# Solving the Maze by Depth-First Traversal

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# Introduction

- In this project, we need to solve the problem whether we can go from the start position to the destination position in the Maze (clear route and unclear route).
- The proposed solution is to apply Depth 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. There are two cases: imagine when a robot without wheel goes in a clear route and a robot with wheel goes in unclear route.

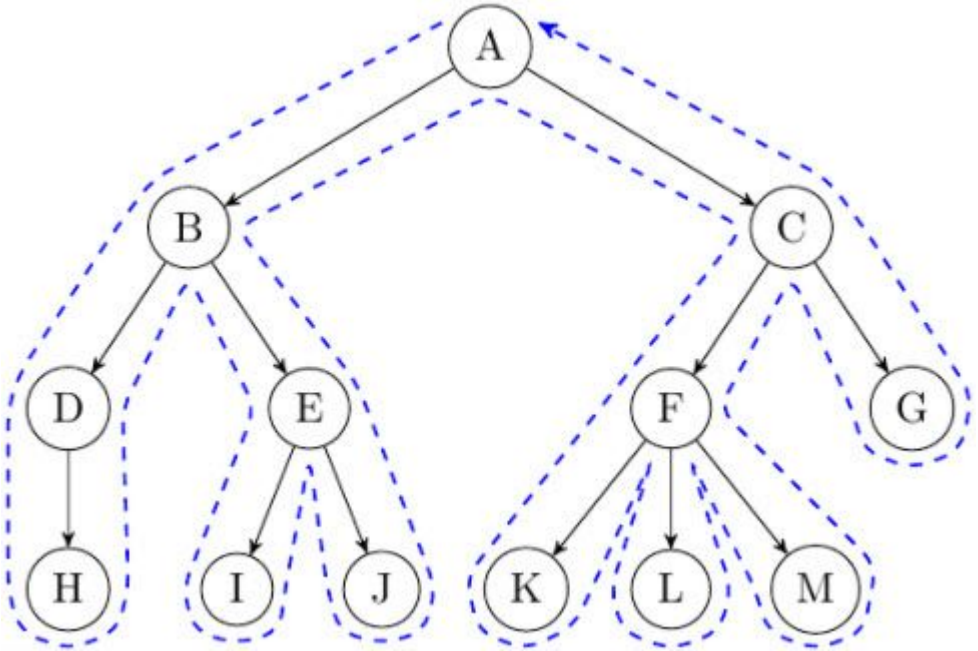
| Robot | Clear route (street, highway) | Unclear route(hospital,hotel) |
|---|---|---|
| Without wheel (legged robot) | Tree (example 1) | |
| With wheel(self driving car) | | Matrix (example 2) |

# Design

- **Solution:**
- We can use Depth First Search or Breadth First Search.
- Depth First Search (DFS) is algorithm traverses a graph in a depthward motion. Depth First Search uses stack to remember to get the next vertex to start a search while the Breadth First Search uses queue.
- Since the robot is the embedded system and memory is important, compare two solutions, Depth First Search is a better solution for the benefit of less memory space and less time if go to the right path.

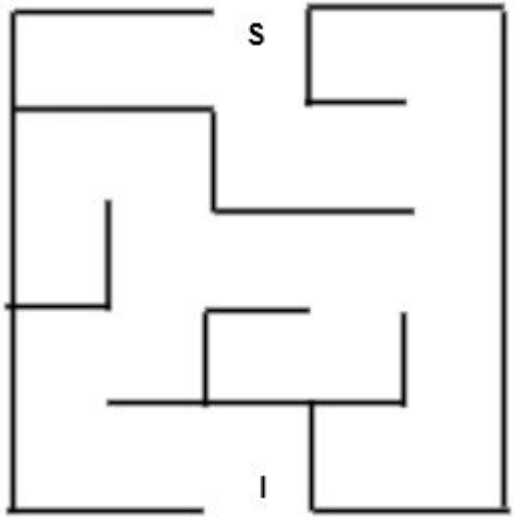
# Design

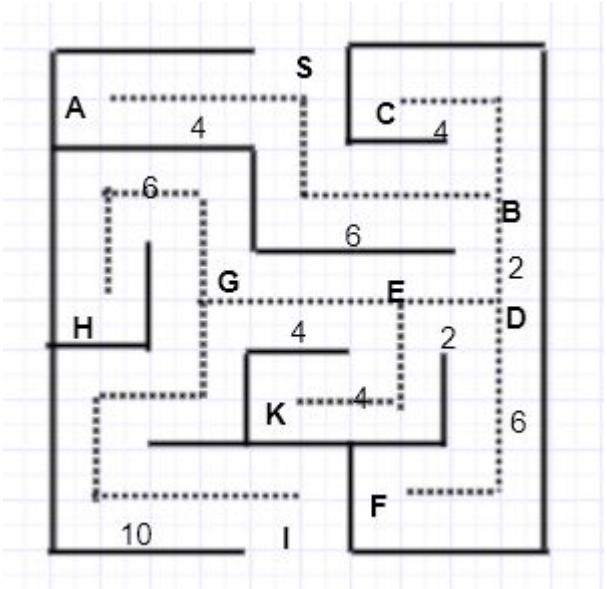
- **Rule 1**
  1. Visit the adjacent unvisited vertex.
     - If there are several vertices, randomly pick one.
  2. Mark it as visited.
  3. Display it.
  4. Push it in a stack.
- **Rule 2**
  1. If no adjacent vertex is found, pop up a vertex from the stack.
     - It will pop up all the vertices from the stack, which do not have adjacent vertices.
- **Rule 3**
  1. Repeat Rule 1 and Rule 2 until the stack is empty.



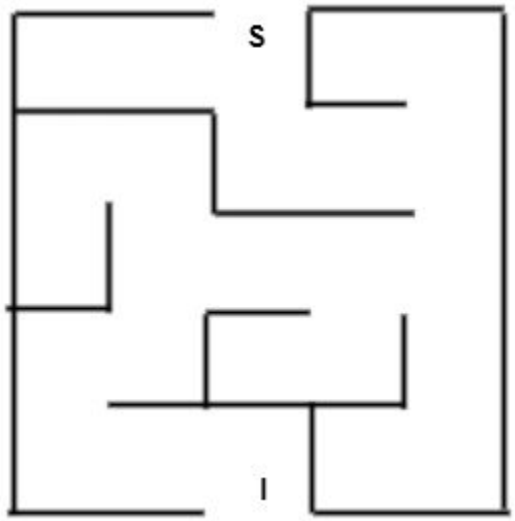
# Example 1

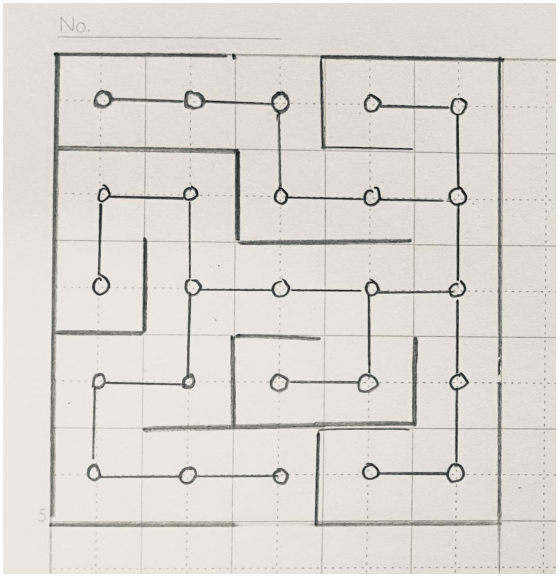
Given a Maze: Return True if can go from start S to destination I. If not, return False



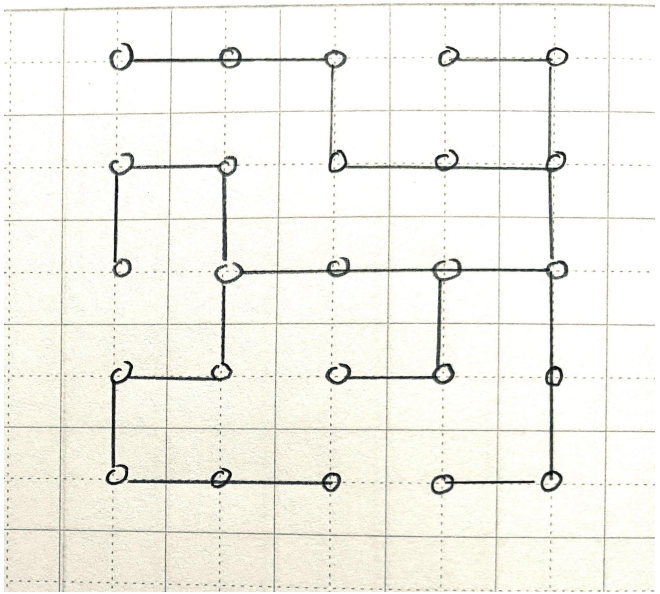



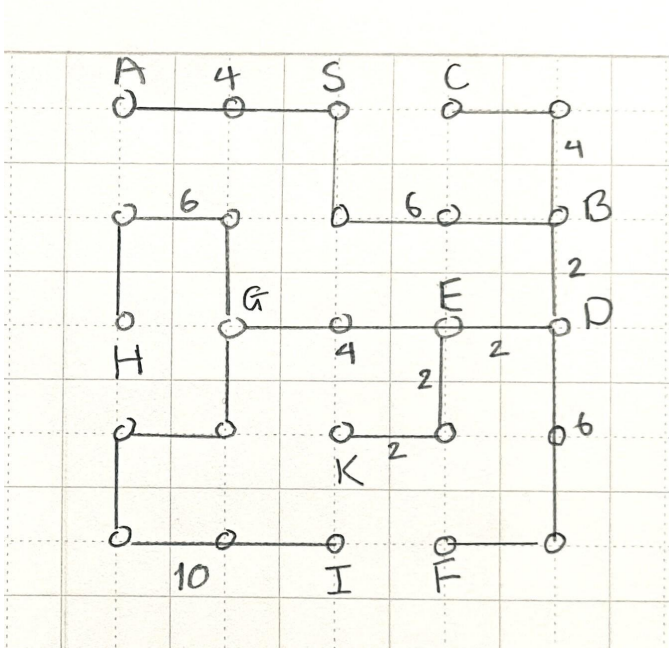
# Step 1 & 2



# Step 3 & 4





# Example 1

**Let's view in form of a tree. S is the node and 2 branches: right, left. Apply DFS**

**From S we can go to A or B. A is dead end. Go to S, B**

**From B we can go to C or D. C is dead end. Go to B, D**

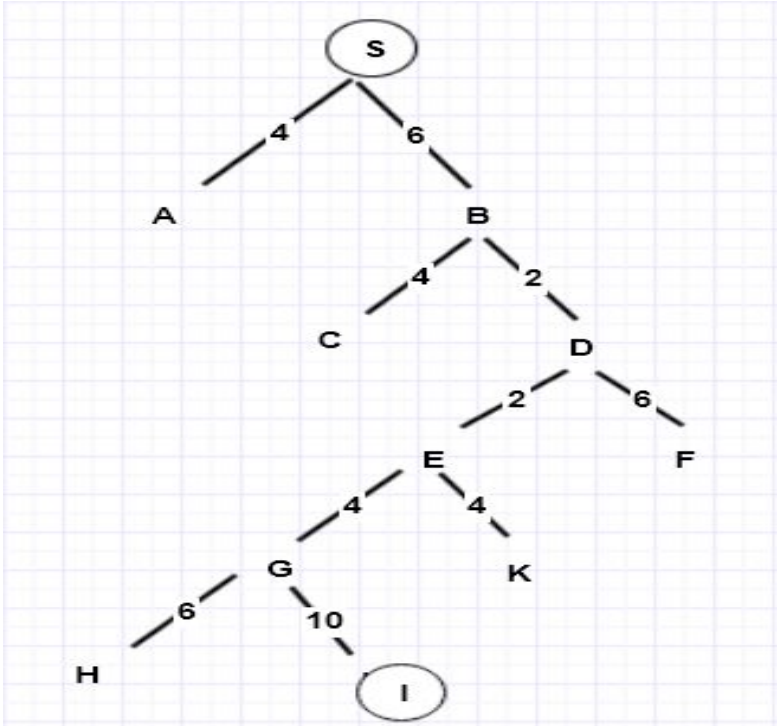
**From D we can go to E or F. Go to E**

**From E we can go to G or K. Go to G**

**From G we can go to H or I. H is not destination. Go to G, I. I is the destination.**

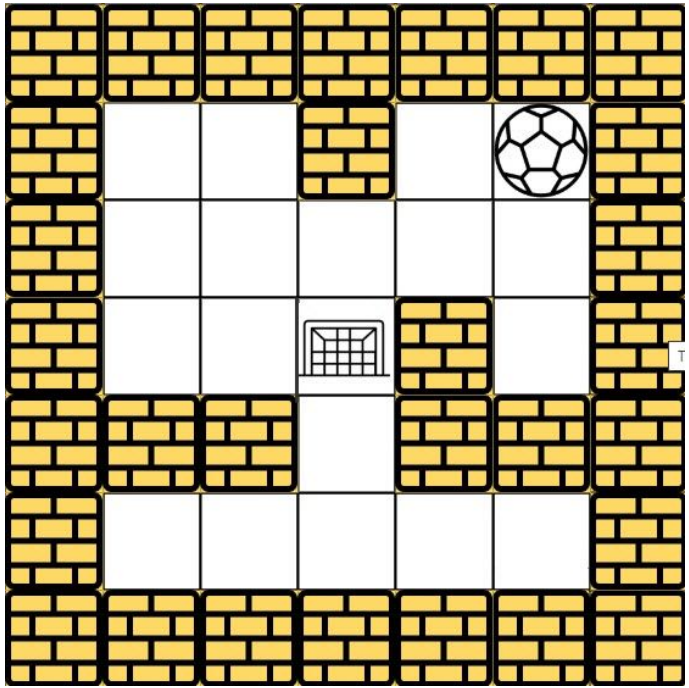
**S -> B -> D -> E -> G -> I : True**

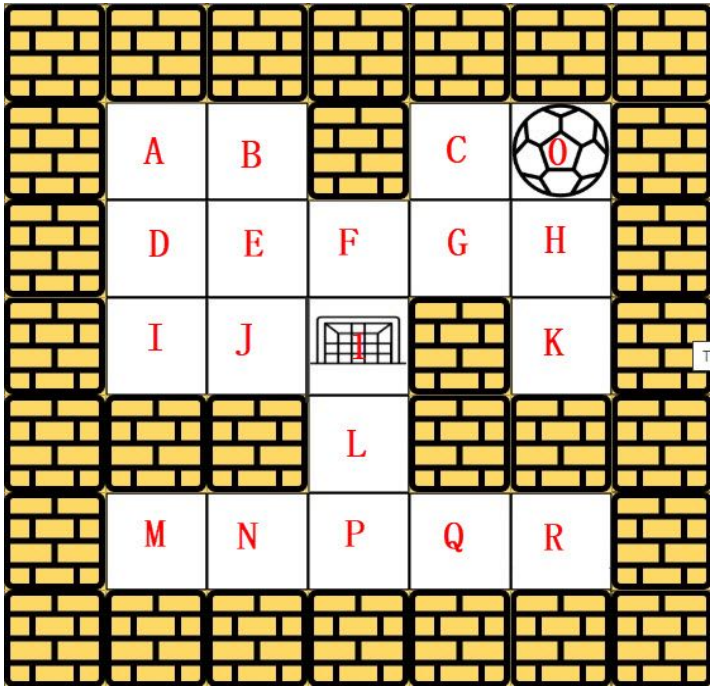
**Distance: 24 units. Save time than BFS (BFS has to pass F and K before go to the destination)**



# Example 2

Conduct Depth_First Traversal - Right, Left, Up, Down

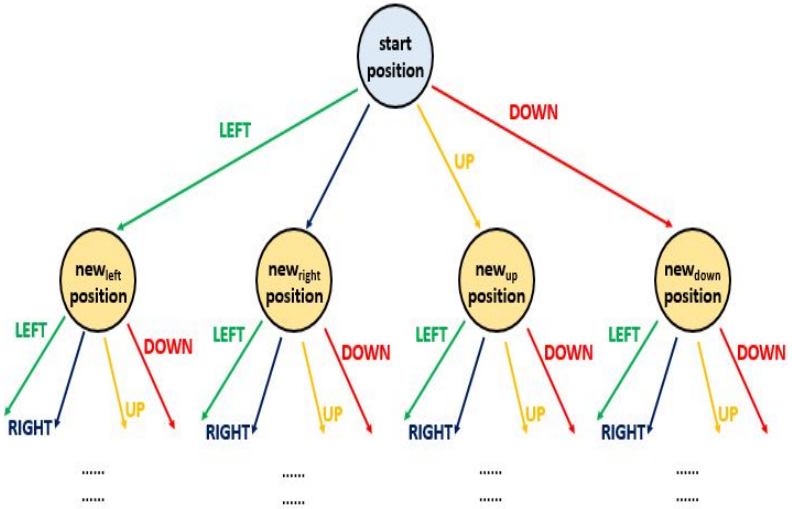




# Example 2

**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 2

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

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

From C can go to G

From G can go to D or H. Go to H

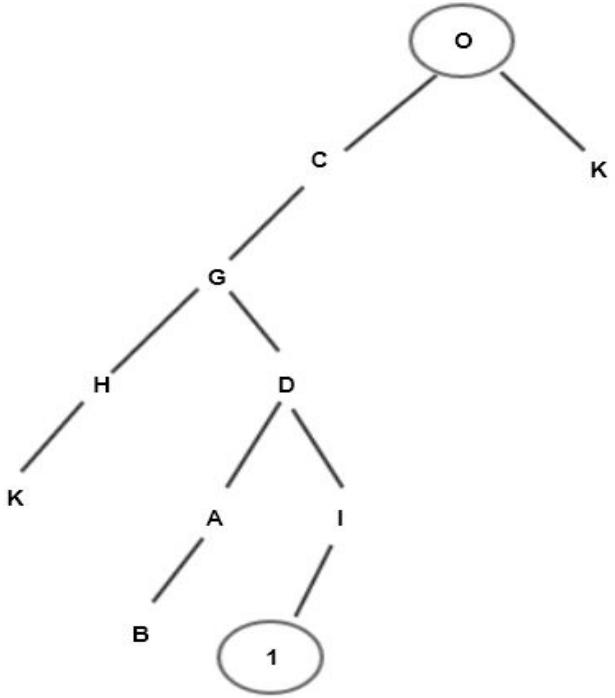
From H can go to K ( K is dead end). Go back to G -> D

From D can go to A or I (other points are visited)

From A can go to B (B is dead end). Go back to A ->D -> I

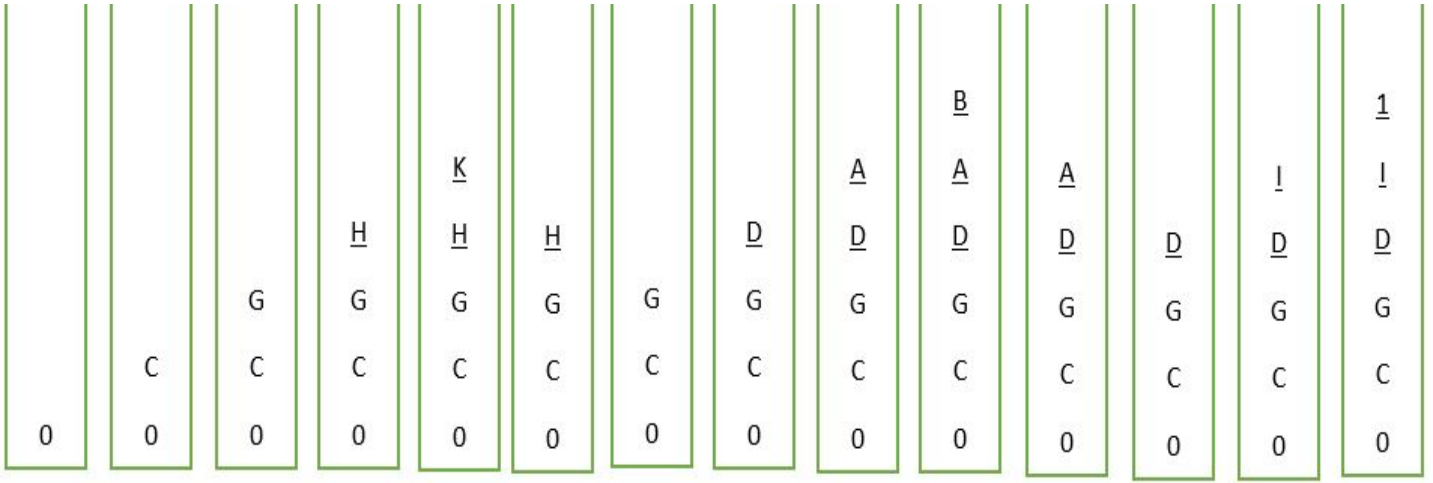
From I can go to 1: destination. True

-> Same time, less memory space than BFS



# Example 2

**Use stack:**



# Implementation

- Implement Depth First Search

  on Python 3

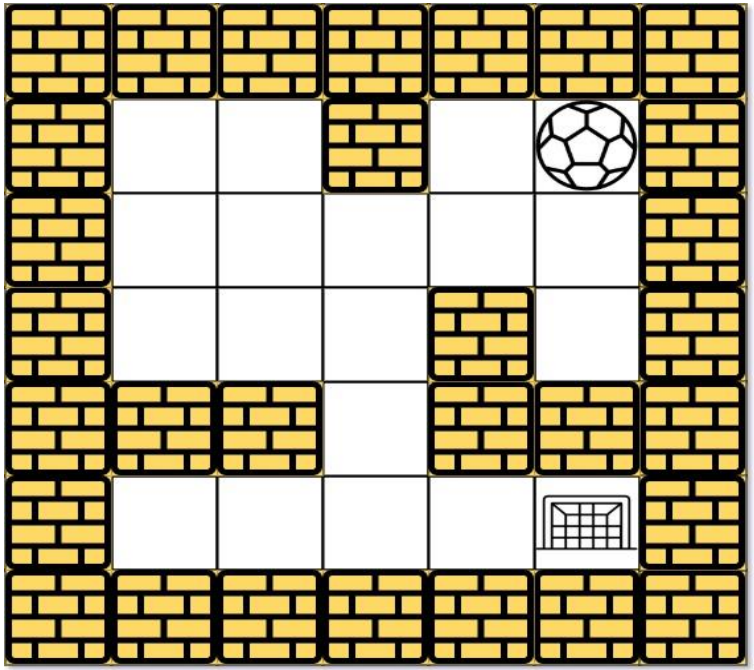
# 490. The Maze ( Leetcode)

## 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

```python
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])
        stack = []
        seen = set()
        stack.append((start[0], start[1]))
        seen.add((start[0], start[1]))
        while stack:
            curr_i, curr_j = stack.pop()
            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:
                    stack.append((i,j))
                    seen.add((i,j))
        return False
```

```python
from typing import List
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])
        stack = []
        seen = set()
        stack.append((start[0], start[1]))
        seen.add((start[0], start[1]))
        while stack:
            curr_i, curr_j = stack.pop()
            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:
                    stack.append((i,j))
                    seen.add((i,j))
        return False

```

PROBLEMS 22 DEBUG CONSOLE OUTPUT TERMINAL JUPYTER Python

```
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>
```

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# 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

- Breadth First Search (BFS) can be another solution. Queue will be used instead of stack.

# Conclusion

- To solve the Maze problem, we imagine two cases: Case 1: a robot without wheel goes in a clear route. Case 2: a robot with wheel goes in unclear route.
- We can view the given space search in a form of a tree with node as the start position and branches are all the different options ( 2 options: right, left for case 1 or 4 options: right, left, up, down for case 2 ).
- Depth - first search (DFS) is useful in cycle detection in graphs such as maze, consumes less memory space and will reach at the goal node in a less time if it traverses in a right path.

# References

Karleigh M, Ken J, Jimin K, Depth-First Search (DFS). Retrieved 07/18/2022 from https://brilliant.org/wiki/depth-first-search-dfs/#complexity-of-depth-first-search

Tutorialspoint. Data Structure - Depth First Search. https://www.tutorialspoint.com/data_structures_algorithms/depth_first_traversal.htm