Gaussian Process based Model Predictive Control for a PEM Fuel Cell

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Projektseminar (2-4 Personen, Homeoffice)

Fuel cell starvation shortens the life span of a fuel cell and can lead to irreversible degradation of its performance over time. In [1] the authors use a model predictive controller to prevent fuel cell starvation during load changes. However, modeling a fuel cell is very challenging. Often, the model cannot capture the real behavior of the system well enough for use in a model predictive controller. Moreover, disturbances and uncertainties further degrade the predictive quality of the model.

A Gaussian process [2] is a machine learning technique, which can be used for regression and to capture uncertainties based on available data. The goal of this project is to investigate how Gaussian processes can be used to improve a model predictive controller for the fuel cell, despite disturbances and uncertainties.

$$2\,H_2 + O_2 \longrightarrow 2\,H_2O$$

Requirements:

- Matlab or Python, model predictive control (MPC), multivariate Gaussian distribution (implementations preferably with ACADO, HILO-MPC or CasADi)

Your tasks will be:

- Understand and implement the fuel cell model

- Nominal nonlinear model predictive control to prevent fuel cell starvation

- Control of the uncertain or disturbed fuel cell using Gaussian process based MPC

- Evaluate, compare and present the results
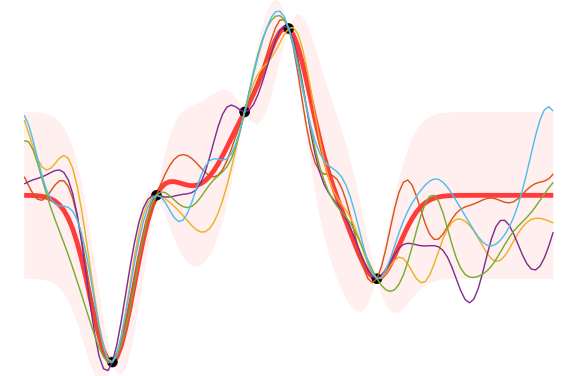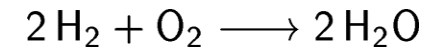
References:
[1] M. A. Danzer, S. J. Wittmann, and E. P. Hofer. Prevention of fuel cell starvation by model predictive control of pressure, excess ratio, and current. Journal of Power Sources. https://doi.org/10.1016/j.jpowsour.2008.12.089

[2] Mark Ebden. Gaussian processes: A quick introduction. https://arxiv.org/abs/1505.02965.

M. Sc. Alexander Rose

E-Mail: alexander.rose@iat.tu-darmstadt.de
Web: http://www.rtm.tu-darmstadt.de

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