Versatile Component Model for Simulating the Bio-mechanical Effects of Macroscopic Tumor Growth

Daniel Abler*, Philippe Büchler[1]
[1]Institute for Surgical Technology & Biomechanics, University of Bern, 3012 Bern, Switzerland
*Corresponding author: daniel.abler@istb.unibe.ch

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The CHIC (Computational Horizons in Cancer) [1] project develops computational models for the cancer domain, as well as a secure infrastructure for data and model access, and reuse. It addresses challenges related to the development, validation and maintenance of multi-scale models by proposing the creation of complex disease models as composition of reusable component models.

We present a versatile component model for the simulation of bio-mechanical aspects of macroscopic tumor growth. The model computes mechanical stresses and strains, resulting from tumor growth or shrinkage in a patient-specific anatomy, from a map of cancer cell concentration. In iterative coupled execution with other component models, its output can be used, for example, to guide the directionality of tumour expansion [2], or to simulate the effect of increased pressure on blood perfusion.

Simulation of the bio-mechanic interaction relies on the finite element method (FEM); it is based on a hyper-elastic material model, as well as organ-specific boundary conditions and material properties. A pre-processing pipeline has been developed to automate the configuration process. In combination with automatic segmentation tools, this pipeline permits rapid generation of patient-specific FEM models for personalized simulations, including the assignment of suitable material parameters and boundary conditions from simple configuration options.

Model and pre-processing pipeline are implemented using Open Source libraries and software packages (CGAL, VTK, FEBio). The model can be parametrised easily for different organs and body sites of interests; it has been applied to the simulation of kidney, lung and brain cancers in the context of CHIC.

References

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