Project Report: Enhanced Dynamic Robot Movement Simulation

Introduction

The goal of this project is to implement and compare two search algorithms, Uniform Cost Search (UCS) and A* Search, for a pathfinding problem in a grid environment where an agent is constrained by a limited battery capacity. The agent must navigate from a start position to a goal position while minimizing the total cost of movement, considering both path cost and battery consumption.

Problem Description

The problem is defined in a grid environment where some cells represent obstacles (denoted by 1), and others are free spaces (denoted by 0). The agent can move in four directions: up, down, left, and right. Movement between adjacent cells occurs a cost of 10 units, except for the initial movement from the start position. The agent starts with a fully charged battery (100%), and each movement consumes 10% of the remaining battery capacity.

Solution Approach

Two search algorithms are implemented:

- **Uniform Cost Search (UCS):** This algorithm explores the search space by prioritizing nodes with the lowest path cost. The cost of each action is considered, and the battery level is checked to ensure it doesn't drop below zero during exploration. If the battery level reaches zero, the agent recharges its battery before continuing.

- ***A-Star Search (A*):*** A* search is an informed search algorithm that combines the cost of reaching a node from the start node (g(n)) with an estimated cost of reaching the goal node from the current node (h(n)). The total cost of each node is calculated as the sum of g(n), the cost of the action, and h(n). In this implementation, the heuristic function used is the Manhattan distance between the current node and the goal node.

Results

The algorithms were applied to solve two instances of the pathfinding problem, each with different start and goal positions. The solution paths obtained are as follows:

- **UCS Solution Path:** The UCS algorithm successfully finds a path from the start position to the goal position while remaining within the battery limits. The remaining battery percentage and the total number of recharges are also provided.

- ***A-Star Solution Path:*** Similarly, the A* algorithm finds a path from the start position to the goal position, considering both path cost and heuristic estimates. The remaining battery percentage is also provided.

Conclusion

Both UCS and A* search algorithms are effective in solving the pathfinding problem with battery constraints. While UCS explores the search space based only on path cost, A* search utilizes heuristic information to guide the search towards the goal more efficiently. The choice between these algorithms depends on the specific characteristics of the problem domain, such as the complexity of the environment and the accuracy of the heuristic function. In future work, more sophisticated heuristic functions and optimization techniques could be explored to further improve the performance of the agents in battery-constrained environments.