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SMEARED METHODOLOGY IN FINITE ELEMENT MODELING OF MECHANICAL PROBLEMS IN COMPOSITE MEDIA

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Tissue space is occupied by different material substances (solid, fluid, gases) with specific mechanical characteristics. In solving problems of mechanical deformation one constitutive law of the medium is commonly used. By applying the basic principles and numerical methods it is possible to obtain solutions for a given problem, however in case of composite media, present in biological systems, it is desired to have more accurate computational models.
The authors recently introduced a smeared modelling concept [1, 2] for physical fields in biological media. General concept of smeared methodology is here extended to mechanics of these composite media. We here present theoretical background, with introducing a composite smeared finite element for mechanics- CSFEM. The CSFEM contains a supporting medium (or the basic medium) in which are embedded other deformable constituents. Interaction relations are introduced at the boundaries between constituents and with the supporting medium, to couple velocities or displacements. The interaction forces, due to relative velocities at the contact boundaries, are modelled by introducing connectivity elements at the boundary nodes. These nodes are occupying the same spatial positions, with the corresponding geometrical and material characteristics assigned, to relate the normal and tangential velocities at the boundaries. Nodal parameters used in the smeared model are: volumetric fractions, fractions of the boundary surfaces, material characteristics of each medium, and the resistance to sliding coefficients. Also, fibrous structure imbedded within continuum constituents, as cytoskeleton fibres within cells, are also included in the CSFEM. In that case a consistent continuum constitutive tensor is derived. Special case of the model is when relative velocities (or displacements) at contact boundaries are set to zero, hence the velocities at the contact nodes are the same.
Accuracy of the model is assessed by comparison with detailed 2D models which consist of fluid domain, solid environment and number of different cell domains. This smeared concept offers a simple modelling of complex tissue deformation as in case of tissue with tumors, or heart wall.

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REFERENCES

[1] M. Kojic, Smeared Concept as a General Methodology in Finite Element Modeling of Physical Fields and Mechanical Problems in Composite Media, JSSCM, Vol. 12, No. 2, DOI: 10.24874/jsscm.2018.12.02.01, pp. 1-16, ISSN: 1820-6530, 2018.

[2] M. Kojic, et al., Smeared Multiscale Finite Element Models for Mass Transport and Electrophysiology Coupled to Muscle Mechanics, Frontiers in Bioengineering and Biotechnology, Vol. 7, DOI: 10.3389/fbioe.2019.00381, ISSN: 2296-4185, 2019.