Karlstad Applied Analysis Seminar (2021)

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April 07, Wednesday, 10:30

Multiscale mathematical model of tumor growth in static vascular environment

Abstract

Tumor growth depends on several factors such as oxygen concentration, cell reproduction, movement, death and vascular environment. We present a multiscale model based on [LMJ17] and [Owe+11], modeling cells as stochastic agents in continuous space and mean-field models for oxygen and extracellular concentrations on a lattice. Furthermore, cell movement is modeled via Brownian motion which affects other intracellular concentrations. It is extended with mean-field concentration by evolving cell densities in the discrete domain. To model the oxygen evolution we consider a reaction-diffusion PDE with mean-field cell densities as a sink. Finally, results are evaluated using a coupled stochastic/deterministic approach based on [LMS17] and [RS11] reducing variance on a post-processing stage.

[LMS17] Lejon, A., Mortier, B. and Samaey, G. 'Variance-reduced simulation of multiscale tumor growth modeling'. In: Multiscale Modeling & Simulation vol. 15, no. 1 (2017), pp. 388–409.

[Owe+11] Owen, M. R., Stamper, I. J., Muthana, M., Richardson, G. W., Dobson, J., Lewis, C. E. and Byrne, H. M. 'Mathematical modeling predicts synergistic antitumor effects of combining a macrophage-based, hypoxia-targeted gene therapy with chemotherapy'. eng. In: Cancer research vol. 71, no. 8 (2011). 0008-5472.CAN-10-2834[PII], pp. 2826–2837.

[RS11] Rousset, M. and Samaey, G. 'Simulating individual-based models of bacterial chemotaxis with asymptotic variance reduction'. In: Mathematical Models and Methods in Applied Sciences vol. 23 (2011), pp. 2155–2191.