Minimally-intrustive level-set based topology optimization

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ABSTRACT

Topology Optimization (TO) is a powerful tool customarily used in industrial applications to enhance the design of mechanical structures. However TO tends to generate complex topologies, often comprising a network of structural members of arbitrary thicknesses, which are hard to build with traditional manufacturing techniques such as casting. Hence, a significant effort has been devoted to the incorporation of manufacturing constraints directly into the TO design process. This presentation focuses on the development of a minimally-intrusive modular software architecture based on the level-set method, a work performed in the context of the TOP project at IRT SystemX (https://www.irt-systemx.fr/en/project/top/). The classical notions of shape derivative and advection of the implicit domain via the solution of a Hamilton-Jacobi equation [1] are coupled with mesh adaptation techniques [2], enabling the generation of a computational mesh conformal to the shape interface at each iteration of the design process [3]. The domain evolution strategy is based on a twofold parametrization of the shape. On the one hand, the level-set-based implicit description allows topology changes to occur. On the other hand, the body-fitted explicit discretization simplifies the computation of the geometrical properties and the physical quantities located on the interface. This framework is particularly propitious for properly evaluating and controlling various geometrical criteria especially member thicknesses [4], that, when left unchecked, may cause detrimental thermomechanical effects in the part while it is manufactured. The proposed strategy also promotes the decoupling of the shape optimization machinery and the finite element engine needed to evaluate the state of the system. The latter feature is of particular interest for industrial problems since the respective evaluations of the different physics (thermal residual stress, heat transfer, fluid-structure interaction) can be obtained using dedicated high-performance (e.g. parallel) solvers.

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