AI MSE REPORT

Problem Title: Pathfinding with A* Algorithm

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1. Introduction

Pathfinding is a method used in artificial intelligence to find the shortest path between two points. The *A (A-Star) Algorithm** is one of the best pathfinding algorithms. It is commonly used in video games, robotics, and navigation systems.

A* works by calculating two main values:

1. **G-cost:** The actual distance from the starting position to the current position.
2. **H-cost:** An estimated distance from the current position to the goal.

By combining both values, A* quickly finds the best possible path.

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2. Methodology

The *A algorithm** follows these steps:

1. **Create a grid (map):** The environment is represented as a grid where:
   - 0 means a walkable path.
   - 1 means an obstacle.
2. **Select a heuristic function:** The **Manhattan Distance** formula is used to estimate how far a point is from the goal.
3. **Use a priority queue (min-heap):** This ensures that the best possible paths are explored first.
4. **Track visited positions:** This prevents checking the same position multiple times.
5. **Find the best path:** The algorithm backtracks from the goal to reconstruct the shortest path.
6. **Display the result:** If a path exists, it is shown; otherwise, a message is displayed saying no path was found.

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3. Code Implementation

```
import heapq  # Import heapq for priority queue (min-heap)

import random  # Import random to generate obstacles in the grid


# Heuristic function: Manhattan distance (used to estimate cost from a
point to the goal)

def heuristic(a, b):

    return abs(a[0] - b[0]) + abs(a[1] - b[1])


# A* Algorithm to find the shortest path from start to goal

def astar(grid, start, goal):

    rows, cols = len(grid), len(grid[0])  # Get grid size


    # Priority queue (min-heap) for open nodes, initialized with (cost,
start_position)

    open_list = [(0, start)]

    came_from = {start: None}  # Dictionary to store the path (where each
node came from)

    g_cost = {start: 0}  # Dictionary to store the cost from start to each
node


    while open_list:

        _, current = heapq.heappop(open_list)  # Get node with the lowest
cost


        # If we reach the goal, reconstruct and return the path

        if current == goal:
```

```
            path = []
            while current:
                path.append(current)
                current = came_from[current]
            return path[::-1]  # Reverse path to get it from start to goal

        # Explore all possible movement directions (left, right, up, down)
        for dx, dy in [(-1, 0), (1, 0), (0, -1), (0, 1)]:
            neighbor = (current[0] + dx, current[1] + dy)  # Calculate new position

            # Check if the neighbor is within grid boundaries and is a walkable path (0)
            if 0 <= neighbor[0] < rows and 0 <= neighbor[1] < cols and grid[neighbor[0]][neighbor[1]] == 0:
                new_cost = g_cost[current] + 1  # Cost of moving to neighbor

                # If the neighbor is unvisited OR we found a cheaper path to it, update it
                if neighbor not in g_cost or new_cost < g_cost[neighbor]:
                    g_cost[neighbor] = new_cost  # Update cost
                    priority = new_cost + heuristic(neighbor, goal)  # Calculate priority
                    heapq.heappush(open_list, (priority, neighbor))  # Add to open list
                    came_from[neighbor] = current  # Track where we came from
```

```
    return None  # No path found


# Function to generate a grid with obstacles
def generate_grid(rows, cols, obstacle_prob=0.2):
    """Generates a grid where:
    - 0 represents a walkable path
    - 1 represents an obstacle (blocked path)
    - obstacle_prob controls the probability of an obstacle appearing"""
    return [[0 if random.random() > obstacle_prob else 1 for _ in
range(cols)] for _ in range(rows)]


# Get user input for grid size
rows = int(input("Enter number of rows: "))
cols = int(input("Enter number of columns: "))


# Generate the grid
grid = generate_grid(rows, cols)


# Display the generated grid
print("\nGenerated Grid (0 = walkable, 1 = obstacle):")
for row in grid:
    print(row)


# Get user input for start and goal positions
while True:
    start_x = int(input(f"\nEnter start row (0 to {rows-1}): "))
```

```
    start_y = int(input(f"Enter start column (0 to {cols-1}): "))
    goal_x = int(input(f"Enter goal row (0 to {rows-1}): "))
    goal_y = int(input(f"Enter goal column (0 to {cols-1}): "))

    start = (start_x, start_y)
    goal = (goal_x, goal_y)

    # Ensure start and goal positions are not on obstacles
    if grid[start_x][start_y] == 0 and grid[goal_x][goal_y] == 0:
        break  # Valid input, exit loop
    else:
        print("❌ Invalid input! Start or goal is on an obstacle. Please enter
different values.")

# Run A* algorithm to find the shortest path
path = astar(grid, start, goal)

# Output the result
if path:
    print("\n✅ Shortest Path Found:", path)  # Display the shortest path
else:
    print("\n❌ No Path Found!")  # No valid path exists’’’
```

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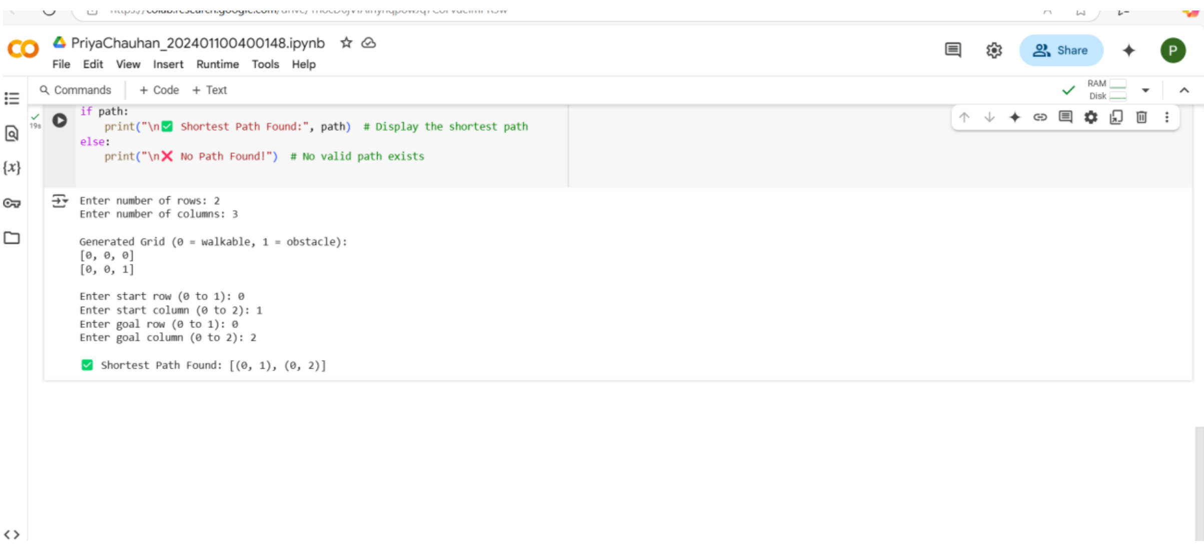
4. Output Screenshots



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5. References & Credits

- The *A algorithm** is a widely used pathfinding algorithm.
- The **Manhattan Distance** heuristic is commonly used in grid-based pathfinding.
- Python’s **heapq library** is used for efficient priority queue implementation.
