Numerical optimization of shape and orientation of locally anisotropic materials

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Shape optimization became a more prominent subject of study due to its direct applications in the additive manufacturing process technologies. Besides, the structures produced by this process are observed to possess a local mechanical anisotropy that can be controlled by varying the manufacturing speed and trajectory. Therefore, it is further interesting to couple the optimization of shape with the optimization of the local anisotropy orientation; which is a non-convex problem for multiple load case examples and analytically unsolvable for non self-adjoints optimization problems; this type of problem require the adoption of a gradient based numerical method to obtain an optimal orientation field. For this purpose, we established an alternate coupled numerical optimization by updating the orientation of the anisotropic tensorial Hooke's law after a certain number of updates on the shape. A level set method is used to optimize the shape and a gradient descent algorithm is implemented to optimize the orientation angle of a locally transversely isotropic material. For the multiple load case problem, a bridge example with three load cases scenario, where its compliance is optimized, is treated. Whereas, for the non adjoint optimization, an example of a force inverter, where the objective function is a mean squared error function, is discussed. The examples of this work were investigated in 2D and 3D.

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