Development of a novel, SPH solver for modelling of tumor proliferation

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October 2017

Aim of research

- Examine capacity of SPH method for modeling complex biological systems (especially tumor proliferation),
- Creating multi-phase model consisting of healthy and cancerous tissues, where healthy tissue serves as a base in which tumor develops,
- Carrying out performance tests and simulations in different environment,

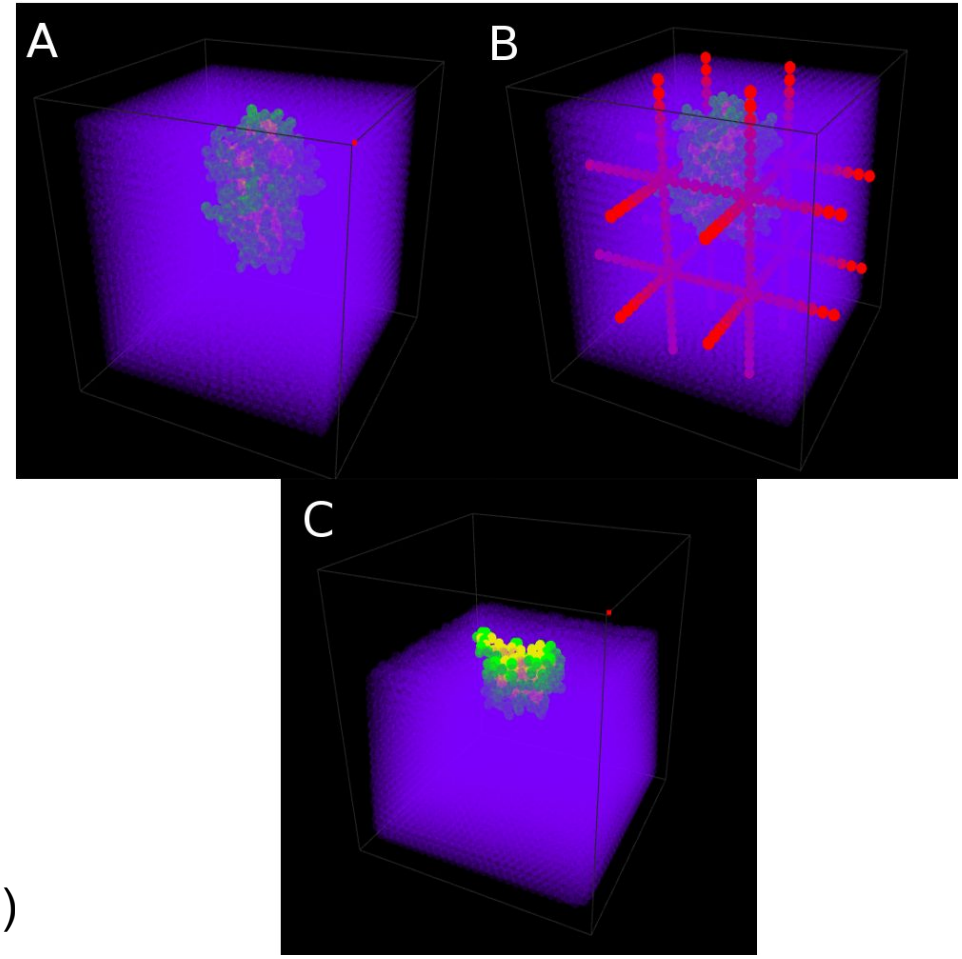
Main simulation setups

A. Model without additional structure of blood vessels (healthy tissue is source of oxygen),

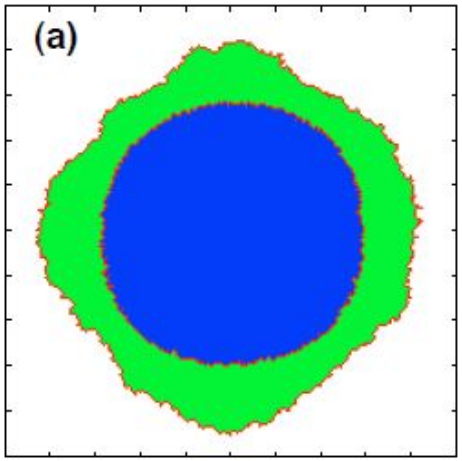
B. Model with additional structure of blood vessels (simplified; blood vessels have no real-life properties)

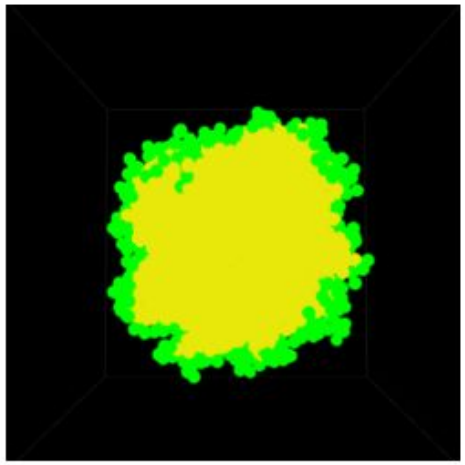
C. Melanoma setup (tumor is located on the skin surface),

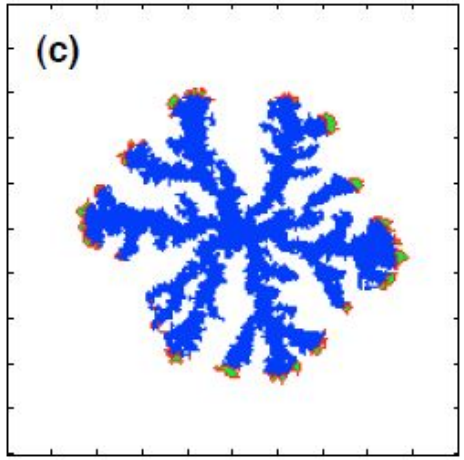
Observation: how tumor growth depends on different parameters (i.e. viscosity, O2 consumption)

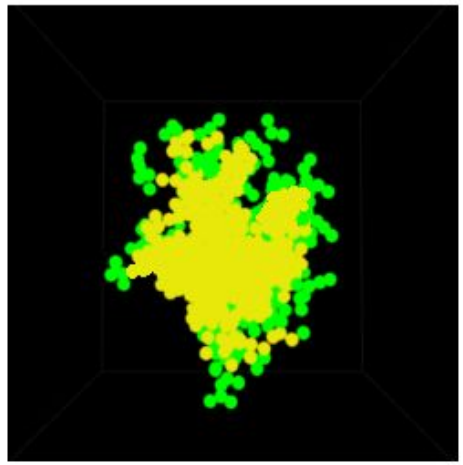


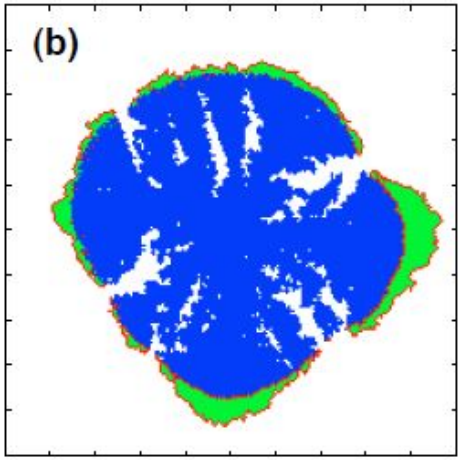
Results

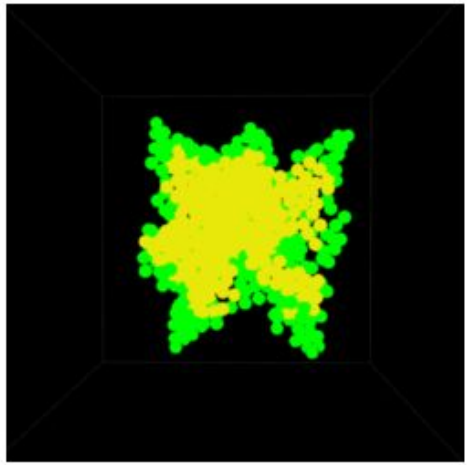












Obtained results confronted with 2-D diffusion-limited model [1]. All pictures has different oxygen consumption rates. It is possible to observe “fingering” effect with incrementation of CR constant - a is the lowest value ($5e^{-6}$), c - the biggest ($5e^{-4}$).

[1] Philip Gerlee and Alexander R. A. Anderson. Diffusion-limited tumour growth: Simulations and analysis. ACM SIGGRAPH Symposium on Computer Animation, 2010.

Conclusions and future work

- It was demonstrated that SPH method has valuable properties to model tumor dynamics in multi-phase environment,
- SPH particles are more flexible than MD (molecular dynamics) particles,
- Few of particles properties are built directly in SPH method (i. e. system pressure, system viscosity, density) and there is no need for additional implementation of those,

Possibilities:

- Create supermodel by combining SPH with created particle automata model [2],
- Possibility to model “cure” and observe tumor behaviour,
- Conducting large-scale simulations (~1,000,000 particles),

Acknowledgements: The work has been supported by the Polish National Science Center (NCN) project 2013/10/M/ST6/00531 entitled: “Multi-scale model of tumor dynamics as a key component of the system for optimal anti-cancer therapy” and resources of plgrid structure.

[2] Witold Dzwinel, David A. Yuen and Rafał Wcisło. A 3-d model of tumor progression based on complex automata driven by particle dynamics.