

TASK:3

Implementation of A * Algorithm to find the optimal path

Implementation of A * Algorithm to find the optimal path using Python by following constraints.

- The goal of the A* algorithm is to find the shortest path from the starting point to the goal point as fast as possible.
- The full path cost (f) for each node is calculated as the distance to the starting node (g) plus the distance to the goal node (h).
- Distances is calculated as the manhattan distance (taxicab geometry) between nodes.

Tools- Python, Online Simulator - <https://graphonline.ru/en/>

PROBLEM STATEMENT: CO2 S3

A software developer working on a project to create a GPS navigation system for autonomous vehicles. The system needs to find the optimal path between two locations on a road network to ensure efficient and safe navigation. To achieve this, you decide to implement the A* algorithm, a popular heuristic search algorithm, in Python.

The road network is represented as a graph, where each node represents an intersection, and an edge between two nodes represents a road segment connecting the intersections. Each road segment has a weight or cost, which corresponds to the distance between the intersections.

The task is to implement the A* algorithm to find the optimal path between two specified locations on the road network. The A* algorithm uses a heuristic function that estimates the cost from each node to the goal, guiding the search towards the most promising path while considering the actual cost of reaching each node.

A * ALGORITHM

AIM

To implement the A* algorithm for GPS navigation in Python to find the shortest (optimal) path from a start location to a goal location

ALGORITHM

1. Initialize the open list as a priority queue (min-heap).
 - Add the start node with:

$$f(\text{start}) = g(\text{start}) + h(\text{start})$$

$$g(\text{start}) = 0, h(\text{start}) \text{ from heuristic.}$$

1. Initialize an empty closed set to keep track of visited nodes.
2. Loop until the open list is empty:
 - a. Remove the node with the lowest f-value from the open list. Let this node be current.
 - b. If current is the goal node, Reconstruct and return the path and total cost.
 - c. If current is already in the closed set, Skip and continue to the next node.
 - d. Add current to the closed set.
 - e. For each neighbor of current:
 - i. If neighbor is in the closed set, skip.
 - ii. Compute $g(\text{neighbor}) = g(\text{current}) + \text{cost}(\text{current}, \text{neighbor})$
 - iii. Compute $f(\text{neighbor}) = g(\text{neighbor}) + h(\text{neighbor})$
 - iv. Add the neighbor to the open list with its f-value, g-value, and updated path.
 1. If open list becomes empty and goal was not reached, No path exists; return failure.

PROGRAM

A* Algorithm for GPS Navigation

```
import heapq

# A* Algorithm Function
def a_star_algorithm(graph, start, goal, heuristic):
    # Priority queue: (f = g + h, g = cost so far, current_node, path)
    open_list = []
    heapq.heappush(open_list, (heuristic[start], 0, start, [start]))
    visited = set()

    while open_list:
        f, g, current, path = heapq.heappop(open_list)

        if current == goal:
            return path, g # Path and total cost

        if current in visited:
            continue
        visited.add(current)

        for neighbor, cost in graph.get(current, []):
            if neighbor not in visited:
                g_new = g + cost
                f_new = g_new + heuristic[neighbor]
                heapq.heappush(open_list, (f_new, g_new, neighbor, path + [neighbor]))

    return None, float('inf') # No path found

# -----
# Main function
```

```
if __name__ == "__main__":  
    # Road Network Graph (nodes = intersections, edges = roads with distances)  
    graph = {  
        'A': [('B', 2), ('C', 4)],  
        'B': [('A', 2), ('D', 5), ('E', 10)],  
        'C': [('A', 4), ('F', 3)],  
        'D': [('B', 5), ('G', 2)],  
        'E': [('B', 10), ('G', 6)],  
        'F': [('C', 3), ('G', 4)],  
        'G': [('D', 2), ('E', 6), ('F', 4), ('H', 1)],  
        'H': [('G', 1)]  
    }  
  
    # Heuristic values (estimated distance to goal 'H')  
    heuristic = {  
        'A': 10,  
        'B': 8,  
        'C': 7,  
        'D': 5,  
        'E': 6,  
        'F': 4,  
        'G': 2,  
        'H': 0  
    }  
  
    # Start and Goal  
    start_node = 'A'  
    goal_node = 'H'  
  
    # Run A* Algorithm  
    optimal_path, total_cost = a_star_algorithm(graph, start_node, goal_node, heuristic)  
  
    # Print Output
```

```
if optimal_path:
    print("Optimal Path:", " → ".join(optimal_path))
    print("Total Distance (Cost):", total_cost)
else:
    print("No path found from", start_node, "to", goal_node)
```

OUTPUT

```
===== RESTART: C:/Users/gvlr4/OneDrive/Documents/vtu26253 task3 output.py =====
Optimal Path: A → B → D → G → H
Total Distance (Cost): 10
```

RESULT

Thus the Implementation of A* Algorithm for GPS Navigation using Python was successfully executed and output was verified.