A parallel dual reciprocity boundary element method implementation for the solution of elastoplastic problems with elastic-plastic domain decomposition

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ABSTRACT

In this study, a dual-reciprocity (DR) boundary element method solution to elastoplasticity problems is considered. In the solution the domain is decomposed into two parts: the elastic part, where the boundary of the region is assumed not to change within time, and the plastic region, where the boundary of the region is subject to change. In the formulation, small strain – small displacement assumption is considered where an updated Lagrangian approach is used to model the deformation. For time integration, forward explicit scheme is considered.

The formulation as well as the implementation is done in 3D space, where the boundary is discretized using triangular elements (constant and linear). Since the elastic domain is considered as non-changing, the system matrices (which arise from the evaluations of the integrals involving first and second fundamental solutions of elastostatics) are constructed once and used along each time step. In the plastic region, a DR formulation is implemented such that, at each time step, a set of system matrices are multiplied to obtain the non-linear contribution to the boundary element equations.

The presented implementation has two parallelisation schemes: firstly, a shared memory (SMP) or a GPU parallelisation is in place for the multiplication of the DR matrices that appear in the solution of the elastic domain. Secondly, parallel solution of the decomposed domains is done using SMP and load balancing. The implementation is done using C++ with several libraries: OpenCL, libFLAME, OpenMP.

Several examples from metal forming applications will be presented and effectiveness and efficiency of the method will be discussed over these examples. In the solutions, Dell R720 Rack server with NUMA architecture is used with 16 physical cores, 384GB RAM and two NVIDIA K40X GPUs.