

Accepted Manuscript

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PII: S0045-7825(16)31249-X
DOI: <http://dx.doi.org/10.1016/j.cma.2017.03.021>
Reference: CMA 11378

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

Received date : 1 October 2016
Revised date : 22 February 2017
Accepted date : 14 March 2017

Please cite this article as: M. Rahman, et al., A fully coupled space–time multiscale modeling framework for predicting tumor growth, *Comput. Methods Appl. Mech. Engrg.* (2017), <http://dx.doi.org/10.1016/j.cma.2017.03.021>

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A Fully Coupled Space-Time Multiscale Modeling Framework for Predicting Tumor Growth

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Abstract

Most biological systems encountered in living organisms involve highly complex heterogeneous multi-component structures that exhibit different physical, chemical, and biological behavior at different spatial and temporal scales. The development of predictive mathematical and computational models of multi-scale events in such systems is a major challenge in contemporary computational biomechanics, particularly the development of models of growing tumors in humans. The aim of this study is to develop a general framework for tumor growth prediction by considering major biological events at tissue, cellular, and subcellular scales. The key to developing such multiscale models is how to bridge spatial and temporal scales that range from 10^{-3} to 10^3 mm in space and from 10^{-6} to 10^7 seconds in time. In this paper, a fully coupled space-time multiscale framework for modeling tumor growth is developed. The framework consists of a tissue scale model, a model of cellular activities, and a subcellular transduction signaling pathway model. The tissue, cellular, and subcellular models in this framework are solved using partial differential equations for tissue growth, agent-based model for cellular events, and ordinary differential equations for

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