Proposal for an Open Invited Track at the IFAC World Congress 2023

Recent Advances in Automated Learning and Calibration of MPC Policies

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Organizers:

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Abstract:

There is a rapidly growing interest in using learning and data-driven techniques for the development of different Model Predictive Control (MPC) formulations. The use of learning tools has gone beyond the more traditional approach of adapting/learning the prediction model or uncertainty description, to more generalized parametrized control policies. Currently there is a lot of research activity in this domain with different approaches to learn the parameters of the policy that would result in a desired performance. For example, the policies can either be learned from expert demonstrations in the context of imitation learning, or using closed-loop performance data in the context of "tuning" or reinforcement learning. We expect that this Open Invited Track will serve as a forum to encourage and discuss new developments at the boundary between model predictive control, reinforcement learning and data-driven optimization.

The topics of this Open Invited Track include but are not limited to: MPC tuning using Bayesian optimization; reinforcement learning and MPC; Approximation of complex MPC laws using machine learning; and adapting learned policies. We welcome novel theoretical contributions, practical implementations and tools, as well as challenging case studies.

Relevant IFAC Technical Committee:

2.4 Optimal Control, 6.1 Process Control

Description:

Several engineering applications ranging from energy, manufacturing, transportation, robotics, power systems, biosystems etc. often feature complex, coupled non-linear multivariable dynamics with several safety-critical constraints and actuator limits that need to be satisfied. Safe and efficient operation of such multivariable constrained systems require advanced control algorithms. Model predictive control (MPC) is a common control strategy for constrained, multivariable systems, and is thus well suited for a wide array of applications. Yet, many MPC applications face important challenges related to the difficulty of modeling complex systems or the need for MPC strategies with provably safe and robust performance that have low online computational and memory requirements.

Model predictive control, as the name suggests, uses a control-oriented model to predict how the system would behave, and uses the predictions to compute appropriate control actions based on a cost function. Control-oriented models are simplified models, where the complex physics is expressed by lumped parameters, where the key is capturing the input-output dynamics rather than high-fidelity physics. Some of these parameters in the control-oriented model may be uncertain, leading to plant-model mismatch. An effective way to handle such mismatch is by tuning the parameters in the control-oriented model that give the best closed-loop performance. In addition to the parameters in the control-oriented model, the cost and the constraints can also be parameterized, resulting in parameterized MPC policy representations.

Recent years have witnessed an enormous interest in the use of machine learning techniques in different fields, including control systems. The use of online learning such as reinforcement learning and Bayesian optimization to learn parameterized MPC policy representations raises fundamental challenges related to the controller properties, such as stability, convergence, constraint satisfaction and performance under uncertainty. In addition, learning/tuning the policies by directly interacting with the real system with safety-critical constraints creates further challenges. The main motivation of this Open Invited Track is to encourage research at the interface between machine learning and model predictive control, which can provide important synergies and contribute to solve the arising challenges.

This Open Invited Track will focus on how recent advances in machine learning can be leveraged to develop and deploy improved MPC schemes. The expected topics include, but are not limited to:

- Bayesian optimization and MPC
- Reinforcement learning and MPC
- Online adaptation/tuning of parameterized policies
- Approximation of complex MPC laws using machine learning

We welcome contributions that focus on the development of theoretical guarantees, methods and software as well as challenging applications. The proposers have already received a confirmation of interest for the submission to this open invited track from leading scientists of the field by the time of submission of this proposal.

About the proposers:
Ali Mesbah has extensive experience in organizing successful invited sessions and workshops on the topic of MPC and learning-based control, including a pre-conference workshop on a related topic at the IFAC 2020 with over 300 participants. Dinesh Krishnamoorthy has experience in organizing pre-symposium workshops at IFAC DYCOPS 2019 and IFAC ACODS 2020, and regularly serves in the program committee of control conferences including IEEE CCTA 2017, AdCONIP 2022, and ECC 2023.