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Fast evaluation of quasi-arithmetic mean based filters for topology optimization

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Abstract

One of the most popular strategies to achieve mesh-independent designs in the material distribution approach to topology optimization is to employ a so-called filtering procedure. Here, we present a framework that views the filtering process as a generalized quasi-arithmetic mean over a neighbourhood. This framework includes the vast majority of available filters used for topology optimization. More precisely, we split the application of the filter into three steps: (i) element-wise application of a function f, (ii) computation of local averages, and (iii) element wise application of a function g. Steps (i) and (iii) consist of element-wise operations and thus scale linearly with respect to the total number of elements. Under the additional assumptions that the mesh is regular, the neighbourhoods are polytope-shaped and that all neighbours in each neighbourhood are weighted equally, the number of operations required for step (ii) scales linearly with the number of elements. The low computational complexity opens up possibilities of using combinations of filters, for example the open--close (dilate after erode after erode after dilate) or close--open (erode after dilate after dilate after erode) that up till now have been considered too computationally expensive.