11th World Congress on Computational Mechanics (WCCM XI)
5th European Conference on Computational Mechanics (ECCM V)
6th European Conference on Computational Fluid Dynamics (ECFD VI)
July 20–25, 2014, Barcelona, Spain

ECSW: AN ENERGY-CONSERVING SAMPLING AND WEIGHTING METHOD FOR THE HYPER REDUCTION OF DISCRETE NONLINEAR FINITE ELEMENT MODELS

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Key words: *Hyper Reduction, Nonlinear Model Reduction, Sampling*

The computational efficiency of a typical projection-based nonlinear model reduction method hinges on the efficient approximation, for explicit computations, of the projection onto a subspace of a discrete residual vector. For implicit computations, it also hinges on an additional efficient approximation of a similar projection of the Jacobian of this residual with respect to the discrete solution. The computation of both approximations is often referred to in the literature as hyper reduction. To this effect, this talk presents ECSW, an Energy-Conserving Sampling and Weighting method for the hyper reduction of nonlinear finite element dynamic models. ECSW is based on mesh sampling and the principle of virtual work. It preserves an energetic aspect of the underlying discrete high-dimensional finite element model that guarantees it to preserve the numerical stability of this model. The talk also includes an accuracy analysis of ECSW that highlights its reliability. This proposed hyper reduction method is first demonstrated for a set of academic but nevertheless challenging nonlinear dynamic response problems taken from the literature. Its obtained performance is compared to that of the Discrete Empirical Interpolation Method (DEIM) and its unassembled variant UDEIM. Next, the potential of ECSW for the solution in near real-time of complex problems is highlighted with the realistic simulation of the transient response of a generic V-hull vehicle to an underbody blast event. For this problem, ECSW is shown to deliver an excellent level of accuracy while enabling the reduction of CPU time by more than four orders of magnitude.