TECHNISCHE UNIVERSITÄT MÜNCHEN
LEHRSTUHL FÜR INFORMATIONSTECHNISCHE REGELUNG
ORDINARIA: UNIV.-PROF. DR.-ING. SANDRA HIRCHE

August 28, 2024

M A S T E R ' S T H E S I S

Event-triggered Learning for Safety-Critical Control Via Parameterized Control Barrier Function

Problem description:

With the increasing complexity of real-world systems and varying environmental uncertainties, constructing an accurate dynamic model is challenging, which poses challenges particularly in safety-critical control. To this end, a Gaussian process-based parameterized high-order control barrier function (GP-P-HOCBF, [1]) is proposed. This method leverages the theoretical prediction error bound to guide the modification of the safe set in each order, thereby ensuring the preservation of the original safety requirements. Moreover, online learning is a promising technique for adapting to different environments and improving prediction accuracy during the operation, resulting in less need to modify the original safety constraint. However, the significant computational demands resulted from continuous online learning deteriorate the real-time property of GP-P-HOCBF. To tackle this problem, event-triggered mechanisms are widely used [2], which determines the state transmission for GP model update and control input generation only when necessary. In this work, we aim to design an event-triggered strategy for GP-P-HOCBF, which guarantees safety with less communication and computation. Moreover, the relationship between safe set modification level and communication efficiency is going to be discussed, which will be demonstrated via both simulation and experiment.

Tasks:

- Design the event-triggered strategy with GP-P-HOCBF, and prove its performance;
- Show the exclusion of Zeno behavior;
- Explore the relationship between safe set shrinkage and trigger times;
- Demonstration the effectiveness via simulation and experiment on Franka Emika.

Bibliography:

[1] Sihua Zhang, Di-Hua Zhai, Xiaobing Dai, Tzu yuan Huang, Yuanqing Xia, and Sandra Hirche. Learning-based parameterized barrier function for safety-critical control of unknown systems, 2024.

[2] Jonas Umlauft and Sandra Hirche. Feedback Linearization based on Gaussian Processes with Event-triggered Online Learning. *IEEE Transactions on Automatic Control*, 65(10):4154–4169, 2019.

Supervisor:	M. Sc. Sihua Zhang, M.Sc. Xiaobing Dai
Start:	xx.xx.xxxx
Intermediate Report:	xx.xx.xxxx
Delivery:	xx.xx.xxxx

(S. Hirche)
Univ.-Professor