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Hamid Ghasemi, Harold Park, Timon Rabczuk

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A level-set based IGA formulation for topology optimization of flexoelectric materials

Hamid Ghasemi[1], Harold Park[2], Timon Rabczuk [3, 4, 1]

[1] Institute of Structural Mechanics, Bauhaus- Universität Weimar, Marienstraße 15, 99423 Weimar, Germany
[2] Dep. of Mechanical Eng, Boston University, Boston, MA 02215, USA
[3] Division of Computational Mechanics, Ton Duc Thang University, Ho Chi Minh City, Viet Nam
[4] Faculty of Civil Engineering, Ton Duc Thang University, Ho Chi Minh City, Viet Nam

Abstract

This paper presents a design methodology based on a combination of isogeometric analysis (IGA), level set and point wise density mapping techniques for topology optimization of piezoelectric / flexoelectric materials. The fourth order partial differential equations (PDEs) of flexoelectricity, which require at least C^1 continuous approximations, are discretized using Non-Uniform Rational B-spline (NURBS). The point wise density mapping technique with consistent derivatives is directly used in the weak form of the governing equations. The boundary of the design domain is implicitly represented by a level set function. The accuracy of the IGA model is confirmed through numerical examples including a cantilever beam under a point load and a truncated pyramid under compression with different electrical boundary conditions. Finally, we provide numerical examples demonstrating the significant enhancement in electromechanical coupling coefficient that can be obtained using topology optimization.

Keywords: Flexoelectricity, Topology optimization, Level set, Isogeometric analysis (IGA), Micro-Nanostructure

Nomenclature

$\boldsymbol{B}_u$, $\boldsymbol{B}_\theta$	the matrices containing the gradient of the $\boldsymbol{N}_u$ and $\boldsymbol{N}_\theta$
$\boldsymbol{C}$ / C_{ijkl}	the fourth-order elasticity tensor
D_Ω	the whole structural domain
$\boldsymbol{d}$ / d_{ijkl}	the fourth-order converse flexoelectric tensor
D_j^s	the surface gradient operator
D^n	the normal gradient operator
$\widehat{D}_i$	the usual electric displacements

Corresponding Authors: E-Mail: hamid.ghasemi@uni-weimar.de; parkhs@bu.edu; timon.rabczuk@tdt.edu.vn