Boundary element based multiresolution shape optimization in electrostatics

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Abstract:
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We present a multiresolution shape optimization framework based on the boundary element method and subdivision surfaces known from computer graphics. While a fine enough mesh is necessary for the accurate analysis of the primal and adjoint boundary value problems, it is advantageous only to define a handful of design parameters to prevent fast mesh deterioration. The subdivision surfaces allow to represent a smooth surface on a hierarchical set of triangular meshes, which leads to the separation of a fine computational mesh from a coarse design grid. Moreover, an optimum found on a coarse mesh can serve as an initial guess for the problem stated on a finer mesh, which leads to a multilevel method.

Shape calculus used for the computation of sensitivity with respect to the design parameters leads to the Hadamard-Zolésio form of the shape derivative. This makes the boundary element method a useful tool, since no volume mesh has to be constructed.

The presented framework has been implemented in the BEM4I library currently under development at the Czech National Supercomputing Centre IT4Innovations in Ostrava. The library is aimed at HPC environment and utilizes modern programming techniques including in-core vectorization and parallelization in shared and distributed memory. The library provides solvers for the 3D Laplace, Helmholtz, and time-domain wave equations. Moreover, it provides a shape optimization module based on the aforementioned state problems.

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