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Effects of discretization on reducibility for PDE models with variable geometry: a preliminary study

Sander Dedoncker[1,2], Frank Naets[1,2], Elke Deckers[1,2] and Wim Desmet[1,2]

[1] KU Leuven, Department of Mechanical Engineering, Division PMA
Celestijnenlaan 300, B-3001 Leuven, Belgium.
e-mail: sander.dedoncker@kuleuven.be
[2] Member of Flanders Make.

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Despite the increasingly large processing power offered by modern computing platforms, the use of models based on parameterized partial differential equations (PDEs) remains a challenge, especially in multi-query settings. In order to reduce computational costs, parametric model order reduction (PMOR) techniques [1] have been developed. In principle, these methods allow considering the geometry as a parameter, but special care is needed in this case since the discretization needs to be adapted to the varying domain geometry. It is intuitively clear that, for projective PMOR techniques to be effective, the physical significance of each discrete variable should remain relatively constant. Presently, we aim to investigate how the choice of discretization – both on a geometric level and in terms of approximation space – can affect the reducibility of the resulting parametrized models. Of particular interest are isogeometric (IG) methods [2]: improved performance is expected due to the tight integration between geometry and analysis models.

The influence of the chosen approximation space and domain parameterization is empirically studied by defining a number of linear dynamic test cases for which both IG and conventional finite-element (FE) models are implemented. The FE method is supplemented with a mesh morphing strategy to preserve mesh topology under changing geometry. We sample the parametric domain and approximate the dimensionality of the underlying solution manifold using the singular values of the snapshot matrix. We also compute local reduction spaces and see how their union performs for the reduction of unsampled parameter points. Preliminary results indicate that IG methods indeed lead to lower-dimensional manifolds and hence higher reducibility.

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