Mesh adaptation is commonly exploited for PDE discretization and it generally consists in the automatic adjustment of the elements of the grid in order to control some quantities of interest, e.g., the discretization error or a functional of the error [1]. The anisotropic version can further lower the computational burden associated with the employed numerical scheme, while ensuring the desired accuracy on the PDE solutions, especially in the presence of phenomena featuring preferential directions. In this presentation, we focus on topology optimization and we suitably combine the mathematical formulation of a standard optimal design method with an ad-hoc anisotropic mesh adaptation procedure [2].

We employ the SIMP method for modeling the design problem [3]. SIMP belongs to the density-based methods, where the material distribution is described via an auxiliary scalar field (i.e., the density) taking values between 0 (void) and 1 (material). The void/material interface represents the structural boundary and is located in correspondence with the 0-1 density gradients.

As a consequence, the employment of customized meshes, possibly following the directional features of such boundaries, is relevant for design purposes. Indeed, the enrichment of SIMP with an adapted anisotropic mesh allows to deliver optimized mechanical configurations, whose geometries are intrinsically smooth thanks to the smart allocation of the mesh elements. The resulting highly detailed structure boundaries make the optimized configurations ideal for a 3D printing phase, with limited post-processing required.

In this presentation, we highlight the properties of this methodology, with a specific focus on the possible industrial applications. We provide several case studies and we challenge the algorithm with different objective functions and design constraints. In particular, we showcase examples of the proposed topology optimization scheme when applied at the macroscale, at the microscale in the context of material design, and in a multiscale framework

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