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Masterthesis

Adaptive and data-driven predictive control of a modular multilevel converter

Description

The modular multilevel converter (MMC) is a key technology for high-voltage dc (HVDC) transmission and medium-voltage drives. Its many coupled states, nonlinearities, and strict operating limits require advanced control, such as model predictive control (MPC), to ensure safe operation.

Robust MPC designs for the worst case of a fixed uncertainty set, which is safe but permanently conservative: the controller keeps paying for an uncertainty that could be measured away. Adaptive and data-driven MPC reduce the uncertainty itself by learning from operating data, so the controller becomes less cautious the longer it runs. This thesis investigates one such approach for the MMC, such as set-membership identification, Gaussian process regression of the model error, or data-enabled predictive control (DeePC), and assesses it against a robust MPC. The methods are established in robotics and process control, but their use in power electronics is still young.

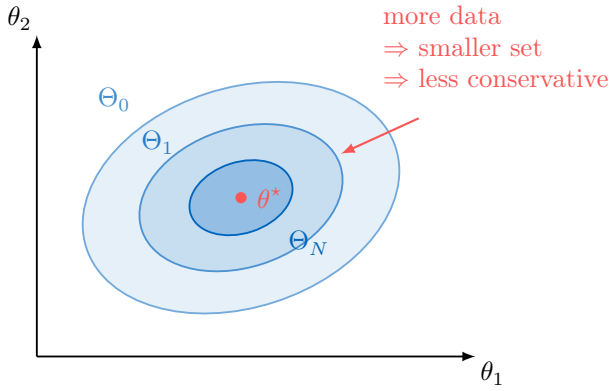

Figure 1: Set-membership identification: the parameter uncertainty set shrinks as data accumulates, and the controller becomes correspondingly less conservative.

Tasks

- State of the art of adaptive, learning-based and data-driven predictive control.
- Comparison of set-membership identification, Gaussian-process-based MPC, and data-enabled predictive control (DeePC) and selection of the most suitable approach for the MMC.
- Design and implementation of the chosen scheme for the MMC.
- Benchmark against the nominal MPC of the MMC.
- Implementation of the proposed algorithms in Matlab & Simulink.
- Experimental validation on the real setup (see figure 2).

Leonardo Testa, M.Sc.

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What we offer

- Work on a real MMC testbench: your algorithm runs on actual hardware, not only in simulation.
- Results can form the basis for a scientific publication.
- Dedicated student workplaces right next to the lab.
- Learning from data is a growing field; you gain identification and machine-learning skills that are in demand far beyond power electronics.
- Start date is flexible.

Prerequisites

- Strong background in control engineering and in linear algebra.
- Experience with Matlab & Simulink.
- Interest in system identification and machine learning, and willingness to work on a topic that is still an active research field.

Contact and further information

- The thesis can be written in English or German.
- Supervision by Leonardo Testa, M.Sc., with weekly meetings.

For questions and application contact Leonardo Testa, M.Sc. (leonardo.testa@hm.edu).

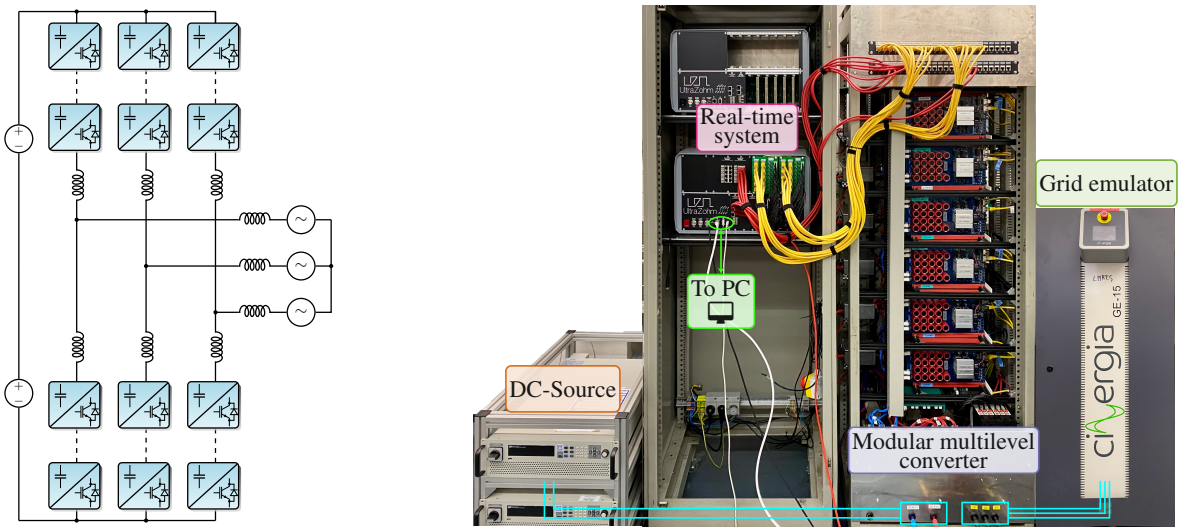

Figure 2: MMC schematic and testbench