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Density-based Topology Optimization of Coated Structures Subject to Dynamic Loading

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ABSTRACT

Topology optimization and additive manufacturing forms a near perfect match, in which the design freedom from the material distribution methods complement the geometric freedom provided by 3D printing and vica versa. Therefore, many obvious directions for further extensions and research exists, with one of them being the design of optimized coating and infill patterns for light weight constructions as shown in e.g. [1,2]. The basic idea of the coating approach is to use the projected gradient of the density field to identify the coating region and to overlay this with the background density field to obtain a single-design field representation of interior, void and coating domains. The infill approach, on the other hand, consists of adding a local volume constraint to the interior domain through a second design variable field. The second design is filtered to ensure a prescribed level of design freedom and the locality is circumvented by a p-norm statement. Thus, one extra design field and one extra constraint is all that is needed compared to the standard minimum compliance problem. The novelty of the presented work consists of extending the above methodologies to cover dynamic loading and adding the possibility to have two distinct materials in the coating region; for example one with highly damping material properties (and a high cost) and one with standard material properties (and a low cost). Firstly, the dynamics are introduced as harmonic loading in the low frequency range. This, amongst others, means that full material utilization is no longer optimal for all problems. To alleviate this we introduce modifications to the interpolation functions and derive bounds on material property-ratios that ensures crisp material interfaces. Secondly, introducing the extra material in the coated region requires the addition of yet a design field as well as the development of new material interpolation functions. We show that this can be obtained by a total of ten filters/projections operations on a total of three globally defined design fields. The application of the proposed design methodology is demonstrated on a number of numerical examples in which different forms of dynamic compliance measures are minimized. [1] Clausen, A., Aage, N., & Sigmund, O. (2015). Topology optimization of coated structures and material interface problems. CMAME, 290, 524–541. [2] Wu, J., Aage, N., Westermann, U., & amp;amp; Sigmund, O. (2017). Infill Optimization for Additive Manufacturing –Approaching Bone-like Porous Structures. IEEE Trans. Vis. Comput. Graph 24(2), 1127–1140.