Task Allocation Algorithms for Multi-Tethered Rover Systems: Traditional vs Timing Formulation

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Introduction/Objectives

Multi-tethered rover (MuTheR) systems show promise in the exploration of dangerous planetary environments. In this two-semester project, the objective of the second half was to compare the performance of an established multi-robot task allocation algorithm to a novel algorithm design.

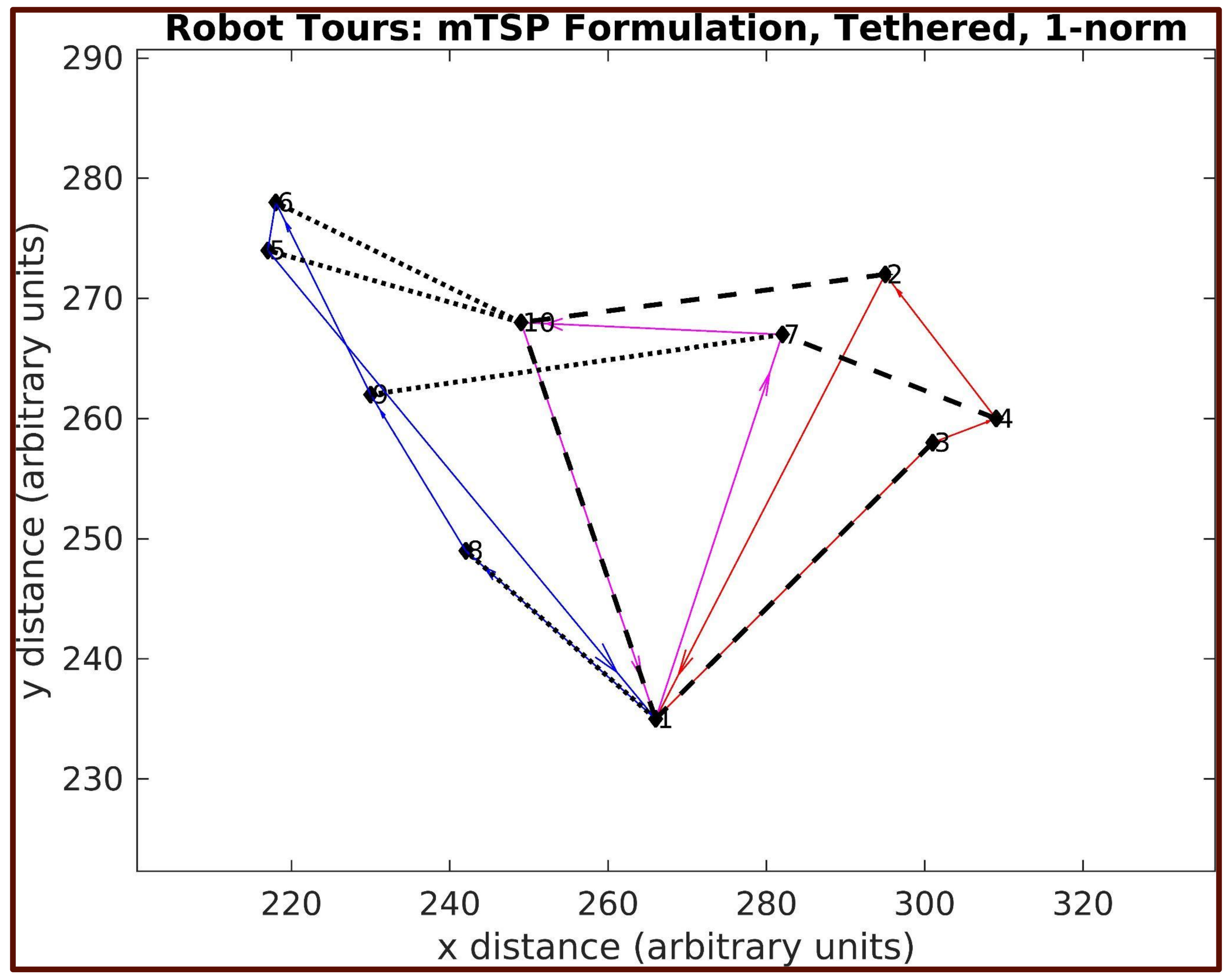
Methods

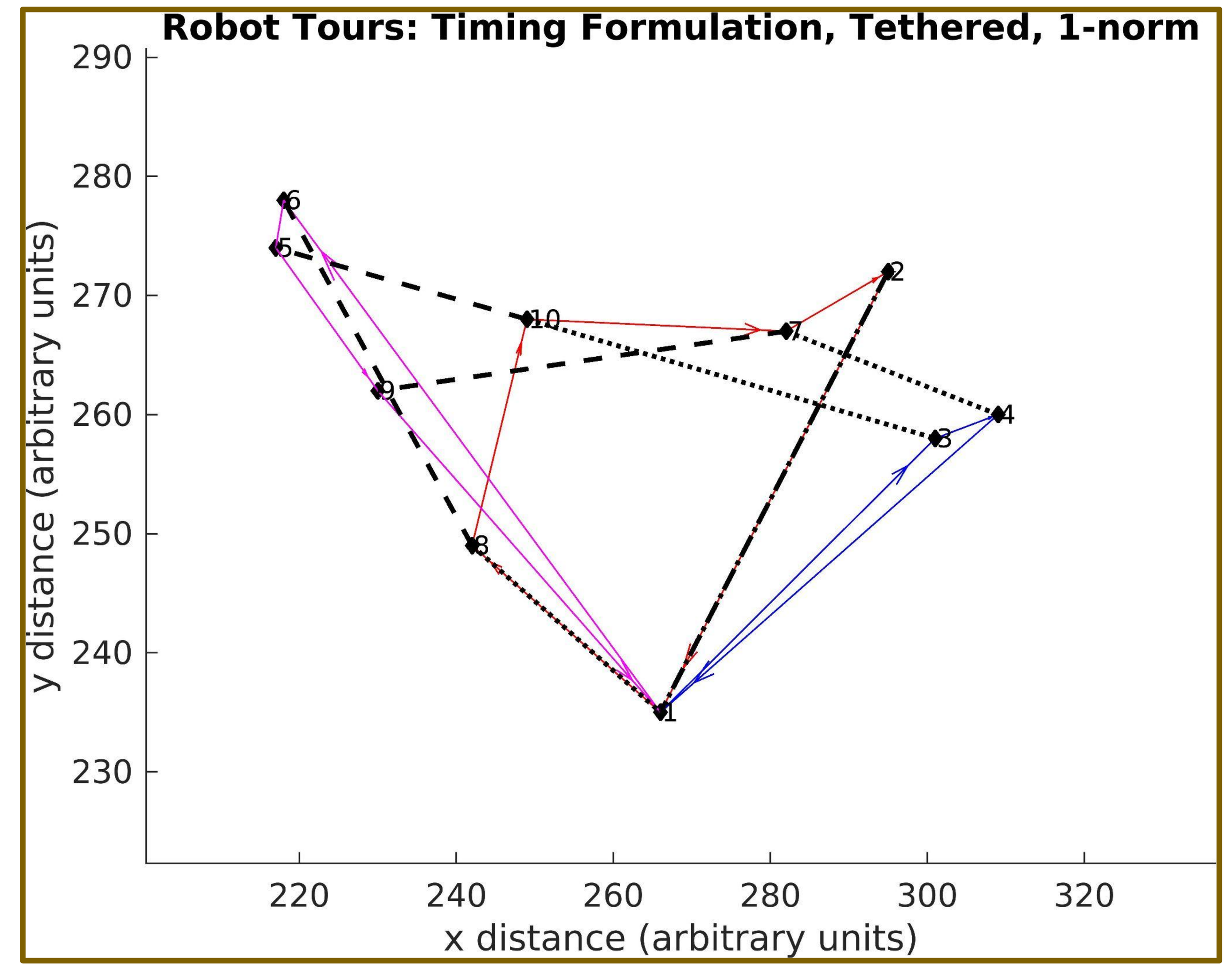
All constraints were written in MATLAB with YALMIP, while Gurobi was used in solving. The Online database TSPLIB was used for node coordinates, and the maximum robot tour length was chosen to be minimized. The two problem-solving approaches were:

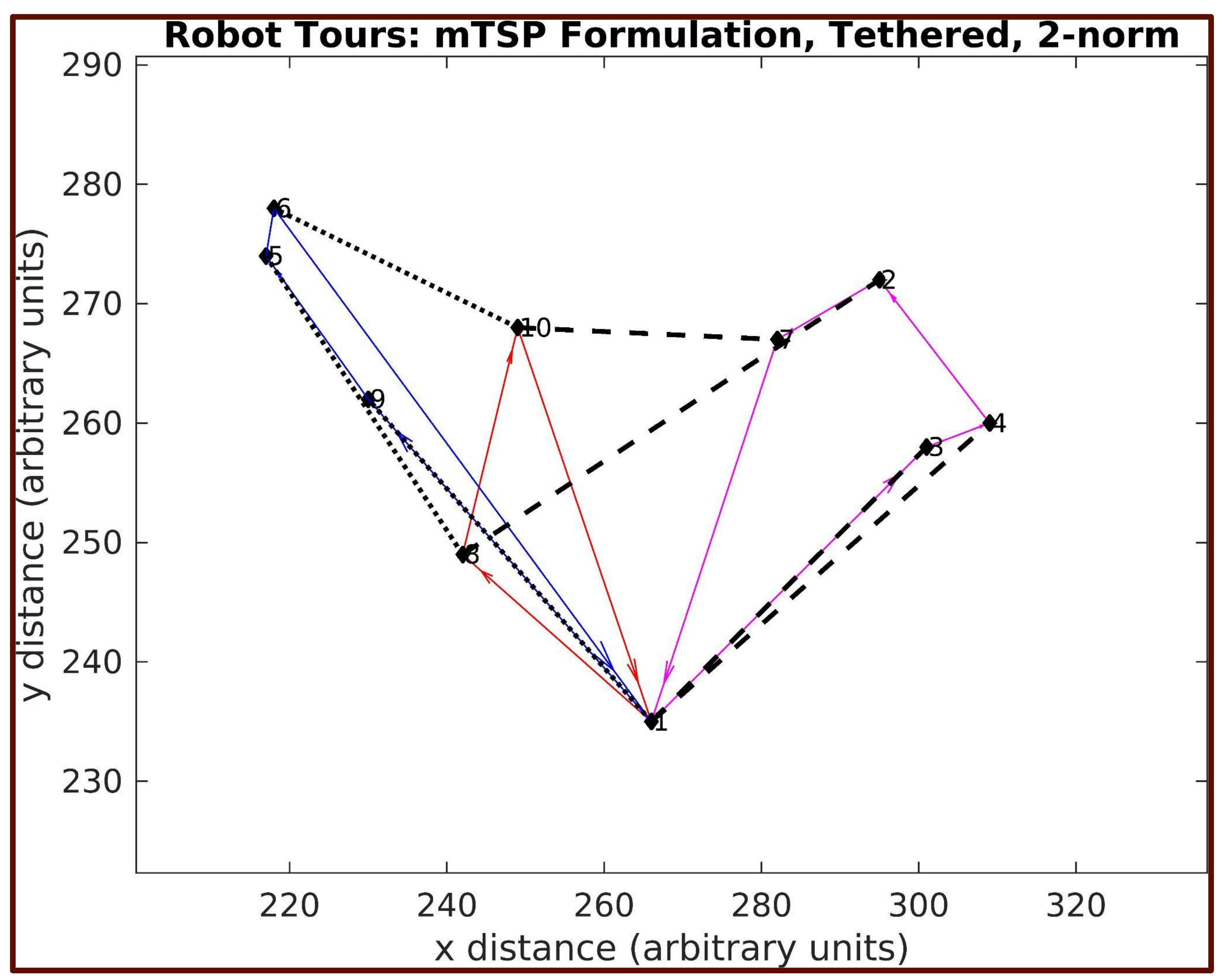
Approach 1:
- Solve traditional multiple Traveling Salesman Problem formulation
- Retrieve tour and check if tour satisfies tether constraint

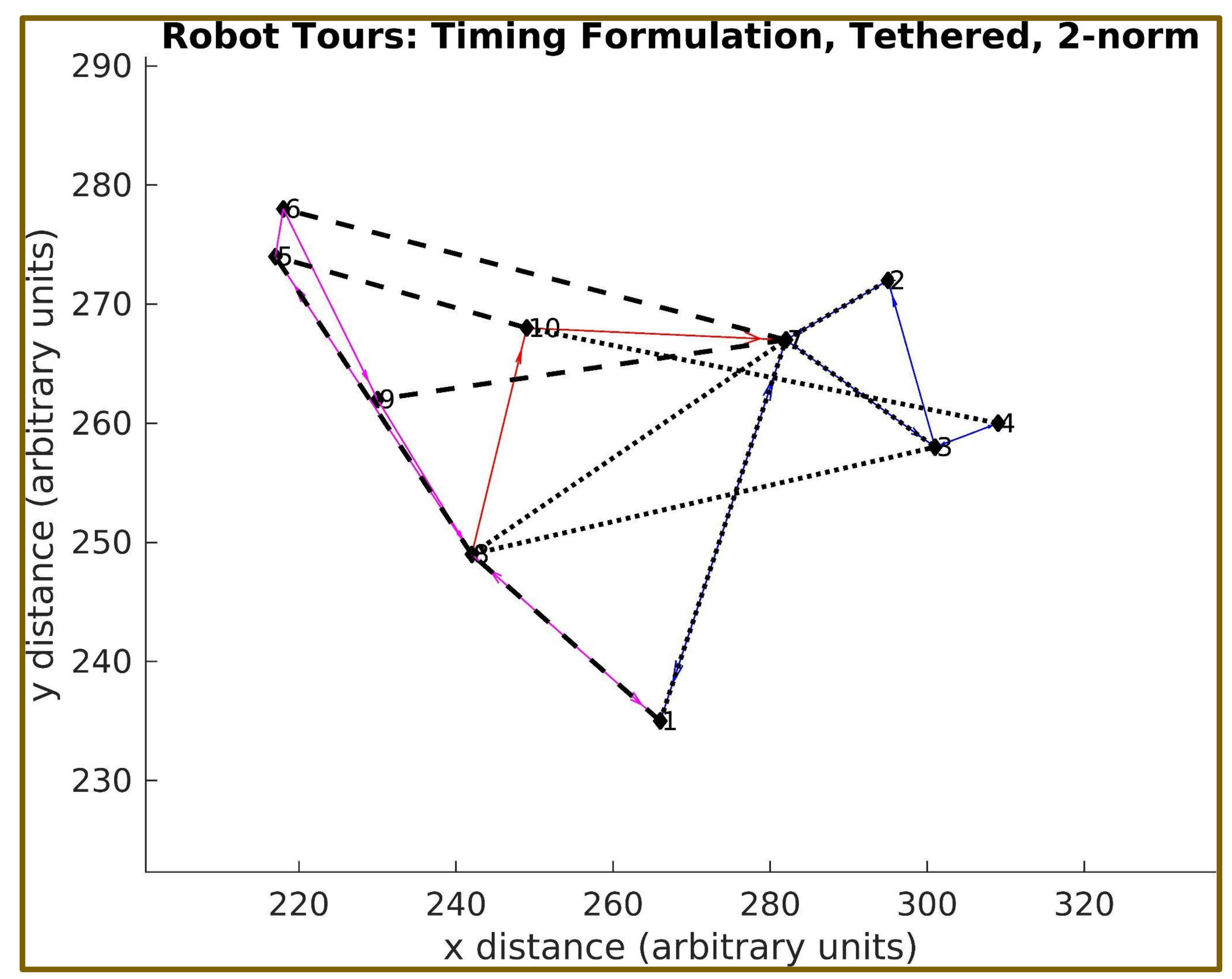
Approach 2:
- Construct a new formulation: solution matrices now represent robots' positions at discrete time steps
- Tether relations can now be incorporated as "online" constraints

Results









Discussion

While Approach 1 could produce results more quickly, its inability to include tour retracing resulted in missed tours at low city numbers. Approach 2 was thus more optimal but suffered long computation times in its 2-norm formulation:

Method		Criteria		
		Speed	Optimality	Realism
Iterative Method	1-norm	✓		
	2-norm	✓		✓
Timing Formulation	1-norm	✓	✓	
	2-norm		✓	✓

Conclusions/Future Work

Two separate approaches to solving tether-constrained multi-robot task allocation problems were deployed: the first approach used results from an established algorithm to find solutions that satisfied tether constraints, while the second approach included the tether constraints as mathematical relations. While the first approach was faster, the second method guaranteed more optimal solutions.

Future work involves increasing the simulations' realism by incorporating elevation changes, obstacles to the node coordinate space. Furthermore, motion planning algorithms could be included sequentially to check the robots' tether constraints as they move between cities.

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