Parameter Estimation for a Cahn-Hilliard Type Tumor Growth Model with Nutrient Dynamics

Leonardo Beretta, Abramo Agosti, Giancarlo Sangalli

University of Pavia, Pavia, Italy
L.BERETTA38@CAMPUS.UNIMIB.IT

Abstract

The Cahn-Hilliard equation is widely used to describe the dynamics of two interacting phases separated by a thin interfacial region and provides a natural framework for modeling tumor growth.

In this work we study parameter estimation for a phase-field model of tumor evolution coupled with nutrient dynamics. The model consists of a Cahn-Hilliard type equation for the tumor phase field coupled with a diffusion equation for the nutrient concentration, including chemotactic effects and reaction terms. This system captures key mechanisms such as tumor proliferation, nutrient consumption, and chemotactic interactions.

The forward problem is solved numerically using isogeometric analysis with second-order B-spline basis functions, which naturally provide the C^1 regularity required by the fourth-order Cahn-Hilliard operator. Time integration is performed using a generalized-α scheme combined with Newton iterations.

The inverse problem is formulated as a PDE-constrained optimization problem for identifying model parameters from observed tumor configurations. The gradient of the objective functional is computed through sensitivity equations derived from the linearized system. The resulting optimization algorithm combines weighted gradient descent with a quasi-Newton strategy based on a Gauss-Newton approximation of the Hessian.

This framework provides a computational tool for calibrating phase-field tumor growth models and moves toward data-driven, patient-specific tumor simulations.