Efficient Path Planning Algorithms for Multilayered Traversability Maps

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Introduction

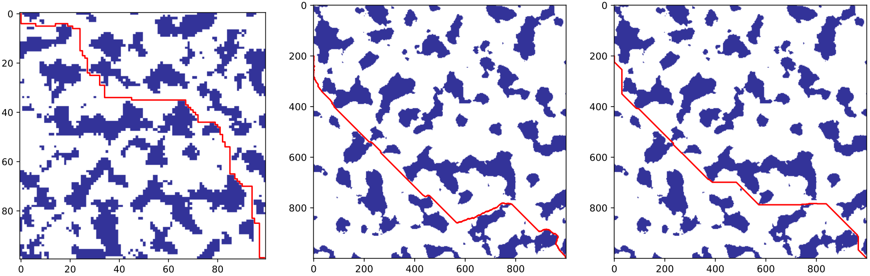
- Motivation: Efficient navigation in multilayered environments.
- Problem: Pathfinding with realistic map representations.
- Objective: Develop algorithms for multilayered traversability maps.

Previous Work and Current Status

- Implemented A* for single-layer maps last semester.
- This semester: Explored A*, Theta*, Anytime Weighted A*, and visibility graphs.
- Focus: Trade-offs in performance and accuracy.

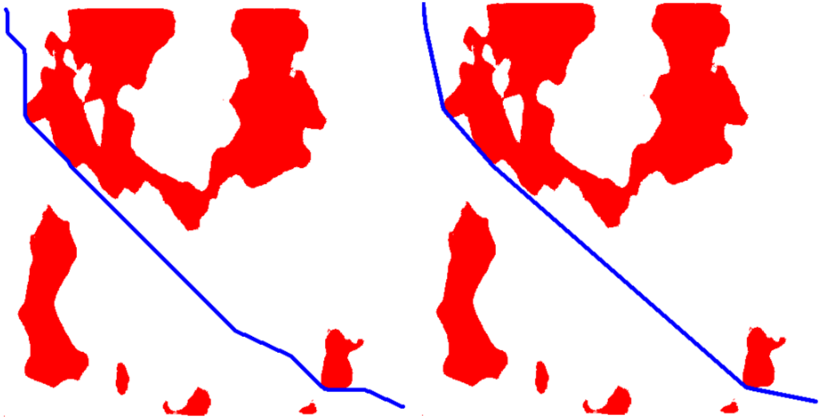
Rasterized Map Representation and A*

- Maps as weighted grids: Traversable and inaccessible areas.
- Heuristic: Guides the search towards the goal.
- Flexibility: Weighted blocked cells to explore paths when necessary.



Theta* Algorithm

- Improves upon A*: Allows straight-line paths.
- Advantage: Reduces path length and computation time.

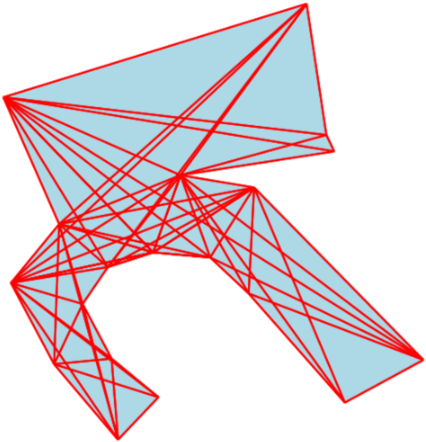


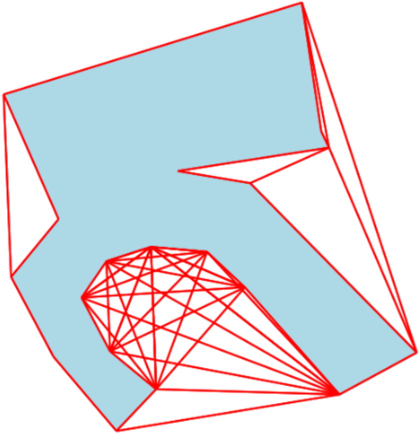
Anytime Weighted A*

- Admissible heuristic
- Balances speed and accuracy: $f(n) = g(n) + \varepsilon h(n)$.
- Advantage: Suboptimal paths early, refined over time.

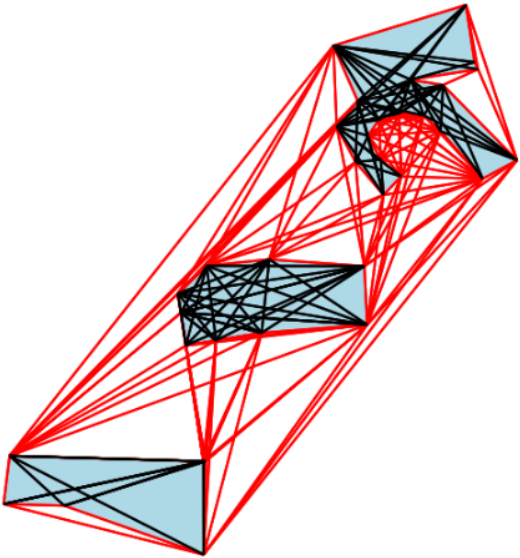
Geometric Approach: Visibility Graphs

- Nodes as polygon vertices; edges as unobstructed lines of sight.
- Challenge: Computational complexity ($O(n^2)$).
- Optimization: Pruning redundant points (ex. convex hull).



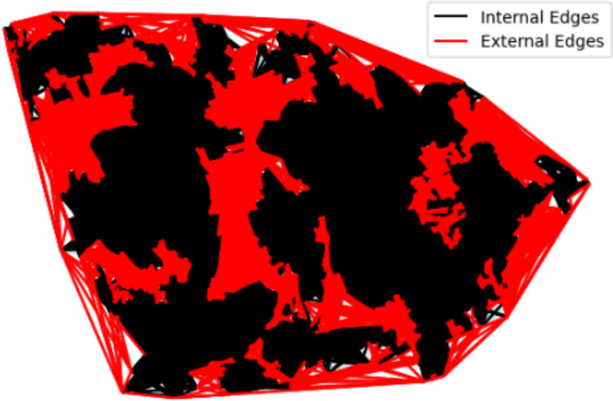


Geometric Approach: Visibility Graphs



Geometric Approach: Visibility Graphs

- Not necessarily gives best path.
- Lots of points (100 000 polygons, $100 - 1000$ vertices each.



Continuous Dijkstra

- Propagates a wavefront through the map.
- Advantage: Enumerates multiple topologically distinct paths.
- Challenge: Handling multilayered maps.

Multilayer Challenges

- How to work with them at all.
- Weight aggregation across layers: Sum, maximum, or convex combinations.
- Open problem: Effective weight functions for aggregated layers.
- Future direction: Machine learning to optimize aggregation.

Performance Comparison

- Rasterized Maps: A* and Theta* are efficient.
- Visibility Graphs: Very high computational cost.
- Hybrid Scenarios: Anytime algorithms look promising.

Conclusion and Future Work

- Summary: Explored diverse algorithms and their trade-offs.
- Future: Hybrid algorithms and ML-based heuristics.

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