Data-driven modeling of parametric dynamical systems

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Abstract

Dynamical systems are a principal tool in the modeling, prediction, and control of physical phenomena with applications ranging from structural health monitoring to electrical power network dynamics, from heat dissipation in complex microelectronic devices to vibration suppression in large wind turbines. Direct numerical simulation of these mathematical models may be the only possibility for accurate prediction or control of such complex phenomena. However, in many instances, a high-fidelity mathematical model describing the dynamics is not readily available. Instead, one has access to an abundant amount of input/output data via either experimental measurements or a black-box simulation. The goal of data-driven modeling is, then, to accurately model the underlying dynamics using input/output data only.

In many situations, the equations representing the underlying dynamics depend on a set of parameters. These parameters may enter the models in many ways, representing, for example, material properties, system geometry, system configuration, initial conditions, and boundary conditions. The goal in such cases is to generate parametric data-driven models that accurately approximate the system dynamics over a range of parameters. In this talk, we will investigate various approaches to data-driven modeling of parametric dynamical systems using systems-theoretical concepts. We will start with the basics of the interpolation theory and barycentric forms of rational approximants for non-parametric systems and then extend this theory to the parametric case. We will illustrate the analysis via various examples ranging from structural dynamics to microelectromechanical systems.

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