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SARRT: A Structure-Aware RRT-Based Approach for 2D Path Planning

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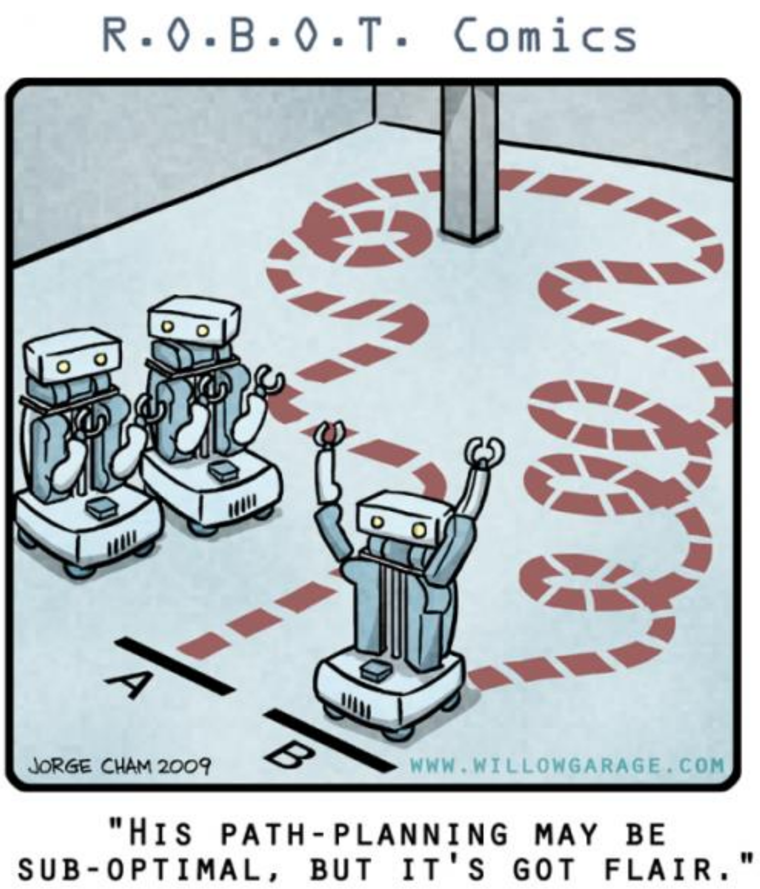
Outline

- Background
- Method
- Results
- Conclusion

Background

- One of the defining characteristics of robots
  - Mobility
- Need to move wisely
  - Motion/path planning
- Methods
  - Optimization-based
  - Sampling-based
    - Rapidly-exploring Random Tree (RRT)



Background

- RRT-based path planning
  - Pros
    - Exploring the space rapidly
    - Efficient for high dimensional problems
    - Easy to include complex constraints
  - Cons
    - Unstable performance
    - Solutions far from optimal
      - Path cost not taken into account

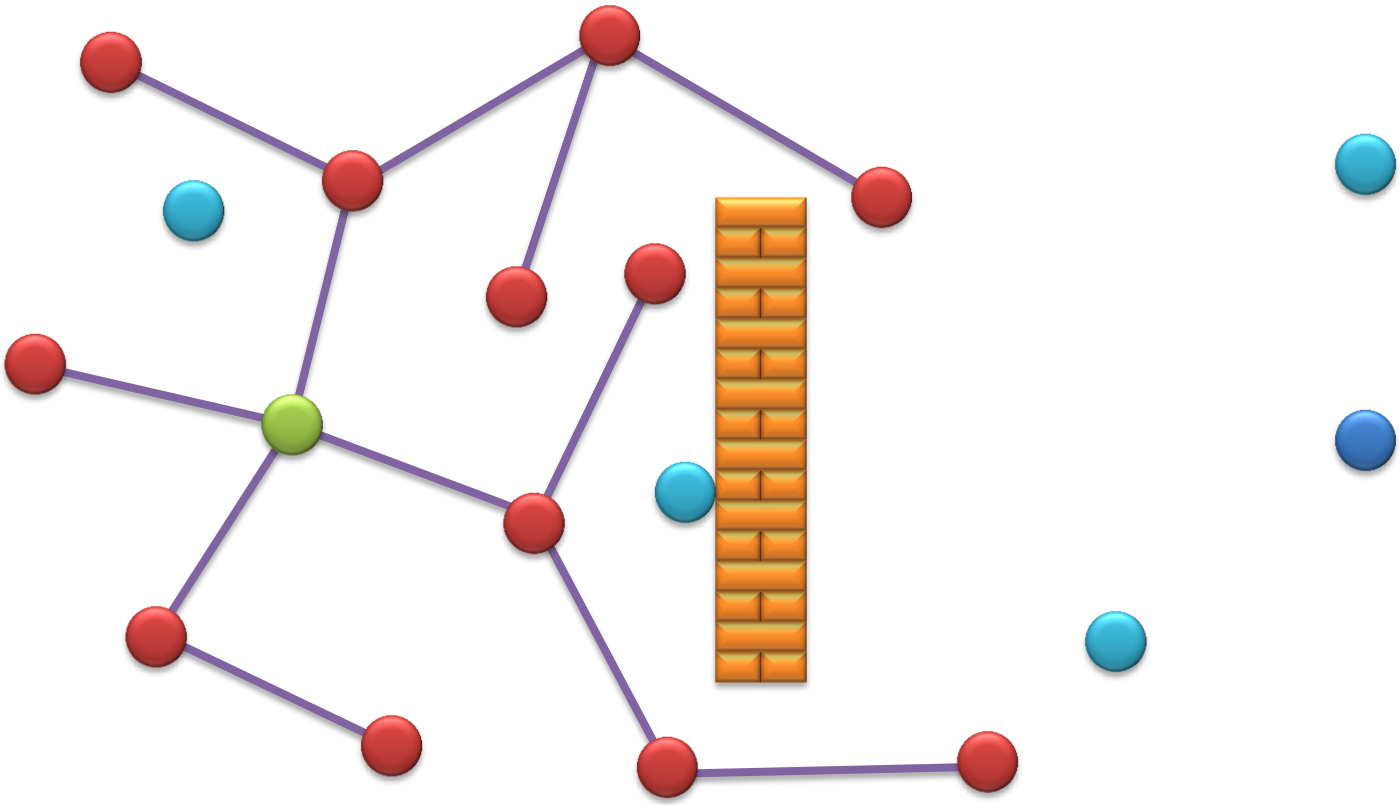
Background

- Contributions
  - A generic planning framework to bias the RRT growth according to given costmap
  - A costmap able to reflect the structure of the free space of the map
  - Laplacian smoothing as a postprocessing step to locally optimize the global path

Structure-Aware RRT-based path planning (SARRT)

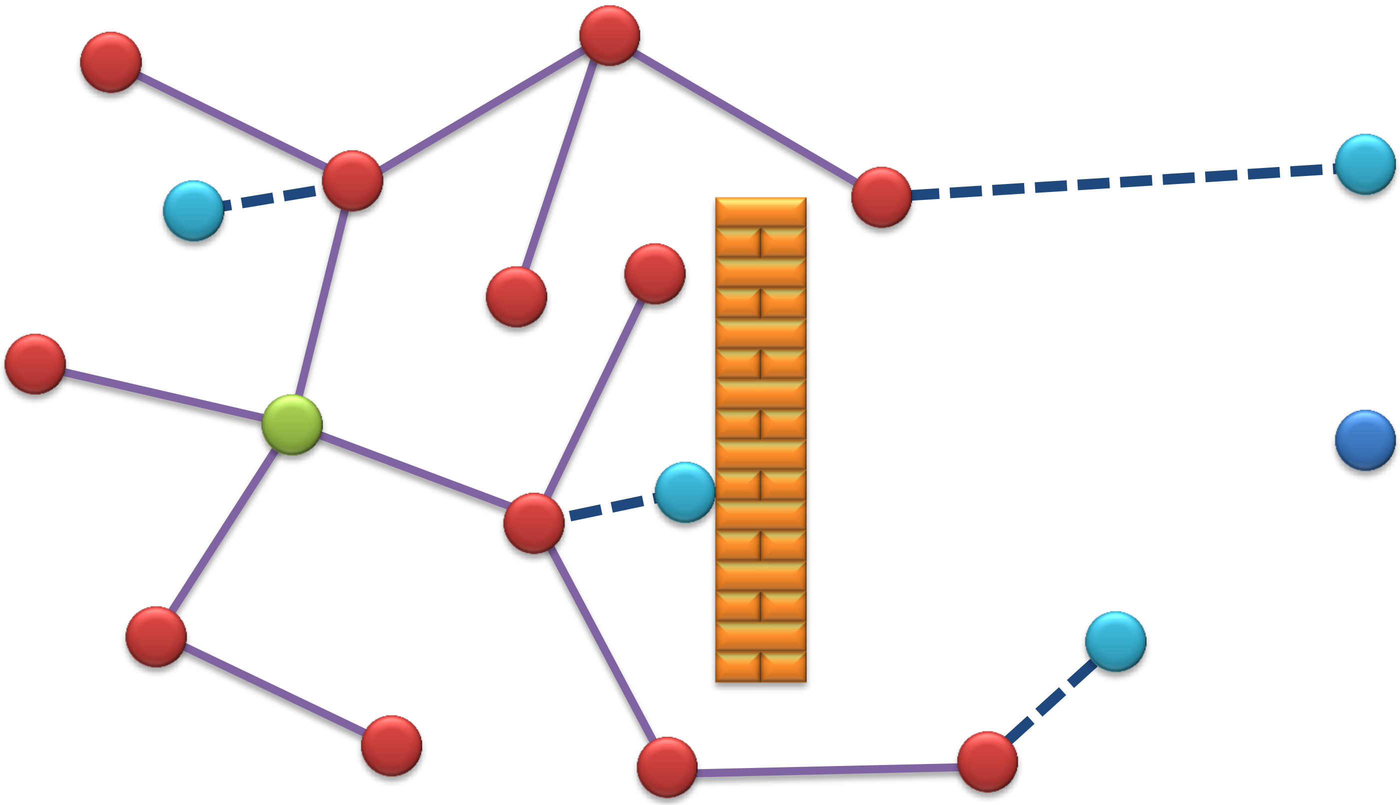
Method

- Generic framework



Method

- Generic framework



Method

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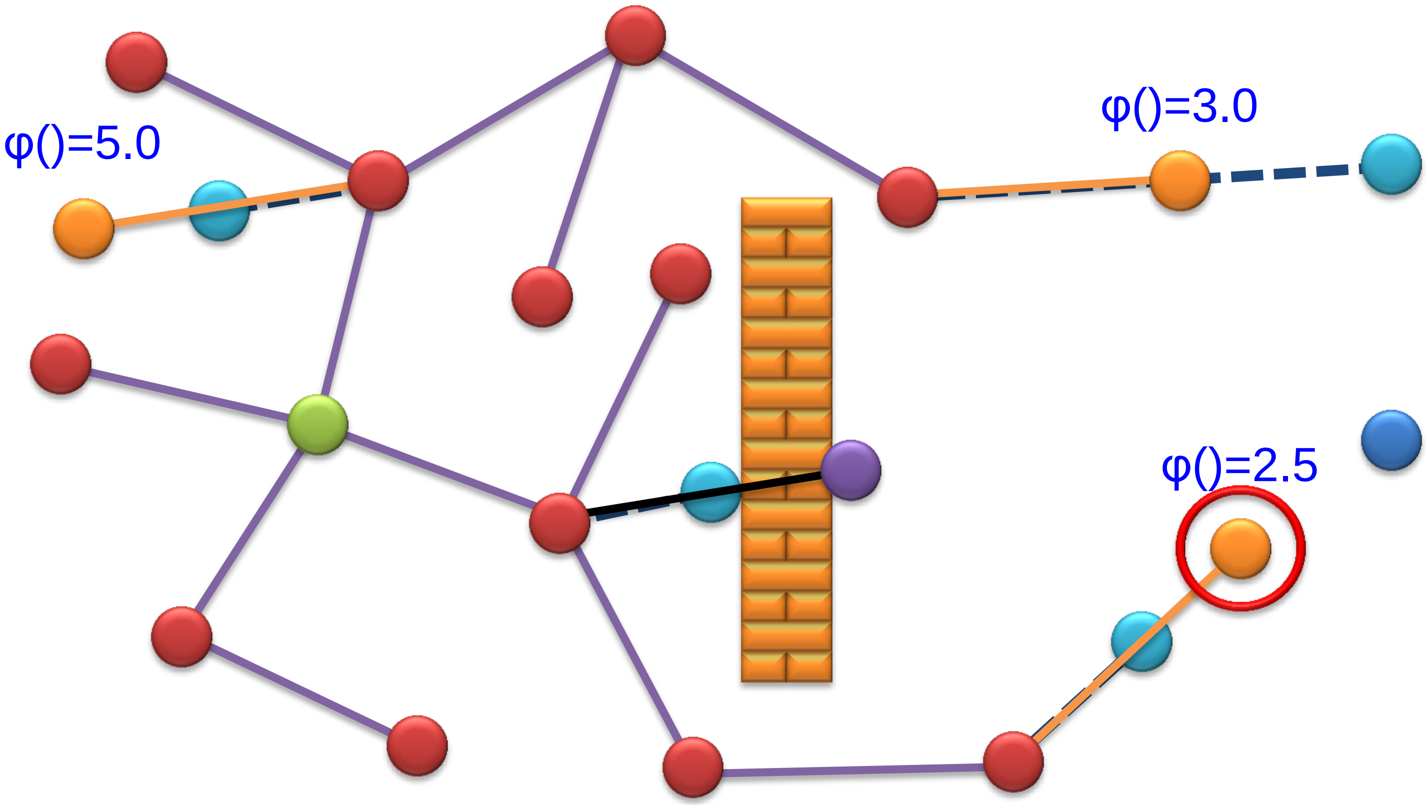
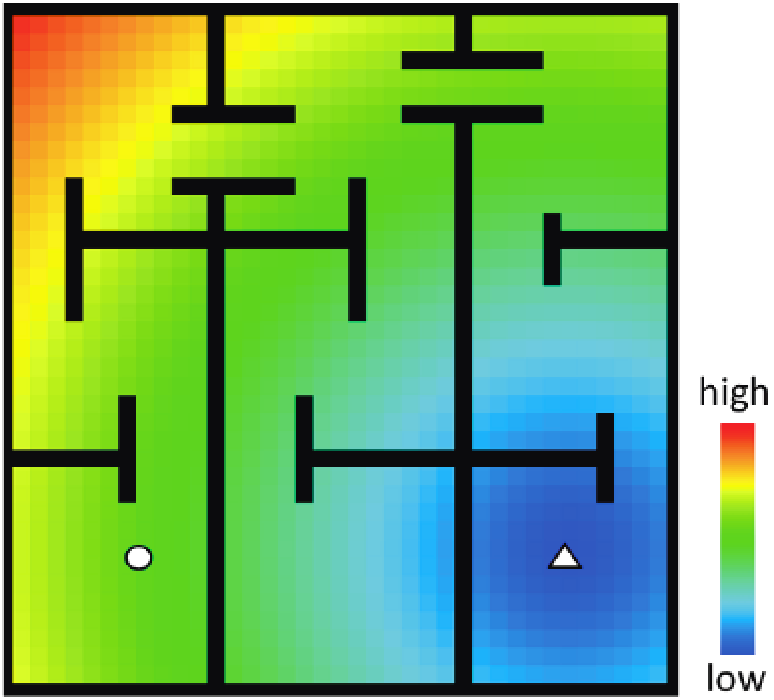
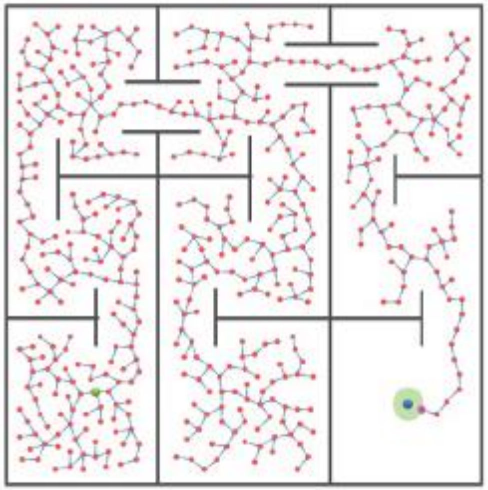


Method

- Structure-aware costmap
  - Euclidean distance as the cost

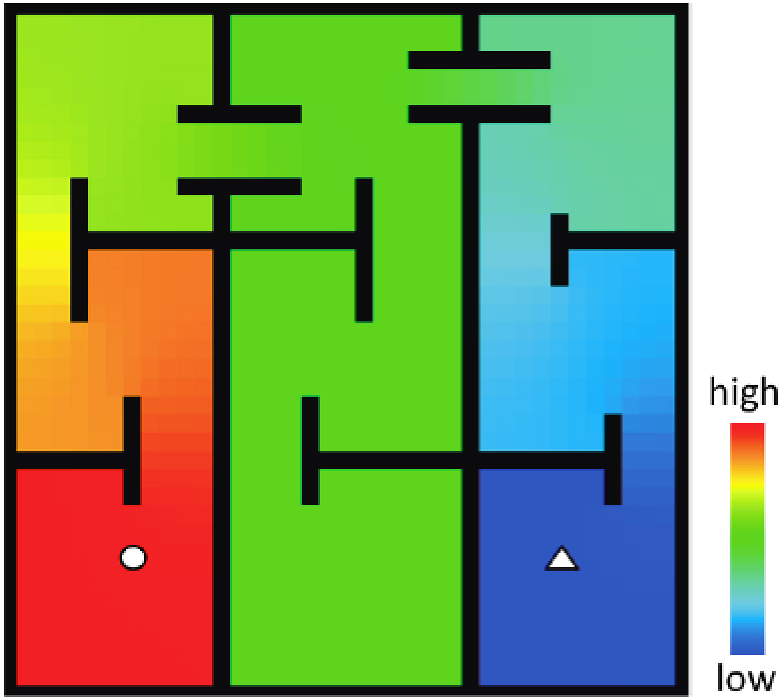


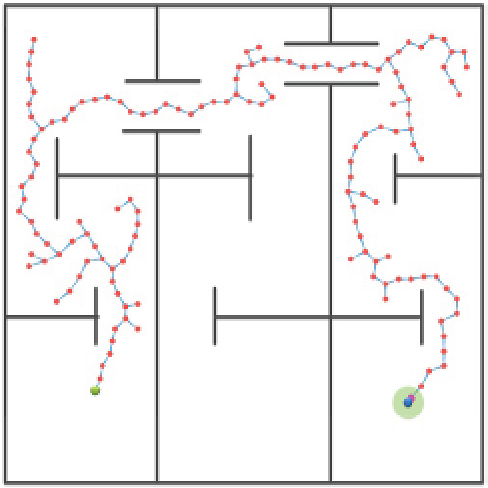


Method

- Structure-aware costmap
  - Mimic the diffusion process
    - By solving the diffusion equation

$$\frac{\partial \phi(\mathbf{r},t)}{\partial t} = D\nabla^2 \phi(\mathbf{r},t)$$

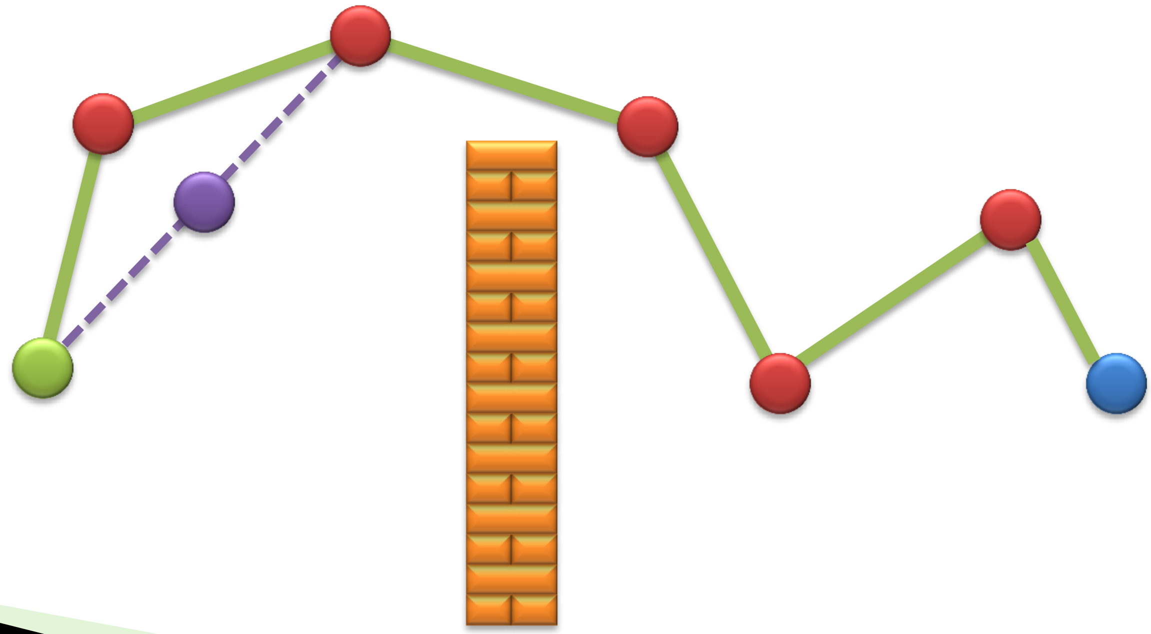




Method

- Local path optimization
  - Laplacian smoothing
    - Per-vertex smoothing operation

$$\mathbf{x}_i = \frac{1}{2}(\mathbf{x}_{i-1} + \mathbf{x}_{i+1}), 2 \leq i \leq N-1.$$



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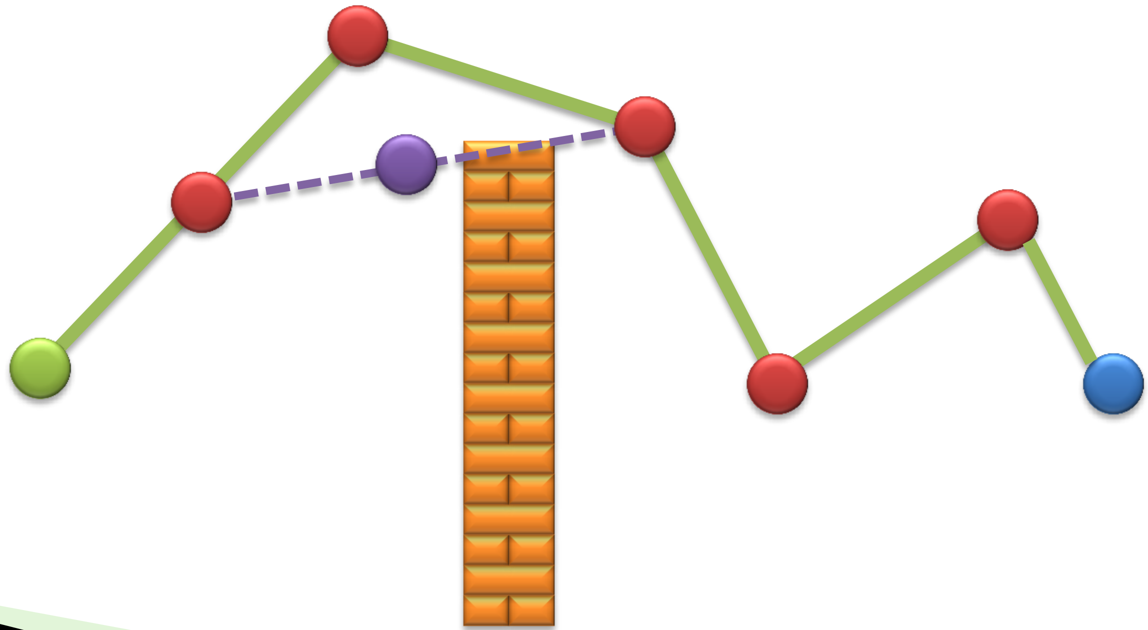

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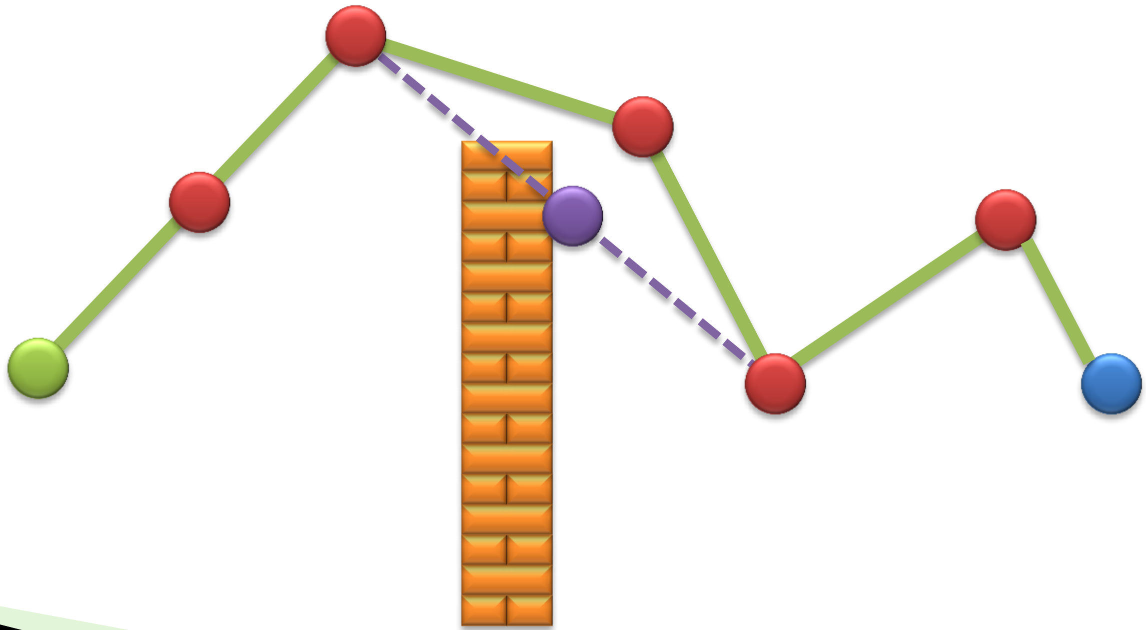

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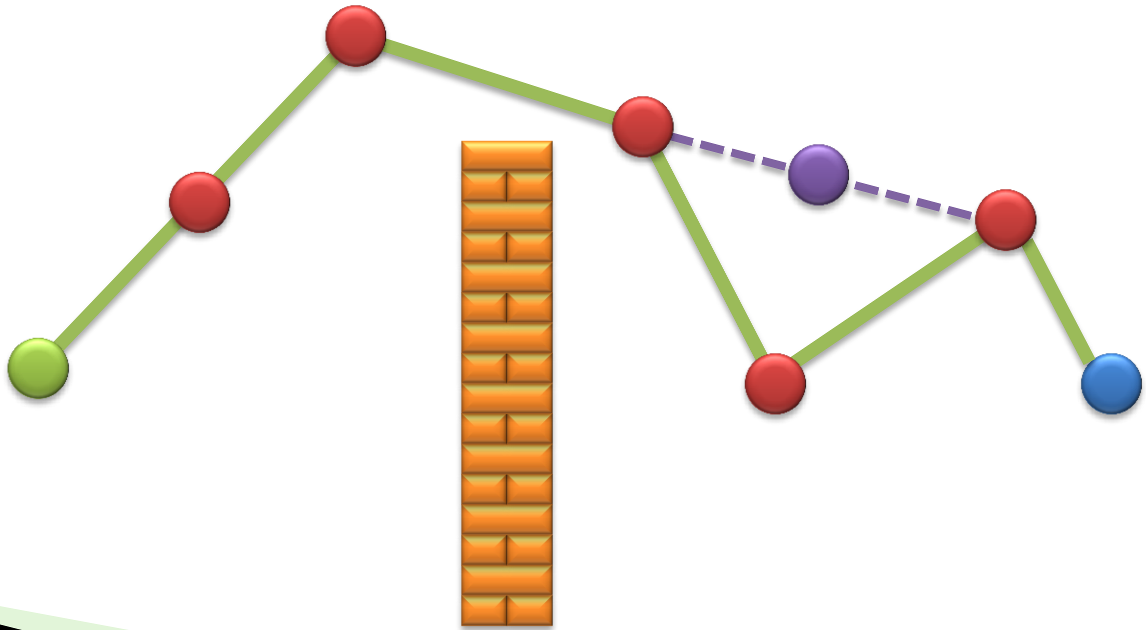

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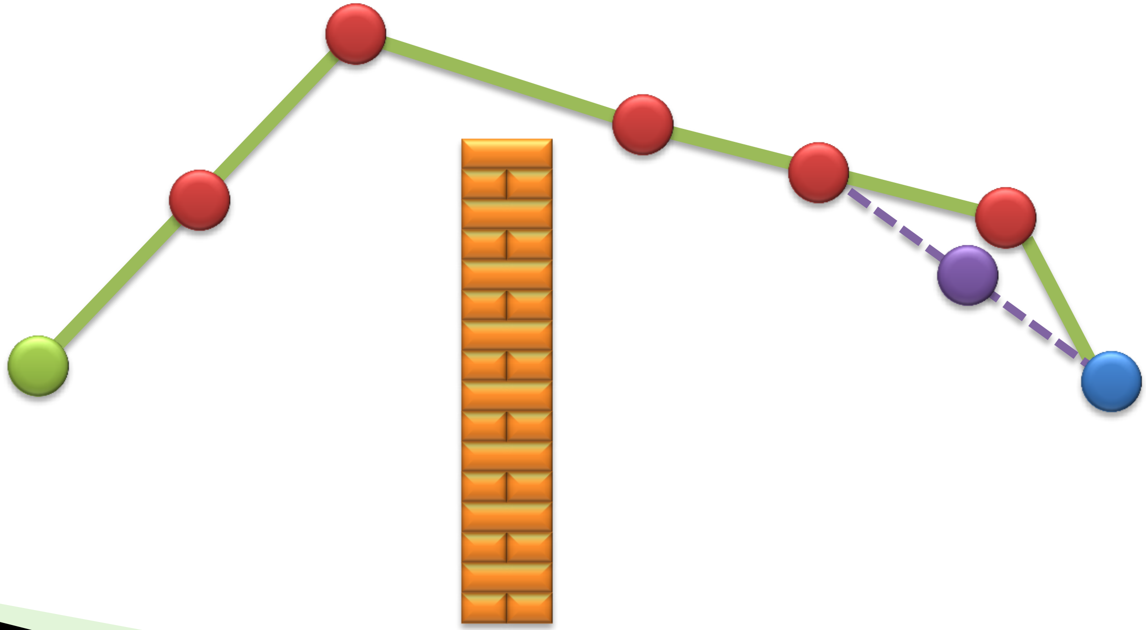

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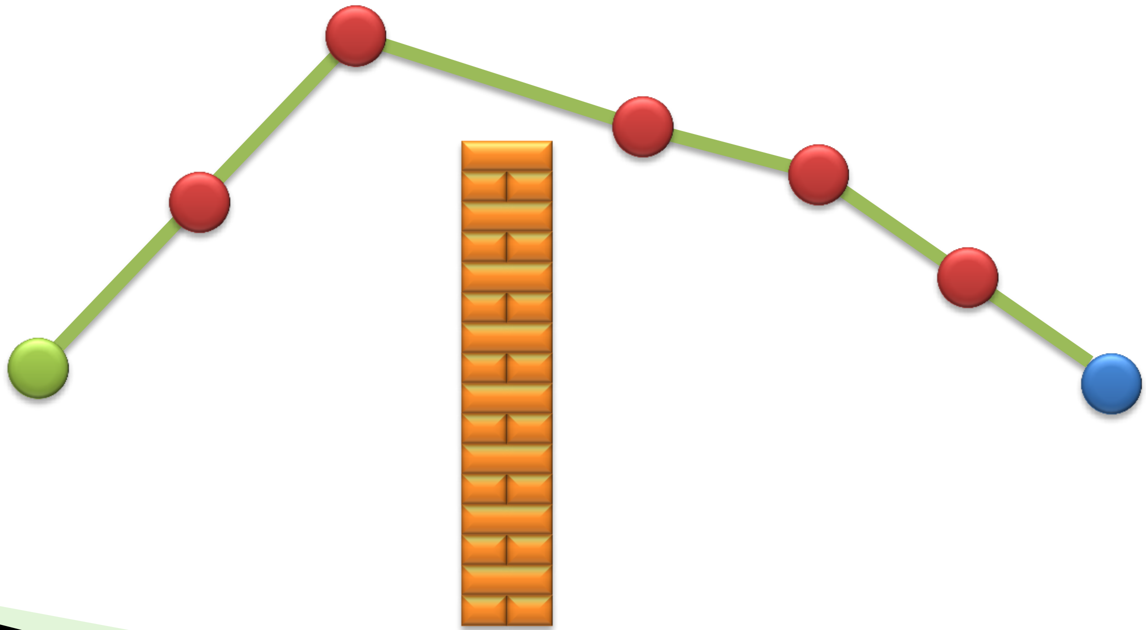

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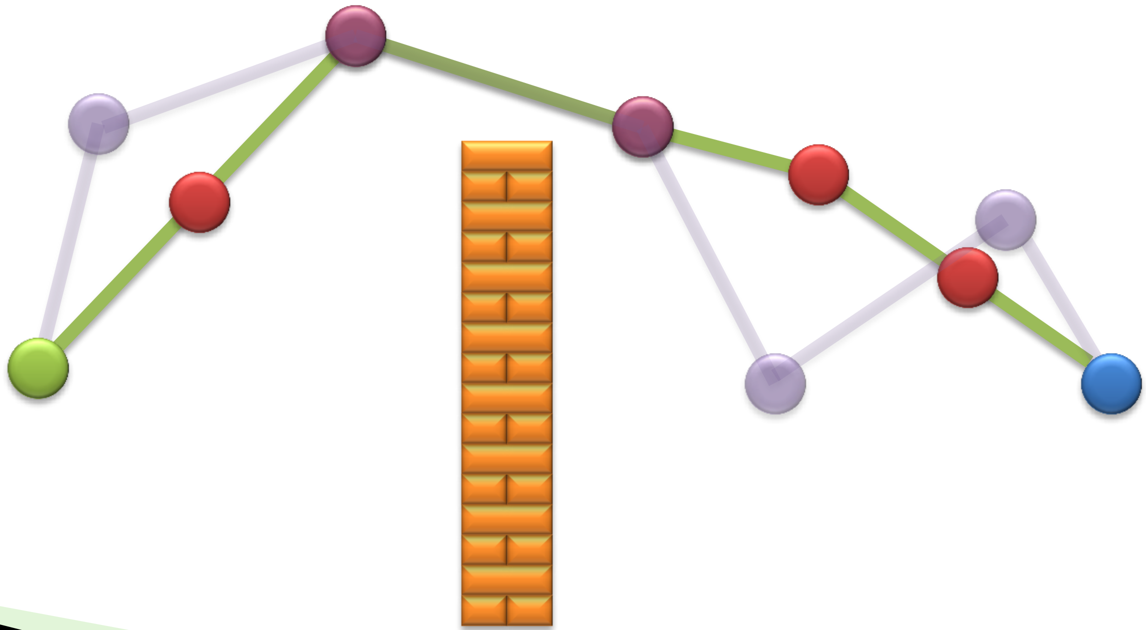
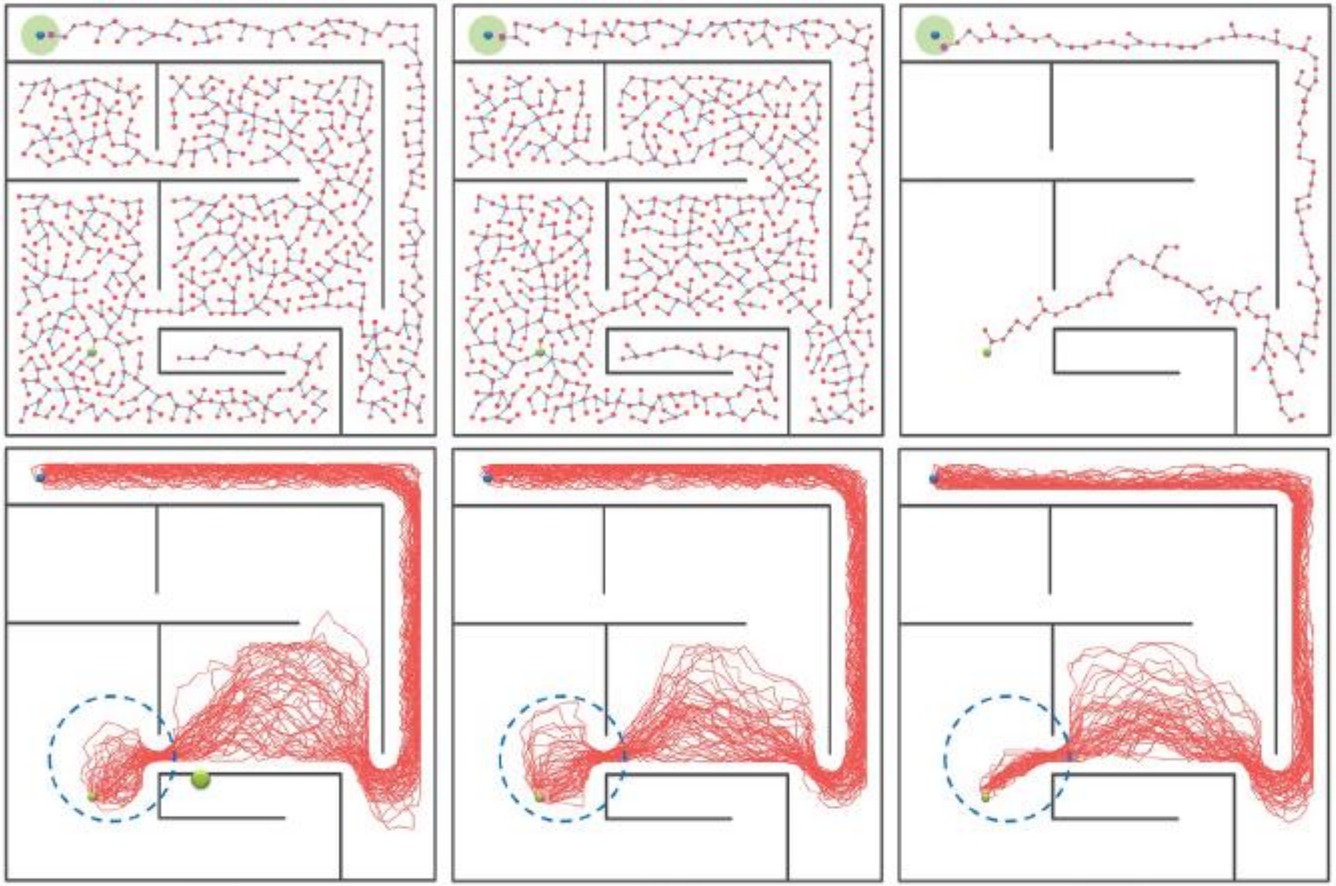


Results

- Hardware platform
  - Desktop computer (Intel Core i7 CPU, 2GB memory)
- Software environment
  - Ubuntu Linux 14.04
  - ROS Indigo
  - Stage simulator
- Problem settings
  - Holonomic point robot
  - 200X200 occupancy grid maps

Results

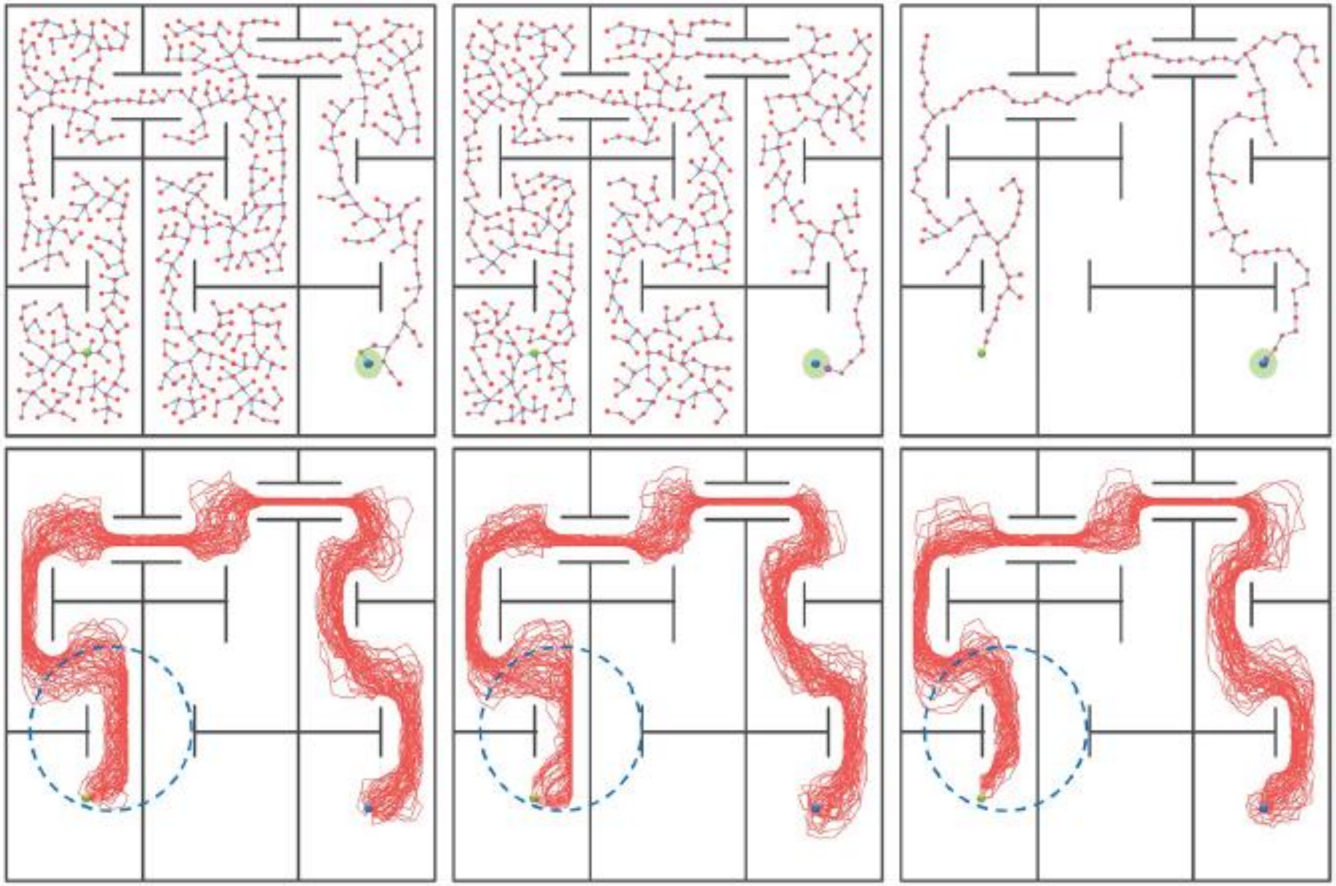
- Comparative experiments



Vanilla RRT | RRT (Euclidean) | SARRT

Results

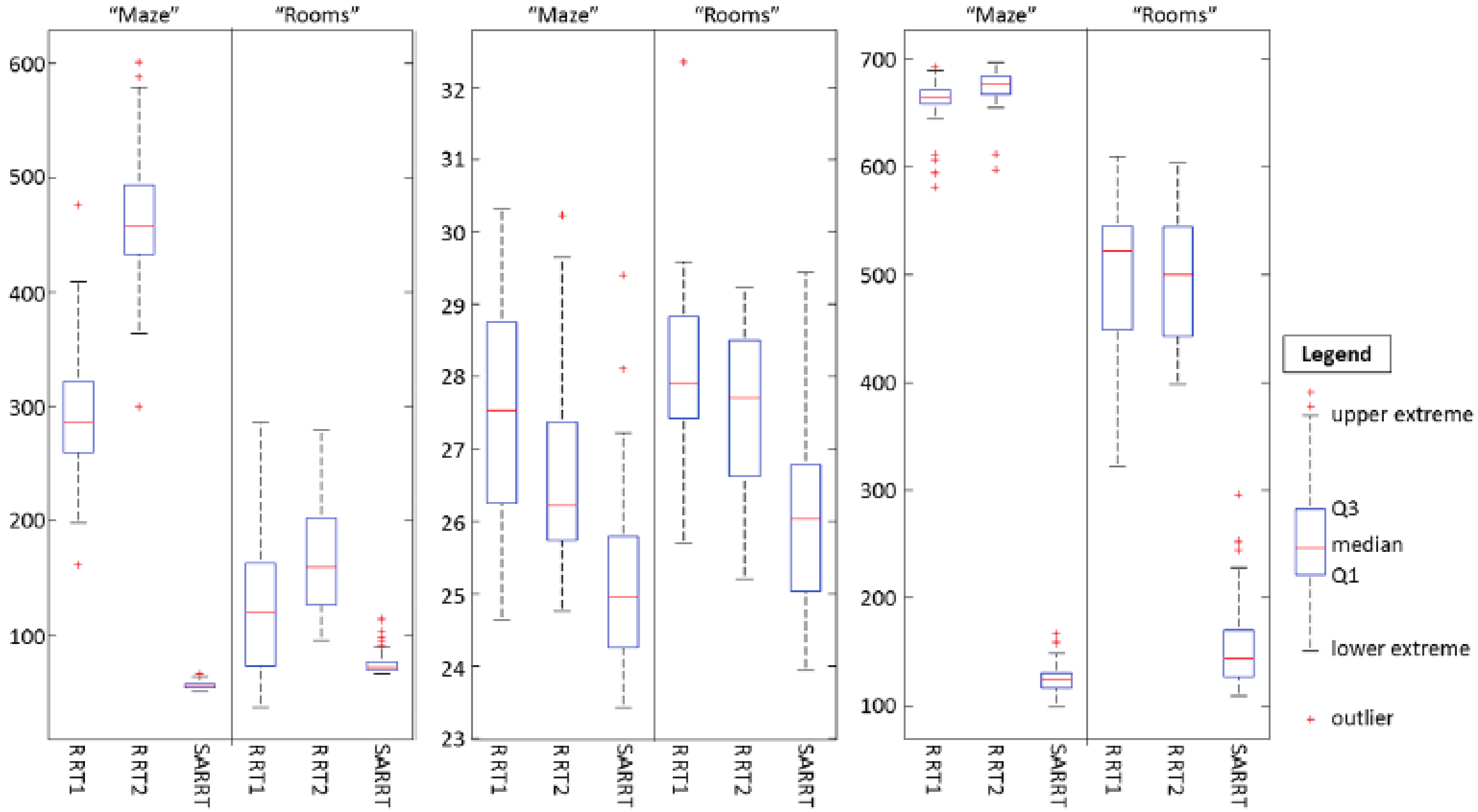
- Comparative experiments



Vanilla RRT RRT (Euclidean) SARRT

Results

- Performance statistics



Runtimes Path length RRT node counts

Conclusion

- SARRT, a novel RRT variant
  - To bias the random tree growth based on a structure-aware costmap
  - Works well in practice
    - Avoids “dead ends” in the map
    - Shows better performance
    - Compatible with other improvements on RRT

Source code available at:

https://github.com/xuefengchang/micROS-SARRT-GlobalPlanner

Conclusion

- Limitations and future work
  - Computationally expensive to obtain the costmap
    - Use more advanced solvers
    - Exploiting multicore CPUs and/or GPUs
    - Try other structure-aware cost functions
  - Only 2D path planning problems with simple holonomic point robots
    - Apply SARRT on more complex problems

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Thanks

Questions?

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