

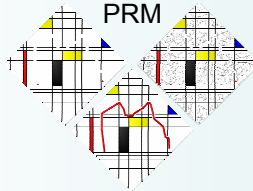
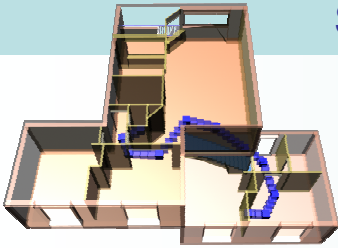
# On the Analysis and Success of Sampling Based Motion Planning



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## Sampling based motion planning



Ingredients of the Probabilistic Roadmap Method

- Sampling strategy
- Neighbor selecting strategy
- Local planner

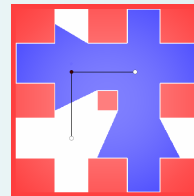
The method works well in practice

- No explicit representation of the free space is required
- Longer connections can be made with a local planner

## Reachability

A problem has been solved if two criteria are satisfied

- **Coverage:** a graph covers the free space if each free sample can be connected to a node in the graph using the local planner
- **Maximal connectivity:** a graph is maximally connected if for each pair of nodes in the graph the following holds: if there exists a path in the free space between those nodes, then there exists a corresponding path in the graph

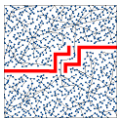


Both criteria have been met

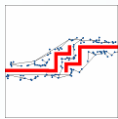
- The white nodes cover the free space
- The black node connects the white nodes
- Hence, a three-node graph solves this problem

## Sampling strategy

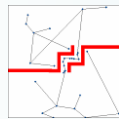
Uniform  
 • Halton



Non-uniform  
 • Gaussian

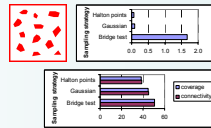


Hybrid  
 • Bridge test

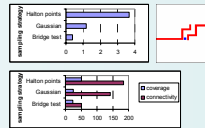


Experiments

• Simple environment



• Narrow passage env.



Conclusions

- The narrow passage problem is caused by the inability to *connect* the nodes. More time should be spent on getting them connected
- An adaptive (hybrid) sampling strategy should be used

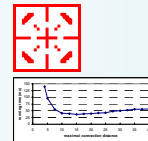
## Neighbor selecting strategy

Criteria for selecting candidates

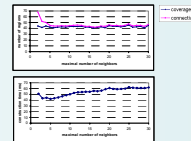
- Maximal connection distance
  - Not too short, not too long
- Maximum number of connections
  - Not too small, not too large

Experiments

• Maximal distance



• Maximal #connections



Conclusions

- A short connection distance kills the power of the planner
- The maximal number of connections must not be too small
- The parameters should be made adaptive

## Local planner

Connecting nodes can be difficult

- Solution: create a more powerful local planner

Potential field local planner (PFLP)

- Choose 8 (26) directions on a unit sphere
- Select those that bring the robot closer to the goal
- Stop when all directions fail

Comparison

• Straight-line LP



• Potential field LP



Conclusions

- The free space is connected in less time with less nodes by the PFLP
- The PFLP is better able to find the entry of a narrow passage, decreasing the number of nodes

## Conclusions and future work

Conclusions

- Sampling based planners work well in practice
- The connectivity problem is the real issue
- The connectivity problem can be handled by
  - adaptive sampling, adaptively choosing the parameters for the neighbor selecting strategy, employing a more powerful LP

Future work

- Improvement of the potential field local planner
- Creating small graphs that fulfill the coverage and maximal connectivity criteria

