Technische Universität Braunschweig

MUSEN

Concurrent multiscale methods in nonlinear-structural mechanics and applications

Lecture of

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The reliable simulation of many engineering structures requires very large-scale computations that can only be conducted on parallel machines. Unfortunately, in the case of highly nonlinear static problems, it is common to observe a deterioration of the convergence of parallel algorithms when increasing the number of cores which can even lead to extending the duration of the computation. The research of effective parallel strategies enabling an efficient use of massively parallel computers is therefore an area of interest for the computational mechanics community.

In all parallel strategies the efficiency, i.e., extensibility, can be obtained if pertinent information is transmitted between the subdomains, which we call here macro-information. The question is now well mastered for most linear problem thanks to BDD [1] or FETI [2] approaches by adding pertinent constraints [13] in the preconditioned conjugate gradient or GMRES strategies. This can be done more explicitly in the micro-macro two-scale strategy proposed in [3-4].

For non-linear problems the classical linearization method leads to solve many linear problem even when the non-linearity is not well balanced [5]. Moreover, the macro-information to be transmitted depends on the state of the structure, two possible explanations to the observed deceptive results already mentioned. Our attempt to circumvent those difficulties involves three main aspects: the enrichment of the macro basis depending on the problem in hand, the nonlinear relocalization technique which aims to automatically iterating only where and when necessary, the approximation of the Schur complement of each substructures to efficiently use the mixed aspect of the micro-macro strategy proposed in [4-5].

Several examples will serve to discuss those ideas:
- the Multiscale Extended Finite Element Method (MSXFEM) [6],
- the non-linear relocalization approach used to deal with both geometrical [7-8] and material nonlinearities as delamination [9-10] and their interaction [11] in a parallel framework,
- a two-scale approximation of the Schur complement whose efficiency has been demonstrated in the case of non-intrusive coupling [12] and the importance of a correct and low-cost of this operator in a DDM framework.

These examples will also serve to discuss open issues and in particular the question of the use of such approaches within industrial software.