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ACCELERATED CRACK DETECTION BY SCALED BOUNDARY FINITE ELEMENT METHOD EMPLOYING HYBRID QUADTREES AND GLOBAL OPTIMIZATION ALGORITHMS

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In this work, a novel crack detection scheme combining the scaled boundary finite element method (SBFEM) [1] with global optimization algorithms is presented. Crack detection schemes [2] adopt optimization algorithms for solving the inverse problem of detection by minimizing the discrepancy between the experimentally measured structural response and numerically simulated estimates. The design variables of such optimization procedures typically comprise the parametrized crack geometry and location. The main computational effort in this inverse procedure constitutes the solution of a substantial number of forward problems for different crack geometry realizations.

SBFEM is a semi-analytical variant of the finite element method, wherein an analytical solution in radial direction is obtained. This is achieved by introducing a scaling centre in the domain, effectively transitioning from a cartesian reference system to one resembling polar coordinates. As a result, the dimensionality of the problem is reduced by one. Since only discretization of the boundary in the finite element sense is required, arbitrary star convex domains, e.g., quadtree representations of computational domains are naturally and efficiently treated.

In this work, emphasis is placed on the reduction of the computational cost associated with a single forward analysis to significantly accelerate computational crack detection procedures. This is achieved by exploiting balanced quadtrees, as they result in a finite number of precomputable polygonal element realizations. Since only polygonal elements need be constructed, any issues concerning the treatment of hanging nodes, commonly associated with conventional schemes, is eliminated. Hybrid quadtrees, which result from performing polygon clipping of boundary transition elements, permit coarser discretization, while better approximating the boundary geometry [3]; this further serves to reduce the computational toll. Numerical examples demonstrate that the combination of SBFEM, quadtrees and global optimization algorithms significantly accelerates computation.

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