Clearance-biased Exploration

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Clearance-biasing: a method of targeting workspace exploration based on the free-space between obstacles in the workspace. It is particularly applied to Dynamic Region-biased Rapidly-exploring Random Trees (DR-RRT), a skeleton-guided RRT.

1 Problem Statement

Existing state-of-the-art planners uses the workspace topology for exploration and to speed up the planning process, but improvements can be made to such methods to exploit these topological characteristics and guide exploration based on other features of the environment and capabilities of the robot.

To approach this problem, we implemented the clearance-bias method which uses a skeleton-guided RRT to guide workspace exploration based on the clearance value annotated to the skeleton. Our experiments showed an overall improvement in planning time and less number of collision detection calls.

2 Game Plan

To implement the clearance-bias method, we need to accomplish the following:

- Annotate workspace skeleton with clearance value
- Use clearance value to bias exploration
- Run experiments to compare basic RRT and skeleton-guided RRT with and without clearance-bias
- Validate and check in clearance-bias method

2.1 Current State

The method for annotating workspace skeleton and using clearance value to guide exploration has been implemented and tested on simple and complex 3D environments. We need to accomplish the following to finish the project:

- Perform statistical analysis using test results from 3D experiments
- Validate and check in existing clearance-method
- Improvements

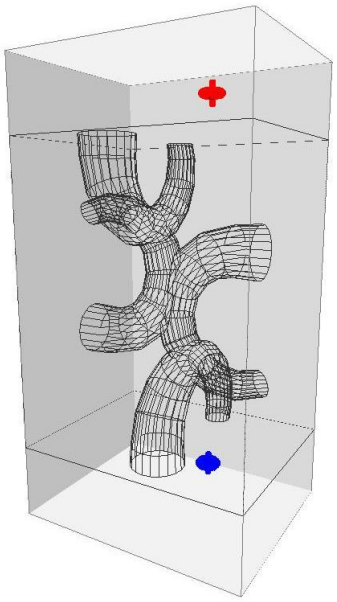

Figure 1: MazeTunnel

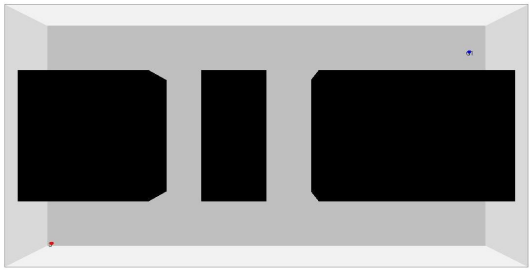

Figure 2: Obstacle

2.2 Perform statistical analysis using test results from 3D experiments

The scripts to perform the experiments has already been written, we just need to use the test results for statistical analysis. We also need to make changes to get the average path clearance while running the experiments. We plan to use both Mean Curvature Skeleton (MCS) and Reeb Graph (Reeb) for the skeleton-biased RRT. For comparison, we would use Basic RRT and DR-RRT with and without clearance bias. These are the metrics we plan to use for our analysis.

- Run time
- Number of collision detection calls
- Number of nodes
- Number of edges

- Average path clearance

Below is a table showing the preliminary results from the test data. on the MazeTunnel environment (Figure 1) For this test, we used the Mean Curvature Skeleton and the results are averaged over 10 random seeds.

Method	Runtime (seconds)	Average Collision Checks	Average Nodes	Average Edges
Clearance-bias	3.27	10572	125	247
DR-RRT	3.40	17559	257	511
RRT	9.66	75175	1829	3655

Table 1: Current Experiment Results

2.3 Validate and check in existing clearance-method

We are in the process of making changes to make the method applicable to different applications, not just robotics. We need to make sure it does not violate the coding standards and implement the feedback from code review.

2.4 Improvement

Additional Features: Add the option to bias towards minimum clearance value.

2.5 Weekly Plan

Week 4: June 17 - 21

- Implement comments from Diane's code review and add option to bias towards minimum clearance value
- Submit another code review
- Finish statistical analysis on experiment results
- Write paper abstract and the experimental analysis section
- Submit statistical analysis and check code into GitHub

Week 5: June 24 - 28

- Work with Bonnie to implement energy annotation
- Submit first literature survey
- Complete and submit the first draft of the paper

Week 6: July 1 - 5

- Test energy annotation implementation
- Use result from test as complex environment results for paper
- Complete and submit the second draft of the paper