Motion Planning (In)feasibility Detection using a Prior Roadmap via Path and Cut Search

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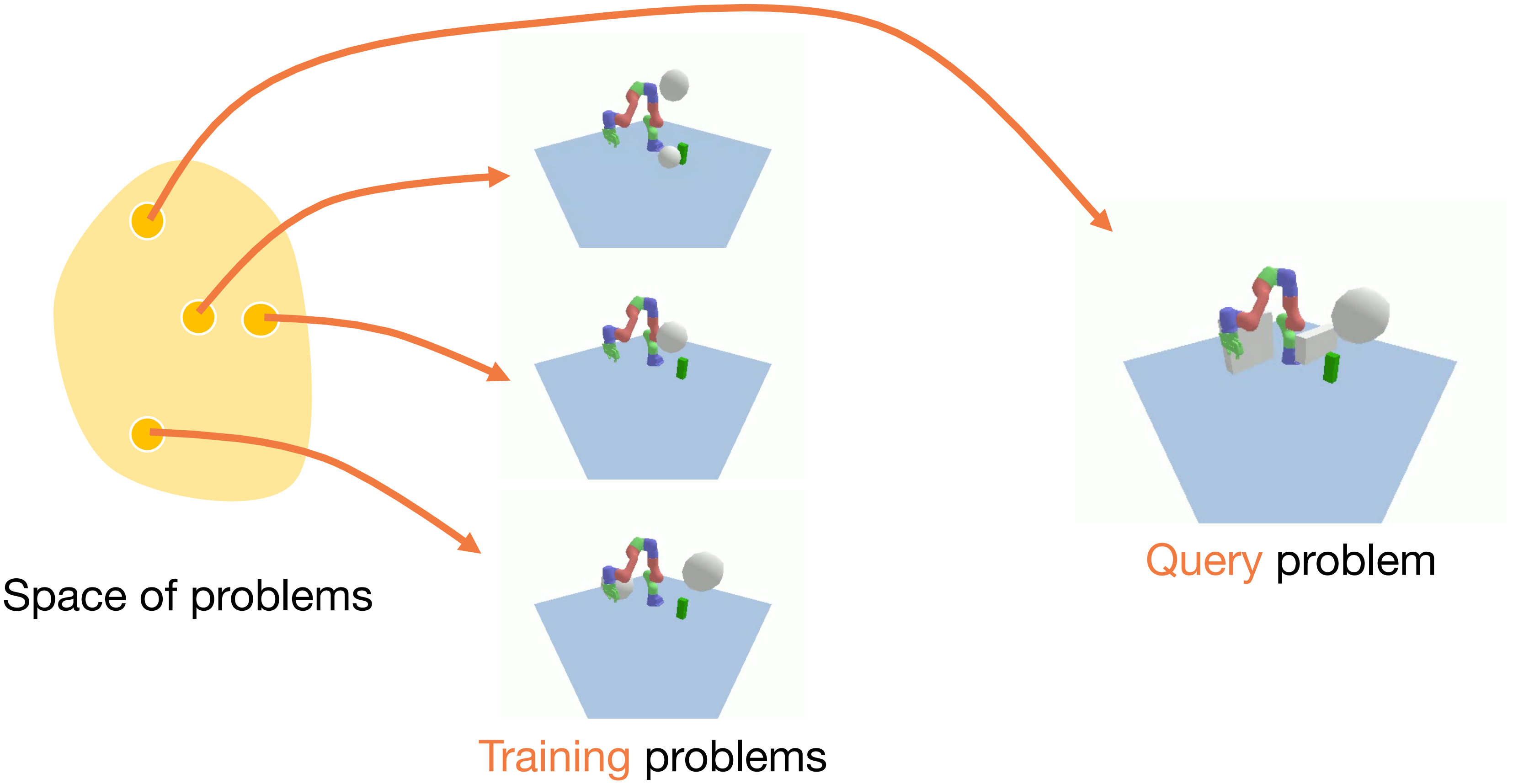
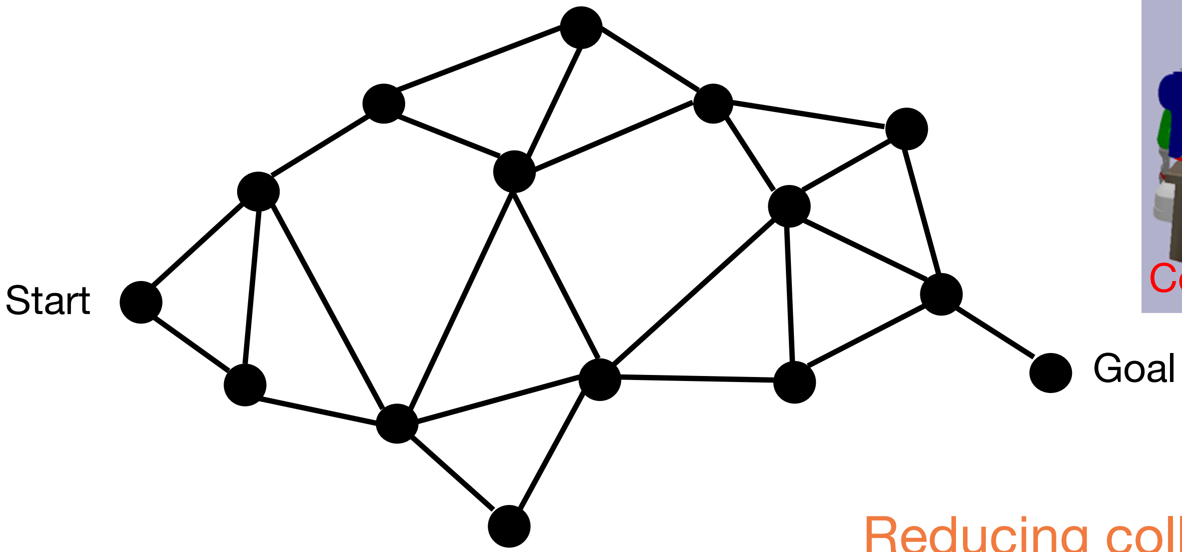
[1]The University of Texas at Austin [2]Sony AI

Learning for motion planning

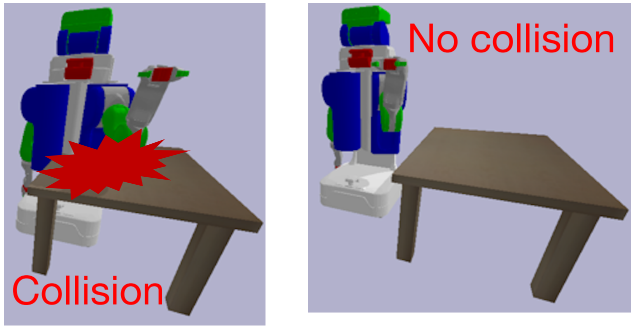


Probabilistic connectivity roadmap

Probabilistic roadmap



Collision-checking procedures

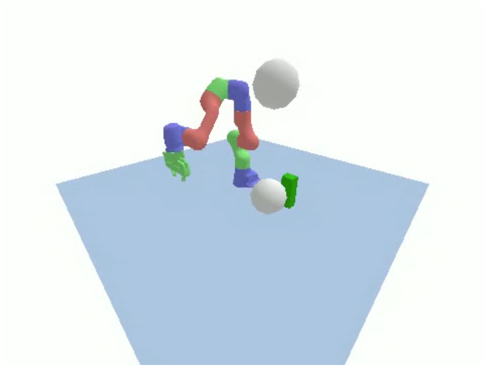


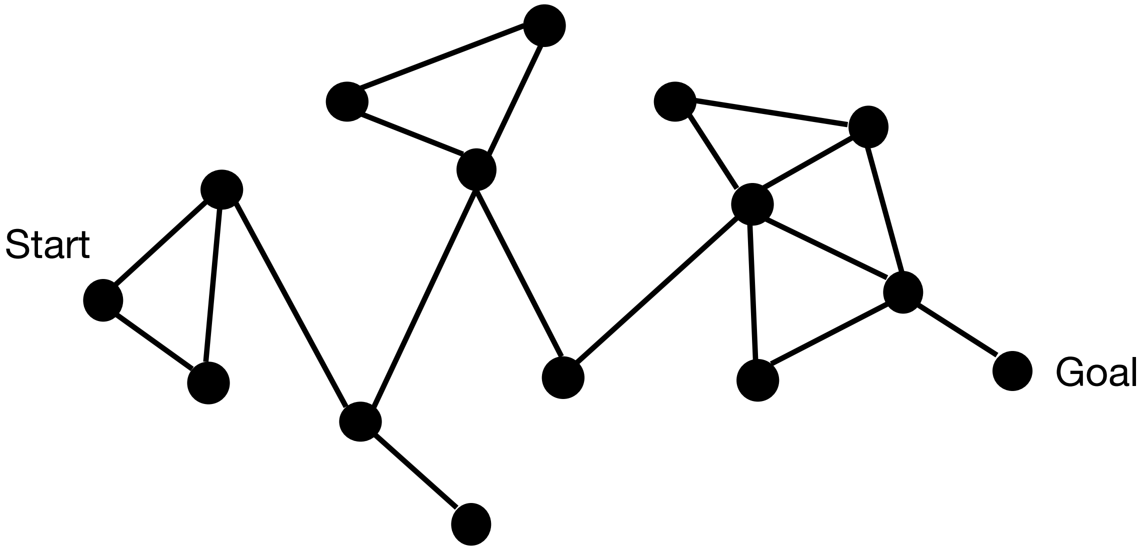
Reducing collision checks is crucial!

Probabilistic connectivity roadmap

Probabilistic roadmap

Training problem 1

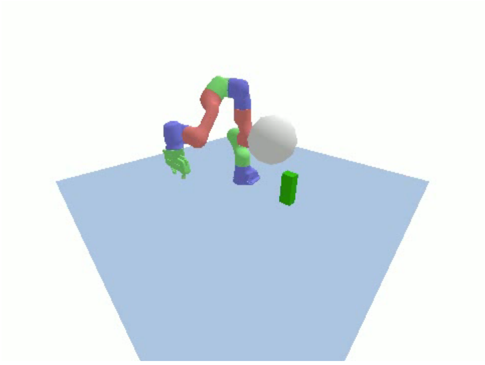


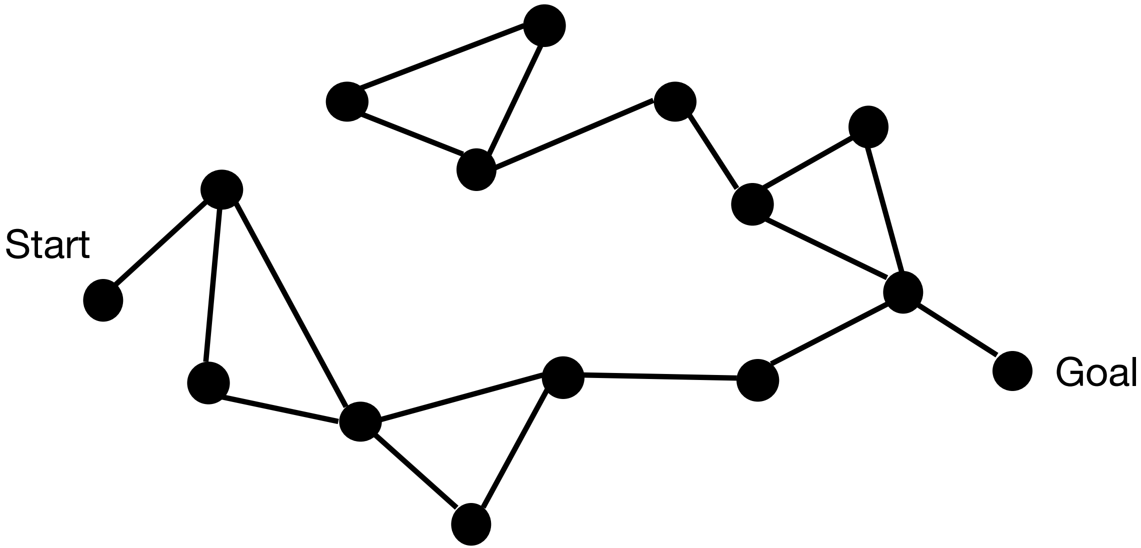


Probabilistic connectivity roadmap

Probabilistic roadmap

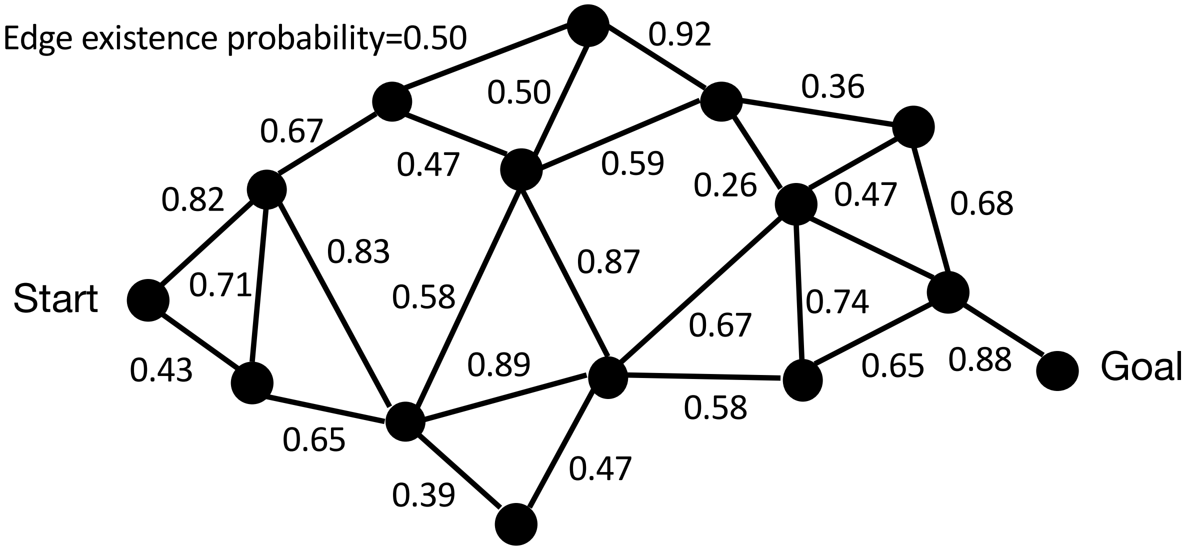
Training problem 2





Probabilistic connectivity roadmap

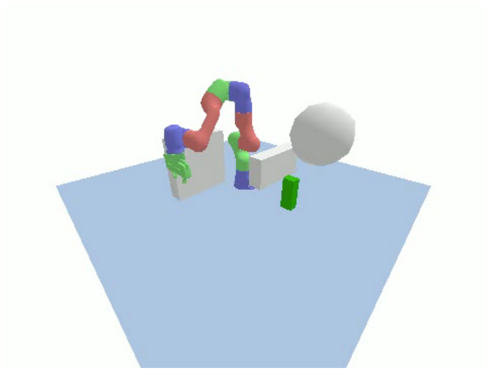
Probabilistic roadmap + edge existence probabilities

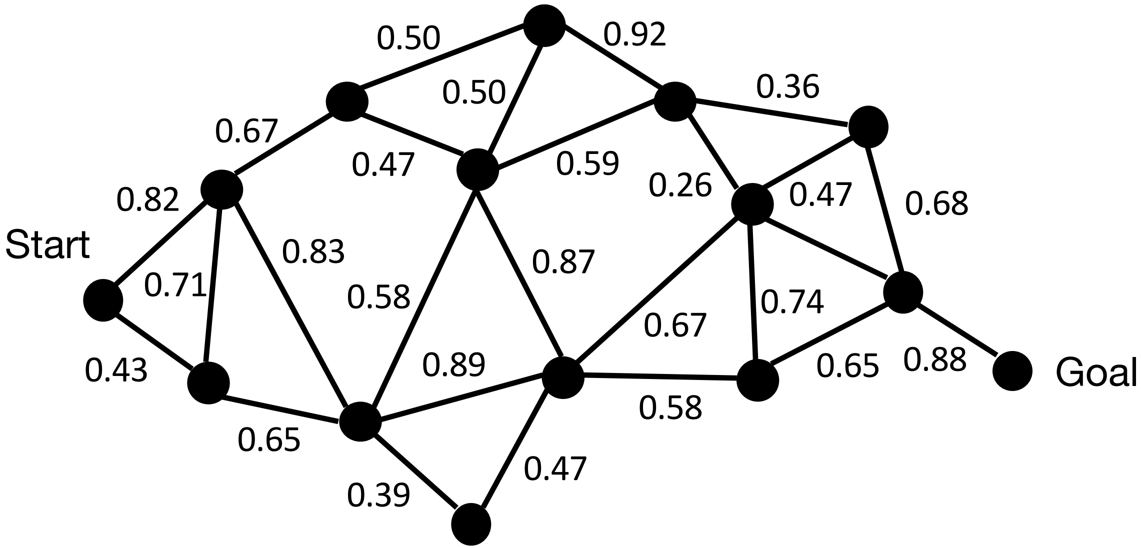


Probabilistic connectivity roadmap

Objective: find a path while minimizing edge collision checks

Query problem

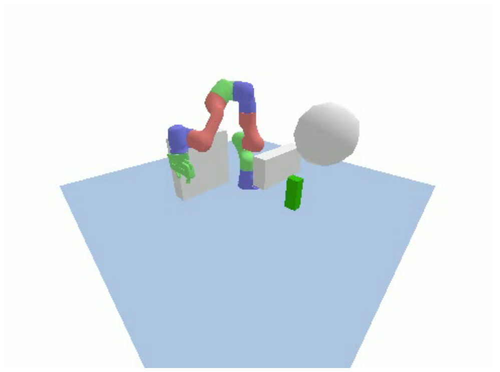


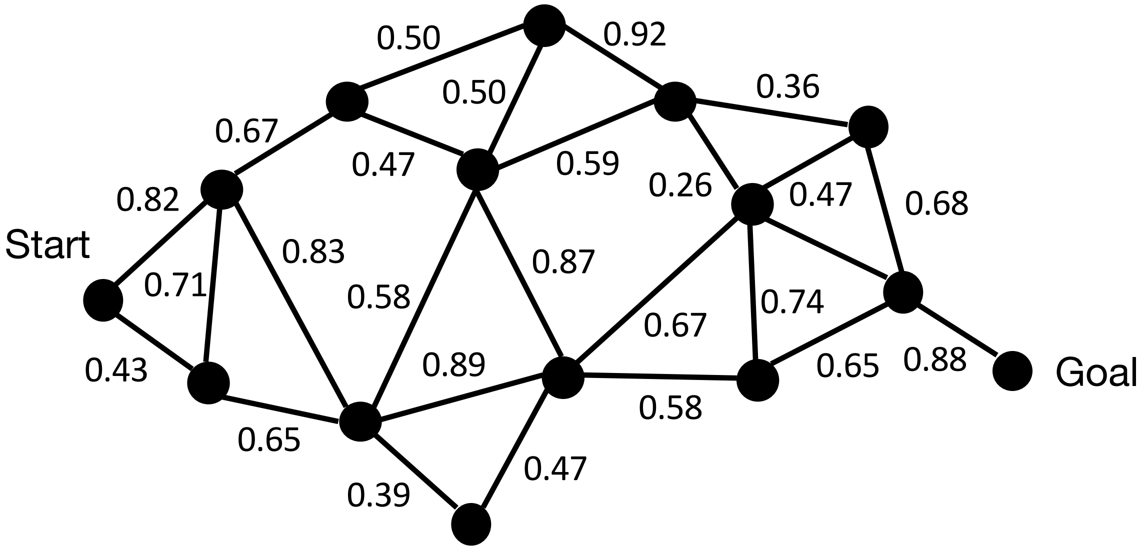


Probabilistic connectivity roadmap

Existing work [1,2,3]: objective is to find the shortest path in the roadmap

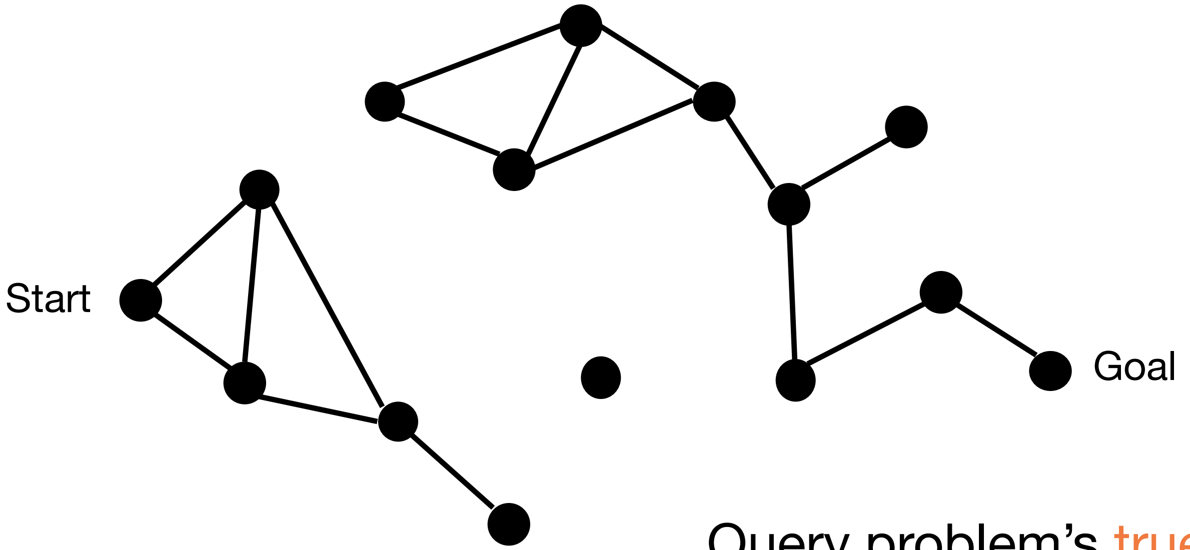
Query problem





Probabilistic connectivity roadmap

Research question: what if no path exists?

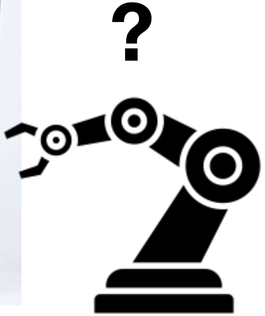


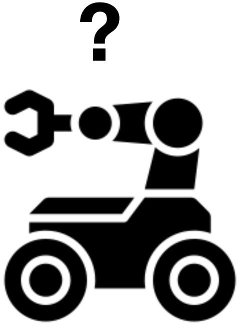
Query problem's true topology

Probabilistic connectivity roadmap

Research question: what if no path exists?

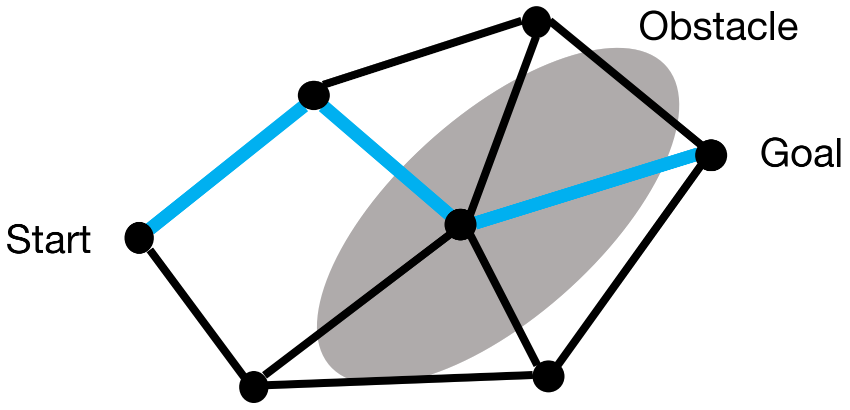
Target object



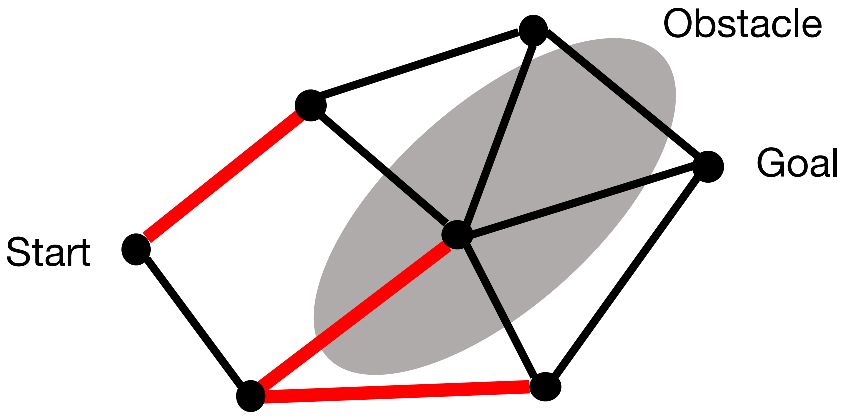


Our proposed approach

Main insight: leverage minimum cut from graph theory as searching solely for either path or cut can be inefficient → iterative search over path space and cut space



Pathfinding

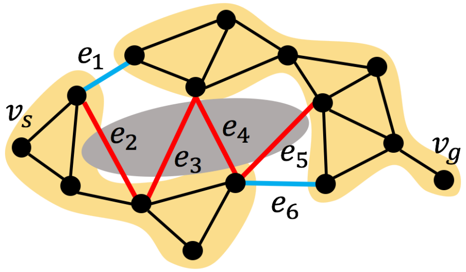


Cut finding

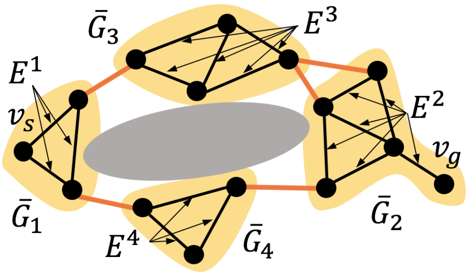
Iterative decomposition

Involved procedures

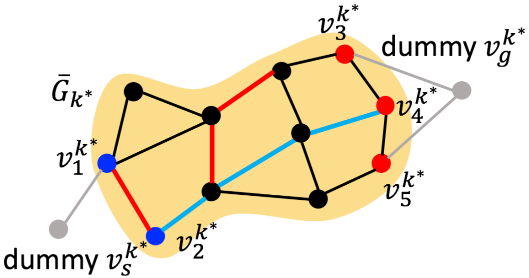
Graph decomposition by cut finding



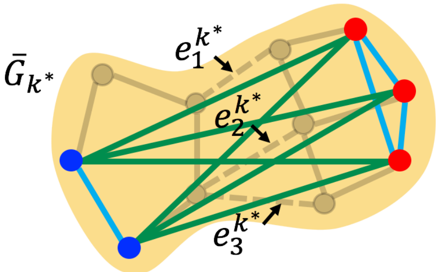
Subgraphs



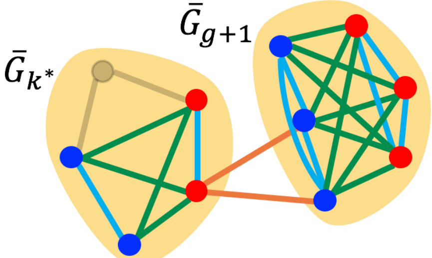
Clustering



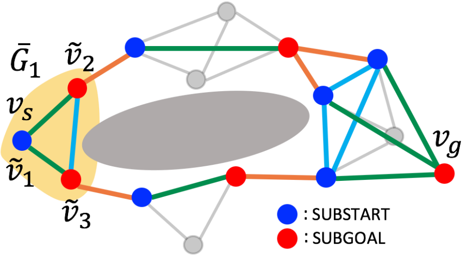
Subgraph partition 1



Subgraph partition 2

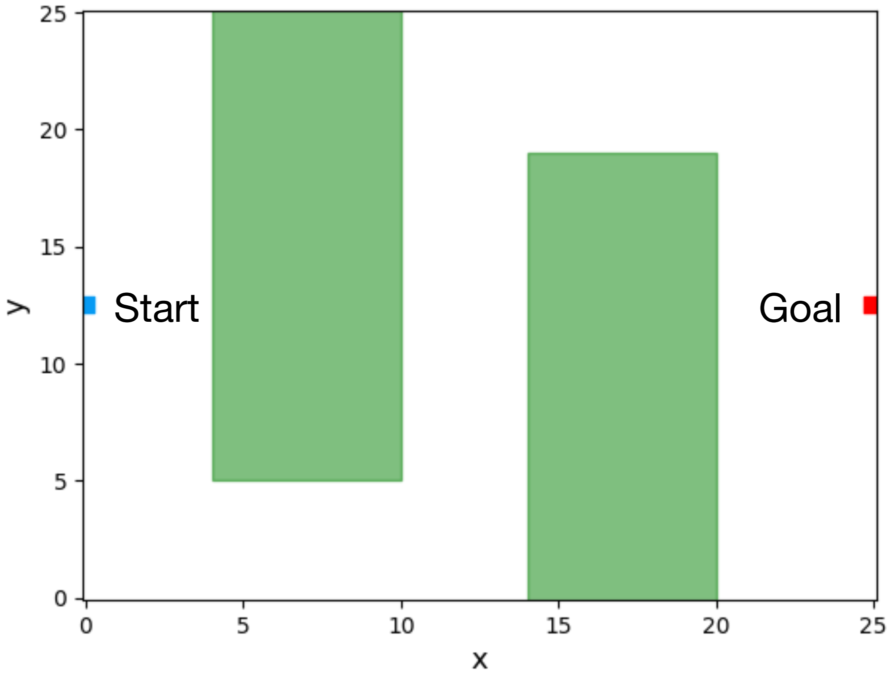


Abstract graph

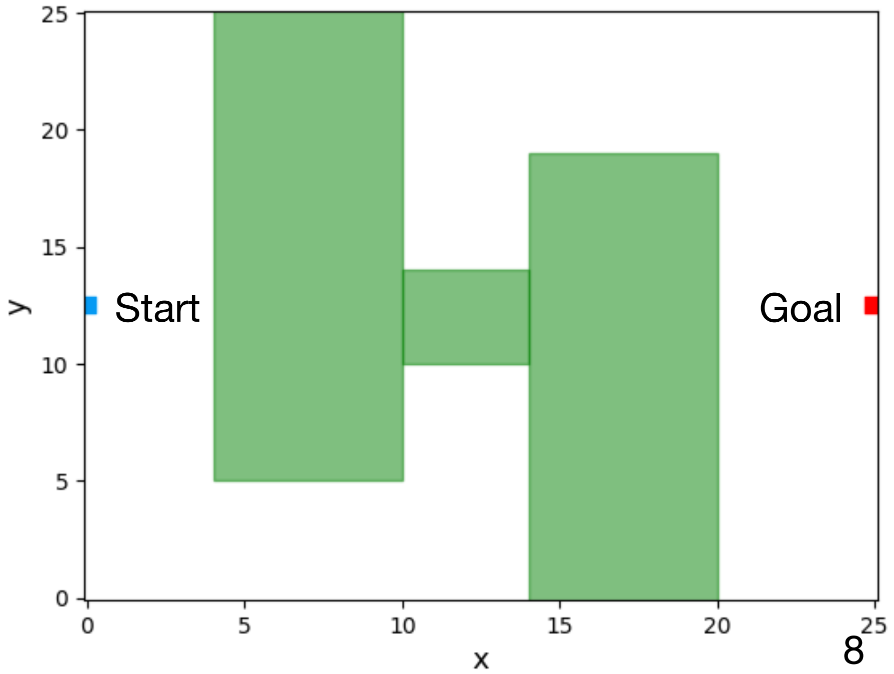


Visualization

Feasible problem

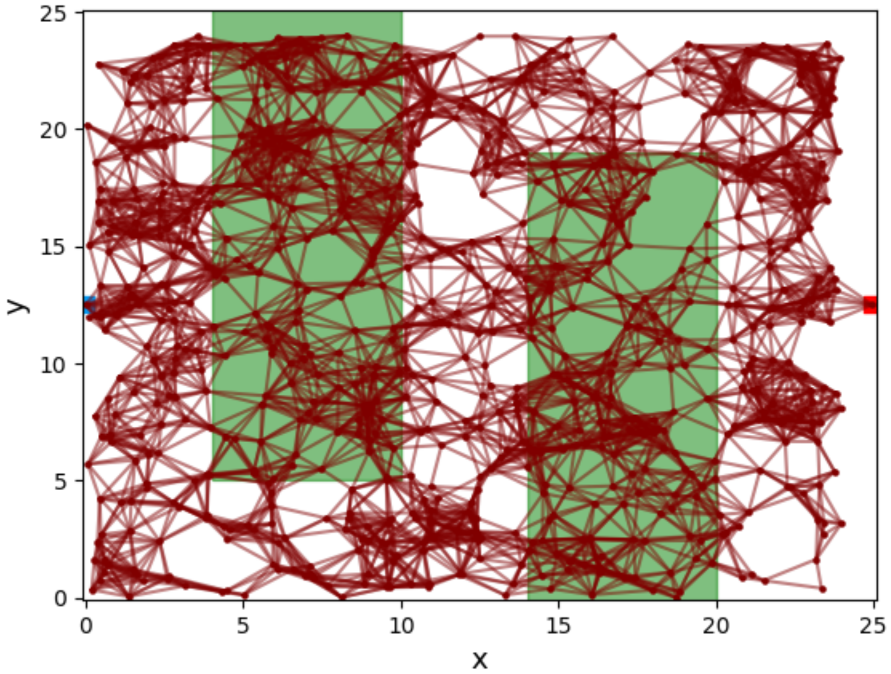


Infeasible problem

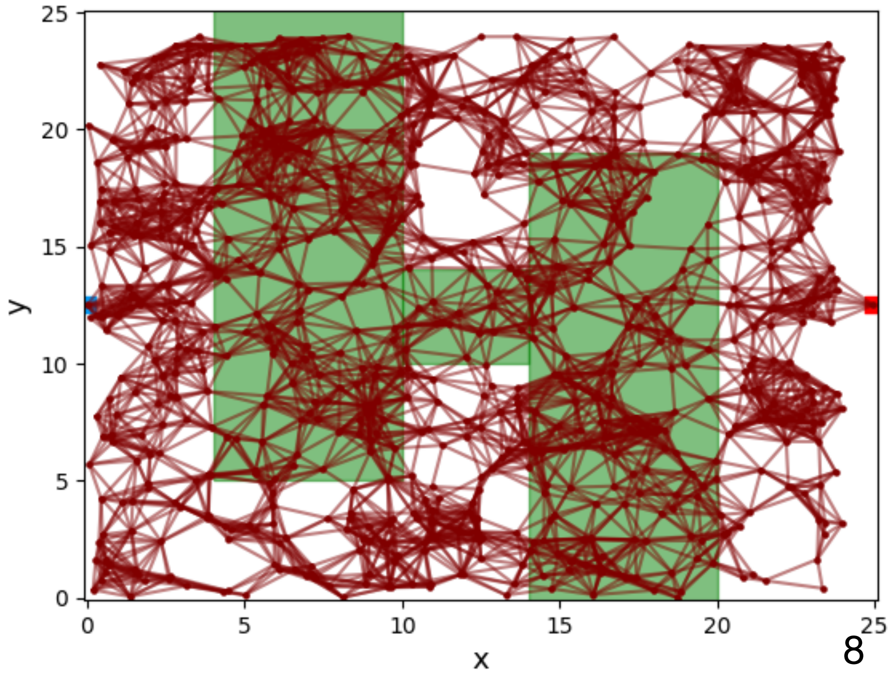


Visualization

Feasible problem

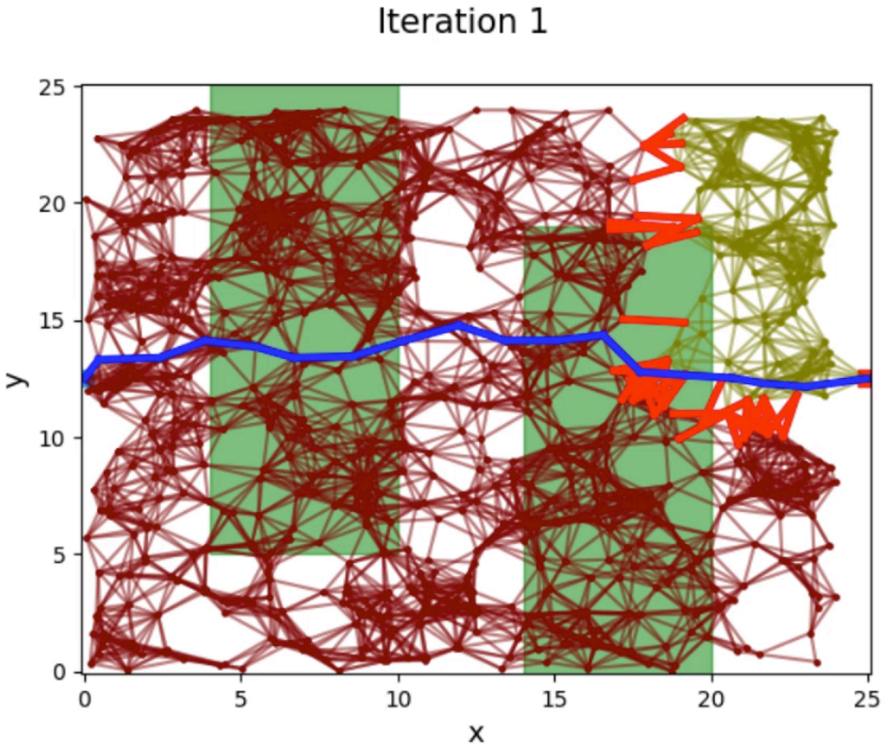


Infeasible problem

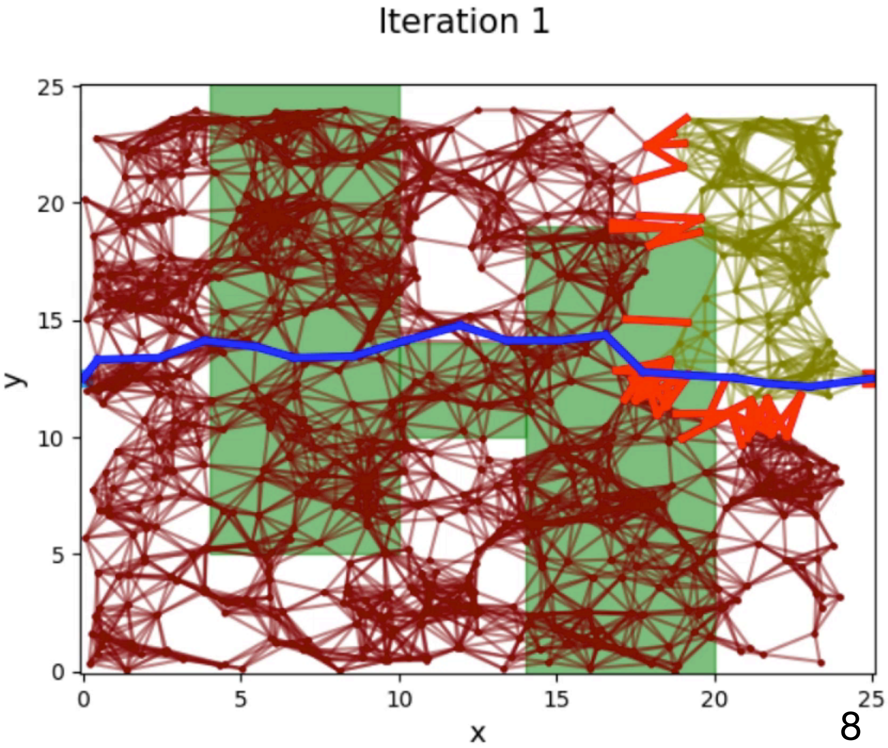


Visualization

Feasible problem

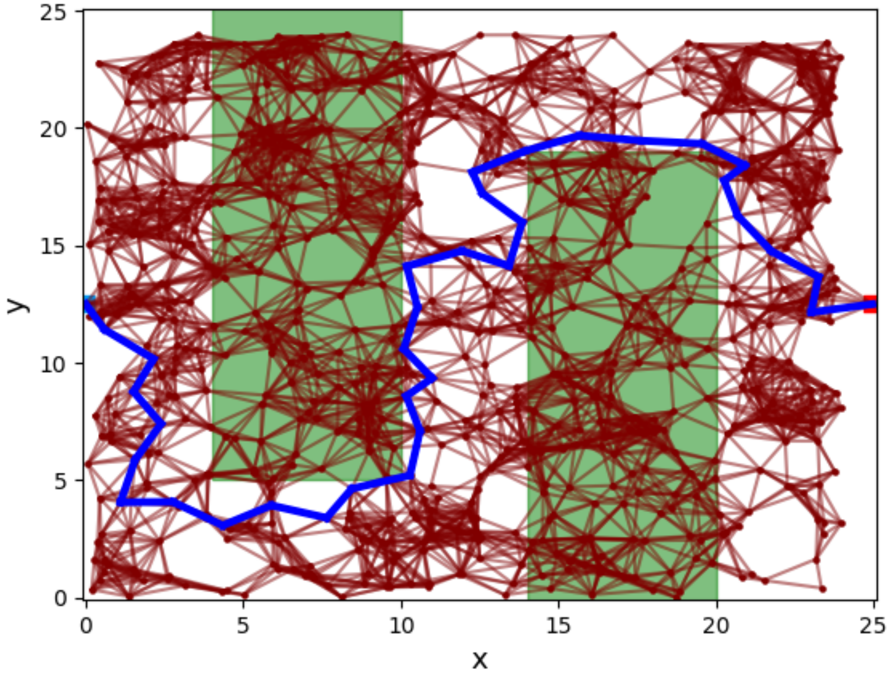


Infeasible problem

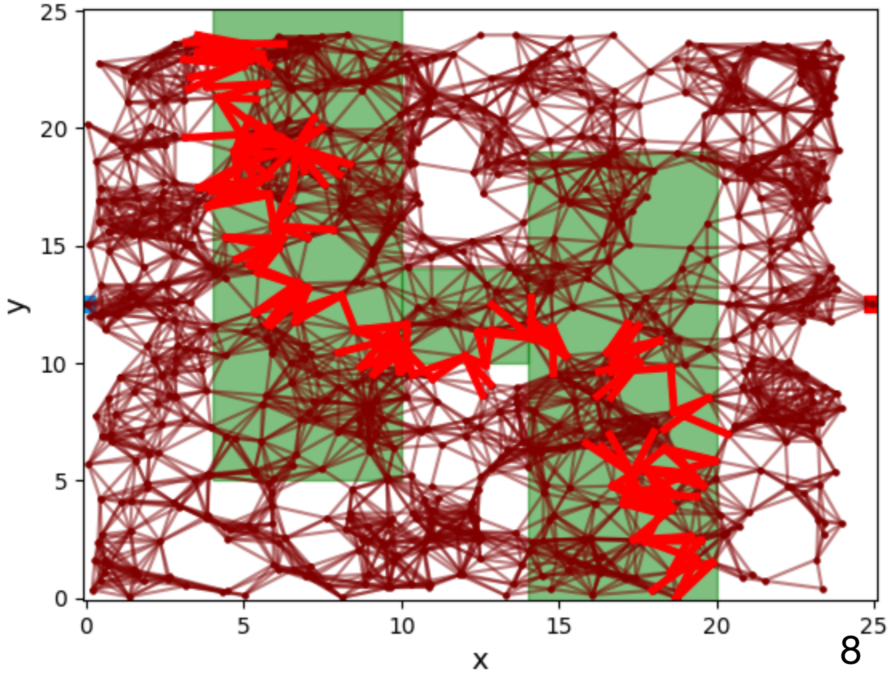


Visualization

Feasible problem



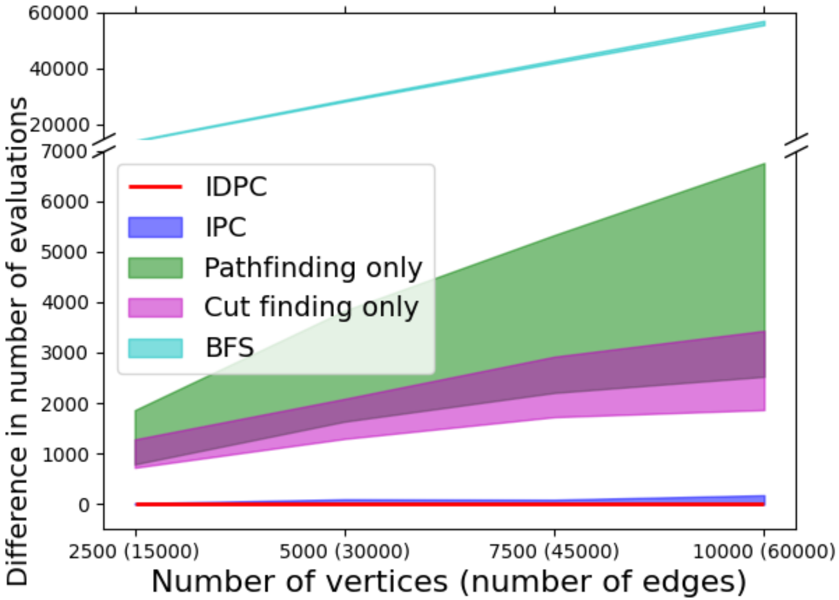
Infeasible problem



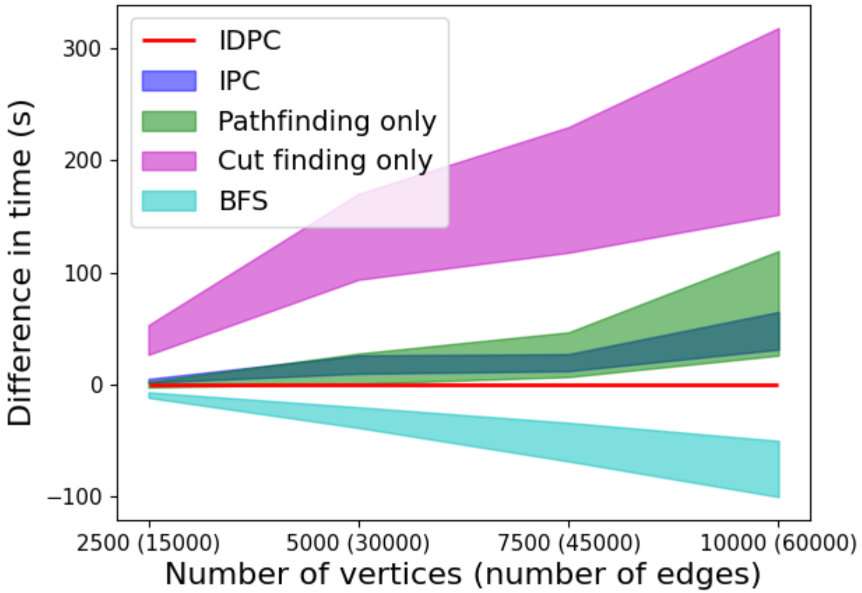
Simulation results

Performance metrics:

1. #edge collision checks

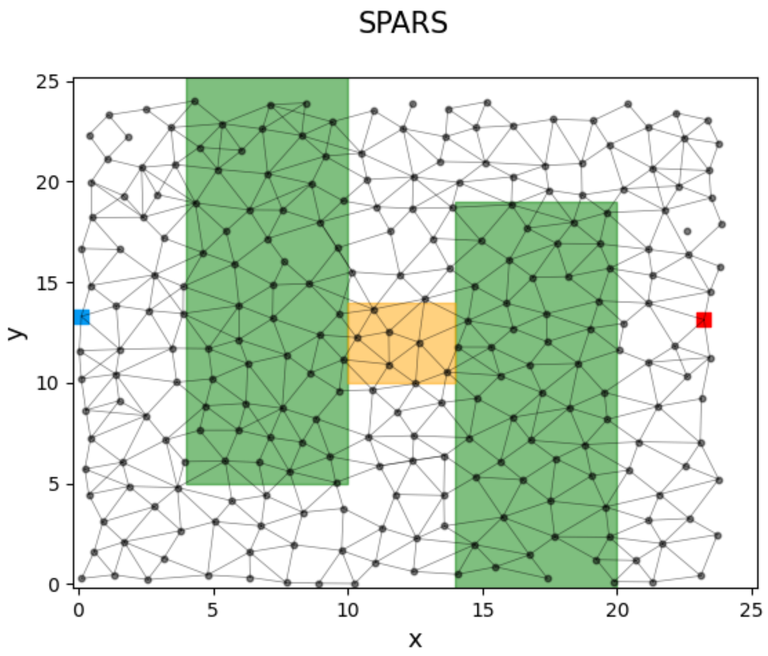


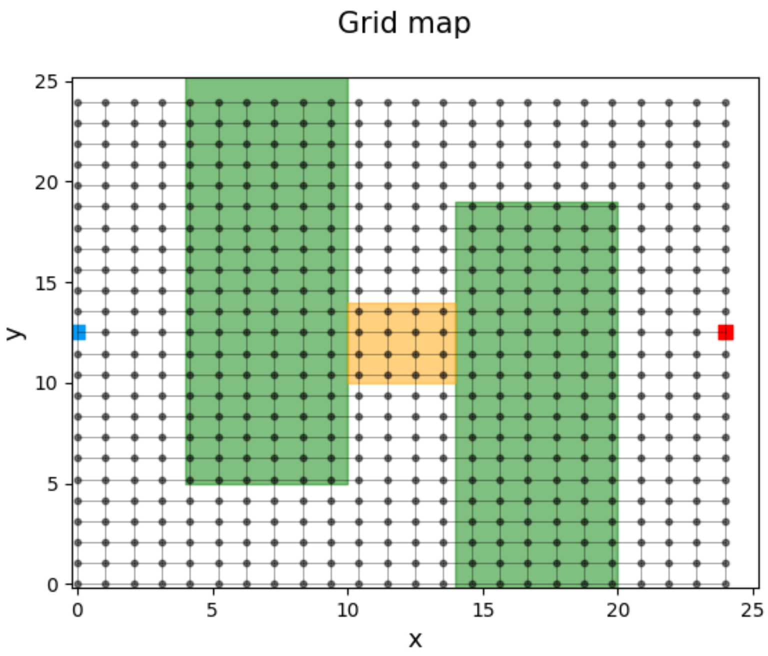
2. wall clock running time



More experimental results

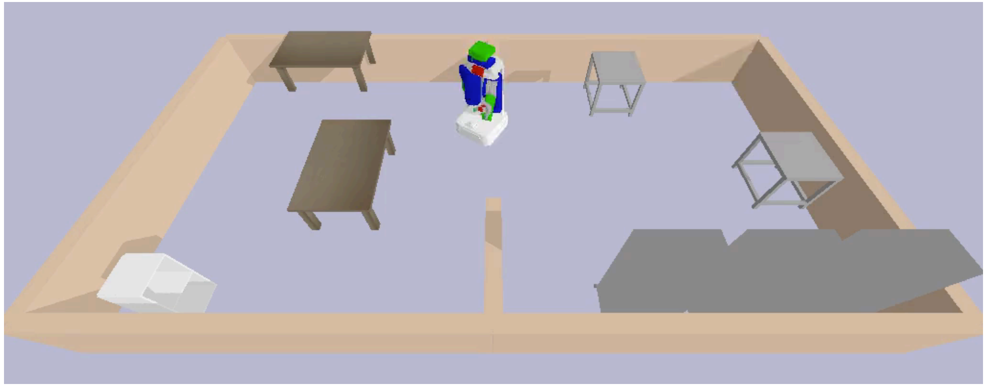
Effect of graph topologies



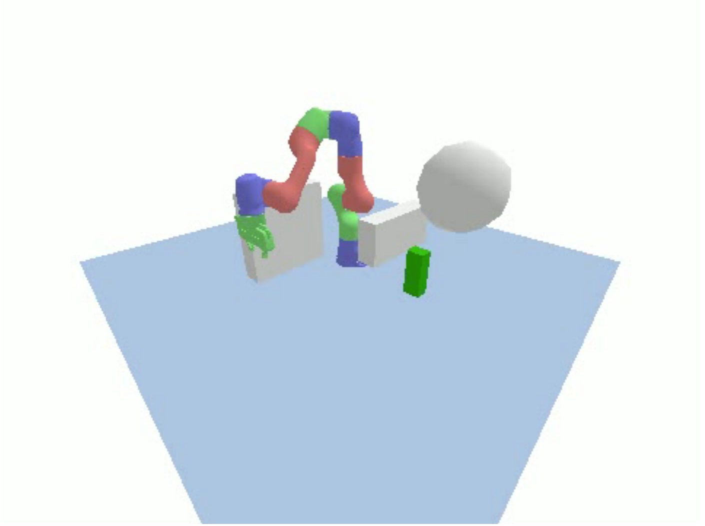


More experimental results

Effect of higher-dimensional problems



Navigation in 3D



Manipulation in 7D

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Learning Agents Research Group
The University of Texas at Austin

Sony AI

Takeaway messages:

1. Motion planning learning framework that utilizes probabilistic connectivity roadmap as prior knowledge
2. Efficient and complete algorithm that iteratively finds either feasibility or infeasibility in the roadmap