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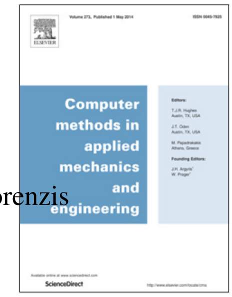

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An isogeometric analysis formulation for red blood cell electro-deformation modeling

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Abstract

An isogeometric analysis formulation for simulating red blood cell (RBC) electro-deformation is presented. Electrically-induced cell deformation experiments are receiving increasing attention as an attractive strategy for single-cell mechanical phenotyping. As the RBC structure consists in a very thin biological membrane enclosing a nearly-incompressible fluid, (i) a surface shell kinematic model and (ii) the imposition of the shell enclosed-volume conservation constraint are proposed within the isogeometric analysis framework. With regard to the electro-deformation, an accurate evaluation of the electric-field induced forces is achieved by the Maxwell stress tensor approach. A staggered fixed-point iteration scheme is then proposed for performing the electro-mechanical coupling, in order to use reliable mechanical and electrical problem solvers sequentially. Supported by the comparison with experimental results and reference solutions, numerical simulations concerning the large deformation of a RBC by optical tweezers and an *in silico* electro-deformation experiment prove the accuracy and the effectiveness of the proposed formulation.

Keywords: Isogeometric analysis, Thin shell, Biological membrane, Electro-deformation, Strong coupling

1. Introduction

Cell mechanical properties have been recognized by the biophysics community to be useful markers of cell state. In particular, the growing evidence that cell deformability may provide a label-free biomarker for determining e.g. metastatic potential, degree of differentiation, or cell activation [1], has prompted the development of a wide range of experimental techniques aiming at cell mechanical phenotyping (reviews can be found in [2, 3, 4]). Increasing

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