Uniform Trajectory Planing for Cyber-Physical Systems

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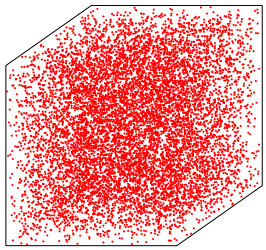
Background

For cyber-physical systems (such as autonomous cars, robots, drones, ...), computing a possible trajectory in space is crucial for the intended application of said system. If the system is modeled using a set (for example, a robot being approximated by a polytope), one can used set-based reachability analysis to over-approximate all safe trajectories the system can take at a given time. This is typically done by computing a reachable set at time t_1, then t_2, t_3, etc.

Once the range of safe trajectories has been determined, the next step is to choose one single trajectory within those safe sets. Since infinitely many such trajectories exist, one common technique is to choose a point at random in each set. However, depending on how the reachable set is defined, the term randomcan be ambiguous, and choosing a truly rr-andomizedpoint within a set, without biases, can be difficult. For example, the points in the figure below are randomly chosen, but not uniformly, so that they are less likely to be near the boundary of the set [1].



Description

The goal of this thesis is to find new ways to randomly sample certain set representations, such as zonotopes, constrained zonotopes, ellipsoids, etc. These sampling algorithms can then be used for a variety of applications, ranging from trajectory planning as mentioned above, but also volume and diameter estimation, or containment/collision checks.

All programming will be done in Matlab, and the final implementation of the approaches should be integrated into the CORA toolbox so that it can be made publicly available in the next CORA release.

Tasks

- Literature review on the topic uniform distributions for sets of different types
- Implementation of algorithms that produce uniformly sampled points
- Evaluation of the performance by comparing the results to the currently implemented method in CORA
- Integration of the final implementation into the CORA toolbox

References

[1] Apostolos Chalkis and Vissarion Fisikopoulos. volesti: Volume Approximation and Sampling for Convex Polytopes in R. 2020.

Supervisor:
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Research project:
justITSELF

Type:
Bachelor or Master Thesis

Research area:
Probability Theory, Reachability Analysis

Programming language:
MATLAB

Required skills:
Good mathematical background. A basic understanding of complexity theory may be useful, but can be learned along the way.

Language:
English

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