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Semester -I A.Y.2025-26 Sub.: - Artificial Intelligence Lab Class: SE

Assignment 07: Implementing a Maze Solver using AI Search Algorithms (BFS & DFS).

Objective: Solve AI search problems using Graph Search Algorithms..

Explanation:

Maze Representation:

- **The maze is represented as a list of lists (a 2D grid).**
- **Each inner list represents a row.**
- **'#' indicates a wall.**
- **' ' indicates an open path.**
- **'S' is the starting point.**
- **'E' is the ending point.**

Common Elements for Both BFS and DFS:

1. **find_start_end(maze) (implicit in the code):**
    - **The first step is to iterate through the maze to locate the start ('S')**

and end ('E') coordinates.

2. directions:

   ○ A list of tuples [(0, 1), (0, -1), (1, 0), (-1, 0)] represents possible movements: right, left, down, up.

3. is_valid(r, c, rows, cols, maze, visited) (implicit in the code):

   ○ Checks if a given cell (r, c) is within the maze boundaries, is not a wall ('#'), and has not been visited yet.

Breadth-First Search (BFS):

- Goal: Find the shortest path from the start to the end.
- Data Structure: collections.deque (double-ended queue).
- How it works:
  ○ Starts at the start node.
  ○ Explores all its immediate neighbors.
  ○ Then explores all unvisited neighbors of those neighbors, and so on. ○ It expands layer by layer, ensuring that the first time it reaches the end node, it has found the shortest path.
- queue = collections.deque([(start, [start])]):
  ○ Each item in the queue is a tuple: (current_position, path_taken_to_reach_here). This is crucial for reconstructing the path. ● visited = set([start]):
  ○ Keeps track of all cells that have been added to the queue to prevent cycles and redundant processing.
- queue.popleft(): Removes the element from the front of the queue (FIFO - First-In, First-Out).

Depth-First Search (DFS):

- **Goal: Find *any* path from the start to the end. It doesn't guarantee the shortest path.**
- **Data Structure: A list used as a stack.**
- **How it works:**
  - **Start at the start node.**

○ Explores as far as possible along each branch before backtracking. ○ It goes deep into one path before trying another.

● stack = [(start, [start])]:

○ Similar to BFS, each item in the stack is (current_position, path_taken_to_reach_here).

● visited = set([start]):

○ Keeps track of visited cells.

● stack.pop(): Removes the element from the end of the list (LIFO - Last-In, First-Out), simulating a stack.

print_path(maze, path):

● This helper function takes the original maze and the found path, then prints the maze with the path marked by '*'.

Choosing Between BFS and DFS for Maze Solving:

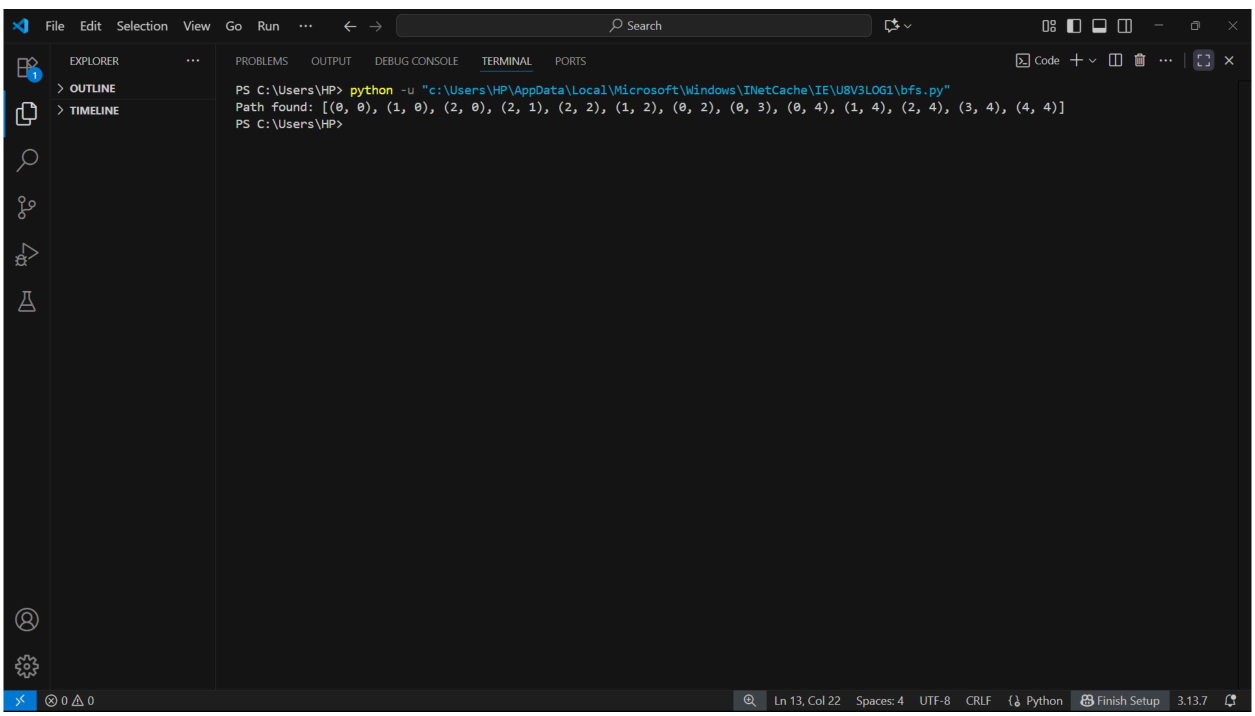
● BFS is generally preferred for maze solving when you need the shortest path because it explores evenly in all directions from the start.

● DFS is simpler to implement recursively (though the iterative stack version is shown here). It can find *a* path quickly, but not necessarily the shortest. If the maze has a very long, winding path to the solution while a shorter one exists, DFS might explore the longer one first.

```
def dfs(maze, start, end):
    stack = [start]  # Initialize stack with start position
    visited = set()  # Track visited positions
    parent = {start: None}  # To reconstruct the path

    while stack:
        position = stack.pop()
        x, y = position

        # Check if we've reached the end
        if position == end:
                    path = []
            while position is not None:
                path.append(position)
                position = parent[position]
            path.reverse()
            return path

        # Mark the current cell as visited
        visited.add((x, y))

        # Explore neighbors (up, down, left, right)
        for dx, dy in [(-1, 0), (1, 0), (0, -1), (0, 1)]:
            new_x, new_y = x + dx, y + dy
            new_pos = (new_x, new_y)

            # Check bounds and conditions
            if (0 <= new_x < len(maze) and
                0 <= new_y < len(maze[0]) and
                maze[new_x][new_y] == 0 and
                new_pos not in visited and
                new_pos not in stack):   # prevent duplicates
                stack.append(new_pos)
                parent[new_pos] = position
    return None  # No path found


# Example maze: 0 -> open path, 1 -> wall
maze = [
    [0, 1, 0, 0, 0],
    [0, 1, 0, 1, 0],
    [0, 0, 0, 1, 0],
    [1, 1, 1, 1, 0],
    [0, 0, 0, 0, 0]
```

```
]

# Start and end positions
start = (0, 0)
end = (4, 4)

# Solve the maze
path = dfs(maze, start, end)
if path:
    print("Path found:", path)
else:
    print("No path exists.")
```

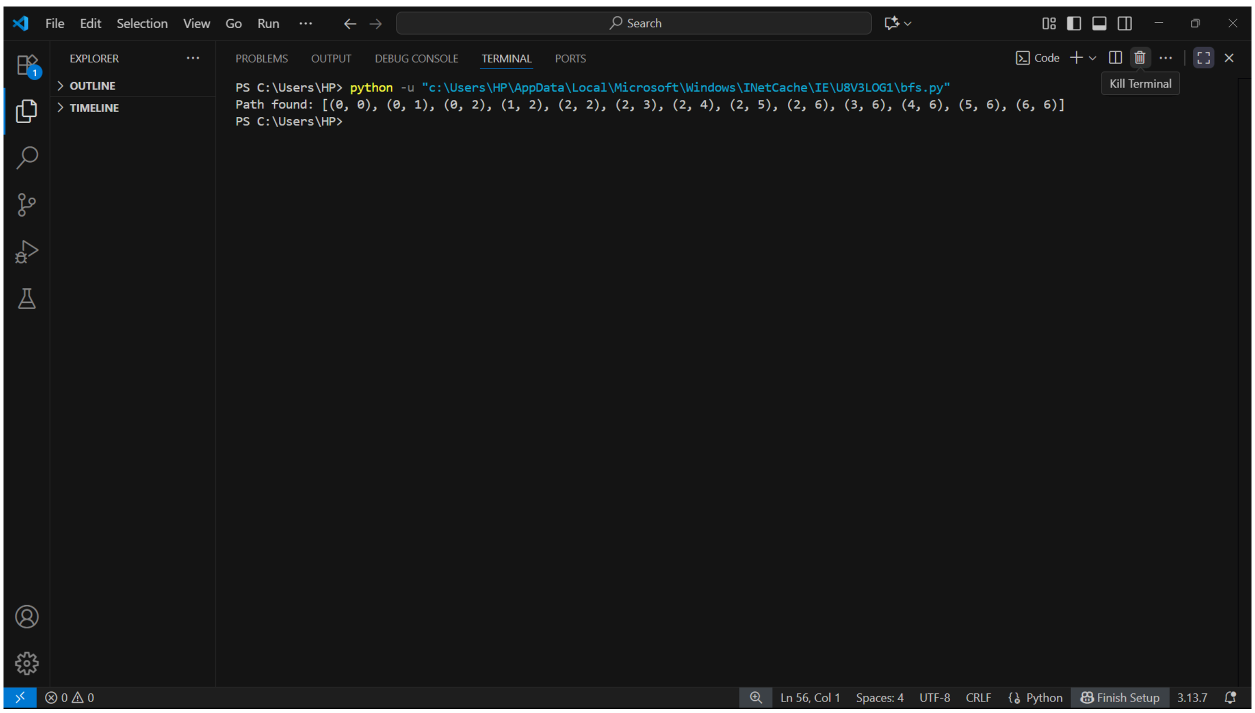
Output :



```
from collections import deque

def bfs(maze, start, end):
    # Directions: up, right, down, left
    directions = [(-1, 0), (0, 1), (1, 0), (0, -1)]
    queue = deque([start])
    visited = set([start])      parent = {start: None}
    while queue:
        current = queue.popleft()
        if current == end:
                    path = []
            while current is not None:
                path.append(current)
                current = parent[current]
            path.reverse()
            return path

        for direction in directions:
            next_cell = (current[0] + direction[0], current[1] + direction[1])

            if (0 <= next_cell[0] < len(maze) and
                0 <= next_cell[1] < len(maze[0]) and
                maze[next_cell[0]][next_cell[1]] != '#' and
                next_cell not in visited):
                queue.append(next_cell)
                visited.add(next_cell)
                parent[next_cell] = current

    return None


# Example maze
maze = [
    ['S', '.', '.', '#', '.', '.', '.'],
    ['.', '#', '.', '#', '.', '#', '.'],
    ['.', '#', '.', '.', '.', '.', '.'],
    ['.', '.', '#', '#', '#', '.', '.'],
    ['.', '#', '.', '.', '.', '#', '.'],
    ['.', '#', '#', '#', '.', '#', '.'],
    ['.', '.', '.', '.', '.', '.', 'E'],
]

start = (0, 0)  # Starting position
end = (6, 6)    # Ending position (exit)
```

```
# Run BFS to find the path
path = bfs(maze, start, end)

if path:
    print("Path found:", path)
else:
    print("No path exists.")
```

Output :



COMPARISON

Aspect	BFS (Breadth-First Search)	DFS (Depth-First Search)
Goal	Finds the **shortest path** from start to end.	Finds **any path** from start to end (not guaranteed shortest).
How it explores	Explores all neighbors at current depth before going deeper.	Explores as far as possible along one path before backtracking.
Data structure	Uses a **queue** (FIFO).	Uses a **stack** (LIFO), often implemented recursively.
Memory usage	Higher — stores all nodes at the current layer.	Generally lower — stores nodes along a single path.
Path length guarantee	Always finds shortest path (minimum steps).	May find a longer or suboptimal path.
Performance	Can be slower and consume more memory on large or complex mazes.	Can be faster initially but may explore longer paths unnecessarily.
Implementation complexity	Iterative, requires explicit queue.	Simpler to implement recursively.
Use cases	When shortest path is needed (e.g., GPS navigation, shortest route).	When any path suffices, or you want quick approximate solutions.
Behavior in mazes with loops	Uses visited set to avoid infinite loops and repeated states.	Same, but can get stuck exploring long branches if no goal nearby.