DATA-DRIVEN MODEL PREDICTIVE CONTROL OF PLASMA EDGE SIMULATIONS USING SOLPS-ITER

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Abstract

Reduced models of the tokamak plasma edge are derived from time-dependent SOLPS-ITER simulations using interpretable data-driven methods. The efficient computation of these reduced solutions facilitates a framework for model predictive control of upstream and downstream divertor conditions. The simulated plasma boundary is actuated by virtual main ion and impurity gas puffs based on predictions obtained from the dynamic mode decomposition (DMD) and the Sparse Identification of Nonlinear Dynamics (SINDy) techniques. We extract equations governing the time evolution of the plasma state from an expansive database of transport runs configured to the DIII-D experiment. A survey of actuation sequences is used to probe system response allowing for successful identification of the dynamics. We develop an automated algorithm to enable training and testing of reduced models capable of a prediction horizon within a cross-validated error threshold. In this presentation we demonstrate an offline evaluation of model predictive control of the computationally expensive SOLPS-ITER code leveraging the inexpensive DMD and SINDy procedures. We show that an optimal actuation sequence required to produce a target trajectory can be determined for static and variable setpoints, subject to physical constraints on the input and output signals. Good agreement is found between feedforward control of SOLPS-ITER with gas puff actuators and the dynamics of the upstream separatrix density. In addition, modifications to DMD and SINDy allow adequate control of the noisy downstream divertor target temperature. The presented data-driven approach to model predictive control is being validated against analytic and empirical correlations of key observables from experiments for online implementation in future devices.

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