Collaborative Multi-Robot Frontier-Based Mapping with Memory Constraints

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Abstract

Simultaneous localization and mapping (SLAM) is a problem in robotics where a robot must track its own location while mapping its environment [2]. Multi-robot SLAM increases the complexity of the problem, particularly when environments are larger, as it is infeasible to assume all robots will be able to store the entire map. This project analyzes multiple algorithms to schedule the movements of robots with a focus on memory constraints. After identifying two variants of the SLAM problem, we analyzed several algorithms that tackled them and validated the results with real-world experiments.

Objectives

Our project aims to determine the optimal frontier-detection algorithm for a group of robots that was reported back to a centralized node to merge map data. To do this, we plan to:

- Identify algorithms suitable to the C-SLAM problem with memory constraints
- Simulate robot mapping and frontier assignment in a series of subproblems
- Implement algorithm with best performance into a real-world system

Acknowledgements

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References

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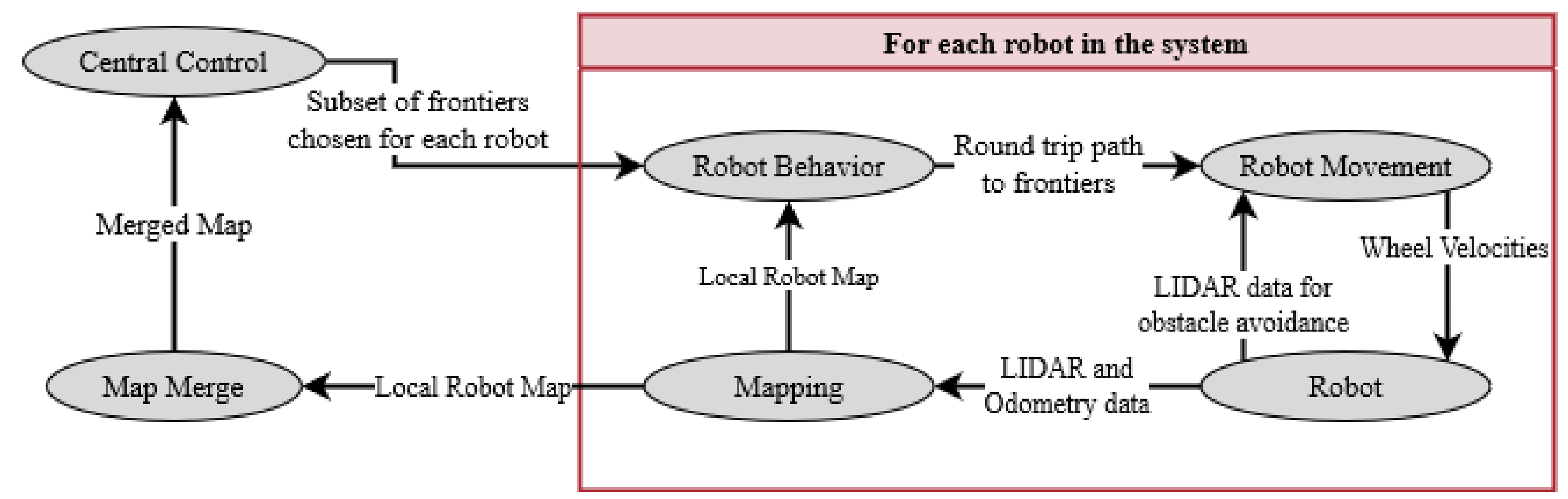
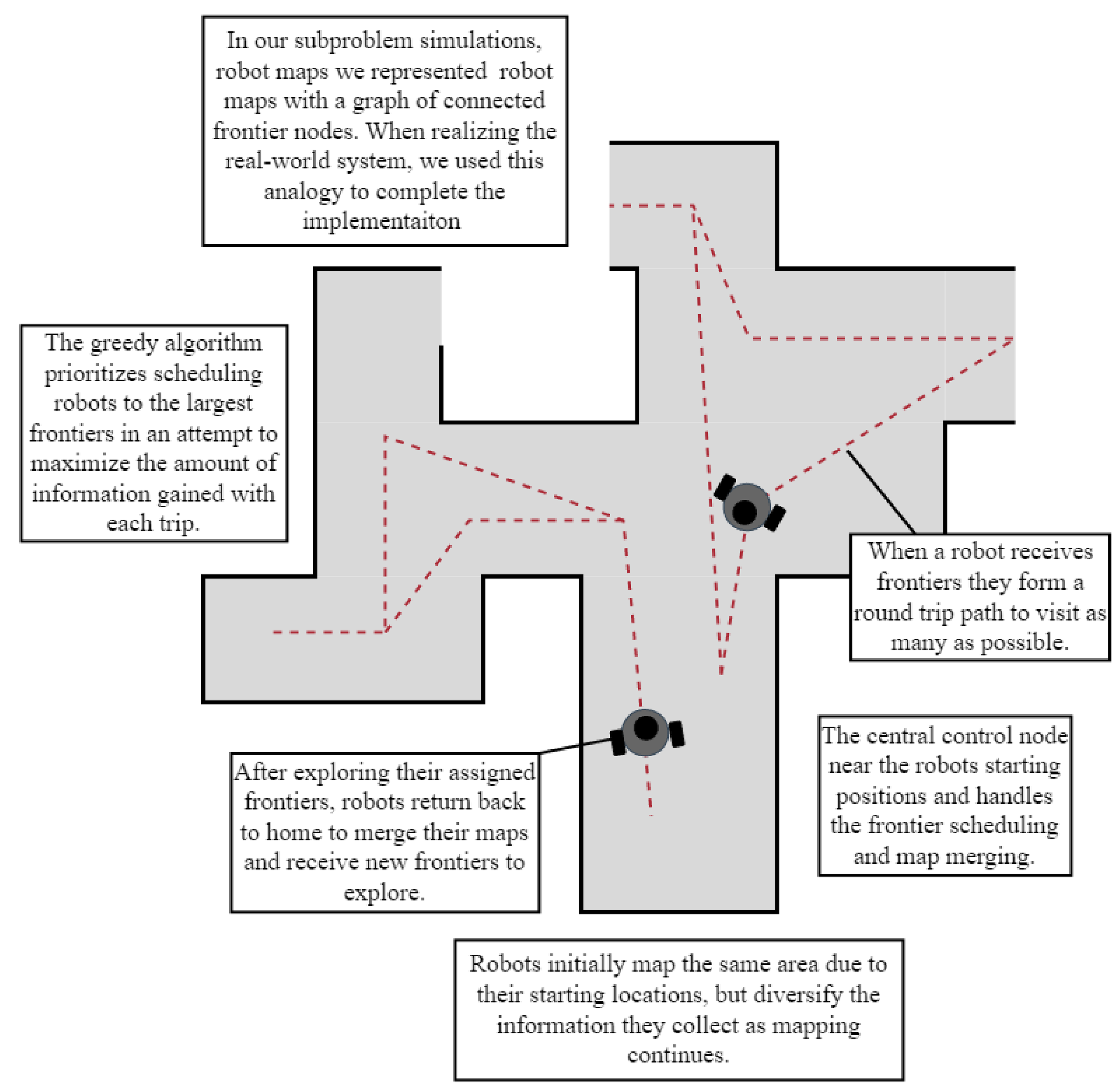
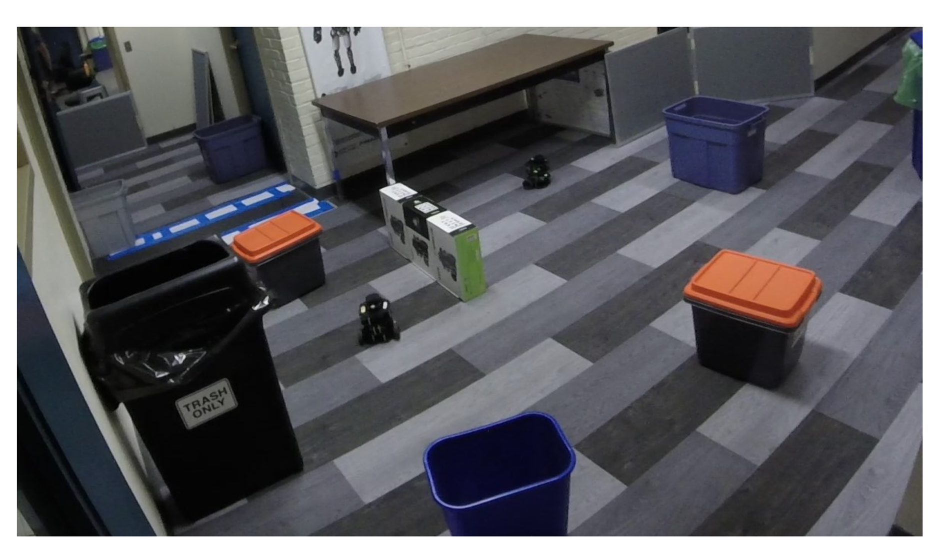
Real-World Implementation







Two turtlebot3s mapping an area with obstacles

Final merged map showing data from different robots

Subproblems

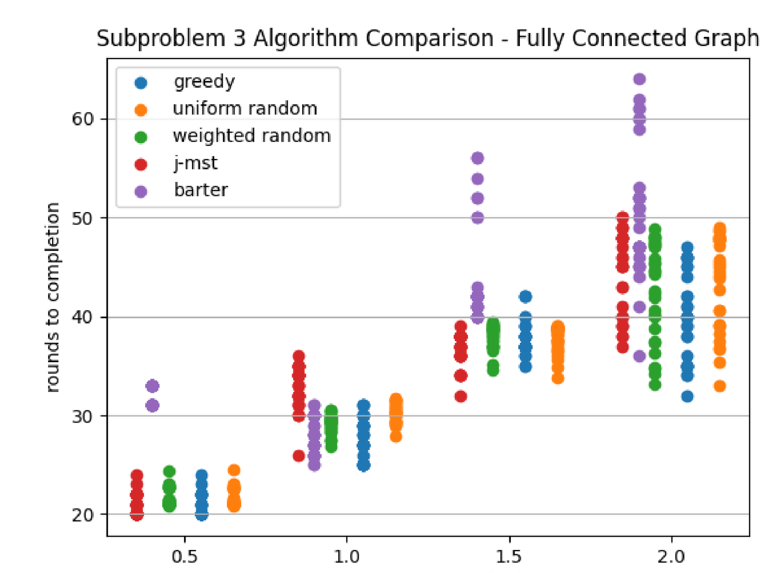
Subproblem 1 - single robot mapping a graph where all nodes and edges are known

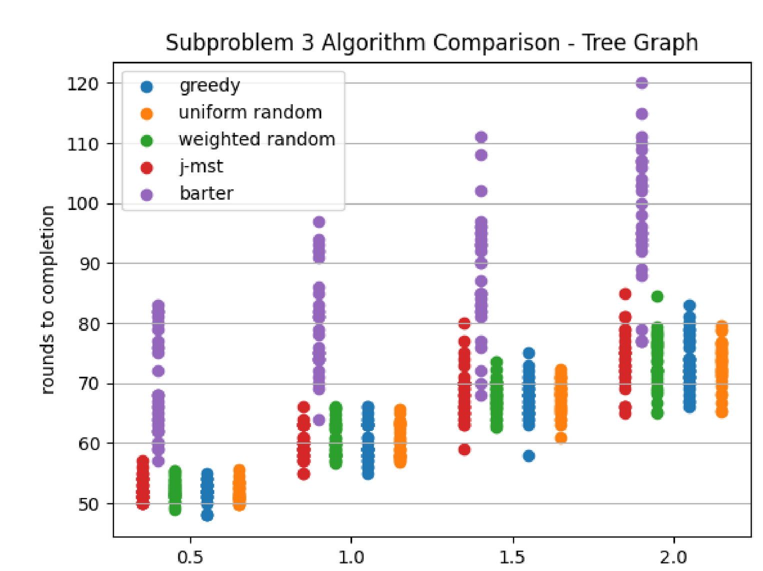
Subproblem 2 - multiple robots mapping a graph where all nodes and edges are known

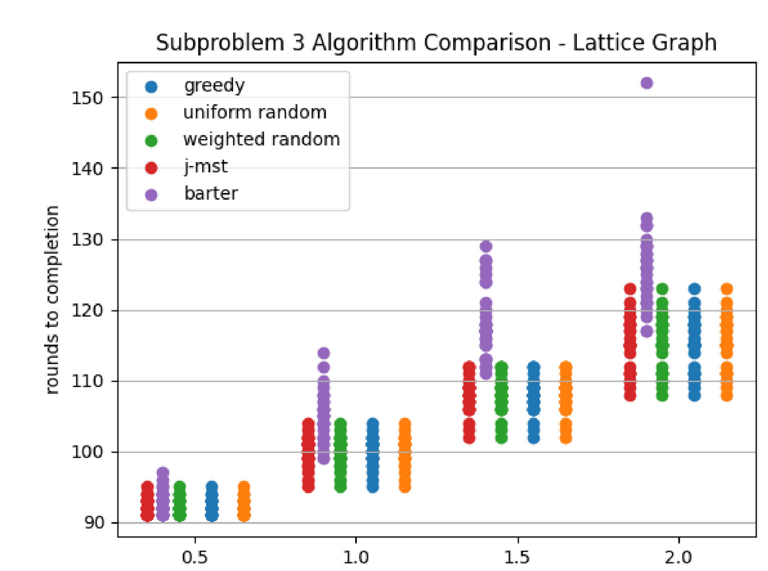
Subproblem 3 - multiple robots mapping an unknown graph

Algorithms

- Greedy - picks next node based on max node memory
- Uniform random - randomly chooses next node with equal weight for each
- Weighted random - randomly chooses next node weighted by amount of memory
- J-sized Min Spanning Tree (J-MST) - constructs minimum spanning tree from edges [3]
- Barter - trades nodes between robots after initial assignment of frontiers [1]







Experimental Results