Data driven feedback control of nonlinear PDEs using the Koopman operator

Dr Sebastian Peitz

University of Paderborn

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Abstract:

In this talk we present a data driven reduced order modeling approach for control of nonlinear PDEs which relies on the Koopman operator. We construct a surrogate model for observations of the system state which can be incorporated in an MPC framework. Two different approaches are considered. In the first one, the dynamic control system is replaced by a finite set of autonomous systems with constant control inputs, which transforms the control problem into a switching time problem. For each of these systems, the Koopman operator is approximated individually. Alternatively, for systems depending linearly on the input, we can construct a bilinear surrogate model by interpolating between two Koopman operators for constant inputs. Using a recent convergence result for Extended Dynamic Mode Decomposition, convergence of the reduced order model based control problem towards the true optimum can be shown. The resulting feedback controller is applied to several examples such as the 1D Burgers equation and the 2D Navier-Stokes equations. Furthermore, experiments with an electrical drive demonstrate the practical use of the approach.