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Domain decomposition method for nonlinear multiscale analysis of structures

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ABSTRACT

In this presentation we consider efficient numerical strategies designed to compute the evolution of large structures undergoing localized nonlinear phenomena such as plasticity, damage, cracking or microbuckling. Despite Newton-Schur-Krylov strategies which associate both Newton type solvers and domain decomposition methods (and especially non-overlapping ones [1,2]) provide an efficient framework for the solution to large systems, in the case of localized nonlinearity the global convergence of the problem may be penalized, leading to the solution to many global systems. Moreover localized nonlinearities often come with other difficulties such as the necessity to adapt the mesh and the time stepping.

In order to improve the computational handling of the localized nonlinearity we introduce new approaches bringing back the solution to the nonlinear problems from the global scale to a local scale. Our strategy is based on a nonlinear domain decomposition method. To reduce meshing and remeshing problems we decide to use an overlapping domain decomposition. The decomposition is introduced via a partition of the unity applied to the global energy [3]. By this way, we can separate nonlinear zones from linear ones and use a local fine mesh and a global coarse one, we can also refine the local mesh without modifying the global mesh. Coupling conditions between the subdomains are imposed via an augmented Lagrangian. The computational strategy is based on the introduction of a nonlinear Steklov-Poincaré operator to condense the problem on the interface. The arising nonlinear interface problem is solved by a Newton-Raphson method.

Then, an iteration of the Newton-Raphson solver is equivalent to the solution to a tangential interface problem and to a set of nonlinear subdomain-by-subdomain problems. The first stage is solved by a classical Krylov solver as in linear domain decomposition methods and the second one by a Newton type local solver. The choice of the augmentation operator enables to improve the convergence by giving more pertinence to the nonlinear sub-iterations and to avoid the apparition of non-physical instabilities during these iterations.

A class of non-overlapping domain decomposition methods close to the one proposed in [4] can be obtained as the limit case of our strategy when the overlap goes to zero.

Examples will be given in the cases where the nonlinearity is geometric or due to the constitutive law (elastoplasticity). Diffused and localized nonlinearity will be considered. Both overlapping or non-overlapping strategies will be assessed.

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