# tahjlaxcl

March 7, 2024

## 1 Node

[1]:
```
import numpy as np
import matplotlib.pyplot as plt
from collections import deque
import heapq

class PriorityQueue:
    def __init__(self):
        self.elements = []

    def empty(self):
        return len(self.elements) == 0

    def put(self, item, priority):
        heapq.heappush(self.elements, (priority, item))

    def get(self):
        return heapq.heappop(self.elements)[1]


# Node Class represents a state in the search tree.
class Node:
    def __init__(self, state, parent=None, action=None, path_cost=0):
        self.state = state  # The current position of the agent in the grid.
        self.parent = parent  # The node in the search tree that generated this␣
↪node.
        self.action = action  # The action taken to get to this state.
        self.path_cost = path_cost  # Cost from the start node to this node.

    # Comparison operator for priority queue.
    def __lt__(self, other):
        return self.path_cost < other.path_cost
```

## 2 Code for A*

[2]:
```
def heuristic(a, b):
    """
    Calculate the Manhattan distance between two points a and b.

    Parameters:
    - a: Tuple representing the x and y coordinates of point a (e.g., (x1, y1))
    - b: Tuple representing the x and y coordinates of point b (e.g., (x2, y2))

    Returns:
    - The Manhattan distance between points a and b.
    """
    (x1, y1) = a
    (x2, y2) = b
    return abs(x1 - x2) + abs(y1 - y2)
```

## 3 Environment Class

[3]:
```
# Environment Class represents the grid and handles state transitions.
class Environment:
    def __init__(self, grid, start, goal):
        self.grid = grid  # The grid layout where 1 represents an obstacle and␣
 ↪0 is free space.
        self.initial = start  # Starting position of the agent.
        self.goal = goal  # Goal position the agent aims to reach.

    # Returns the possible actions from a given state.
    def actions(self, state):
        possible_actions = ['UP', 'DOWN', 'LEFT', 'RIGHT']
        x, y = state

        # Remove impossible actions based on grid boundaries and obstacles.
        if x == 0 or self.grid[x - 1][y] == 1:
            possible_actions.remove('UP')
        if x == len(self.grid) - 1 or self.grid[x + 1][y] == 1:
            possible_actions.remove('DOWN')
        if y == 0 or self.grid[x][y - 1] == 1:
            possible_actions.remove('LEFT')
        if y == len(self.grid[0]) - 1 or self.grid[x][y + 1] == 1:
            possible_actions.remove('RIGHT')

        return possible_actions

    # Returns the state resulting from taking a given action at a given state.
    def result(self, state, action):
```

```
        x, y = state
        if action == 'UP':
            return (x - 1, y)
        if action == 'DOWN':
            return (x + 1, y)
        if action == 'LEFT':
            return (x, y - 1)
        if action == 'RIGHT':
            return (x, y + 1)

    # Checks if the goal has been reached.
    def is_goal(self, state):
        return state == self.goal
```

## 4 Agent

[4]:
```
class Agent:
    def __init__(self, env):
        self.env = env
        self.battery_level=int(100)
        self.total_rechage=int(0)


    # Performs Uniform Cost Search to find the lowest cost path from the␣
↪initial state to the goal.
    def uniform_cost_search(self):
        frontier = PriorityQueue()  # Priority queue for UCS.
        frontier.put(Node(self.env.initial, path_cost=0), 0)
        came_from = {self.env.initial: None}
        cost_so_far = {self.env.initial: 0}

        while not frontier.empty():
            current_node = frontier.get()

            if self.env.is_goal(current_node.state):
                return self.reconstruct_path(came_from, current_node.state)

            for action in self.env.actions(current_node.state):
                new_state = self.env.result(current_node.state, action)
                new_cost = cost_so_far[current_node.state] + 1  # Assuming␣
↪uniform cost for simplicity; adjust if varying costs.
                if new_state not in cost_so_far or new_cost <␣
↪cost_so_far[new_state]:
                    cost_so_far[new_state] = new_cost
                    priority = new_cost
```

```
                    frontier.put(Node(new_state, current_node, action,␣
↪new_cost), priority)
                    came_from[new_state] = current_node.state

        return []

    def a_star_search(self):
        # The start node is created with a path cost of 0.
        start_node = Node(self.env.initial, path_cost=0)
        frontier = PriorityQueue()
        frontier.put(start_node, 0)  # Priority is f-cost, initially the␣
↪heuristic cost from start to goal
        came_from = {self.env.initial: None}  # Tracks the best path to a node
        cost_so_far = {self.env.initial: 0}  # Tracks the g-cost (cost so far␣
↪to reach a node)

        while not frontier.empty():
            current_node = frontier.get()

            if self.env.is_goal(current_node.state):
                return self.reconstruct_path(came_from, current_node.state)

            for action in self.env.actions(current_node.state):
                new_state = self.env.result(current_node.state, action)
                new_cost = cost_so_far[current_node.state] + 1  # Assuming␣
↪uniform cost for simplicity
                if new_state not in cost_so_far or new_cost <␣
↪cost_so_far[new_state]:
                    cost_so_far[new_state] = new_cost
                    priority = new_cost + heuristic(new_state, self.env.goal) ␣
↪# f-cost = g-cost + h-cost
                    frontier.put(Node(new_state, current_node, action,␣
↪new_cost), priority)
                    came_from[new_state] = current_node.state

        return []

    def reconstruct_path(self, came_from, current):
        path = []
        while current in came_from:
            if self.battery_level == 0:
                self.total_rechage += 1
                self.battery_level = 100
            else:
                self.battery_level -= 10
            path.append(current)
```

```
            current = came_from[current]
        path.append(self.env.initial)
        path.reverse()
        return path
```

# 5 Plotting

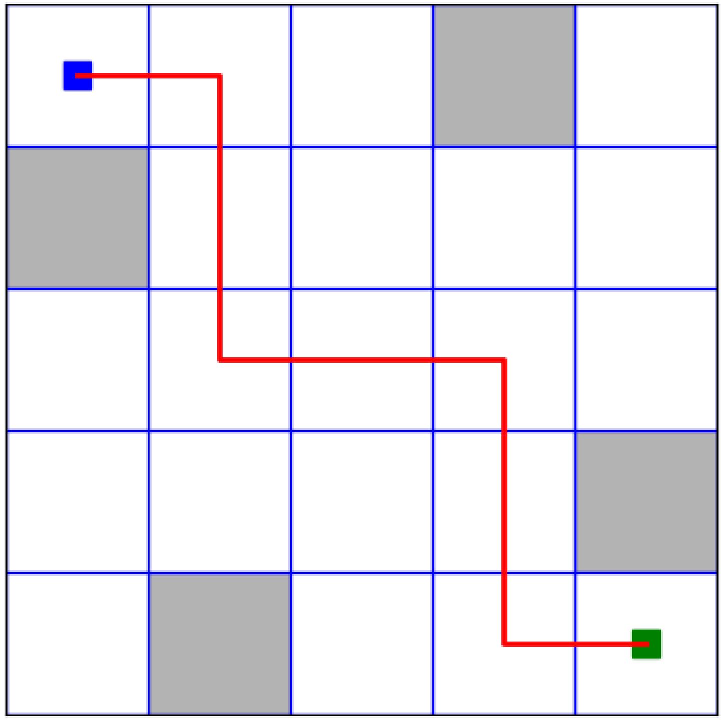
[ ]:
```
# Visualization Function plots the grid and the found path.
def visualize_grid_and_path(grid, path):
    grid_array = np.array(grid)  # Convert grid to numpy array for easy␣
 ↪plotting.
    fig, ax = plt.subplots()
    ax.imshow(grid_array, cmap='Greys', alpha=0.3)  # Grid background.
    start = path[0]
    goal = path[-1]
    ax.plot(start[1], start[0], 'bs', markersize=10)  # Start position in blue.
    ax.plot(goal[1], goal[0], 'gs', markersize=10)  # Goal position in green.
    xs, ys = zip(*path)  # Extract X and Y coordinates of the path.
    ax.plot(ys, xs, 'r-', linewidth=2)  # Plot the path in red.
    ax.set_xticks(np.arange(-.5, len(grid[0]), 1), minor=True)
    ax.set_yticks(np.arange(-.5, len(grid), 1), minor=True)
    ax.grid(which="minor", color="b", linestyle='-', linewidth=1)
    ax.tick_params(which="minor", size=0)
    ax.tick_params(which="major", bottom=False, left=False, labelbottom=False,␣
 ↪labelleft=False)
    plt.show()
```

# 6 User

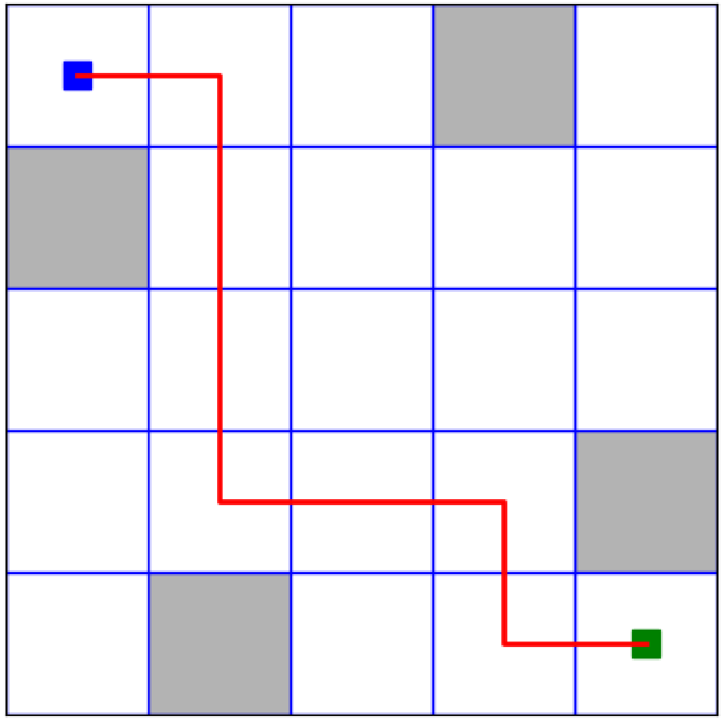
[ ]:
```
# Define the grid, start position, and goal position
grid = [
    [0, 0, 0, 1, 0],
    [1, 0, 0, 0, 0],
    [0, 0, 0, 0, 0],
    [0, 0, 0, 0, 1],
    [0, 1, 0, 0, 0]
]

start = (0, 0)
goal = (4, 4)

# Create the environment and agent
environment = Environment(grid, start, goal)
agent = Agent(environment)
```

```python
print("Solution with Uniform Cost Search: \n\n")
# Solve the problem with Uniform Cost Search
solution_path = agent.uniform_cost_search()
print("Solution Path: \n", solution_path)

# Visualize the solution
visualize_grid_and_path(grid, solution_path)


agent1 = Agent(environment)

print("\n\nSolution with A* Search: \n\n")
# Solve the problem with the A* algorithm
solution_path1 = agent1.a_star_search()
print("Solution Path: \n", solution_path1)


# Visualize the solution
visualize_grid_and_path(grid, solution_path1)

USF_battery = agent.battery_level
USF_cost=agent.total_rechage*100+USF_battery

a_star_battery = agent1.battery_level
a_star_cost=agent1.total_rechage*100+a_star_battery

print(f"Battery level on UCS: {USF_battery} Rechaged: {agent.total_rechage}␣
↪time and A*: {a_star_battery} Rechaged: {agent1.total_rechage} time")

if USF_cost<a_star_cost:
    print("\n\nUSF is better.")
elif USF_cost>a_star_cost:
    print("\n\nA* is better.")
else:
    print("Both needed same rechage")
```

```
Solution with Uniform Cost Search:


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



```
Solution with A* Search:


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



```
Battery level on UCS: 10 Rechaged: 0 time and A*: 10 Rechaged: 0 time
Both needed same rechage
```

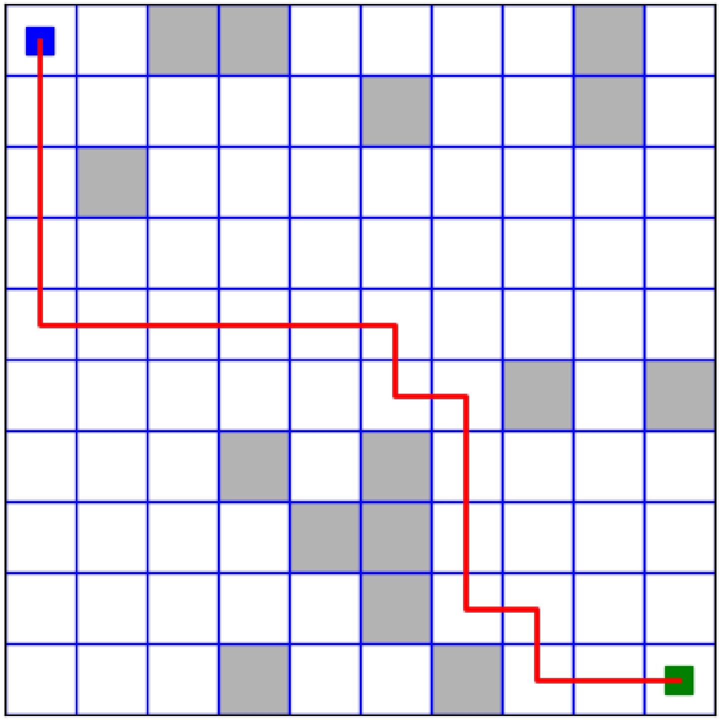
## 7 Code Randomly

[ ]:
```
# Generate a Random Grid Function
def generate_random_grid(size, obstacle_probability):
    return np.random.choice([0, 1], size=(size, size),␣
 ↪p=[1-obstacle_probability, obstacle_probability])

# Define the size of the grid and the probability of an obstacle in each cell
grid_size = 10
obstacle_probability = 0.2  # 20% chance of being an obstacle

# Generate a random grid
grid = generate_random_grid(grid_size, obstacle_probability)

# Define start and goal positions
start = (0, 0)
goal = (grid_size - 1, grid_size - 1)

# Ensure start and goal are not obstacles
grid[start] = 0
```

```
grid[goal] = 0

# Create the environment and agent
environment = Environment(grid, start, goal)
agent = Agent(environment)

print("Solution with Uniform Cost Search: \n\n")
# Solve the problem with Uniform Cost Search
solution_path = agent.uniform_cost_search()
print("Solution Path: \n", solution_path)

# Visualize the solution
visualize_grid_and_path(grid, solution_path)


agent1 = Agent(environment)

print("\n\nSolution with A* Search: \n\n")
# Solve the problem with the A* algorithm
solution_path1 = agent1.a_star_search()
print("Solution Path: \n", solution_path1)


# Visualize the solution
visualize_grid_and_path(grid, solution_path1)

USF_battery = agent.battery_level
USF_cost=agent.total_rechage*100+USF_battery

a_star_battery = agent1.battery_level
a_star_cost=agent1.total_rechage*100+a_star_battery

print(f"Battery level on UCS: {USF_battery} Rechaged: {agent.total_rechage}␣
↪time and A*: {a_star_battery} Rechaged: {agent1.total_rechage} time")

if USF_cost<a_star_cost:
    print("\n\nUSF is better.")
elif USF_cost>a_star_cost:
    print("\n\nA* is better.")
else:
    print("Both needed same rechage")
```

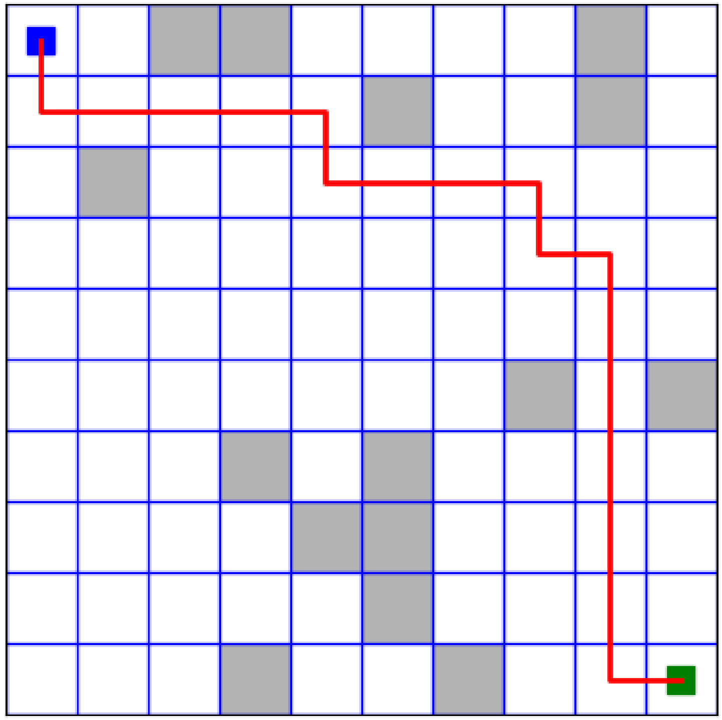
```
Solution with Uniform Cost Search:



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

4), (4, 5), (5, 5), (5, 6), (6, 6), (7, 6), (8, 6), (8, 7), (9, 7), (9, 8), (9, 9)]



Solution with A* Search:

Solution Path:
 [(0, 0), (0, 0), (1, 0), (1, 1), (1, 2), (1, 3), (1, 4), (2, 4), (2, 5), (2, 6), (2, 7), (3, 7), (3, 8), (4, 8), (5, 8), (6, 8), (7, 8), (8, 8), (9, 8), (9, 9)]



```
Battery level on UCS: 20 Rechaged: 1 time and A*: 20 Rechaged: 1 time
Both needed same rechage
```