

Data-driven surrogate modeling of structural instabilities in dielectric elastomers

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Dielectric elastomers (DEs), a class of incompressible electroactive polymers, are soft composites that deform mechanically under the action of an applied electric field. Under certain electro-mechanical loading conditions, DE specimens buckle resulting in inhomogeneous deformation on the structural level [1]. The objective of this work is to characterize the onset of such structural instabilities in DE film-substrate bilayers over a wide range of tunable geometrical and material properties by adopting a data-driven surrogate modeling approach. The required data is generated using a finite-element-based instability analysis framework, for which a saddle-point-based variational principle for electro-elastostatics, involving the deformation map and the scalar electric potential as the primary fields, is implemented [2]. In this setting, the onset of structural instability corresponds to the signature change of the global indefinite tangent matrix, as shown in [3]. Within the considered design space for the DE bilayer, the data points are sampled by implementing the Sliced Latin Hypercube Design (SLHD) algorithm proposed in [4], which has been shown to ensure space-fillingness of the resulting sampled data points. Machine-learning-based surrogate models are then developed to predict the critical applied surface charge density for the onset of wrinkling instability and the resulting number of half waves on the surface of DE bilayers.

References

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