Three-Dimensional Isogeometric Tumor Growth Simulations

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ABSTRACT

Despite an ongoing research aimed at developing the cure for cancer, an efficient general-purpose treatment remains elusive, and therapies must be planned on a case by case basis by monitoring and predicting tumor development. This creates demand for cancer simulation software that can adapt to each individual case based on available data and accurately precict tumor reaction to treatment. Since the simulated phenomenom is complex, highly non-linear and depends on a large number of parameters, methods required to tackle this problem necessitate employing very fast numerical solvers. In this work we describe application of fast L^2-projection based isogeometric solver to 3D tumor model based on [1]. This is an extension of the two-dimensional version described in [2]. We first present the model, consisting of two interacting parts. Continuous part is the system of PDEs describing the relations between continuous densities of tumor cells, tumor angiogenic factors (TAF), extracellular matrix (ECM), ECM degraded by tumor and oxygen. The discrete component is the vasculature network that provides the oxygen and develops in response to presence of TAF. We also present a sensitivity analysis illustrating how our 3D tumor model is sensitive for changes of particular model parameters. Finally, we present numerical results of simulating tumor development in 3D. Our 3D simulator has been speed up by employing parallel GALOIS framework [4] and fast integration with a new quadratures [5]. We compare our L^2-projection based method with the classical finite difference method and the Adaptive Wavelet Collocation method. The results suggest that L^2-projection based solver is a viable and efficient method for tumor simulation problems.

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