Multiscale developments of the cellular Potts model

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Abstract

Multiscale problems are ubiquitous and fundamental in all biological phenomena that emerge naturally from the complex interaction of processes which occur at various levels. A number of both discrete and continuous mathematical models and methods have been developed to address such an intricate network of organization. One of the most suitable individual cell-based model for this purpose is the well known cellular Potts model (CPM, [1]). The CPM is a discrete, lattice-based, flexible technique that is able to accurately identify and describe the phenomenological mechanisms which are responsible for innumerable biological (and non biological) phenomena. In this presentation, we first give a brief overview of its biophysical basis and discuss its main limitations. We then propose some innovative extensions, focusing on ways of integrating the basic mesoscopic CPM with accurate continuous models of microscopic dynamics of individuals [2]. The aim is to create a multiscale hybrid framework that is able to deal with the typical multilevel organization of biological development, where the behaviour of the simulated individuals is realistically driven by their internal state. Our CPM extensions are then tested with sample applications that show a qualitative agreement with experimental data [3-5]. Finally, we conclude by discussing further possible developments of the method.

References