踏實了不少。

說到remaining questions，應該是heuristic的方法應該不止這一種吧，還有老師提到的自己生產題目，目前我只有想法，就是先隨便產生一個小紅在(2, 4)上的puzzle，把這個狀態當成是最後的答案，然後用上面那五種方法，看看能不能讓小紅走回(2,0)或(2,1)，如果可以，那可能就是一個好題目，不行就再試一組，簡而言之，就是先產生答案，再倒回去變成題目。

附錄

Code

compile方式：python test.py 1 prog1\_puzzle/L01.txt (1-5代表五種演算法)

程式有放在github

<https://github.com/tim310579/Artificial-Intelligence/tree/main/HW1>

test.py(主程式)

from Puzzles import \*

from Algos import \*

from sys import argv

import datetime

import psutil

import os

begin = datetime.datetime.now()

useless, algo, filename = argv

#print(algo, filename)

f = open(filename, 'r')

k = f.readlines()

#for lines in k:

#print(lines)

tmp = []

for lines in k:

words = lines.split(' ')

#print(words[3])

ori = Orientations.vertical

length = VehicleTypes.car

words[4] = words[4][0]

if words[4] == '1': ori = Orientations.horizontal

if words[3] == '3': length = VehicleTypes.truck

tmp.append(Vehicle((int(words[2]), int(words[1])), ori, length, words[0]))

#print(words[2], words[1], words[4], words[3])

trafficJamtmp = Puzzles(6, 6, 2, tmp)

f.close()

#print(trafficJamtmp)

def printSolution(puzzle, solution):

for m in solution:

print(puzzle)

print(m)

puzzle.move(m.pos, m.moves)

print(puzzle)

# Create AI agent and run on specified puzzles

agent = Algos()

solution = ''

if algo == '1':

solution = agent.bfs(trafficJamtmp)

#print('BFS')

elif algo == '2':

solution = agent.dfs(trafficJamtmp)

#print('DFS')

elif algo == '3':

solution = agent.ids(trafficJamtmp)

#print('IDS')

elif algo == '4':

solution = agent.a\_star(trafficJamtmp)

#print('A\*')

elif algo == '5':

solution = agent.ida\_star(trafficJamtmp)

#print('IDA\*')

#solution = agent2.dfs(trafficJamtmp)

printSolution(trafficJamtmp, solution)

print('Algorithm: ', end='')

if algo == '1': print('BFS')

elif algo == '2': print('DFS')

elif algo == '3': print('IDS')

elif algo == '4': print('A\*')

elif algo == '5': print('IDA\*')

print("Puzzle completed in " + str(len(solution)) + " moves.")

print("Number of nodes visited in search: " + str(agent.nodesVisited))

#print("Space: " + str(agent.space))

end = datetime.datetime.now()

print('Time: ', end-begin)

#info = psutil.virtual\_memory()

#f = open('result/statistic.txt', 'a')

#f.write(str(len(solution)) + ' ' + str(agent.nodesVisited) + ' ' + str(end-begin) + '\n')

#f.close()

Algos.py(演算法部分)

from Puzzles import \*

from collections import deque

import copy

from queue import PriorityQueue

class Algos:

def \_\_init\_\_(self):

self.nodesVisited = 0

self.space = 0

def bfs(self, puzzle):

bfsQueue = deque([])

self.nodesVisited = 0

self.space = 0

# The current node/state

current = BfsNode(puzzle, [])

seenPuzzleStates = {}

seenPuzzleStates[str(current.puzzle.getGrid())] = True;

while not current.puzzle.won():

self.nodesVisited += 1

for m in current.getPossibleMoves():

# Duplicate puzzle state and perform a move

newState = copy.deepcopy(current)

newState.puzzle.move(m.pos, m.moves)

self.space += 1

# If new state is unseen, add to queue and seen states list

if ((not str(newState.puzzle) in seenPuzzleStates) or seenPuzzleStates[str(newState.puzzle)] > len(newState.movesSoFar)):

bfsQueue.append(BfsNode(newState.puzzle, current.movesSoFar + [m]))

seenPuzzleStates[str(newState.puzzle)] = True;

current = bfsQueue.popleft()

return current.movesSoFar

def dfs(self, puzzle):

# Queue to hold untraversed nodes

dfsQueue = deque([])

self.nodesVisited = 0

# The current node/state

current = DfsNode(puzzle, [])

seenPuzzleStates = {}

seenPuzzleStates[str(current.puzzle.getGrid())] = True;

while not current.puzzle.won():

self.nodesVisited += 1

for m in current.getPossibleMoves():

# Duplicate puzzle state and perform a move

newState = copy.deepcopy(current)

newState.puzzle.move(m.pos, m.moves)

# If new state is unseen, add to queue and seen states list

if ((not str(newState.puzzle) in seenPuzzleStates) or seenPuzzleStates[str(newState.puzzle)] > len(newState.movesSoFar)):

dfsQueue.append(DfsNode(newState.puzzle, current.movesSoFar + [m]))

seenPuzzleStates[str(newState.puzzle)] = True;

current = dfsQueue.pop()

return current.movesSoFar

def ids(self, puzzle):

cnt = 0

idsQueue = PriorityQueue()

self.nodesVisited = 0

self.space = 0

# The current node/state

current = IdsNode(puzzle, [], 0)

seenPuzzleStates = {}

seenPuzzleStates[str(current.puzzle.getGrid())] = True

#print(type(current))

while not (current.puzzle.won()):

if 1 == 1:

self.nodesVisited += 1

for m in current.getPossibleMoves():

cnt += 1

#print('iiii')

# Duplicate puzzle state and perform a move

newState = copy.deepcopy(current)

newState.puzzle.move(m.pos, m.moves)

self.space += 1

# If new state is unseen, add to queue and seen states list

if ((not str(newState.puzzle) in seenPuzzleStates) or seenPuzzleStates[str(newState.puzzle)] > len(newState.movesSoFar)):

#idsQueue.append(IdsNode(current.thedeep+1, newState.puzzle, current.movesSoFar + [m]))

idsQueue.put((current.thedeep+1, cnt, IdsNode(newState.puzzle, current.movesSoFar + [m], current.thedeep+1)))

seenPuzzleStates[str(newState.puzzle)] = True;

#deep += 1

#current = idsQueue.popleft()

tmp = idsQueue.get()

current = tmp[2]

#print(tmp[0])

return current.movesSoFar

def a\_star(self, puzzle):

# Queue to hold untraversed nodes

a\_starQueue = PriorityQueue()

self.nodesVisited = 0

self.space = 0

# The current node/state

current = A\_starNode(puzzle, [], 0)

seenPuzzleStates = {}

seenPuzzleStates[str(current.puzzle.getGrid())] = True;

cnt = 0

while not(current.puzzle.won()):

#print(current.blocking)

self.nodesVisited += 1

for m in current.getPossibleMoves():

cnt += 1

# Duplicate puzzle state and perform a move

newState = copy.deepcopy(current)

newState.puzzle.move(m.pos, m.moves)

self.space += 1

# If new state is unseen, add to queue and seen states list

if ((not str(newState.puzzle) in seenPuzzleStates) or seenPuzzleStates[str(newState.puzzle)] > len(newState.movesSoFar)):

#a\_starQueue.append(A\_starNode(newState.puzzle, current.movesSoFar + [m], 0))

a\_starQueue.put((current.blocking, cnt, A\_starNode(newState.puzzle, current.movesSoFar + [m], current.getblocking())))

seenPuzzleStates[str(newState.puzzle)] = True;

#current = a\_starQueue.popleft()

tmp = a\_starQueue.get()

current = tmp[2]

return current.movesSoFar

def ida\_star(self, puzzle):

ida\_starQueue = PriorityQueue()

self.nodesVisited = 0

self.space = 0

# The current node/state

current = IDA\_starNode(puzzle, [], 0, 0)

seenPuzzleStates = {}

seenPuzzleStates[str(current.puzzle.getGrid())] = True;

cnt = 0

while not(current.puzzle.won()):

#print(current.blocking)

self.nodesVisited += 1

for m in current.getPossibleMoves():

cnt += 1

# Duplicate puzzle state and perform a move

newState = copy.deepcopy(current)

newState.puzzle.move(m.pos, m.moves)

self.space += 1

# If new state is unseen, add to queue and seen states list

if ((not str(newState.puzzle) in seenPuzzleStates) or seenPuzzleStates[str(newState.puzzle)] > len(newState.movesSoFar)):

#a\_starQueue.append(A\_starNode(newState.puzzle, current.movesSoFar + [m], 0))

ida\_starQueue.put((current.thedeep, current.blocking, cnt, IDA\_starNode(newState.puzzle, current.movesSoFar + [m], current.getblocking(), current.thedeep+1)))

seenPuzzleStates[str(newState.puzzle)] = True;

#current = a\_starQueue.popleft()

tmp = ida\_starQueue.get()

current = tmp[3]

return current.movesSoFar

class BfsNode:

def \_\_init\_\_(self, puzzle, movesSoFar):

self.puzzle = puzzle

self.movesSoFar = movesSoFar

def getPossibleMoves(self):

results = []

current = self.puzzle

for v in current.vehicles:

for i in current.moveRange(v):

#print('v:',v,'v')

# Don't move if move length is 0

if not i == 0:

results += [Move(v.pos, i, v.orientation, v.number)]

#print(results)

return results

class DfsNode:

def \_\_init\_\_(self, puzzle, movesSoFar):

self.puzzle = puzzle

self.movesSoFar = movesSoFar

def getPossibleMoves(self):

results = []

current = self.puzzle

for v in current.vehicles:

for i in current.moveRange(v):

#print('v:',v,'v')

# Don't move if move length is 0

if not i == 0:

results += [Move(v.pos, i, v.orientation, v.number)]

#print(results)

return results

class IdsNode:

def \_\_init\_\_(self, puzzle, movesSoFar, thedeep):

self.puzzle = puzzle

self.movesSoFar = movesSoFar

self.thedeep = thedeep

def getPossibleMoves(self):

results = []

current = self.puzzle

for v in current.vehicles:

for i in current.moveRange(v):

#print('v:',v,'v')

# Don't move if move length is 0

if not i == 0:

results += [Move(v.pos, i, v.orientation, v.number)]

#print(results)

return results

class A\_starNode:

def \_\_init\_\_(self, puzzle, movesSoFar, blocking):

self.puzzle = puzzle

self.movesSoFar = movesSoFar

self.blocking = blocking

def getPossibleMoves(self):

results = []

current = self.puzzle

for v in current.vehicles:

for i in current.moveRange(v):

#print('v:',v,'v')

# Don't move if move length is 0

if not i == 0:

results += [Move(v.pos, i, v.orientation, v.number)]

#print(results)

return results

def getblocking(self):

current = self.puzzle

blockingcars = 0

red\_car\_pos = 0

for v in current.vehicles: #find red car

if v.number == '0':

if v.pos[0] == 4:

return 0

else:

red\_car\_pos = v.pos[0]

break

blockingcars = 1

for v in current.vehicles:

if v.orientation == Orientations.vertical and v.pos[0] > red\_car\_pos: #may block

if v.vType == VehicleTypes.car and (v.pos[1] == 1 or v.pos[1] == 2): #is block

blockingcars +=1

elif v.vType == VehicleTypes.truck and (v.pos[1] >= 0 and v.pos[1] <=2): #is block

blockingcars +=1

return blockingcars

class IDA\_starNode:

"""Represents a single state of the BFS

Attributes:

puzzle (JamPuzzle): the puzzle state this node represents

movesSoFar (Move[]): array of moves taken to get to the current

state. Holds the solution at the end, since BFs itself

doesn't track moves so far for each state.

getPossibleMoves(self): retrieves list of all valid moves from this

node's state

"""

def \_\_init\_\_(self, puzzle, movesSoFar, blocking, thedeep):

"""Constructor takes a puzzle state and list of moves taken

so far to get there.

"""

self.puzzle = puzzle

self.movesSoFar = movesSoFar

self.blocking = blocking

self.thedeep = thedeep

def getPossibleMoves(self):

"""Find the moveRange() of each vehicle in puzzle state and

adds every move (except 0 moves) in the range for each vehicle

to a result list of Move objects

Return:

Move[]: the array of all valid moves for this node's state

"""

results = []

current = self.puzzle

for v in current.vehicles:

for i in current.moveRange(v):

#print('v:',v,'v')

# Don't move if move length is 0

if not i == 0:

results += [Move(v.pos, i, v.orientation, v.number)]

#print(results)

return results

def getblocking(self):

current = self.puzzle

blockingcars = 0

red\_car\_pos = 0

for v in current.vehicles: #find red car

if v.number == '0':

if v.pos[0] == 4:

return 0

else:

red\_car\_pos = v.pos[0]

break

blockingcars = 1

for v in current.vehicles:

if v.orientation == Orientations.vertical and v.pos[0] > red\_car\_pos: #may block

if v.vType == VehicleTypes.car and (v.pos[1] == 1 or v.pos[1] == 2): #is block

blockingcars +=1

elif v.vType == VehicleTypes.truck and (v.pos[1] >= 0 and v.pos[1] <=2): #is block

blockingcars +=1

return blockingcars

class Move:

def \_\_init\_\_(self, pos, moves, orientation, number):

self.pos = pos;

self.moves = moves;

self.orientation = orientation;

self.number = number;

def \_\_str\_\_(self):

#print(self.orientation, self.number)

#return "Move car at ("+str(self.pos[1])+','+str(self.pos[0])+") by "+str(self.moves)+" to ("+str(self.pos[1])+','+str(self.pos[0])+")"

action = "< " + self.number + ", " + str(self.pos[1]) + ", " + str(self.pos[0]) + " >"

if self.orientation == Orientations.horizontal:

return action + " ==> < " + self.number + ", " + str(self.pos[1]) + ", " + str(self.pos[0]+self.moves) + " >"

else:

return action + " ==> < " + self.number + ", " + str(self.pos[1]+self.moves) + ", " + str(self.pos[0]) + " >"

Puzzles.py(圖形部分)

from enum import Enum, IntEnum

class VehicleTypes(IntEnum):

car = 2

truck = 3

class Orientations(IntEnum):

horizontal = 0

vertical = 1

#class Number(IntEnum):

class Puzzles:

def \_\_init\_\_(self, gridSizeX, gridSizeY, doorPos, vehicles):

self.gridSizeY = gridSizeY

self.gridSizeX = gridSizeX

self.doorPos = doorPos

self.vehicles = vehicles

def getSizeTuple(self):

"""Returns grid sizes as an (x, y) tuple

Return:

(int, int): tuple representing (width, height) of puzzle grid

"""

return (self.gridSizeX, self.gridSizeY)

def getGrid(self):

#symbol = ord('A')

symbol = ord('1')

grid = [["\_" for y in range(self.gridSizeY)] for x in range(self.gridSizeX)]

for v in self.vehicles:

# iterate through each vehicle, assigning it a symbol and replacing its

# covered locations with that symbol in the grid

tempSymbol = chr(symbol)

if v.pos[1] == self.doorPos and v.orientation == Orientations.horizontal:

#print(v.pos[1])

tempSymbol = '0'

else:

symbol += 1

if symbol == 58: symbol += 7

locs = v.coveredUnits()

#print(locs)

for l in locs:

#print(l,"lll")

grid[l[0]][l[1]] = tempSymbol

return grid

def move(self, pos, moves):

"""Wrapper for moveVehicle()

Args:

pos ((int, int)): position of vehicle to move (x, y)

moves (int): number of moves to move vehicle

"""

v = self.getVehicleAt(pos)

if v == None:

raise Exception("Can't move vehicle; not found", pos)

self.moveVehicle(v, moves)

def moveVehicle(self, veh, moves):

orient = veh.orientation

newPosList = list(veh.pos)

newPosList[orient] += moves

veh.pos = tuple(newPosList)

def moveRange(self, veh):

minMove = 0

# iterate over spaces behind to check

for i in range(-1, -veh.pos[veh.orientation]-1, -1):

# Only way to change a value in a tuple by index :/

newPosList = list(veh.pos)

newPosList[veh.orientation] += i

newPosTuple = tuple(newPosList)

blocked = False

for v in self.vehicles:

if newPosTuple in v.coveredUnits():

blocked = True

break

if blocked:

break

else:

minMove = i

maxMove = 0

# iterate over spaces ahead to check, not pos of vehicle. Accounts for length of vehicle

for j in range(veh.vType, self.getSizeTuple()[veh.orientation]-veh.pos[veh.orientation]):

# j is # of spaces ahead of vehicle position to check!

# not position to check, or # of moves

newPosList = list(veh.pos)

newPosList[veh.orientation]+=j

newPosTuple = tuple(newPosList)

blocked = False

for v in self.vehicles:

if newPosTuple in v.coveredUnits():

blocked = True

break

if blocked:

break

else:

maxMove = j - veh.vType + 1

return range(minMove, maxMove+1)

def getVehicleAt(self, pos):

for v in self.vehicles:

if v.pos == pos:

return v

return None

def won(self):

v = self.getVehicleAt((4, self.doorPos))

#print('haha:', v,'over')

if v != None and v.orientation == Orientations.horizontal:

return True

return False

def \_\_str\_\_(self):

result = " " \* self.doorPos + " " + " " \* (self.gridSizeX - self.doorPos - 1) + "\n"

grid = self.getGrid()

result += "\n".join([" ".join([grid[x][y] for x in range(self.gridSizeX)]) for y in range(self.gridSizeY)]) + "\n"

return result

def \_\_eq\_\_(self, b):

return self.getGrid() == b.getGrid()

class Vehicle:

def \_\_init\_\_(self, pos, orientation, vType, number):

self.pos = pos

self.orientation = orientation

self.vType = vType

self.number = number

def coveredUnits(self):

if self.orientation == Orientations.vertical:

result = [(self.pos[0], self.pos[1] + i) for i in range(int(self.vType))]

if self.orientation == Orientations.horizontal:

result = [(self.pos[0] + i, self.pos[1]) for i in range(int(self.vType))]

return result

def \_\_str\_\_(self):

orientTxt = "Horizontal" if self.orientation == Orientations.horizontal else "Vertical"

vehTxt = "Car" if self.vType == VehicleTypes.car else "Truck"

positions = str(self.coveredUnits())

return orientTxt + " " + vehTxt + " at (" + str(self.pos[0]) + "," + str(self.pos[1]) + ") covering " + positions