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

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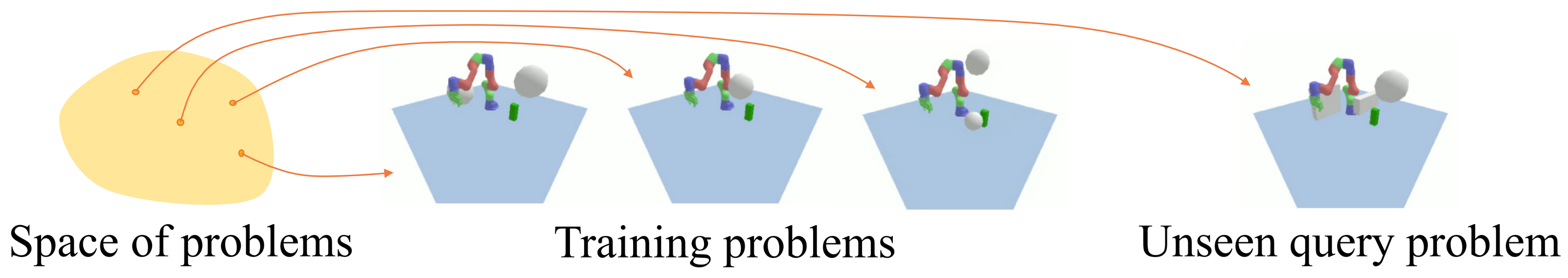
## Takeaways

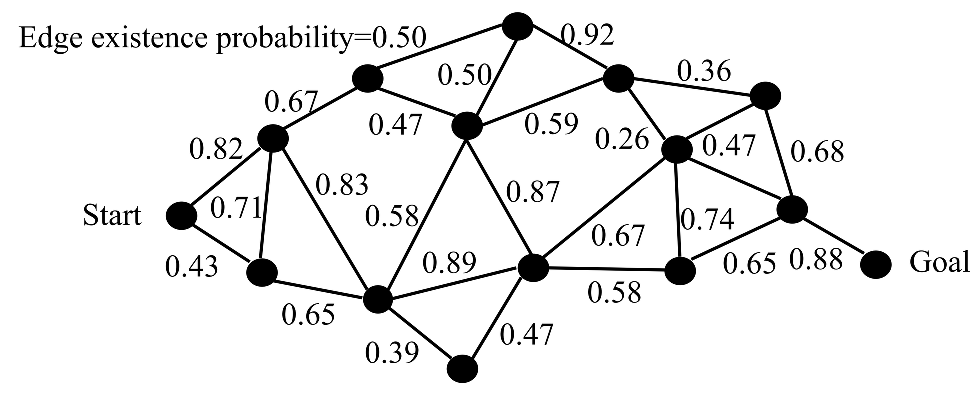
- Given training problems drawn from an unknown distribution, a **probabilistic connectivity roadmap** is learned.
- The proposed algorithm performs **iterative path and cut searches** in the roadmap to **determine (in)feasibility efficiently**.
- The algorithm is **provably complete** and its **efficiency** has been verified through extensive experiments.

## Problem Statement

### Considered learning framework




1. Learning a probabilistic connectivity roadmap from training problems.
2. Finding either a path or a cut in the roadmap.
3. Improving a path quality to optimal, or finding an infeasibility proof in the continuous C-space.



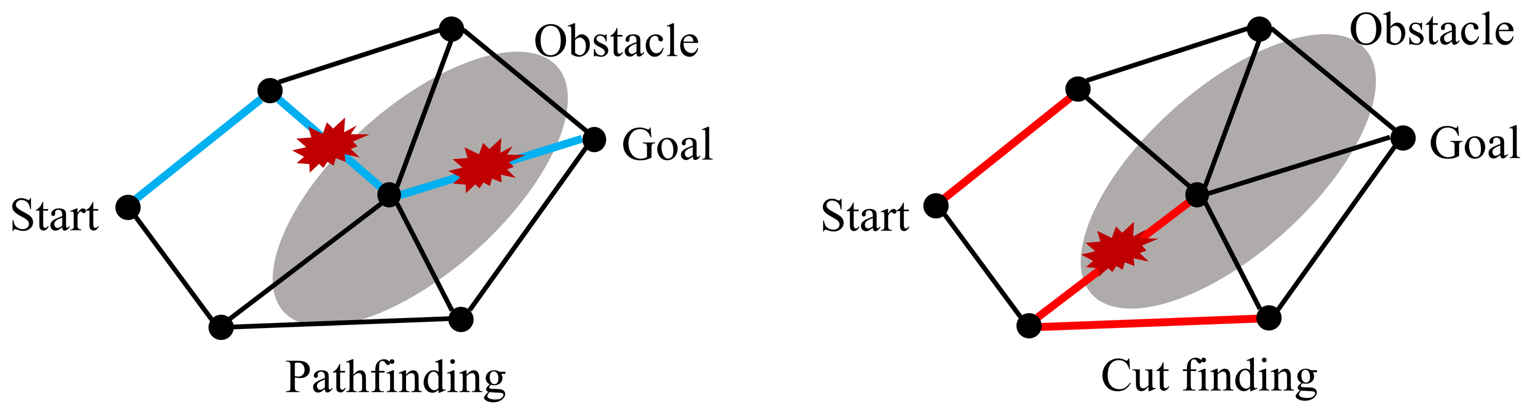
Probabilistic connectivity roadmap

- We often encounter motion planning problems that are infeasible.
- Existing approaches that leverage pathfinding only can be inefficient for solving infeasible problems.
- Evaluating edge collision checking is expensive.

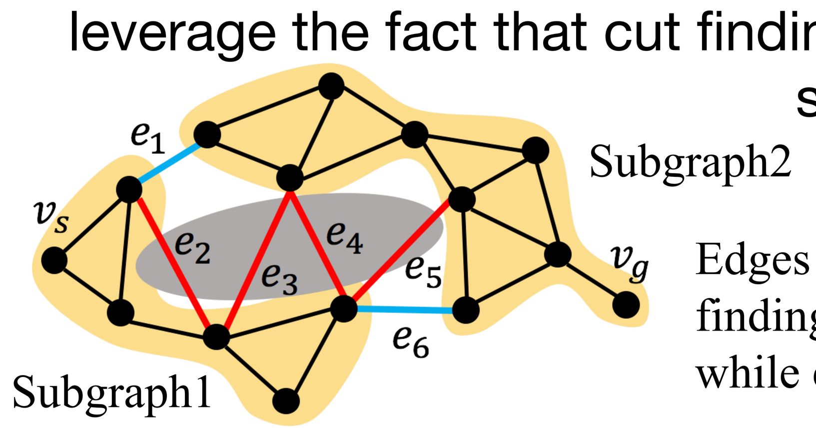
**Objective**: Given a probabilistic connectivity roadmap, find either a path or a cut in the roadmp while minimizing edge evaluations.

## Algorithmic Insights

- Search over both path and cut spaces.
- Leveraging state-of-the-art off-the-shelf cut finding and pathfinding algorithms.
- One search guides another, effectively reducing the search spaces.

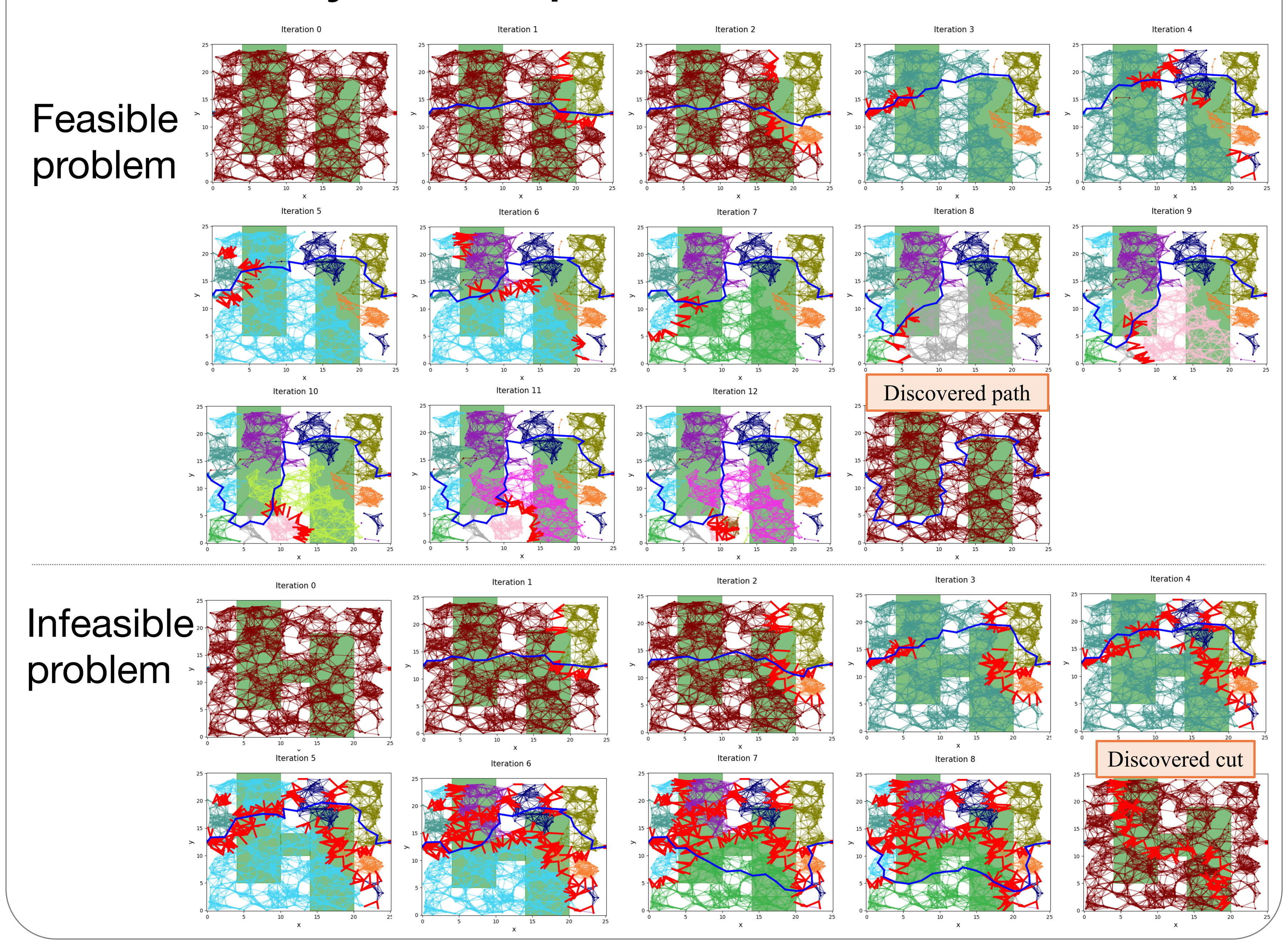



- Cut finding is generally more expensive than pathfinding; we leverage the fact that cut finding separates the roadmap into two separate subgraphs at each iteration.



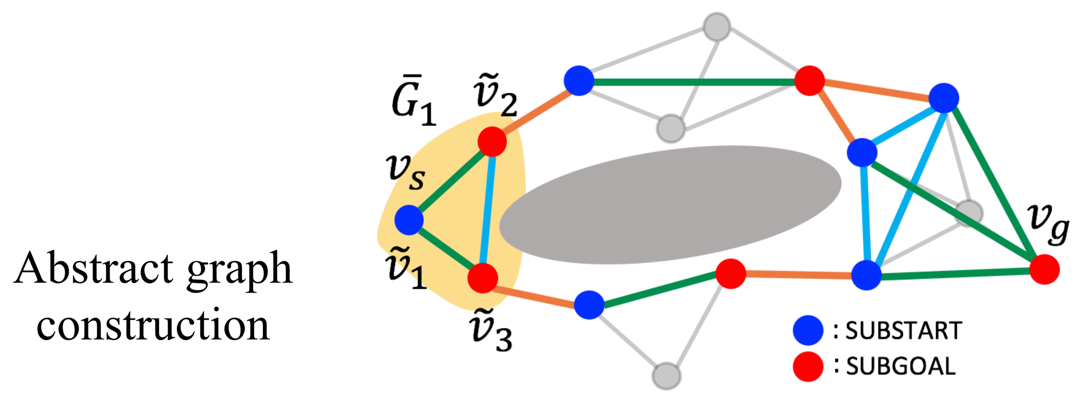

Edges $e_1, \ldots, e_6$ form a candidate cut found by cut finding. $e_1$ and $e_6$ are confirmed to be collision-free while $e_2, \ldots, e_5$ are confirmed to be in collision.

## Toy Example Visualization




## The Proposed Algorithm (IDPC)

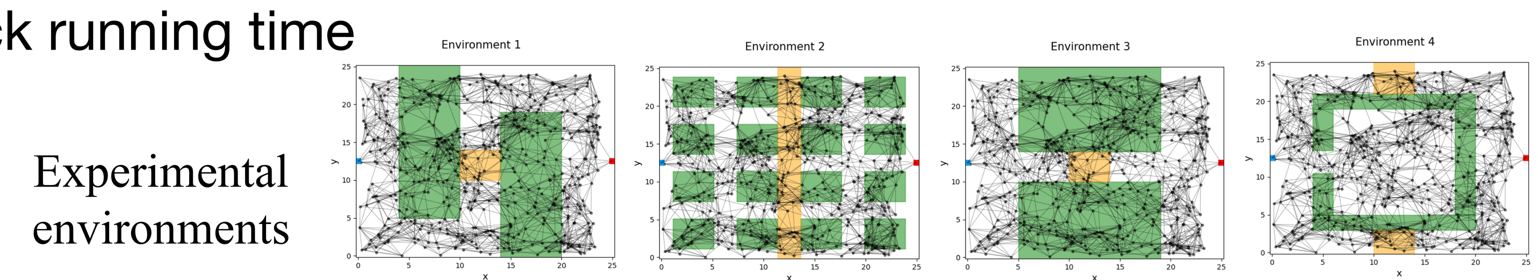
- Divide-and-conquer paradigm.
- While a path is globally searched, a cut is locally searched within the decomposed subgraphs. This induces several procedures, such as clustering, partitioning, and abstract graph construction.
- An abstract graph is necessary to determine a global cut from the local cuts collect from subgraphs.

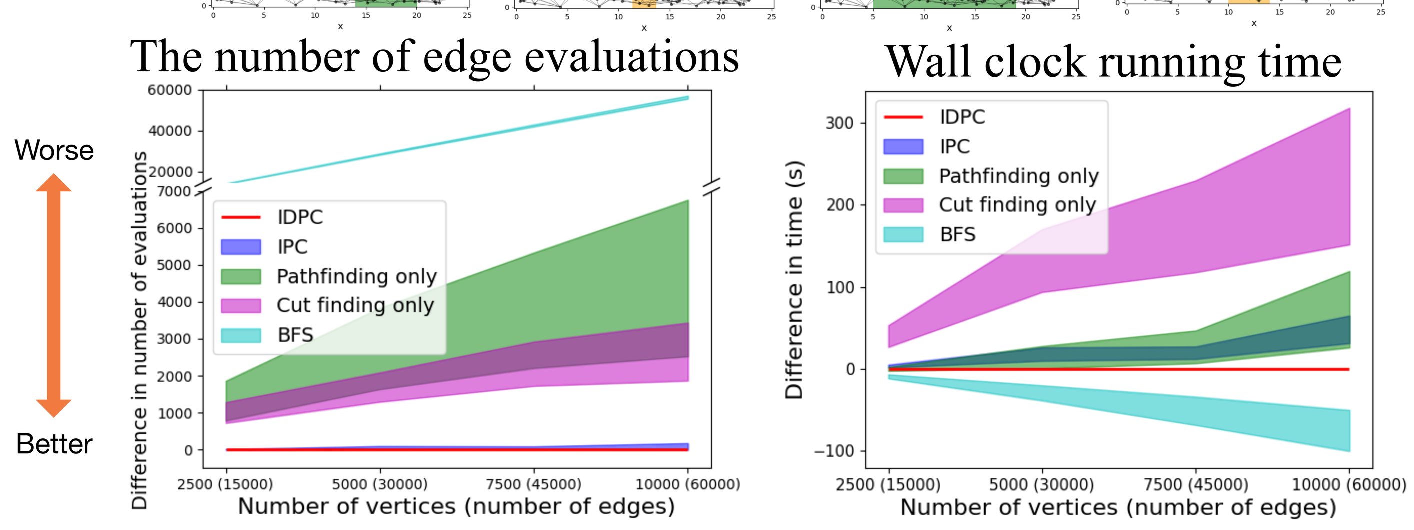



- Provable compelte: the algorithm ensures correct identification of either a path or a cut in the roadmap.

## Experiments

- Comparison with baselines (pathfinding only, cut finding only, BFS)
- Performance metrics: (1) the number of edge evaluations, (2) wall clock running time




- About 40 seconds runtime difference compared to the best-performing baseline in the largest roadmap setting.
- More evaluations:
  (1) Effect of calibration levels: performs well even with uninformative priors.
  (2) Effect of roadmap topologies
  (3) Effect of higher-dimensional problems.