Clearance-bias Exploration - A Robot Motion Planning Algorithm that Finds Safer Paths Faster

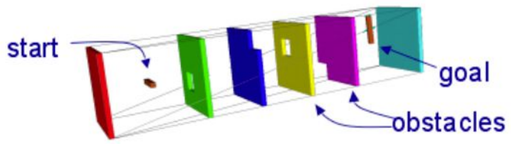
Department of Computer Science, University of Illinois at Urbana-Champaign

Regina Rex rrex@uwsuper.edu
Diane Uwacu duwacu@tamu.edu
Shawna Thomas sthomas@cs.tamu.edu
Nancy M. Amato namato@illinois.edu

Motion Planning

Input: robot, an environment, start and goal point

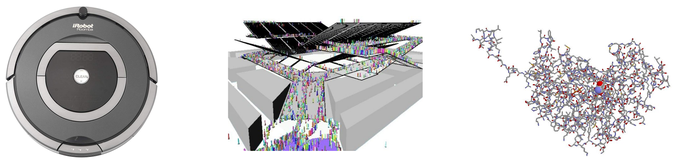
Output: path from start to goal without colliding with obstacles



Example of a Motion Planning Problem

Applications of Motion Planning

Robotics Building Evacuation Bioinformatics



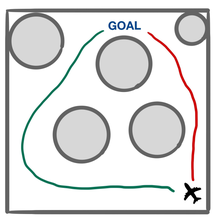
(a) (b) (c)

(a) iRobot Roomba (b) Simulation of a building evacuation (c) Studying Protein molecules

Motivation

Research Problem

- Existing Motion Planning algorithms use workspace property to guide planning, e.g., Skeleton-guided planners
- These algorithms are not exploiting workspace properties while planning



Mobile Robot with safer path (green) and shorter/less safe path (red)

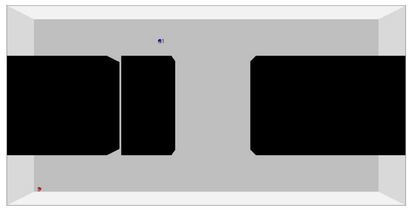
Approach

- Introduce the idea of using workspace metrics to bias how the environment is explored [2]
- Use max clearance to find safer paths and min clearance to explore hard areas

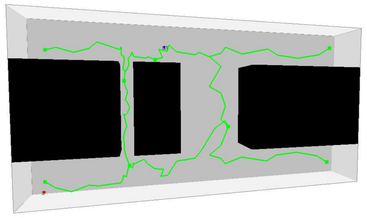
Clearance-bias Exploration

The Clearance-bias Metric is applied to Dynamic Region-biased Rapidly-exploring Random Tree (DR-RRT) [1]

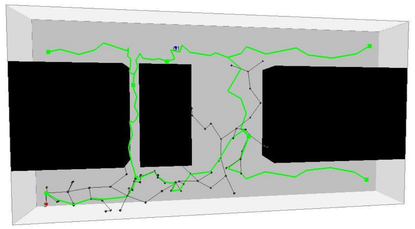
Example Execution



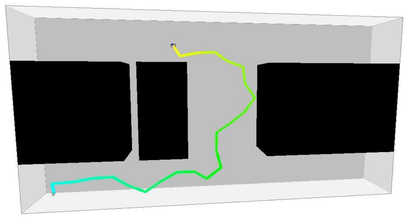
Environment with Start (red) and Goal (blue)



Workspace Skeleton (WS)



Max Clearance-bias Planning Process



Safer path found with Max Clearance-bias

Algorithm

Algorithm 1 Clearance-bias DR-RRT

Input: Environment env, Start s, Goal g, (min/max, clearance) $biasMetric$
Output: Path p

```
WS ← GetWorkspaceSkeleton(env)
AS ← AnnotateSkeleton(WS)
g ← s
r ← GetInitialRegion(AS, s)
while ¬done do
    C_r ← GetChildren(r)
    r ← SelectRegion(C_r, biasMetric)
    T ← GrowRRT(r)
end while
p ← Query(T, g)
return p
```

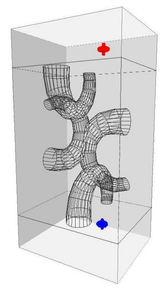
Example Results

Method	Regular DR-RRT	Biased DR-RRT
Bias Metric	Planning Success	Maximum Clearance
Avg Collision Detection Calls	117,043	96,586
Avg Path Clearance	3.27	4.63

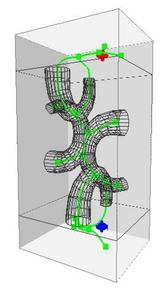
Table showing experiment results averaged over ten random seeds in the 3D Obstacles Environment.

Experiments

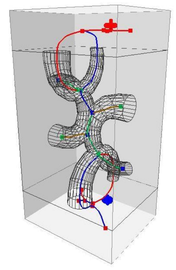
We compare: **Regular DR-RRT** and **Max Clearance-bias**



MazeTunnel Environment



(a) WS

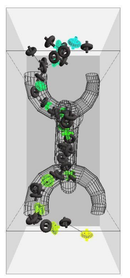


(b) Annotated WS

(a) Regular DR-RRT roadmap

(b) Regular DR-RRT roadmap & path

(a) Max Clearance-bias roadmap



(b) Max Clearance-bias roadmap & path

Method	Avg Run Time	Avg Collision Detection Calls
Regular DR-RRT	0.4634	11,552
Max Clearance-bias	0.1833	6,157

Table showing experiment results averaged over ten random seeds in the MazeTunnel Environment.

Conclusion & Future Work

Conclusion

- We utilize workspace properties such as clearance to find safer and more feasible paths in a faster time

Future Work

- Extend the clearance method to other motion planning applications like animation and Image-guided Medical Needle Steering

Acknowledgment & References

Acknowledgment

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References

[1] J. Denny, R. Sandstrom, A. Bregger, and N. M. Amato, "Dynamic Region-biased Rapidly-exploring Random Trees," In. *Proc. of the Twelfth International Workshop on the Algorithmic Foundations of Robotics* (WAFR), San Francisco, CA, USA, Dec. 18–20, 2016.

[2] R. Rex, D. Uwacu, S. Thomas, N. M. Amato, "Metrics for Efficient Environment Exploration in Robot Motion Planning," Technical Report, TR18-002, Parasol Laboratory, Department of Computer Science, Texas A&M University, College Station TX 77848, USA, Aug 2018.