

Strongly parallel methods for numerical simulation in nonlinear structural mechanics

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ABSTRACT

A current technique to solve large nonlinear mechanics systems of equations in parallel combines a Newton algorithm and a linear domain decomposition (DD) approach. This process is not always optimal, especially in the case of localized nonlinearity. Indeed, DD is only used here to solve Newton's tangent system, which does not take into account the linear or nonlinear behavior of each subdomain. In this context, a better way for capitalizing the parallelization technique would be to use DD approach for both nonlinear and tangent problems.

Starting from this consideration, we propose a new resolution process, which decomposes the global nonlinear large-scale problem in several little nonlinear subproblems, corresponding to subdomains' equilibriums [1]. These subproblems are solved independently, and connected by the interface continuity conditions.

The latter system is solved by a global interface Newton algorithm, while local Newton algorithms are applied for substructures' equilibriums. From these local resolutions, tangent operators are computed, as well as the nonlinear interface global residual, which are the two necessary ingredients for building the tangent problem of the global interface Newton's algorithm. A classic linear version of DD approach is then used to solve this tangent system, through a Krylov solver.

The interest of such algorithms is to improve the scalability of the DD method by reducing the number of communications between subdomains - and thus, processors. Indeed, when comparing the new approach with the classic one, we observe that the numbers of outer Newton and inner Krylov iterations are reduced at the price of few extra inner independent Newton resolutions.

The presentation will detail the resolution process, show its performances on two test-problems, and present several optimizations that have been theoretically investigated and numerically implemented:

- Synchronization of stopping criteria with global residual to avoid oversolving and reduce communications (framework of inexact Newton algorithms) [2].
- The influence of interface conditions, in particular Robin conditions [3].

References

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