Model Predictive Control for the Modified Quadruple Tank System

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Abstract

In this paper, we present in a tutorial fashion the implementation of Model Predictive Control (MPC) on a virtual model of the modified quadruple tank system. The modified quadruple tank system is an example of a multi-input-multi-output (MIMO) system with known and unknown disturbances. Model Predictive Control is well known for its ability to deal with multivariable and complex control problems, to handle constraints such as actuator limitations and to provide the solution in a systematic way. Due to these advantages, MPC is suitable for a MIMO-system with complex interactions between the manipulated and the controlled variables. In this paper, we use the modified quadruple tank system as an example to present the implementation of a Model Predictive Controller for a system whose features resembles industrial systems. As such the paper is an example of the implementation of an advances process control strategy. The starting point for the development of the MPC is an already existing simulation model of the modified quadruple tank system. The dynamics of this system of stochastic differential equations is represented in the MPC using a deterministic-stochastic linear transfer function model. The deterministic-stochastic linear transfer function model is realized as a discrete-time state space model that has a deterministic and a stochastic component. The MPC consists of a state estimator and a constrained regulator. The state estimator is a Kalman filter that estimates the current (filtered) state of the system based on the model and the measurements. The predictions in the Kalman filter are used by constrained regulator to predict the future output trajectory given an input trajectory. The constrained regulator is an optimal control problem (OCP). The objective of the OCP consists of a tracking error term that penalizes deviations of the predicted outputs from the setpoint and a regularization term that penalizes the changes in the inputs (manipulated variables). The resulting OCP is represented as a QP that can be solved efficiently in real-time. Simulations demonstrate the performance of the MPC for the modified quadruple tank system.

Keywords: Model Predictive Control, Four Tank System, MIMO, Kalman Filter, Simulation for Control and Optimization

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