SimVascular 2.0: A Sustainable Open Source Software Pipeline for Patient Specific Blood Flow Simulation and Analysis

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Introduction

- SimVascular (www.simvascular.org) is an integrated software package that provides a complete pipeline from medical image data to patient specific blood flow simulation that has contributed to numerous advances in personalized medicine, surgical planning, and medical device design.
- SimVascular was originally an internal research code developed in the laboratory of Prof. Charles A. Taylor (formerly of Stanford University) and was released as open source code in 2007 but not publicly maintained.
- Beginning in September 2013, S2S-SSI funding has been enabling the revitalization of SimVascular with state-of-the-art technology given four specific aims with the goal to expand the user community and enable large-scale simulation-based research studies.

Specific Aims of SimVascular Project

1. Launch a new sustainable project with a modular architecture that incorporates benchmarking methods and test suites.
2. Provide open source alternatives for all embedded commercial components in SimVascular, providing a free solution for researchers.
3. Incorporate new machine learning segmentation algorithms enabling high throughput simulations for research studies with large patient populations for the first time.
4. Merge state-of-the-art cardiovascular modeling advancements into a unified platform that includes multi-scale modeling, new optimizations and analysis of unsteady fluid mechanics.

SimVascular 2.0 Open Source Software Improvements

- SimVascular 2.0 is an open source pipeline for the process of cardiovascular modeling and simulation consisting of five core modules [1-3] (Fig. 1). Improved portions in the past year are highlighted in blue.

New State of the Art Machine Learning Methods

- New methods use training algorithms to learn image characteristics for particular image data sets (i.e. coronary arteries) [4].
- An edge map is created from the learned image characteristics.
- Models are constructed quicker using this clean and defined edge map (Fig. 2).
- Improves image segmentation in several ways:
  1. Works consistently on all images, regardless of quality or modality.
  2. No user defined parameters required.
  3. Allows for mass processing of images.

New Graphical User Interface

- A new Graphical User Interface (GUI) is under development (Fig. 3).
- Increases modularity by making everything plugin/extension based (similar to MITK, www.mitk.org).
- Improves DICOM support by extending the MITK image processing modules.
- Modernizes the project around Python and Qt. The GUI is built with Qt and a Python interpreter allows access to the core functionality of SimVascular.

Open Source CAD Support

- Integration of OpenCASCADE enables users to construct a CAD model using open source tools.
- Customized lofting operations create anatomic solids comparable to those in Parasolid 26.1 [5] (Fig. 4).
- The OpenCASCADE kernel is complete with the ability to create ventricular bifurcations, and tag faces for boundary condition application.
- Enhances compatibility with other solid modeling applications and solvers that require a CAD type model.

References


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