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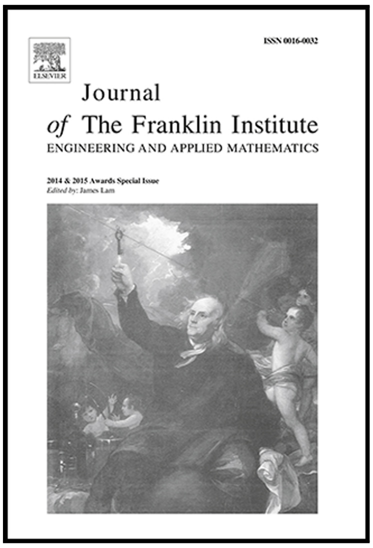

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Data-driven Subspace Predictive Control: Stability and Horizon Tuning

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Abstract

Data-driven Subspace Predictive Control (SPC) is an advanced model-free process control strategy in the presence of system constraints. Efficient implementation of SPC requires appropriate tuning of the controller horizons, which are called Prediction Horizon and Control Horizon. This tuning is a critical step to guarantee the SPC closed-loop stability and to enhance the closed-loop performance and robustness. In this paper we propose an optimal tuning method for unconstrained SPC, which can guarantee stability, computational efficiency and optimality of the unconstrained SPC closed-loop system and is applicable to non-minimum phase open-loop stable or marginally stable systems. Derivation of general form of closed-loop transfer function for unconstrained SPC, and providing a necessary and sufficient condition of the closed-loop stability is the primary contribution of this work. In addition, the stability analysis enabled us to propose an algorithm to determine the shortest-feasible-prediction-horizon and the feasible range of prediction horizon. Consequently, these results are used in proposing a new algorithm to determine the SPC horizons in optimal manner. Simulation results illustrate effectiveness and importance of our proposed stability analysis and horizons tuning algorithm for unconstrained SPC.

Keywords: Data-driven approach; Subspace predictive control; Stability; Optimal SPC Horizons; Prediction Horizon; Control Horizon.

1. Introduction

Data-driven Subspace Predictive Control (SPC) is one of the most popular predictive control strategies in industry over the past decade [1–4]. SPC was first introduced in [5], and it is based on the combination of subspace predictor and Model Predictive Control (MPC) algorithm. In SPC the subspace predictor matrices are obtained directly from the experimental input-output (I/O) data by using the subspace matrices, which eliminates the intermediate parametric model identification step. Therefore, SPC is called a *model-free* or *data-driven* approach. Some features of SPC, such as no pre-assumptions about the system model and calculation of prediction matrices without iteration and solving Diophantine equation are advantages of SPC in practical applications [2, 6].

MPC and SPC have same cost function and tuning parameters that includes prediction horizon, which shows number of sample times requires to estimate the future output, control horizon that is the number of sample times to calculate the optimal control signal sequence, and weighting matrices to penalty the tracking error and the control signal. Appropriate choice of these parameters can significantly influence the closed-loop stability, performance and robustness. Poor tuning of these parameters makes the closed-loop system more sensitive to changes in system parameters, noise and disturbances. There are extensive studies in the literature that provide several tuning strategies for MPC [7–10], and a survey of tuning methods was provided in [11]. However, existing a complex interaction between the system and controller parameters, and desired performance and stability

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