M.Sc. Thesis Project Proposal

Real-time MPC with complexity guarantees

Background

A control strategy which is increasingly applied for difficult control tasks, especially when physical constraints inherent to the controlled system have to be handled, is model predictive control (MPC), where the control problem is tackled by continuously solving mathematical optimization problems. These optimization problems are solved in each time step (to introduce feedback), which for systems with fast dynamics often leads to over thousands of optimization problems to be solved each second. This makes it important that the optimization solvers which are used are efficient, reliable and robust, properties which become even more important when MPC is applied in real-time applications on embedded systems, since the optimization problems also have to be solved with limited computational power and memory. To be able to guarantee that the optimization problems will be solved within a limited time frame, we have recently proposed a method [1] which determines the *exact* computational complexity of a popular class of optimization methods commonly used in real-time MPC (active-set methods).

Project

The goal of this project is to get an MPC based controller running on a platform in real-time. To accomplish this, investigation of the applicability of different optimization methods for use in real-time MPC, while taking into account the limitations inherent in embedded systems such as limited computing power and memory, is needed. A special focus is to apply the recently developed complexity certification framework [1] to be able to provide guarantees on worst-case computation time for the applied solver, for all possible optimization problems which might be encountered.

Depending on the interest, different platforms can be consider, including a truck and trailer system, a mini-segway or a CrazyFly. This is a project at the research front which, if successful, can lead to a research publication.

Background knowledge

It is desirable that the candidate has background knowledge or interest in

- Mathematical optimization (preferably optimal control),
- Programming in C and/or C++.

Contact information

If you are interested in this project and/or have questions, you are welcome to contact either Daniel Arnström at daniel.arnstrom@liu.se or Daniel Axehill at daniel.axehill@liu.se.

References

[1] D. Arnström and D. Axehill, "A unifying complexity certification framework for active-set methods for convex quadratic programming," *ArXiv e-prints*, Mar. 2020.