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IMPLEMENTATION OF MAXIMUM LENGTH SCALE CONTROL WITHIN THE CONTEXT OF AN INDUSTRIAL TOPOLOGY OPTIMIZATION SOFTWARE

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Abstract: In structural design, some issues relevant to a manufacturing process, a functional design, or purely aesthetic conditions may require a proper control of the allowable member sizes of structures. A maximum length scale may be introduced as manufacturing constraint to avoid overheating in the bulk of a 3D printed part. Conversely, imposing minimum length scale limits impracticable small details and prevents also numerical issues related to checkerboard patterns and mesh dependency. Suitable formulations of these conditions must be provided in order to define a well posed topology optimization problem. In the SIEMENS topology optimization tools (Samcef Topol, NX Nastran SOL 200), several manufacturing constraints have been implemented (symmetry, casting, extrusion, etc). Among them, the enforcement of a minimum length scale is available, based on filtering techniques. With the aim to provide additional control of the maximum allowed thickness of a structure, dedicated formal constraints have been proposed in the literature [1]. This scheme limits dependency on parameters with regard to other alternatives (e.g. using penalization). Imposing a maximum fraction of material in the neighborhood of each point of the structure, this approach results in as much additional constraints as local controls provided. In the context of FE density-based topology optimization, each element may be subject to maximum length scale control, for which as many sensitivities as design variables are involved. This leads to a computational burden for the optimizer which becomes unbearable in industrial applications. Combining several strategies to improve performance of the local approach (i.e. active set strategy, continuation method), this work achieved the industrialization of the method. Thanks to agglomeration techniques classically used for stress constraints, local constraints are condensed into a single one. Furthermore, in line with [2] modifying the neighborhoods used for local constraint computation, a strategy is proposed to enforce the maximum length scale with accuracy. Finally, dedicated treatments of the elements located near the boundaries of the design domain and with non-optimizable elements are introduced, providing a robust control of the maximum length scale everywhere in the design space. Performance, accuracy and robustness of the resulting approach are validated on industrial applications.

References

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