Rafał Wcisło
AGH University of Science and Technology
e-mail: wcislo@agh.edu.pl
Witold Dźwinel
AGH University of Science and Technology
e-mail: dzwinel@agh.edu.pl

Complex Cellular Automata based on particle dynamics as a framework for modeling solid tumor growth and angiogenesis

To simulate the growth dynamics of tumor in both its avascular and angiogenic phases we propose a novel computational paradigm based on, so called, complex automata approach (CxA). It combines the cellular automata modeling (CA) with off-grid particle dynamics coupled by continuum reaction-diffusion equations. The particles represent both tissue cells and fragments of vascular network. They interact with their closest neighbors via semi-harmonic central forces simulating mechanical resistance of the cell walls. The particle dynamics is governed by both the Newtonian laws of motion and the cellular automata rules. The rules represent cell life-cycle stimulated by various biological processes such as carcinogenesis and diffusion-reaction processes involving nutrients and tumor angiogenic factors. We discuss the main advantage of CxA model such as its ability of simulating mechanical interactions of tumor with the rest of the tissue. We show that our model can reproduce realistic 3-D dynamics of the entire system consisting of the tumor, normal tissue cells, blood vessels and blood flow. We conclude that the CxA paradigm can serve as an efficient and elegant general framework of more advanced multiple-scale models of tumor coupling microscopic in-cell processes with its macroscopic evolution. Finally, we discuss the main requirements and design components of an interactive visualization engine based on CxA paradigm. Such the system can be used as a valuable tool for educational purposes and, in the nearest future, for in silico experiments, which can play the role of angiogenesis assays in planning cancer treatment.