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Diffusion and Advection using Cellular Potts Model DEBASIS

DAN, Center for Biocomplexity, Department of Physics, Indiana University Bloomington, USA, JAMES GLAZIER, Center for Biocomplexity, Department of Physics, Indiana University Bloomington, USA — The Cellular Potts Model (CPM) is a robust cell level methodology for simulation of biological tissues and morphogenesis. Standard diffusion solvers in the CPM use finite difference methods on the underlying CPM lattice. These methods have difficulty in simulating local advection in the ECM due to physiology and morphogenesis. To circumvent the problem of instabilities we simulate advection-diffusion within the framework of CPM using off-lattice finite-difference methods. We define a set of generalised fluid "cells" or particles which separate advection and diffusion from the lattice. Diffusion occurs between neighboring fluid cells by local averaging rules which approximate the Laplacian. CPM movement of the cells by spin flips handles the advection. The extension allows the CPM to model viscosity explicitly by including a relative velocity constraint on the fluid. The extended CPM correctly reproduces flow profiles of viscous fluids in cylindrical tube, during Stokes flow across a sphere and in flow in concentric cylindrical shells. We illustrate various conditions for diffusion including multiple instantaneous sources, continuous sources, moving sources and different boundary geometries and conditions to validate our approximation by comparing with analytical and established numerical solutions.

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