Student projects on “Modeling the energy supply of the brain in health and disease”

UNIVERSITY OF BERN

ARTORG CENTER
BIOMEDICAL ENGINEERING RESEARCH

Master thesis projects and student assistant opportunities are available. Below we provide an overview of the topics we are interested in. The precise project will be defined depending on the student’s background and interest and in line with the current research focus.

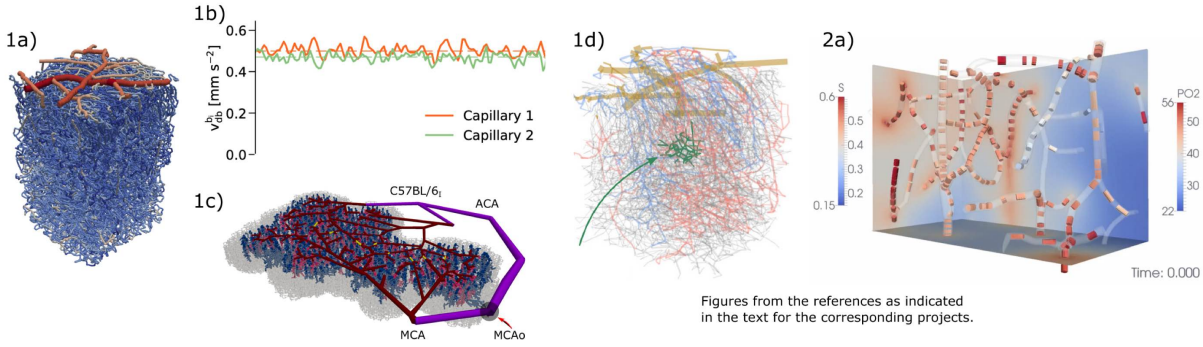
Project background

The key energy substrates of the brain are glucose and oxygen. Both are delivered to the brain via an intricate network of blood vessels. Recently, novel datasets resolving the entire vasculature of the mouse brain became available, which offer unique opportunities to study the brain’s energy supply. This requires developing and applying novel numerical methods to simulate blood flow and nutrient transport in large microvascular networks and the surrounding tissue. Besides looking at the healthy brain we are interested in pathologies like stroke and Alzheimer’s disease.

On-going research projects

1) Blood flow modeling in realistic microvascular networks (Python)
   a) Investigating the role of microvascular alterations (microstrokes, reduced vessel density, …) [1], [2].
   b) Quantifying temporal fluctuations in microvascular flow [3].
   c) Reperfusion dynamics after stroke [4].
   d) Inverse modeling (tuning of diameters & boundary conditions by incorporating in vivo data) [5], [6].
   e) Code development related to the projects above.
2) Oxygen transport
   a) Resolving individual red blood cells (OpenFOAM/C++) [7].
   b) In large microvascular networks (DumuX/C++, https://dumux.org) [8].

All projects are purely computational. As mentioned above, the precise topic can be defined based on the student’s interests and current necessities. The tasks range from simulation studies to the development of novel numerical models.



Figures from the references as indicated in the text for the corresponding projects.

Requirements

You should be motivated to work on interdisciplinary research questions and able to work and acquire knowledge independently. Knowledge of mathematical and numerical modeling of physical processes and fluid dynamics is advantageous. Moreover, some prior experience in programming with Python, C++, or Matlab is a plus.

Application

If you are interested in the topics outlined above, please contact Dr. Franca Schmid (franca.schmid@unibe.ch). Please include the following information in your mail: 1) what kind of position are you interested in (including start date and duration), 2) a few words about your motivation, 3) the topic that interests you the most, 4) comment on your prior experience in modeling and programming, 5) CV and 6) full transcripts from studies.

The Institute

You will be a member of the Cardiovascular Engineering research group (Chair: Prof. Dr. Dominik Obrist), which works on various topics related to biomedical flow systems and offers a creative and international working environment. The group is part of the **ARTORG Center for Biomedical Engineering Research**, which is the

University of Bern´s transdisciplinary Center of Excellence for medical technology research. Its mission is to tackle unmet clinical needs and envision future challenges in diagnosis, monitoring, and treatment to create viable healthcare technology solutions with imagination, agility, and purpose. Its projects run from discovery and basic research to clinical translation.

References

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[8] T. Koch, 'Projection-based resolved interface 1D-3D mixed-dimension method for embedded tubular network systems', *Computers and Mathematics with Applications*, vol. 109, pp. 15–29, Mar. 2022, doi: 10.1016/j.camwa.2022.01.021.