Development of monolithic and staggered schemes for coupled electromechanics with high order curvilinear finite elements

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ABSTRACT

The paper presents a high order curvilinar finite element framework for monolithic and staggered analysis of geometrically linearised and highly nonlinear coupled electromechanical problems. The framework encompasses an accurate high order implementation of the convex multi-variable electro-elasticity and its particularisation to the case of small strains, whence and wherein circumventing the requirement for symmetrisation of the resulting Maxwell and Minkowski-type stresses and an eventual non-symmetric finite element formulation. While the monolithic approach is always utilised in the case of highly nonlinear problems, the geometrically linearised problems can be efficiently solved for using a staggered scheme. High order finite elements with optimal nodal distributions are employed not only to alleviate the problem of bending, shear and volume locking, but also to facilitate numerical simulations of application-oriented actuators and energy harvesters with accurate boundary representation bypassing the need to rely on prototypes and simplified geometrical representations. To this effect, an a posteriori curviliner mesh deformation technique is employed to represent the true CAD boundaries of electromechanical components, while still utilising standard finite element interpolation functions. Numerous examples in the context of actuation, morphing and sensing are presented to verify the robustness of the formulation.

REFERENCES

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