Proper orthogonal decomposition and discrete empirical interpolation in CFD applications

Martin Isoz*

Institute of Thermomechanics, Czech Academy of Sciences
Dolejskova 1402/5, 182 00 Prague 8, Czech Republic
isozm@it.cas.cz

ABSTRACT

Current progress in numerical methods and available computational power combined with industrial needs promote the development of more and more complex models. However, such models are, due to their complexity, expensive from the point of view of the data storage and the time necessary for their evaluation. The model order reduction (MOR) seeks to reduce the computational complexity of large scale models. We present an application of MOR to the problems originating in the finite volume (FV) discretization of incompressible Navier-Stokes equations. Our approach to MOR is based on the proper orthogonal decomposition (POD) with Galerking projection. Moreover, the problems arising from the nonlinearities present in the original model are adressed within the framework of the discrete empirical interpolation method (DEIM). We provide a link between the POD-DEIM based MOR and OpenFOAM, which is an open-source CFD toolbox capable of solving even industrial scale problems. The availability of a link between OpenFOAM and POD-DEIM based MOR enables a direct order reduction for large scale systems originating in the industrial practice.

Acknowledgments:
The work of M. Isoz was supported by the Centre of Excellence for nonlinear dynamic behaviour of advanced materials in engineering CZ.02.1.01/0.0/0.0/15/003/0000493 (Excellent Research Teams) in the framework of Operational Programme Research, Development and Education. Moreover, the author thankfully acknowledges financial support from IGA of UCT Prague, grant numbers A2_FTOP_2016_024 and A1_FCHI_2016_004 and from the Czech Science Foundation, grant number GACR 13-01251S. Also, the author would like to express his deepest thanks to the Mass Transfer Laboratory of UCT Prague for providing theirs, yet unpublished, experimental data for the model validation. Last, but not least, the author would like to thank Michael Hinze from the University Hamburg for many helpful discussions on the proper orthogonal decomposition.

References

[1] S. Chaturantabut and D. C. Sorensen. Nonlinear model reduction via discrete empirical interpolation. *SIAM J. Sci. Comp.*, 32:2737–2764, 2010.
[2] R. Pinnau. Model reduction via Proper Orthogonal Decomposition. In W. H. A. Schilders, H. A. van der Vorst, and J. Rommes, editors, *Model order reduction: theory, research aspects and applications*, chapter 2, pages 95–109. Springer Berlin Heidelberg, Berlin, Germany, 2008.
[3] S. Volkwein. *Proper orthogonal decomposition: theory and reduced-order modelling*. Univer- stity of Konstanz, Konstanz, Germany, 1 edition, 2013.