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Topological derivative in constrained optimization problems via the null-space algorithm

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ABSTRACT

The optimization of structural designs through topology optimization techniques has become pivotal in achieving efficient and lightweight structures, especially in the transport industry.

The topological derivative plays a crucial role in topology optimization by providing valuable information about the sensitivity of an objective function with respect to infinitesimal perturbations in the material distribution. In the last years, the topological derivative has been succesfully used in many engineering problems when combined with level-set and incorporated in a fixed point algorithm: the slerp algorithm [1].

However, when dealing with constrained optimization problems, the slerp algorithm needs to incorporate additional numerical schemes. In the last years only the augmented Lagrangian scheme has been used in this scenario and in general it has shown a slow rate of convergence.

We propose to incorporate the slerp algorithm to the null-space optimizer to deal with the constraints. The Null-space has exhibit solid performance when considering the level-set and the shape derivative in the Hamilton-Jacobi algorithm [2]. In other words, we extend the null space algorithm from shape to topological changes.

Through a series of case studies, we demonstrate the efficacy of this approach.

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[2] Feppon, F., Allaire, G., & Dapogny, C. (2020). Null space gradient flows for constrained optimization with applications to shape optimization.ESAIM: Control, Optimisation and Calculus of Variations, 26, 90.