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Nonlinear model reduction for one-dimensional solidification process in additive manufacturing

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Due to the notable potentials of additive manufacturing (AM), the interest in AM has risen significantly across several industries during the past decade. One of the key factors governing the mechanical properties of an additively-manufactured part is the solidification microstructure. However, the spatial and temporal resolution required for the simulation of the solidification process is several orders of magnitude smaller than the dimensions of the final part imposing infeasibly high computational expenses on the simulations. Model order reduction can potentially help reduce this computational burden and allow for the development of microstructure-aware models at part scale. We have developed a projection-based model reduction for a one-dimensional solidification model consisting of the phase-field equation for the order parameter coupled with the heat equation. The inherent nonlinearity of the full model is accounted for by lifting transformations to expose a polynomial structure where the operators of the ROM for the lifted model are learned non-intrusively using the operator inference method (OpInf). Owing to the non-intrusive nature of OpInf, the lifted form need not be discretized and solved, and its ROM operators are learned from snapshots of the original full model.

Primary author: KHODABAKHSHI, Parisa (Oden Institute for Computational Engineering and Sciences, UT Austin)

Co-author: WILLCOX, Karen (Oden Institute for Computational Engineering and Sciences, UT Austin)

Presenter: KHODABAKHSHI, Parisa (Oden Institute for Computational Engineering and Sciences, UT Austin)

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