Body-fitted discretization, accurate interface tracking and geometrical constraints in topology optimization

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ABSTRACT

Topology optimization aims at computing the most efficient distribution of material within a design space such that the obtained solution respects the specifications of the problem at stake. Several topology optimization methods have been proposed and are currently employed in industry for designing mechanical parts, such as the SIMP method, the homogenization method and the level-set method.

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 proposed strategy enables the rapid prototyping of mechanical parts without the need for further post-processing treatment, making the process of conception more intuitive for the user and the geometrical definition of the optimal structure less ambiguous.

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 conception 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, resulting in an accurate estimation of geometrical criteria such as thickness constraints [4]. It 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 can be obtained using dedicated high-performance (e.g. parallel) solvers.

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