Efficient Multiscale Modelling of Path Dependent Problems

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ABSTRACT

Multiscale methods are nowadays widespread in computational mechanics. Use of different kinds of methods is limited with specifications of the problem that we want to solve. If the difference between two scales is finite, or in the region of high gradients, standard two level finite element homogenization approach FE^2 fails, then some sort of domain decomposition method can be applied. We implemented one of such methods, that was described by Markovič and Ibrahimbegović in [1], with use of sensitivity analysis. Method is called MIEL, Mesh inside Element Method.

For automation of the FE^2 multiscale scheme first order sensitivity analysis is sufficient for an arbitrary nonlinear, time dependent and coupled problem and was described by Šolinc in [2], whereas sensitivity analysis based automation of MIEL scheme requires second order sensitivity analysis. Correct sensitivity analysis of coupled path dependent problems [3] is performed at the micro level, leading to the macro tangent that is algorithmically consistent with the path following procedure at the micro level.

Idea was, creation of computational environment, where the multiscale code is automatically derived and various types of multiscale approaches can be freely mixed. Described method uses an advanced feature of software tools AceGen and AceFEM [4], that is automatic generation of the finite element codes for analytical first and second order sensitivity analysis based on automatic differentiation. The automatic-differentiation-based (ADB) formulation enables unification and automation of various multiscale approaches for an arbitrary nonlinear, time dependent coupled problem (e.g. general finite strain plasticity).

Presented multiscale computational environment is fully parallelized for multi-core processors. Micro problems are distributed on kernels in a way that each individual micro problem is always evaluated at the same kernel. With parallelization computational time is significantly reduced and more complex problems can be solved.

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