Orchestrating clinical simulation with FEniCS

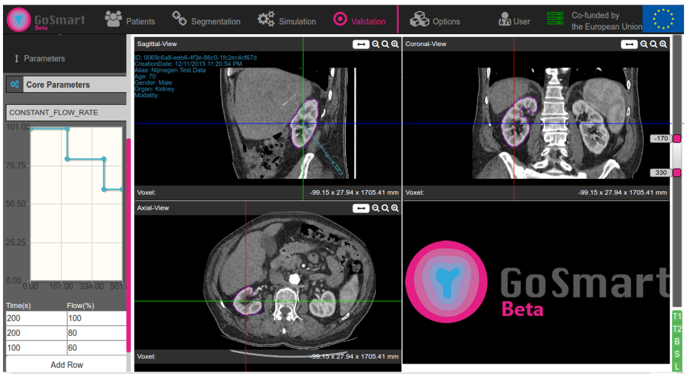
Phil Weir, NUMA Engineering Services Ltd.. phil.weir@flaxandteal.co.uk,
Roland Ellerweg, Fraunhofer Institute of Technology, roland.ellerweg@fit.fraunhofer.de,
Jack S. Hale, University of Luxembourg, jack.hale@uni.lu

Keywords: *clinical domain model, containerization, web, clinical simulation, Docker, minimally invasive cancer treatment.*

In a clinical research environment, it is necessary to perform simulations where geometry and parameters are configured at runtime, often by users with significant clinical experience, but without deep knowledge of programming or numerical tools. Providing an online interface for both clinical and technical users, not fixed to pre-existing models or medical equipment, requires adaptable and comprehensive numerical libraries for technical end-users to build upon. FEniCS is well-placed to fulfil this need, supported by the breadth of Python.

The Go-Smart EU-FP7 Project (http://gosmart-project.eu) implements this within the field of minimally invasive cancer treatments, by establishing a web-based platform for clinical training, numerical model validation and interdisciplinary research [1].

Within this project, FEniCS provides steady-state solutions for energy deposition during microwave tumour ablation, using transverse-magnetic axisymmetric Maxwell's equations coupled to Pennes' bioheat equation, with an empirically-derived nonlinear dependence of electrical parameters on tissue temperature [2]. Integrated FEniCS support assists technical end-users in incorporating their own numerical models of minimally invasive treatments.



CONSTANT_FLOW_RATE

Time(s)	Flow(%)
200	100
200	80
100	60

ID: 0069c6a8-eeb6-4f3e-86c0-1fc2ec4cf67d
CreationDate: 12/11/2015 11:20:54 PM
Alias: Nijmegen Test Data
Age: 70
Gender: Male
Organ: Kidney
Modality:

Voxel: -99.15 x 27.94 x 1705.41 mm

Voxel: -99.15 x 27.94 x 1705.41 mm

Voxel: -99.15 x 27.94 x 1705.41 mm

Figure 1: Go-Smart web interface launching a simulation. The input form is dynamically generated based on the choice of equipment, clinical protocol and a numerical model.

The web interface allows users to segment image data, graphically place percutaneous needles and enter clinical procedure steps, which are made available to modellers' code through Python objects. Modellers and manufacturers may combine simulation models, clinical protocols, patient-specific measurements and equipment parameter sets through the web interface.

A Python server, Glossia (https://github.com/go-smart/glossia), enables remote management of simulations over standard web protocols. All software is containerised using Docker to ensure security, efficiency, reproducibility and system independence [3].

References

[1] P. T. Weir, D. Reuter, R. Ellerweg, T. Alhonnoro, M. Pollari, P. Voglreiter, P. Mariappan, R. Flanagan, C. S. Park, S. Payne, E. Staerk, P. Voigt, M. Moche and M. Kolesnik:

Go-Smart: Web-based Computational Modeling of Minimally Invasive Cancer Treatments *IEEE International Conference on e-Health and Bioengineering*, 2015.

[2] Z. Ji and C. L. Brace: Expanded modeling of temperature-dependent dielectric properties for microwave thermal ablation *Physics in medicine and biology*, 56.16 (2011): 5249.

[3] J. S. Hale, L. Li and G. N. Wells: FEniCS in Linux Containers (poster) *FEniCS Workshop, Imperial College London*, 2015.