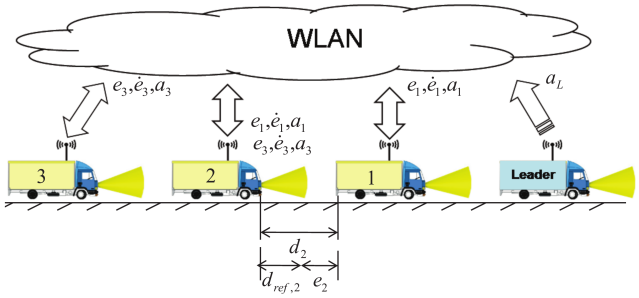
Robust Model Predictive Control for Vehicle Platooning

Background

Model predictive control (MPC) has proven to be a very successful control method for complex systems over the last decades [1]. The great popularity is mainly due to its simple concept and its ability to deal with state and input constraints. In order to use MPC in safety-critical applications, e.g., autonomous driving or human-robot collaboration, formal robustness guarantees against uncertainties are needed. Thus, robust MPC approaches are required that guarantee constraint satisfaction for all possible realizations originating from uncertainties, e.g., unknown but bounded disturbances.



Vehicle platoon with one leader and three followers (taken from [2]).

Description

A very popular robust MPC method is called tube-based MPC [3] It ensures that the state trajectory of the system stays within a tube of fixed size. Moreover, there exists a great variety of extensions of this method, such as parameterized or elastic tube-based MPC [4, 5]. The aim of this thesis is to implement and compare the tube-based MPC approach with our reachable-set-based method [6, 7]. The considered application is a vehicle platooning benchmark with a variable number of following vehicles [2]. We intend to include the results of this thesis in an international publication.

Tasks

- Familiarizing with robust model predictive control
- Familiarizing with reachability analysis
- Implementing tube-based MPC
- Comparing the performance of tube-based MPC with our reachable-set-based MPC

References

[1] D. Q. Mayne, "Model predictive control: Recent developments and future promise," *Automatica*, vol. 50, no. 12, pp. 2967–2986, 2014.

[2] I. Ben Makhlouf and S. Kowalewski, "Networked cooperative platoon of vehicles for testing methods and verification tools," in *Workshop on Applied Verification for Continuous and Hybrid Systems*, 2014, pp. 37–42.

[3] D. Q. Mayne, M. M. Seron, and S. V. Raković, "Robust model predictive control of constrained linear systems with bounded disturbances," *Automatica*, vol. 41, no. 2, pp. 219–224, 2005.

[4] S. V. Raković, B. Kouvaritakis, M. Cannon, C. Panos, and R. Findeisen, "Parameterized tube model predictive control," *IEEE Transactions on Automatic Control*, vol. 57, no. 11, pp. 2746–2761, 2012.

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justITSELF

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Background in control theory, optimization, and dynamical systems beneficial

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[5] S. V. Raković, W. S. Levine, and B. Açikmese, "Elastic tube model predictive control," in *American Control Conference*, 2016, pp. 3594–3599.

[6] M. Althoff, "Reachability analysis and its application to the safety assessment of autonomous cars," Ph.D. dissertation, Technical University of Munich, 2010.

[7] ——, "An introduction to CORA 2015," in *Workshop on Applied Verification for Continuous and Hybrid Systems*, 2015, pp. 120–151.

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