A flexible and extensible modelling framework for the simulation of vascular tumour growth: an extension to the Chaste open source C++ library for computational physiology and biology

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Abstract

Chaste Cancer, Heart And Soft Tissue Environment is an open source C++ library for the computational simulation of mathematical models developed for physiology and biology. Code development has been driven by two initial applications: cardiac electrophysiology and cancer development. ... [Note: This is to be completed ...]

Keywords: Chaste - agent-based simulation - multi-scale model - vascular tumour growth - on-lattice model - off-lattice model

AUTHOR SUMMARY:

- Insert a few bullets in here explaining major contributions of paper.

Contents

1 Introduction

- Purpose of software, what is missing in current VT software.
- Aims of the present release.
- Background/Chaste Overview.
- Paper Structure.

Multi-scale models of vascular tumour growth are usually comprised of several interacting sub-models, which include the effects of blood flow, cell cycling, nutrient transport and angiogenesis []. There are many ways to formulate the sub-models, incorporating different biophysical details []. It is of interest to determine how overall predictions of vascular tumour growth depend on the choice and combination of sub-models. To perform such an investigation, it is necessary to design models and software that allow the overall vascular tumour growth model to be constructed in a flexible, modular fashion.

In the present study, a new framework for modelling vascular tumour growth is presented, based on the Chaste (Cancer, Heart and Soft Tissue Environment) open source software library []. The framework allows for on- and off-lattice modelling of tumour growth and angiogensis, incorporates models of blood flow, haematocrit transport and structural adaptation and includes tools for the construction and analysis of vessel networks and complex tissue domains in two and three spatial dimensions.

2 Design and implementation

- Describe how the cell based simulation classes are implemented so that they are extensible and easily customisable. In particular we should aim to describe how the template method pattern and strategy pattern are employed within the Solve method (the modifiers are essentially glorified strategies).
- Emphasise composability of simulations.
- Code chart.

3 Results and exemplar simulations

3.1 Avascular tumour spheroid growth

3.1.1 On-lattice

3.1.2 Off-lattice

3.2 Vascular tumour growth

3.2.1 On-lattice

3.2.2 Off-lattice

3.3 An off-lattice model of corneal angiogenesis on a complex domain

3.4 Modularity

Modularity and how it helps with validation and verification.

4 Discussion and future work