Model order reduction approach for problems with moving discontinuous features

Harshit Bansal
Department of Mathematics and Computer Science, Eindhoven University of Technology
bansalharshitiit@gmail.com

Stephan Rave
Applied Mathematics, University of Muenster
stephanrave@uni-muenster.de

Laura Iapichino
Department of Mathematics and Computer Science, Eindhoven University of Technology
l.iapichino@tue.nl

Wil Schilders
Department of Mathematics and Computer Science, Eindhoven University of Technology
w.h.a.schilders@tue.nl

Nathan van de Wouw
Department of Mechanical Engineering, Eindhoven University of Technology
n.v.d.wouw@tue.nl

The motivation of this work is to enable the usage of multi-phase hydraulic models, such as the Drift Flux Model (DFM) [1], in developing automation strategies for real-time down-hole pressure management in drilling systems. The DFM is a system of multi-scale non-linear hyperbolic Partial Differential Equations (PDEs) and its response is dominated by wave propagation characteristics. The central aim of this work is to accurately capture wave-front propagation (and wave interaction) phenomena (induced by slow or fast transients) in a reduced-order modeling framework.

Moving discontinuities (shock-fronts) are representative features of the models governed by hyperbolic PDEs. Such features pose a major hindrance to obtain effective reduced-order model representations [2]. This motivates us to investigate and propose efficient, advanced, and automated approaches to obtain reduced models, while still guaranteeing the accurate approximation of wave propagation phenomena.

RATIONAL APPROXIMATION FOR DATA-DRIVEN MODELING AND COMPLEXITY REDUCTION OF LINEAR AND NONLINEAR DYNAMICAL SYSTEMS (MS - ID 69)

We propose a new model order reduction (MOR) approach to obtain an effective reduction for transport-dominated problems or hyperbolic PDEs. The main ingredient is a novel decomposition of the solution into a function that tracks the evolving discontinuity and a residual part that is devoid of shock features. This decomposition ansatz is then combined with Proper Orthogonal Decomposition applied to the residual part only to develop an efficient reduced-order model representation for problems with multiple moving and possibly merging discontinuous features. Numerical case studies show the potential of the approach in terms of computational accuracy compared with standard MOR techniques.

REFERENCES

[1] S. Evje and K. K. Fjelde. Hybrid Flux-Splitting Schemes for a Two-Phase Flow Model. Journal of Computational Physics, 175(2):674–701, 2002.

[2] M. Ohlberger and S. Rave, Reduced basis methods: Success, limitations and future challenges, Proceedings of the Conference Algoritmy, 2016.