Component wise hyperreduction in nonlinear mechanics

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Abstract

Many mechanical systems consist of substructures. This holds the potential for model order reduction, if these substructures are used multiple times in different mechanical systems, or are repeated in the same structure. In our method, we reduce the number of degrees of freedom of each substructure independent of the other substructures and assemble them to the global reduced mechanical system.
The model order reduction method consists of two parts. The first part is the hyperreduction of the substructures, where we use energy conserving sampling and weighting (ECSW) with a projection matrix computed by proper orthogonal decomposition (POD). The second part is the connection of the components to form a global system. Here we use a mortar tied contact formulation, which enables us to connect components with non-matching meshes. A further advantage is that the Lagrange multipliers can be removed from the equation system by static condensation, by choosing dual shape functions for the Lagrange multipliers.
The substructure projection matrices are computed from snapshots of the substructure. The snapshots can be computed directly with the substructure or with a small subsystem that includes the substructure to be trained. The computed projection matrices are stored and can be used in different mechanical systems under varying loading conditions.
We apply the method to nonlinear mechanical simulations involving plasticity, viscoelasticity, and geometric nonlinearities.

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