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EFFICIENT DIMENSIONAL REDUCTION OF NONLINEAR FINITE ELEMENT MODELS

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This work presents a rigorous approach for efficiently reducing the complexity of general, parametrized nonlinear finite element models. The first step in this approach consists in the standard Galerkin projection of the semi-discrete motion equations onto a reduced-order space. The basis for this reduced-order space is determined by processing pre-computed displacement solutions using the Singular Value Decomposition (SVD), in order to identify the dominant displacement modes of the problem, which will constitute the desired reduced basis.

The second step of the approach concerns the reduction in complexity of the vector of internal forces. Although the number of entries of this vector has been already reduced, its complexity still depends on the number of finite element integration points. The key for reducing the complexity of this vector lies in the decomposition of this internal force vector into the product of a parameter-independent matrix of strain modes and a parameter-dependent vector of global stresses. The reduction in complexity is achieved by replacing this global stress vector by a low-dimensional interpolant. To construct the basis matrix for this interpolant, we solve the projected motion equations for representative input parameters, and then process the resulting stress solutions, using the SVD, to uncover the dominant stress modes of the problem. The basis matrix for the interpolation, however, cannot be solely formed by these dominant stress modes, for it gives rise to ill-posed problems. We demonstrate that, to amend this shortcoming, one has to include also the reduced strain modes obtained in the decomposition of the internal forces (see Ref. [1]).

[1] Hernández, J., Oliver, J., Huespe, A., Caicedo, M., Cante, J., 2014. High-performance model reduction techniques in computational multiscale homogenization. Computer Methods in Applied Mechanics and Engineering 276, 149–189.