Vishal Sharma

Robot Navigation in a Maze Using DFS (with Python Code)

This project demonstrates how to design a robot navigation strategy for a simple maze using the Depth-First Search (DFS) algorithm, as explained in the provided PDF. The workflow includes representing the maze, implementing the DFS algorithm, reconstructing the path, and executing the solution.

1. Importing Required Libraries

In [1]:
```
import numpy as np
import matplotlib.pyplot as plt
```

2. Maze Representation

We'll define a simple 5x5 maze for demonstration. The maze is represented as a 2D list where 0 denotes open paths and 1 denotes walls or obstacles.

In [2]:
```
maze = [
    [0, 0, 1, 0, 0],
    [0, 0, 0, 0, 0],
    [0, 1, 1, 1, 0],
    [0, 1, 0, 0, 0],
    [0, 0, 0, 1, 0]
]

start = (0, 0)  # Top-left corner
goal = (4, 4)   # Bottom-right corner
```

3. Helper Function to Get Neighbors

The function below finds all valid (open) neighboring cells for a given cell, considering movement in up, down, left, and right directions

In [3]:
```
def get_neighbors(maze, cell):
    neighbors = []
    directions = [(-1, 0), (1, 0), (0, -1), (0, 1)]  # Up, Down, Left, Right
    rows, cols = len(maze), len(maze[0])

    for dir in directions:
        neighbor = (cell[0] + dir[0], cell[1] + dir[1])
        if 0 <= neighbor[0] < rows and 0 <= neighbor[1] < cols:
```

```python
            if maze[neighbor[0]][neighbor[1]] == 0:  # Open cell
                neighbors.append(neighbor)

    return neighbors
```

4. Implementing the DFS Algorithm

Here is a Python implementation of the DFS-based maze navigation strategy:

In [4]:
```python
def dfs(maze, start, goal):
    stack = [start]
    visited = set()
    visited.add(start)
    parent = {start: None}

    while stack:
        current = stack.pop()
        if current == goal:
            break
        for neighbor in get_neighbors(maze, current):
            if neighbor not in visited:
                stack.append(neighbor)
                visited.add(neighbor)
                parent[neighbor] = current

    # Reconstruct path
    path = []
    step = goal
    while step is not None:
        path.append(step)
        step = parent.get(step)
    path.reverse()

    # Check if a path was found
    if path[0] != start:
        return None
    return path
```

5. Executing DFS and Outputting the Path

In [5]:
```python
optimal_path = dfs(maze, start, goal)
if optimal_path:
    print("Optimal Path:", optimal_path)
else:
    print("No path found from start to goal!")
```

```
Optimal Path: [(0, 0), (0, 1), (1, 1), (1, 2), (1, 3), (1, 4), (2, 4), (3, 4),
(4, 4)]
```

6. Visualizing the Maze and Path

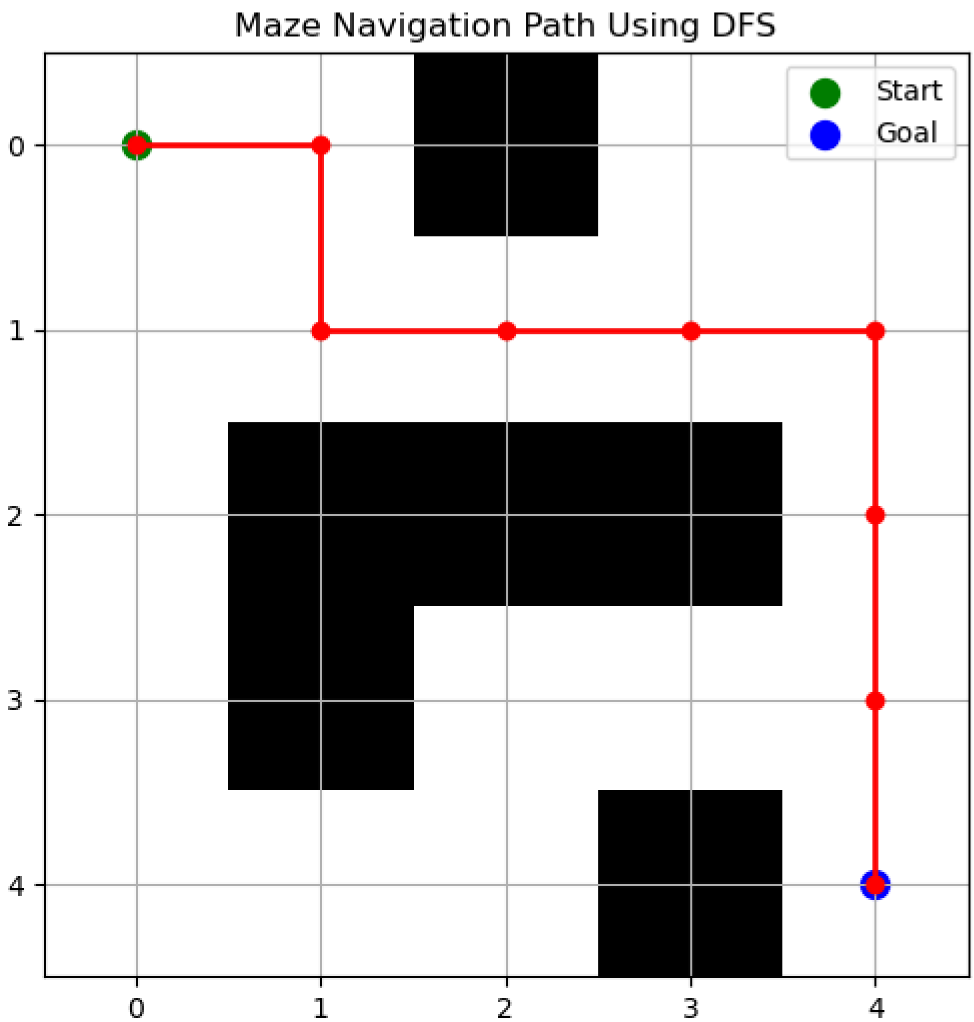
In [6]:

```
def visualize_maze(maze, path):
    maze_arr = np.array(maze)
    plt.figure(figsize=(6,6))
    plt.imshow(maze_arr, cmap='binary', origin='upper')

    # Plot path if one exists
    if path:
        path_coords = list(zip(*path))
        plt.plot(path_coords[1], path_coords[0], color='red', linewidth=2, mar
        plt.scatter(path_coords[1][0], path_coords[0][0], color='green', s=100
        plt.scatter(path_coords[1][-1], path_coords[0][-1], color='blue', s=10

    plt.legend()
    plt.xticks(np.arange(maze_arr.shape[1]))
    plt.yticks(np.arange(maze_arr.shape[0]))
    plt.grid(True)
    plt.title("Maze Navigation Path Using DFS")
    plt.show()

# Call visualization
visualize_maze(maze, optimal_path)
```



7. Handling No Path Found

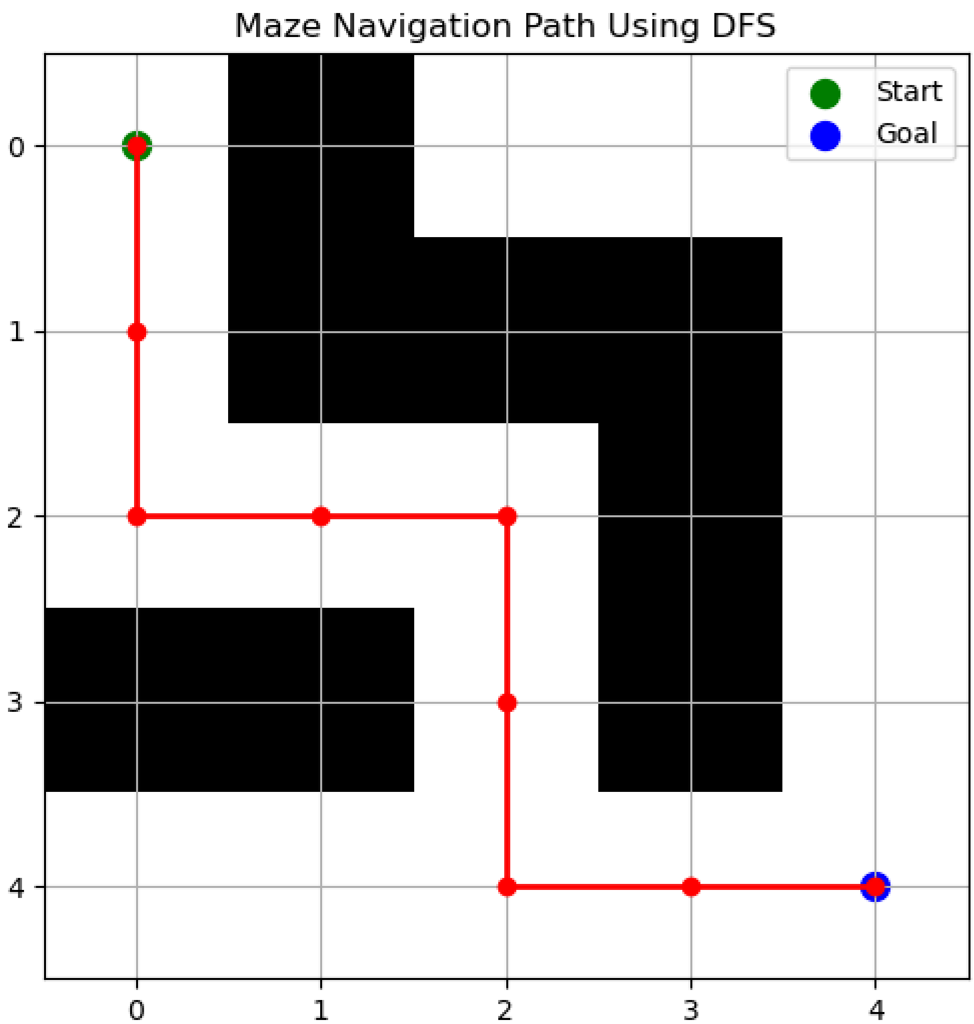
The dfs function ensures that a result is only returned if a path exists. Otherwise, it indicates that no path could be found, handling edge cases gracefully.

8. Custom Maze Datasets

You can create and test with your own datasets by redefining the maze variable. For example:

In [7]:
```
custom_maze = [
    [0, 1, 0, 0, 0],
    [0, 1, 1, 1, 0],
    [0, 0, 0, 1, 0],
    [1, 1, 0, 1, 0],
    [0, 0, 0, 0, 0]
]
custom_optimal_path = dfs(custom_maze, (0,0), (4,4))
visualize_maze(custom_maze, custom_optimal_path)
```

```python
print("Optimal Path:", custom_optimal_path)
```




```
Optimal Path: [(0, 0), (1, 0), (2, 0), (2, 1), (2, 2), (3, 2), (4, 2), (4, 3),
(4, 4)]
```

9. Conclusion

This project provides a complete Jupyter Notebook-style workflow for robot navigation in a maze using DFS, including sample datasets, Python code, and visualization. You can extend this strategy with other search methods or more complex mazes as needed

```
In [ ]:
```