

Improvements of Interval Matrix Exponentiation applied to Reachability Analysis for Linear Systems with uncertain parameters



Technische Universität München



Fakultät für Informatik

Lehrstuhl für Echtzeitsysteme und Robotik

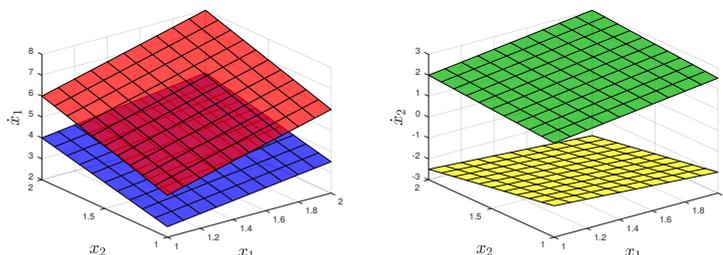
Background

Uncertain system parameters are a common feature of many technical real world applications such as robotic manipulators or autonomous cars. Since for most of these applications safety is a very critical aspect, formal verification methods for systems with uncertain parameters recently gained a lot of research interest. In this context, reachability analysis represents a very powerful tool, since this method is able to provide formal guarantees while explicitly considering the parameter uncertainty.

Description

The focus of this thesis is reachability analysis for linear systems with uncertain parameters. For reachability analysis, the zonotope-based approach from [1] is used, which is implemented in the CORA toolbox [2]. Since it is in general not possible to calculate the exact reachable set of a system, reachability analysis calculates a tight over-approximation of the exact reachable set instead. For linear systems with uncertain parameters, the size of this over-approximation error mainly depends on the calculation of the interval matrix exponential.

The goal of this thesis is to implement the novel approach for the calculation of the interval matrix exponential described in [3]. This implementation should then be integrated into the CORA toolbox for reachability analysis. Finally, the performance of the new approach compared to the method from [1], which is already implemented in CORA, will be evaluated with numerical tests on several benchmark systems.



Tasks

- Implementation of the approach for the calculation of the interval matrix exponential described in [3]
- Integration of the implementation into the CORA toolbox
- Evaluation of the performance with numerical tests on several benchmark systems
- *Optional:* Development of additional extensions to further improve the calculation of the interval matrix exponential

References

- [1] Matthias Althoff. Reachability analysis and its application to the safety assessment of autonomous cars. *Technical University of Munich*, 2010.
- [2] Matthias Althoff. An introduction to cora 2015. In *ARCH@ CPSWeek*, pages 120–151, 2015.
- [3] Alexandre Goldsztejn. On the exponentiation of interval matrices. *arXiv preprint arXiv:0908.3954*, 2009.

Supervisor:

Prof. Dr.-Ing. Matthias Althoff

Advisor:

Niklas Kochdumper, M.Sc.

Research project:

faveAC

Type:

BA/MA

Research area:

Reachability Analysis, Interval Arithmetics

Programming language:

MATLAB

Required skills:

Very good mathematical background, programming in MATLAB

Language:

English, German

Date of submission:

22. Juni 2018

For more information please contact us:

Phone: +49.89.289.18144

E-Mail: niklas.kochdumper@tum.de

Internet: www6.in.tum.de