# Title: First and second order shape optimization based on restricted mesh deformations

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# Abstract

In shape optimization problems involving partial differential equations, the domain is often represented by a computational mesh, and the optimization proceeds by repeatedly updating the mesh node positions. It is well known that such a procedure eventually may lead to a deterioration of mesh quality, or even an invalidation of the mesh, when interior nodes penetrate neighboring cells. We examine this phenomenon, which can be traced back to the ineptness of the discretized objective when considered over the space of mesh node positions. As a remedy, we propose a restriction in the admissible mesh deformations, inspired by the Hadamard structure theorem. First and second order methods are considered in this setting. Numerical results show that mesh degeneracy can be overcome, avoiding the need for remeshing or other strategies. FEniCS code for the proposed methods is available on GitHub.