MAX-PLANCK-INSTITUT
FÜR DYNAMIK KOMPLEXER
TECHNISCHER SYSTEME
MAGDEBURG

CSC Seminar

SPEAKER

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TITLE

GAMM test talk: Application of operator inference to reduced-order modeling of constrained mechanical systems

ABSTRACT

Constrained mechanical systems occur in many applications, such as modeling of robots and other multibody systems. In this case, the motion is governed by a system of differential-algebraic equations (DAE), often with large and sparse system matrices. The problem dimension strongly influences the effectiveness of simulations for system analysis, optimization, and control, given limited computational resources. Therefore, we aim to obtain a simplified surrogate model with a small number of states that is able to accurately represent the motion and other important properties of the original high-dimensional DAE model. Classical model reduction methods intrusively exploit the system matrices to construct the projection of the high-fidelity model onto a low-dimensional subspace. In practice, the dynamical equations are often an inaccessible part of proprietary softwares, i.e., there is a need for equivalent model-free reduction approaches to generate reduced models using only accessible simulation data. In this work, we show an application of the non-intrusive operator inference (OpInf) method to DAE systems of index 1, 2, and 3. Considering the fact that for proper DAEs there exists an ODE realization on the so-called hidden manifold, the OpInf optimization problem directly provides the underlying ODE representation of the given DAE system in the reduced subspace. An important advantage is that only the DAE solution snapshots in a compressed form are required for identification of the reduced system matrices. Stability and interpretability of the reduced-order model is guaranteed by enforcing the symmetric positive definite structure of the system operators using semidefinite programming. The numerical results show the implementation of the proposed methodology for different examples of constrained mechanical systems, tested for various loading conditions.

Tuesday, April 1, 2025 at 2 pm

seminar room Prigogine