Master's Project

Real-time ADMM iterations for sparse predictive control

Background: For many control applications, it is desirable to minimize the intervention of the controller. In other words, it is desirable to set the control action to zero as often as possible (cf. Fig. 1). This behavior can be enforced based on predictive control with l_0-norm penalization of the control sequence. The corresponding optimal control problem is hard to solve since the l_0-norm is non-convex. Hence, convex relaxations using the l_1-norm instead of l_0 are usually considered [1]. The resulting optimization problem is convex but, depending on the system dimensions and the prediction horizon, the numerical effort for its solution can still be high. Approximate solutions can be obtained with, e.g., proximal algorithms such as the alternating direction method of multipliers (ADMM, see [2]). For such iterative solvers, the accuracy typically increases with the number of iterations evaluated in every time step. Surprisingly, stable behavior of the closed-loop system can often be achieved with only one ADMM iteration per time step. Such so-called real-time iterations are considered in some existing control schemes. However, a comprehensive system theoretic analysis of the stability of the resulting closed-loop system is often missing.

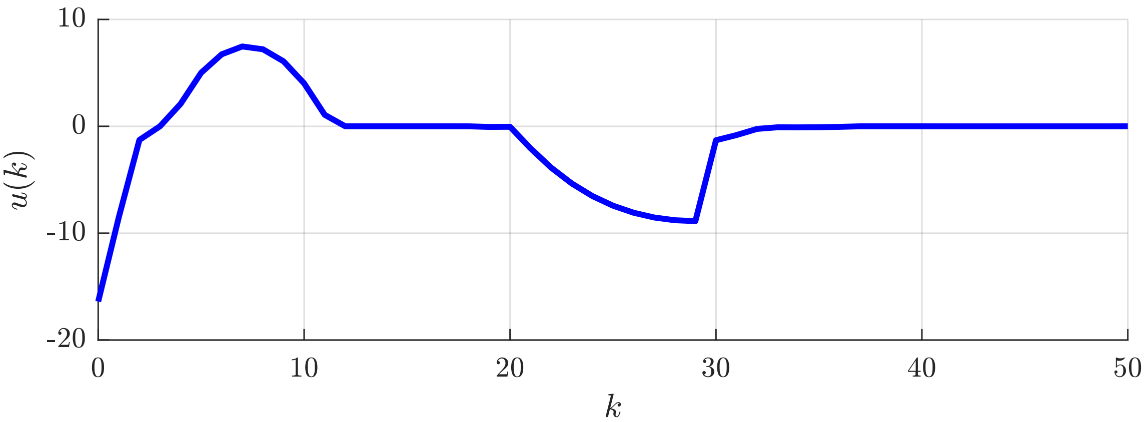

Figure 1: Illustration of a sparse input trajectory originating from the example in [1].

Project: The thesis considers real-time ADMM iterations for the initially described predictive controller promoting sparse control sequences. Based on a recent publications on the topic [1, 3], the student should systematically analyze the stability of the closed-loop system for various parametrizations. Extensive numerical studies should pave the way for more fundamental observations.

Prerequisites: A strong mathematical background. Knowledge of system and control theory. Knowledge of or willingness to learn numerical optimization via ADMM.

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References

[1] M. Nagahara, J. Østergaard, and D. E. Quevedo, "Discrete-time hands-off control by sparse optimization," *EURASIP Journal on Advances in Signal Processing*, vol. 76, pp. 1–8, 2016.

[2] S. Boyd, N. Parikh, E. Chu, B. Peleato, and J. Eckstein, "Distributed optimization and statistical learning via the alternating direction method of multipliers," *Foundations and Trends in Machine Learning*, vol. 3, no. 1, pp. 1–122, 2011.

[3] R. Van Parys and G. Pipeleers, "Real-time proximal gradient method for linear MPC," in *Proc. of the 2018 European Control Conference*, 2018, pp. 1142–1147.