

SHAPE OPTIMIZATION OF STRUCTURES IN CONTACT

Kenneth E. Swartz, Eric B. Chin, Michael Tupek

Lawrence Livermore National Laboratory

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Abstract

Design optimization of structural components in contact is of great interest to the engineering community, yet little work exists on this topic due to its complexity. These design optimization problems are very challenging due to the large computational cost incurred by finite element contact algorithms, the non-smooth nature of contact interactions, and the numerical difficulties associated with solving these often ill-conditioned problems. This work extends the so-called “parameter-free”, i.e. free form, shape optimization method to handle contact interactions between structures on large 3D meshes. A mortar-penalty contact algorithm implemented in LLNL’s Tribol code is employed that ensures design derivatives are sufficiently smooth. This method leverages Enzyme for automatic differentiation to obtain exact consistent tangent matrices and accurate design sensitivities. LLNL’s open-source Smith code is used to solve the nonlinear finite element simulations which use an extremely robust energy-based trust region solver to reliably converge contact simulations with either force or displacement control. The Livermore Design Optimization (LiDO) software is used to pose the design problem, which includes parameterizing the finite element mesh, accumulating total design sensitivities and interfacing with nonlinear programming libraries to solve the overall design optimization problem. Various example problems are shown demonstrating the scalability of the software tools, robustness of the algorithms, and flexibility of the design process.

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