11th World Congress on Computational Mechanics (WCCM XI)
5th European Conference on Computational Mechanics (ECCM V)
6th European Conference on Computational Fluid Dynamics (ECFD VI)
July 20–25, 2014, Barcelona, Spain

TOWARDS PATIENT-SPECIFIC SIMULATIONS AND VALIDATION OF A TUMOR ANGIOGENESIS MODEL USING ISOGEOMETRIC ANALYSIS

Guillermo Vilanova[1], Ignasi Colominas[1], Thomas J.R. Hughes[2] and Hector Gomez[1]

[1] Group of Numerical Methods in Engineering, Universidade da Coruña, Department of Mathematical Methods, Campus de Elviña, 15192 A Coruña, Spain, gvilanovac@udc.es
[2] Institute for Computational Engineering and Sciences, The University of Texas at Austin 201 East 24th Street, University Station C0200, Austin, TX 78712, USA.

Key words: *Tumor Angiogenesis, Isogeometric Analysis, Phase-field Modeling*

Angiogenesis is the growth of new capillaries from pre-existing ones. This complex biological phenomenon plays a critical role in the development of cancer, as tumors gain the ability to promote angiogenesis. The new capillaries provide the tumor the necessary nourishment for its fast growth as well as they are used by the cancer cells to metastasize. For this reason, impeding angiogenesis has became a promising cancer therapy [1]. However, many aspects of the physics and biology of angiogenesis are still unknown and researches from multiple disciplines study this phenomenon under different perspectives.

Here we investigate tumor angiogenesis by means of a hybrid mathematical model [2] which is able to describe the vascular growth. The model includes mobile, agent-based components and high-order partial differential equations. In [3] we put the model into a coherent mathematical framework that enables the coupling between the discrete and continuous equations and we developed an efficient and robust computational method based on isogeometric analysis [4] that deals with the high order terms. These permitted us to perform accurate three-dimensional simulations of an extended version of the model [5]. Moreover, we present a simulation in a cornea that shows how the computational method has the potential to enable calculations on patient-specific anatomies.

In this work we explain our computational method based on isogeometric analysis for the tumor angiogenesis model, we show three-dimensional simulations performed in the complex geometry of a cornea, and we describe a method to validate quantitatively the results.

REFERENCES

[1] J. Folkman. Tumor angiogenesis: therapeutic implications. *The New England Journal of Medicine*, Vol. **285**, 1182-1186, 1971.

[2] R.D.M. Travasso, E. Corvera Poiré, M. Castro, J.C. Rodríguez-Manzaneque and A. Hernández-Machado. Tumor angiogenesis and vascular patterning: A mathematical model. *PLoS ONE*, Vol. **6** (5), e19989, 2011.

[3] G. Vilanova, I. Colominas and H. Gomez. Capillary networks in tumor angiogenesis: From discrete endothelial cells to phase field averaged descriptions via isogeometric analysis. *International Journal for Numerical Methods in Biomedical Engineering*, Vol. **29** (10), 1015–1160, 2013.

[4] J.A. Cottrell, T.J.R. Hughes and Y. Bazilevs. *Isogeometric Analysis: Toward Integration of CAD and FEA*, Wiley, 2009.

[5] G. Vilanova, I. Colominas and H. Gomez. Coupling of discrete random walks and continuous modeling for three-dimensional tumor-induced angiogenesis. Accepted for publication in Computational Mechanics, 2014.