Accepted Manuscript

Modeling extracellular matrix viscoelasticity using smoothed particle hydrodynamics with improved boundary treatment

Tommy Heck, Bart Smeets, Simon Vanmaercke, Pinaki Bhattacharya, Tim Odenthal, Herman Ramon, Hans Van Oosterwyck, Paul Van Liedekerke

PII: S0045-7825(16)31877-1
DOI: http://dx.doi.org/10.1016/j.cma.2017.04.031
Reference: CMA 11433

To appear in: *Comput. Methods Appl. Mech. Engrg.*

Received date : 22 December 2016
Revised date : 21 April 2017
Accepted date : 25 April 2017

Please cite this article as: T. Heck, et al., Modeling extracellular matrix viscoelasticity using smoothed particle hydrodynamics with improved boundary treatment, *Comput. Methods Appl. Mech. Engrg.* (2017), http://dx.doi.org/10.1016/j.cma.2017.04.031

Modeling extracellular matrix viscoelasticity using smoothed particle hydrodynamics with improved boundary treatment

Tommy Heck[a], Bart Smeets[b], Simon Vanmaercke[b], Pinaki Bhattacharya[a], Tim Odenthal[b], Herman Ramon[b], Hans Van Oosterwyck[a,c,e,*], Paul Van Liedekerke[d,e]

[a] *Biomechanics Section, KU Leuven, Celestijnenlaan 300C, 3001 Heverlee, Belgium*
[b] *MeBioS, KU Leuven Kasteelpark Arenberg 30, 3001 Heverlee, Belgium*
[c] *Prometheus, Division of Skeletal Tissue Engineering, KU Leuven, Herestraat 49, 3000 Leuven, Belgium*
[d] *INRIA Paris, 2 Rue Simone IFF, 75012 Paris, France*
[e] *Joint last author*

Abstract

We propose viscoelastic smoothed particle hydrodynamics (SPH) with extended boundary conditions as a new method to model the extracellular matrix (ECM) in contact with a migrating cell. The contact mechanics between a cell and ECM is modeled based on an existing boundary method in SPH that corrects for the well-known missing kernel support problem in Fluid Structure Interactions (FSI). This boundary method is here extended to allow the modeling of moving boundaries in contact with a viscoelastic solid. To validate the method, simulations are performed of tractions applied to a viscoelastic solid, Stokes flow around an array of square pillars, and indentation of a viscoelastic material with a circular indenter. By drop out of the inertial terms in the SPH equations of motion, the new SPH formulation allows to solve problems in a low Reynolds environment with a timestep independent of the particle spacing, permitting to model processes at the cellular scale (i.e. μm-scale). The potential of the method to capture cell-ECM interactions is demonstrated by simulation of a self propelling object that locally degrades the ECM by fluidizing it to permit

*Corresponding author: hans.vanoosterwyck@kuleuven.be; Celestijnenlaan 300C - box 2419, 3001 Leuven, Belgium