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Adaptation of multi-fidelity optimization schemes to nonlinear structural dynamics applications

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Optimization schemes based on surrogate models for problems with expensive blackbox objective functions have been around for many years [1]. More recently, the idea of multi-fidelity schemes was introduced, where the simulation model - then called high-fidelity model - is complemented with a less accurate but much cheaper low-fidelity model. Both models are then used together to build a multi-fidelity surrogate model. Using rather new multi-fidelity infill criteria, the model can adaptively be improved through both high- and low-fidelity evaluations to obtain sufficient results with lower computational effort (e.g. [2]).
One challenge in multi-fidelity optimization is the choice of low-fidelity model. In literature, different approaches have been suggested, the most common being the use of a simulation model with coarser spatial and/or temporal discretization. Along with this popular variant, we investigate other techniques such as the use of projection-based non-intrusive reduced order modeling (ROM) methods as low-fidelity models. Compared to the former, these methods require initial training time but are usually much faster evaluated.
One essential component of each population-based optimization is some form of initial design of experiments (DoE). Surrogate models and other data-based methods usually perform very well in interpolation but may encounter problems with extrapolation. To that end, we investigate a recently proposed adaptation to the popular Latin hypercube sampling (LHS) that places samples closer to design space boundaries and thus increases the range in which interpolation is realized in surrogate model creation.
In the present work, we aim to investigate performance of multi-fidelity optimization schemes in challenging nonlinear structural dynamic applications such as automotive crashworthiness or sheet metal forming. We compare them to single-fidelity optimization schemes and apply the adjustments described above.

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