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A Multilevel Technique based on Nested Local Meshes for Nonlinear Mechanics

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In this paper, an adaptive mesh refinement (AMR) method, called the local defect correction (LDC) technique [1] is applied to solids mechanics with the objective of conducting reliable nonlinear studies within acceptable computational times and memory space. This method, devoted to localised phenomena simulation, has stood the test of time in fluid mechanics but is almost unused in other fields of physics. However, as no theoretical reason seems to justify this restriction, it appears worthwhile to extend this approach to solids mechanics. The LDC method consists of recursively generating local nested sub-grids with finer and finer discretisation steps from an initial coarse grid. An iterative process based on prolongation and restriction operators is performed to link the solutions from each grid. As the meshes are no longer data-fitted the theoretical convergence rate is limited. Nevertheless, this limitation appears also in much industrial software that avoids the remeshing technique with the objective of saving CPU time. A Zienkiewicz and Zhu *a posteriori* error estimator [2] is used to automatically detect the local zones to refine.

The test case of this study comes from an industrial situation: the pellet-cladding interaction in pressurised water reactors [3]. During the irradiation, the fuel pellet swells and the cladding creeps and shrinks that induces contact. This phenomenon is very localised. Complete three-dimensional simulations are currently impossible as a result of the required unstructured and irregular mesh. The LDC approach appears to be well suited to overcome this kind of issue.

Our simulations focus on the cladding response. The contact with the pellet is represented by a discontinuous pressure on its internal radius. As this test case is not an academic problem but an industrial one, analytical solutions are generally not available. Our approach is first validated by using a linear behaviour, comparing two and three dimensional local defect correction (LDC) simulations with solutions obtained using very fine global meshes. The expected results are obtained: the final corrected coarse solution is as precise as the solution computed on a unique uniform mesh having a discretisation step equal to the local finest grid one. The LDC approach is also compared with a classical finite element resolution. Using the LDC solver allows CPU time and memory space to be saved. Moreover, this approach is extended to nonlinear behaviour and particularly creep behaviour. The conclusions obtained in the linear validation study are still valid.

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