On Application Oriented Experiment Design for Closed-loop System Identification

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Abstract

System identification concerns how to construct mathematical models of dynamic systems based on experimental data. A very important application of system identification is in model-based control design. In such applications it is often possible to externally excite the system during the data collection experiment. The properties of the exciting input signal influence the quality of the identified model, and well-designed input signals can reduce both the experimental time and effort. The objective of this thesis is to develop algorithms and theory for minimum cost experiment design for system identification while guaranteeing that the estimated model results in an acceptable control performance. We will use the framework of application oriented Optimal Input Design (OID). First, we study how to find a convex approximation of the set of models that results in acceptable control performance. The main contribution is analytical methods to determine application sets for controllers with no explicit control law, for instance Model Predictive Control (MPC). The application oriented OID problem is then formulated in time domain to enable the handling of signals constraints, which often comes from the physical limitations on the plant and actuators. The framework is the extended to closed-loopsystems. Here two different cases are considered. The first case assumes that the plant is controlled by a general (either linear or non-linear) but known controller. The main contribution here is a method to design an external stationary signal via graph theory such that the identification requirements and signal constraints are satisfied. In the second case application oriented OID problem is studied for MPC. The proposed approach here is a modification of a results where the experiment design requirements are integrated to the MPC as a constraint. The main idea is to back off from the identification requirements when the control requirements are violating from their acceptable bounds. We evaluate the effectiveness of all the proposed algorithms by several simulation examples.

Key Words
system identification, closed-loop identification, experiment design for identification