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A Nutrient-Quided Chemotaxis-Haptotaxis Approach for Modeling the Invasion of Tumor Cells

We propose a hybrid continuum-discrete model to simulate nutrient-guided malignant brain tumor cell invasion. The lattice-based spatio-temporal model consists of three reaction–diffusion equations that describe interactions between cancer cells, the extracellular matrix (ECM) and nutrients. In addition to random diffusion and haptotactic movement, the migration of cancer cells is directed towards the gradient of the diffusible nutrients as oxygen and glucose [3], which is referred to as chemotaxis. As for the description of the initial migratory response of endothelial cells to the tumor angiogenic factors and the extracellular matrix macromolecule fibronectin [2], we model a system of nonlinear partial differential equations. While [1] focuses on tumor cell adhesion, we model both, the effects on the migration of tumor cells by the ECM and, additionally, by the attraction of higher nutrient concentrations. Moreover, we assume that every cell is able to push a neighboring cell of the same size towards an empty site.

Simulation studies show that the model is consistent with experimental in-vitro invasion results as regards the spatial distribution of the tumor interacting with the ECM. Furthermore, we demonstrate the flexibility of the model realizing simulations with varying arrangements of nutrient delivering blood vessels.

References

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