Test Case Generation for Autonomous Trucks using Machine Learning Techniques

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Background

Safety is of utmost importance when it comes to developing autonomous vehicles. A major building block to ensure safety, is to automatically create models of the autonomous system capturing all possible behaviors. These models are non-deterministic and one can verify them with reachset conformance checking [2, 5, 3]. However, a key question remains: How to automatically generate test cases, such that all relevant scenarios are covered?

Description

In order to automatically find interesting test cases, machine learning techniques should be applied—in particular, Bayesian optimization [4]. The advantage of Bayesian optimization is that due to Gaussian regression, we can argue how likely it will be that there still exist a test case that could falsify the obtained model.

In a nutshell, the idea of using Bayesian optimization for conformance testing is as follows: Given a number of previous test results, Bayesian optimization builds a Gaussian process regression model, which can be used to derive predictions for useful parameter values that have not yet been tested.

This thesis is carried out in collaboration with Volvo trucks in Gothenburg, Sweden.

Tasks

- Familiarizing with the literature cited in this thesis proposal.
- Familiarizing with existing software for conformance checking in the tool CORA [1].
- Identifying a nominal truck model.
- Creating a reachset-conformant truck model for a single test case.
- Creating a reachset-conformant truck model for a set of test cases.
- Implementation of Bayesian optimization.
- Automatic test case generation for reachset conformance.
- Developing further methods for test case generation based on machine learning.
- Comparison of developed methods.
- Documentation of results.

References

[1] M. Althoff. *CORA 2015*. Technische Universität München, 2015.

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Research project:
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Type:
MA

Research area:
Autonomous driving, machine learning, system identification

Programming language:
Python, MATLAB

Required skills:
Good programming skills, knowledge in machine learning and/or system identification

Language:
English

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[2] M. Althoff and J. M. Dolan. Reachability computation of low-order models for the safety verification of high-order road vehicle models. In *Proc. of the American Control Conference*, pages 3559–3566, 2012.

[3] S. B. Liu, H. Roehm, C. Heinzemann, I. Lütkebohle, J. Oehlerking, and M. Althoff. Provably safe motion of mobile robots in human environments. In *Proc. of the IEEE/RSJ International Conference on Intelligent Robots and Systems*, pages 1351–1357, 2017.

[4] C. E. Rasmussen and C. K. I. Williams. *Gaussian Processes for Machine Learning*. MIT Press, 2006.

[5] H. Roehm, J. Oehlerking, M. Woehrle, and M. Althoff. Reachset conformance testing of hybrid automata. In *Proc. of Hybrid Systems: Computation and Control*, pages 277–286, 2016.

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