Framework for Open Source Software Development for Organ Simulation in the Digital Human

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The current state of the field of medical simulation is characterized by scattered research projects using a variety of models that are neither interoperable nor independently verifiable models. Individual simulators are frequently built from scratch by individual research groups without input and validation from a larger community. The challenge of developing useful medical simulations is often too great for any individual group since expertise is required from different fields, from molecular and cell biology, from anatomy and physiology, and from computer science and systems theory.

Open source, open architecture software development model provides an attractive framework as it addresses the needs for interfacing models from multiple research groups and facilitates the ability to critically examine and validate quantitative biological simulations.

The focus of our research is to explore the feasibility of developing open source, open architecture models of different levels of granularity and spatio-temporal scale for a project that has been labeled the Digital Human project, an initiative which aims to build a complete functioning library of interactive views and simulations of human anatomy, physiology, pathology, histology and genomics. While the emphasis of our research is on how the simulations that we develop will allow for the interconnections between individual organ simulations, and between different types of physical processes within a given organ, we will develop our tools on a specific test bed application: the construction of a heart model for simulation of heart surgery.

We are developing a draft API for organ models in surgical simulation. The focus of the initial draft is on the interface for the mechanical models of organs. Several heart models have been selected from the literature to determine the requirements on the open source simulator framework to be able to include these models in the simulator. These models are actually very low level and detailed models of heart, and are beyond the proposed scope of a surgical simulator. In particular, the Peskin-McQueen heart model, which is a model of the muscle mechanics coupled with hemodynamics, is being studied in order to determine the proper paradigm to handle coupled models within the simulator, even though a comparatively higher-level model will actually be used in this project.

Parallel to the effort on the API development, we are developing a surgical simulator framework, which is based on our earlier VESTA surgical training simulator test-bed, to accommodate open source release, and to follow the open architecture specifications of the API mentioned above. The simulation environment

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is also being designed to support parallelization of parts of the computation, for example the finite element computations for mechanical deformations of organs.

As a test-bed application for the API and surgical simulation environment development, we are also developing a basic model and simulation of heart. The model being developed will include basic electromechanical, circulatory, and physiological behavior of the heart.