Abstract

Mathematical models in physiology are useful to formulate and verify hypotheses, to make predictions, to estimate hidden parameters and in education. This thesis deals with modelling in physiology using the *Modelica* language. New methods for model implementation and simulator production were developed.

Modelica is an *open standard equation-based object-oriented language* for modelling complex systems. It is highly convenient in physiology modelling due to its ability to describe extensive models in a lucid hierarchical way. The models are described by algebraic, ordinary differential and discrete equations. Partial differential equations are not supported by the Modelica standard yet.

The thesis focuses on two main topics: 1) modelling of systems described by partial differential equations in Modelica 2) production of web-based e-learning simulators driven by models implemented in Modelica.

A Modelica language extension called PDEModelica1 for 1-dimensional partial differential equations was designed (based on a previous extension). The OpenModelica modelling tool was extended to support PDEModelica1 using the method of lines. A model of countercurrent heat exchange between the artery and vein in a leg of a bird standing in water was implemented using PDEModelica1 to prove its usability. The extension was applied in a model of advection and diffusion of CO_2 and O_2 in snow, which aimed to complement experiments on breathing of an individual buried in an avalanche. In both models PDEModelica1 was proved useful.

A framework termed Bodylight(.NET) for production of web-based client-side simulators utilizing .NET technologies was developed. This framework is currently obsolete. Another framework (Bodylight.js) based on JavaScript technologies was implemented recently. A model is implemented in Modelica, exported to FMI and transcompiled to WebAssembly using Emscripten. Interactive animations are created using Adobe Animate. A new tool called Bodylight.js Composer allows to produce the final simulator comprising the interactive animations, plots and various input and output widgets and the model running in background. A simulator series on sodium and water maintenance in the nephron has been the most complex application implemented using Bodylight.js so far. Other simulators (for example Blood circulation, Cardiac Pressure-Volume) were also implemented. This novel technology was found convenient for its purpose as implementation of such simulators would be extremely laborious otherwise.