EngOpt2018 - 6th International Conference on Engineering Optimization
Instituto Superior Técnico, Lisbon Portugal • 17-19 September, 2018
Editors: H.C. Rodrigues, J. Herskovits, C.M. Mota Soares, et al.

Abstract ID 1298

TOPOLOGY OPTIMIZATION OF COMPLIANT FLUIDIC CONTROL STRUCTURES UNDERGOING LARGE DEFORMATIONS

Prabhat Kumar[1], Paola Fanzio[1], Luigi Sasso[1], Matthijs Langelaar[2]

[1]Delft University of Technology, Netherlands
p.kumar-3@tudelft.nl, p.fanzio-1@tudelft.nl, l.sasso@tudelft.nl

[2]TU Delft, Netherlands
m.langelaar@tudelft.nl

Keywords: Topology optimization; Compliant mechanisms; Geometrical and material nonlinearity; Nonlinear finite element method;

Abstract: In this work, topology optimization is used to design compliant fluidic control structures (CFCSs). A compliant mechanism which transmits force, motion and/or energy into different output responses at associated different locations within the design space while experiencing large deformation with the purpose of regulating fluid flow, can be termed as a CFCS. Such output responses, herein, are characterized via opening and/or closing of predefined holes having different positions, shapes and sizes. In a CFCS, a hole can be closed if its boundaries move towards each-other in response to the external input actuation. Conversely, in case of opening, they should move apart. A least square error objective with respect to a target boundary shape and/or position is proposed to achieve CFCSs with desired opening and/or closing functions, under selected resource constraints. Such mechanisms can be used as tunable fluidic control devices which can vary their shapes and functions in specific, predetermined ways in response to external loadings while undergoing large deformation. It has been noticed that topology optimization techniques based on gradient search involving large deformation experience numerical instabilities when extreme deformation occurs in lower stiffness finite elements/regions. To avoid such anomalies, we use the approach presented in [1] for the topology optimization. Material and geometrical nonlinearities are considered to cater to large deformation, which proves essential to obtain effective CFCSs. The Newton-Raphson method in association with updated Lagrangian formulation based finite element method is used to solve the mechanical equilibrium equations. The structures are actuated via uniformly displacement (stretching) loads. Various single/multi-functional compliant devices are presented, and their performances are compared with their respective prototypes to show the efficacy of the approach.

References:

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