

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:
 $f(\text{start}) = g(\text{start}) + h(\text{start})$
 $g(\text{start}) = 0$, $h(\text{start})$ from heuristic.
2. Initialize an empty closed set to keep track of visited nodes.
3. 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.
4. 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/student/AppData/Local/Programs/Python/Python313/task3-26597.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.