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# Simultaneous Optimization of Topology and Orientation of Anisotropic Material using Isoparametric Projection Method

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## Abstract

New fiber reinforced composite fabrication technologies, such as tailored fiber placement or continuous fiber printing technology, enables realization of arbitrary orientation distribution of reinforcement fiber in a structure. Thus, building structures with optimal shape, topology and fiber orientation is now possible with aid of these technologies. In order to design such optimal strucures, we propose a general topology optimization method, which is capable of simultaneous design of topology and orientation of anisotropic material, by introducing orientation design variables in addition to the density design variable. The proposed method supports not only discrete fiber orientation but also continuous fiber orientation design by using a Cartesian style orientation vector as the design variable combined with a projection method using isoparametric shape functions. The proposed method is less likely to be trapped at unwanted local optima when compared with classic continuous fiber angle optimizations, CFAOs, which directly uses orientation angle as the design variables; this is because vector representation offers more paths from one design solution to another, including an orientation vector with smaller norm, which represents weaker orientation. Another advantage of the proposed method is that it is compatible with filtering methods, especially design variable filtering, so that designers can control the complexity of the orientation angle distribution. The proposed method is built upon modern topology optimization technique, thus, it is versatile and flexible enough to solve multiload problems or even multiphysics problems.

**Keywords:** topology optimization; orientation design; isoparametric projection; tailored fiber placement; 3D printing.