Reduced-Order Adaptive Output Predictors for a Class of Uncertain Dynamical Systems

Roghaiyeh Ansari
Ph.D. student of Mechanical Engineering
rhansari@vt.edu

Abstract: When the structure of the plant is known, but parameters are changing due to aging issues, or operating conditions, offline techniques can be ineffective for parameter estimation. The online parameter estimation schemes are beneficial to provide a frequent estimate of the parameters. For many processes (e.g., chemical plants, biological systems, nuclear reactors), the order of the model is quite large or unknown, and only signals available are the input and output. Filtering each side of input and output with an nth-order filter, equal to the order of the system dynamics, is one way to avoid the problem. In this situation, control approaches for unknown models rely on a predictor.

The overarching goal of this research is to present a reduced-order adaptive output predictor for the minimum phase LTI SISO unknown system to simplify the controller design for complex unknown or high-order models. This output predictor uses only the history of the system input and output stored in autoregressive filtered vectors to encapsulating a complex unknown model in a simple known virtual structure such that output tracking control for the unknown system becomes equivalent to constructing a tracking control for the predictor, which is a known virtual system. This approach makes designing and implementing the controller more straightforward and helps to avoid numerical difficulties in digital processing. The exponential stability of the prediction error and ultimate boundedness of the tracking error is proven by using the Lyapunov method. Moreover, the proposed predictor is analytically and experimentally verified using the double pendulum and single pendulum output tracking problem. The numerical and experimental studies demonstrate that the proposed reduced-order adaptive output predictor scheme can track the output when the parameters and order of the model are unknown.

Acknowledgement: This work was partly supported by Sponsor 1 Grant no. 1604279.