Online Dataset Management for Switched Systems via Machine Learning

Context

The behavioral framework is a model-free, data-driven approach that characterizes dynamical systems directly from their measured trajectories. Since the introduction of Willems' Fundamental Lemma [1], which describes a system's behavior from a finite number of samples, it has led to several control designs, notably Data-Enabled Predictive Control (DeePC) [2]. This method has been applied successfully in many applications such as robotics, power systems, and temperature regulation. However, these solutions rely on pre-collected datasets, which become obsolete when the system dynamics change. For switched systems, this can severely degrade control performance and compromise safety. Detecting operating-mode transitions quickly is therefore a key challenge.

Research team overview

The AUT team is part of IETR and is located on the Rennes campus of CentraleSupélec. It consists of 8 faculty researchers, as well as PhD students and postdoctoral fellows.

The team develops advanced methodological approaches for the analysis, control, identification, and state estimation of dynamic systems, with a focus on the distribution and hierarchical structuring of processes. It also incorporates predictive control to anticipate and optimize system behavior in real time. These efforts have practical applications in the energy sector, where the team actively contributes to the development of Intelligent Energy Systems.

The team is particularly interested in energy efficiency, the integration of renewable energy sources, and energy management. Finally, its research also addresses the sizing and active management of microgrids to ensure their optimal operation and to enhance their flexibility.

Supervision

This study is supervised by Romain Bourdais (romain.bourdais@centralesupelec.fr), Stanislav Aranovskiy (stanislav.aranovskiy@centralesupelec.fr) and Maxime Manzano (maxime.manzano@centralesupelec.fr) and takes place at the CentraleSupélec premises.

Description: Real-Time Detection of Mode Switches in Data-Driven Control via Machine Learning

This research project aims to develop algorithms for real-time detection of the operating mode of switched systems, using data-driven methods. Existing approaches detect a mode switch by spotting inconsistencies between the current trajectory and past behavior [3]. They need to accumulate a minimum number of samples after the switch, which delays detection. This project proposes to reframe switch detection as a clustering/classification problem solved with machine learning techniques. Features will be built from two sources: a short sliding window of recent measurements and a dataset

of past behavior. They must react rapidly to a mode change so that the controller can adapt with minimal delay.

Detection must run in real time, using only the current window and past data, within the control loop's time budget. The internship will therefore address three questions: which features to construct, how to select the most discriminative ones, and how to do so under computational constraints.

Two fallback solutions are foreseen if feature-based detection proves insufficient: subspace tracking algorithms and subspace-distance methods [4,5]. In addition, if the measurements are not rich enough, instrumental excitation will be investigated. The developed methods will be validated in simulation and on real systems to assess their robustness under realistic operating conditions.

Working program

1. Literature study and simulation testbed setup
2. Feature engineering and ML algorithms development
3. Results evaluation and comparative analysis in simulation
4. Results evaluation and comparative analysis on real systems

References

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