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Parameter-free shape optimization

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Shape optimization problems arise with a large variety in many engineering applications. Typically, such problems are constrained by a partial differential equation describing, e.g., fluid or structural mechanics. Following variational principles, a sensitivity of the objective function with respect to the shape is derived. In parameter-free approaches, the sensitivity is found as a distribution over the design surface. A discretization of the shape is only carried out afterwards. In parameterized approaches, on the other hand, the sensitivities correspond to the partial derivatives of the objective functions with respect to a finite set of design parameters. In order to extract a descent direction to be used in the scope of a steepest descent algorithm, auxiliary problems have to be solved in the parameter-free approaches. They basically serve two purposes. Firstly, they are used to find a descent direction that is smoother than the sensitivity distribution. Secondly, they extend the distribution from the boundary into the domain in order to update the underlying discretizations. In a mathematical sense, they assure that a given space of admissible shapes is not left during the optimization. Typical examples for auxiliary problems are convolution filters or the Laplace-Beltrami equation. They are combined with an extension operator in order to extend the smoothed sensitivity into the domain. Other possibilities, e.g., auxiliary problems stemming from the Steklov-Poincaré metric, provide the smoothed sensitivity on the boundary and its extension to the domain interior in one step. In this minisymposium, presentations about recent developments in the field of parameter-free shape optimization are welcome. This includes investigations of different means to obtain a descent direction as well as comparisons to parameterized approaches and novel applications to engineering problems. We explicitly appreciate researchers from both areas - mathematics and engineering - in order to exchange novel ideas about the oftentimes different perspectives on the topic.