Space-Time Finite Elements and Model Order Reduction

Max von Danwitz[1] Fabian Key[2] Norbert Hosters[3] Marek Behr[4]

Space-time finite element methods provide a combined discretization of space and time for the numerical solution of partial differential equations (PDEs). In this contribution, we study space-time discretizations for time-dependent scalar transport and flow problems.

As a prototype test, the convergence behavior of time-discontinuous space-time finite element methods is numerically investigated for a scalar advection-diffusion model problem. Therein, the model parameter choices include the parabolic and hyperbolic limit cases. The computational error analysis demonstrates temporal superconvergence of prismatic space-time finite elements for parabolic problems [1].

After tests of the prototype, this contribution focuses on heat flux and fluid flow applications with simplex space-time meshes [2]. For such applications, there is a large demand for solutions that are fast to evaluate with limited computational power, yet, lay within reasonable accuracy bounds. E.g., in the context of digital twins, fast-to-evaluate models are required to interact with sensor data of the real system under consideration. To address this issue, a reduced-order model (ROM) can be obtained through the application of a projection-based Model Order Reduction (MOR) approach [3]. We report first results of a MOR approach for deforming domain problems based on space-time finite elements.

References:

[1] https://arxiv.org/pdf/2206.01423.pdf

[2] https://onlinelibrary.wiley.com/doi/epdf/10.1002/fld.4743

[3] https://onlinelibrary.wiley.com/doi/epdf/10.1002/pamm.202100071

[1]University of the Bundeswehr Munich, Institute for Mathematics and Computer-Based Simulation (IMCS), Munich, Germany
max.danwitz@unibw.de

[2]TU Wien, Institute of Lightweight Design and Structural Biomechanics (ILSB), Vienna, Austria
key@ilsb.tuwien.ac.at

[3]RWTH Aachen University, Chair for Computational Analysis of Technical Systems (CATS), Aachen, Germany
hosters@cats.rwth-aachen.de

[4]RWTH Aachen University, Chair for Computational Analysis of Technical Systems (CATS), Aachen, Germany
behr@cats.rwth-aachen.de