Solving the Maze by Breadth-First Traversal

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Introduction

- In this project, we need to solve the problem whether the ball can go from the start position to the destination position in the Maze (wheeled robots move in a hotel).
- The proposed solution is to apply Breadth First Search.
- The solution will be explained and tested in some examples with diagram and programming.

Design

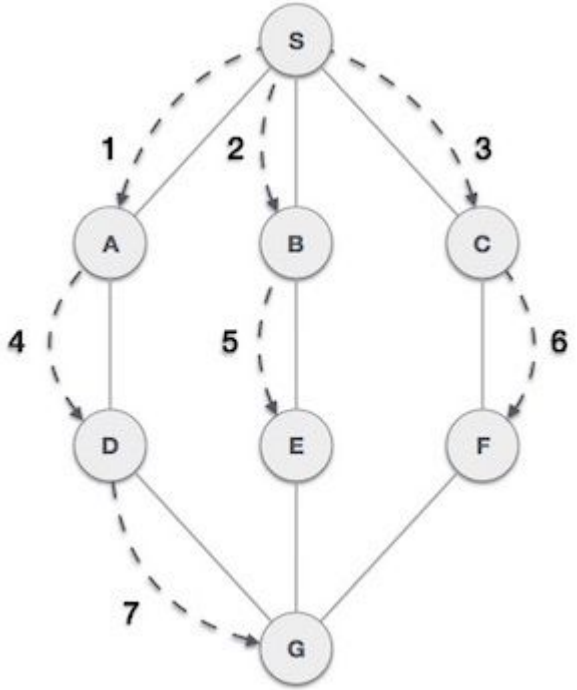
- **Problem:** Find the way to go from the start position to the destination position in a Maze. The ball can go through the empty spaces by rolling right, left, up, down, but it won’t stop rolling until hitting a wall. When the ball stops, it could choose the next direction.

Design

- **Solution:**
- We can use Depth First Search or Breadth First Search.
- Breadth First Search (BFS) algorithm traverses a graph in a breadthward motion and uses a queue to remember to get the next vertex to start a search, when a dead end occurs in any iteration, while the Depth First Search (DFS) uses stack.
- Since we need to find the optimal answer so Breadth First Search is a better solution.

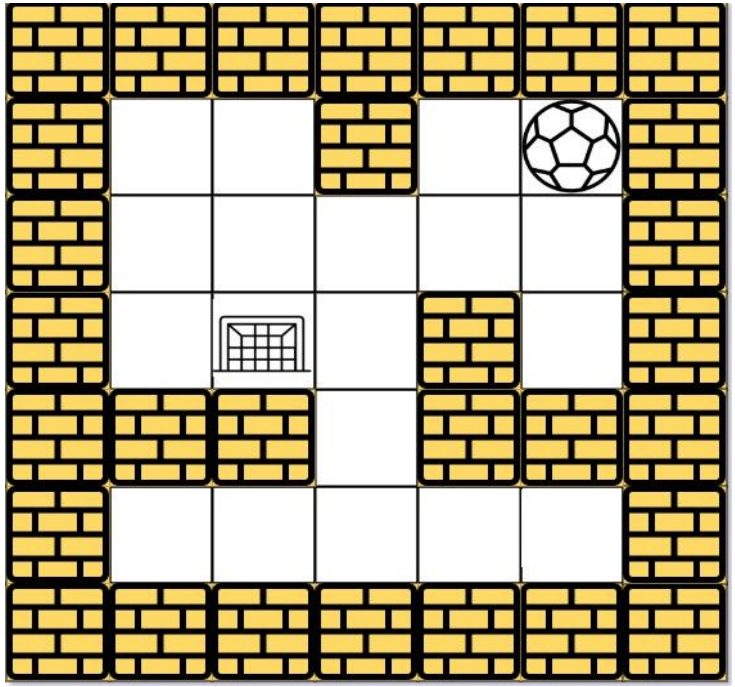
Design

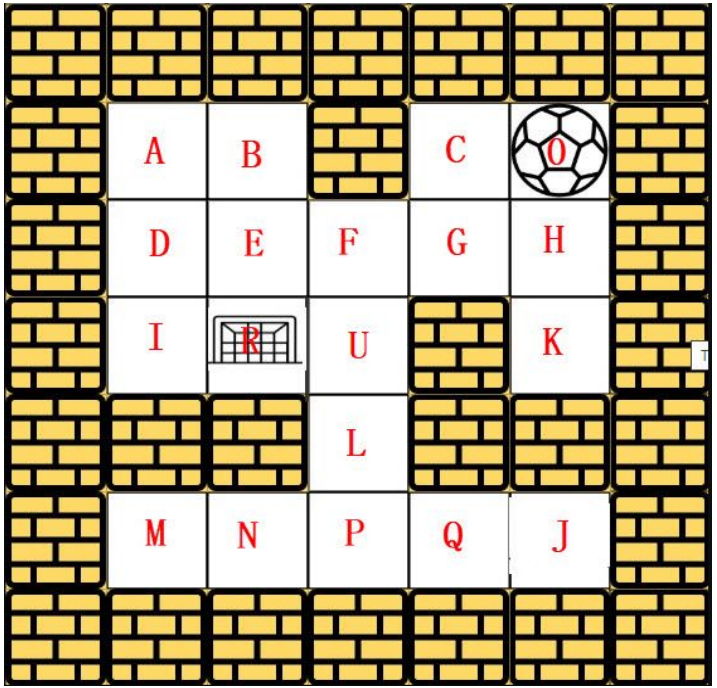
- **Rule 1**
  - Visit the adjacent unvisited vertex.
  - Mark it as visited. Display it.
  - Insert it in a queue.
- **Rule 2**
  - If no adjacent vertex is found, remove the first vertex from the queue.
- **Rule 3**
  - Repeat Rule 1 and Rule 2 until the queue is empty.



Example

Conduct Depth_First Traversal - Right, Left, Up, Down

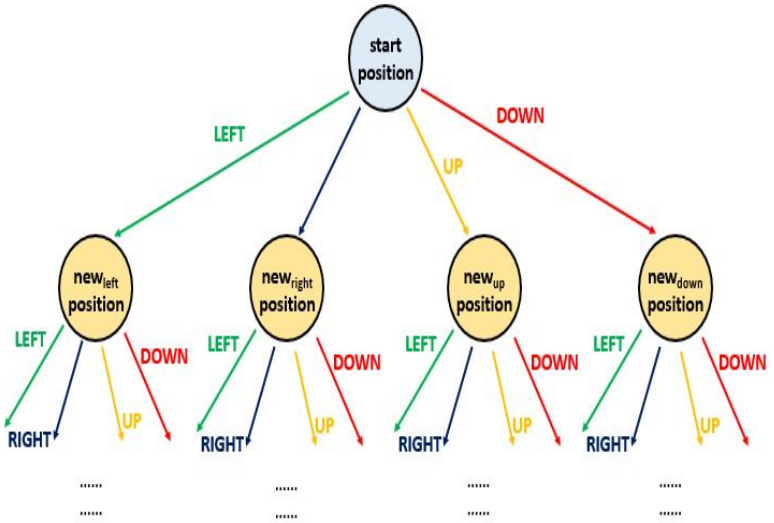




Example

Let's view the given search space in a form of a tree:

- **Starting position: the root node of the tree**
- **Right, left, up or down: 4 different routes, 4 branches**
- **The new node reached from the root traversing over the branch represents the new position occupied by the ball after choosing the corresponding direction of travel**



Example

In a tree: 0 is the node, 4 branches: right, left, up, down. Appy BFS:

From 0 can go to C (or K). K is dead end. Go to C

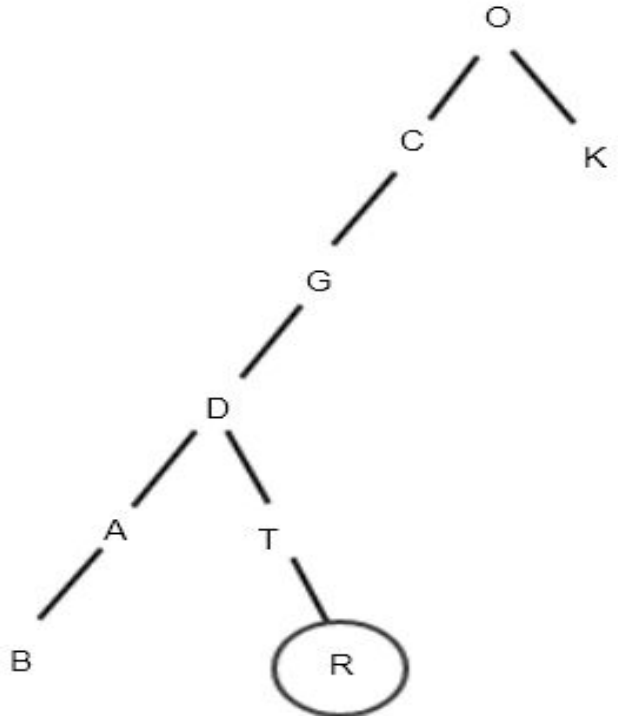
From C can go to G

From G can go to D. (H is visited)

From D can go to A or T.

From A can go to B

From T can go to R: destination. Return True



Example

Use queue:

Visited: 0 0 Queue:	Visited: 0 1 Queue: 0 1. Add 0 to the queue 2. Mark 0 as visited	Visited: 0 1 Queue: 1. Remove 0 from the queue 2. Print 0	Visited: 0 C K 1 1 1 Queue: C K 1. Add C and K to the queue 2. Mark C and K as visited
Visited: 0 C K 1 1 1 Queue: K 1. Remove C from the queue 2. Print 0 C	Visited: 0 C K G 1 1 1 1 Queue: K G 1. Add G to the queue 2. Mark G as visited	Visited: 0 C K G 1 1 1 1 Queue: G 1. Remove K from the queue 2. Print: 0 C K	Visited: 0 C K G 1 1 1 1 Queue: 1. Remove G from the queue 2. Print 0 C K G

Visited: 0 C K G D 1 1 1 1 1 Queue: D 1. Add D to the queue 2. Mark D as visited	Visited: 0 C K G D 1 1 1 1 1 Queue: 1. Remove D from the queue 2. Print: 0 C K G D	Visited : 0 C K G D A T 1 1 1 1 1 1 1 Queue : A T 1. Add A, T to the queue 2. Mark A, T as visited Visited: 0 C K G D A T 1 1 1 1 1 1 1 Queue: T 1. Remove A from the queue 2. Print: 0 C K G D A	Visited: 0 C K G D A T B 1 1 1 1 1 1 1 1 Queue: T B 1. Add B to the queue 2. Mark B as visited
Visited: 0 C K G D A T B 1 1 1 1 1 1 1 1 Queue: B 1. Remove T from the queue 2. Print: 0 C K G D A T	Visited: 0 C K G D A T B R 1 1 1 1 1 1 1 1 Queue: B R 1. Add R to the queue 2. Mark R as visited	Visited : 0 C K G D A T B R 1 1 1 1 1 1 1 1 Queue : R 1. Remove B from the queue 2. Print 0 C K G D A T B	Visited : 0 C K G D A T B R 1 1 1 1 1 1 1 1 Queue : 1. Remove R from the queue 2. Print 0 C K G D A T B R

Implementation

- Implement Breadth First Search on Python 3

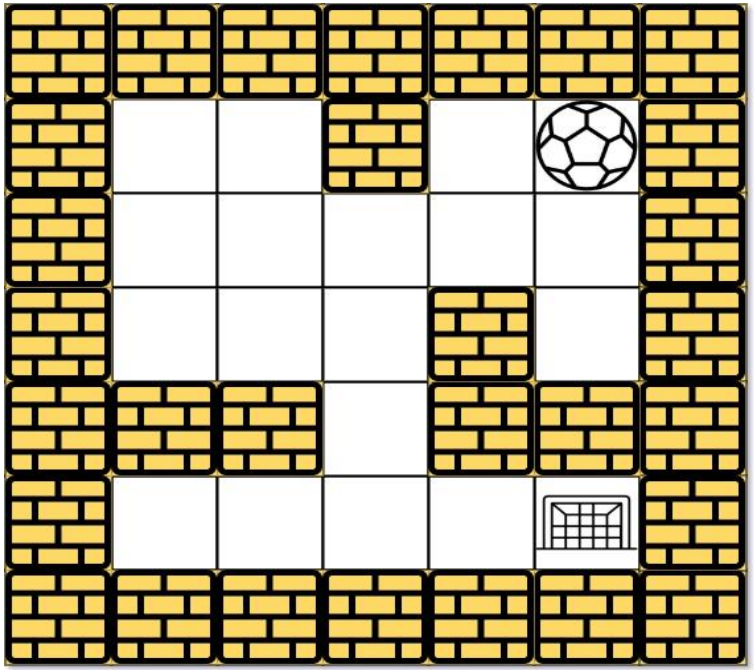
490. The Maze (Leetcode)

Description:

There is a ball in a `maze` with empty spaces (represented as `0`) and walls (represented as `1`). The ball can go through the empty spaces by rolling up, down, left or right, but it won't stop rolling until hitting a wall. When the ball stops, it could choose the next direction.

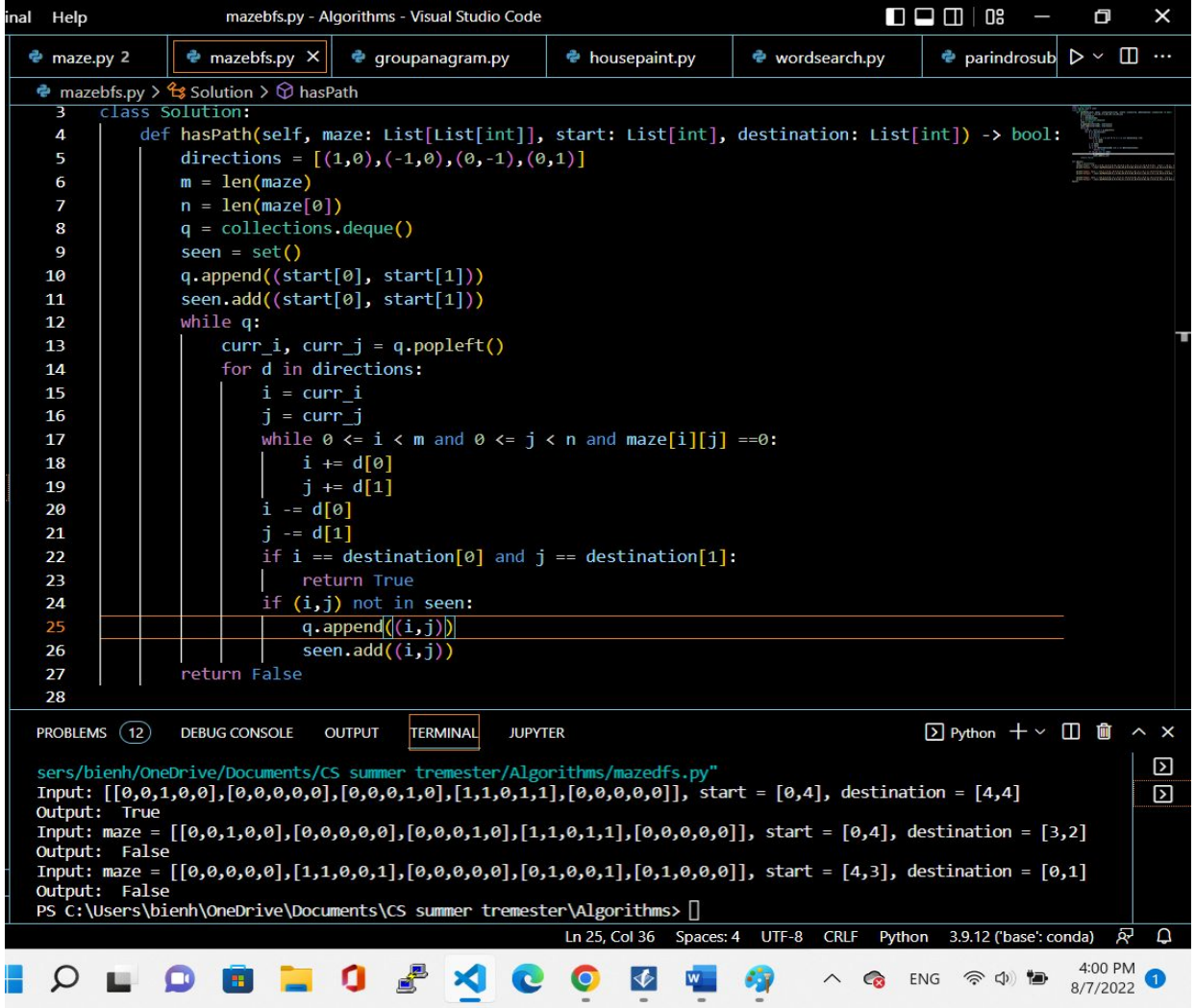
Given the `m x n` `maze`, the ball's `start` position and the `destination`, where `start = [start`$_{row}$`, start`$_{col}$`]` and `destination = [destination`$_{row}$`, destination`$_{col}$`]`, return `true` if the ball can stop at the destination, otherwise return `false`.

You may assume that the borders of the maze are all walls



Programming

```
import collections
from typing import List
class Solution:
    def hasPath(self, maze: List[List[int]], start: List[int], destinatio
        directions = [(1,0),(-1,0),(0,-1),(0,1)]
        m = len(maze)
        n = len(maze[0])
        q = collections.deque()
        seen = set()
        q.append((start[0], start[1]))
        seen.add((start[0], start[1]))
        while q:
            curr_i, curr_j = q.popleft()
            for d in directions:
                i = curr_i
                j = curr_j
                while 0 <= i < m and 0 <= j < n and maze[i][j] ==0:
                    i += d[0]
                    j += d[1]
                i -= d[0]
                j -= d[1]
                if i == destination[0] and j == destination[1]:
                    return True
                if (i,j) not in seen:
                    q.append((i,j))image.png
                    seen.add((i,j))
        return False
```


inal Help
mazebfs.py - Algorithms - Visual Studio Code
maze.py 2
mazebfs.py
groupanagram.py
housepaint.py
wordsearch.py
parindrosub
mazebfs.py > Solution > hasPath
class Solution:
def hasPath(self, maze: List[List[int]], start: List[int], destination: List[int]) -> bool:
directions = [(1,0),(-1,0),(0,-1),(0,1)]
m = len(maze)
n = len(maze[0])
q = collections.deque()
seen = set()
q.append((start[0], start[1]))
seen.add((start[0], start[1]))
while q:
curr_i, curr_j = q.popleft()
for d in directions:
i = curr_i
j = curr_j
while 0 <= i < m and 0 <= j < n and maze[i][j] ==0:
i += d[0]
j += d[1]
i -= d[0]
j -= d[1]
if i == destination[0] and j == destination[1]:
return True
if (i,j) not in seen:
q.append((i,j))
seen.add((i,j))
return False
PROBLEMS 12
DEBUG CONSOLE
OUTPUT
TERMINAL
JUPYTER
Python
sers/bienh/OneDrive/Documents/CS summer tremester/Algorithms/mazedfs.py"
Input: [[0,0,1,0,0],[0,0,0,0,0],[0,0,0,1,0],[1,1,0,1,1],[0,0,0,0,0]], start = [0,4], destination = [4,4]
Output: True
Input: maze = [[0,0,1,0,0],[0,0,0,0,0],[0,0,0,1,0],[1,1,0,1,1],[0,0,0,0,0]], start = [0,4], destination = [3,2]
Output: False
Input: maze = [[0,0,0,0,0],[1,1,0,0,1],[0,0,0,0,0],[0,1,0,0,1],[0,1,0,0,0]], start = [4,3], destination = [0,1]
Output: False
PS C:\Users\bienh\OneDrive\Documents\CS summer tremester\Algorithms>
Ln 25, Col 36
Spaces: 4
UTF-8
CRLF
Python
3.9.12 ('base': conda)
ENG
4:00 PM
8/7/2022

Test

```
def main():
    test = Solution()
    print("Input: [[0,0,1,0,0],[0,0,0,0,0],[0,0,0,1,0],[1,1,0,1,1],[0,0,0,0,0]], start = [0,4], destination = [4,4]")
    print("Output: ",test.hasPath([[0,0,1,0,0],[0,0,0,0,0],[0,0,0,1,0],[1,1,0,1,1],[0,0,0,0,0]],[0,4],[4,4]))

    print("Input: maze = [[0,0,1,0,0],[0,0,0,0,0],[0,0,0,1,0],[1,1,0,1,1],[0,0,0,0,0]], start = [0,4], destination = [3,2]")
    print("Output: ",test.hasPath([[0,0,1,0,0],[0,0,0,0,0],[0,0,0,1,0],[1,1,0,1,1],[0,0,0,0,0]], [0,4],[3,2]))

    print("Input: maze = [[0,0,0,0,0],[1,1,0,0,1],[0,0,0,0,0],[0,1,0,0,1],[0,1,0,0,0]], start = [4,3], destination = [0,1]")
    print("Output: ",test.hasPath([[0,0,0,0,0],[1,1,0,0,1],[0,0,0,0,0],[0,1,0,0,1],[0,1,0,0,0]],[4,3],[0,1]))
main()
```

Output

Input: [[0,0,1,0,0],[0,0,0,0,0],[0,0,0,1,0],[1,1,0,1,1],[0,0,0,0,0]], start = [0,4], destination = [4,4]

Output: True

Input: maze = [[0,0,1,0,0],[0,0,0,0,0],[0,0,0,1,0],[1,1,0,1,1],[0,0,0,0,0]], start = [0,4], destination = [3,2]

Output: False

Input: maze = [[0,0,0,0,0],[1,1,0,0,1],[0,0,0,0,0],[0,1,0,0,1],[0,1,0,0,0]], start = [4,3], destination = [0,1]

Output: False

Enhancement ideas

- Depth First Search (DFS) can be another solution. Stack will be used instead of queue.

Conclusion

- Although Breadth First Search is less space efficient than Depth First Search, it always returns the optimal answer
- Breadth First Search is applied in finding shortest path and minimum spanning tree for unweighted graph, Peer to Peer Networks (ex: BitTorrent), Crowlers in Search Engines, Social Networking Website, GPS Navigation systems, and so on.

References

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