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Multiscale coupling of individual-based cancer models with arbitrary vasculature and fiber structure

Cicely K. MacNamara[1], Alfonso Caiazzo[2], Ignacio Ramis-Conde[3], and Mark A. J. Chaplain[1]

[1] School of Mathematics and Statistics, Mathematical Institute, University of St Andrews, United Kingdom, KY16 9SS, www.st-andrews.ac.uk/maths/
[2] Weierstrass Institute for Applied Analyis and Stochastics (WIAS) Leibniz Institut im Forschungsverbund Berlin e.V., Berlin, Germany, www.wias-berlin.de
Universidad de Castilla la Mancha, Departamento de Matemáticas, Facultad de Educación, Cuenca, Spain, www.matematicas.uclm.es/depmate/

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Cancer growth is a complex multiscale problem, which depends on different physical phenomena, such as diffusion of nutrient in the tissue, mechanical interaction between cancer cells and fibre structure, vasculature remodeling (angiogenesis) and blood flow. The goal of this work is to describe a set of computational and mathematical models that, combining discrete description (based on individual based models – IBMs) and continuum descriptions allow to simulate the interaction of cancer cell population with the surrounding tissues.

The first contribution concerns the mutual coupling of IBMs for cancer cells [2] with an arbitrary vessel structures, considered as sources of oxygen. In this case, the blood vessels are geometrically represented in the IBM, interacting mechanical with cancer cells based on simple repulsion-adhesion forces. Moreover, the IBM is coupled to a finite element method for the diffusion of oxygen within the tissue (as in [1]). In this model, the vasculature is represented using the *immersed boundary method*, i.e., the vasculature is not explicitly resolved by the computational mesh, allowing for arbitrary vasculature trees, and, at the same time, improving the efficiency of the simulation.

Secondly, we focus on the interaction between cancer cells and the surrounding fibre matrix. In this model, the IBM for cancer cells is coupled to an IBM for fibres, describing the interaction by means of repulsive and adhesion forces depending on cell polarity and on fibre direction. To demonstrate the potential of the model, we provide an example of how a finger-like structure arises in an oriented matrix environment.

REFERENCES

[1] A. Caiazzo and I. Ramis-Conde. Multiscale modelling of palisade formation in gliobastoma multiforme. *J. Theor. Biol.*, 383:145–156, 2015.

[2] I. Ramis-Conde, M. A. J. Chaplain, A. R. A. Anderson, and D. Drasdo. Multi-scale modelling of cancer cell intravasation: the role of cadherins in metastasis. *Phys Biol*, 6(1):016008, 2009.