Contribution ID: **34** Type: **Presentations**

Modeling and simulation of complex human physiology systems

Wednesday, 10 April 2013 14:00 (30 minutes)

Impact

The simulation application and related computational tasks can be controlled via mobile devices with limited computing or storage capacity with the introduced technology.
Some of them are already available via the URL and used for educational purposes.

We developed a pilot model and simulation of acid-base disturbance, where the simulation is executed on the server side (deployed in NGI cloud) and the clients asks occasionally data via the RESTful web service. The application shows some acid base disturbances in a clinically used nomograms which may help to understand the key quantities and features of this condition.

As recommended by Hester et al.[2] the Hummod can be and is used in research to verify and validate mathematical models with experimental data. The implementation of Hummod in Modelica [3] would expand into this domain as well. The technology also allows to hide technical details of distributed computing and application architecture from users of the medicine or physiological domain and keep their focus on the topic related to human physiology.

[1] Fritzson P, Brunus P. Modelica –A General Object-Oriented Language for Continuous and Discrete-Event System Modeling and Simulation. Simulation Symposium, 2002. Proceedings. 35th Annual: 365-380
[2] Hester R.L., Iliescu R, Summers R. Coleman T.G. Systems biology and integrative physiological modelling, The Journal of Physiology, Volume 589, Issue 5, pages 1053–1060, March 2011
[3] Kofranek J., Matejak M., Privitzer P. HumMod-Large Scale Physiological Models in Modelica, Proceedings 8th Modelica Conference, Dresden, Germany, March 20-22, 2011, 713-724, Linköping Electronic Conference, Proceedings (ISSN: 1650-3686)

Summary

Modeling and simulation may improve understanding of complex human physiology and it can bring a new knowledge hidden in number of details of complex modeled reality. It is used to teach students of medicine the topic of physiology and pathological physiology. And it is also used in a research to understand the complex functionality of human body with specific focus on selected functionality, e.g. in the process of so called “model identification” to verify the model with reality and to compute unmeasurable data and model parameters.

Current effort is to built web based simulation with distributed design where demanding simulation is performed on a server and visualization is provided by clients which may be classical desktop PC, notebooks and mobile devices like smartphones or tablets.

URL

http://www.physiome.cz/atlas

Description

Modeling and simulation tools are used to develop web based simulation application. Acausal modeling is a modeling style based on equations. Causal modeling is based on assignment statements, but acausal modeling gives ability to express equation and give the flexibility to modeling tool to state which variables will be inputs and which will be computed as outputs without significant change of model itself[1]. Hummod - a large scale physiological model - integrates all known parts about human physiology into one model, where interaction

between physiological systems can be observed[2]. Implementation of such model in Modelica language brings standardized way in modifying complex model[3].

Current effort is to bring simulation application to the mobile user's platform to support lectures in physiology and give ability for further self studying at home for students. There are two approaches. First is to bring whole application to the client's computer. Either in native code or technology which brings rich Internet application to client's browser including ADOBE Flash, MS Silverlight or HTML5 and Javascript. These type of application are available at URL www.physiome.cz/atlas.
The second approach is to distribute the visualization part to client application and leave simulation and data management on the server and communicate via some standardized protocol. This approach is currently in development utilizing RESTful web service providing data access to simulation results.

The used modeling and simulation tools require specific platform (Windows based) and licensed libraries. Cloud computing in contrast to grid computing brings a possibility to built own virtual infrastructure with all necessary libraries. The pilot deployment were performed within the scientific EGI infrastructure as well as in commercial without need to develop cross platform compatibility.

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Session Classification: Community Applications

Track Classification: Community Platforms (Track Lead: P Solagna and M Drescher)